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The application of the internet of things in the South African livestock farming

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The Application of the Internet of Things in the South African Livestock Farming

Student number: 2295069



A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business

Supervisor: Dr Leona Craffert

Johannesburg, 2020

KEY WORDS

Internet of Things, IoT applications, Business models, IoT scalability, IoT Business value, IoT ecosystem, South African livestock farming, Agriculture, Design Thinking

ABSTRACT

South Africa will need to increase its food supply by 50% by 2050, catering to an estimated population of seventy-three (73) million. In Quarter four (Q4) of 2019, the agriculture sector employed 885 000 people in South Africa and continues to play a vital part in job creation in the rural areas. There are 35 000 registered commercial farmers in South Africa, with 40% made up of field crop farmers while 60% comprises livestock farming. However, South African livestock farmers (producers) need to continuously deal with the changing environmental, social and economic factors that require innovative methods to ensure the sustainability of livestock production income. While the livestock farming sector needs to contribute towards the food security agenda, livestock farmers continue to deal with challenges related to predation of livestock and a surge in livestock theft.

South Africa has realised the importance of the fourth industrial revolution as its potential to propel the country to the new age of digital prosperity. The advances in digital technologies have seen the emergence of new and complementary business models transforming many industries. Digital platforms such as the Internet of Things are poised to provide solutions to some of the most complex cross-industry challenges. In South Africa, there is an emergence of innovative data collection methods such as big data analytics and IoT currently being used for field crop and livestock monitoring, giving rise to precision farming. While IoT promises potential business value generation, recent studies show that IoT applications are confronted with challenges resulting in a handful of IoT projects deemed successful.

The study explored the determinants that affect the Internet of Things (IoT) application in South African livestock farming. First, it evaluates the technical factors that play a role in the implementation of IoT; secondly evaluates the non-technical factors and assesses the positioning of IoT solutions to customers (livestock enterprises) by IoT service providers as means for business value generation. Drawing from these different viewpoints, (1) technology, (2) user, and

(3) the business aspect of IoT, the Design Thinking Framework was used to provide guiding principles that may be utilised to facilitate the application of IoT in South African livestock farming.

This qualitative study followed the snowballing sampling approach to conduct telephonic interviews with IoT experts. The data was collected from a saturated sample size of 13 participants who posed local and international exposure in IoT application and livestock farming. Furthermore, a sizable group out of the 13 subjects were livestock farmers interviewed for triangulation purposes.

DECLARATION

I, _Thuthuka Thandukwazi Mhlongo_, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in Digital Business at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Thuthuka T Mhlongo Signature: 

Signed at Midrand……

On the 30th Day of …September…… 2020.

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First, thanks to God the almighty.

Great thanks and appreciation to my family, especially my wife Sinenhlanhla Mhlongo, who held the fort at the home front, provided mental strength and support while I embarked on my academic journey.

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LIST OF ACRONYMS

Abbreviation/Acronym	Explanation
2G	Second Generation
3G	Third Generation
4G	Fourth Generation
AI	Artificial Intelligence
AMQP	Advanced Message Queuing Protocol
API	Application Programming Interface
CoAp	Constraint Application Protocols
GSM	Global System for Mobile Communication
ICT	Information and Communications Technology
IT	Information Technology
IoT	Internet of Things
LP-Wan	Low Powered Wide Area Network
Lora-Wan	Long-range Wide Area Network
LTE	Long Term Evolution
MQTT	Message Queuing Telemetry Transport
NB-IoT	Narrow-Band Internet of things
PoC	Proof of Concepts
REST	Representation State Transfer
R&D	Research and Development
RSQ	Research Sub Question
SI	System Integration
SLA	Service Level Agreement

1 INTRODUCTION

The chapter introduces the purpose of the study and the research question and sub questions that guided the study. It follows with the context of the study, the identified research problem statement.

1.1 Purpose of the study

This qualitative study will explore IoT platform experts' perceptions or views of the role of technical and non-technical factors in the application of the IoT platform model in South African livestock farming. It furthermore aims at exploring the challenges IoT experts experience in positioning the IoT solution to livestock farmers.

1.2 Context of the study

This section provides the current state of the topic and progress made by referencing existing literature and other industry-related publications to provide context to the study.

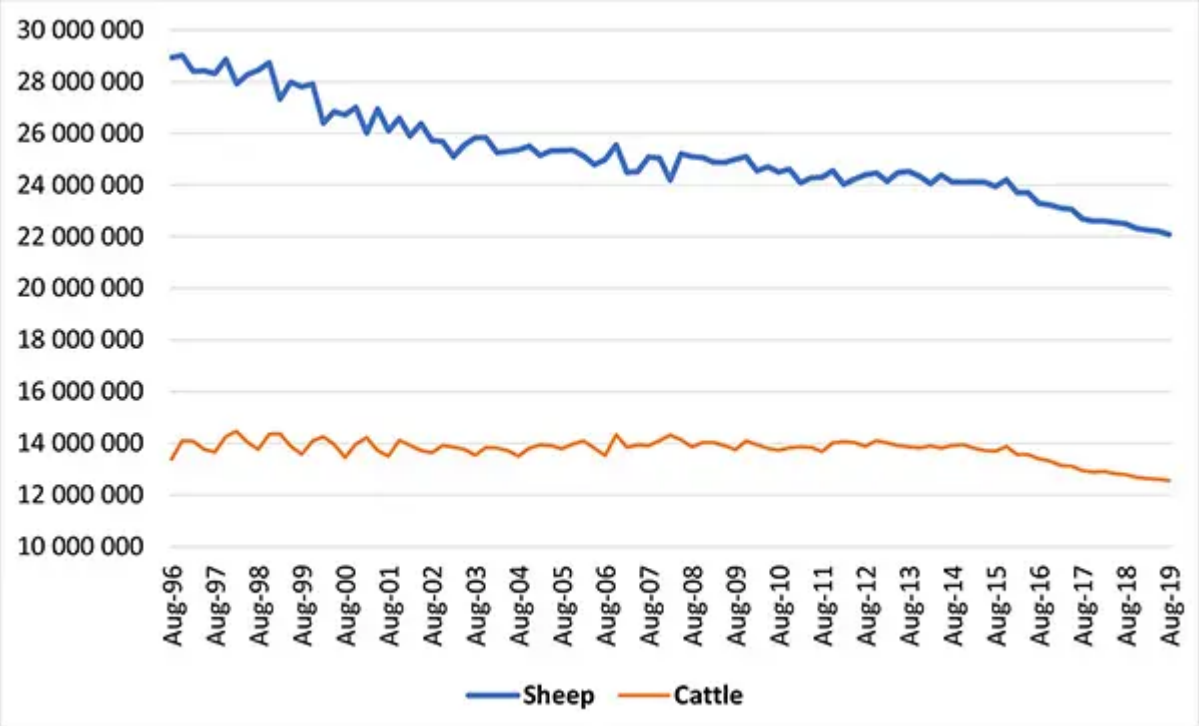
In this study, livestock farming refers to animals that are managed for human food production. Therefore, it is limited to animals conventionally found within the agricultural setting (e.g. cattle, sheep and goats).

It must be noted that the South African agriculture industry at the time of this research is confronted with surmountable challenges that pertain to food security (Department of Agriculture, Forestry and Fisheries, 2014). There is an increasing and urgent need to deal with the impact of climate change leading to unpredictable weather patterns such as drought (Mare, et al., 2018), urbanisation, declining water quality and industry job losses (von Bormann, 2019). According to the World Wildlife Fund (WWF) (von Bormann, 2019), South Africa will need to increase its food supply by 50% by the year 2050, catering to an estimated population of seventy-three (73) million. In Quarter four (Q4) of 2019, the agriculture sector employed 885 000 people in South Africa and

plays a vital part in job creation in the rural areas while there are 35 000 registered commercial farmers in South African, with 40% made up by field crop farmers while 60% comprises of livestock farming (Aguera, et al., 2020).

South African livestock farming can be in the position to contribute significantly to the 50% target for food security. Livestock products contributed 27% of the consumer food basket with the consumption of 50 – 90 g/capita/day (Meissner, Scholtz, & Plamer, 2013). Large parts of South Africa are well suited for livestock production due to the country's diverse natural habitat, with 80% of the agricultural land suitable for livestock farming. The sector contributes 40% to agriculture income (Oduniyi, Rubhara, & Antwi, 2020). Due to such favourable conditions, the country experienced rapid growth in the livestock sector (Maré, 2020). However, according to Maré (2020), the growth trend ceased in 1996 due to the decline in the national sheep flock. The national cattle herd's decline later followed it in 2015. The decline was attributed to many factors that were related to the economics of livestock production. Livestock sector risks were associated with predation, theft, animal health, price volatility and high labour intensity (Maré, 2020). Between 1999 and 2019, the national sheep flock decreased by 24%, from 29 million sheep to 22 million. While the cattle herd decreased by 10% between 2015 and 2019. Figure 1.1 shows the national South African cattle and sheep decline from 1999 to 2019.

Figure 1.1: National South African cattle and sheep numbers from 1996 to 2019 (Maré, 2020)



South African livestock farmers (producers) need to continuously deal with the changing environmental, social and economic factors that require innovative methods to ensure the sustainability of livestock production income (Oduniyi, Rubhara, & Antwi, 2020). South Africa started seeing an increase in livestock theft, which contributed to the decline of the national sheep flock and cattle herd (Maré, 2020). Between 2011 and 2012, the value of livestock (cattle, goats and sheep) stolen amounted to R830 906 600 South African Rands (Clack, 2013). Twenty-nine thousand (29 000) cases were logged in South Africa for livestock theft from 2018 through 2019 (Chelin, 2019). At the same time, the predation of livestock in South Africa is estimated to cost over R 1 billion in losses per year (Kerley, et al., 2017). According to the authors, the livestock farmers have been dealing with predation for 350 years in South Africa. The predation challenge has resulted in the eradication of much of the apex predators over the years while the black-eyed jackals and caracal are striving at the expense of livestock farmers.

South Africa has realised the importance of the fourth industrial revolution as its potential to propel the country to the new age of digital prosperity. In preparation for the advancement in technologies, the country developed three policies that are designed to underpin the country's digital readiness plan, (1) the 2012 National Development Plan (NDP), (2) The National Broadband Policy focused on South Africa's connectivity, and (3) the 2016 National Integrated ICT Policy White Paper (Gillwald, Calandro, Sadeski, & Lacave, 2019). The NDP has a 2030 vision to have an inclusive and dynamic information society and knowledge economy and reduce the country's digital divide due to limited information and communication technology (ICT) infrastructure, affordable high-speed broadband and access to digital services by all South Africans.

The advances in digital technologies have seen the emergence of new and complementary business models transforming many industries (Ben-Dov, 2019). Digital platforms such as the Internet of Things are poised to provide solutions to some of the most complex cross-industry challenges (Suleman, 2016). While in South Africa, there is an emergence of innovative data collection methods such as big data analytics and IoT currently being used in South Africa for field crop and livestock monitoring, giving rise to precision farming (Aguera, et al., 2020). IoT sensors are being applied across the sector to collect data in the field, and crops sensors are being used to measure the suitability of the soil for farming. At the same time, livestock sensors are used to measure vital signs and track animals' whereabouts and activities.

The Internet of Things presents numerous use case applications for agriculture that promises to reduce farming production-related problems (Nortje, 2020). IoT claims to increase crop quality, maximise yields (Sha, 2018), reduce irrigation wastage (Doyle, 2019), and overall input costs reductions through better management of the production process. At the same time, livestock farmers are positioned to reap the rewards from real-time monitoring and tracking of livestock, resulting in improved herd management. An estimated 12 million agriculture sensors (things) are to be installed globally by 2023 (Meola, 2020). There is growing interest to digitally transform the sector in support of the food security agenda. Microsoft South Africa invested forty (40) million Rands to

stimulate technological advances and applications within the sector (Moss, 2020). At the same time, the Research ICT Africa report (Aguera, et al., 2020) makes a thought-provoking finding that advanced technologies such as IoT can alleviate food insecurity when applied under the right conditions. It was estimated that the IoT spend in South Africa will reach R28 billion by the end of 2019. One industry purported to reap valuable benefits from the Internet of Things platform-based solutions is the agriculture sector (Botha, Malekian, & Ijiga, 2019), (Farmers Review Africa, 2020).

1.3 Research problem

The real-world application of IoT is proving rather challenging based on recent studies. A study by Cisco (2017) indicated that only 26% of IoT companies realised success from their IoT projects. At the same time, the Beecham Research report expanded on previous studies, finding that 58% of Internet of Things projects failed within the pilot phase (Duke-Woolley, 2020). Recent studies have identified emerging determining factors such as a fragmented IoT ecosystem, technical complexities (Wiggers, 2019), the impact of technical skills (CompTIA, 2019), customer's receptiveness to IoT based solutions, and evolving IoT business models (Elizalde, 2020). These emerging factors appear to be presenting challenges in the real-world application of IoT platform models. The high failure rate in the IoT application calls for closer research to explore IoT application in South African livestock farming, considering the emerging factors attributed to failures, such as lacking technical skills, fragmented IoT ecosystems, technical complexities, and technology adoption.

IoT application in South African livestock farming relies on several key dependencies that make IoT implementations feasible. These dependencies are captured in the World Economic Forum's Global Competitiveness Index, which measures the competitiveness of 140 countries in their readiness for the fourth industrial revolution (4IR). The country's fourth industrial revolution readiness for digital technologies has been regressing, with South Africa dropping in the chart standings used to measure progress with regards ICT as a pre-requisite to reaching the United Nations economic growth and human development goals (Gillwald, Calandro, Sadeski, & Lacave, 2019).

According to Pennington, 2018, the country performed poorly from 2016 to 2018 on several human development sub-indices, ranking 85th in ICT adoption. Only 54% of the adult population had access to the internet and 116th in digital skills out of 140 countries. Access to technology, digital services, and the availability of technical skills is cited above as some of the crucial factors in IoT application. While in the WIPO's Readiness for the future of Production Report that measures the rate of technology and innovation in 100 countries, South African was ranked as number 45th and 49th as it needs to spend more on R&D expenditure and patent publications.

While IoT has been purported to yield great results by South African publications across several sectors (Botha, Malekian, & Ijiga, 2019), (Letsebe, 2018), and (Hussain, 2016). Authors provide a positive and promising outlook of IoT applications in South Africa with minor considerations for the technological readiness of the country's infrastructure, the adoption rate, the availability of IoT technical skills and related technical complexities in implementing IoT.

1.3.1 Prior and related Work

Numerous related characteristics of IoT platforms have been the subject of other studies that have approached the topic from different and isolated facets about variations of IoT business and technological models. Contributions regarding specific business models and technology architectures have laid the foundation for some of the emerging concepts discussed in this study. For example, authors such as Hussain (2016) have surveyed the sustainability of IoT as potential business products on which new technology ventures can develop offerings for the South African market. At the same time, other studies focused on the innovation of IoT business models as means of ensuring sustainable business operations following the growth of the IoT ecosystem, e.g., (Fleisch, Weinberger, & Wortmann, 2014), (Hodapp, Remane, Hanelt, & Lutz, 2019), (Dijkmana, Sprenkelsa, Peeters, & Janssen, 2015). Other aspects relate to the technology building blocks and architecture, which continue to be the subject of study in the technology field due to the proliferation of IoT technologies, e.g., (Banafa, 2016), (Kumara & Mallick, 2018), (Lea, 2018). (Lee,

2019). However, this previous work focused on specific characteristics in isolation within specific domains of business or technology. The isolated approach undermines the complexities of implementing sustainable IoT platform models. Attempts to simplify and decouple crucial attributes of implementing IoT platforms may be the fundamental cause of some of the challenges accredited to project failures. IoT platforms need to involve considerations following aspects of IoT:

- The required technical skills to develop and integrate complex, interrelated technologies,
- The identification of business models that are fitting to the customer context where IoT is to be implemented,
- defining the role of the customer and industry expertise in the development of IoT solutions.

Therefore, this study explores IoT platform models considering business, technical aspects, and the customer context, mainly focusing on South African livestock farming to make a theoretical contribution. It further makes a practical contribution by providing guiding principles in the application of IoT platform models.

This study aims to contribute to the emerging concepts that threaten IoT implementations' success (Duke-Woolley, 2020). These emerging concepts concern the following:

- The fragmentation of IoT covered by the authors Aly, Khomh, Gueheneuc, Washizaki, and Yacout (2018).
- The growing concerns related to the lack of IoT skills,
- Technical complexities resulting from lack of standardisation across the involved technologies

- Evolving IoT business models that are changing industries and the future of digital business platform models, e.g., (CompTIA, 2019), (Elizalde, 2020; Duke-Woolley, 2020), (Cusumano, Yoffie, & Gawer, 2020).

This study explores these concepts and their interconnection in applying IoT platform models in South African livestock farming.

Therefore, there are several gaps in the existing literature and publications. They fall short in proving a multidimensional perspective of IoT implementations linked to the business, technology, and user aspects involved in IoT implementation. This study aims to provide such a perspective from the IoT experts to add to the existing body of knowledge about determinants attributed to technical, non-technical and the receptiveness of IoT applications as perceived by IoT experts towards livestock farming. Further exploration of IoT application will provide guiding principles to facilitate the real-world application of IoT platforms in South Africa.

1.4 Research Questions

1.4.1 Research Questions 1.

What are the factors to be considered for the application of the IoT platform model? (in South African livestock farming)

The following sub-questions aims to guide the scope of the research by focusing on three IoT impact areas, (1) technical, (2) non-technical and (3) customer context:

1.4.2 Research Sub Questions 1.1

What are the technical factors that IoT platform experts consider as relevant to the implementation of IoT?

1.4.3 Research Sub Questions 1.2

What are the non-technical factors that IoT platform experts consider as relevant in the application of IoT platform models?

1.4.4 Research Sub Questions 1.3

What are the challenges that IoT platform experts experience in positioning IoT solutions for a targeted industry (livestock farming sector)?

1.5 Significance of the study

The study explores the factors that facilitate implementing the IoT platform model within South African livestock farming. It investigates and aims to identify non-technical and technical considerations that lead to the functional implementation of the IoT platform model. It further aims to understand the receptiveness of farmers to IoT based solutions as positioned by IoT experts.

By identify the technical and non-technical factors and the difficulty experienced in engaging with customers, IoT implementation can potentially be more successful (in practice).

The research findings may be used as guiding principles that will assist IoT experts in navigating some of the pitfalls attributed to IoT implementations in livestock farming.

1.6 Delimitations of the study

This study emphasises South African livestock farming (e.g. cattle, sheep and goats), thus excluding other farming types.

The study investigates the technical composition of IoT from a practical application viewpoint and explores non-technical aspects of IoT from an IoT experts viewpoint.

The qualitative research focused on IoT experts categorised as IoT practitioners and IoT service providers while livestock farmers are used for triangulation purposes.

1.7 Definition of terms

Internet of Things: "The Internet of Things (IoT) describes the network of physical objects— "things"—that are embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet" (Oracle, 2020).

Business Model: a rationale by an organisation in how it creates, deliver and capture value (Osterwalder, 2010)

Platform Model: "A platform is a business model that creates value by facilitating exchanges between two or more interdependent groups, usually consumers and producers." (Moazed, 2020)

Emerging: becoming apparent or prominent

Livestock farming: In this context, livestock refers to animals that are managed for human food production. It is limited to animals conventionally found within the agricultural setting (e.g. cattle, sheep and goats).

IoT Experts: It is a collective definition of IoT service provider and IoT practitioners

IoT Service providers: These companies operate within the South African context, emphasising operationalising IoT Platforms as part of their business value proposition. They have a business focus on providing IoT solutions across industry sectors to help understand the phenomena.

IoT practitioners are experts who possess explicit or implicit knowledge in applying IoT platforms in South Africa.

Customers in the context of this study **refer to** the users or the beneficiaries of an IoT solution.

The **IoT Practitioners** in this study have shared their experiences and insights from any of the two contextual standpoints:

- A practitioner that is servicing an IoT Service Provider that implanted IoT solutions in an organisation or enterprise.
- A practitioner that is servicing an organisation or an enterprise that implemented an IoT solution.

PoC: Proof-of-Concept In this study, participants use the terms PoCs and pilots interchangeably to refer to small scale IoT implantations.

1.8 Assumptions

This study assumes that participants will possess adequate business and practical knowledge and skills that constitute IoT platforms' application. In addition, the participants will provide experiences that are unbiased and accurate.

- This study presumes that IoT applications aim to capture and deliver business value with a primary focus on livestock farming.
- IoT experts can relate to livestock farming
- IoT experts will have in-depth knowledge of IoT implementations
- Livestock farmers will share truthful insights about their livestock challenges and needs.

2 LITERATURE REVIEW

2.1 Introduction

IoT is changing the way business is done for many industries. Those companies that can identify and apply potential use cases are set to drive innovation over the next ten years (Ben-Dov,2019). It appears that both academia and market industry experts are of the view that the application of IoT presents opportunities for addressing some of the industry-specific challenges (Healthcare, Automotive, Retail and Agriculture) (Grossman, 2016), (Suleman, 2016). It is estimated that globally there will be 41.6 billion connected devices (things) by 2025 (IDC, 2019), indicative of IoT growth. At the same time, it is estimated that the Internet of Things combined market will grow to about $550 billion by 2021 (Columbus, 2018). According to CompTIA (2019), global IoT spending is projected to reach $1.2 trillion by 2022. While in South Africa, it is projected that the IoT connections will grow from 8.8 to 35 million between 2015 and 2020 (Pater, 2017).

George Kalenaila, the research director for telecoms and IoT at IDC SA, has been quoted by Letsebe (2018), stating that the South African IoT addressable market opportunities will grow to $1,7 billion by 2021. However, George further states that since the IoT ecosystem is fragmented, so will its value, as IoT solution providers are yet to deliver business value within a customer environment (Letsebe, 2018).

IoT platforms facilitate value through the exchange of data (information) between the IoT system components, IoT physical devices(things), network infrastructure, cloud infrastructure and people (customers or beneficiaries of IoT). However, according to Florentine (2017), a study indicated that 47% of organisations lack IoT skills and the impact of skills results in projecting failures, a view shared by Wiggers, (2019).

The chapter recognises existing but evolving and emerging factors in implementing IoT by reviewing existing literature and other IoT related publications. The literature

review will cover the following topics: below sections will be explored and linked to the context of the study:

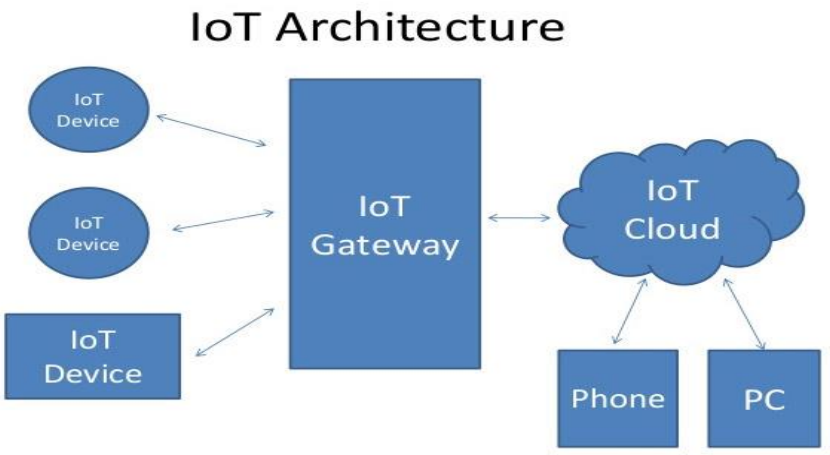
- **IoT technical Building blocks**:
  review their interactions and identify related complexities in the implementation of IoT
- **IoT skills (emerging concept):** review their availability and the resulting impact in implementing IoT implementations.
- **IoT ecosystem**: review IoT ecosystem role players and their contribution to the implementation of IoT.
- **IoT business models** (evolving concept): reviews IoT business models that lead to intended business value realisation.
- **South African livestock farming**: reviews challenges faced by farmers and explore IoT potential opportunities.
- **Customer involvement in IoT Platform design** (emerging concept): review the role of the farmer as the benefactor and the farming environment.
- Theoretical model

2.2 IoT Platform and the underlying technical building blocks

An IoT platform is a system that comprises several segmented technology components. IoT platforms are broadly distinguishable by the following logical architecture that defines functional building blocks (system components) presented in figure 2.2 by (Lvivity, 2020).

IoT platform models need to consider several interrelated technical components required for end-to-end IoT implementations. This section takes an in-depth view of the interrelated architectural building blocks that are the technical foundation for IoT platform models. According to Kumara and Mallick (2018), the IoT building blocks differ depending on the context in which they are applied.

Figure 2.1: IoT Architecture model



This technical view of IoT is supported by Khodadadi, Dastjerdi, and Buyya (2016) and Tamboli (2019), in which they define the IoT platform as follows:

- **Devices (Things)**: The physical sensors and devices that collect and measure the data. They are installed within a business area interest (such as livestock in a farm) to gather data for upstream processing and analysis (Tamboli, 2019).

- **Gateways**: These devices facilitate the exchange of data from devices to other upstream services over computer-based networks. They facilitate communication between the physical and digital components over the internet protocol (IP). They use various communication protocols such as REST, MQTT, AMQP, and CoAp to disseminate data across other build blocks (Tamboli, 2019).

- **Cloud platform**: is a digital technology platform that offers IoT cloud infrastructure, platform, and software to develop IoT data processing, analysis, storage and distribution capabilities (Lea, 2018).

- **Applications**: software interfaces (tools) developed explicitly to present the business value as insights generated from the IoT value chain. Applications

exchanges value between the intended recipients (e.g. farmers) and the rest of the platform (Tamboli, 2019).

The fragmented IoT technology landscape presents technical complexities such as lack of interoperability, cybersecurity concerns and scalability challenges due to lacking communication standards across the technology building blocks (Business Report Online, 2019; Oxford Analytica, 2019). According to authors Aly, Khomh, Gueheneuc, Washizaki, and Yacout (2018), different interoperability complexities have emerged, threatening the success of IoT, namely semantic, technical, and cross-domain interoperability. According to the authors, these emerging threats are due to the lack of standards across various evolving IoT technologies that need to facilitate data transmission throughout the horizontal IoT building blocks. The involved platform technologies such as devices need to be operable, communicable and programmable independent of the manufacturer. The authors raise challenges from the lack of interoperability amongst the many technologies developed for IoT and attributed threats when integrating these technology building blocks. The authors point out the impact of lacking standards, which should ensure consistent interoperability, resulting in technical complexities threatening value realisation from IoT projects. (Aly et al., 2018). Hence, IoT building blocks require consideration for end-to-end interoperability to guarantee service delivery (Oxford Analytica, 2019). These technical complexities require domain-specific skills to navigate diverse technical challenges presented by a lack of standardisation amongst the collaborative technologies.

Proposition 1: Technical factors play a role in the application of the Internet of Things Platform business model in livestock farming in South Africa

2.3 IoT Skills

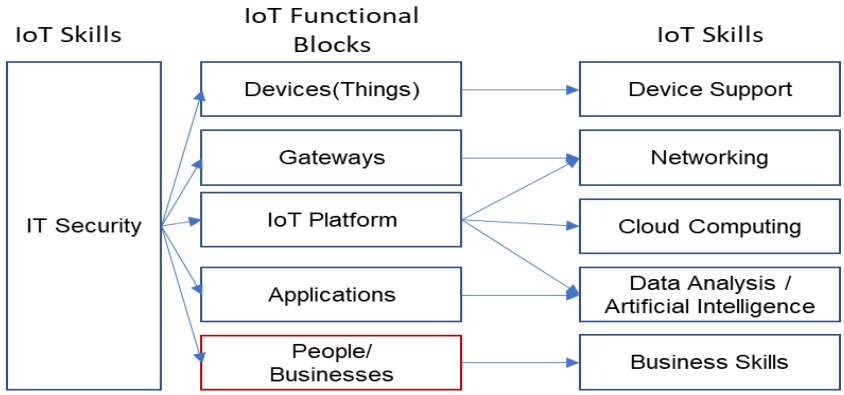
One of the emerging concepts in the application of IoT is the importance of specialised skills. According to Gaskin (2020), IoT applications require a variety of skills. Furthermore, the author Gaskin (2020) states that it is not only the technical skills that are essential, as IoT platforms must align with the overall customer business

objectives it intends to support. Therefore, industry domain knowledge is crucial for identifying business opportunities that align with IoT capabilities.

A study that interviewed 500 respondents about their use, attitudes and predictions of IoT within their businesses surveyed several industries, Agri-tech, mining, energy and transportation, across Europe, Middle East and Africa (EMEA), the Americas and the Asia Pacific and Japan (Florentine, 2017). According to Florentine (2017), 47% of organisations lacked IoT skills, while a Gartner study, according to the same article, stated that 30% of IoT projects runs twice as long due to a lack of skills. According to CompTIA (2019), the skills required for IoT applications comprise of a combination of IT and IoT specialised skills identified as follows 1) IT security, 2) data management, 3) Networking, 4) data analysis, 5) device support, 6) cloud computing and 7) Artificial intelligence.

An assessment of the listed skills above shows an alignment with the identified IoT technical building blocks (see section 2.2). In figure 2.3, the author provides an illustrative view of the skills matched against the respective technical building blocks.,

Figure 2.2 The IoT Functional Building Blocks and related Skills



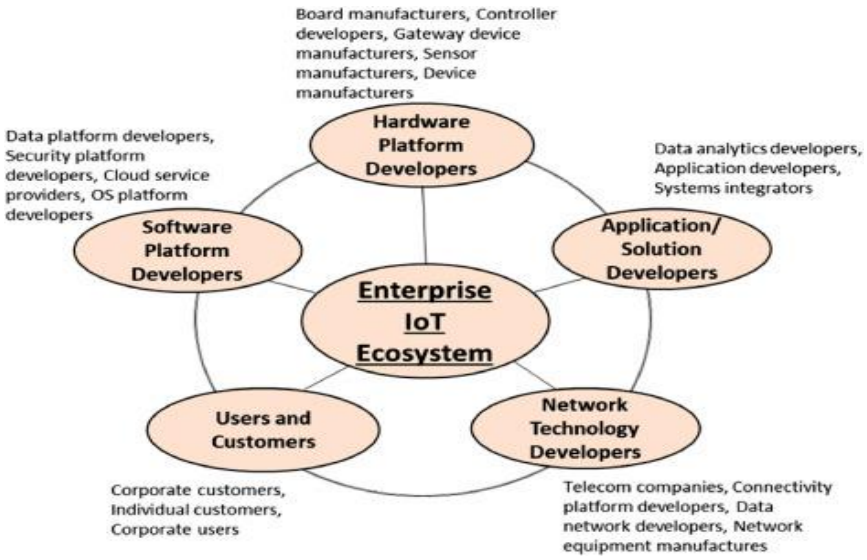
IT Security cuts across all IoT functional blocks as it focuses on data privacy, integrity, identity management, access control (devices and users), and network security (Mahbub, 2020). Device support ensures that the physical devices are maintained. Networking supports communications between the interrelated components (i-Scoop, 2020). Applications, data analysis and artificial intelligence deliver the captured data

in the form of business insights (business value) to customers (D'mello, 2019). The value can be presented in user interactive analytics dashboards, while business insights can be delivered in a representation layer through mobile devices. Therefore, a lack of IoT skills hinders achieving the desired technical and subsequent business outcomes.

2.4 IoT Ecosystem

The literature on IoT business models (see section 2.5) identifies the importance of strategic partnerships to implementing an IoT solution (Hodapp, Remane, Hanelt, & Lutz, 2019). Conceding IoT building blocks require complex cross-domain expertise, and effective implementation of IoT solutions would require the collaboration of IoT ecosystem players (Aly et al., 2018). Existing literature indicates that the IoT ecosystem is fragmented, making it challenging for IoT service providers to deliver IoT value to customers (Letsebe, 2018). The IoT ecosystem is segmented with ecosystem players providing various IoT technologies and services from a vertical standpoint (Business Report Online, 2019). The IoT applications require building block technologies and suppliers to integrate the various components into a single functional system. Figure 2.4 provides a view and role of the IoT ecosystem.

Figure 2.3 A view of IoT ecosystem players (Lee, 2019)



There are five IoT ecosystem players identified (Lee, 2019), namely (1) software platform developers (e.g., data platform developers, security platform developers, cloud service providers), (2) hardware platform developers (e.g., IoT device manufacturers /suppliers), (3) network technology developers (e.g., telecom companies, connectivity platform developers, data network developers and network hardware suppliers/ manufacturers), (4) application/solution developers (e.g., data analytics developers, applications developers), and (5) users and customers (e.g., customers, individual customers, farming enterprises).

The authors Russo & Wang (2020) state that IoT value creation requires all ecosystem players to work together jointly. The author further highlights the evolving ecosystem operational models that are seeing ecosystem players partnering to lower the development and integration cost while increasing the value output of IoT solutions. Russo & Wang (2020) warns that ecosystem incumbents who fail to partner and co-develop IoT products with other incumbents and position their operations to play in one of the three IoT operational areas (models) covered in table 2.1 will mainly remain commodity hardware providers and are likely see their customer relationships get eroded. The authors state that IoT incumbents can contribute to the IoT ecosystem within one or more of the following critical operational areas, namely orchestrators,

contributors, or enablers. Table 2.1 below indicates how Russo & Wang (2020) segment the IoT ecosystem into three (3) operational areas.

Table 2.1: IoT ecosystem operational areas

Orchestrators	Contributors	Enablers
Consolidate the fundamental building blocks of an IoT platform by inviting both contributors and enablers in delivering value to an industry or customer.	Contributes by developing additional IoT services that leverage from the orchestrator IoT platform.	Participate by manufacturing/ supplying IoT infrastructure (hardware & software), which is fundamental to the development of IoT platforms. (Network, Cloud manufacturers/suppliers, see figure 2.4)

Orchestrators identify business opportunities and build up resources to develop, operate the IoT platform and deliver IoT solutions to end customers (Russo & Wang, 2020). In addition, they invite Enablers to provide underlying technology capabilities (i.e. devices, connectivity) to develop an innovation platform. While Contributors develop services that leverage platforms developed by Orchestrators (i.e. develop a transaction platform out of the innovation platform).

Russo & Wang (2020) argues that the Internet of Things should be approached from the demand and supply side. There has been an emergence in partnerships between the IoT companies and vertical industry companies to co-creation industry solutions (Shakib, 2019). The supply and demand side partnering approach is developed to address multiple objectives, namely co-development, drive/driving adoption of IoT within the focus industry, (and) promote/promoting common data and technology standards (mitigate the fragmentation of technology standards and minimise technical complexities within the industry) (Russo & Wang, 2020).

2.5 IoT Business Models

Osterwalder (2010) defines a business model as the rationale by an organisation to create, deliver and capture value. This study assesses IoT platforms based on business value creation as positioned and delivered by IoT service providers to the customer (livestock farmer).

The rise in platform businesses has led to the success of enterprise businesses such as Amazon, Uber, Facebook and Take-a-Lot (Evans & Gawer, 2016). Platform business models can be categorised into four distinctive platforms: transaction, innovation, integration, and investment platforms (Evans & Gawer, 2016). Evans and Gawer (2016) define these platform business models as follows:

- **Transaction platform**: a technology, product or service that facilitate transactions between user, suppliers and buyers.
- **Innovation platform**: a technology, product or service that serves as the foundation on which other services are developed.
- **Integration platform**: is a technology, product or service that combines both a transaction platform and the innovation platform, e.g. Maersk installing IoT technology on its freight container business and provide access to the platform data to customers and business partners as value creation.
- **Investment platform**: consists of companies that have developed a platform portfolio strategy and acts as a holding company or an active platform investor.

The platform model that is gaining traction for value creation opportunities within an IoT ecosystem is the Integrated platform cited in several publications, e.g. (Evans & Gawer, 2016), (Chaabane I. , 2017), (Cusumano, Yoffie, & Gawer, 2020), (Russo & Wang, 2020).

The authors, Dijkmana, Sprenkelsa, Peeters, & Janssen (2015), cover essential building blocks of the IoT business models using the Osterwalder (2010) business model canvas as a framework. The authors interviewed cross-industry businesses and IoT practitioners to determine the critical building blocks of an IoT business model.

The survey indicated that the (1) value proposition, (2) customer relationships, and (3) key partnerships are the most crucial building blocks in IoT business models. Further research by Hodapp, Remane, Hanelt, & Lutz (2019) (build from the three) shows the evolving nature of IoT business models as consisting of the following: (1) value proposition (core capabilities), (2) interface (platform integration), (3) service platform, (4) organising model (partner system) and (5) revenue model (pricing model). The authors provide fifteen (15) business model dimensions that make up the five building blocks. These dimensions are illustrated in Figure 2.5 (Hodapp, Remane, Hanelt, & Lutz; 2019):

Figure 2.4 Taxonomy of IoT platform business models (Hodapp, Remane, Hanelt, & Lutz (2019)

VISOR	Dimension	Characteristics of the dimensions						
Value proposition	Core capabilities	Embedded device operation	Connectivity enablement	Device management	Device data storage	Analytics	Application development	Multiple capabilities
	Device support	Selected 3rd party devices	Exclusively provider´s devices	Selected 3rd party devices and provider devices	Any device, if provider's standards are used			
	Customer type	Consumer	Business	Business and consumer				
	Industry focus	Single-industry platform	Cross-industry platform					
Interface	Platform integration	In enterprise system	In web services	In multiple diverse systems	No integration opportunities			
	Application sales channel	Marketplace functionality	External marketplace necessary					
	Platform openness	Fully proprietary	Hardware proprietary	Software proprietary	Open source			
Service platform	Operational level	Operated on device	Operated on cloud	Operated on device and cloud				
	Core technology	Telecommunications	Sensors and microcontroller	Cloud technologies	Other technologies			
Organizing model	Partner system	Open partner system	Proprietary partner system	No partner system				
	Degree of support	Non personal technical support	Personal technical support	Personal technical and business support				
	Operation mode	Operated by platform provider	Operation by 3rd party possible					
Revenue Model	Pricing model	Developer projects are free and enterprise projects are priced	Developer and enterprise projects are priced	Free for use				
	Transaction based revenues	Per connected device	Per API call	Traffic based	Combination of multiple sources	Per request	Free for use	
	Continuous revenues	Time based (monthly / yearly) minimum fees	Pure pay as you grow (no continuous fees)					

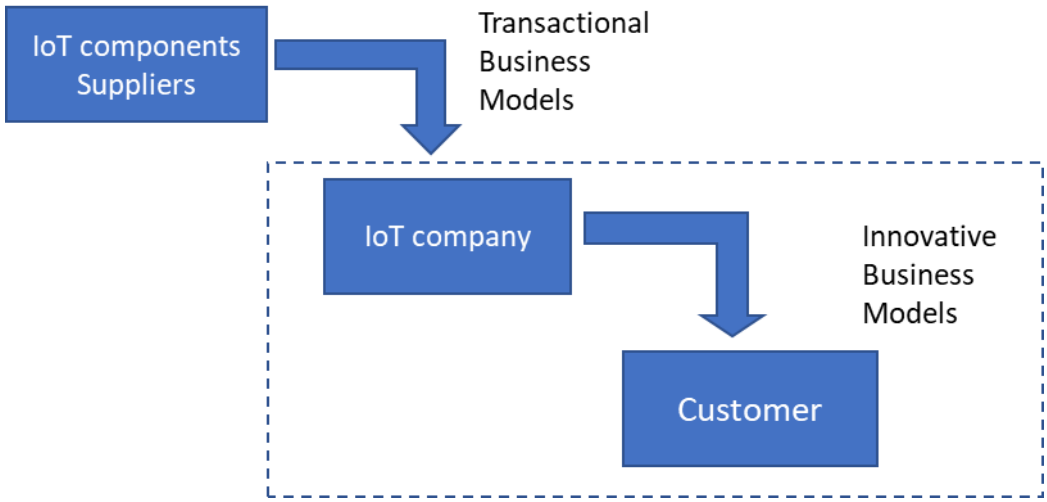
The dimensions listed in the figure above brings forth the emerging and evolving concepts, e.g., partnerships, platform integration, device support, core technology, industry focus, operational model core capabilities and pricing models.

The author Elizalde (2020) expands the pricing model dimension covered in figure 2.5 and provides seven variations of IoT pricing (revenue) models, each fitting to different

IoT platform model applications. Figure 2.5 reflects the level of complexity and interconnectedness that is to be considered in IoT platform models.

The evolutionary nature of business models continues to be the subject of many studies. Chaabane (2017) illustrates in figure 2.6 how partnerships between the different IoT ecosystem players can result in new IoT business models. In addition, the author illustrates an integrated platform model (**transaction** and **innovation** models) introduced in section 2.2.

Figure 2.5 Business Model: from supplier to customer (Chaabane I. B., 2017)



IoT component suppliers are IoT ecosystem players or platform Enablers (refer to section 2.2, figure 2.4 and table 2.1), while an IoT company relates to the platform orchestrators defined in Table 2.1. The author Chaabane (2017), lists the following business outcomes from **integrated** business models: (1) cost-savings, (2) revenue-sharing, product-sharing, transactional, Performance-as-a-Product, and Product-as-a-Service. A detailed illustration by the author on IoT platform business models applied using a farming case study can be found in appendix F1.1 to F1.3.

The convergence of platform business models and traditional business models results in the evolution of IoT business models that require careful consideration of many dimensions to ensure the viability of IoT business operational models. The emergence of IoT business models is cited to present value creation opportunities for IoT

ecosystem providers. IoT providers can mitigate the fragmented IoT ecosystem and co-development IoT solution with industry companies (Chaabane D. I., 2017), (Evans & Gawer, 2016).

Proposition 2: Non-technical factors play a role in the application of the Internet of Things Platform business model in livestock farming in South Africa

2.6 South African Livestock Farming

Whilst having noted the industry challenges in the above sections with clear definitive objectives for the sector to ensure food supply for the foreseeable growing SA population. The issues such as livestock theft are on the increase. Twenty-nine thousand (29 000) cases logged in South Africa for livestock theft from 2018 through 2019. According to a UNISA study from the School of Criminal Justice, the estimated financial loss to livestock amounted to R1.3 billion, increasing from R487 million in 2012 (Chelin, 2019).

Solutions to the most immediate farming challenges may be collaboratively resolved by applying the relevant Internet of Things use cases (CSO, 2020). The application of IoT platform models in South African (SA) agriculture could stand to benefit farmers (Sha, 2018) (IoT for All, 2019). Sha (2018) argues that challenges faced by the agriculture sector can be resolved, and business insights can be harnessed from IoT applications to manage farming resources. Sha (2018) cites several IoT potential in agriculture, such as enhancing agricultural productivity to meet food demand, water utilisation, maximise yields and minimise wastage due to real-time field data collection.

Microsoft South Africa has shown confidence in the sector by investing 40 million Rands into advancing technology application within SA agriculture (Moss, 2020).

The purported benefits derived from IoT application in livestock farming range from remote and real-time tracking of the herd, monitoring health, and overall stock well-being (Doyle, 2019). These capabilities could further assist in monitoring pregnant

cows' health and detect sickle stock, allowing the farmer to take appropriate actions to avoid the spread of possible diseases (Ravindra, 2020).

2.7 Customer involvement in platform design and application

Technology-supply companies such as Microsoft (Azure), Amazon (AWS) and Bosch, who typically form part of the fragmented IoT ecosystem, seem to shift towards a co-creation model in partnership with industry (Russo & Wang, 2020). These IoT ecosystem partnerships result from potential value-creation opportunities that can lower the development, integration, and operational cost and increase adoption of the IoT solutions within the targeted sector, as discussed in the previous section of this chapter. A more recent collaboration is that of Maersk (a freight transportation company) and Microsoft (digital technology services provider), resulting in a co-innovated IoT solution that tracks and monitors the quality of perishable goods and products stored within refrigerated shipping containers (Shakib, 2019). These partnerships are illustrative of the integrated platform model discussed in section 2.5. Maersk's container business model can now transact using real-time traceable data on goods and products by facilitating value between customers and business B2B. This case study shows an emerging trend where an IoT service provider (Microsoft) implements an IoT solution (innovation model) in a customer setting (Maersk) that results in a transaction model that facilitates the exchange of value (product traceability and quality assurance) between producers and consumers of goods. Maersk and Microsoft are now orchestrators (refer to section 2.5). Microsoft is extending these IoT partnerships by investing R40 million into the South African agriculture industry to develop partnerships between small to medium-sized technology and agriculture companies to accelerate the adoption of digital solutions such as IoT to address food security concerns (Aguera, et al., 2020). Other than Microsoft, other IoT ecosystem technology companies are collaborating with the industry for similar desirable results. Amazon Web Service announced the partnership with a farming solution provider for a supply-side partnership (Amazon, 2020).

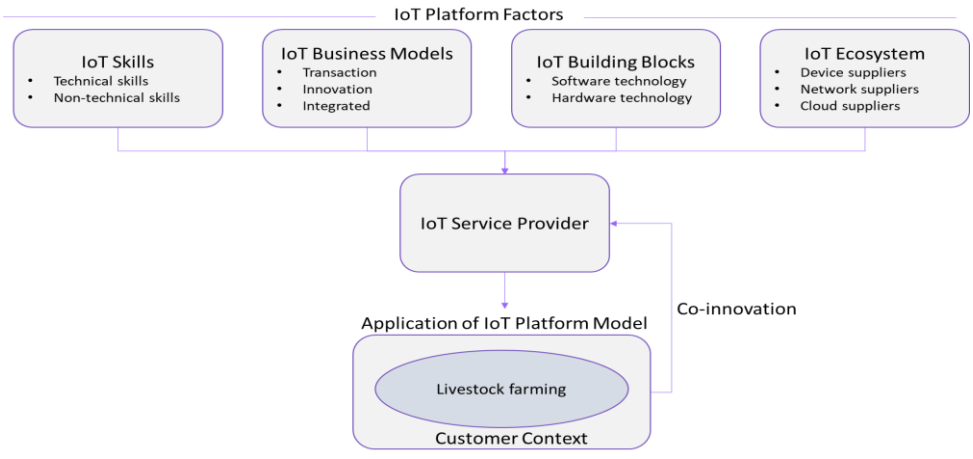
The above emerging concept of customer involvement in solution development is worth further exploring to understand the determinants and approaches.

Proposition 3: Customer involvement is required in the application of the Internet of Things Platform business model in livestock farming in South Africa

2.8 Conceptual Model

The emerging complexities and evolving factors of IoT platform models present both opportunities and challenges. Academia, IoT ecosystem players, IoT market and industry experts identify the potential value that can be harnessed for IoT applications (Botha, Malekian ad Ijiga, 2019; Columbus, 2018; Hussain, 2016). As covered in this chapter, the emerging trends reflect the emergence of new and evolving concepts shifting towards co-creation or customer-centricity. The demand and supply side IoT ecosystem partnerships for industry-specific solutions are a testament to an emerging customer-centred approach in IoT platform models to jointly design IoT solutions that address industry-specific business challenges. Figure 2.7 present concepts using a conceptual diagram.

Figure 2.6: Conceptual model



The identified elements and concepts already discussed seem to play a crucial part in the application of the IoT platform models. The conceptual framework employed above

reflects existing and emerging concepts that support the research proposition that co-created IoT solutions result in tangible business value. The IoT service provider is the customer touchpoint with consolidating ecosystem players as enablers.

2.9 Theoretical Model

Design thinking is one framework designed for complex problem solving applied across various disciplines (Dam & Siang, 2020). Brown (2008) defines design thinking as a methodology that imbues a full spectrum of innovation activities with a human-centred design approach. Design thinking is a five-step process, (1) empathise, (2) define, (3) ideate, (4) prototype, and (5) test, that is based on understanding through observation on what people need and dislike about a particular product (Brown, 2008).

Linke (2017) explains the design thinking steps in detail as follows:

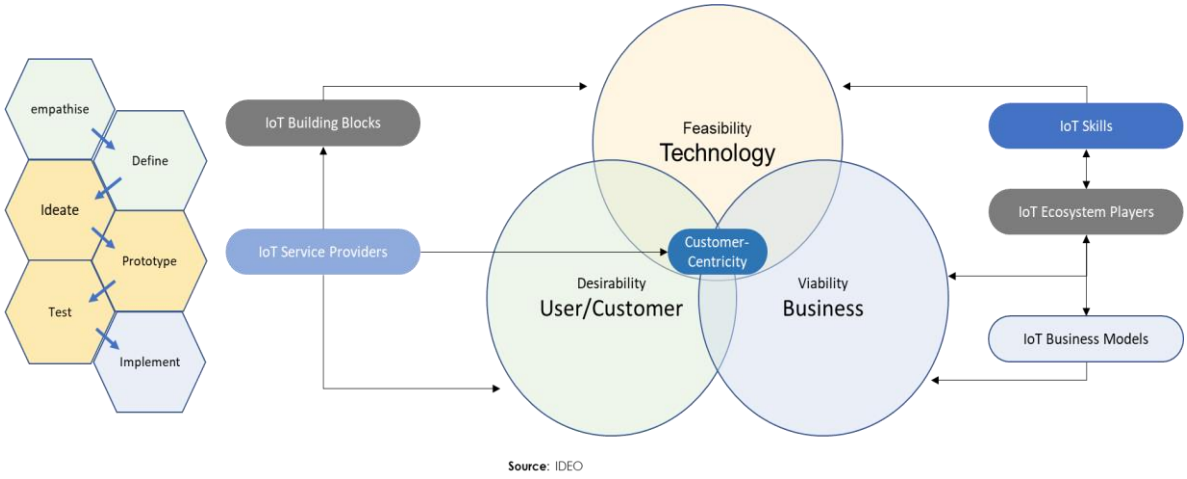
- Understand the problem (emphasize): the problem you are trying to solve before trying to find a solution as, at times, the problem you are addressing may not be the actual problem that needs to be resolved.
- Involve users (define): providing solutions to a problem requires insights from the impacted user to make that the solution being designed addresses the challenges and meets the user's needs.
- Gold Wild (ideate): this phase involves brainstorming ideas and designing the solution. It assesses many factors such as business viability, technology feasibility, and the proposed solution's customer desirability.
- Prototype and Test: in this phase, the ideas are developed for modelling and prototyping to test for the desired outcomes. This process is repeated, gathering feedback from users until the solution delivers the desired outcomes.

After prototyping the solution, it is time to implement the solution at scale, which involves financial investment and time.

The design thinking model captured in the diagram below aligns with the IoT themes that have been identified during the literature review as they relate to technical, non-

technical and the customer context aspects. The IoT platform model, as covered in the sections above, comprises interdependent and complex collaborative technologies, customer contextual challenges and business-related aspects. These merging factors in IoT applications are the reasons this study identifies the design thinking framework as the appropriate model to support the research process. In addition, the model accommodates the IoT relationships that are in consideration within this study.

Figure 2.7: Theoretical model – IDEO Design Thinking Framework (IDEO, 2021)



2.10 Conclusion of Literature Review

An IoT platform model is a culmination of many complex factors expanding across several domains. The foundation of IoT platforms is heavily dependent on a somewhat predefined logical architecture comprising specialised technical domains. The development of the functional building blocks of an IoT platform seems to heavily rely on the emerging and crucial concept of specialised (and lacking) skills. The prevailing view from the literature is that a blend of technical and business skills is crucial in implementing IoT platform models (Gaskin, 2020). While there are numerous studies on IoT architecture and business models, since IoT is an emerging technology, these aspects continue to evolve, introducing new concepts influenced by real-world factors. This view is mainly due to the premise that the value proposition of IoT applications

differs based on the context in which they are applied (industry). Therefore, a significant in-depth understanding and industry expertise emerges as crucial in IoT value realisation. Hence, recent publications are citing that IoT service providers are starting to involve industry (customers) in developing IoT solutions to capture business value.

While academia and IoT industry experts have identified IoT as the technology posed to addressing some of the industry business challenges, however, based on recent publications, a growing number of IoT applications fail to realise the desired business outcomes. Furthermore, as an emerging technology, the IoT ecosystem is fragmented, resulting in numerous complexities attributed to IoT project failures.

While previous research studies have tackled other aspects of IoT, such as IoT business models and technology-related challenges, these factors are not static. They continue to evolve as IoT platforms get widely applied. Emerging concepts need to be explored to determine how the IoT value proposition is positioned to customers. This study explores the discussed IoT theoretical models in conjunction with real-world IoT implementations based on the IoT service providers and practitioners' experiences.

The propositions that underpin this study are stated below:

2.10.1 Proposition 1

Technical factors play a role in the application of the Internet of Things Platform business model in livestock farming in South Africa

2.10.2 Proposition 2

Non-technical factors play a role in the application of the Internet of Things Platform business model in livestock farming in South Africa

2.10.3 Proposition 3

Customer involvement is required in the application of the Internet of Things Platform business model in livestock farming in South Africa

3 RESEARCH METHODOLOGY

This chapter focuses on the various methods and procedures that are instrumental in supporting the research objective.

- Section 3.1 Research approach selected for the study, which is a qualitative approach.
- Section 3.2 Research design that takes on the interpretive description approach and provides reasons for the selection
- Section 3.3 Data collection method
- Section 3.4 Population and sample
- Section 3.5 The research instrument
- Section 3.6 Procedure for data collection
- Section 3.7 Data analysis and interpretation
- Section 3.8 Limitation of the study
- Section 3.9 Validity and reliability or transferability and dependability
- Section 3.10 Demographic profile of respondents
- Section 3.11 Ethical considerations

3.1 Research approach

This study follows a qualitative methodology approach. According to Creswell & Creswell (2018), qualitative research is a process that involves emerging questions, procedures and data that are mainly collected within the participant's settings. Qualitative research investigates how the various aspects of an event, an occurrence, a case, or processes interact from different analysis views. It aims to elicit the experiences, perspectives and knowledge of the research participants about the phenomena (Bannister-Tyrrell & Meiqari, 2020).

Qualitative research comprises several interpretive techniques that aim to describe, decode and translate the meaning of the phenomena. These techniques can take the

form of individual in-depth interviews, observations, case studies, grounded theory, ethnography and action research (Schindler, 2019).

However, emerging qualitative methodologies do not entirely fall within the boundaries of the qualitative approaches mentioned above. Therefore, in this study, we focus on a generic qualitative approach. According to Kahlke (2014), the generic qualitative approach may be used to examine an occurrence, similarly to the grounded theory but without any desire to producing a new theory. The author further cites that the generic approach aims to achieve the same objectives as other qualitative approaches: to understand how people interpret, construct, and make meaning of their world and experiences.

It is essential to highlight that the generic approach has two distinctive sub-categories: interpretive and descriptive qualitative. The study focuses on the use of the interpretive technique. Kahlke (2014) states that the interpretive description approach was used in nursing research to draw on experiences and evidence from clinical practice and interpret the findings back into a real-world setting. The approach can well be applied across disciplines. It focuses on formulating research questions from practice to provide theoretical and methodologically sound evidence to be applied back into a practical setting (Kahlke, 2014).

This study uses the interpretive description approach to develop guiding principles that lead to successful IoT Platforms applications. The literature review in this study established that most IoT applications fail to realise the intended business objectives. The application of IoT is proving to be rather challenging in practice than theoretically stated by most publications. The large percentage of IoT project failures are a testament that a more carefully considered approach is required to contribute to existing literature to support IoT practitioners and service providers that want to take on IoT projects.

3.2 Research design

This study makes use of the interpretive description approach. The interpretive description approach is best suited since it is designed to inform the researcher how participants (practitioners, service providers and customers and other industry experts) interpret and construct IoT applications based on their expertise and experiences (Kalkhe,2014). The interpretive descriptive approach enabled the exploration of how IoT can be applied within South African livestock farming from the perspective of research participants

The study examines multifaceted composites and interrelated dependencies introduced in chapter 2. The study explores technical necessities, skills, and business-related considerations as a holistic IoT ecosystem. The intended objective is to gather insightful knowledge and practical experiences from different IoT domain perspectives.

3.3 Data collection methods

Qualitative studies collect data using multiple sources such as observations, interviews, documentation, audio-visuals and digital materials (Schindler, 2019). This study focused on qualitative interviews for data collection, in which the researcher conducted individual telephonic interviews (Schindler, 2019).

The advantage of using interviews as a data generation method is that they are ideal for dealing with the topic in-depth and in detail. According to Oates (2012), qualitative interviews are flexible and require little equipment, mostly a preference for participants compared to questionnaires. In addition, the researcher can adjust their line of questioning as the interview progresses.

Though there are significant advantages, there are also drawbacks to the method such that interviews are time-consuming as it requires transcribing, analysis and the interpretation of unstructured data. However, participants can provide historical

information (Schindler, 2019). Schindler (2019) notes that not all participants may be equally articulate, and some insight may be lost in translation.

This study made use of in-depth, individual interviews. This approach enabled the researcher to be flexible and adjust the questioning line, and probe for new perspectives and insights from the participants.

3.4 Population and Sample

The target population for this study can be defined as those people with knowledge and experience of IoT implementations with specific reference to IoT implementation within a livestock farming context.

However, the nature of the study called for multiple perspectives on the implementation of IoT in livestock farming. Therefore, it was deemed essential to ensure that the sample included the diversity of insights and experiences from those typically involved in IoT implementations. As identified in the literature review, IoT implementations typically include the following role-players, namely the IoT service providers and practitioners who typically act as a conduit between IoT service providers and the customer or beneficiary

3.4.1 Population:

- **IoT Service Providers**: The first targeted population consist of IoT service providers. It is a targeted list of businesses mainly focused on delivering IoT solutions to South African customers. Targeting IoT services providers allows for a vast array of experts in a single space. Service providers have been identified in chapter 2 as crucial in the IoT ecosystem.
- **IoT Practitioners:** The second targeted population consist of IoT practitioners. These participants have practical knowledge and experience of how IoT constructs are implemented and have the

necessary insight into IoT models' complexities. In addition, this population understands IoT application's technical aspects and has in-depth and detailed practical accounts from the field. IoT practitioners are also normally employed by businesses.

- **Customers:** The third population is the livestock farming enterprises which stand to be benefactors from IoT solutions. This population is identified as key in highlighting some of the challenges experienced in livestock farming that may be addressed by applying IoT in their livestock farming context. This targeted population has been added for tri-angulation purposes to test the validity of information obtained from IoT service providers and practitioners.

3.4.2 Sample and sampling method

According to Creswell & Creswell (2018), sampling design consists of two designs, single-stage and multistage. The single-stage is when the researcher has access to the names of participants in the population. The multistage or clustering is when the research first identifies groups or an organisation and then identifies names within that organisation and sample amongst them. The study started off with the multi-stage approach by identifying the particular companies involved in providing IoT services. These services providers were then approached to identify particular individuals or IoT experts to participate in the study.

There are several sampling methods, such as a random sample, systematic sample and nonprobability sample (Creswell & Creswell, 2018). This study applied the nonprobability sample known as snowball sampling. The term snowball sample is a nonprobability sample method used by the researcher to select a more representative sample of the target population (Naderifar, GoliHamideh, & Ghaljaei, 2017). According to the authors Naderifar, GoliHamideh, & Ghaljaei (2017), in the snowball sampling approach, it is not clear who will be included in the final sample. The snowball sampling uses a recruitment technique in which the research participants are asked to assist the researcher in identifying other relevant subjects (Oregon State University, 2020).

The approach is due to a diverse targeted population derived from the literature review process and to ensure that other relevant subjects are identified in the field.

Therefore, snowball sampling was applied to identify subjects with practical knowledge and experience in the area of interest. Utilising this approach allowed the researcher to avoid ambiguous and misleading roles and titles but instead rely on other research participants to uncover other knowledgeable subjects that might otherwise go unnoticed.

3.4.3 Data saturation

The principle of data saturation was followed in defining or determining the sample size of the study. Data saturation is reached when no new insights or information can be established (Schindler, 2019). Thus, the saturation point influences the population size. In this study, the saturation point was reached by the researcher after having conducted thirteen interviews. The interview questions were open-ended, and the researcher probed the participants for in-depth accounts based on the responses. The subsequent section provides details on the profiles of the participants.

3.5 The research instruments

Interviews are a primary instrument used in qualitative research methodologies (Oates, 2012). Interviews can be conducted individually or in groups, and the researcher should endeavour to elicit crucial information from participants without making them feel uncomfortable (Schindler, 2019).

This study used semi-structured in-depth individual interviews as the method for collecting data. This approach allowed the participants to elaborate in-depth and in detail on their experiences on the research topic. It relies on the dialogue between the researcher and the participants to gather various data (Creswell & Creswell, 2018). Telephone interviews provide a geographic advantage as it allows the engagement

with participants not to be limited by distance and physical boundaries (Creswell & Creswell, 2018).

The study made use of an interview schedule that was structured to explore the main three (3) themes identified in the literature review. The three themes were designed to answer the research question from different perspectives, as listed in section 1.4. Each theme in the interview schedule consisted of several open-ended questions to elicit insight into emerging IoT application concepts. The themes on which the questions were based were discussed in chapter 2 under the theoretical model in section 2.9 (Business, Technology and User). The interview guide for the targeted participants can be found in Appendix D.

3.6 Procedure for data collection

As approved by the University of Witwatersrand ethics committee, permission letters were sent using email to communicate to several organisations that showed up on the researcher's internet search using a combination of search tag words. After organisations granted the required approval, the researcher was referred to the respective contact people responsible for IoT. The researcher then issued Information letters that provided contextual background on the research study. If the participants agreed to participate, an interview was scheduled based on the subject's availability. After each interview session, a request was made to identify a colleague or other knowledgeable people who could contribute to the research topic. The participants were provided with a brief description of the identified themes (business, technology and user) to guide the interview. Consequently, each participant could recruit colleagues they believed had knowledgeable insights regarding the specific focus areas and thus followed the snowballing sampling method.

The rest of the procedure is captured in a sequential format below.

1. The interview sessions were scheduled with participants based on their availability, and the interviews were conducted using audio and video sessions. There were two tools used to conduct the interview.

    a. Microsoft Teams was used to conduct interviews and used to record the session. Permissions from the participants were requested using the ethics consent form, and before the start of an interview session, verbal consent was requested to record the session.

    b. Several participants opted for a telephonic interview due to inadequate network coverage. This group was predominantly made up of livestock farmers. These interviews were still recorded using a digital recorder.

2. The interview schedule was used to guide the interviews, while particular questions were used to probe depending on the background and perspective of the participants as IoT service provider, practitioner or farmer (customer)

3. The recorded interviews were labelled and grouped according to the three main categories provided in table 4.2.

    a. IoT Practitioners, b) IoT Service Providers, c) Customers Livestock farmers

4. The interviews will be securely stored in an online data repository for six (6) months which will get destroyed.

3.7 Data analysis and interpretation

This study made use of the thematic data analysis approach. The thematic analysis identifies and reports patterns from the analysed data (Castleberry & Nolen, 2018). According to Castleberry & Nolen (2018), the method is a descriptive and flexible way of reducing the data to manageable and identifiable patterns. In this study, the six-phase thematic approach covered by Braun & Clarke (2006) was adopted and consisted of the following phases: (1); familiarisation with the data; (2) generating initial

codes; (3) searching for themes; (4) reviewing themes; (5) defining and naming themes; and (6) producing the report.

The thematic method is appropriate for data analysis. It allows for the data set to be interpreted to develop themes and patterns from the participants' responses, provide in-depth knowledge of the topic, and arrive at concise qualitative findings.

3.7.1 Data Analysis Procedure

The process followed for data analysis is described below:

1. The interviews were transcribed into text, and notes taken during interviews were processed and linked to the interview transcripts

2. The transcribed text was further processed by cleaning any unrelated data such as pauses, mispronunciations, emphasis and focus on essential words as guided by (Miles, Huberman, & Saldana, 2014). Table 3.1 provides information on the interviews, with listed dates, raw and processed transcript pages.

3. The transcripts were then analysed and coded. According to Miles, Huberman, & Saldana (2014), coding is about assigning symbolling meaning to text collected in the field.

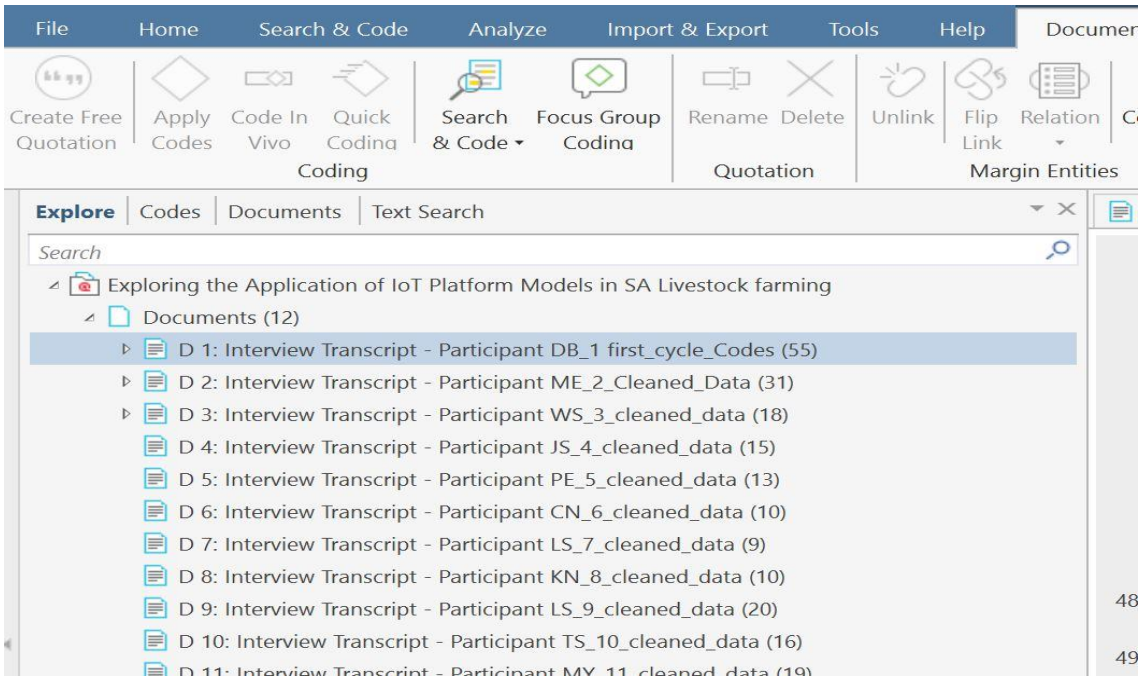
Table 3.1: Telephonic Interviews of Study Participants

Participant	Date of Interview	Duration
DB	January 27, 2021	34 minutes
MY	February 01, 2021	30 minutes
LS	February 02, 2021	31 minutes
ME	February 04, 2021	32 minutes
WS	February 24, 2021	31 minutes
JS	February 24, 2021	38 minutes
NS	March 09, 2021	40 minutes
KN	March 20, 2021	27 minutes
LS	March 20, 2021	35 minutes

TS	March 21, 2021	38 minutes
PE	March 30, 2021	31 minutes
CN	April 08, 2021	32 minutes
MB	April 10, 2021	20 minutes
Total		419 minutes

4. **The First and Second Cycle Coding** approach was used to develop codes, pattern codes, categories, and themes. The First Circle assigned codes to chunks of source data. Miles, Huberman, & Saldana (2014) state that there are 25 basic methods to coding. In this study, a combination of coding methods fitting to the data sources was used. These methods included In Vivo, descriptive and emotion coding.
5. The transcripts were uploaded into Atlas.ti to assist with the coding of the material, as shown in figure 3.1.

Figure 3.1: Sample of participants transcripts on Atlas.ti



6. The First Cycle coding resulted in two hundred and seventy-five (275) codes. The questions for each category had been designed to elicit insights from the participants. However, several of the questions emerged during the interview

sessions based on the participant's responses. The emerging questions were framed in a manner that linked to the research question and sub-questions.

A similar approach to the Tabletop categories identified by Saldana (2016) was followed, ordering the codes in categories from top to bottom based on the frequency they appeared. The approach was achieved using the CAQDAS Atlas.ti software, and the codes were further iteratively analysed. The Initial two hundred and seventy-five (275) are listed in table 3.2 below.

Table 3.2: **Emerging codes from the First Cycle coding process**

CODES		
Quantifiable business value	Lack of skills slows IoT projects	Customer needs
Customer maturity level	Lack of Budget planning	Customer defined Use Cases
Systems Integrators	IoT requires a sizeable investment	Lack of large-scale project planning
Device management	Justifying the investment in IoT	Defined business challenge
Devices	tracking livestock	Dashboard
scale out to production	Device connecting to cloud	Strategic partnerships
Platforms	Connectivity based on use case	Livestock theft
Connectivity	Expensive cellular connectivity	Device installation
Lack of maturity level	IoT is less about technology	Device partner
Device sending data to cloud	Devices are crucial in IoT	Technical expertise
defined business case	Demonstrate business value to customers	Business model
Business outcome	understanding of the customer business	Poor network coverage
Lack of skilling is slowing IoT adoption	Proof of concepts	Business knowledge
Lack of clear IoT Strategic objectives	Scaling up complexities	Connectivity in remote locations

Lack of skills delays deployment of IoT solutions	Applications	Livestock monitoring
Understanding architecture	Access to cloud data	Undefined project objectives
Better insights	Livestock security	Customer environment
Lack of a clear business challenge to be solved	Cost of doing IoT	A need to change customer perspective about long timelines
Understanding business objectives	Sensors	Pay per use model for services
Lack of technical skills in the market	Communication protocols	Saving costs
Device Connectivity	Connectivity issues	Device software skills
	Allow for budget planning	Upskilling
Determine cost	Cloud software	Convince customer through demonstration
device theft	Send device data to cloud	Device hardware skills
IoT must be a business discussion	Large scale IoT projects failure	Customers don't know where and how to apply IoT
Low powered Wan	technology standards	Device supply
Realised customer value	Pilot scaling out	Poor device selection
IoT devices skills	There is enough IoT skills	LoraWan
LTE	Relevant data	Small scale pilot
Sigfox	Device scaling up challenges	Device installation complexity
Customer not receptive to new methods	Herd management	Undefined Business Case for a project
Generate revenue	Project lifecycle	Know devices to be installed
Network service providers	Pilot	Research use case requirements
Customer IoT awareness	Failure to upskill own workforce fast enough	understanding the project timelines
Demonstrate livestock location	Help quantify the required budget	Livestock data collection
Additional services	Fewer successful IoT project due to lack of skills	Challenge of finding the right technical skills

Customer are aware of IoT and its potential value	Configure devices	Solution support
Hardware	Field force	Device security posture
connectivity partner	Capable systems integrators	APIs
Hardware partner	Connecting to cloud	Supply side technologies
Systems Integrators required to pull all the different bit together	Business partner	Cost of data
Difficulty in justifying return on investment for large IoT projects	Specialised partner	IoT is bring together different applications or technologies
New business model	Business domain partner	Fragmented communication protocols
Connectivity protocols	Project resource, time, money	Platform partner
Benefits of connecting assets	Sensor data	Deep technical expertise
Different IoT technologies	IoT security	Reduce production failures
Fragment technology landscape	IT experts	Customer buys the hardware
IoT for different areas on the business	Data volumes	Leadership support
Data analytics	Cloud partner	ROI
Operating the solution	Pilot demonstrate business value	Understanding the required technical skills for the IoT project
Sustainable business case	maintaining the solution	Ideation workshop
Deploy software	Profitability	Fragmented suppliers
Increase efficiency in production	Monthly subscription fee for the data	Cloud skills
delivering the successful projects	B2C customer wants to own the device	fewer of expertise and partners in Middle East and Africa
Project handover to customers	Subsidised business model	manage sensors
Livestock specific devices	Subsidised hardware model	Different IoT solutions across the business
Transfer knowledge to customers	Device engineers	benefits

Trained systems integrators	Service contracts	Help quantify business challenges
Competitors	Monthly subscription fee for notifications	Adoption
Transformation strategy	B2B pay opt for high subscription fees	Lack of technology standards skills
Smart Cities	data points	Platform skills
Connected cows	Cat 4	Service providers
Skills Transfer	NB-IoT	Perceived complexity
Making money from connected products	Customised IoT devices	Unquantified IoT business value
storing of data	Customer patterns	MQTT
Production side	Data outage	Smart buildings
Upload data to cloud	IoT device service providers	Pilots
Data collection frequency	Selling more livestock	Industries taking on IoT
Network partner	Investing in cloud	Size of customer
Metrics	available skills	A stretched partner ecosystem due to lack of skills
Real-world demonstrate	Cloud Readiness	Cloud governance
Demonstrate livestock eating patterns	Device connectivity scaling up challenges	cloud side scaling up challenges
customer side	Building growth plans	Agriculture
Making sense of collected data	Device life cycle	technical capabilities
Demonstrate livestock health	Connected factories	Skilling
Systems integrator specialist skills	Significant IoT demand	Change management
Service provider funded pilot	There are big handles in scaling IoT	scale of data
Livestock device selection	Poor device management	processing data
Building new connected products	Vertical IoT solution	Slow onboarding of technical skills to deliver IoT projects
Two customer areas to be addressed by IoT	Poor device data management	data at the edge
UI design	fragmented IoT ecosystem	Off the shelf hardware
Device battery	Poor device data collection	real-time

Device firmware updates	IoT is a business discussion	
Service Level Agreement	Cheap devices	
Cloud architecture	Many different sensors for various IoT solutions	
End to end solution	NFC devices	
Network charging models	One IoT platform across the organisation	
Private long-range network s	Software as a service	
Solution generalist	Off the Shelf IoT devices	
Building own private network	determine level of complexity	
Better customer experience	Procurement	
Technology problems	device selection	
core responsibilities of service providers	determine required resources	
troubleshooting	Complex network of requires IoT suppliers	
PoC	undermining the complexity of large-scale projects	
Subject matter expert	Single of the customer IoT landscape	
charging models	Lack of device strategy	

7. **The Second Cycle coding** revisits the initial codes to analyse further and refine the codes. The codes were then clustered, formulating high-level categories using the code mapping and code landscaping methods from the first cycle coding (Saldana, 2016). The infrequent codes were analysed and compared with recurrent codes. The presentative data recorded was evaluated to establish if they have not already been represented in other high-level categories. Those codes with common patterns from the recorded chunks of data were collapsed into the appropriate high-level categories, allowing for significant themes.

Figure 3.2 below shows the process in an illustrated operational model diagram by (Saldana, 2016).

Figure 3.2: Illustration of Saldana Code Cycle Coding

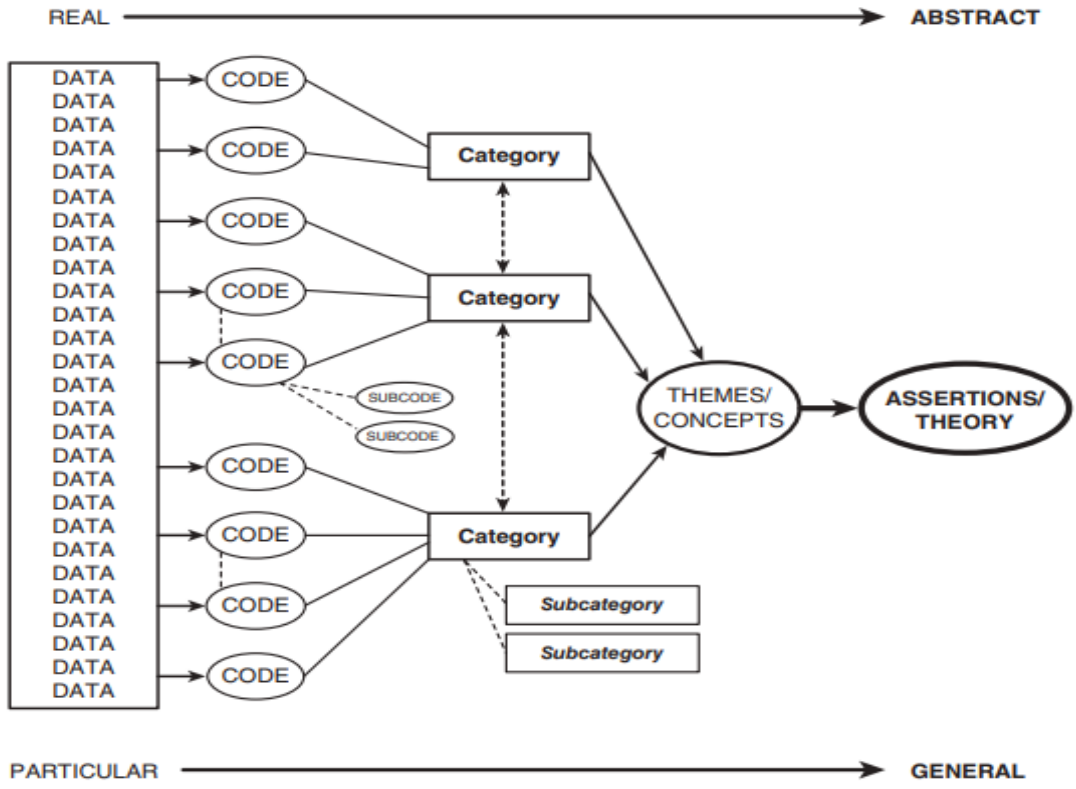


Image source: (Saldana, 2016)

In between the first and second cycle, coding memoirs were jotted for mapping codes linked to notes taken during interviews and emerging patterns and categories. After the Second Cycle coding, thirteen (13) categories emerged, consisting of one hundred and twenty-nine (129) codes and subcodes. The memos were then checked to validate the intended meaning concerning the codes. For illustration purposes, an example was the grouping of the codes, “devices”, “hardware”, “configure devices, “device management”, “device selection”, and “sensors” under one category. The sample list making up the category of IoT Devices is shown in table 3.3.

Table 3.3: **Illustration of consolidated codes into the Category: IoT Devices**

Category: IoT Devices	
Hardware	Sensor data
Off the Shelf IoT devices	Device Connectivity
Device security posture	Device security posture
Device hardware skills	Poor device selection
Device connecting to cloud	Know devices to be installed
Devices are crucial in IoT	Livestock device selection
Sensors	Device life cycle
Customised IoT devices	Device battery
Send device data to cloud	Device firmware updates
Device management	Cheap devices
Device scaling up challenges	Device selection
Configure devices	Lack of device strategy

The above codes were identified from the inferences made by participants in recorded data as referencing IoT devices.

8. Table 3.4 lists the thirteen (13) categories that developed from the process discussed.

Table 3.4: Thirteen categories that developed from 129 codes and subcodes

Categories
Connectivity
Devices
Cloud Platform
Operational model
Fragmented Technologies
Partners
Skills
Customer needs
Domain Knowledge
Customer challenges
IoT Investment
Lack of maturity level
IoT Strategic Objectives

9. The analyses of the categories led to the following emerging themes (1) IoT Scalability, (2) Systems Integration, (3*)* Business Value, and (4) Customer Maturity Level. Table 3.5 shows the themes as they derived from the categories and the linkage to the research questions

Table 3.5: An illustrated model of the emerging themes derived from categories.

Categories	Themes
Connectivity	IoT Scalability
Devices	
Cloud Platform	
Operational model	
Fragmented Technologies	System Integration
Partners	
Skills	
Customer needs	Business Value
Domain Knowledge	
Customer challenges	
IoT Investment	
Lack of maturity level	Customer Maturity Level
IoT Strategic Objectives	

3.8 Limitations of the study

The limitation of the study has been identified as follows:

- Anticipated limitations are related to gaining access to the targeted population.
- Limited exposure in conducting research interviews
- The outputs of the interviews are dependent on the experience of the participants, the expertise and the researcher's experience.
- The study is confined to the livestock farming context. While certain aspects (business engagement processes, IoT building blocks and IoT skills) of the study may be transferable in other sectors, this study is focused mainly on livestock farming.
- The study does not delve into the technical details related to IoT security, communication protocols and mobile applications. However, the importance of these items is inferred.

3.9 Transferability and Dependability

According to the issue pertaining to the trustworthiness of qualitative research, there are aspects to be considered that provides a degree of validity and reliability as seen in quantitative research. These are known as transferability, dependability, credibility and confirmability. These concepts and how it relates to the study are discussed below.

3.9.1 Transferability

This study aims to draw out the influences of IoT model applications from the targeted population that can be likely used in similar situations. However, the study focuses explicitly on livestock farming as its context for its application. However, several contributing factors from the targeted population produced insightful findings transferable to IoT implementations in other areas and sectors. It is important to note that the targeted population is identified based on crucial determinants of IoT models and their relations to the context in which they will be applied. While the study's context was confined to livestock farming, several findings can be considered when embarking on IoT implementation in other sectors. The aspects related to business engagement processes, business models, complexities related to IoT building blocks, and the considerations on the lack of IoT skills in the South African market (Chaabane, 2017), (Cisco, 2017), (Daniel Elizalde, 2021)

3.9.2 Credibility

According to Patton (2001), the credibility of a qualitative study depends on four inquiry elements.

- In-depth and systematic field world that delivers quality data
- Analysis of data to deliver credible data
- The credibility of the inquirer is dependent on experience and track record.

- Readers and user's philosophical beliefs. In this study, the triangulation of sources was used to validate the findings against the selected groups of participants. The customer target group discussed in section 3.4 was used for triangulation purposes. The information gathered from the two groups (1) IoT Service Provider and (2) IoT Practitioners about the implementation of IoT in South African livestock farming were checked against the (3) Customer (livestock farmers) targeted group to establish the credibility of the insights. In addition, theoretical triangulation was used to confirm the credibility of the findings by evaluating the existing literature.

Member-checking: Further to this, the collected data was confirmed with participants for intended meaning and clarity to avoid misinterpretation.

The data collected during this study is made available to the research readers under the appendices section. This is to ensure that the data is reflected from its raw stage throughout the analysis and interpretation stage. Thus, the approach aims to increase the credibility of the research and the process followed. Accurate details of the participants have been provided while adhering to anonymity to ensure that the solicited data will represent their expertise and experiences. The targeted population groups aimed to ensure that the collected data is not biased, and triangulation was used to check for validity across the population groups.

3.9.3 Dependability

According to (Elo, et al., 2014), dependability means the constancy of data over a period of time and under different situations. Therefore, the quality of the data collected depended on the experiences and perspectives of the participants and the researcher's ability to extract content that is rich for thorough analysis and interpretation. The collected data has been cross-referenced against other the targeted populations.

3.10 Demographic profile of respondents

The selection of research participants of a particular profile comprises IoT service providers, practitioners, and customers (farmers), based on the literature review. The importance of various skills and roles in applying IoT platform models was highlighted as crucial. However, in the study, the IoT roles gathered during the literature review may not be consistently defined across the targeted population. Hence, snowball sampling is best suited as it allowed for the selection of the best-suited participants.

The study focused on participants who have applied their skills and gained practical experience from IoT project implementations.

The participants consisted of a blend of IoT experts, practitioners and livestock farmers as potential benefactors from IoT applications. At the time of the interviews, the IoT experts and practitioners held positions in leading multi-national IoT services and platform providers or related organisations involved in IoT implementations. The rest applied their expertise in various organisations responsible for IoT implementations. The expertise and exposure of the participants cut across geographical regions. All participants were provided with identity codes for anonymity, as seen in table 3.6. This study focused on the South African context, and all the participants had South Africa as one or only primary area of focus.

Table 3.6: Demographic Profiles, Region and Gender of Participants

Participant ID	Job Title	Region	Gender
DB	Senior IoT Lead	EMEA	Male
MY	Senior IoT Technical Specialist	EMEA	Male
LS	Head of Product IoT	MEA	Male
ME	IoT Solution Manager	EMEA	Male
WS	Business Development Manager for IoT/IIoT	EMEA	Male
JS	Senior Solution Architect	MEA	Male
NS	Farmer & Businessman		Male
KN	Senior Software Engineer & Big Data Analyst	SA	Male
LS	Software Engineer	SA	Male
TS	Lead Systems Engineer/Solutions Architect	SA	Male
PE	Product Manager	SA	Male
CN	Farmer	SA	Male
MB	Farmer	SA	Male

MEA = Middle East & Africa

EMEA = Europe Middle East & Africa

SA = South Africa

The regions highlight the broad level of perspectives and the participants' exposure to the research topic.

3.11 Ethical considerations

The six Ps of research, purpose, product, process, participants, paradigm, and presentation, make clearances to how the participants should be treated (Oates, 2012). The author further elaborates on the rights of the participants detailing them as follows:

- The right to not participate
- The right to withdraw
- The right to give informed consent

- The right to anonymity
- The right to confidentiality

This study conducted responsible and ethical research. The researcher behaved with integrity, no unnecessary intrusion, no plagiarism and adherence to the professional and the University codes of conduct were observed. The purpose of the study was shared with participants both verbally and in writing. The participant's consent was received in written form and verbally. The participants were informed before interview sessions of the data collection method, indicating what and how the data will be used in the research. All verbatim transcripts and the final report will be made available to the participants.

Permission to conduct the research was approved by the Wits Post-Graduate Committee. The ethics clearance from the Post-Graduate Committee (PGC) can be found in appendix A.

4 PRESENTATION OF FINDINGS

4.1 Introduction

This chapter presents the findings from the data collection procedure covered in chapter 3. First, these findings are presented and described under the three Research Sub Questions (RSQ), RSQ1.1, RSQ1.2, and RSQ1.3, introduced in chapter 1 of the study. Next, the participants' demographic profiles are presented in table 4.1 as contextual background from which the participants' perspective was conveyed. Finally, the categories and themes that emerged from the data analysis procedure are presented in table 4.1. This chapter will follow a similar structure to present the findings in an intertwined manner. The structure in this chapter is as follows:

- Section 4.1 Themes and sub-themes linked to research questions
- Section 4.2 Demographic Profiles
- Section 4.3 Present findings related to proposition 1
- Section 4.4 Present findings related to proposition 2
- Section 4.5 Present findings related to proposition 3

Table 4.1 shows the themes and sub-themes as it relates to the three sub-questions of the research project.

Table 4.1: Emerging themes and sub-themes related to the research question

<table>
<tr><th colspan="3">Research Question</th></tr>
<tr><td colspan="3">RQ1: What are the factors to be considered for the application of the IoT platform model? (in livestock farming in South Africa)</td></tr>
<tr><th>Categories</th><th>Themes</th><th>Sub Questions</th></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Connectivity</td><td rowspan="4">IoT Scalability</td><td rowspan="5">SQ1.1: What are the technical factors that IoT platform experts consider as relevant to the implementation of IoT?</td></tr>
<tr><td>Devices</td></tr>
<tr><td>Cloud Platform</td></tr>
<tr><td>Operational model</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Fragmented Technologies</td><td rowspan="3">System Integration</td></tr>
<tr><td>Partners</td></tr>
<tr><td>Skills</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Customer needs</td><td rowspan="4">Business Value</td><td rowspan="4">SQ1.2: What are the non-technical factors that IoT platform experts consider as relevant in the application of IoT platform models?</td></tr>
<tr><td>Domain Knowledge</td></tr>
<tr><td>Customer challenges</td></tr>
<tr><td>IoT Investment</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Lack of maturity level</td><td rowspan="3">Customer Maturity Level</td><td rowspan="3">SQ1.3: What are the challenges that IoT platform experts experience in positioning IoT solutions for a targeted industry (livestock farming sector)?</td></tr>
<tr><td></td></tr>
<tr><td>IoT Strategic Objectives</td></tr>
</table>

Due to the systematic design of IoT platforms, the categories are presented under each theme in an intertwined manner. Thus, the interrelated categories will be presented using ***bold and italic text*** to draw forth the colourations to the respective themes.

4.2 **Demographic profiles**

This section presents the demographic split of the participants listed in table 4.1. The initial version was presented in chapter 3. However, during the interview sessions, it was discovered that some of the participants possessed more than the anticipated domain knowledge and had experience as IoT service providers and practitioners. At the same time, one of the farmers also had experience as an IoT service provider within livestock farming. Therefore, table 4.2 is split into four columns; participants are labelled using code names (e.g. DB, MY) for anonymity. The "✓" symbol represents the participant's domain area of knowledge, while the "X" symbol represents the participant's lack of contribution under that domain category.

Table 4.2: Participants' area of expertise

Participants	IoT Practitioners	IoT Service Providers	Farmer
DB	✓	✓	X
MY	✓	✓	X
LS	✓	X	X
ME	✓	✓	X
WS	✓	✓	X
JS	✓	✓	X
NS	**X**	✓	✓
KN	✓	**X**	**X**
LS	✓	**X**	**X**
TS	✓	✓	**X**
PE	✓	**X**	**X**
CN	**X**	**X**	✓
MB	**X**	**X**	✓

✓ **:** Area of expertise **X:** Little or no expertise

4.3 Findings of the study related to the technical factors that play a role in IoT platform application

This section focuses on presenting results related to the technical factors that IoT platform experts consider relevant to IoT application. This pertains to the first proposition of the study: *A range of technical factors play a role in the application of the Internet of Things Platform business model in livestock farming in South Africa*

This dimension is essential to this study as it explores the technical characteristics that make up IoT platform models and their impact on the application of IoT implantation. Two themes emerged during the data analysis process, namely IoT scalability and Systems Integration. These themes are presented in the following two sub-sections.

4.3.1 Theme 1: IoT Scalability

Under the IoT Scalability theme, the four categories are connectivity, devices, cloud platform and operational model, and are presented below in an integrated manner.

Table 4.3: IoT Scalability theme & categories

Connectivity	IoT Scalability
Devices	
Cloud Platform	
Operational model	

According to the participants, the scaling of IoT project remains an enormous challenge, mainly due to numerous compounded technical and non-technical complexities that come with large-scale IoT projects. The participants indicated that scaling IoT projects' challenges resulted from the lack of planning for large-scale projects. Participants explained that customers were eager to jump into small pilot projects or proof of concepts without developing a proper scalable project plan. However, these poorly planned and designed proof of concepts (PoCs) were later expected to scale into large projects, mainly resulting in problems. The participant,

MY, a service provider, explained how such poorly planned projects could end up failing once implemented:

> *"I have seen customers coming back to us because they had a project in production, but it failed. Why? Because of that cloud provider provided them with the solution. The solution would not scale, and that is the problem with the idea to only build a PoC. They are the easiest to build. The question here is about* ***how can you do it at scale****? "*

There was consensus among the participants regarding underestimating the complexities of scaling small pilots or PoCs into large-scale implementations. At the same time, the participants made it clear that pilots and PoCs were crucial in the early stages of IoT projects. Indicating they are used to prove the feasibility of customer use cases and demonstrating potential business value. Participant DB explained as follows:

> *"The pilot tends to be used to validate both the use case in the business case at the small scale to ensure that we are getting the level of effect that we would expect."*

Most participants stated that complexities were related to the IoT system components (devices, connectivity and cloud platform). However, challenges with PoCs occurred when it was time to scale. The participant, DB, captures the challenges experienced when transitioning from a small-scale pilot into large scale IoT implementations:

> *"And the next stage that becomes challenging is how do we* ***scale-out****. This* ***small-scale pilot*** *can often show benefit and its effective, but if the scaling from connecting 10* ***devices*** *to 10,000* ***devices****, we then have to understand how that scales up both on the* ***device side****, the* ***connectivity****, and if we are using cloud the* ***cloud side*** *as well. So really, the next stage then is around building out scaling growth*

> *plans, understanding the effect on cost, understanding the effect on complexity."*

Participants stated that the lack of a ***device strategy*** added to the IoT scalability challenges. Selecting a fit for purpose IoT devices was indicated as crucial in IoT applications. The selection of IoT devices was necessary to ensure that they were suitable for addressing business challenges within the customer environment. The participants identified several factors worth considering on the device side, device battery life, durability, firmware updates, device connectivity, device security, and technical skills to develop and configure the devices. DB explained the device-related considerations:

> *"So quite often, customers will try and buy the cheapest **device** that they can to solve the problem without understanding for the right word, what effect that will have on the solution. So, for example, they buy a cheap device, you know it comes from somewhere in China, but what they have not looked into is what is the **security posture of that device**? How do they **update** it? How do they manage it? What is the lifecycle you know after two years? If it needs to be replaced, would that company still be able to sell the same device to you? So, from that side, I think the **devices are probably one of the most important parts of the IoT solution** because if you start with the poor device and poor data and poor management of those devices. Then that cost of that fleet of assets out in the field can be hugely expensive and end up being more expensive than whatever you implement in the **cloud**."*

In South African livestock farming, the participants stated that IoT must be approached from a customer-defined use case. It must consider the environment in which it is to be applied and identify challenges that will need to be addressed by constructing a well-considered project plan. The participant JS emphasised the importance of understanding the customer use case when considering the applicability of IoT. JS

notes the importance of **connectivity** and **devices** within the context of SA livestock farming:

> *"The challenges for me are mainly around **connectivity** having broadly available connectivity for IoT".*
>
> *"I think it will be very important to really understand what will be the use case for farming. If you are going to be handling data at the **edge**, let's say you want to apply this from the security point of view. You want to track your livestock, and you want to react. Maybe there's a use case where you want to react from a security point of view, and you need the real-time type of reaction, then this **connectivity issue can be real**."*

While PE listed ***connectivity*** as a priority in his list of possible IoT challenges, network connectivity is crucial in disseminating data across IoT platform. An overwhelming number of participants (DB, ME, WS, JS, PE, KN, LS, TP) identified the importance of network connectivity, specifically within South African livestock farming. Citing that traditionally livestock farms in South Africa are in the country's far and remote rural outskirts. When LS responded to a related question, he furthermore inferred the challenges that could inhibit the scalability of IoT:

> *"On a farm. Yeah, from inception, I would look at **network coverage**. You know, next, we have to look at the **devices**. So the infrastructure, network infrastructure has to be good to support that solution. Another thing would be money. You need to have the necessary budget to see such projects through because they are very capital intensive. The type of **device** that you will be using. Because there are **devices** that should be equipped for cows, guard against **device getting damaged** so, and the device has to be a bit more durable. Making sure that **devices cannot be stolen**."*

The participant, KN, shared similar considerations regarding an IoT use case in livestock farming and was captured as follows:

> *"I think the biggest issue would be the **device side** of things to build. What would you be the **measuring devices** on the cattle themselves? I think in this use case because looking more at farms in the countryside. I think the **network** is probably the biggest issue you are going to have".*

There was a high prevalence of participants identifying inadequate network coverage (JS, DB, WS, PE, LS, TS, KN) and device selection (LS, TS, KN, DB, ME) as a challenge in implementing IoT in livestock farming. Therefore, the participants were probed further on whether IoT was feasible in the livestock farming contextual setting. The participants responded with an overwhelming yes. In their responses, they proposed alternatives solutions to the inadequate network challenges. Technologies such as Sigfox, LP-Wan, and LoraWan were listed as preferred options.

In contrast, the preferred network technologies were claimed to be not yet available in rural areas. However, most participants' prevailing option was 3G, 4G, a cellular network provided by mobile network operators. Some participants (JS, DB) highlighted that the cellular network as an option would add to the overall cost when scaling the solution. Cellular networks were identified as an expensive option when compared to Sigfox or LoraWan. However, cellular networks provide better coverage across the country. The participant, JS, explained:

> *"So, we do have Sigfox as you are aware, which is global. But you would find that their infrastructure is still really concentrated on urban areas. So, if I put it in the context of agriculture again, maybe there lies the challenges in terms of **connectivity**. When I say connectivity, I am saying a choice, so, if you are going to depend on connectivity from a 3G mobile networks or if its 4G mobile networks in South Africa, we do have quite good coverage in the likes of Vodacom and MTN. But if you would look at people such as your Sigfox as people*

suggest your LoraWan infrastructure, which is very specific to IoT, I do not think it is broad enough yet to cover the whole range of customers. Those, are the challenges that I would think of."

Participant DB elaborated further on challenges concerning network connectivity in the context of South African livestock farming:

*if we start to look at **connectivity** in remote rural areas. Most customers tend to jump onto the cellular bandwagon as the first step. It is generally readily available. Its downside, it tends to be very expensive. Especially if you have got a use case that is transporting a lot of data over the cellular network but with the advance of newer technologies like you know Cat 4 and LTE, NB-IoT these kind of long-range cellular low lower bandwidth but lower-cost technologies are starting to become more prevalent, But then you become tide to essentially the network providers in the location of the cellular masts (towers). So, if we think of very remote parts of Africa, for example, it's going to be pretty tough to get decent network connectivity, and we start to drop down to some of the legacy technologies like 2G, but again start dropping down to some of the legacy technologies like 2G in order to get the range on the cellular network then it becomes hugely expensive as well. So, more and more, we are starting to see the rise of some of the LP Wan technologies like LoraWan, Sigfox. I wouldn't say they've been deployed at huge scale yet, but in some areas with the use of those technologies. Lora, I tend to see it used more around the kind of private long-range networking just because of the way Sigfox tends to charge. But Sigfox I know it has got a little bit of coverage in Africa and some of the parts of the world. So yeah, it is back to what I said earlier. You **know connectivity is crucial**, but it is very **much tied to the use case** that's being solved in terms of how it is chosen as a technology.*

MB, a farmer, located in Kokstad, confirmed the challenge concerning inadequate internet network coverage. Participant MB responded as follows regarding the inadequate network coverage:

> *"Yebo, **connectivity** is bad this side. I had to buy additional network boosters. With our livestock security partner, we resort to using radio to communicate, it is cheap, and we do not have to worry about a bad network."*

The participant, NS a service provider and farmer, explained how they had to resort to the cellular network in the implementation of their IoT solution as the only plausible option:

> *"Yeah, so we have had to solve that problem. In an ideal world, each cow will be wearing a **device**. You know, that tracks everything, every second, and that is in a perfect world. So, the challenges have been that we had to solve. We eventually resolve that by using **SIM cards**. The other option would have installed a base station and have these **devices connect** to the antenna. However, that is not yet possible at this point."*

The findings under this section presented and described the scalability of IoT projects as dependent on numerous interrelated technical factors, namely connectivity, devices, cloud platforms and operational models. The technical complexities seem to mainly relate to the fragmented technology landscape and lack of standards. The importance of technical expertise and the capability to integrate the many disjointed parts of IoT (devices, connectivity and cloud platform) were highlighted.

4.3.2 Theme 2: Systems Integration.

Under the Systems Integration theme, the three sub-themes identified are fragmented technologies, partners, and skills. Technologies, partners, and skills. Given its interrelatedness, these are discussed in an integrated manner. The term Systems

Integrators (SI) was implied interchangeably with IoT Service Providers by the participants.

Table 4.4: Systems Integration theme and categories

Fragmented Technologies	**System Integration**
Partners	
Skills	

The participants stated that IoT requires pulling together different technology components (**device, connectivity and platform**). They indicated that the implementation of these different technologies required specialised skills. The participants agreed that IoT was made up of fragmented technology, which introduced implementation complexities. Participant, WS, highlighted the challenge about the fragmented technology landscape:

> *"OK, I mean they are some pretty big hurdles starting from like we want an IoT solution, and we can see IoT bringing value in our business to actually implementing it. There is definitely some kind of big hurdles there; I think the primary complexity around what I would call a **fragmented technology landscape**".*

The participants stated that the complexity is attributed to fragmented technologies and the technical skills required to navigate and manage the many IoT technology standards. In addition, IoT Practitioners must have the competency to configure numerous IoT devices lacking in protocol standardisation. Once the customer use case has been defined, and all the requirements are understood, the next phase needs to address the technical aspect of an IoT solution through an architectural design session. The design session considers the requirements from the device side, the connectivity side, and the cloud side. LS2 stated that the technical design sessions are an integral part of any IoT solution to assess technical challenges. In addition, technical skills were also highlighted as essential in integrating IoT components. LS2 further noted the critical role of ecosystem ***partners*** in the implementation of IoT solutions:

> *"Then we move to the technical side. That is an architectural design session. That is where we ask our architects to sketch out an architecture that can technically implement that value proposition by utilising IoT, and then they put in what kind of product and services are needed on the **cloud side** and also on the **device side** to establish this solution, and that is the technical side. Now it is time to implement that solution, and that is where we bring in our **partners** that have **independent skills** at doing that, so they help implement first the PoC, proof of concept."*

A pattern emerged from most of the participants concerning the availability or the lack of IoT skills. Some participants believed there is a lack of IoT skills in the South African market, which directly impacted the ability to integrate and scale IoT solutions. Failure to source the required skills have resulted in IoT project delays and even failures. The following participants are quoted on their respective views on skills:

Table 4.5: Participants' comments on the Lack of IoT Skills

Participants	Comments
DB	*"So, I certainly think that the lack of **skills** is slowing the adoption of IoT."*
JS	*"So, if you look in the South African context, in my view, I have not seen the wide use of IoT at the moment, so we are still ready in inception in terms of real practical business use case application for IoT. So, I would say they are still quite **limited skills** in the market today. However, there are companies in South*

	Africa that are really trying to close this specific gap."
LS	*"The **skills are in demand**, as I have already indicated, and to upskill is also an issue to get to that level of expertise that the person who left. It would take another three to four years, so it becomes a challenge".*
TS	*"Especially in South African, we **do not have enough skills,** and if we have the skills, we do not know how to keep them. I think they are continuously looking for exciting things to do."*
WS	*"The standards piece, I think, is still forming, so there **might be a bit of a shortage of skill** in that space. The standards should you be aiming to get these different technologies to talk to each other. There might be a slight skills shortage there, but on the whole,".*

Participant WS, as quoted above, further added on the same thread, sharing his overall view on IoT skills:

> *"I do not think there is a **skill shortage** at the moment."*

Other participants stated that the IoT skills were available, a view that LS2 and KN shared. At the same time, KN referred to the level of competency required to deal with IoT technology standards when integrating IoT solutions. He explained as follows:

> *"My perspective. There is a lot of **standards** that you should be following when it comes to IoT solutions, such as the protocols that are out there. People need to understand them and apply them in the right way".*

There are opposing views in terms of the availability (or not) of IoT skills. Representatives of the multinational service providers, in particular, are of the opinion that skills are a commodity that could be shared from different regions. Therefore, these service providers could source skills from various regions and deploy them in South Africa on high-priority projects.

A thought-provoking perspective raised by participants is that technical skills need to be pulled together under one provider or systems integrator. WS commented on systems integrators as crucial in pulling together the required skills:

> *"OK, so **system integrators** or solution providers are absolutely key for the future of IoT. I think that what we are seeing is definitely going to need a **system integrator** involved in pulling all of these different bits together."*

> *"All they need to do is **bring these skills altogether** to deliver solutions, and they are skills that exist, but you do need to kind of bring them together under one housing and then you also need to make sure you have the **platform piece skills,** and you need to make sure you have the skills to handle the different and maybe the standards piece".*

The participants (DB, WS, PE, LS, KN, TS) emphasised the significance of system integrators in the future of IoT. Participants indicated that the Service Providers should be a single point of contact for customers (farmers). They stated that system integrators should have all the necessary resources to deliver the value of IoT value, and the customer should not be bothered by a fragmented IoT ecosystem. KN pointed

out some of the challenges concerning IoT integration in the absence of a systems integrator**:**

> *"I think the biggest challenge that I have faced was on the technical side, but more with regard to **integration** between the different contractors, because you had to handle the **software side** of things, **the cloud**, and then we had the **hardware** that was being built and installed by somebody else. The delays were between integrating the two parts".*

PE commented on the possible challenges when integrating IoT components which at times led to IoT project delays:

> *"Sometimes the **system is easy to integrate**, so sometimes it is hard, but mostly it is not often impossible to do it, just something that takes a bit longer to connect."*

The findings were that Service Providers or SI worked closely with other ecosystem technology partners to consolidate a fragmented IoT ecosystem. An account by WS points to an emerging collaborative effort to minimise the complexities resulting from a fragmented technology landscape:

> *"We are starting to see standards evolve across these technologies, so whether it's MQTT or some of the industrial kind of protocols. These are standards that these **hardware** players are starting to conform to, so I think we are starting to see- the supply side and these **systems integrators** forming to be able to **bring these kinds of technologies together** into a meaningful kind of solution for customers. So, I think we are starting to see that **integration** happening."*

The participant TS provides a holistic view that considers the device side and the need for IoT to integrate into other systems:

> *"Identifying what sort of **sensors** you need in a cow and **device management**, how to **provision devices**, manage the updating of device software You would probably have lots of data from different customers, so you want to allow them to see the data and make decisions from there, and also **integrate with third parties".***

The participant LS also shared his considerations on IoT technology components and system integration:

> ***"**everything is evolving around data, and it also revolves around the **device** itself. But you could have **the device, but if it's not talking to the right systems** if it's **not integrated** with the right systems out of use. You need an alignment across the business for **integration** and to make the solution better".*

The integration of the IoT ecosystem was highlighted as crucial, and its dependence on specialised skills was recognised to be one of the primary causes of project delays. The participants, DB, comments on the impact that skills have on IoT projects:

> *"You know the constraint because they cannot **upskill** their own workforce or onboard additional **skilled workers** fast enough to be able to deliver the level of projects that the wider market wants to deploy. So certainly**, it's driving the deployment timescales to be much longer**."*

The participant LS responded as follows when asked about the impact the lack of skills had on projects:

> *My experience in that either the **project comes to a halt,** or it moves slowly, but **eventually dies a natural death**."*

This section presented the findings relating to systems integration. IoT is identified as a culmination of many fragmented technologies required to be cohesively integrated into a functional system. The crucial role of system integrators is evident, with

participants indicating they needed to combine skills capable of dealing with complex protocol standards presented by the various technologies. The responses linked the success and the future of IoT to ecosystem partnerships.

4.4 Findings of the study related to the non-technical factors that play a role in the application of IoT platform models

This section focuses on presenting results related to the non-technical factors that IoT platform experts consider relevant to IoT application. This pertains to the second proposition of the study: *A range of non-technical factors play a role in the application of the Internet of Things Platform business model in livestock farming in South Africa*

4.4.1 Theme 3: Business Value.

The main theme that emerged in response to the non-technical factors that IoT experts consider relevant in the application of IoT platform models is that these IoT applications need to produce business value. The participants highlighted the importance of identifying customer challenges and needs. Furthermore, indicated that industry domain expertise (DB, ME, CN, TS, LS, KN, and LS2) combined with a positive business case (DB, LS2, MY, NS and ME) are likely to translate into quantifiable business value (DB, ME, JS, NS, CN, LS, KN, TP and LS2). Extrapolated data codes such as “IoT needs to demonstrate business value”, “IoT needs to produce quantifiable business value”, and “the need to understand the customer’s business”, along with sizable IoT investment to see through the completion of an IoT implementation resulted to the Business Value theme.

Under the Business Value, the four sub-themes are customer needs, domain knowledge, customer challenges, IoT investment and are presented below in an integrated manner.

Table 4.6: Business Value theme and categories

Customer needs	Business Value
Domain Knowledge	
Customer challenges	
IoT Investment	

The participants were unanimous that the application of IoT in any customer context needs to deliver ***business value***. According to the participants, having ***domain business expertise*** in the targeted industry allowed service providers to collaborate with customers through ideation workshops to identify ***business challenges***, ***business needs*** and ultimately demonstrate and prove the ***value of IoT to the business***. The participants stated that initiatives such as small-scale pilots and PoCs are initially designed to demonstrate the desired business outcomes at a small scale. The view from participants was that most projects are begun without quantifying the business value. Participants stated that potential beneficiaries would embark on these projects without clarifying the business challenges that need solving. According to the participants, the lack of definitive IoT business objectives vastly contributes to the inability to realise the full business potential of IoT. The participants stated that customers were quick to jump into proving the technology through PoCs without first taking the time to plan, scope and justify the required project investment. According to participant MY, IoT must be approached from a business perspective. This view was supported by JS, stating that IoT should be a business discussion and not a technology discussion. The participants explained:

MY:

> *"It is not a technical solution, I mean, it is definitely a technology solution, but it is a business solution before anything else. You need to look at it from a business perspective. When it comes to IoT, my main audience is not the typical IT within a company. Sometimes IT is empowered, but IoT is a business solution, not an IT solution. If I go to a customer and I see customers coming to us, we would like to*

build this solution. They do not know why? Or yeah, we would like to do this. OK,"

JS:

*"I think the very important thing when you think about IoT, and you shouldn't be thinking about IoT from the technology point of view, from a shiny toy, you need to be thinking about it from the **business outcomes**".*

The participants shared a view that IoT discussions should establish the ***business objectives*** and how IoT can assist in realising these objectives. Like MY, participant LS2, a service provider, stated that he would approach the decision-makers with several questions to establish the customer's readiness. However, the participant indicated that the primary focus would be to gather crucial business information using a series of ideation workshops. He further stated that the ideation workshops helped identify ***business challenges***, specify ***customer needs***, draw out the value proposition, establish the required ***budget***, and determine project timelines. Participants LS2, MY, ME, JS, and DB view these steps as decisive in defining the business objectives and ensuring authorisation from the decision-maker in the early stages of the project. Participant, LS2, explains the intended objectives of the ideation workshop:

*"We run a workshop that we call an ideation workshop. This is about figuring out what can IoT help that customer with? That is brainstorming and trying to figure out **value propositions**, so ideations understanding the whole concept, what can it bring? What can it help us with understanding the context?"*

Another key factor identified by participants (DB, ME, CN, TS, LS, KN and LS2) was the importance of having the needed business ***domain knowledge*** to engage and understand the customer business context. They stated that understanding the customer's business was vital in addressing ***customer challenges***. Participant ME

explained the need for domain knowledge within the context of South African livestock farming:

> *"You need to know how to position IoT for livestock, and this is where business knowledge is crucial. One needs to understand herd management,* ***challenges experienced by farmers****."*

Participant TS commented on the reasons why business subject matter expertise is vital:

> *"Then a subject matter expert is required to support the team with* ***business knowledge*** *to assist the team in focusing on the* ***business challenges*** *to be solved."*

Understanding the customer context can assist the service providers and practitioners identify business challenges in need of a solution. Participant MY shared a series of questions that would typically be asked by a decision-maker (Farmer) during the business engagement process. The questions are designed to establish whether the customer (farmer) has a clear vision in pursuing an IoT based solution to resolve their business challenges. Ultimately the discussions are designed to arrive at a quantifiable Rand amount that the business would gain through cost savings or generate new revenue streams. MY commented as follows:

> *"I see customers coming to us, we would like to build this solution. They do not know why? Or yeah, we would like to do this. OK, why do you want to do this? Why do you want to connect these machines? Because we want to see the numbers of those. Why do you want to see the numbers? Is it big? I mean, what is the value when you are thinking about a solution? I would say like it is really in the heart of a digital transformation in another company has to be when you are building that solution, you need to think of looking at reducing costs, right? I mean, you need to find that quantitative work or quantitative figures you would find to reducing costs. Are we trying to improve*

> *operations? Then identify the customer service that I am going to provide. Right, eventually, all of the work you are doing has to be* ***defined into a dollar value****. If you cannot, and that is very common, if you cannot reach that dollar value, then you need to go back to your business side of things and try to learn why are you doing this".*

Participant MY indicated that the business value should be quantifiable and be brought down to a monetary value. Participant LS2 referred to a similar approach when engaging a customer. However, he stated that his first question would be around establishing the available budget for the project. He commented as follows:

> *"So, it is full of quick questions like, do you have a* ***budget*** *so the budget only comes if the senior management believes in this backed up by the* ***IoT strategy*** *so that they* ***can allocate money****. You have the budget, and then do you have the authority. R&D can only take it so far technically the authority has to come from the senior management backed up by an* ***IoT strategy that identifies focus areas*** *of activities and then a project".*

The participants stated that the business engagement process should include four crucial considerations***,*** 1) ***customer needs,*** 2) ***project authorisation,*** 3) ***budget planning,*** and 4) ***timelines***. LS2 stated that these listed items need to be guided and backed up by an IoT strategy. The participant further explained as follows:

> *"So, if all those four things.* ***Budget****, authority,* ***needs*** *and time are available. There is a high likelihood that the project will easily move beyond the PoC phase because it involves the commercial side and not only the technical technology side items".*

The participants agreed that the ***IoT investment*** was the most decisive part of any IoT project. Once the customer had developed IoT strategic objectives, they should have a clear contextual IoT use case that is authorised, well-funded with definitive project timelines. The next phase of the business engagement (ideation) workshop

moves into an architectural design session. The design phase takes into consideration the technical requirements of the use case. Primarily a pilot would be designed first, at a small scale, to validate the feasibility of the use case and assess whether the desired business outcomes can be realised. A pilot would allow service providers to cost the technical requirements as part of the project business case. A positive business case ensures the customer of a return on investment (ROI) and provides a proper scaling plan for the IoT implementation.

In this section, the participants identified and discussed the non-technical factors that need to be considered when embarking on an IoT implementation, namely identifying customer needs, the requirement for domain knowledge, and understanding customer challenges. In addition, they identified the need or requirement for business domain expertise to allow the service providers to engage and understand the customer context.

4.5 Findings related to the challenges IoT experts experience in the positioning of IoT solutions to customers (in livestock farming)

This section presents results related to challenges IoT experts experience in positioning IoT solutions to customers (farmers) in livestock farming. This pertains to the third proposition of the study: *IoT experts experience various challenges in positioning IoT solutions to customers (farmers) in the South African livestock farming industry*

The dimension was necessary for identifying and exploring challenges service providers experience when offering IoT Solutions to potential beneficiaries (livestock farmers). Therefore, the livestock farmers' perspective presented in this section were used for triangulation purposes.

4.5.1 Theme 4: Customer Maturity Level.

The central theme that emerged in response to the challenges experienced by service providers was the Customer Maturity level. The two sub-themes that emerged under the Customer Maturity Level theme are lack of maturity level and IoT strategic objectives. These sub-themes are discussed below in an integrated manner.

Table 4.7: Customer Maturity Level theme and categories

Lack of maturity level	Customer Maturity Level
IoT Strategic Objectives	

There was consensus amongst the participants that IoT applications depended on the understanding of the customer's business. The participants agreed that most potential beneficiaries (livestock farmers, customers) were aware of IoT. However, they were not sure how it would be applicable within their business environment. Therefore, it was no surprise that most potential IoT customers (farmers) lacked an ***IoT strategy defining IoT business objectives***. Participant LS2 indicated that IoT customers have not figured out why and how they want to utilise and create value out of IoT implementations. The participants found that the lack of ***strategic objectives*** concerning IoT implementations was a significant reason most IoT projects would fail. According to the participants, the low levels of customer maturity on the potential value of IoT presented challenges for service providers looking to demonstrate or even prove IoT's value proposition. Farmers in this context were reluctant in trading in their old and proven farming methods for IoT based solutions. Participant PE, a practitioner, shared his experience having worked with livestock farmers on an IoT pilot:

> "*I think a lot of farmers generally are quite stuck in their ways like they don't really see or will not see the benefit of adding cloud data and Advanced Analytics and stop something that they have been doing for the last 50 years. I think that is where you might get a bit of pushback. So, it is important to try, and when they are not clear use cases like cattle being stolen, then it is a kind of tricky thing to sell".*

Participant, ME, delved deeper into how low maturity levels can be a challenge for service providers looking to provide IoT solutions:

> *"It really depends on the competition and on the **maturity level of the customer**. So it is really something that even if you pitch it five times with all the numbers associated with it, it is really difficult if the customer has a **low maturity level** towards the need to change their business model, not totally moving away from their core services but more towards providing additional services".*

The statement from ME, implies that low levels of maturity can supersede quantifiable IoT business value. Therefore, a proposed change in a farmer's operational model can present reluctance in adopting the solution. Participant ME elaborated further by stating that farmers needed to have a compelling business need. The need must be compelling enough to apply pressure for them to shift their way of thinking. ME elaborated as follows:

> *"Therefore, **if the customer is not in a mature state of mind**, it becomes difficult to achieve success. Unless they are under pressure from outside or from the competition bypassing them."*

While participant, PE, indicated that the approach used in positioning IoT did not seem to matter, it instead depended on who was being engaged. He attributed his views to an age factor, stating that the older farmers were stuck in their old ways and unlikely to be receptive to technology. He explained as follows:

> *"It does not matter how we engage them, but it does depend a lot on whom we engage, and I think **the older generations has difficulty seeing the benefits**, whereas someone who has worked and grown up with using technology to make their life easier than they are quite a lot more open to seeing the benefits of maybe adding further technology or changing technology that they are using so I mean like*

> *I said when we did this,* ***it did not really get much further than at a concept****,"*

In contrast, participant ME pointed to the importance of service providers having the required ***domain business knowledge*** to be able to position IoT benefits to livestock farmers. Finally, participant ME shared a scenario between a livestock farmer and a service provider:

> *"How would connecting my cows help me sell more cows? You need to know how to position IoT for livestock, and this is where business knowledge is crucial. One needs to understand herd management, challenges experienced by farmers and provide a positive business case that will* ***quantify the return on investment****. How IoT can help the farmer, for example, with security, eating patterns, and location within geofencing stuff like this, OK?* ***But the big question is, what is in it for the customer or your farmer****?"*

The above statement from participant ME suggests that the farmers' needs or interests must be central in an IoT discussion. Thus, implying that service providers or practitioners' domain knowledge of livestock farming may enhance farmers' maturity levels and allow them to be more receptive to the business value of IoT. The link between business domain knowledge and business value was presented under Theme 3 in section 4.4.1.

At the same time, participant PE as a practitioner expected farmers to understand and accept proposed IoT solutions without engaging farmers at the livestock farming domain level. The participant, NS, provided a farmer's perspective on the maturity and receptive levels in livestock farming. NS seem to agree that farmers are willing to engage with service providers provided that the focus is on addressing pertinent livestock farming challenges. He expanded in the following manner:

> *"I think everyone is willing to listen. The issue comes down to pricing, mostly. That is almost always the first thing you hear. And then how*

effective or efficient the solution would be, and mostly those are two main concerns from farmers across the board,"

Participant CN, a livestock farmer, indicated that he was not familiar with the concept of IoT, though he was experimenting with this technology. After a brief explanation of the concept, the farmer indicated they had just started experimenting with an IoT solution at the farm.

"I think we are already there at the Internet of Things, just that it is the terminology that I was not familiar with because we currently are running an experiment with our animals in various farms where we are trying to track our own animals are due to those particular reasons".

Participant CN, as a farmer, proved that livestock farmers could be receptive to IoT based solutions. What was interesting with CN is that he did not bother to know the type of technology used in the experiment. Instead, he was relatively straightforward on why he had agreed to experiment with IoT. Nevertheless, it was essential to understand how the service provider convinced CN to embark on an IoT experiment. He responded as follows:

*"For me, **being a young person is obviously technologically advance into other aspects of things**, and now it is just my work which I was like. Why is my line of work so behind everything? Like if I want to do something, I can do it with the touch of a button, purchase things, get things delivered, and track them. When it comes to the farm, what can exactly be done to try to solve my biggest problem? I have to be constantly here at the farm, looking after the assets, and at some point, I actually considered buying a drone to fly it over the animals to just randomly check them instead of driving to them every now and again, you know. So, I think when this idea was brought up, I was at the stage of considering a drone, and then boom, something better came through. So, I am was like my prayers have been*

> *answered. This is what I have been looking for, so it is like, no, let us try it. You know it was like, let us do it. Because I believe that is what I needed to put a little bit of ease onto my work lifestyle. So, it was very much easier to take another step".*

It appears there are several factors to be considered when positioning IoT to customers. The age of farmers and their exposure to other technologies became evident as an influential factor. NS thinks that the farmers' mindset is the biggest stumbling block in the adoption of new technologies. He referred to his understanding of how farmers think gained from (Mullainathan & Shafir, 2013). Below he is quoted sharing his account when he introduced IoT devices (livestock collars) to other farmers:

> *So, going back to the adoption of technology, we found exactly the same constraints in terms of the mindset that would be there. When we presented a collar that can solve a farmer's problem, we picked up on the same behaviour. Our approach was to change the behaviour of people, and to achieve that, we needed to change the owner of the asset owner of the asset is? So, if the owner changes from a farmer to a person with an invested interest in owning a cow as an asset. The farmer no longer has much of a choice as now he needs to ensure that the cow lives. That is the model which seems to have to change the mind. There are psychological factors that lead to some of the decisions from farmers.*

Other than the age and exposure to technology, the farmers' mindset factor influences the decision-making process.

Other factors were identifying clear IoT-related business objectives, understanding the **farmer's business challenges and needs**. Therefore, it was essential to get a view of the most pertinent livestock business challenges. CN lamented as follows when asked to share his immediate challenges:

*"Mostly, it is **security, second theft**, you know the lack of security and theft, I think, animal health and nutrition, I sort of understand what happens. You see, when animals are sick, this is a problem in a population of 100 animals; maybe ten would get sick, and then you cure five or more. So, animal health and nutrition is not the biggest problem, but it is the security, recording and capturing of data. I think we still very much behind with everything when it comes to capturing data. You still have to do it manually, but the one that really worries me the most is theft. Livestock is a very, valuable asset and I have to stay out there every night? You have to be out there in the field in the grass while others are sleeping comfortably in their beds at night, and your biggest asset has to be out there at night. Unfortunately, there is not much we can do about it because that is the natural habitat of your biggest asset. So, it is the biggest issue for me- its security and theft."*

Whereas MB, the farmer located within Kokstad, shared similar challenges concerning livestock theft in the area. He indicated that sheep and goats were more likely to be stolen when compared to cattle. He provided a view by indicating that farms that other farms surrounded were at a much lower risk from livestock theft. Nevertheless, the surrounded farms still needed to deal with predation challenges. MB specified that livestock would get hunted and killed by rooikats and jackals lurking in the area. He shared the following experience on the matter:

"In the year 2020, yeah, it was 2020. Out of one 152 sheep, 35 were lost to rooikat and jackals. If you look at those numbers, it's a lot of money that I lost just last year. "

MB spent most days accounting for stock patrolling the parameter fence around his farm, examining the fence openings. Participant NS also weighed in sharing his knowledge on the prominent livestock challenges:

*"I think mainly livestock in South Africa estimated that about 10 billion Rands worth of cattle is stolen every year. Hello. So, livestock farmers are most concerned with **livestock theft**, which would be at the top of their priority list."*

Participants stated that business challenges and needs should be drawn out from the farmer's (customer) IoT strategy objectives. Participants commented on the importance of an IoT strategy, business domain knowledge in realising business value, as captured in Table 4.7

Table 4.8: Participants' comments on the Lack of IoT Strategy

Participants	Comments
LS2	*"Yeah, so if you start from the top, the **lack of IoT strategy** within the companies that we are selling to. So that means fundamentally, they still need to figure out how they would like to utilise and create value out of an IoT implementation and describe that in an IoT strategy because within IoT strategy for the company."*
MY	*"Believe it or not, the majority of customers, and it is a fact. I am covering the Middle East and Africa, and you would find that **they do not know why they get into IoT**. Sometimes they just want to follow the trend."*
TS	*"I think the first challenges is we **tend to look at IoT in isolation**. What I mean by*

> *that is that we do not bring in the business context.* ***We do not know what actual problem we will be trying to solve****, and we do not know what the* ***business value*** *we are trying to add either the customer which, could be internal or external."*

4.6 Summary of the findings

In this chapter, we presented the findings from the participants in an integrated manner. The four (4) themes, (1) IoT Scalability, (2) Systems Integration, (3) Business Value, and (4) Customer Maturity Level, were presented with supporting verbatim comments from participants. Significant factors were enclosed in the findings, which related to a range of technical and non-technical considerations. The categories/themes were highlighted in ***bold and italic*** text to draw colouration between the categories and themes.

5 CHAPTER 5 DISCUSSION OF FINDINGS

5.1 Introduction

The primary purpose of this study was to explore the factors in the application of the Internet of Things in South African livestock farming. Three (3) research sub questions were designed to answer the primary research question. The research sub-questions aimed to determine technical, non-technical factors and the challenges experienced by IoT service providers in positioning IoT solutions to livestock farmers. In line with the research objectives, the subsequent sections in this chapter will discuss the findings in detail with the support of illustrative models. The structure of the chapter will be as follows:

1. **Research Sub Question 1.1**: will discuss the technical findings in the application of IoT in response to Research Sub Question 1.1
2. **Research Sub Question 1.2**: will discuss the non-technical findings in the application of IoT in response to Research Sub Question 1.2
3. **Research Sub Question 1.3**: will discuss the challenges in positioning IoT to customers in conjunction with Research Sub Question 1.2

5.2 Discussion of results

5.2.1 Discussion of the results pertaining to Proposition

This section focuses on discussing the findings related to Proposition 1: *Technical factors that play a role in the application of the Internet of Things Platform business model in livestock farming in South Africa.* The discussion will cover the themes of IoT Scalability and Systems Integration

The research participants indicated that the fragmented nature of the technical elements, namely devices, network connectivity, cloud platform and the operational model, contributes towards the complexities related to IoT implementation and scaling of initiatives

It seems that there is a need to carefully select IoT devices to be aligned to the customer context and use case. The requirement for a device strategy to guide this process has been highlighted.

IoT Scalability

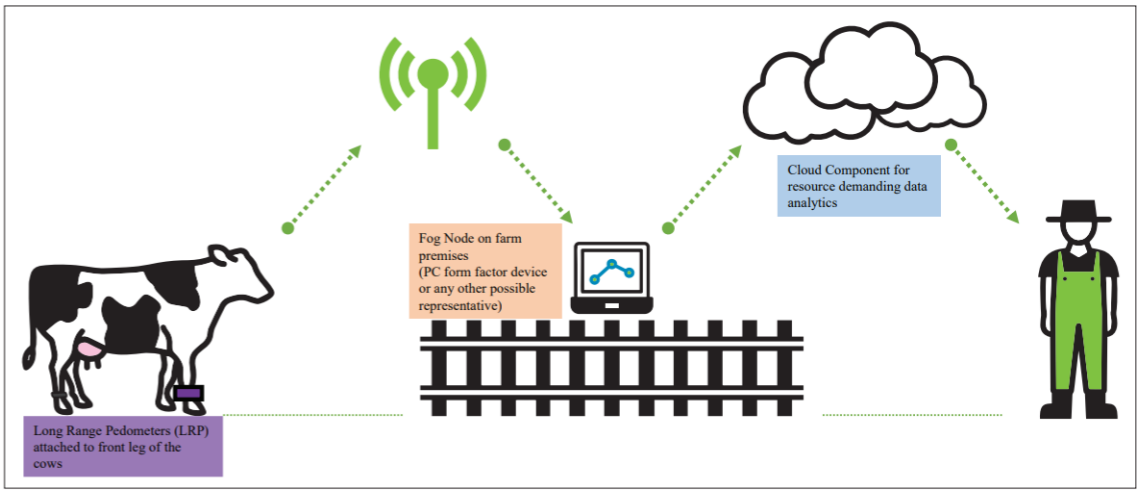
Devices: When selecting a livestock IoT device, several factors need to be considered for livestock farming, such as the device battery life. Raturi & Buckmaster (2019) argue or opine that the selection of devices should consider the following. The lifetime of a battery is critical as the frequency of having to replace the device battery can be problematic in large-scale implementations. Frequently replacing battery due to the device short battery lifecycle can be an **operational** nightmare (Raturi & Buckmaster, 2019). Second, battery replacement's practicality and time-consuming nature need to be considered: it implies that farmers or service providers will need to walk up to livestock and detach devices, replace the batteries, and go out in the field to locate the animals to reinstall the device. Other device considerations pertain to the device design: first, a decision needs to be made on which part of the animal the device will be installed, for example, a collar around the neck, a brace on a leg, a tag on an ear. A carefully chosen design can avoid stressing the animals (Raturi & Buckmaster, 2019). Other factors are device interoperability and communication protocols. These technical factors require to be strategically planned, and the lack thereof can lead to incompatible devices, thus limiting the ability to scale and integrate IoT platforms. Consequently, IoT devices are crucial in collecting relevant data about livestock through embedded sensors. The data gets transmitted from connected livestock devices over the network into a cloud platform for processing (Taneja, et al., 2019).

In a dairy farm application of IoT, the authors Taneja, et al., (2019) describes a decision-making approach during their design stage to guide device selection as those

revealed in this study. Starting with *decision 1*: which ***device*** should be used and whether to opt for off-the-shelf devices. *Decision 2*: which network device should be leveraged for ***connectivity*** (Taneja, et al., 2019). *Decision 3:* focused on the communication protocols between the main components. The decision-making process described by research participants is in alignment with this approach.

Figure 5.1 illustrates the application of IoT in a dairy farm.

Figure 5.1: An illustration of an IoT application in a dairy farm (Taneja, et al., 2019).

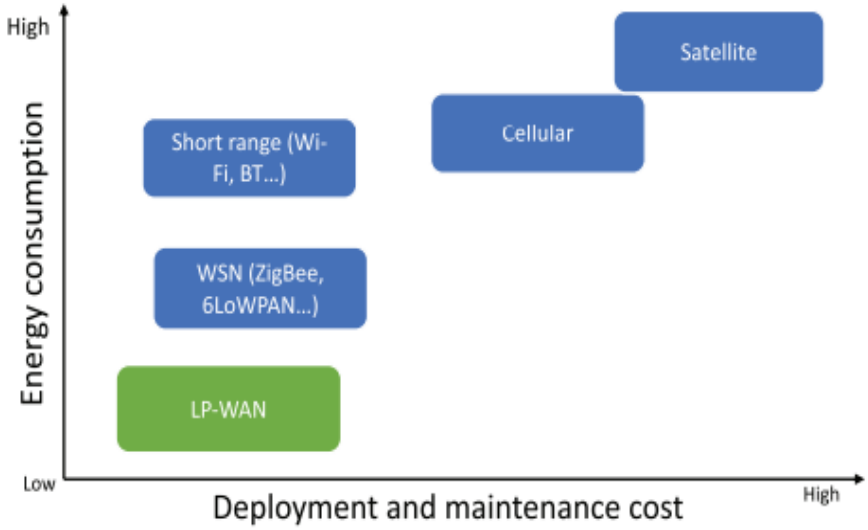


Connectivity: Inadequate connectivity in rural South African, where most livestock farmers are situated, was highlighted as one of the biggest IoT challenges in this study. Without adequate network connectivity, IoT components cannot disseminate data across the system. There are various IoT network connectivity technologies and service providers operating in the IoT ecosystem. Therefore, it seems imperative to source an affordable network connectivity service with broad coverage from the IoT network providers. Research participants identified several preferred network technologies, namely, the NB-IoT, Sigfox, and LoraWan. The authors Citoni, Fioranelli, Imran, & Abbasi (2019) cover the technical reasons why LoraWan is the preferred IoT network for farming use cases, indicating its low maintenance cost, low energy consumption, and scalability the primary reasons. Furthermore, t authors indicate that the LoRa network has been tested to cover a range of 15 kilometres in

rural open space (Citoni, Fioranelli, Imran, & Abbasi, 2019). The range makes the network favourable for livestock farming, as animals can cover long distances when gracing.

However, in the South African livestock farming context, these preferred and affordable IoT networks, such as Sigfox, are not yet widely available in South Africa, with network coverage of only 53% of land cover. Although South African mobile network operators provide decent cellular network coverage across the country, research participants believed that cellular network services are expensive for IoT implementations. The findings from this study align with views shared by Citoni, Fioranelli, Imran, & Abbasi (2019) in their study. They cited that cellular networks are expensive and flawed by design. They limit the number of devices connecting to a base station while providing the connected devices with large bandwidth capacity. Limiting the number of connected devices prevents IoT device scalability, while the high service price point adds to the solution's total cost. Figure 5.2 illustrates how LP-WAN (LoraWan) networks compare to cellular and other options.

Figure 5.2: Comparison of IoT enabling communication technologies



Source: (Citoni, Fioranelli, Imran, & Abbasi, 2019).

It is located on an ideal intersection with low energy consumption, preserving device battery power and low deployment and maintenance cost, thus keeping the solution costs down. Furthermore, it demonstrates that selecting an appropriate and affordable network is critical to an IoT solution's total cost and minimises operational maintenance. Importantly IoT devices and the cloud platform should be able to connect and communicate over the selected network. Therefore, it is crucial to ensure component interoperability, integration and scalability during IoT implementations.

The IoT cloud platform is responsible for processing and analysing the data for desired business insights. The intelligence and value of IoT solutions are based on the cloud platform's ability to process data at scale and speed. Therefore, the IoT cloud platform and the network capacity must be able to dynamical scale with the growing number of devices and the volume of data to be processed.

Systems Integrator

Skills: According to the findings, the complexities of the technical considerations in IoT implementations require specific IoT configuration skills. Gaskin (2020) and CompTIA (2019) state that IoT implementations require various skills (data security, IT security analytical data science, networking, cloud computing, device management and technical support). While Florentine (2017) states that 47% of 500 respondents interviewed by Vanson Bourne, a specialist technology market research company lacked IoT skills. These respondents were qualified by their involvement in their organisations' IoT-based solutions (Inmarsat, 2017). At the same time, Wiggers (2019) attributed technical complexities, IoT device security concerns and the lack of skills to maintain and support network-connected devices to IoT project failures.

In contrast, the findings of this study revealed differences in opinions amongst participants regarding the lack of skills. Multinational IoT service providers view skills as a commodity that can be sourced and moved to any region in which they are required. Therefore, they were of the view that skills were not a challenge. However, the South African participants provided a local perspective on IoT skills, stating a lack of IoT specific skills. Despite these opposing views, participants were unanimous on

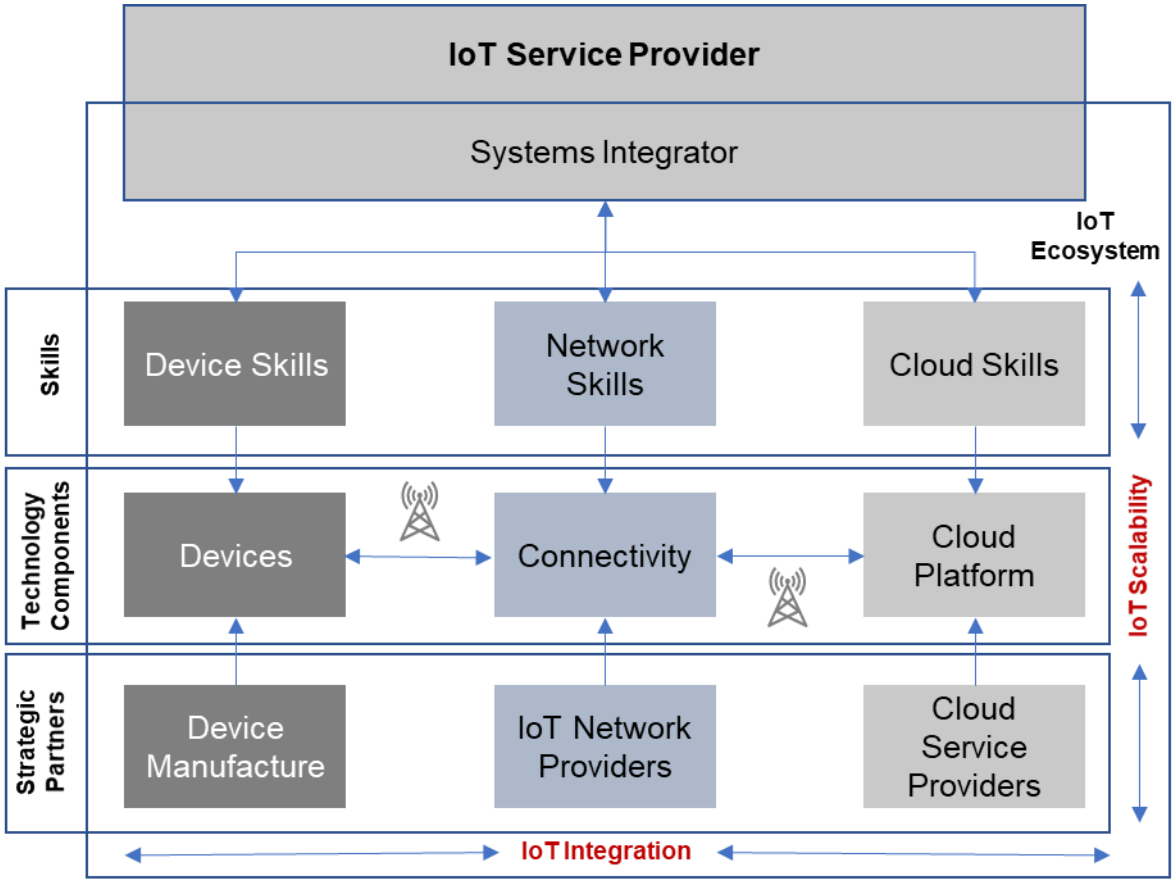
the fragmented nature of the IoT ecosystem and the clear skills gap regarding the ability to integrate the various components within the IoT ecosystem. It seems that IoT skills are device, network and cloud technologies specific. These domain-specific skills require experts to work together during an IoT platform implementation to integrate the fragmented IoT technology components into an interconnect IoT platform model.

The participants stated that it was essential to pull together IoT skills and technology providers into a single capable systems integrator. The systems integrator, also termed an IoT service provider by some participants, need to ensure that the fragmented technologies and skills are merged into a single IoT service provider entity. Such an approach may facilitate the provisioning of IoT resources to resolving the many implementation complexities pointed out by participants, thus avoiding project delays and failure.

However, according to Valdez-de-Leon (2017), there is no one company with the capability to do it all in IoT. The author further explained that an IoT ecosystem is a network of independent contributors that **partner** to create mutual value. Rather than seeing systems integrator as a single IoT business entity, it comprises interdependent **partnerships** by ecosystem players (Valdez-de-Leon, 2017). Therefore, system integrators are units of interlinked ecosystem players presenting themselves as a single competitive unit to deliver mutual value to the customer.

Nonetheless, livestock farmers should ideally deal with a single IoT service provider to serve as a systems integrator. Ideally, the service provider should have core partnerships with other ecosystem players. It enables the service provider to manage technical complexities, integrate the fragmented technology landscape, address skills, transition farmers to a new operational model, and deliver an end-to-end IoT platform through ecosystem partnerships. In figure 5.3 below, the researcher demonstrates the technical considerations from the findings in a diagram format.

Figure 5.3: An illustration of the technical factors



(Image source: Mhlongo, T, 2021)

5.2.2 Discussion of the findings pertaining to Proposition 2

This section focuses on discussing the findings related to Proposition 2: *Non- technical factors play a role in the application of the Internet of Things Platform business model in livestock farming in South Africa.* It discusses what the participants considered crucial non-technical factors in IoT application, namely business value and the sub-themes of the need for domain expertise, the identification of customer challenges, identification of customer needs, and authorised IoT investments.

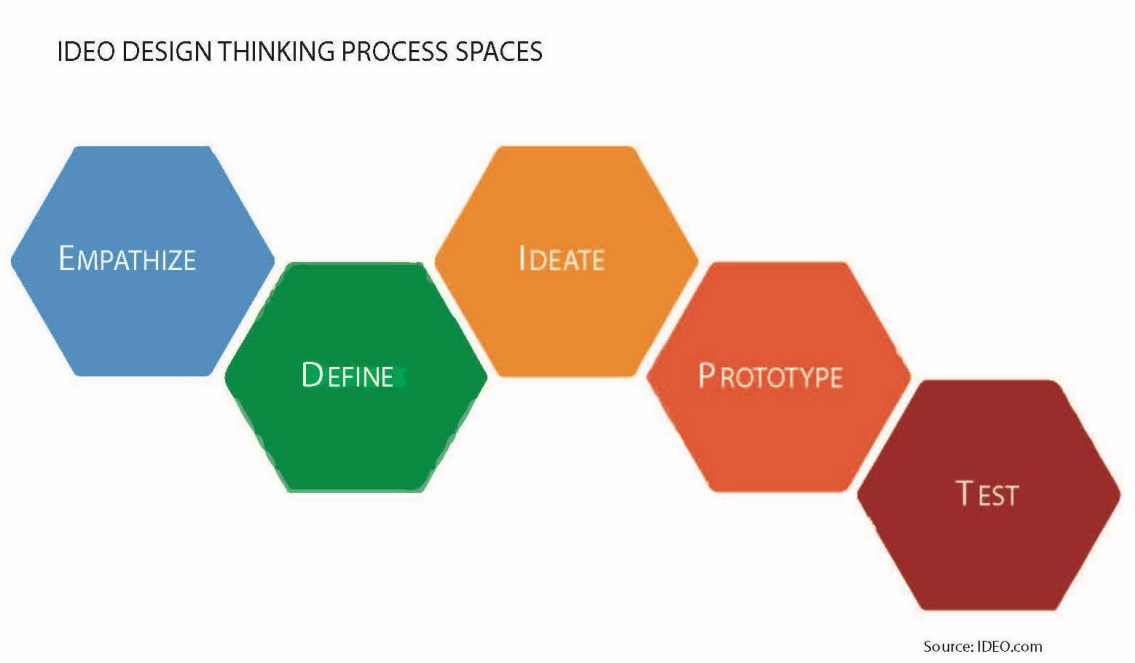
Business Value

Participants were unanimous that the primary purpose of applying IoT in any customer context needs to materialise into quantifiable business value. The sentiments from the participants are aligned with a statement from George Kalebaila, a research director for telecoms and IoT. He states that IoT service providers need to demonstrate that IoT can deliver value within their client's specific environment and further adding that customers want and need tangible results that align with their business priorities (Letsebe, 2018).

Based on this study, if IoT is to realise customer contextual business value, there are four (4) aspects that require consideration: (1) ***domain expertise to understand the customer context***, (2) ***identification of challenges faced by the customer***, (3) ***defining customer's needs***, (4) and an ***authorised IoT investment***. IoT applications differ depending on the context in which they are applied. Therefore, understanding the farmer's environment and challenges enables the IoT service providers to determine the farmer's specific needs when intending to implement an IoT solution. In order to establish and understand challenges faced by livestock farmers, livestock farming domain knowledge is imperative. Research participants discussed the value of conducting ideation workshops. Service providers and livestock farmers can work together to identify business challenges, define farming needs, quantify the value of IoT, technically design the solution, establish the required investment, and test for the desired results with pilots.

The findings are aligned with the sentiments of Andries Lombaard, the country manager of IDC SA: "a winning strategy would be focusing on analysing specific challenges, then concentrate on designing solutions that overcome those problems." (Letsebe, 2018). Therefore, the business engagement process explained by participants and discussed in section 4.4.1, chapter 4, seems to align with the IDEO Design Thinking process. Figure 5.4 exemplify the IDEO Design Thinking process.

Figure 5.4: An illustration of the IDEO Design Thinking process (IDEO, 2021)



According to the IDEO design thinking process, the customer (farmer) is approached with several questions aimed to establish four key determinants: *(1)* ***customer needs,*** *(2)* ***project authorisation,*** *(3)* ***budget planning,*** *(4)* and ***timelines*** (IDEO, 2021). Once the business needs are clearly defined, the project needs to be authorised to resolve and deliver against the identified requirements. Next, the project needs to be supported by an IoT investment, and definitive timelines see through the implementation to its finality. The next phase is the technical design session, in which IoT architects design a use case-based solution. The technical factors (devices, connectivity, skills, scalability, system integration and operational model) discussed in the previous section should typically be thought through during this stage. The final step involves prototyping the proposed solution through a proof of concept (PoC) or a small-scale pilot to test the technical feasibility and measure the desired business outcomes.

5.2.3 Discussion of findings pertaining to Proposition

This section focuses on discussing the findings related to Proposition 3: *Challenges IoT experts experience in positioning IoT solutions to customers in South African livestock farming*. First, the customer maturity level is discussed with reference to the two sub-elements attributed to customer maturity level, namely (1) Lack of maturity level and (2) IoT strategic objectives.

It transpired from the data that the positioning of IoT platforms as a potential solution for users (livestock farmers) points to two key factors. Namely, customer' maturity in adopting IoT and the ability of the service providers to present a compelling IoT strategy that can deliver on the value proposition. In addition, participants were of the opinion that farmers need to determine the effectiveness of the proposed solution. In cases where value is not easily articulated, it was recommended that service providers conduct PoCs or pilots to demonstrate the value of insights that can assist farmers in managing their farming challenges.

Farmer's maturity Level

Some participants were of the opinion that age and exposure to other technologies might influence the farmers' decision to adopt an IoT solution. In their view, older farmers tend to be dependent on old and proven farming methods and seem to approach IoT solutions with reluctance. In contrast, the younger generation of livestock farmers seems to be more receptive to new technological solutions for their problems. Furthermore, what seems to be a prominent factor, relates to the operational efficiency and the IoT solution cost of ownership. Several participants (NS, LS2, JS, WS, MY, and ME) emphasised the requirement for service providers to understand the farmers' pain points and develop a solution suited to the farmers' business needs.

There is not much literature or studies on IoT adoption within the South African livestock farming sector. The authors Aguera, et al. (2020) state that the digitalisation of agriculture in South Africa is predicated on devices and data affordability and

sufficient internet access and use. While only 53% of South Africans are connected to the internet, the survey found a gap between urban and rural internet users (Aguera, et al., 2020). The authors Aguera, et al. (2020) viewed this gap as indicative of the level of ICT infrastructure needed in rural areas to uplift farmers who operate mainly in rural parts of South Africa. One of the main reasons for slow internet access is the high cost of mobile data in South Africa. South Africa is ranked 33rd out of 46 countries with high data prices (Aguera, et al., 2020). The findings in this study align with Aguera, et al. (2020), as the participants indicated that the mobile networks available in rural areas tend to be expensive compared to the desired IoT networks.

The author Giaffreda (2019) shared insights regarding IoT adoption barriers within the sector of agriculture. He states that most farmers are stuck in the old methods inherited from their predecessors while also pointing out the digital divide as a challenge. Furthermore, he laments that inadequate internet connectivity in farms essentially prevents access to technology. Lastly, Giaffreda (2019) highlights the importance of value creation, stating that co-creation is critical in achieving precise and applicable IoT solutions for farmers to adopt. According to Aguera, et al. (2020), advanced technologies and digitalisation are starting to emerge in the South African agriculture sector despite the adoption challenges. The authors view that large-scale commercial farmers are likely to adopt IoT adoption due to the high cost.

Although the findings in this study presented an innovative approach shared by one participant in reducing the cost of an IoT solution while increasing the likelihood for the IoT solution to get adopted by farmers. The findings highlighted that using an IoT hybrid business platform model (innovation and transaction) assisted in bringing the cost down by introducing the livestock investors (consumers) in the platform business to lower the cost of IoT.

IoT livestock farming strategy

In positioning IoT to livestock farmers, service providers need to find innovative ways to strategically assist farmers in understanding and appreciating the value of IoT. According to Duke-Woolley (2020), in a study by Cisco, 74% per cent of global respondents from a survey of 1,845 IT and business decision-makers viewed IoT strategy and planning as the most relevant phase to their ultimate success. While the participants believed that livestock farmers were open to IoT-based solutions, they identified the requirement for IoT service providers to focus on the value proposition and make the solution affordable for the farmer. In a discussion paper, Deliotte (2017) identifies innovative livestock farming business models for positioning IoT to livestock farmers for business value generation through the use of data. A specific interest in the data brokerage business model occurs when the opportunity is created by combining data generated from various platforms. For example, the livestock data collected by IoT devices can be streamed into a livestock trading platform. As a result, investors interested in trading on livestock can also remotely track the livestock they purchased through a single platform.

The participant NS a farmer and a service provider shared his experience of approaching livestock farming from a strategic point of view given his farming domain knowledge and understanding of how livestock farmers think. He introduces an IoT-based solution to farmers that integrates with a multisided digital platform to help track and monitor livestock. Knowing the farmers' mindset, he devised a new business model that minimised high costs attributed to IoT solutions. He introduced a demand-side into the livestock business, which allowed the public to invest in owning livestock without the intricacies of owning a livestock farm. The investor would buy livestock on a digital platform while the farmer takes custodianship of the animals within his/her farm. The value exchange is generated through a transactional digital platform. According to Evans & Gawer (2016), the transaction models create business value by facilitating exchanges between two or more participants, such as matching a consumer (livestock investor) with a service provider (a livestock farmer). IoT in this context is used to provide the new owner and the farmer the ability to track and monitor

livestock remotely from the internet. The approach is like that of tracking stock in a Johannesburg stock exchange (JSE). However, as pointed out by participant NS, this particular solution required the service provider to apply his technical and domain knowledge and understand the farmers' mindset while the farmers had to adjust their approach to the underlying business model.

5.3 Livestock farming challenges

In the study, the farmers shared two common farming problems: (1) livestock theft and (2) predation. Predators such as the rooikat (caracal) and jackals terrorise livestock farmers in parts of South Africa. In 2020, participant MB, a livestock farmer, indicated losing 35 sheep from the 152 he owned to predators. Existing literature on livestock predation in South Africa estimates losses of over ZAR1 billion per year, and it is stated that this problem on the increase (Kerley, et al., 2017). In comparison, livestock theft in South Africa shows there were twenty-nine thousand (29 000) cases logged in South Africa for livestock theft from 2018 through 2019 (Chelin, 2019). A UNISA study from the School of Criminal Justice estimated that the financial loss due to theft amounted to R1.3 billion (Chelin, 2019). This study revealed that farmers spent their daily activities on herd management and the surveillance farms' parameter fence to safeguard against intrusion from criminals and predators.

Farmers have taken the predation problem into their own hands. According to Walt (2020), a sheep farmer in the South African Karoo developed a sheep collar device consisting of a poisonous pouch that the sheep will wear. When attacked, the predator will bite into the poisonous pouch and killing the predator instantly.

Figure 5.5: Sheep collar device with poisonous pouch



(Image source: *Eddie Steenkamp)*

This use case shows how domain knowledge can be innovatively applied to resolve livestock farming challenges.

While another livestock use case made use of IoT sheep collar devices to safeguard against theft and predation in South Africa (Booysen, 2019), the author Booysen (2019) indicated that the collar could be installed on a single sheep out of a flock of 300 to minimise device cost. If the tagged sheep starts behaving abnormally, the collar senses the sudden and sporadic movement and alerts the farmer. Since sheep move in a flock, there is no need to have the collar installed on all sheep. The collar device is valued at ZAR6 100, and the service provider configures the device to the farmer's smartphone for notification. Additional notifications can be configured to send to livestock security or any other third party needing to respond to the likely threat. The author indicates that the collar comes with a mobile app that shows the farm's map and tracks and monitors the flock through the installed collar.

This study does not delve into the ethical consideration of the proposed collar device. Instead, it aims to point out that innovation and value can be realised in finding economical and appropriate solutions to the customer environment. The sheep use case shows that livestock farmers are willing to adopt new methods to preserve their livestock while saving costs.

5.4 Conclusion

The study has outlined key IoT related considerations evaluated from three different but interrelated views, (1) business, (2) technology and (3) customer perspective. The key takeaways are as follows:

- An IoT strategy is necessary to determine which business objectives can be achieved by implementing an IoT solution.
- A co-creation business engagement model coupled with business domain knowledge can assist farmers in identifying business needs that are likely to yield positive business outcomes.
- Understanding the business challenges faced by livestock farmers through domain expertise places the service providers in a better position to propose solutions that can be economical and deliver operational efficiency. Thus, increasing the probability of the solution being operationalised by farmers. Furthermore, identifying the needs of livestock farmers can enable service providers and farmers to co-design IoT solutions geared to addressing the more prominent customer challenges.
- Clear IoT business objectives enable technology solution architects to design solutions suited for livestock farming conditions. In addition, knowing upfront what operational data needs collecting from the field can assist IoT practitioners and service providers select suitable technology components (devices, connectivity and cloud) that are interoperable, can integrate and scale with minimal complexities.

- The fragmented IoT technology landscape introduces several complexities related to varying communication protocol standards brought about by the lack of standardisation amongst ecosystem role players. It introduces numerous technical difficulties that can lead to incompatibility between the core IoT building blocks (devices, network and cloud) and possibly result in complex and costly system integration challenges. These integration challenges can impede the desire to scale IoT solutions from PoCs or even small-scale pilots and lead to implementation failures.
- IoT Service providers are best equipped when in partnership with other ecosystem players to ensure access to reliable and sustainable technologies that are purposefully suited for the customer use case and are selected to deliver an interoperable IoT platform model.
- The availability of IoT technical skills can help reduce numerous technology-related complexities that the many fragmented technology components can present. Access to core IoT skills can help alleviate IoT implementation project delays synonymous with projects that lack access to skills. A failure to source the correct blend of IoT skills can lead to delays and even failure to realising the desired IoT business value.
- Preferred IoT network connectivity options (e.g. LoraWan, Sigfox) are limited in the rural parts of South Africa, limiting the options to the expensive cellular network. The presumably related high data cost and mobile network devices' energy consumption need to be considered part of the technical design and the solution pricing model.

All the business aspects must be well-thought-out to yield desired outcomes in IoT application in livestock farming. Ultimately IoT is a business solution that is enabled by complex technologies and skills. Therefore, the farmers business interest must be the focal point behind IoT implementations. In addition, the quantified value must be attractive enough to farmers to overcome some of the challenges presented in this study.

6 CONCLUSIONS & RECOMMENDATIONS

6.1 Introduction

This chapter includes a consolidation of the findings presented in the previous chapters to answer the main research problem: What are the factors to be considered for the application of the IoT platform model in South African livestock farming?

- Section 6.2: Conclusions on the research
- Section 6.3: Recommendations
- Section 6.4: Suggestions for any further research

6.2 Conclusions regarding the Research Question

6.2.1 Primary Research Question

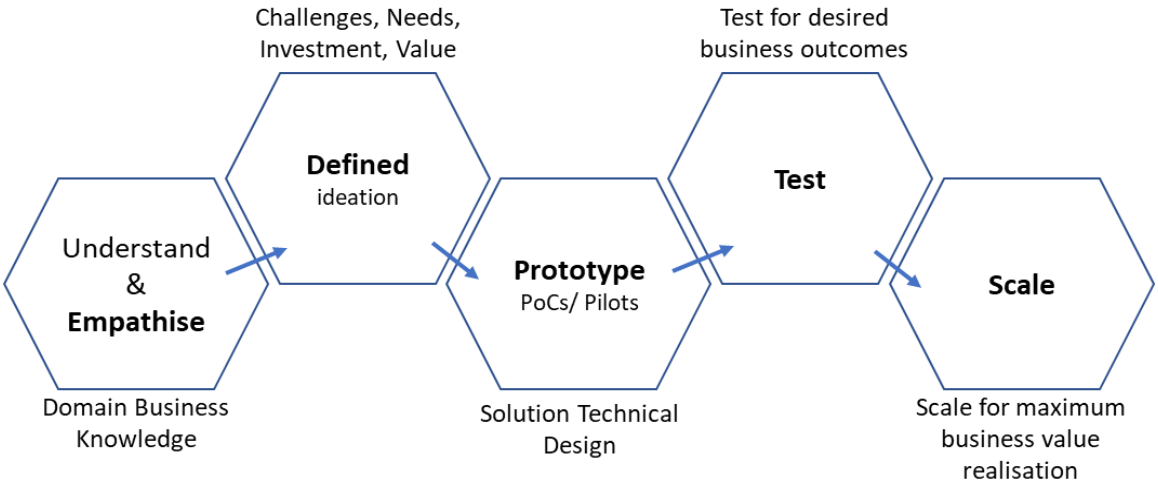
What are the factors to be considered for the application of the IoT platform model in livestock farming in South Africa?

It is evident from the findings that the application of IoT in South African livestock farming requires consideration in three key focus areas, namely, (1) business, (2) technology and (3) customer.

***Business*:** Participants were clear about the requirement that IoT should always be approached from a business perspective. This view is supported in recent articles aiming to guide IoT services providers and product managers to solve IoT challenges with design thinking techniques (Daniel Elizalde, 2021). Service providers need to possess enough domain knowledge about the farmers' operations to solve their farming challenges. Without clear business objectives, it becomes difficult to identify a specific business area in which IoT can be best applied for value generation. Therefore, it seems imperative that farmers (customers), with the support of service providers, first define their primary business objectives and then explore how IoT can

enable these objectives. In working closely with farmers, service providers can identify immediate challenges. Utilising ideation workshops, as shared by participant (LS2, MY, ME) and (Lima Dantas D., 2020), both farmers and service providers can understand business challenges, define IoT objectives, assess the required investment and quantify the business outcomes in monetary value. Figure 6.1 is an adaptation model from (Plattner, 2019) to illustrate the findings against the design thinking process.

Figure 6.1: Findings illustrated against the Design Thinking process



Once the requirements are defined, the next phase of the business engagement process shifts towards technical considerations.

Technology: Starting with architectural design, solution architects can identify the required technical and functional components. Based on the responses of research participants, three technical focus areas require careful planning, namely IoT devices, connectivity and the cloud platform. Service providers need to consider the livestock farmer's environment and identify contextual technical challenges within the early conceptual stages. This is especially relevant for livestock farming that is situated mainly in the rural outskirts of South Africa, presenting little or no network connectivity coverage from the preferred IoT network providers. Such a challenge needs to be well-thought-out, and an alternative solution needs to be identified and tested.

Respondents pointed to the fragmented nature of the IoT technology landscape that requires a specific set of integration skills to facilitate the complex implementation of IoT. It is a similar view shared by Aly, Khomh, Gueheneuc, Washizaki, & Yacout (20218), in which the authors discuss the same complexities covered in the study and several others.

Concerning the IoT device requirements, this seems to be a technical area that requires a strategic approach. Knowing what needs to be measured from the customer's environment allows the solution architects to plan for the type of devices to be procured, select a suitable network for connectivity, and a scalable cloud platform for data storage and processing. The list below provides key technical consideration revealed in this study:

- What kind of devices are well suited for livestock, and where should they be installed on the livestock?
- How to guard against possible device theft?
- What data and sensors are required for the desired business insights?
- How frequent the devices need to connect to the network to send out data?
- Making determinations on the device battery life, charging and replacement
- Evaluate the communication protocols and standards and ensure interoperability between the selected technologies
- Selecting a long-term device partner that will ensure ongoing supply and support of the devices throughout the device solution lifecycle.
- Cloud platform features, capabilities and scalability factors
- Finding a blend of IoT technical skills to resolve imminent technical complexities

- Consolidating a fragmented IoT ecosystem (device, connectivity and cloud providers) by pulling together crucial resources into a single technology entity for system integration

A well-designed IoT solution that has considered the listed factors should ideally scale from a pilot into a large-scale implementation. Another underestimated consideration is the operationalisation of the IoT solution. Once the solution is implemented, who manages and operates the system? An ideal operational model needs to consider that technology may not be the customer (farmer's) core business interest but in realising business value. Hence both parties, farmers and service providers, need to define a balanced model that will deliver value (Sniderman & Raynor, 2021). Therefore, the service provider needs to have a support and maintenance plan to ensure sustainability.

Customer Context: It is quite evident from the perspectives of research participants that in addition to the technical and the commercial aspects of IoT implementations, a customer-centric dimension is required to squarely focus on the farmer's contextual requirements. Service providers need to inquire about psychological and) social factors such as the receptive mindset, digital literacy and the cost of adoption Aguera, et al., (2020) that may influence farmers in the adoption of technology. The study shared the views that age and exposure to other technologies may influence farmers receptiveness to technological solutions, a perspective also reported in Giaffreda (2019). (revealed that older generation farmers preferred to stick to their proven farming methods than to adopt new technologies. In contrast, the younger generation of farmers exposed to other forms of technology is more receptive to technology in their farms.). However, research participants highlighted that in their view, farmers are willing to listen and adopt new concepts provided it addresses the perceived high cost of the technology, improve productivity and deliver operational efficiency.

Figure 6.2 adapts the design thinking innovation framework to encapsulates crucial factors that need to be considered in implementing IoT in South African livestock

farming. Central to the IoT application in livestock farming is innovation and customer value.

Figure 6.2: Innovation framework for the application of IoT in South African livestock farming

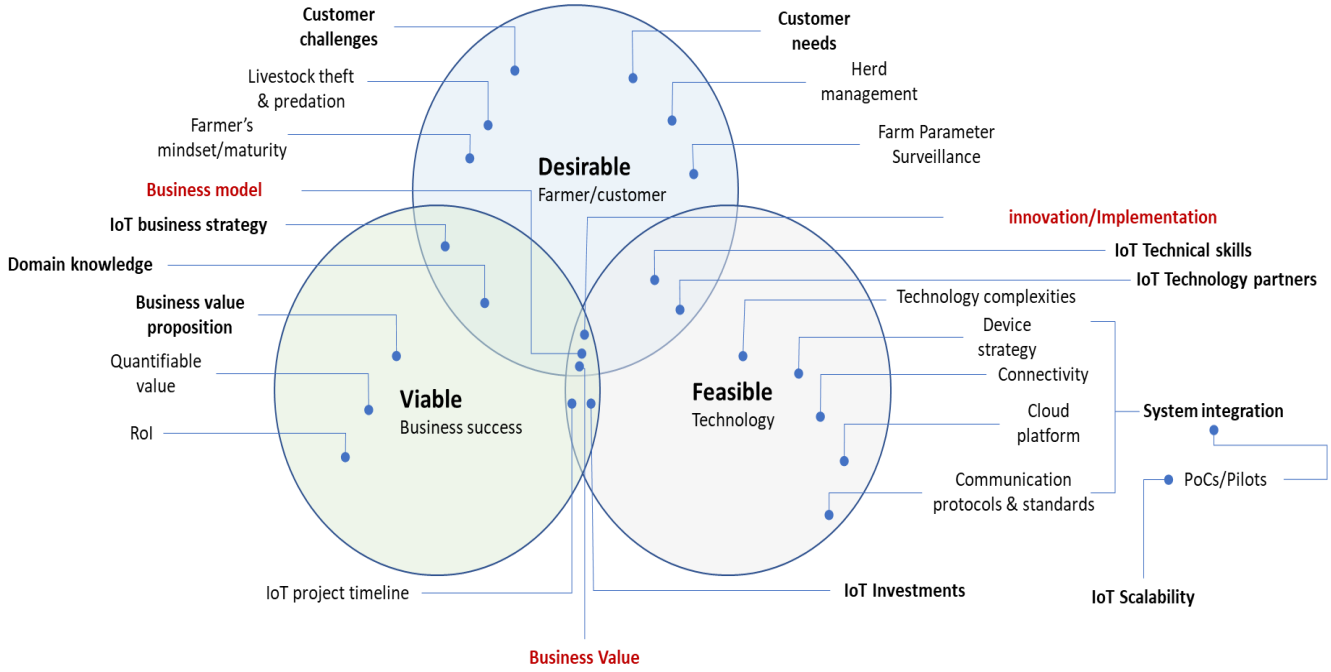


Figure 6.2 is a design thinking framework which the researcher has adapted for the livestock farming context.

6.3 Recommendations

This section provides commendations for IoT service providers and practitioners when approaching an IoT implementation and recommendations for further research. The section makes recommendations based on the interpreted findings from this study in conjunction with existing and researched methodologies to guide IoT service providers and practitioners when approaching IoT implementations.

IoT Service providers: IoT solution presents many complexities, including business, technology and human determining factors. Finding a suitable IoT solution for livestock

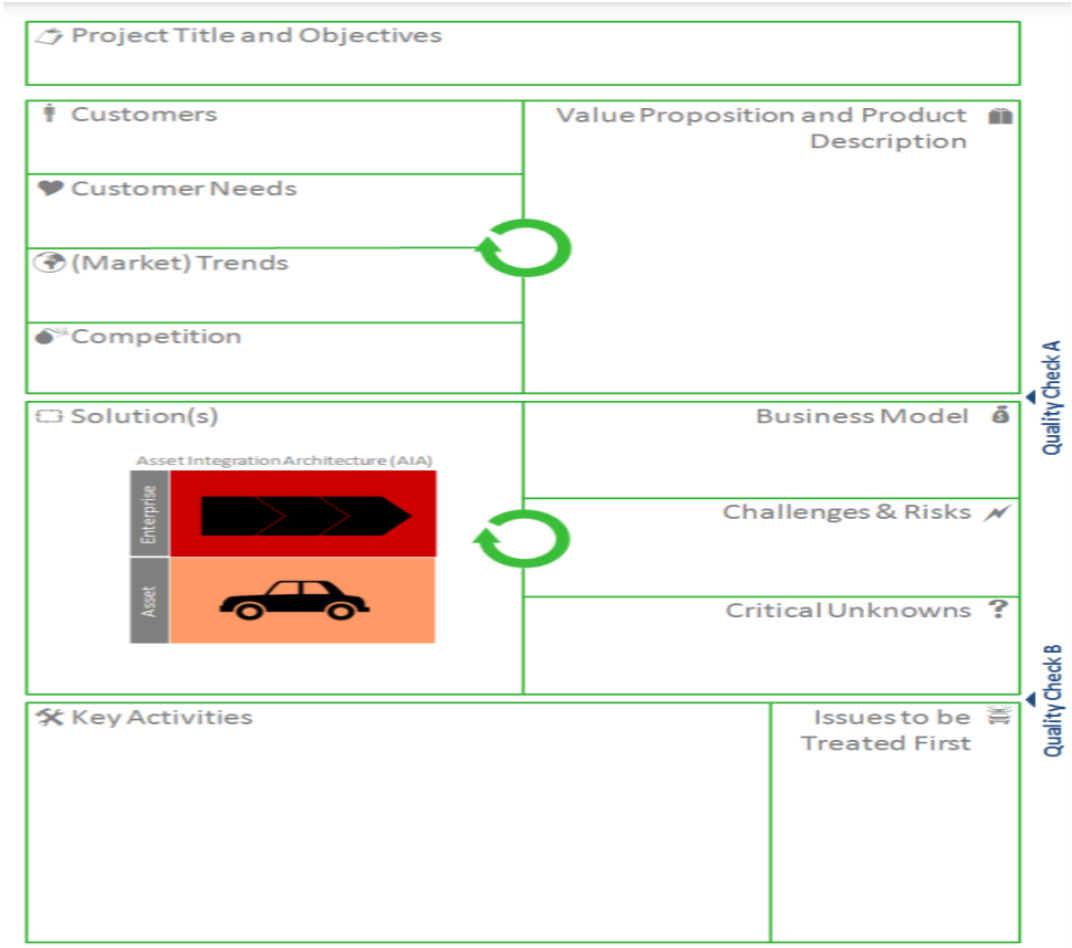
farmers requires deep domain expertise in understanding the farmer's challenges and explore opportunities to co-create with farmers innovative and purposeful IoT solutions.

- **IoT Strategy**: Service providers need a go-to-market strategy, a clear vision and goals that will guide them in identifying IoT business opportunities. If a service provider decides to focus on a specific industry vertical (i.e. livestock farming), they must consider the industry factors. Competencies in the relevant focus area must be developed for execution capability, (1) **business domain expertise**, required for industry engagement and assist customers with the value proposition, (2) **IoT technical innovation lab** for research and development converging on domain-related technical complexities, (3) **ecosystem partner alliances** to advance technology, skills and systems integration IoT service capabilities (4) an operational model and change management process to be adopted when introducing new IoT solution to customer environment, (5) IoT maturity assessment to gauge receptive levels of the intended benefactor (i.e. farmer, farming enterprise) (Slama, Puhlmann, Morrish, & Bhatnagar, 2015).
- **Skills**: technology domain expertise play a crucial part in the application of IoT platform models. The lack, therefore, remains a concern in the South African perspective. Service providers need to work closely with tertiary institutions to help develop and contribute to the curriculum to develop the areas lacking in the market. In addition, IoT ecosystem players need to sponsor public events designed to train and cultivate a pool of IoT skills in preparation for the growing IoT demand.
- **Ecosystem partnerships**: it is evident from the study that a fragmented ecosystem will find it even more challenging to deliver value. The lack of preferred IoT network connectivity service providers in remote areas indicates that service providers need to develop back to back contractual arrangements with other IoT ecosystem enablers. The approach would allow them to collaborate in delivering mutual value to the livestock farming sector. IoT device

strategy, network and cloud complexities can be overcome by developing a mutual IoT go-to-market strategy. A clear go-to-market strategy minimises the technical complexities as the designated ecosystem partners can systematically select and supply IoT technologies (device connectivity, cloud) best suited for livestock farming requirements.

- **Network connectivity**: this remains the biggest concern in implementing IoT in South African livestock farming. The lack of preferred networks in targeted livestock farming areas means that service providers must consider limited and expensive networks. IoT networks such as LoraWan and Sigfox need to start considering making their services available in the rural parts of the country. If network players approach livestock farming as an ecosystem unit, value can be realised with minimal challenges.
- **Customer context**: Farmers need to be approached from a business perspective focusing squarely on their business challenges, objectives, and the value proposition of IoT implementation in the livestock farming context.
- **Ideation**: The design thinking innovation process seems to be identified as an appropriate engagement tool that can assist service providers in determining livestock farming challenges and needs. The output from the ideation sessions with the customer leads to the next phase, enabling solution design and prototyping to assess the solution feasibility and viability. The viability study clarifies the required IoT investment, which is supported by a positive business case. Figure 6.3 recounts the crucial elements in determining the value proposition.

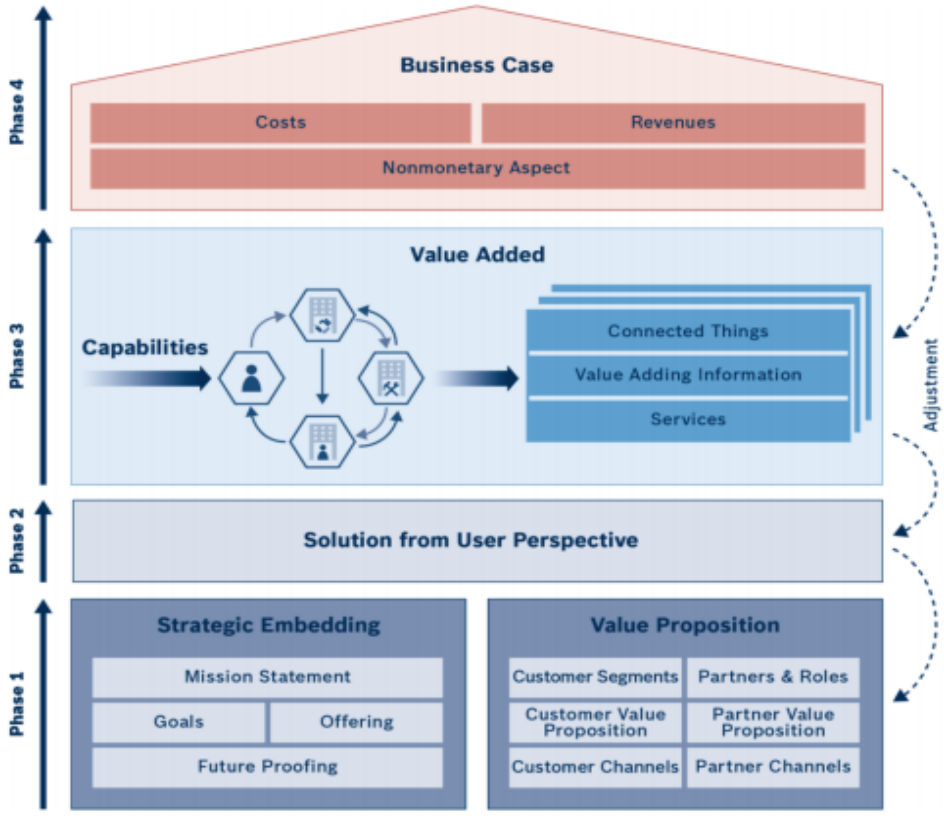
Figure 6.3: Innovation Project Canvas



(Source: http://innovationprojectcanvas.com/)

- **IoT Business Value Models:** The IoT business value can be segmented into internal business improvements and new business models (Slama, Puhlmann, Morrish, & Bhatnagar, 2015). Detailed IoT business models are referenced in the Bosch whitepaper (Fleisch, Weinberger, & Wortmann, 2014). The authors Slama, Puhlmann, Morrish, & Bhatnagar (2015) provide a recommended IoT business model builder that service providers can adopt and adapt. Figure 6.4 presents the business model builder by Bosch Software Innovations.

Figure 6.4 IoT Business Model Builder



source: Slama, Puhlmann, Morrish, & Bhatnagar (2015)

It seems preferable for service providers to present themselves as a single ecosystem unit and a reliable customer business partner equipped with all the necessary IoT capabilities to ensure end-to-end business value realisation. Hence, service providers should consider developing strategic partnerships with other IoT ecosystem players to ensure the technical quality, reliable supply of required technologies, and continuous support and maintenance of the implemented solutions. The role of technical skills cannot be understated as they are required to navigate the complexities of IoT technical composition. Conclusively, all the technology components must be integrated into a functional system to realise any purported business value. The study has demonstrated that farmers are willing to evaluate new methods to tackle livestock theft and predation challenges.

IoT Practitioners need to continue to be on the lookout for emerging IoT technologies, concepts and standards. They must be upskilling their competencies to keep up with changes in technology. A focus on the technology selection and standards is crucial to the overall success of the project. They need to appreciate and understand that IoT is a tool designed to enable business value, which means the ultimate focus to deliver farming insight that will equip livestock farmers with the ability to respond to their particular challenges.

6.4 Suggestions for further research

The Application of IoT in SA livestock farming remains a complex network of interrelated factors cutting across business, technology and customer-centricity. This study discussed a broad spectrum of IoT related factors that can be further research in-depth. The following topics require further research as they continue to evolve with the advances in IoT technologies and increasing farmer (customer) awareness levels.

- IoT security concerns; security considerations in IoT platform models cut across the breadth of an IoT implementation, from devices, network, cloud and applications used by customers. There is already considerable literature on the topic, and with cybersecurity incidents on the increase, further studies can add to the body of knowledge.
- IoT business models continue to evolve, and there seems to be an emergence of IoT business models designed purposefully for specific customer contexts. Therefore, as the customer challenges and needs vary based on the industry and context, ongoing studies and improvements need to be undertaken to further contribute to the existing body of knowledge.
- Communication protocols and standards; this area remain a challenge that was highlighted as one of the technical factors attributed to IoT project failures
- Livestock farmers; it appears there is growing interest in how IoT can be applied within agriculture to realise the many cited business benefits. However, the remoteness of most farms still presents some challenges, such as the

availability of technology infrastructure that enables the implementation of IoT. Further studies may be conducted to understand the adoption challenges within the livestock context broadly.

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APPENDICES

APPENDIX I: Supervisor Student Agreement

Statement of principles for postgraduate supervision

In a context of academic freedom and within a framework of individual autonomy and the pursuit of knowledge, this statement is written in the belief that there is a reciprocal relationship and mutual accountability between supervisor and student

THE SUPERVISOR AND THE STUDENT:

1. Will establish agreed roles and clear processes to be maintained by both parties. In the case of joint supervision, everybody's role and responsibilities need to be clarified.
2. Will meet regularly and as frequently as is reasonable to ensure steady progress towards the completion of the proposal, research report, dissertation or thesis. This time varies but the normal minimum requirement for face-to- face contact spread across each year of registration is: 10 contact hours for an Honours project, 15 contact hours for a Masters by coursework and research report and 24 contact hours for a Masters by dissertation and a PhD.
3. Will keep appointments, be punctual and respond timeously to messages.
4. Will keep one another informed of any planned vacations or absences as well as changes in his or her personal circumstances that might impact on the work schedule. Unplanned absences or delays should be discussed as soon as possible and arrangements should be made, to catch up lost time.
5. Will ensure that research on animal or human subjects is conducted according to the procedures and the requirements of the relevant Ethics committee.

THE SUPERVISOR:

1. Undertakes to provide guidance for the student's research project in relation to the design and scope of the project, the relevant literature and information sources, research methods and techniques and methods of data analysis.
2. Will provide guidance at the commensurate NQF level requirements for autonomy and accountability that the student is expected to demonstrate
3. Has a responsibility to be reasonably accessible to the students.
4. Will be prepared for meetings with the student. This includes being up-to-date on the latest work in his/her area of expertise.
5. Will expect written work as jointly agreed, and will return that work with constructive criticism within a timeframe (a suggestion of 2-4 weeks) jointly agreed at the outset of the research.
6. Will provide advice that can help the student to improve his/her writing. This may include referrals for language training and academic writing. The supervisor will provide guidance on technical aspects of writing such as referencing as well as on discipline specific requirements. Detailed correction of drafts and instruction in aspects of language and style are **not** the responsibility of the supervisor.
7. Will guide the student in the production of a research report, dissertation or thesis. Provision should be allowed for adequate, mutually respectful, discussion around recommendations made.
8. Will assist with the construction of a written time schedule, which outlines the expected completion dates of successive stages of the work.
9. Will ensure the student has the opportunity to present work at postgraduate/ staff seminars/national/international conferences as appropriate.
10. Will assist with the publication of research articles as appropriate.
11. Will discuss the ownership of research conducted by the student in accordance with the University guidelines and rules on intellectual property, co-authorship and copyright.
12. Will ensure that the student knows what plagiarism is, and what the consequences are for academic dishonesty in accordance with the University's policy on plagiarism.
13. Will ensure that the student is made aware in writing of the inadequacy of progress and/or of any work where the standard is below par. Acceptability will be according to criteria previously supplied to the student.
14. Has a duty to refuse to allow the submission of sub-standard work for examination, regardless of the circumstances. If the student chooses to submit without the consent of the supervisor, then this should be clearly recorded and the appropriate procedures followed.

THE STUDENT:

1. Takes full responsibility for the research undertaking and its successful completion; including managing the process and managing the supervisor where required
2. Will attend such courses and lectures that are compulsory for the degree, and undertakes to fully catch up any work, lectures, assignments, that are missed.
3. Undertakes to work independently under the guidance of the supervisor. This includes reading widely to ensure that the seminal **and** current literature pertinent to his/her chosen topic has been identified, consulted and critiqued.
4. Undertakes to work in accordance with the academic standards specified in the SAQA NQF level descriptor document for the appropriate level of the qualification (NQF 9 for Master's degrees and NQF 10 for PhDs)
5. Is obliged to make appointments to see the supervisor and will arrange meeting times well in advance.
6. Should submit written work for discussion with the supervisor well in advance of a scheduled meeting. The kind and frequency of written work should be agreed with the supervisor at the outset of the research.
7. Written work that is submitted should be relatively free from basic spelling mistakes, incorrect punctuation and grammatical errors. Responsibility for the accuracy of language, the overall structure and coherence of the final research report, dissertation or thesis rests with the student
8. Undertakes to heed the advice given by the supervisor and to engage in discussion around suggestions made. Ultimately the student has to take responsibility for the quality and presentation of the work.
9. Should strive, within reasonable bounds, to maintain a focus on his/her research area and to work within the agreed time schedule.
10. Agrees to honour agreements about ownership of the research and in accordance with the University's guidelines and rules in relation to co-authorship, copyright and intellectual property.
11. Will ensure that the work contains no instances of plagiarism, that all citations are properly referenced, and that the list of references is accurate, complete and consistent.
12. Agrees to work in accordance with the criteria of acceptability as supplied by the supervisor.
13. Will not expect the supervisor to be a proof-reader or editor of the work
14. Undertakes not to place the supervisor under undue pressure to submit work for examination until the supervisor is satisfied that it has reached an acceptable level of quality.

We confirm that we have read and understood this statement and agree to be guided by its principles for as long as we continue to work together.

Name of student: Thuthuka Mhlongo

Student's signature: T Mhlongo

Name of Supervisor: Leona Craffert

Supervisor's signature: L Craffert

Name of Co-Supervisor: _____

Co-Supervisor's signature: _____

The broad area of study is: Business Science

Provisional submission date is: February 2021

Degree: MM in Digital Business

School: WBS - Digital Business

Faculty: Faculty of Commerce, Law and Management

Date: 1 October 2020

Specific agreements pertaining to: ownership and joint publication, funding, may be attached and signed.

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APPENDIX A: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF GRADUATE SCHOOL OF BUSINESS ADMINISTRATION ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: WBS/BA2295069/788**
PROJECT TITLE	The application of the Internet of Things in South African livestock farming
INVESTIGATOR	Mr Thuthuka Mhlongo
SCHOOL/DEPARTMENT OF INVESTIGATOR	MM (Digital Business)
DATE CONSIDERED	16 November 2020
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	LOW RISK
EXPIRY DATE	30 JUNE 2021

ISSUE DATE OF CERTIFICATE 30 November 2020 **CHAIRPERSON** _____
(Dr MDJ Matshabaphala)

cc: Supervisor: Leonora Craffert

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

T T Mhlongo
Signature

Date 01 / 12 / 2020

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

APPENDIX B: Permission Letter



University of the Witwatersrand,
Faculty of Commerce, Law and Management

Company Name
[**DD/MM/YYYY**]

Dear Sir/Madam,

Re: Permission to conduct research at (Company Name).

My name is **Thuthuka T. Mhlongo**.

I am studying for my Master of Management Digital Business at the School of Business at the University of the Witwatersrand. I am seeking permission to conduct my research at **Company Name**.

I am researching to *explore the application of the Internet of Things platform models focusing on South African Livestock farming*. The research project aims to explore the determinants that influence the application of the Internet of Things (IoT). It is primarily focusing on relevant IoT skills, IoT business models, the IoT ecosystem and the role of the envisioned customer/industry (area of interest is livestock farming in South Africa). Furthermore, the study aims to contribute to the existing body of knowledge by providing guiding principles about the application of IoT in the context of livestock farming. The recent emerging reports are indicating that few IoT projects make it past the proof-of-concept (PoC) phase to achieve the intended business objectives. I believe that **Company Name** has extensive practical exposure in providing IoT solutions across South African industries.

The research will entail collecting data from **Company Name** as a reputable South African IoT Solution Provider and from its IoT practitioners who are knowledgeable and have practical and applicable experience in the application of IoT. I am much aware that the IoT services sector is competitive due to a growing South African market. Therefore, I would like to assure **Company Name** that the interviews will remain highly confidential.

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I hope to invite individuals from your organisation, with your guidance and support, to participate in this study. Should they agree, they will be asked to partake in a virtual/telephonic interview that will take approximately 30 – 45 minutes. The interviews will be recorded to have them transcribed for the study. I am willing to work around the identified participants' schedule.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated *confidentially*, and identities (their names and the name of the organisation) will be *anonymous* unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study. The results will be communicated in a Research Report.

The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during the study without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study. All research data will be preserved *anonymously* for *six (6) months* in a secure repository while it gets transcribed for the report, and it will soon after the research get destroyed.

I, therefore, request permission in writing to conduct my research at your organisation. The permission letter should be on your organisation's headed paper, signed and dated, and explicitly referring to myself by name and the title of my study [*The Application of the Internet of Things in South African livestock farming*].

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,
Thuthuka Mhlongo
Mobile: +27 73 XXX XXXX
Email: 2295069@students.wits.ac.za

Supervisor: Leona Craffert
Contact: contact number
Email: leona.craffert@wits.ac.za

APPENDIX C: Research Info Sheet

Dear Participant,

My name is Thuthuka Mhlongo, and I am a master's student in Digital Business at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project in which I am **The Application of the Internet of Things in South African Livestock farming** under the supervision of **Dr Leona Craffert**. This research project aims to explore the application of the Internet of Things (IoT) with a specific focus on livestock farming in South Africa. Furthermore, contributing to the existing body of knowledge by providing guiding principles about the application of IoT in livestock farming.

As part of this project, I would like to invite you to participate in a telephonic/virtual interview. This activity will involve semi-structured questions regarding your in-depth knowledge and experiences in IoT application, and it will take approximately 30 - 45 minutes. With your permission, I would also like to record the interview using a digital device.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation, but there are no disadvantages or penalties if you do not choose to participate or withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely **confidential,** and **anonymity** can be assured depending on your preference. The final report will or will not make use of your name or any identifying information. I will be using a pseudonym (false name) to represent your participation in my final research report if you prefer anonymity. The information you give to me will be held securely and not disclosed to anyone else. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.
If you have any questions during or afterwards about this research, please contact me on the details listed below. This study will be written up as a research report available online through the university library website. The data collected from this research project will be stored in secure cloud-based storage and kept for six months. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical),
telephone +27(0) 11 717 1408, email hrec-medical.researchoffice@wits.ac.za

Yours sincerely,
Thuthuka Mhlongo

Researcher:
Thuthuka Mhlongo, 2295069@students.wits.ac.za, 073 396 7818
Supervisor: Leona Craffert, leoan.craffert@wits.ac.za

APPENDIX D: Interview Guide



A. Opening

- **Establish Rapport**: a complete introduction of who I am and the institution under which I am conducting the research study.
- **Clearly state the purpose:** Indicate the objective of the interview and the topic context. State that the interview aims to gather perspectives from IoT practitioners and service providers based on their knowledge and experiences in the application of IoT platforms. Indicate that the information will add to the existing body of knowledge and guiding principles in applying IoT platform models within a real-world context and livestock being the focal area of interest.
- **Time**: State upfront the duration of the interview. The interview should take us about 30 - 45 minutes. Clarify issues of ethics and confirm whether the participant is still available to answer the questions.
- Demographics: the study focuses on the three (3) primary demographics extrapolated from the literature review. The first target group is the IoT practitioners responsible for developing, deploying, and supporting IoT solutions. The other group comprises IoT service providers, representative of organisations that offer IoT services and solutions. Lastly, the focus will be that of farming enterprises who will be used for triangulation purposes.

B. Body

I. **IoT Practitioners: (related to IoT functional blocks & skills)**

A. What are the kinds of IoT challenges that you have mostly been confronted with?

B. If you were to list in order of priority the main IoT challenges, which ones would you identify as crucial and non-crucial?

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C. What are IoT technical and non-technical elements that are crucial to the application of IoT? And Why?

D. How can the lack of or the availability of essential IoT skills impact the application of IoT projects?

E. What technical and non-technical challenges would you identify as potential project stoppers?

F. What are the types of challenges that can be identified when applying an IoT solution for livestock farming?

G. What are other notable items that you would consider necessary when implementing an IoT solution?

II. IoT Service Providers (Applicable IoT business models & the ecosystem)

A. What are the kinds (sorts) of challenges that customers would like to be addressed? brought by customers/clients?

B. How receptive (or not receptive) are your potential clients to the application of IoT? Please elaborate And Why?

C. Which Industries are more likely to realise the benefits of IoT, and Why?

D. What are the important considerations in providing IoT solutions?

E. How important are the industry and the customer context (environment) in which the IoT solution is applied?

F. How feasible is the application of IoT platforms within the livestock farming sector?

G. Can you provide some learnings of applications by your company (failed attempts or successful applications by your company?

H. How important are strategic partnerships in providing IoT solutions? May you list the type of partners and their role in the application of IoT?

I. What are other notable items that your company considers necessary when implementing an IoT solution within the livestock farming sector?

III. IoT Customers (Livestock farmers)

A. Are you aware of the (Do you know about the) Internet of Things? If yes, what of it in relation to your business domain?

B. What is the current state of IoT business within the livestock farming sector?

C. What is the list of items that keep you (Farmers) awake at night regarding your business?

D. What is your view on the application of IoT (technology) within livestock farming? Furthermore, which technology would you deem as promising to support your business objectives?

E. Have you or would you consider implementing IoT in your business? And Why?

F. If IoT can provide you with real-time herd monitoring and management from your mobile device, would you consider employing IoT in your business?

G. Which business challenges would make you consider IoT if it claimed to have the ability to resolve them?

APPENDIX E1: Interview Transcripts of participant DB



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Faculty of Commerce, Law and Management,

University of the Witwatersrand,

telephone +27(0) 11 717 1408,

email: hrec-medical.researchoffice@wits.ac.za

The Interview Transcript - Participant DB_1 (DB1)

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted

Participant's Rights

Discuss the contents of the Research Informed Consent Form as part of the ethical procedure

- Provide assurance that the data will remain private and confidential
- Discuss the questioning approach
- Inform the participant of their rights to reframe from answering questions that they may not be comfortable to discuss.

- Inform the participant that the report will be made available to them on request
- Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Q1: What are the kinds of IoT challenges that you have mostly been confronted with?

DB1 : So I think primarily the first major challenge that I come across with customers is that everybody wants to do IoT, But nobody knows what they want to do, how they want to do it, and what the budget is they need to do it. So, you know, lots of customers, lots of companies. Understand that IoT is out there and it can drive efficiencies, improve operations, you know, all these kind of things that we talk about empowering employees, so it's a trend that you know over the last few years has grown more and more in the market and customers want to for want of a better phrase do IoT. But they often don't know what they want to do. So quite often, the biggest challenge when working with customers is really trying to nail down what exactly is the business challenge that you're trying to solve. Right, and if we can, if we can write that business challenge down in simple terms, you know I want to increase the efficiency of my production operations by 20%. Or I want to reduce. I want to reduce the scrappage on the wastage of my production line. You know, if you can define that business challenge and then quantified in terms of what driving the deficiency will make, then those other things start to fall into place. We can start to build the budgets; we can start to understand the timeline that it's going to take. We can understand what technical skilling we need in order to solve that problem, so I think that's generally the major issue I come across with customers. Other things that are barriers to, I guess, to starting IoT projects is the perception of complexity in IoT, which is sometimes true. What I mean by that is. IT is perceived as complex because not only do you have devices, but you have devices connectivity, you need multiple partners potentially to help solve a problem, so there's a real perceived element that doing an IoT project is going to be hugely complex. I'm going to take a very long time and quite often. Changing that perception in a customer's mind can be quite challenging, so we must demonstrate how we can do things quickly and easily. So, there's a couple of things off the top of my head. I think then. The final thing I would say. Is around skilling. I don't think. A lot of I don't think there's a lot of technical skill available in the market. It seems to be quite niche, especially in our region in the Middle East and Africa. I think in. In Europe, the technical skill that's available in terms of engineers and people who are knowledgeable about IoT and how to implement IoT. But the talent pool is much bigger. Certainly, within

Middle East and Africa region, it's challenging to find people who have the right technical skills to help deliver these projects.

Researcher: No thanks, DB1. I think you also then subsequently answered my second question. I think let me maybe latch on onto the complexity. I mean under complexity you List 3 crucial things. Devices which are a component of IoT right on their own. I believe they require their own technical expertise, which you touched on by indicating that within our region, which includes Africa, we are lacking in skills right in that regard, compared to continents such as Europe, which has taken on IoT much more earlier on. In this context,

Q2: How does then the lack of skills impact the success of IoT within the context of the Middle East and Africa?

DB1: So, I certainly think that the lack of skill is slowing the adoption of IoT. You know, in Middle East and Africa region, we have small pockets of expertise in a small number of say partners or customers who have got the expertise to be able to deliver these solutions. If we look at the partner ecosystem, for example, who are helping customers to deploy IoT solutions? Those partners are often stretched. You know the constraint because they can't upskill their own workforce or onboard additional skilled workers fast enough to be able to deliver the level of projects that the wider market wants to deploy. So certainly, it's driving the deployment timescales to be much longer. And I think what's happening as well is with those partners becoming the go-to or the known IoT organisations. It means a lot of the smaller partners, service providers that, you know, might not be technically capable, quite often get overlooked because they're not seen as having had the expertise or delivered the number of projects as large as the more successful partners. So, I think that lack of skilling is really kind of slowing down the adoption within the region.

Researcher: There's a technical aspect which you covered which you indicated the impact that it has on the overall on the application of IoT, and I think you briefly also touched on non-technical, which is the business aspect of why most organisation would embark on IoT. Beyond the hype, you then briefly touched on the business need.

Q3: What is the business need that is driving or propelling the organisation to take on an IoT application? You want to maybe delve a whole lot more onto that in terms of what?

DB1: So yeah, I think the first thing is customers and businesses are quite good at defining the use case. They want to do so. You know, they come to me and say I want a connected factory or fleet management, you know they have a use case in mind, but the bit that they don't often define is what's the business case for doing this project, right? Because they. They haven't taken the time to quantify the effect of the project on either, you know if it's driving

efficiencies, but what kind of efficiency is it going to drive? How do we quantify that? So just to use the manufacturing example again, you know, if we reduce our wastage by 20%, what does that equate to in terms of money? And you know, so that that's really where they are challenged, and I think when we do a lot of work with customers is when they come to us with these use cases, we help them quantify those challenges. First of all, in terms of understanding what effect driving those efficiencies will have, or whether it's fleet management, improved maintenance, reduced insurance claims for car crashes, and all these kinds of things. So, we start to put numbers around everything that then helps in the process of defining the scale of the budget that's available to be able to drive the project forward. So that's the first stage, and usually, from there, we then have to look at moving into a pilot. Now that the pilot tends to be used to validate both the use case in the business case at the small scale to ensure that we're getting the level of effect that we would expect, right? And then the next stage that becomes challenging is how do we scale out, right? This small-scale pilot can often show benefit and is effective, but if the scaling from connecting 10 devices to 10,000 devices, we then have to understand how that scales up both on the device side, the connectivity, and if we're using cloud the cloud side as well. So really, the next stage then is around building out scaling growth plans, understanding the effect on cost, understanding the effect on complexity. The additional resource is we need to manage the solution. Additional people that we might need to onboard it up so all those kinds of things. So that's the processes that we normally tend to go through from the business side and. Customers don't often see that piece. You know, they see that I want to do fleet management because it's going to save me at the moment. Without having a proper plan and a proper business case built around it.

Q4 What are the key challenges because devices, as you indicated on their own needs to be fitting to the problem that's being solved, right?

Q5And #2 What are the challenges if we were to break down IoT in its components and focus on devices, have you experienced challenges when it comes to IoT devices?

DB1: So, I see a couple of routes that people take around devices so. First of all, there's the route where devices are being bought off the shelf, right? So quite often, customers will try and buy the cheapest device that they can to solve the problem without understanding the for the right word, what effect that will have on the solution. So, for example, they buy a cheap device, you know it comes from somewhere in China, but what they haven't looked into is what's the security posture of that device? How do they update it? How do they manage it? What's the lifecycle you know after two years if it needs to be replaced, or that company still be able to sell the same device to you. So, from that side, I think the devices are probably one of the most important parts of the IoT solution because if you start with the poor device and poor data and

poor management of those devices. Then that cost of that fleet of assets out in the field can be hugely expensive and end up being more expensive than whatever you implement in the cloud. So, I think there's that first route to off buying off the shelf devices. There needs to be. The complexities of security and management and firmware updating and having all that in place with whoever you prefer the devices from needs to be there. Then the alternative route is where I see customers using custom built devices. You know where they are using off the shelf MCUs or CPU based devices, and then our custom developing their own code to go onto those and their own enclosures for whatever particular purpose the device is being used for. So, in that kind of instance, then yeah you can build in the level of security required by your solution, but it comes back to that question about technical skilling. You need to have engineers who can do hardware development, development firmware for devices, understand security posture and MCUs and embedded hardware development. So, these are all kind of added complexities that need to be taken into account.

Researcher: Definitely, and my subsequent question to that is that these devices obviously need to be then connected, and you have already touched on the list of items that you deemed as important. Connectivity was one of them. So, you said device connectivity is crucial when scaling.

Q6: Why and how important is connectivity in the application of IoT while taking into consideration the different customer context in which an IoT solution can be applied?

DB1: Yeah, I mean connectivity is crucial, and it's often very much tied to the use case that's being solved. So you know, for example, connected consumer devices quite often if you've got a connected coffee machine or you know connected fridge, then it's going to be sat in a home that has either no standard wired Internet connectivity or it's going to have Wi-Fi. So, in that case, you know you you've effectively got within bounds, unlimited connectivity, your device can send and receive whatever it needs within the bounds of. Whatever network connection that particular consumer is has got at home, but outside of that, you know if we start to look at connectivity in remote rural areas. Most customers tend to jump onto the cellular bandwagon as the first step. It's generally readily available. It's the downside, so it is. It tends to be very expensive. Especially if you've got a use case that is transporting a lot of data over the cellular network but with the advance of newer technologies like you know Cat 4 and LTE, NB-IoT these kind of long-range cellular low lower bandwidth but lower-cost technologies are starting to become more prevalent, But then you become tide to essentially the network providers in the location of the cellular masts (towers). So, if we think of very remote parts of Africa, for example, it's going to be pretty tough to get decent network connectivity, and we start to drop down to some of the legacy technologies like 2G, but again. So yeah, so start dropping down some of the legacy technologies like 2Gin

order to get the range on the cellular network, then it becomes hugely expensive as well. So, more and more we're starting to see the rise of some of the LP Wan technologies like LoraWan, Sigfox. I wouldn't say they've been deployed at huge scale yet, but in some areas with the use of those technologies LoRa, when I sent to see it used more around the kind of private long-range networking just because of the way Sigfox tends to charge the charging model but Sigfox I know it's got a little bit of coverage in Africa and some of the parts of the world. So yeah, it's back to what I said earlier. You know connectivity is crucial, but it is very much tide to the use case that's being solved in terms of how it's chosen as a technology.

Researcher: So DB1, you listed various types of connectivity technologies that's well available depending on the context as you are indicating the use case. So, if one were to take a livestock use case scenario as a solution knowing it would most likely be in a remote countryside.

Q7: What would be the ideal connectivity technology that you would foresee being applicable in solving such a use case?

DB1: Yeah, in that kind of scenario, I would. I would primarily see either one of the LP One technologies, the low power wide area network technologies, or cellular. That's pretty much what I would see for that kind of scenario. I think. As I said, the challenge is going to be around coverage for cellular, certainly in remote areas. LP again, you're going to have challenges with courage with LP one cause if we look at like Sigfox, for example, it tends to only cover densely populated areas. LoRa, while again it's private networking. So, you'd have to build your own private network environment to be able to track livestock over a wide environment. Now that's not to say it can't be done, it just has to be part of that business case that's built in, you know, put up a tower for LoraWan network or a couple of towers for one network.

Q8: In this case, how would an IoT practitioner or service provider like yourself engage such an enterprise in terms of making them realise that IoT can be applied in their context and that it can extract large amount of business value that can assist them?

Q9: And how do IoT service providers like yourself, show the value to enterprises such as those of livestock farming?

DB1: So, I think generally it's done through the small-scale pilot approach I don't like to use the phrase proof of concept because. In this situation, pilot means that the technology is already proven. We know it works. We should have been able to demonstrate that it works and brings value at a larger scale. So, when we move down to bring this technology to a smaller enterprise, then we really move forward with the small-scale pilot first to demonstrate the value and that's usually a funded pilot. You know we provide essentially a free

service to begin with, show the customer how it works. What it does, it demonstrates the true value that you can get from the demonstrate. For livestock farming, demonstrate that you can see the health of the livestock where they are wondering when they are eating and drinking all these kinds of things? And really, it's through that real-world demonstration of the value that then the customer understands the value of what they can get from it themselves. I think you know you can show somebody slides or talk to them and demonstrate things until you blue in the face, but I think it's giving that real-world demonstration that really gets people over the line.

Researcher: OK. Thanks, DB1. We almost towards the end of our interview.

Q10: What are the showstoppers? that would stop the likes of yourself in successfully implementing an IoT solution in a Livestock customer context?

DB1: The biggest showstopper for me is having feet on the ground, in the country or location where you want to deploy the solution. So, this is in my terminologies, the systems integrators. So yeah, it's easy to deploy and IT solution into the cloud as software. You know it can be, it's there, it could be accessed from anywhere, but at the end of the day there still has to be someone who has to go and physically put these devices into the environment in which they meant to operate. So, it's a little bit easier in the Consumer devices space, because the consumers are buying them and putting them out there themselves. But in the enterprise environment where we're doing connected fleet connected factory transport and logistics, you know even livestock as you mentioned, there has to be someone that is installing these devices, configuring them and making sure they connect to the cloud and are sending data. And that's where I see the biggest challenges it's really identifying capable systems integrators with the expertise to do that. At scale.

Researcher: So DB1, a leading question to that, is that if you have the field forces or an expert that would be on the field where the solution needs to be implemented.

Q11: So, in this case, its someone who will then go in to identify the livestock, identify the devices, have those devices plugged or installed in those livestock situations, and then making sure that technically everything is working. Is that what you're referring to when you say? Field force, system integrators, are you referring to those type of experts?

DB1: Yes, exactly. I mean, it also depends on the complexity, again of the device and the use case. I mean, in certain instances, it's relatively easy to write a document that explains to you know how you install it, set it up, switch it on, and make sure it connects. But then you know in other use cases, it's going to be far more complex. You know, in a manufacturing use case, you might have to connect these things into production systems where they read

data, and that's going to require specialist skill. In the livestock scenario, the devices might have to be fitted to the livestock in a certain way so that it doesn't harm them or hurt them, and the sensors are collecting the right data, so I think. You know, depending again depends on the use case, it needs to be carefully researched and as into what do we need to do to get these devices to be installed, connected and working successfully? Do we need trained integrators who go on-site and pass that knowledge on to an installer who will then do the installs that in this case, it could be the farmer? Or do we create a device that is simple enough to be able to be installed with a basic manual, and the device connects itself but? Once it's switched on, so I mean, that's it's a bit of an open-ended answer, to be honest with you, but it depends on the complexity of the situation.

Researcher: You know it's insightful, and the last one. Then once you have your field force workers having done their research, having established what ideal devices are and how to install these devices

Q12: How do IoT experts like yourself manage the transition from a successful pilot and then hand over the solution to the livestock enterprise to ensure that the project does not fail because of lack of transition from successful implementation?

DB1: Yeah, we usually do that as part of the pilot. We do skills transfer, so the way in which we work as we work directly alongside the operators or whoever will operate the solution once it's been handed over into the enterprise. So, you know there are multiple parts of delivering successful projects. So, we as I said, we have the device side where we have the SI (system integrators) and we will probably work alongside them and making sure they're skilled up in terms of what they need to do to get the devices installed. But then there's also the cloud side where we have to deploy the software, configure it, check that it's running, look at all the metrics, make sure that there's no errors. Those kinds of things. Look at the device fleet that's out in the field, whether it's connected, the status, all these kinds of things. So throughout the lifecycle of the project, we work alongside those operators and upskill them and help them document the processes and practices that are required at the time of the pilot, now once that's, part of that pilot program, and that should mean then that when we do decide we want to scale out into production, those operators are armed with the knowledge, or at least a level of knowledge of what they need to do in order to operate the system successfully. Now, of course, as this system starts to scale up, we do still sit alongside those operators because there will be issues, errors, bugs. You know you name it. You always come across challenges as you scale-out. we handhold essentially the operators through that first stage of scaling out into production so that we can help resolve the issues at that stage.

Researcher: DB1, thanks. Have a good one. I appreciate it. I'll keep you informed once everything is done by myself.

DB1: Great stuff, alright. Have a good day.

Researcher: Bye-bye.

APPENDIX E2: Interview Transcripts of participant ME



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The Interview Transcript - Participant ME_2 Service Provider Q

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted
- Greetings and casual chat

Participant's Rights

2. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Assure the participant that the data will remain private and confidential
    - Discuss the questioning approach

- Inform the participant of their rights to reframe from answering questions that they may not be comfortable discussing.
- Inform the participant that the report will be made available to them on request
- Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

1. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
2. Geographical regions in which their expertise have been applied
3. Expertise applicable exposure is on which types of industries
4. Profession background and years of experience

The participant is based out of Germany and was identified as a customer-oriented service provider with over 25 years of product development experience in ICT across multiple geographies, including emerging markets such as South Africa. In their current position, the participant works closely with customers, assisting them in developing new solutions to transform their businesses digitally. The products are predominantly around IoT, Big Data and Machine learning solutions that deliver tangible business value

> **Q1:** As part of the introduction, what is your area of expertise? Are you more on the business side of IoT, or you more on the technical side of IoT?
>
> **ME:** Yeah, I am in between Thuthuka. It is really something like that. I, of course, need to have a proper understanding of the technology and architecture and maybe suggest a better way of having it done. But technology is not something that I really have a deep understanding of. However, I am more focused on the business interest of IoT. I attend to get questions like why should I do IoT, and sometimes, to be honest, I need to say it does not make sense because it is not that they do not have the business model or they do not have the revenue streams coming out of this. And then it is really something where you know maybe it is a great product or great architecture and what would be great in doing IoT, but it should all come back to the return on

investment. If the business model is not sustainable, this is where my expertise is normally applicable mostly between the technical side and the business side.,

Researcher: It makes sense that you pivot between technical, but more on the business and the customer engagement side of things.

Q2: What are the kinds of challenges that customers would like to be addressed within the context of IoT?

ME: Yeah, there are different ones. So, if I can split it up into two big patterns, the one side is towards production and the customer environment, it is to support production. On the other side, it is really about. Connected products and how they make more money with these kinds of products if they are connected, and these would be the two big patterns. If we go down on the production side, you know it is really about getting better insight. Looking within the supply chain information, the customers want to know how they can increase efficiency in their production factory and gain more knowledge of measurements, in the quality, and get to know how they could save money if they get all that data as part of the service contract. They want to see less production failures, and if there any, they want to know the cause for product failure and reduce the high rate of failures can avoid (undesired) production outcomes and save on cost. A sustainable business is required to deliver on such requirements. They want to know if they can make money out of it or is it some kind of a fancy buzzword like predictive maintenance., First, there needs to be a sustainable business case to position IoT to customers. Explain what kind of added value and if it is something that they can make money from, and it can benefit their customers. Customers in manufacturing have machines that are over 80 years old which are still running fine. They always want to know why they should buy new equipment or install new sensors and at what cost is connected machine comes down to? What are the benefits of getting them connected? The discussion is not about technology but more about providing the customer with a positive business case that can demonstrate business value through cost savings or generate more revenue? One needs to understand their customer's business and the business relationship between the customers and their customers; you really need to have an expert that understands that type of business in which the IoT solution will be delivered.

Researcher: Thank you for that one. My subsequent question

Q3: How receptive are your potential clients when it comes to the application of IoT? I think you touched on it briefly in terms of they do not see the value. Sometimes adding, plugging in or connecting their existing 80-year-old machines when they will not see the value or return on investment. So, when you see potential value that can be extracted, how receptive are your potential customers to IoT?

ME: It really depends on the competition and on the maturity level of the customer. So it is really something that even if you pitch it five times with all the numbers associated with it, it is really difficult if the customer has a low maturity level towards the need to change their business model, not totally moving away from their core services but more towards providing additional services. IoT requires a transformation approach at the customer side. While matured customers are looking to partner with service providers to build their own connected products to sell them to their customers and transform their product offering. Therefore, if the customer is not in a mature state of mind, it becomes difficult to achieve success. Unless they are under pressure from outside or from the competition bypassing them. If I use the context of the livestock, you know. The customer or farmer wants to touch something they can see; for example, if I sell a cow for 10,000, how would connecting my cows help me sell more cows? You need to know how to position IoT for livestock, and this is where business knowledge is crucial. One needs to understand herd management, challenges experienced by farmers and provider a positive business case that will quantify the return on investment. How IoT can help the farmer, for example, with security, eating patterns, and location within geofencing stuff like this, OK? But the big question is, what is in it for the customer or your farmer? If the farmer has more data, then you start moving really fast out of the technical discussion towards the business discussion. For example, because you can connect every cow, can monitor the locations of each cow through GPS, can see vital signs and act proactively and save the cow if it is getting ill, and can allow you to sell more cows. But if the farmer is investing in this kind of technology, he needs to understand the data and how this data will help his farming business sell more cows or sell them at a better price. In my experience, you will always have this kind of challenges, and it is less about technology.

Researcher: Thank you, and my subsequent question

Q4: What are the important considerations when providing IoT solutions? So, when you are going out to engage potential customers. What are the key important things? I think you have addressed most of those being a positive business case and knowing exactly what business value IoT brings to that customer.

ME: Yep, so depending on the size of the customer so I am normally in the enterprise space. It is cloud governance, so that they want to know is who has access to their data? Who is responsible for the cost of the data, and who is responsible for operating the whole solution? Because this is sometimes a little bit of a shortcoming from a customer side as they go to the cloud as they believe that everything, everything will be managed. However, it is not always the case in IoT. Therefore, I normally ask these three main questions, are they cloud-ready? So, do they have cloud governance? Are they willing to invest in cloud governance? Secondly, do they have the know-how if they want to

operate the solution on their own, to maintain it because it needs the manpower, you know? They are come back to me and ask how much a solution like this cost? We already have the architecture; what is the cost? But more clarity is needed behind the architecture; what is the data frequency? How often do you want to upload the data to the cloud? Once you have all the numbers, you can assist the customer with the cost or business case. They at times respond and say it is too expensive, and I say OK, but what do you want to achieve with the solution and what is the money you want to earn with the solution? Customers struggle a lot to define the benefits in money terms and the business. The problem is that business sometimes ask IT to develop the solution for them, and IT does not have the operational knowledge and cannot justify the investment to business and cannot define the business value from an operations point of view. It only focuses on the technology side of the solution and not the end to end benefits.

Researcher: All right, thank you. That was very, very insightful

Q5: Tell me about strategic partnerships in providing IoT solutions? and may you list the type of partnerships that are within the IoT value chain? So, for you to put an end to end solution?

ME: So, for me, partnerships are essential. So, if you do not have a partnership, normally, it does not work out. So, for me, it is really something where I see we you only win if you have strategic partners, and strategic partners could be different variations. So, like if we are staying with the livestock use case, you need the hardware, you need a kind of sensor for the cows, so this is not something a service provider may provide. Then you need a Telco, who are providing the connectivity. This is also not something that a service provider may have as core to their business, and then you need cloud software, and a service provider like ours comes into play. Where we can collect and the data and store it in a data Lake., and then we also need a business partner because we are no livestock experts. We do not know what the farmer knows, and, I need a strategic partner to make out the data that is coming from the herd adjust it for the customer, the farmer, so that it makes sense. Because if I only throw him some data over the fence, he will not understand it because it is not where he is coming from. So strategic partnerships in the IoT space are, for me, totally essential, and this spans from the hardware over the connectivity towards UI design. So sometimes a partner can do everything, which is great because it makes it easier for them. Sometimes you need to rely on specialised partners because they specialise in cow sensor hardware which may not be mainstream.

Researcher: Thank you, I have got a last one. I think we have covered more on the non-technical side of IoT. We spoke about cloud governance, making sure that the environment in which the solution is going to be applied is well understood and that the customer needs to be cloud-ready and prepared. We

spoke about ROI understanding the overall benefit, business benefits and value and how can the customer extract this value and pass it on to their customers.

Q6: Tell me more about the technical aspect of the IoT solution? So, if you have a business case, you know exactly what you want to achieve, you know where the value is going to be gained. If you implement your IoT solution, how do the technical aspect of IoT fit into the puzzle?

ME: It is important, it is really important because. It is really valuable. If you take a look at herd management service, you have a business case, connected cows, and I see that one of my cows is moving at 80 mph towards another location, and you know something is wrong. So, if there is an outage for four or eight hours, and you cannot get any data from a cow, you know there must be a problem. So, it is very important to have somebody that has a clear understanding of where the problem might be. Why do I have this data outage? Is it connectivity? is it the device battery on the sensor? The farmer may not know how to troubleshoot the problem as they are no subject matter expert in this regard. In IoT, you need somebody who has an overall view and understands the whole architecture and identifies where is the problem; you really need subject matter experts for such deep technology problem. This is where strategic partnership becomes important to give support to troubleshoot, looking at an end to end solution, start from the sensor up to the application used by the farmer. So, someone that has technical expertise along the whole end to end solution, somebody who has a proper understanding of all the pieces which are glued together to have this end to end solution. It is the core responsibility of the service provider to order a strategic partner to have this running and to provide the technical expertise so that the customer, the farmer in your use case, has this type of support to ensure better customer experience because at the end the farmer is not an IT expert, he just wants to see information on his mobile or application, where are my cows and if there is a cow showing 80 mph moving out of my land, I know that she is not running it may be in a truck. So, if this customer experience is not there, the farmer will not be happy with the solution. To maintain the solution from end to end, it is important to have a generalist that has an understanding of the architecture and the solution. But then you really need somebody who has deep technical expertise on all the different building blocks. The implementation can be great, but I have seen things fall apart when there is no technical support to maintain the solution.

Researcher: Thank you, Sir. Thank you very much. I want to throw in it the last question,

Q7: What are the **business models** that customer seems to opt for when I mean business model? What buying plan does the customer go for when acquiring an IoT solution

ME: What I see in this area is that the customer buys the hardware and then go for a pay per use model for the service part of the solution. I connect 5000 cows on my herd, and then I will pay a monthly subscription fee for the data and for alarming whatever there is something wrong with the cows. In a B2B environment, so enterprise to enterprise it is more towards not buying they will take a higher subscription fee, but therefore, there are also strict SLAs, strict uptime rates etc. So, these are the two big patterns I see with my customers, so if you are really doing a B2C. The customer really wants to own the device and pay then. By design, they say I want this data point, or I want this extra point or feature as additional so they can end up paying a premium fee. Enterprise customers use this kind of approach, they will not own the solution but will enforce SLAs, and the solution is one that is outcome-based revenue. Others go for a subsidised model similar to a mobile plan, you get subsidised on the hardware and pay for predefined data volumes, and this can be a two or three-year contract. Yes, you can add more data set and pay for those data points.

Researcher: I would like to really pass my gratitude and appreciation for your expertise, your insights, your knowledge. I really appreciate this. It will go a long way within the South African context in terms of other practitioners who want to implement such solutions.

ME: Thank you.

Researcher: Thank you, Sir, I really appreciate it. Have a good one, enjoy and stay safe. **ME:** Thank you. You as well stay healthy

Researcher: thank you. Bye-bye, thank you.

ME: Thank you bye-bye.

APPENDIX E3: Interview Transcripts of participant WS



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The Interview Transcript - Participant WS_3 (WS)

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted

Participant's Rights

3. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable discussing.
    - Inform the participant that the report will be made available to them on request

- Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

5. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
6. Geographical regions in which their expertise have been applied
7. Expertise applicable exposure is on which types of industries
8. Profession background and years of experience

Section B:

The participant was identified as an IoT solution provider with over ten years of experience across various IT roles. The participant deals with customers located across multiple geographies, including South Africa. In their current position, the participant works for one of the leading multi-national IoT service providers.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The participants' expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

> **Researcher**: Part of an excellent Rd for the digital business and which looks in terms of the new technologies and how do we then bring that apart within the respective organisation and what? How can we, as the students and the researchers can ready the organisation to make sure that they adopt and receive it or see the value in digital technologies and services right? However, my focus is more on the IoT and its applicability when it comes to its applicability within a South African livestock farming context. Although most of my research is more on IoT and why IoT in the recent research has shown that several IoT projects do not see it past the PoC phase. It seems that there are challenges that prevent most organisations or entities or service providers from taking IoT projects from a conceptual stage into production and then realise the value or the purported value. So, my research focuses on what are the key determinants or considerations in the application of IoT within South African livestock farming.

Researcher: So, I just want to understand. Maybe your background in terms of where you fall in. So, let me just give you an idea of broken up my interview into three categories, right? One is focusing on IoT practitioners. The guys that will be heavily involved in the lifting and shifting at the technical level and then the other aspect would be more on IT service providers focusing on the business or the commercial side of IoT.

WS: so, if I could put it in different words. So yeah, so the first one is very clear that that is kind of the hands-on people doing all the actual words, But the second one we are talking more like a system integrator?

Researcher: Yes, it could be a system integrator, or it could be a company that offers packaged IoT solution.

WS; OK, I got it. I cut across the two worlds, but I do not have in-depth knowledge of the area, I will tell you.

Researcher: So, I will start then with the IoT service provider side and then just mix the questions up with the IoT practitioner questions.

Q2: What is the kind of challenges that customers would like to be addressed when it comes to IoT?

WS: Yeah, I think that we get approached with so many kinds of different challenges from customers. We are seeing a lot of different customer needs if I am to group customer patterns. We see a lot in kind of smart buildings management, Smart city solutions and definitely a move into agriculture. For sure, there is a fair bit of kind of investments, I think the interest in agriculture is one of the big ones. and connected factories, I would say those are the big ones.

Researcher: Thank you, and you have also answered the following question in terms of what industry or sectors are seeing potential business value from IoT.

Q3: How feasible is the application of IoT platforms within those specific sectors? Based on your expertise or experience? Yeah, so is this the kind of how feasible is IO T in those spaces?

WS: There is significant interest across those sectors. In smart buildings, you will see a lot of organisations—kind of investing in their organisations that used to maybe be in a particular technology area. So, let us say, for instance, they were maybe they were doing alarms for buildings. Now they are kind of pivoting that towards IoT solutions doing your kind of building management and in

smart cities. There is a heap of work in that space, so many different applications, such as the smart dustbins, waste management, air quality management, traffic management, there is a heap of applications in the smart city space in the factories. There is a lot of work going on. Organisations with more legacy type equipment in those factories and how they are kind of connecting up some of that legacy equipment with modern-day sensors, even on pretty industrial legacy equipment and being able to start sensing stuff and being able to therefore manage production lines kind of better. So, the answer is there is a heap of interest across all those industries. Then there is a separate thing on that, how well have they scaled? Maybe that is a separate question. So, in terms of demand and interest, insignificant across all of those sectors.

Researcher: So, let me piggyback on that question in terms of scaling.

Q4: So, with regards to scale, please share where maybe the challenges?

WS: OK, I mean they are some pretty big hurdles starting from like we want an IoT solution, and we can see IoT bringing value in our business to actually implementing it. There is definitely some kind of big hurdles there; I think the primary complexity around what I would call a fragmented technology landscape, and so it realizes that once you have got an IoT solution that you can buy, for an example, what I would call a vertical IoT from one company and you buy the entire vertical solution from that company. The challenge is that it handles just one area of an enterprise-wide organisation. That vertical solution can provide you with the sensors and provide you with that connectivity and provide you with a dashboard and show you the results based on sensor data. However, the challenge is that the production line may consist of many different areas that make up the entire production area. Installing a vertical solution in one part of the business fails to show an overall end to end encompassing solution. This may mean the organisation needs several vertical solutions across the production line or factory floor. Having one vertical solution with several sensors is one thing but implementing these vertical solutions across the factory starts to introduce complexity.

So, an organisation may need 40 vertical solutions in my factory to really have proper insights. But then we need different sensors for our 40 vertical solutions etc. So suddenly, you are getting many different vertical solutions, and it basically impossible to do to have 40 vertical solutions across your factory. So, then customers stop this approach and start looking at having one overarching IoT platform that all of these solutions feed into and feed data into. OK, so that is better. because then we have got one platform but. The reality is that all 40 of these different platforms. The different vertical solutions are not going to have the same communication protocols are not going to use the same API's. Each supplier of the vertical solution is going to have their own business model, so maybe some of them are software as a service, some of them are just a

license fee model, some of them will maybe just sell you the solution and leave you to it. So it is all of these different fragmented suppliers with different fragmented business models, different fragmented communication protocols and connectivity protocols, and it makes it incredibly complex to be able to weave all of these different things together in order to get this kind of single view of your factory or a single view of your customer.

Researcher: Thank you for that WS, I think you touched on some interesting points. Let us delve deeper into the complexity you have just touched on.

Q5: When does the customer realise the complexity of an IoT project? It is when the project is already underway or at the start of the project?

WS: So, I think it happens later. I think the initial interest, at the face of it, recognises that IoT could give them these insights they quickly get engaged in these PoC and the innovation teams get involved, so that happens quite quickly and early on using those proof of concepts trying to prove out how IoT can help business. And I think it then comes slightly further down the line in once they have started and had planned out the bigger projects and once they start procurement as soon as they start looking at procurement, then they start realising that we cannot actually buy most of our solutions from one supplier. We have to have 40 different suppliers supplying these 40 different solutions. Now think it is at that point that their realisation starts kind of creeping in some organisations or which are more mature. They have been through it once. So, they sort of understanding what they are going for, but I would say the majority of organisations, I think, hit that hurdle once they start going to procurement.

Researcher: I think then it starts to make sense. Then my next question links to the suppliers or partnerships.

Q6: How important are strategic partnerships? You have indicated the complexity linked to multiple suppliers.

WS: OK, so system integrators or solution providers are absolutely key for the future of IoT. I think that what we are seeing is definitely that you are going to need a system integrator involved in pulling all of these different bits together. Also, what we see in the industry is or in the supply side of these technologies more and more, off the shelf hardware and in the earlier days. We saw organisations producing these full vertical solutions so they would produce the hardware, connectivity and the platform and they wrap it all up into a vertical solution, but more recently, I started seeing a shift in 2019 in the way that the technology was working and I saw a move from 2018 to 2019. Quite a large shift, I cannot remember exactly about a 30% shift in organisations moving from selling vertical solutions to selling hardware, and So what that is showed me is that these organizations are struggling to sell their vertical solutions. And they are now open to selling just the technology and so that means that these

systems integrators can now start buying sensors and plug them into one platform. And also, we are starting to see standards evolve across these technologies, so whether it is MQTT or some of the industrial kind of protocols, mbus, etc. These are standards that these hardware players are starting to conform to, so I think we starting to see- the supply side and these systems integrators forming to be able to bring these kinds of technologies together into a meaningful kind of solution for customers. So, I think we are starting to see that integration happening in the last 18 months.

Researcher: Thank you. You have also touched on some other areas that would have been in my follow-up question. As you expanded, I got more insight. My follow-up question is around IoT skills

Q7: What is the impact of the skills on IoT projects?

WS: OK, so. You know, I think I would have initially said that a couple of years ago looking at IoT. I think, at the time, I would have said that a lack of knowledge or education in the space is impacting the sector. But actually, nowadays, I do not think I would say that anymore. I think that the technologies and people now get what is IoT and are recognizing that IoT is bringing together multiple different applications in that kind of a holistic view. And so, I think that the service providers, the system integrators they actually have those capabilities now. They have people who understand these different technologies, hardware etc. all they need to do is bring these skills altogether to deliver solutions, and they are skills that exist, but you do need to kind of bring them together under one housing and then you also need to make sure you have the platform piece skills, and you need to make sure you have the skills to handle the different and maybe the standards piece I think is still forming, so there might be a bit of a shortage skill in that space. The standards should you be aiming to get these different technologies to talk to each other. There might be a slight skills shortage there, but on the whole, I would say no, I do not think there is a skill shortage at the moment.

Researcher: Thank you, and then probably what will be my last question.

Q8: Do you have noticeable challenges within IoT that I may not have covered in my questions?

WS: So, there is one which I definitely see a lot of, and that is around IoT projects. When at a proof of concept stage, they can show a certain return on investment, and if you could look at them as a standalone thing, they show a certain return on investments, but the investment to implement that IoT solution across the business at scale requires quite a sizable investment and it is quite hard to prove that when you scale the IoT proof of concept across the business will return a certain X investment times X investment, and it becomes difficult to make that board-level decision, and by struggling to make decisions to go

ahead with scaled large IoT projects they tend to fail. Be because they struggle to be convinced that those projects will provide the return on investment they are looking for at that scale. It is a big investment, and then the problem is circular. So, because they do not make the big IoT investment, they do not get the returns and therefore, they can never prove that it would work. And so, I think that that the proof of IoT investment or return on investment, sorry. That the lack of proof that there is return in investments holds up large scale investment in IoT projects.

Researcher: Thank you. I guess. It also then answers the question around why we do not see most of these proofs of concept scaling to a point where their ROI is realised. Thank you very much. It was insightful greatly appreciated.

WS: This is the greatest pleasure. Good luck. I am thrilled you doing this research.

Researcher: Thank you very much.

WS: Cheers bye-bye.

APPENDIX E4: Interview Transcripts of participant JS



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The Interview Transcript - Participant JS_4 (JS)

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted

Participant's Rights

4. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable discussing.
    - Inform the participant that the report will be made available to them on request
    - Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

9. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
10. Geographical regions in which their expertise have been applied
11. Expertise applicable exposure is on which types of industries
12. Profession background and years of experience

Section B:

The participant was identified as an IoT solution provider and technical lead with over eighteen years of experience across various IT roles. The participant deals with customers located across multiple geographies covering the Sub-Saharan region, which includes South Africa. In their current position, the participant works for one of the leading multi-national IoT service providers.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The participants' expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

> **Researcher**: So, JS, as part of my master's in digital business, I am conducting a research study exploring the application of IoT platforms in the South African livestock farming. So, what I'm going to be asking you several question about the application of IoT. My questions aim to get insights from your experiences in IoT projects. Based on your background we will tough on both technical and the business side of IoT. The questions are separated into three categories. 1 under IoT practitioners looking at the technical aspect, and then IoT service providers focused on the business aspect of IoT.
>
> **JS S**: Yeah, I can do both.
>
> **Researcher**: So, let me start with the questions under the IoT practitioner section

Q1: What are kinds of IoT challenges that you have mostly been confronted with?

JS_S: Yeah, so I think context is important, so I'll just speak from the South African context. What I have observed a practitioner, so the challenges for me are mainly around connectivity having broadly available connectivity for IoT. So, we do have Sigfox as you are aware which is which is global. But you would find that they are infrastructure is still really concentrated on urban areas. So if I put it in the context of agriculture again, maybe there lies the challenges in terms of connectivity. When I say connectivity, I'm saying a choice, so, if you are going to depend on connectivity from a 3G mobile networks or if its 4G mobile networks in South Africa, we do have quite good coverage in the likes of Vodacom and MTN. But if you would look at people such as your Sigfox as people suggest your LoRa Wan when they're infrastructure, which is very specific to IoT, I don't think it's a broad enough yet to cover the whole range of customers. Those are the challenges that I would think of now.

Q2: Do you see connectivity as being a challenge in the in remote areas? Especially when we link it to livestock farming?

JS S: Yeah, I think it will be very important to really understand what the use cases will be, for farming. if you are going to be handling data at the edge, let's say you want to apply this from the security point of view. You want to track your life stocks and you want to react. Maybe there's a use case where you want to react if its security point of view and you need the real time type of reaction then this connectivity issues can be real. Depending on the use case, if you are going to be processing data mainly locally, connectivity might not be a big challenge because you might want to process that data and if you are going to link it to the cloud then you might be able to. Then once you get the connectivity back to the cloud, you are able to get that data so their connectivity challenges will really be unpacked when you have really unpacked what is the specific use case? But in general, the challenges that you will find is exactly like I've mentioned in my in my earlier response that their choice for customers, right? So, their connectivity choice will be limited, and so they might want to then be limited to GSM. So, depending on what type of a solutions you're going to put an, you might be challenged with connectivity, but I'm not saying it's impossible. I have seen. Organisations in South Africa leveraging even the USSD gateway connectivity for IoT as solutions if you think USSD bandwidth which requires is very low. It's already widely available from the GSM. I think it's 2G. You are able to access it, so it will depend on the use case. So, if you can live with it then you should be able to be.

Researcher: OK. Thanks, thanks, JS. So, my follow-up question says

Q3: What are IoT technical and non-technical elements there are crucial in the application of IoT? So, I think you've touched on one of them which, talks to connectivity right

JS S: Sorry I didn't get your first.

Researcher: Yeah, so I'm. IoT technical and non-technical elements that are crucial or that are crucial.

JS S: Well. Yeah, I think for me in the **devices** themselves, right that that is critical that you are able to have **organisations** that can able to **deliver** on the **device side**, that's one element. The **connectivity** as we mentioned that that is actually one critical element and the **cloud**, because if you, if you know that IoT at a value or the business outcome that you really get from IoT is to really be able to get a **data, so the volumes**, the **scale of data** and requires you to have an environment such as cloud that allows you to be able to handle that data at that scale. So, for me those are the three elements the device, the connectivity and the cloud. So, when I say cloud, I'm mentioning it loosely right? So, within the cloud they are quite key capabilities that you will require once you get into the account as well. So just to unpack those a little bit. What will be **critical is their platform** of choice for your IoT needs to be able to give you the benefits to be able to get a data analytics. In such a seamless way for you to really be able to **derive those business outcomes**. So, the data analytics components once it gets to the cloud, it will become quite critical.

Q4: Are IoT skills a factor?

JS S: It is actually as you were asking me. I was already thinking I missed something. on the functional side, and I think the **skills availability is actually quite a big factor** as well. So, if you look at **IoT it's quite a specialised field**. So, if one is a **software developer**, it doesn't necessarily mean that this person can build IoT solutions, right? So, it requires some sort of specialty, a merger in skills that comes with a combination of software, and of someone who appreciate electronics as well so that you can really deal with the **device**. How do you **program the device**? How do you **manage sensors** so all those requires quite as special a skill set?

Researcher: OK, the next question

Q5: Are those IoT skills available in the South African context?

JS S: I think it could impact them. So, if you look in the **South African** context, in my view I **haven't seen the wide use of IoT** at the moment, so we are still ready **in inception in terms of real practical business use case** application for IoT. So, I would say they are still quite **limited skills** in the market today,

however, there are companies in South Africa that are really trying to close this specific gap.

Researcher: So, while you are at that question. My follow-up question links to that, so it goes.

Q6 (SP question): How receptive are your potential clients to the application of IoT? So, you indicated IoT has not really have been deployed at scale. It has not really reached its maturity or its potential in the South African context. How receptive would a customer if I was targeting a livestock farming enterprise to IoT?

JS S: I think the very important thing when you think about IoT and you shouldn't be thinking about IoT from the technology **point of view,** from a shiny toy, you need to be thinking about it from the business outcomes. So, if you going to approach a farmer, you need to be able to speak in such a language that you going to help this farmer to achieve **business outcomes**. So, you will be **solving real challenges**, so you won't be approaching it in a manner which this is the market trend, and everyone is thinking IoT. It's a fourth industrial revolution. You're not going to win in terms of their reception, so **companies usually will be very receptive if you show the value on how you come to help them to achieve their own business outcomes** just like any other technologies that you're going to sell to end users.

Researcher: No, it makes sense. So, in terms of context, not only just livestock, meaning the customer environment, although in this case, I refer to livestock, it could be anything. How important So what I am gathering from you? Looking at this question, you are saying the use case is key. Say the customer, context and environment that which that solution is going to be applied is also important as it either reduces the of options for the application of the solution from the connectivity side.,

JS S: That's correct.

Q7: Then the issue of a business case. How important is that? Although you are presenting to the customer the value that it can show, how important is the business case in making sure that when you are presenting the solution, it makes sense?

JS S: Yeah, so it's. It's actually 100% important, right? That's all or nothing, so you are not selling technology. You are selling solution. So, you need to be able to show or sell the value based on business outcomes. So, you are not selling a technology to the end customer, but you are selling a solution. So, for you to be able to package a solution you need to be selling what is going to be the **business outcomes** that you going to derive from that solution. So, for me that is very critical. They all know nothings scenario.

Q8: How do you view the role of strategic partnership within the IoT space, knowing that it is in different areas of disciplines?

JS S: Yeah, so I would say the organisation or the entity. That is going to sell these solutions to their customers. They need to do the heavy lifting in terms of ensuring that they already have those **strategic partnerships** in place so that the end customer get a **package solution**. So, what I mean by that is if you are going to be selling this to an end customer, you need to already know how you going to be getting the devices as an example. **Some Services providers have actually ventured into creating their own devices right to close that gap. So, for example, in December they created. a device on where it is specific to the manufacturing industries that has use cases such as predictive maintenance. So, you get a to just plug and play the device? It gives **you a mobile application** that you can use **to monitor your devices**. It already gives you an **edge gateway** allowing you to connect seamlessly to the cloud. It requires a package solution where they don't have to go and procure those different critical components on their own but work with partners. So, you when you are selling to the end user you need to have made those partnership the **device manufacturers** the cloud an element and the connectivity element as well.

Researcher: So, you would have these as back to back. So, you come there already showing a single point of contact with the customer. If they don't have to deal with the fragmented aspect of IoT. So, you then indicating that when you offering a solution is already a fluid and engaged partnership between the different components and different service provider.

JS S: Yes, that's correct. Come with an already well packaged solution so that the customer just sees a solution and they don't have to worry about the heavy lifting of other things, right?

Researcher: No, it makes sense. My last question, which may be loaded right if one goes and dig deeper on IoT and its purported value across sectors of business IoT seems to promises a lot of benefits but the recent research reports are showing that most of IoT initiative or whether you call them project are not seeing it past the POC phase , more and more of those IoT projects never go pass the PoC and end up actually showing the business value. So, my question leading from that. Is

Q9: What is the challenge that's preventing IoT projects from going all the way from the proof of concept to pilot from pilot to scalable business solution so that It starts presenting that business value that it promises? Thanks.

JS S: Yeah, if so maybe if, I could answer it in two folds, right? I will try to link it to when we look at those an IoT projects because IoT is trendy. So, organisations usually are happy to jump into the, band wagon that we would

like to test, and we would like to pilot IoT. Without having really have done thorough thinking in terms of the **business outcomes that they would like to achieve**. So they need to be very selective in terms of the specific use case that they are addressing, whether it is really **addressing a real business challenge** and whether **it's really going to deliver a real business outcome,** so I wouldn't think that a pilot will fail if it meets all those criteria. if it really solves a specific a business need.

Researcher: Thanks

Q10: So, with that coming up, does it then plug into the business case? Do you think that the business case for these PoC are designed for small scale projects and maybe the reason why they never scale to realise the business value?

JS S: Yes, definitely. I think for me it's probably when they do those PoCs they really focus on the technology and they just do exactly, so they don't look beyond just the POC. They don't look beyond this POC that we are doing or they the choice of the use case that we are doing It's really going to be solving a specific business challenge and it has real business outcomes. I think that's where probably a they are missing it as they do those specific PoCs. So, they just want to test the technology. In that case If that is the outcome that is required, that is a success for that pilot, but I would rather do a pilot that says I'm going to show you the technology on how does it really solve your business challenges and I'm going to sell a business outcome. I'm going to plug into your goals and what is the business outcome do I get with this specific solution? If you tick all those boxes, I do see those pilots really going beyond just pilots.

Researcher: Thanks

Q10: Is there anything I have not considered in my questions that you can think of to bring the application of IoT within the South African context into a desirable maturity level?

JS S: I think for me you've touched on all the important elements for IoT. What is required and perhaps maybe one thing that South Africa can do as an organisation to really Fast track, the use of IoT in the South African context in general is to **ensure that skills element** is addressed. So, what I mean by that incentivise maybe universities to really start injecting IoT in their course work to ensure that when we build those engineers that they are ready for the market. Because those are the engineers that can really see this potential, and we potentially can really use IoT to compete globally. We can export, IoT solutions globally as well, which will be good for our employment crisis that we have. So, we really need to use technology or leverage technology to see how we can help with that as well.

Researcher: OK, I would like to thank you. Very much for your expert opinion. Really appreciated.

JS S: That's not a problem. Thank you so much.

Researcher: Thank you so much and we should catch on later on. Thanks, baba.

JS S: Take care.

Researcher: Cheers. Bye.

APPENDIX E5: Interview Transcripts of participant PE



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The Interview Transcript - Participant PE_5

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted

Participant's Rights

5. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable to discuss.
    - Inform the participant that the report will be made available to them on request
    - Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

13. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or Customer)
14. Geographical regions in which their expertise have been applied
15. Expertise applicable exposure is on which types of industries
16. Profession background and years of experience

Section B:

The participant was identified as an ICT Practitioner that has engaged and practically embarked on a smart farm IoT concept within the South African livestock context. The participant is focused on innovative solutions across various sectors and has over 15 years on product development.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The participant's expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

> Hi, PE, which area of IoT are comfortable to share your expert insights between the practitioner side covering technical side of IoT and the service provider side looking at the business aspect of IoT solutions?
>
> **PE**: More on the software side. We don't do hardware so it will be on the **API side**, so we wouldn't install any hardware. We just be given the endpoints then connected to the cloud or whatever.
>
> **Q1**: What are the kinds of IoT challenges that you have mostly been confronted with?
>
> **PE**: I guess the main one would be **connectivity**, A lot of these places that we are talking about in farm areas at the moment don't have all the best connectivity. I don’t think that's going to change quickly in the next few years. A lot of these places barely have a 3G connection. So, I think that's always

going to be the main **limitation of IoT implementations.** Obviously, you do get certain IoT devices that don't need internet connection or cell phone signal, whatever and work slightly differently, but overall, I think the **biggest limitation is. connectivity.**

Researcher: Thank you for that response. So, my subsequent question

Q2: Do you think that it is practical for livestock farmers to make use of IoT considering the limitations around connectivity?

PE: I think there are ways to work around that, like. I mean, there are **IoT devices** that can track activity that **don't need to be connected** to satellite or a **cell tower**. So, or you can have those NFC **devices**, which when they come into contact with something or a cattle walking through a gate or walking past a certain fence, then it can count **them or track** their activity without having to be permanently connect to the Internet. So, I think there are ways to work around. Those kinds of limitations, obviously it makes things a lot easier if they can just connect directly to the Internet themselves, but there are ways to work around it.

Researcher: Thank you

Q3: if you were to list in the order of priority which IoT challenges would you identify as crucial? looking at the end to end solution.

PE: so, obviously first is **connectivity**. I think that limits you a lot by what you can do. I think then the other thing might be cost don't want to be putting in **IoT device** on every single sheep or cow. That's where it starts **getting expensive**. I think that's another consideration mean maybe put on one or 2 of your herd so you can just keep track of where they are together. And then. Are they in? There could also be. I mean the **theft of the devices** themselves is also a concern. I mean, it's one thing to try and stop your cattle from being stolen, but if someone is stealing security cameras themselves, then then that's also a problem.

Researcher: OK. We have got connectivity; we have got the cost of actually implementing the solution. Overall, then we've got the potential theft of devices as being one of the key points considered challenges.

Q3: What are the IoT technical and non-technical elements that are crucial to the application of IoT? So, you are looking both at the technical side. I know that is where you are experienced do you have any that may not be necessarily technical but very key in pulling everything together?

PE: you want to be able to know that your devices can talk to each other. I think most of these devices to give the opportunity for interfacing between each

other, or your **centralized data system** or whatever it might be, but you need to make sure that they can do that. You don't want to buy some **IoT to buy such locked into some service** that you need to pay some ridiculous amount of money for a license or can't have it connected with something else. So, you don't want to end up. Yeah, like 10 cameras or devices that don't talk to other 10 devices. I think that's also. Something to consider.

Researcher: And then you, you mentioning day talking to each other

Q4: do you find based on your experience, or have you experienced any issues with communication between the various set of devices? I do not know whether that is what you were eluding to,

PE: yeah, sometimes it's something so ease and other. Sometimes the system is easy to integrate so sometimes it's **hard(complex),** but mostly it's not often impossible to do it just something that takes a bit longer to connect.

Researcher: And then linking to that, maybe PE the skills as you, saying some are easy to integrate. Some may be more of a pain to do integrate, and that lead to the required to integrate all the devices together?

Q5: How important therefore are the technical skills in pulling IoT applications together or solutions?

PE: OK, it's important, I guess it **depends on how big your operation** is to think somebody 's there are definitely situations where you could probably order these things and install them yourselves. But if you want its more advanced features likesome of the **data** related features or alerting and another kind of advanced tracking then I think the skill set would need to be quite advanced, it **really depends on how big the operation is.** I think like be quite easy for farmer to install a few security cameras himself and set it up if he knows his way around a computer. But if it involves connecting to Gate monitors and water monitors then I think there's quite a lot of technical ability required.

Researcher: And then subsequent questions to that

Q6: Have you gathered that the skills are freely available in the South African context?

PE: Yeah, I think there is a lot of IT companies that offer these skills. I don't think that SA is limited on the skills set. To be able to implement these solutions.

Researcher: Great. Add the other one that I am looking at, so I think you have touched on it. I think you have touched on the challenges that are related to

livestock farming. You have indicated that the remoteness of the actual solution creates a little bit of a challenge or leading up to that, and then

Q7: Do you have any other noticeable issues that you have experienced when it comes to implementing an end to end IoT solution?

PE: I think a lot of farmers generally are quite stuck in their ways like they don't really see or won't see the benefit of adding **cloud data** and **Advanced Analytics**. And stop something that they've been doing for the last 50 years. I think that's where you might get a bit of pushback. So, it's important to try and **when they aren't clear use cases** like cattle **being stolen, then it's kind of tricky thing to sell**.

Q8: Have you ever find that customers are much more receptive on IoT depending on how you are engaging them?

PE: It doesn't matter how we engage them, but it does depend a lot on who we engage and I think the **older generations as difficult seeing the benefits**, where as someone who's worked and grown up with using technology to make their life easier than they are quite lot more open to seeing the benefits of maybe adding further technology or changing technology that they're using so I mean, like I said when we did this, it didn't really get much further than at a concept,

Researcher: So why do you think your project did not move past the concept stage?

Q8: What do you see as challenges with regards to moving IoT projects past the concept or pilot phase?

PE: I think the **rollout is a big thing** that's stops these PoCs from getting any further. I mean because there's such a **big hardware element** to this, it's one thing for us to come in and say cool these are all the things that you can do and this is what you can track and monitor but at the end of the day, someone has to go and lay that cable someone has to put up their **pole**. Someone is to put that collar on that sheep that's a lot of these things end up falling into more work for the farmer. this software and device company's kind offer the solution they don't offer the implementation I think that's a big thing to have to try and consider too.

Researcher: So Lastly, the cost aspect

Q9: Can you tell me more about the cost of implementing the solution?

PE: Yeah. Look, I said, I can't tell you how much these things cost but I guess it also depends on just what you're doing so **certain devices** would be a lot

cheaper like maybe some little bit more expensive like say magnetic lock on your on your barn door or remote locking for tractors and things like that. Stuff that is quite expensive, there's a lot of the cabling starts, adding up as an expense. if you just putting for example, one of the network mobile operators are now selling these tracking ***devices***. Those GPS things they are like 600 Rands each those little devices so. I think this it all **depends on what you want your rolling out**. I think a very basic. IT system with maybe a few cameras and some tracking devices and maybe it gave monetization wouldn't be a particularly expensive exercise. But it's all **relative to how much the farmer chooses to roll out**.

Q10: And how does it link to the cloud costs so the volume of data? So, let us assume you have different data collection points and William study.

PE: It's **negligible when compared to the hardware costs**. The cloud costs unless it's a really, huge farm. I don't think you're ever going to find that the data costs are particularly expensive I think for medium to large size farm. I think with constant data coming in. It's still it's not going to be a huge expensive **cloud** operations. , it depends if you also have video stream, if you're going to record every minute of the videos come into your security cameras and that's obviously it's not adding up to quite a bit of **cloud space**. But if it's done smartly your cloud expenses can be kept low.

Researcher: we are coming to the end of the interview, mostly Max take us 30 minutes. So, the last part is. If someone was to approach a similar project like you have done so looking at livestock. I think based on the National Development Plan. I mean, security is one of the key items. We've seen recently the likes of Microsoft investing somewhere in the region. I think of 40,000,000 into agriculture.

Q11: If someone or new entrants into the market and looking at how they can best approach livestock farming to enable farmers with this technology, what would be your guided advice as to how and what they need to consider overall?

PE: I think if I were to be if I was farmer suffering from livestock theft with a particularly large farm and I'm having trouble managing my herd. I would look at using drones to track livestock. However, cameras alone on a large farm would be difficult with just IoT devices due to the cost to track all your cattle with a large herd that would probably be expensive to put devices in all of them. I think with something like drones you can also do monitoring and for security send out a drone.

Researcher: Thank you very much. you shared quite a lot of insight

PE: Yeap perfect feel more than welcome to reach out to me anymore. Thank you.

Researcher: Thank you appreciate your time. one cool.

PE: You too, bye-bye.

APPENDIX E6: Interview Transcripts of participant CN



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The Interview Transcript - Participant PE_6 (CN)

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted

Participant's Rights

6. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable discussing.
    - Inform the participant that the report will be made available to them on request

- Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

17. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
18. Geographical regions in which their expertise have been applied
19. Expertise applicable exposure is on which types of industries
20. Profession background and years of experience

Section B:

The participant is a young farmer that has been farming livestock for over four years. He meets with a group of livestock farmers on an occasional based where they discuss challenges and opportunities related to the state of farming in SA.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The participants' expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

> **Researcher**: Thank you so much for your time. Start date, just bear with me. I think it is going to start recording now. Yeah, it started, so welcome and thank you very much. I will start with my first question, so my question. My question towards you or maybe
>
> **Q1**: Please, a bit of your background you are in livestock farming confirmed, right?
>
> **CN**: Yes, I am a farm man, animal Technician with livestock wealth with them for four years running now and my job, as if I manage it, is to ensure that the day to day basis on the farmer carried through and that our animals are all taken care of such that they do produce and give us the products that we need. So, in a nutshell, that is what I do. I ensure that animals are well taken care of you. Researcher: Thank you, your expertise and insights will be definitely

valuable. So, let me start with my first question, so I do not keep you very much.

Q2: Are you aware of the technology known as the Internet of Things? If yes, in what relation to your business have you seen this technology being applied?

CN: I am not quite sure if I am familiar with the term, but I think. You are looking at the Internet—I and looking at our line of business. Social media platforms and the Internet to interact with our customers. So, I think I will say yes, even though I am not quite sure. What is the Internet of Things?

Researcher: OK, let me share what is the Internet of Things. I will give a little bit of context with what it is aimed at and what the technology is all about. So, the Internet of Things uses the Internet as you have eluded just now. But it uses the Internet to connect your assets. In this case, I think as a farmer, your valuable key asset will be the livestock itself., So what the technology claims that it can attach some kind of a device or mechanism on your cow as a form of identity and capture data of the asset. So IoT then claims to provide these devices that can be used for tracking the whereabouts of your livestock from within your mobile phone, and it claims that it can assist farmers with herd management.

CN: OK, I think we are already there at the Internet of Things, just that it is the terminology that I was not familiar with because we currently are running an experiment with our animals in various farms where we are trying to track our own animals are due to those particular reasons. The reasons which you just mentioned now, one being the head activity. Look at how animals are moving. I think that will help us. When it comes to tracking animals looking at their movement, then you can talk through moving slow. Moving fast, there might be some change, and it also helps in terms of having to count your stock. You know in all that it also tracks their location. So, I think we already there with the experiment and how we looked at it. That could be a solution to quite a lot of our problems and would make us running the farm to be more efficient. So yeah, I think it is their way to go going forward with the farming app that I do. Believe that. But farming present all around the world. I feel like the farming sector should also be there, not left behind this. Special in particular. I think it is a very great initiative a lot of recent work and effort and work needs to be put on to make the lives of the Livestock farmers be easier? Let me make an example for you. Every year December Holidays, December Holidays, especially Christmas is the Holidays. I am always here. I cannot go anywhere. For the past four years, ever since I left school. Christmas. Time and Easter times and other busy times of the year. I have to be here just to check on our livestock. Not that we are doing a lot of things. I just to be here to count cattle at least twice a day. If all those trackers and collard were already here, I would be in Dubai with my family here, and I will be checking animals over the phone and checking if they are still there. Do you know? So now I have to sacrifice. I

am times free, which I usually spent with loved ones just because I need to take care of the animals from the farm. Researcher: Nice one, thank you for that. CN: I think I just gave you the perfect example.

Researcher: That is great insight like it is a big factor. Thank you for a lot of insights

Researcher: OK. So, you have given so much insight, so maybe to share with you briefly what I have done approaching this. You are very key to this research. Why? Because you the customer. The inside that you have just given me now gives me a perspective from the technology side. Because you know technologists, they always make things about technology rather about you as you have now just given me inside to say why would the solution of such a which we take as ITB. Value to you because you have now indicated that through your whole life experience as a manager in the farm and the farm are you have to do then the Liberals work of actually manually or physically accounting for stock or assets within your possession. However, then the introduction of the likes of Io T can enable you and free you then to spend their leisure time with the loved ones but also allow you to cater or to look into other aspects of your business just outside what you have been doing and what you have been predominantly be focusing on. So that gives great insight. And then my follow-up question to that would be around.

Q3: What is the state of the experiment or the pilot that you guys are running based on your own view? Is it giving you value? Is there improvement?

CN: At the moment, I mean we just started last month. But I think it is a great step towards relieving us. You know we are looking at when this thing actually happens and comes out alright in the next few months, or a year it will help us a lot. So, I think one is knowing that in a few months from now the situation will not be the same. It will really help and put a lot of relief on us. Thinking that this is what we have been hoping for, waiting for the past four years or something.

Researcher: Interesting.

Q4: What is the list of items that keeps you awake at night? Regarding your business challenges?

CN: Mostly, it is. Security, second theft, you know the lack of security and theft, I think, animal health and nutrition, I sort of understand what happens. You see, when animals are sick, this is a problem in a population of 100 animals; maybe ten would get sick, and then you cure five or more. So, animal health and nutrition is not the biggest problem, but it is the security, recording and capturing of data. I think we still very much behind with everything when it comes to capturing data. You still have to do it manually, but the one that really

worries me the most is theft. Livestock is a very, valuable asset and I have to stay out there every night? You have to be out there in the field in the grass while others are sleeping comfortably in their beds at night, and your biggest asset has to be out there at night. Unfortunately, there is not much we can do about it because that is the natural habitat of your biggest asset. So, it is the biggest issue for me- its security and theft.

Researcher: OK, definitely it gives insight. The issue is the external factors that are brought about by external elements such as people coming into your land for livestock. The experiment that you guys are running on IoT is aimed at curbing the security and theft problem?

CN: Yes, first and foremost, to try to curb the theft problem and to try and improve data capturing on my animals and actually have that kind of data recorded. The movement of animals can also help us, but that is a secondary problem. The primary one is security and theft, so improving our head management with the data provided by using technology that will be captured by the tracker and all that.

Researcher: So, you keep breaking a bit. So, if I pause a bit, it is when I am waiting for your feed to connect back. So, what I have picked up from the previous question. The key things that keep you awake at night are security and theft, s nutrition and all other internal management aspects; you then followed up with the next question in terms of theft and whether the solution that you are experimenting on is providing that particular support, and you indicated that was the objective, although it would have added value beyond security and theft, it will allow you to then look at grazing patterns and the movement of your herd. Though that is secondary, the primary concern has to do with theft and security of your most valuable asset and then allowing you to be able to track and monitor and account for your valuable asset no matter where you are, because you will then be continuously connected whether you be at home or somewhere away on holiday with your family, but you have that comfort to know the status of your herd. Did I capture that correctly?

CN: perfectly. That is what I was trying to explain.

Researcher: Thank you so much so.

Q5: What is your view around the application of this technology called IoT within livestock? Maybe it is unfair to you because you already answered that. You said you know this technology can support you on theft and security. It can add value, giving you enough time on your hands to manage other aspects of your life and give you that work-life balance. Where you not always confined into a single space, so can I then wrap that question as that being the answer?

CN: yes, absolutely. I think it will be redundancy if you go back to it, but yeah, that is one

Researcher: and then follow up one just to make sure we covered it. It says

Q6: Have you or would you consider implementing IoT in your business? I think if I am not mistaken, you also cover this question because you not only thinking about implementing it, but you have already started experimenting with IoT.

CN: Yes. I think I would also encourage other guys to try and move towards IoT. I think it will be beneficial to any business rather than just in our particular case. I think it is the answer to a lot of questions

Q8: The most important question before the experiment that you have shared with me. Before you agreed to experiment with this technology, how receptive were you to new methods compared to traditional and tested methods?

Q9: What were the key points from the service provider that got you interested?

CN: For me, being a young person is obviously technologically advance into other aspects of things, and now it is just my work which I was like. Why is my line of work so behind everything? Like if I want to do something, I can do it with the touch of a button, purchase things, get things delivered, and track them. When it comes to the farm, what can exactly be done to try to solve my biggest problem? I have to be constantly here at the farm looking after the assets, and at some point, I actually considered buying a drone to fly it over the animals to just randomly check them instead of driving to them every now and again, you know. So, I think when this idea was brought up, I was at the stage of considering a drone, and then boom, something better came through. So, I am was like my prayers have been answered. This is what I have been looking for, so it is like, no, let us try it. You know it was like, let us do it. Cause I believe that is what I needed to put a little bit of ease onto my work lifestyle. So, it was very much easier to take another step.

Researcher: So, I gather. and recollecting again, one key factor for you was one your age. Being a young farmer, at that age, you being exposed to other various forms of technology. As you indicated on your phone, a click of a button can make things happen and that exposure made you want to see the same advancements with your and convenience that is being granted by technology. So, when then the service provider approached, you saw it as being an opportune time to experiment and see how you can then advance your sector your business by actually taking on this experiment with the service provider. Did I capture that accurately?

CN: Yes, absolutely, that is correct.

Researcher: Great.

Q10: What is your role or involvement as a customer with this solution? Are you expected to manage the technology, or are you just expected to just use the technology from your side?

CN: at this very moment in time, they help us with setting up the of this thing? I do not know why they put those things and then the collars and all that, so from there, we just need to play around with these trackers and see how they actually work, and we have to give them feedback that first, and then we will see where do they need to improvise at this very moment in time is just to be the end-user of the product and see how it works for us.

Q11: OK, so at this point, you have your phone, and then you just gauge, and you give them feedback as to where you are things. What is expected when there are problems with the solution?

CN: At the moment, the arrangement we are still experimenting with it, and whatever we find out to be unclear, we feedback to them, and we try and review the solutions with them.

Researcher: OK, good, so which means they provide you with full support. You continue with your business, and you are not going to be managing technology. Should there be any issues, you give someone a call and that someone must come in and address whatever technical issues. Would that be correct?

CN: Yes, yes, number one.

Researcher: So, let us talk about theft.

Q12: Do you find that as a farmer, this is a general trend being experienced by livestock farmers across South Africa?

CN: I have been in Free State. Gauteng Province, Mpumalanga, and been to Lesotho and various places in KZN. Wherever we gather as livestock farmers, there is going to be someone who is going to be complaining about cattle or sheep or goat that went missing. So even though they are places, the hot spots which are much closer to certain areas like abattoirs where they slaughter animals or are closer to the borderline to the next province or next town tend to be the highest risk as it is much easier to move those animals everywhere. The issue is the volumes and the frequency. Cattle will go missing on a weekly basis in Vryheid and on a daily basis up in Free states near the Lesotho border, but it is the same problem. It is the quantity of animals moved and the frequency of them. I promise you every livestock Farmer would have a story to tell about cattle going missing.

Researcher: Thank you, let me recap it, so it starts to make sense. So, it seems to be a generic problem. However, to your point, it is all dependent on the location that those farmers who may be located in hot spot areas where the frequency becomes much more at a higher rate. So, you will find areas with daily incidents which are then experiencing those issues. I think you indicated in the Free State may seem to be exposed to much more frequency or higher frequency of theft. This can be on a daily basis, but it also seems to be linked to the volume as well. not just the frequency is not just one cow going missing. It can be a combination of the two, the volumes and the frequency can go together where they may have lesser frequency and smaller volumes. While in some areas where you will find that the volumes are high, and the frequency is high. It is taking, for example, ten assets, for instance, wherein the lower hotspot areas, you might find someone coming weekly, just stilling a single cow and then come back again the following week because they may have the means of moving those particular assets in volumes.

CN: Yes, absolutely.

Researcher: Thank you very much

CN: OK bye, thanks bye.

APPENDIX E7: Interview Transcripts of participant LS



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The Interview Transcript - Participant LZ_7 (LS)

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted
- **Participant's Rights**

7. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable to discuss.
    - Inform the participant that the report will be made available to them on request
    - Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

21. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or Customer)
22. Geographical regions in which their expertise have been applied
23. Expertise applicable exposure is on which types of industries
24. Profession background and years of experience

Section B:

The participant was identified as an IoT Practitioner based within a customer context. Though expertise was not specifically on livestock farming, however, the practitioner has been involved in several IoT project for the past six years.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The participants' expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

Researcher: Let me project. A consent form.

LS: Yeah, sure, I see it all right.

Researcher: So, as I said, I'm doing my master's let me try. You will see that this is the same thing I'll send you, so here it says informed consent. I loser sampler blah blah blah and so on, right? You will then indicate whether you want it to be confidential, anonymous and indicates that you haven't given me consent. I will be asking open-ended questions.

LS: OK. Ready.

Q1: What are the kinds of IoT challenges that you have mostly been confronted with? In your experience?

LS: IoT challenges, as in pertaining to the technology or in general,

Researcher: It's an open question, so you can cover all aspect of IoT

LS: The challenges that I have experienced a lot especially working with IoT projects, there was a bit of **a push back**. **IoT solutions are not easily adopted**. I'm not sure **whether it's the lack of skills,** but what I've experienced it's difficult to innovate in the IoT space because there's **just too many people pulling in different directions on a project**, so I think that's the biggest challenge, that I have faced a human factor, it was not the technology, it was just humans who just made it difficult. Also, **change management** is not so excellent. cause solutions that are **IoT related were a bit hard to be adopted by the business at large.** But as much as a **lot of people may like a solution. But there was a strong chance that it will never see the light of day**. Yeah, so there are also **organisational politics**, yes, that's the major one as well. Politics when and when there's a change of leadership, everything changes, yeah, so those for me were the major factors.

Researcher: OK, **lack of leadership alignment**. Alright, so I'm recapping several things that you highlighted. IoT solutions are not that easily adopted by organisations that have different objectives from an organisational perspective, pulling from different directions. It seems as if the **objectives are not made clear,**

Q2: Share more about the lack of leadership alignment from a business objective point of view?

LS: There isn't alignment. From leadership, you know from an objective point of there isn't in my experience, because you'd find that with the leadership, they themselves fail to align objectives and to decide where to steer the project. Then that misalignment will cascade down to everyone that is involved in the project. Since most of the projects on IoT cut across through all the major business units in the organisation, this becomes a huge challenge. So, you would find that if we need data, that's going to support the solution from a specific business unit. It would be a challenge to gain access to that data as leadership is not in alignment with the objectives for the project. You find that we will never achieve seeing the project through.

Researcher: OK.

Q3: If you were there to list in order of priority the main IoT challenges, which one would you identify as crucial?

LS: On top would be **leadership like acceptance** from leadership and alignment amongst themselves. The second one would be the **solution being accepted by the entire business community** because I think there's also that **misconception that IoT is going to replace jobs**. I think we'll be heading in the right direction and then. After that would be to have technical skills, you need the retention of those people because the. 4th Industrial Revolution, have. Developers, engineers are on-demand, so organisations need to have some sort of retention plan for those skilled people. After that, it would be to have the **necessary budget** for projects. I think that's those are the major ones for me.

Researcher: So, you said **leadership, buy-in**, yes. So, I think leadership buying links to the above points. That you've raised around **change managemen**t around **adoption** around **different objectives** on the project, right? You also then indicated the **overall stakeholder buy-in just not just leadership but the people who would be impacted, whether in a positive or negative way, by the project.** Then you said **technical skills and** having a retention plan to make sure that there's continuity on projects. You highlighted **budget, having** a clear budget for each project to make sure that there's enough money to complete that particular initiative or project. Did I capture that accurately?

LS: Yes. Good, very, very, very clear.

Q3: If leadership buy-in was not an issue, how would that impact the application of IoT?

LS: You know when leadership is bought into a solution, it gives us as developers the confidence as well to know that whatever information or data that we need throughout the organisation, who will get access because we have the backing of leadership, so it gives us that, confidence that regardless of what happens, I will get this done and I will get the data that I need because **everything is evolving around data** and it **also revolves around the device itself**. But you could have **the device, but if it's not talking to the right systems** if it's **not integrated** with the right systems out of use. You need an alignment across the business for integration, and to make the solution better, you know to enhance the solution, you know so. If leadership is brought into that, it makes it easier to succeed

Researcher: OK, it makes

Q4: How crucial are technical and non-technical skills in the application of IoT project.

LS: Yeah, **very crucial** the biggest problem I think we were facing now is key resources leaving you know highly skilled people are leaving, but you find that

they leave the organisation due to lack of clear, direct or objectives **I'm a person who likes doing things that have a purpose and when there is no impact when you struggle to see what you are doing or what you are working on making a difference in someone's life or in the organisation. You tend to be disgruntled or to be a bit demotivated because you feel like you no longer have a purpose.** You will even consider other opportunities because you know that nothing is going to change. I think for me personally, having the proper and the right skills to see through IoT projects is crucial.

Researcher: Then the leaving of the skills. So, as you say, they are on the move. **The demand is high for this type of skills** as skills leave the organisations, they subsequently leaving the project or the IoT initiative

Q5: What impact have you seen and experienced when these skills start leaving Green dreams are actually taking place in IoT project?

LS: **My experience in that either the project comes to a halt or it moves slowly, but eventually dies a natural death**. We've seen it in cases when a key resource leaves, for instance, the morale is low because we are losing people and then more people start leaving highly skilled people you know, and then whoever is left would be like, I also need to leave before all of this pressure is put on me, you know, and then we start living. We start living in numbers because we're all afraid that we saw the pressures that the previous guy was under, and then he leaves and then who's next in line now, you know. So, let me leave before it's my turn to be under fire. So yeah, yeah, I think that's the impact that I've seen now of people highly skilled people leaving **IoT projects that it's either this low to no progress on the project just dies**.

Q6: How difficult is it when these skills leave to replace them?

LS: It's not possible. It is not possible because I'm making an example if. More than ten people leave in 2 – 3 years replacements of the same level of skills is difficult. The skills are in demand, as I have already indicated, and to upskill is also an issue to get to that level of expertise that the person who left. It would take another three to four years, so it becomes a challenge.

Researcher: So, there's a skills demand. OK. Let me add a subsequent question.

Q7: What technical or even non-technical challenges that you would identify as potential Project Stoppers?

LS: I. I think I've named the politics one leadership. There's one other one. Let the team in itself. You know, sometimes when you are working on multiple projects, we are understaffed most of the time, so you'd find that you in charge

or involved in about three projects, and all of these three projects are heavy barring projects, especially if the projects cut across the organisation and require a multitude of technical skills. So that's another thing for me when we don't have focused people on a specific project.

Researcher: So, you find yourself having to be **diverse in the skills** that you possess. You find that those varying skills are not being applied in just one project, but they are also being applied in a different context. Over and above, there are a lack of resources. Meaning being understaffed and then being stretched too thin along with these multiple projects.

Q8: Would you then say that is also why you see the projects not progressing at the desired pace?

LS: Yeah, very much so. Putting developers in positions where they have to attend too many meetings. That's another one. You know where you supposed to be developing, but you spend most of your time in meetings or being a project manager or presenting somewhere to some person. You find 30 - 20% of your time. You spend doing non-dev work. Yeah, you're doing other things some admin you know, sometimes there's documentation, yes, it's necessary, you know, but you find that sometimes even touching a little bit on being a business analyst, you touching a little bit on being a project manager.

Researcher: I think you've touched on something interesting. You've actually indicated that the **skills are crucial**, but you now seem to be getting deeper into the various skills in which they are required in running the project. While you said yeah, developers are being pulled into meetings, so technical resources are being pulled into meetings to pose as project managers or business slash take his slash. All kinds of various roles that should be supplementing or complementing the entire team and that is made up, but you're finding that technical resources are expected to have these very or variant types of skills which are called the point, and then it holds other aspects of IO T application such as dev work or the development of work because they're being dragged into meeting that being seen as project managers, they then supposed to do all kinds of reporting and documentation. That intent is then so. Then my question would be a two to have a holistic team for the IoT application. What are the skills that may be listing those you've already mentioned? Business analysts, project management, Dev, what are others. T

Q9: What would be those skill sets you deem necessary for the application of IoT projects?

LS: Uh, a business analyst, project managers, the product owner as well, we need a solution architect, and we need a developer who has different skills, database administrator. There has to be an app developer, a front-end

developer. Those are their skills that I would say are needed to successfully run an IO T project.

Researcher: OK. I think we are towards the end of our session. I have one more question, sort of two in one.

Q10: If looking at a different context at which IoT can be applied, let's focus, maybe on livestock farming? If, a farmer, was interested in implementing IoT within their farm to manage their farm **Q11**: What would be crucial in making sure that their solution becomes implemented and remains functional?

LS: Yeah, on a farm. Yeah, from inception, I would look at **network coverage**. You know, next, we have to look at the **devices**. So, the infrastructure, network infrastructure has to be good to support that solution. Another thing would be **money**. You need to have the necessary budget to see such projects through because they are **very capital intensive**. The **type of device** that you'll be using. Because there are devices that should be equipped for cows. Guard against device getting damaged so, and the **device has to be a bit more durable**. Making sure that **devices cannot be stolen** because if it's as easy as approaching a cow and unhooking the device, then it serves no purpose. You know, because if I'm going to steal your livestock. I can just unhook the device so. There needs to be a way in which we could embed the device somewhere where it's actually difficult to remove it.

Researcher: it must not be prone to theft, yeah?

LS: Yeah. The **device specifications** as well checking **the ingress protection** of those devices, and **device capabilities** that it will be able to **stream the data** that you want into a specific **platform**, and the **platform itself**, because **data needs to be hosted somewhere**, it needs to sit somewhere, and **your solution needs to be hosted somewhere**. So yeah, I think for me, those are the major ones that could hold the project.

Researcher: OK. Thank you very. I think you've covered mostly my last question. I will just summarise some key points you have shared with me:

I think you've identified a number of items that are key. One is leadership buy-in stakeholder engagement and change management and making sure that clarity is given to all stakeholders around the objectives of IoT projects within the organisation. Making sure that if there's leadership, buy-in, and everyone is pulling towards the same objectives and that the objectives are very clear. The **budget**, **investment** towards the projects is key to ensure there are enough resources for the project to continue without any hiccups. Furthermore, it is the **technical aspects that are crucial.** The skills drain impacts projects immensely. R**eplacing the skills** and the IP project is challenging because the rate of upskilling anyone in the organisation or replacing the skills has a steep

learning curve and becomes costly while delaying the project. The demand for technical skills is high. You indicated network connectivity becomes instrumental, especially in areas where probably it's remote, like in livestock, farming., but also you then supported with the requirements for a **clear investment.** You also touched on other items around the **technical skills** and that a variety of skills are required to actually pull an IoT team together. Lastly, in livestock farming, other than the network, the budget, you then cited how crucial are IoT devices, by ensuring that they are well designed for the environment in which they are going to be implemented. Devices must not be prone to theft and need to be durable. One last item was around the data platform as being pivotal to host the data coming from devices. Have I summarised it well?

LS: Perfect stuff.

Researcher: Thank you very much for your time and expertise. I'm going to now stop recording an official thank you.

LS: It's a pleasure. Researcher: Goodbye.

APPENDIX E8: Interview Transcripts of participant KN



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The Interview Transcript - Participant KN_8

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted
- **Participant's Rights**

8. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable to discuss.
    - Inform the participant that the report will be made available to them on request
    - Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

25. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or Customer)
26. Geographical regions in which their expertise have been applied
27. Expertise applicable exposure is on which types of industries
28. Profession background and years of experience

Section B:

The participant was identified as an IoT Practitioner based within a customer context. Though expertise was not specifically on livestock farming, however, the practitioner has been involved in several IoT project for the past six years.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The participants' expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

Researcher: so, let us start. So, the first question that I have for you is

Q1: What are the kinds of IoT challenges that you have mostly been confronted with?

KN: I think the biggest challenge that I have faced was on the technical side, but more with regard to **integration** between the **different contractors**, because you had to handle the **software side of things**, the **cloud,** and then we had the **hardware** that was being **built and installed by somebody else**. The delays were between integrating the two parts.

Researcher: So, it was integration between the clouds software running on the cloud and the hardware installed by another service provider?

KN: Yes.

Q2: What was most frustrating or what mainly was the cause of delay in the integration?

KN: The delays that I experience most of the time was due to the communications between the two sides cloud and hardware teams. It was not getting the right information when it was required and chasing people for the required information.

Q3: Would you find that it is purely misalignment in terms of what is required, or you have found that it is a misalignment in terms of the variety of skills in those three areas?

KN: No, it was just miscommunication. I mean, the level of skills on both sides were sufficient. We had a good understanding from both sides on the respective fields, it was just the fact that people assumed what needed to be done, and they made certain assumptions that were not actually correct at times. So, that just caused misalignment.

Q4: Where was the communication breakdown?

KN: Sometimes OK, you would follow an agenda, but a lot of the time where people usually get stuck on the wrong points in the meeting or in a discussion and then things tend to be drawn out. When that happens, then you know people tend to get excited and go off track and sometimes then miss or lose focus on what was meant to be the objectives.

Researcher: So, my next question,

Q4: if you were to list in order of priority the main IoT challenges, which ones would those be?

KN: It depends; from my experience, **communication** has been one of the big issues. But in the field as well, **technical skill** can also be just as important. You need to have people who understand or interpret the scope requirements the right way as well, and that is where the **technical skills** come in.

Researcher: So, but where is that? Where the technical skills come in? So, you said, that is where the technical skills come in in in taking the scope that requirement, converting that into something tangible into a product into something that can be. I guess that is what you are saying.

KN: Yeah.

Q5: So, when it comes to technical skill. In your experience, has that been a challenge? What more can you tell me about the technical skills?

KN: My perspective. There is a lot of **standards** that you should be following when it comes to IoT solutions, such as the protocols that are out there. People

need to understand them and apply them in the right way. Firstly, putting together the **solution on paper** and applying it or developing it. So yeah, there is a bit of **know-how** that's needed.

Q6: Did you find that gathering those skills, I mean those technical skills, was challenging?

KN: it was not difficult, but it is not easy at the same time. How you are doing it. Obviously, some experience in the field to understand it fully before you can actually say you know what certain things mean.

Researcher: So, would you say that upskilling was necessary?

KN: yes, to some degree? Alright, yeah, alright.

Researcher: OK, my next question.

Q6: What are IoT technical elements that are crucial to the application of IoT and why?

KN: I guess the most crucial skills will be on the **software side**. Mainly because that is where your IoT comes into play, that is your **data** traffic, your throughput. It is your pipe too, and you get **insights** from your data that's sitting on your **mobile device**. So yeah, a well-built platform gives you the room to be able to use the data more efficiently and effectively? An IoT device can be anything as simple as a small Wi-Fi module with one input. One output is giving you an on and off or something. You know, something that's limited, and the device is sending that out to a platform, and it is not necessarily that difficult from my experience.

Q7: Is there a lack of IoT skills? In your point of view.

KN: I do not think there is. No, I just had a conversation with somebody a while back, and they were building a system that necessarily used individual devices too. Get to pull data and get insights off a system but, this person did not actually think what he was doing was an IoT system. I do not think we lack in skills.

Researcher: Thank you.

Q8: What are the technical challenges that you would identify as potential projects stoppers?

KN: Well, I guess. The one is definitely hardware, the **hardware component**. You need something that can measure a kind of measuring device first to get

any kind of data out. Secondly, then the other one is the **platform,** but in some of the project that I have been on, the **network coverage** is one of your very biggest issues. I mean, because we were living in a Third world country, we have a lot of blank spots in the country. There is no network coverage, and you would experience areas where there is just no connectivity that can actually be a detriment to your solution.

Q9: What are the types of challenges that can be identified when applying an IoT solution for livestock farming?

KN: Well, I think the biggest issue would be the **device side** of things to build. What would you be the measuring devices on the cattle themselves? I think in this use case because looking more at farms in the countryside. I think the **network** is probably the biggest issue you are going to have. You are not going to get a lot of coverage in those areas. I mean the hardware side of things for tracking, you already have devices small enough that can fit on the livestock like in the neck, or you can embed it. I mean, you can even tag it on the ears of the cows.

Researcher: Thank you, so connectivity and devices seem to be top of your considerations

Q10: What are other notable items that you would consider necessary. When implementing an IoT solution?

KN: Yes, necessary would have to be **data engineering** and **data analytics skills**.: I mean, the thing is, the way I see it. People, individuals are given certain titles such as data engineers, data scientists. These all fall under the same umbrella. You need to pull each of those skills together to be able to pull up an IoT solution. The engineering needs to be there so that you can **access your data faster**. In an ideal solution, if it is **real time solution**, you want to have quick access, quick processing and get that to be able to get to the real-time output right. Data scientists, data analysts are needed to have some kind of meaningful **insights coming out of your data**. Other than just having a **dashboard report** that's being produced. And the IoT part is basically **connectivity** and understanding how the **data is coming to do** and being able to work with that data.

Researcher: You are saying there are a particular set of skills that are instrumental in making sure that you have a much more working solution. So, in this case, you are saying these are the key things that need to be considered. Is that dev engineers, it is data analysts that will analyse the data that data scientists. It is then the **software,** connectivity components skills that come into that. So, we will call them software and probably cloud skills within the platform?

KN: Alright.

Researcher: Thank you, that is all the question I had for you. Appreciate your time and expert opinion.

KN: Not a problem.

APPENDIX E9: Interview Transcripts of participant LS2



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The Interview Transcript - Participant LS2_9

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted
- **'Participant's Rights**

9. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable to discuss.
    - Inform the participant that the report will be made available to them on request
    - Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

29. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
30. Geographical regions in which their expertise have been applied
31. Expertise applicable exposure is on which types of industries
32. Profession background and years of experience

Section B:

The participant was identified as an IoT Practitioner based within a customer context. Though expertise was not specifically on livestock farming, however, the practitioner has been involved in several IoT project for the past six years.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The 'participants' expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

> **Researcher**: I have several questions that I am going to ask you. They are open-ended, and the objective is that you can then elaborate on your expert insights.
>
> **Q1**: Your background within IoT, is it on the technical side or on the business side?
>
> **LS2**: I would say it is **50:50,** so my background is I have done the most complicated IoT devices of them all, and that is a mobile phone. So, I did that for 12 years, where I started designing the chips. The electronics inside the mobile phones and then after that I reached a level of a senior architect. That is a point where I touched the business side of things. The more commercial site, so that is the product portfolio planners, product owners, program managers, it is about budgeting, it is about investing into new projects and market evaluations and so forth. I moved into the more commercial side, and I moved into a position of global account. Being a global account manager to look at the strategy for involvement in the exact same projects but just from an electronic manufacturing supplier side and then it was about account management, putting in account plans, you know, focus areas, activities,

different projects and bringing in sales results of those activities. So yeah, the short answer is I am looking into both commercial and technical sides.

Researcher: Thank you very much.

Q2: What kinds of IoT challenges have you mainly been confronted with, looking into both the commercial point of view and maybe from a technical perspective?

LS2: Yeah, so if you start from the top, the **lack of IoT strategy** within the companies that we are selling to. So that means fundamentally, they still need to figure out how they would like to utilise and create value out of an IoT implementation and describe that in an IoT strategy because within IoT strategy for the company, they can easily put down some **focus areas** that they would like to **invest** in and based on that they can easily establish projects that implement IoT because it is part of the strategy, so that's on the business level side. **The lack of IoT strategy it is coming**, and the more they get to know about IoT and **IoT security**, the more they are coming back to get more knowledge. Once I get involved, it's about figuring **out the paint** so that **if they have a budget**, how far they have the **allocated money to invest in a project** and then also the persons I talked to is not the **technical designer engineer** in one corner of the organisation. 'It is the sponsor of this project, the senior sponsor. So, **do they have the authority to start on this project** at all with **time, money and resources** and then also have they actually **identified the value proposition behind it**? You know what tasks that they plan to answer with IoT. So that means that if they **actually figure out what value they try to gain from IoT**. It is also some of the challenges. Lastly, the timing, are they involved in the best possible timing to get things started and have they already created a schedule? When they would like to do it and **how long time,** they would like to spend on it? So, coming back to the **IoT strategy** for the **focus areas and projects** and is very clearly linked together, but let us say everything is set up and aligned, and we are ready to go. Then from my side, the process that we are following for implementing IoT is both technical and commercial. So, let me start from the beginning; we run a workshop that we call **an ideation workshop. This is about figuring out what can IoT help that customer with**? That is brainstorming and trying to figure out **value propositions,** so ideations understanding the **whole concept**, **what can it bring**? What can it help us with understanding the context? Then we move into the commercial side, where we offer a **business model workshop. So, this is about pinpointing the value proposition** to the exact customer segment and also figuring out which channels we're going to sell this product via, and how are we going to **establish customer relationships from that value proposition of IoT to the end customer**? **So, this is done together with the customer** and then discuss how is the customer going to implement the solution? What kind of resources does it need and **what kind of organisation** is it, and what kind of **partners do you need to hook up with**

to get this done? Based on that, there are some **revenue streams coming in,** and **there is a cost base to it**. The main point is to get a **positive business case**, a hugely positive business case that can let you know, indicate that implementing IoT will bring value in dollars to a great extent. If that is established is a key driver for companies because it is about earning money right by the end of the project. Let us say the commercial side is now established, and we understand the value proposition, the dollars in their **revenue streams identified**. Then we move to the technical side. That is an **architectural design** session. That is where we ask our architects to sketch out an **architecture** that can technically implement that value proposition by utilising IoT, and then they put in what kind of product and services are needed on the **cloud side** and also on **the device side** to establish this solution, and that is the technical side. Now it is time to implement that solution, and that is where we **bring in our partners** that have **independent skills** at doing that, so they help implement first the PoC, proof of concept, and then the account to the customers. See the working example of what we are trying to accomplish. At this point, it is so important that we actually have established this **senior management buy-in** to the IoT strategy, **budget time**, **resources** from their side because now it is time to move on from the proof of concept into a **pilot** phase. That is the first major step and very dangerous because that triggers the **consumption of time**, **money** and **resources**, and that is where we deploy maybe **1000 devices into a pilot project to capture data to bring it into the cloud.** See **dashboards that are actually bringing the value proposition** that we figure out from the **business Model** Workshop. Now on a larger scale of maybe 1000 devices. Once that is done, it is about time to go to market, and that is also as a service provider, we help to figure out a **business plan** on **how to actually deploy this product into the market and make it work in the market**. Only at that point, it is possible **to scale the whole solution to capture the market** and then also to grow the customers business. So, this is the process that we are following, and the tricky point is after the first PoC. We typically see that oh, it this possible, then we could do this and then we can expand the PoC and we grow, and we can modify it. So, after the PoC, the customer is very involved, and they would say they take over. Basically, they take over because, at that point, they know that they **can see the opportunities within IoT** and fundamentally, as a service provider, I have done my job at that point.

Researcher: Thank you, that was so insightful, and you actually answered most of the questions that I had for you. The subsequent question links to a recent research report that IoT projects do not go past the PoC phase.

Q3: Do you see this challenge as being linked to not having a positive business case and #2 the technical aspect that brings that allows the PoC to scale from pilot to production?

LS2: So, I would say technically wise, everything is possible. **It is not about the technical side**, not at all. At any point, it is about the senior management or customer have not created an IoT strategy. They have not committed themselves to the company to reap the benefits of implementing IoT, and once they have not done that. The way companies work is that they have an R&D department, the R&D department needs to figure out what is the latest technology greatest things in the market, technical side and they go out and **talk to the supplier**. AWS, Microsoft Google. What is the latest and greatest in technology? Because we are in an R&D department and then they start all kind of technical activities **without the commercial side of it included**. So, once they reach the POC level, that is as far as this R&D department can actually bring things because that is what they do. That is where their work stops. At that point, the only way to bring it forward is that you include t**he company's sales, marketing and product planners, portfolio planners in the senior management because** they are the **ones that decide to move forward into a pilot phase** and bring it to market and ask R&D Department to scale it. So if there is no IoT strategy, if there is no **business model workshop**, and if there is no **attractive positive business case** identifies with the help of senior management, financial Department sales, marketing, the product planners, if they are not involved from the start, then we have the problem of only going to the PoC and not continuing afterwards. They can service and operate the devices in the market because there is a business case behind it. So that is bringing us back to this business model, so it is full of quick questions like **do you have a budget** so **the budget only comes if the senior management believes** in this **backed up by the IoT strategy** so that they **can allocate money**. You have the budget, and then do you have the **authority**. R&D can only take it so far technically **the authority has to come from the senior management** backed up by an IoT strategy that identifies focus **areas of activities and then a project,** and that is done in collaboration with the Financial Department, sales, marketing and product planners. So, the authority must come from those persons as well. So, it is not only R&D. They are **one out of typically seven decision-makers**. And then you have the need, and that comes from the product planners. The marketing brings in requirements from the market, and together with sales and the product planner. Use those requirement collections to figure out a new product that the market needs. Once the market tells what they need, you have identified the need and the last bit independent question is time. So, **do you have a project schedule established**? Is the timing good to start this project? It's coming back to the projects that are based on focus areas that are based on an **IoT strategy that is supported by senior management in the company**. So, if all those four things. Budget, authority, needs and time are available. There is a high likelihood that the project will easily move beyond the PoC phase because it involves the commercial sides and not only the technical technology side.

Researcher: Thank you.

Q4: How important is the customer context? How viable is IoT application within livestock farming for an instant?

LS2: Yeah, you know, the trick is to validate any of the needs that have been identified, analysed and collected, and what that means is that **you really need to work with the customer** segment, so by that, I mean, **who is it that is going to benefit from IoT in livestock**? Let us say it is the farmer. So, you need to talk to the farm and say with IoT and connected livestock, what kind of jobs or tasks that you do, Mr Farmer? Will it be supported by IoT like what you normally do it manually that we can now do automatically digital, and then he would say, well, every morning I count all my cows that they are in the specific field. I spend maybe 10 minutes doing that every morning, but if I can just pick up my **mobile phone** and see the number, then that could be done in 10 seconds, so **I will be saving time**. If I get this IoT connection done so this kind of use cases needs to be identified, **verified with the customer segment**, the farmer. If we come and say, well, Mr Farmer, I have a solution that can ease up the counting of your livestock every morning. That is fine, but I never count my life stock. I do not need that. I do not have a need to count my livestock then the whole value proposition is not verified. It is simply not there so. So, remember to **bring in the benefit of IoT needs to be backed up by the commercial side value proposition** that **saves money** you can be effective with the customer. You can save time. You can save waste. You can optimise things in your business that needs to be available. Because that is what is going to drive the project, because saving money free up money to pay for the project by the end of the project, and then the free of money should only be a portion of what you spent implementing that project, so this is so important to start on the commercial side 1st, and that's only done by **looking into the customer segment and the value proposition** that you like to offer with IoT.

Researcher: So, latching on the aspect of commercial and a positive business case.

Q5: How important are the strategic partnerships as a service provider

Q6: What pricing model that you have seen being more relevant in the various customer context.

LS2: To make it short. **Pay as you go**. Pay for your services. The amount of usage you do that is typical. What, for instance, service providers are earning a lot of money on this approach, and then you pay on some sort of **subscription-based model**. So, as a service, you know you implement **IoT as a service**. So, the way that is done is that service providers provide the platform, work **together with partners** to actually implement the solution, so there are three phases. There is the **development phase**, together with the Partners, and once that is done, it runs in the cloud. Then you would have a phase called **operational**. You need to operate your solution, you need

persons to look at the **dashboards** to draw conclusions and take actions like, this morning I had 10 cows in the field, and this afternoon there is only 8 coming in. What is happening? Is it true, or is it not true? Maybe I should send out some person to evaluate this so this kind of operation is needed and then finally is the maintenance, also if you **need to scale up** or **you need to scale down** or if you need to expand your platform, so all this is first of all this. Three different phases and throughout it, and there is this. PoC as you go based on how much you utilise services from the cloud, **so it's a monthly fee based** on what you use and then if you go into the operational and maintenance, provide that as a service like we already have a company that can actually provide this service. All you need to do is pay a monthly fee to get the benefit of this solution. So, I would say **the pricing model is this once per month and according to what you do and then as a service.**

Researcher: Thank you. My last question,

Q6: How important are the technical skills that bring the solution together?

LS2: Yes, so I would say the implementation of it would typically be a service provider house doing that, and they have the deep knowledge of how to put it together and make it work. The next level is the operations of it, you train your own operators to actually look at the **dashboard**, and if something is broken, you go back to the provider house for deep knowledge and then for maintenance. You might also want to go back to your provider house too. Get them to help expand or scale up or scale down, so I would say it is important to have a certain level of knowledge. The technical side is never the problem because there are enough skilled employees that can implement the solution, and then if you as a company do not want to create your own solution, do it in **collaboration with partners,** and they only **take care of the operations** of it. Exactly where the company adds value and focus on that only. So, I would say minimise your own involvement in the deep technical stuff. Only focus where you bring in value. And bringing value is if you have an operator looking at 10 cows every day are available and if not then you inform the farmer. Oh, you missed one count today. What has happened? So that is the service that you provide, and that is the level of skills that you need to look at the **dashboard and help identify issues and problems and notify relevant technicians or farmers and so forth**. I would say go up in the value chain. Focus on the top level where you provided as a service and operated. The next level is where you try to do it in house. That is where you need to focus on hiring skilled persons, and then that is the two levels I would focus on and my clear advice. **Move up the value chain to where you gain the most value compared to your needed technical skills**.

Researcher: Thank you so much. It has been insightful, has been great. I have to inscribe as soon as I complete my scribing or would probably share with you just for validation in terms of where I have captured what you have shared with

me accurately. I would like to thank you for your professional time in your valuable time. Thank you so much. It is really appreciated and have yourself a good one.

LS2: Yes, thank you

APPENDIX E10: Interview Transcripts of participant TS



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The Interview Transcript - Participant TS_10

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted
- **'Participant's Rights**

10. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential

- Discuss the questioning approach
- Inform the participant of their rights to reframe from answering questions that they may not be comfortable to discuss.
- Inform the participant that the report will be made available to them on request
- Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

33. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
34. Geographical regions in which their expertise have been applied
35. Expertise applicable exposure is on which types of industries
36. Profession background and years of experience

Section B:

The participant was identified as an IoT Practitioner with over seven years of hands-on experience. The participant has a strong engineering background and has applied his skills in the manufacturing and transportation industries.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The 'participants' expertise and insights will contribute to gaining more knowledge pertaining to IoT business models and the IoT ecosystem.

Researcher: So, let me start with my first question.

Q1: What are the kinds of IoT challenges that you have mostly been confronted with, challenges that you've identified in the space?

TS: Well, thanks. There a multitude of challenges in my experience and my background in the field and through my studies. I think the first challenges is we **tend to look at IoT in isolation**. What I mean by that is that **we don't bring in the business context**. We **don't know what actual problem we will be trying to solve,** and we don't know what the **business value** we are trying to add either the customer which, could be internal or external. The second one is around **management** and the structure of the organisation. I tend to find, in most cases, management if they understand what IoT is and what potential benefits it could bring. They **don't put in the needed support,** and that could be either **financial** or by providing you with the **right resources**. I think those two listed most critical. They **'don't provide resources financial resources**. And if they **tend to support, it's not enough. W**e also have this challenge that, especially in the context of South Africa, we tend to listen to consultants a lot. We speak to a lot of consultants, which ultimately lead to some confusion. If you move past management to organisational processes, you get to the skills level. We tend to not be sure of the skills to have in the organisation. Is its **subject matter experts who will know the business and they know the processes**? -Is it **the technical skills that know how to implement the technology**? I think we struggle to find the balance between the two. **Especially in South African, we don't have enough skills,** and **if we have the skills, we don't know how to keep them**. **I think they are continuously looking for exciting things to do**. The other problem is that the workload that at times may have IoT teams overwhelmed. It is not because they 'can't do the work, there are so many things that we try to do at the same time, and **we don't focus on one thing** to make sure that it works and then move on to the next thing. I think we're all over the place, and that is at least from my background, then I want to come back to an organisation as a whole. In most cases, **IoT is still new,** usually championed by perhaps a certain Department. They say, OK, let's look at how IoT can assist us as a department. Suppose you look at an organisation that has multiple business units that should function together as a unit but are not within the same business domain. There are underlying core technologies that you can use generically across the board. **We struggle to see where we should centralise** and where we **should decentralise certain activities within the value chain of IoT**. Those are the biggest challenges, I would say. I think technical challenges, yes, you do get them, but I don't think they're that bad, there are ways around that, but I think **organisational problems** and **management problems** and **skills** for me are the big problems. I think the **interdependencies between departments within an organisation needs to be well documented and be well known because we need to know how one process would affect the other process. Otherwise, you're doing things blindly without knowing how they affect other functions in an organisation**.

Researcher: Thanks for that one. I think you have touched on some interesting items.

Q2: Do you want to expand more on the blend of skills and where you have identified challenges in those blends of skills?

TS: OK, Let's look at, for example, an IoT platform. There are several areas you need to invest in when it comes to skills. The team needs to understand and complement the technology stack that the organisation has chosen. Then a **subject matter expert is required to support the team with business knowledge to assist the team in focusing on the business challenges** to be solved. It means that you need to have someone who understands current maintenance processes within the organisation, and I also think where the organisation itself wants to go in terms of its maintenance practices, which is something I think there is not there at the moment. We tend to have meetings, but **no one is sure what they want to achieve**. If the skills are limited, you tend to be expected to be an expert at **everything and that waste time, and you ultimately can't see the value of what you are trying to do**. That is what I was referring to by saying a blend of the right skills.

Researcher: No interesting. The next set of questions, I think you've touched on some of them.

Q3: If you were to list in order of priority the main IoT challenges. Which ones would you identify as showstoppers?

TS: **I think like any other project, you need to know what problem you're solving**. I think that's the first one. Then the rest comes in, knowing what you are solving, the **business domain**. And **what is the value you going to ultimately add** like in any other project? are you planning to bring new function within the business. Is it a **new business model** that you have to adapt? You know you need to figure out things like that. Some people call it the **feasibility study**. You know, some people call it FEL-1, and I guess it also depends on the domain or industry you are working on. But **understanding the problem you're trying to solve** is key. Two, once you understand the problem, then you must know as an organisation what are skills you have and where they are missing in terms of having the right team to take on such a program. Then three is **management support**. Management support and having the right team, but you need to have the right support from management. They need to know where the project is going and what is needed from them to make it successful. They are so busy with so many things, and they forget that they actually still have to manage the team and give the team direction. So, that would be the top three. I think skills only helps if you bring in consultants if You need to have your business knowledge, and **you need to understand your processes and to identify where IoT will add value before we even invest time and money because then you can see where within that process challenges are**. Ultimately choose a technology stack that you know you as a company will be able to build competence over a period of time and stick to it.

Researcher: Thank you.,

Q4: Do you perhaps have a list of crucial IoT skills that are top of mind that can complement and make sure that the solution is delivered? Application.

TS: It is a blend of skills. Let me first focus mainly on technical skills, and perhaps towards the end, look at maybe generic skills. Let's look at **IoT, it has about 5-6 layers within the architecture,** and I want to maybe perhaps approach it from that point of view, per layer, what sort of skills you would need. Let's start with devices, and I think what's key if they are remote, they need to be able to communicate with each other. They need to be **able to save power over a period of time**. At a device level, you need people to understand **software development**. After development, I think you need **hardware engineers**. You also need people to understand **communication protocols**, who understand different communications and how they interface with each other. Over and above that, you also need **network engineers** to some extent as well, because then the interface between your service in your devices so and also in some cases your device can be mobile, they'll be going through different tech stacks, so you need people to understand networking handovers. Then from there, it's the **Gateways**. I think those are the key guys that need to be there and depending on an application that you're doing, and you require a **business subject matter, an expert within that applicable area**

Researcher: So, I've gathered you listed mostly technical skills? Yeah, let me get the other skills.

TS: So then the best **management software I think there is a matter of knowing the software, knowing different communication protocols** and knowing how you can manage like things like updates nor then from there think it's design, design patterns, how people, what is the best practices out there and it really comes with experience. You know that's over and above the three already mentioned. I think you need someone who is good in **software architecture,** and that will include things like your **enterprise architecture**. Things like your design patterns and those are the most important and understand different frameworks and their weaknesses. Then on the storage site. What is key is your **SQL** and understanding different. But it's technologies and what they offer, but they don't offer, but over and above that, I think it's your **data management** that is very key. Having someone who can model who can look at a business field or a business domain a model that domain you know at an object level. A software engineers with subject matter expert knowledge, APIs, I think that you basically need your software engineers. UI expert and **web technologies** and your **data analyst,** that term for me, for now, include your **machine learning**, guys, your statistician. to sum it up, I think then someone will manage such a process that you're. **Business analysts**, your **systems engineer** type of guys and your **project managers,** your **marketing** guys, maybe marketing will also depend on the type of

problem-solving, whether it's an internal project or external project. I think marketing is quite important. Then someone who understands security, people who can govern your platform.

Researcher: Great, thanks.

Q5: if you were to implement an IoT solution design within the context of livestock farming, what would you identify as potential challenges within the context of livestock farming?

TS: Challenges, right?

Researcher: ' 'It's an open question. You can bring in any other aspect of IoT.

TS: I think the first one for me would have the ability to always transmit data. So, having **network communications**, yes, things like **Sigfox**. But then there are those narrowband type communications. Then you will get your **mobile network operator but will struggle to get network within remote areas**, right? So, I think the challenge will be having a network that will expand to remote areas in a cost-effective manner and still have enough bandwidth to send the small packets, but a lot of them at the same time. So, you need something that has a long-range of communication, and it must be cheap at the same time. Then the second challenge would be the intelligence you will put in your **devices**? cause then how do you know if, for example, if livestock has been stolen or is just running around? I think you will need to have such intelligence within the device. You only want to send an event of concern and sometimes just ping the device to check if it's still functional, and that is the intelligence within the device. Identifying what sort of **sensors** you need in a cow and device management, how to provision devices, manage the updating of device software You would probably have lots of data from different customers, so you want to allow them to see the data and make decisions from there, and also **integrate with third parties**. So, I think having that intelligence in your **smart devices** will be most critical, followed by **having the ability to send that data to a remote server** and having that ability to **disseminate data** to **third parties and your clients**. Over and above those put **applications** that have the right business data,

Researcher: Thank you very much.

Q6: What are other notable items that you would have considered as necessary when implementing an IoT solution that may not have been covered by my line of questioning?

TS: I think, just to summarise. It's quite important not to go for a big bang approach. First, you need to get focus. Implement the small stuff and learn from the mistakes all the time. In a way, I think it links with knowledge

management, even knowledge management, in the sense that you continuously learn from your mistakes. Your team continuously share with each other continuously learn from each other because things change quite quickly, especially in this space. Note challenges and be ready for them and be resilient. 'Don't go it because you think it will bring immediate success but doing it knowing that you have a vision and you continuously everyday learning to get to that vision, then improving on what you already have. I hope that helps.

Researcher: Yes, it helps. I would like to give thanks with regards to expert insights. It's been valuable and insightful

TS: Thanks, looking forward to it, and I'll send you the consent form so shortly after. OK, thank you. Thank you. Bye.

APPENDIX E11: Interview Transcripts of participant MY



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The Interview Transcript - Participant MY_11 (MY)

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted

Participant's Rights

Discuss the contents of the Research Informed Consent Form as part of the ethical procedure

- Provide assurance that the data will remain private and confidential
- Discuss the questioning approach
- Inform the participant of their rights to reframe from answering questions that they may not be comfortable to discuss.

- Inform the participant that the report will be made available to them on request
- Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

37. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
38. Geographical regions in which their expertise have been applied
39. Expertise applicable exposure is on which types of industries
40. Profession background and years of experience

Section B:

The participant was identified as an IoT Service provider covering the Middle East and Africa region. Manages the delivery of IoT solutions that are designed to generated business value across multiple industries.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The 'participants' expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

> **Q1**: What are the kinds (sorts) of challenges that customers would like to be addressed?

> **MY**: One of the biggest problems when it comes to ideas that you will find a lot of customers coming to us, like guys, would like to build this solution. When you ask them why? Believe it or not, the majority of customers, and it is a fact. I'm covering the Middle East and Africa, and you would **find that they don't know why they get into IoT**. **Sometimes they just want to follow the trend**. OK, sometimes they feel like this is the way of doing digital transformation. It is not a technical solution, I mean, it is definitely a technology solution, but **it**

is a business solution before anything else. You need to look at it from a business perspective. When it comes to IoT, my main audience is not the typical IT within a company. Sometimes IT is empowered, but **IoT is a business solution**, not an IT solution. If I go to a customer and I see customers coming to us, we would like to build this solution. They do not know why? Or yeah, we would like to do this. OK,

why do you want to do this? Why do you want to connect these machines? Because we want to see the numbers of those. Why do you want to see the numbers? Is it? Is it big? **I mean, what is the value when you are thinking about a solution**? I would say like it is really in the heart of a digital transformation in another company has to be when you are building that solution, you need to think of looking at **reducing costs**, right? I mean, you need to find that **quantitative work or quantitative figures** you would find to **reducing costs**. Are we trying to improve operations? Then identify the customer service that I am going to provide. Right, eventually, all of **the work you are doing has to be defined into a dollar value**. If you cannot, and that's very common, if you cannot **reach that dollar value, then you need to go back to your business side** of things and try to **learn why are you doing this**. If it is a factory, why am I if I want to implement the predictive maintenance solution? Why I want to do this is, do I have a lot of downtime within my factory? If the answer is no, then fine, then why do you even need a solution. The thing is, what if I have a lot of downtime in that downtime when it happens on a frequent basis? It cost me an X amount of dollars per month or per year, then this and then that would eventually convert for some customers that could be millions of dollars per day for some customers that could be a few thousands of dollars per day. Is it really worth it from an **ROI perspective**? **You need to calculate the business case** before the technical use case. **The biggest problem with IoT projects is that you'll find a lot of customers jumping right into the technical use case before going first into the business case**. Why do we want to do this? **Is the ROI defined or not**? after you do all this work, then fine. OK, then this solution is very important to build. Then you jump into the technical use case. Whether you're going to use this platform or other platforms. Then that's a technical discussion, whether that platform is scalable enough? Is it secure or not, right? And then that's when you try to weigh your options, but you will find a lot of cases is happening from the other way around. But then the first question that a lot of people miss is why are we even doing this? And that's where you find a lot of PoCs or pilots fail. Once I'm done with this, what am I doing next? OK, what are the **KPI or the success criteria** that would ensure the continuity of going beyond the pilot or a PoC into production, since that is the whole point? My work is about going into production, not into building a PoC or Pilot.

Researcher: No, thank you very much. I think you elaborated very well. So, Mohammed, my next question would be Q2: Which industries are more likely to realize the benefits of IoT?

MY: It depends, really. It is in almost each and every industry. If you think about Vehicle with me like transportation is definitely one, smart buildings. I mean anything that you would put the word smart to it. It would probably have an idea factor in it. I mean so for me, like covering the Middle East and Africa, for example. If I look at South Africa, mining customers, I am talking from a proportional point of view, yes. Well, I think the mining industry is very good in South Africa. Going to Germany, for example, you find manufacturing. Within Europe, vehicles and transport are related. Governments can definitely be part of an IoT like smart cities, which includes smart building, energy management, smart transportation, smart infrastructure, smart metering, and other several use cases where I will study? I mean, like health care, right? If you look at a hospital, for example, the smart building of that hospital, that is an IoT project. It is my smart energy solution that's horizontal. So, you got a vertical and horizontal solution. The horizontal solution, for example, smart building that would work whether this it is in a bank in a financial sector, or a hospital which is a healthcare industry

Researcher: So, in South Africa, looking most within agriculture. If you look at livestock,

Q3: How viable is the application of IoT in livestock farming within the South Africa context.

MY: Yeah, 100%, I think so. Whenever you look at IoT, it is more about **when there is a problem. I would say that's when IoT really thrive**. Right, that is how I look at it. The problem with the likes of livestock, it depends on your customer. **If the customer is aware of what IoT can do as a solution** or not, that is one of the biggest things that I always look at. They might be aware of how they can track the livestock, for example, but the question is, why would you even want to track livestock? Is it because you want to increase your production, or you want to track illness? You want to track where these maybe animals have been or use it to isolate those animals for quarantine. I mean, these are the things that you need to think of and the questions before you can jump into any other thing. How is all this really costing me? **How can I increase the production by 10%, and how much that 10% would eventually turn into a dollar sign for me? If it is, is it really worth it to invest? Put all that investment or not?**

Researcher: Thank you.

Q4: What are the types of business models that are conducive to customers when rolling out an IoT solution in a customer environment?

MY: So, the whole world is moving toward the Opex versus Capex model, right? So, **pay as you go** is always the safest option. But it also depends, some customers want to own everything for themselves. There is no model that you

know is better than the other, but I see like the world is moving towards the Opex model. It does not make sense for the customer to buy everything now is. Here is the thing, buying devices. Try to think of it that way. I am buying those devices like 100,000 devices. The question is, these devices have a device life cycle. Are they going to last you long? Five years, ten years? I mean, if the device lasts less than that probably may be a problem for you when you think about buying devices. During those years, you need a support plan. It depends on your model. do you want to put the whole money upfront and buy the devices upfront? Or do you want to actually rent devices? Probably it would be a cheaper and less risky approach. So, there's no right or wrong. Eventually, it is a decision that needs to be taken based on the ROI and sometimes regulations as well.

Q6: How important are strategic partnerships in providing IoT solutions?

MY: So, **the ecosystem of the IoT is fragmented**. I mean, that is how it is. It is a fact, and the fragmentation has to do with IoT touching too many different things, talking about **hardware**, we are talking about **connectivity**, and we are talking about **different protocols** were talking about **security**. I mean, we are talking about the **device providers. We ar**e talking about the **cloud.** Monitoring the other thing is you need someone who is maybe **specialist in data science** company **machine learning models** for you right? And how are you going to **maintain the solution** stuff? So, the problem of multiple partners together to come up with the right one that is hard or having to work with multiple partners can be painful for some customers. I have seen partners accusing each other when things stop working. The best thing is honestly trying **to avoid having multiple vendors** have a single vendor. Yes, maybe that vendor would outsource to other vendors the sourcing of devices, connectivity, platform and the likes. But having multiple partners is not always the best-case scenario.

Researcher: Thanks

Q7: Is there any other thing that you would deem as crucial in the application of IoT?

MY: **I think that the ROI part, the business case, always is the heart of any solution success again**. I had a customer before without mentioning names, but that customer is in the food industry. I remember the customer came to me. They would like to do a connected factory. I would like to connect each and every device within our plants to the cloud, and **the question is why** they **do not know,** and they said because our management said we need to do that, and I was like no I am not going to work with you just because of your management. What are your pain points, and then I kept interrogating them? What, are your biggest issues? Do you have any downtime? Yeah, we do. How much time does it occur, OK? If you even reduce those downtimes instead of

five or seven days until the end, if you even reduced it, they have millions of dollars of savings from you. Once you turn that on within a customer's head, even if they do not have the budget, I am telling you they are going to make that budget. Why? Because that is millions of dollars. Then, believe me, eventually, whatever they are going to pay for the cloud, for the project to build a solution, they are going to get the ROI right away.

Researcher: thank you

Q7: Do you find that the technical aspects of IoT can be a failing point?

MY: Yes, they can. I mean, luckily, I have never had that before, but they definitely can. I have seen customers coming back to us because they had a project in production, but it failed. Why? Because of that cloud provider provided them with the solution. The solution would not scale, and that is the problem with the idea to only build a PoC. They are the easiest to build. The question here is about **how can you do it at scale?** That is the trickiest part. How can you do this when you have a million devices? So, **do I have the right security** that would prevent things like denial of service attacks, all of the threat modelling, spoofing, elevation of privileges, and that's where the technical discussions would come in? You need to understand why you are choosing a specific platform, right? Because first of all, you need one that can scale, it must be secure, can connect to virtually any device. One thing you always need to avoid as a customer is vendor locking, and we find a lot of solution providers stuck in these types of contracts. But now they found that older solutions are not open source, known open protocols, no open standards, nothing like that. They are using their own proprietary protocols and so on and so forth. So eventually, what they get vendor locked based solution It costs millions because now they are locked in with that partner with limitations on scaling horizontally.

Researcher: Thank you so much. Great thanks for your time, your expertise, your knowledge. It will go a long way. Thank you very much, I have captured the notes, and I will share those notes with you just so that you make sure I have captured them correctly. Thank you.

MY: OK, bye-bye.

APPENDIX E12: Interview Transcripts of participant NS



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The Interview Transcript - Participant NS_12

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted

Participant's Rights

11. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable to discuss.
    - Inform the participant that the report will be made available to them on request

- Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

41. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
42. Geographical regions in which their expertise have been applied
43. Expertise applicable exposure is on which types of industries
44. Profession background and years of experience

Section B:

The participant was identified as both a service provider and part of a group of farmers that busy evaluating an IoT solution within livestock farming. The farmers' group meets with a large community of livestock farmers and can provide insight into challenges faced by livestock farmers in the South African context.

The aim of the questioning to positioned to explore the determinants in the application of IoT solutions. The 'participants' expertise and insights will contribute to gaining more knowledge about IoT business models and the IoT ecosystem.

Researcher: I am going to ask you questions based on the two business hats that you wear. The mixture of questions will be based on your role as a solution service provider and livestock farmer. Is that OK with you?

NS: Yeah, OK, sure.

Researcher: So, we will start quickly without wasting more time. So, I will start with the service provider type of question.

Q1: What kinds of sorts of challenges would customers like to have addressed within livestock farming?

NS: I think mainly livestock in South Africa estimated that about 10 billion Rands worth of cattle is stolen every year. Hello. So, livestock farmers are most concerned with livestock theft, which would be at the top of their priority list.

Researcher: OK, so the leading question to that is linked to livestock theft. Do use

Q2: Do you see livestock theft taking place throughout South Africa? Or do you find it in specific areas where it is a real challenge?

NS: Yeah, I would say it is in specific areas. So, if you live very close to the community or very close to the national border, there is a high risk you will lose cows that will be moved across the border.

Researcher: OK. So, there are specific hotspot areas, and those are closer to the border.

Q3: Do you mind sharing which areas are exposed to theft?

NS: Yeah, it is Lesotho, Underberg, Matatiyela, Kokstad. Those kinds of areas, yeah, if these people come in and take 50 cows, 100 cows at a go, and Fifty cows, that is almost a million Rands.

Researcher: So, you are talking about 50 to 100 cows at one go that can be stolen within these areas in terms of transporting these livestock,

Q3: What form of transportation is being used to move around? About 50 to 100 cows?

NS: OK. Yes, and mostly on food.

Researcher: So, another question.

Q4: Are livestock farmers receptive to technology-based solutions in this instance, such as the Internet of Things? Is that something that they are familiar with?

NS: I think everyone is willing to listen. The issue comes down to **pricing,** mostly. That is almost always the first thing you hear. And then how **effective or efficient the solution** would be, and mostly those are two main concerns from farmers across the board,

Researcher: so, you have indicated **pricing**. This would be the pricing of the solution

NS: Correct, yes, with cows, you know, **IoT has been used extensively to track elephants, lions and most expensive rhinos and all that stuff, you know, but with cows, the commodity is very cheap in comparison**. So, let us say, for argument's sake, a value of a cow is 10,000 Rand. Then the question is always asked, how much should be an acceptable price to protect an asset that is worth 10,000 Rand. Yeah, so if it is the solution comes and quote a price of 5000 Rands to protect a 10,000 Rand asset may be a challenge. Again, that is just an example, however, and the price point needs to make sense.

Researcher: thanks for that one. I think it makes sense. Because you are giving it a perspective, so you have an asset of a value of 10,000, Rand in his entire life span right, so it is the schedule that can be purchased as you indicate there around about their 10 12,000. Rent so if you are coming with the solution and their livestock. Farmer has probably 100 of those. They then have to find a solution that would make business sense. For the entire head at a price point that is attractive for them. To see the benefit of having that asset living up until it is purchased rather than it being stolen, so with that, said in your space. Where do you find where you are meeting the customer, in this case, livestock farmers, with a solution that? Maybe it is price or list, for that matter is that the approach may be there to find. Being much more attractive rather than outright ownership of the solution to the farmers and being a service that maybe you come up with a different business case to allow then the value to **the business case** and the **ROI** to be above the actual cost of the asset.

Q5: Do you find the total cost of the solution is attractive to the targeted farmers?

NS: Yeah, so for us with the group of farmers that I am part of from day one, we always have people saying they have got a solution. People may have a solution **but do not seem to have a use case**. OK, who is willing to pay for this thing. And the man did I want to know so in our case, you know. We are using the technology as a tool to make the investor happy; you know, and the investor? Who is the owner of the cow has a vested interest? In knowing more about the cows, they own. So, then we have created a way of ensuring that. The investor in the cow has the means to know the status of their asset. This is how we use technology to provide assurance to the customer who may be far from Johannesburg. Therefore, the investor subsidises the solution, which makes the price point attractive.

Researcher: thank you. I think that makes sense Because then it talks to that **business case you are talking about, so there is a use case**. There is a business case, and the business case looks at the investor who has the interest to ensure their interests. As part of the **business model,** that way, it takes away the strain the pain away from the actual livestock farmer themselves but allows **them the accumulated cost to be shared across**

those who are investing. I think it is the perfect business sense, and I do not have a lot of questions left,

Q6: Have you found that the challenge of network connectivity is something to be concerned about?

NS: Yeah, so we have had to solve that problem. in an ideal world, each cow will be wearing a device. You know, that tracks everything, every second, and that's in a perfect world. So, the challenges have been that we had to solve. We eventually **resolve that by using SIM cards**. The other option would have installed a **base station and have these devices connect to the antenna. However, that is not yet possible at this point.**

Researcher: Thank you for that, and then maybe another question.

Q7: How is the transition the technology from the service provider over to the farmer?

NS: Yeah, so no, the interface days that is the App that we use. So that the family would use it to track and monitor the cattle, so, we have developed an interfaces alert system that works on the App and via SMS as well where. Where even someone who does not have the App and then we can get an alert that there's something wrong happening with this specific cow at a specific farm. So, then some can consume the data is coming out of the device.

Researcher: My following questions.

Q8: Can this IoT solution you are referring to be positioned to target small and medium livestock farmers? Instead of large commercial farmers?

NS: 100%. So, for the rural guys. They are the ones who suffer the most from theft. People just come in and empty the crawl or come guns blazing and tell everyone to stay indoors, and anyone that comes out will get shot. With cattle, theft for the small farmers can happen while asleep, and when they wake up, there is nothing or a brazen theft at gunpoint where I am forced to lock myself in the house while people help themselves to my livestock. Yeah, so our solution should be able to work on any of those two occasions. If the person is locked inside the house and cannot call the police, the solution should alert through an SMS to alert security.t and who call the police for support.

Researcher: Thank you. It not much of a question. I would probably like you to share where we are in the South African context on this topic.

Q9: What are other notable items that your company considers crucial in the application of IoT solution within the livestock farming sector in SA?

NS: Sure, there are many things that I could think of. There was a study that was done about why poor farmers remain poor. But here they were studying why poor farmers in India and the same in Africa remained poor? The farmers would have an option for insurance on their asset but will opt not to take it. During the monsoon season, the rains result in insurmountable losses in livestock and other assets. It was studying the psychology behind the farmer in his right mind would not ensure assets knowing that there is a probability for losses. This behaviour translates into the South African context as well. If you look at the farmer, knowing very well that this cow was going to die. They would pass out an opportunity to ensure the cow at R1000, which is worth R10 000 to R12 000.

NS: Yeah. It is one of the main things that keep farmers from adopting new solutions, whether it is insurance, better seeds or better technology. So, going back to the adoption of technology, we found exactly the same constraints in terms of the mindset that would be there. When we presented a collar that can solve a farmer's problem, we picked up on the same behaviour. Our approach was to change the behaviour of people, and to achieve that, we needed to change the owner of the asset owner of the asset is? So, if the owner changes from a farmer to a person with an invested interest in owning a cow as an asset. The farmer no longer has much of a choice as now he needs to ensure that the cow lives. That is the model which seems to have to change the mind. There are psychological factors that lead to some of the decisions from farmers.

Researcher: That was such valuable insight. That that I have to say. I think your analogy, and especially we tend to see this a lot in your knowledge on cars. You buy a car for some awkward reason. You believe that insurance is a waste of income. You then cancel this thing with the mindset that somehow maybe nothing will ever go wrong, and I think that analogy then clarifies it, and then I like how you are then linking it into those being a stumbling block that you had faced with that mindset of farmers who are saying I will not pay 1000 RND as an example to have the interest of this and the change in the mindset and having someone whom I am then looking this on behalf, then propels the farmer to start thinking differently. This asset is not just mine, and it is a guaranteed payment from my investors. I am now a Guardian or custodian of this asset for someone who has invested interest, and therefore, the mindset takes a shift. It is no longer I about me as a farmer but a service provider in livestock management.

APPENDIX E13: Interview Transcripts of participant MB



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The Interview Transcript - Participant PE_13 (MB)

Introduction

- Introduction and greetings
- Provide background on the purpose of the study
- Refer to the info sheet shared with the participant for context on the study
- Indicate how the interview will be conducted

Participant's Rights

12. Discuss the contents of the Research Informed Consent Form as part of the ethical procedure
    - Provide assurance that the data will remain private and confidential
    - Discuss the questioning approach
    - Inform the participant of their rights to reframe from answering questions that they may not be comfortable discussing.
    - Inform the participant that the report will be made available to them on request

- Inform the participant that the transcript will remain anonymous and confidential

Permission

- Request approval to record the interview

Section A: Contextual questions

45. What area of expertise within the Internet of Things value chain?
    - To establish which set of questions are applicable (IoT practitioner, IoT service provider or customer)
46. Geographical regions in which their expertise have been applied
47. Expertise applicable exposure is on which types of industries
48. Profession background and years of experience

Section B:

The participant was identified as both a livestock farmer situated with the Kokstad areas in South Africa. His farm is located amongst a community of livestock farms, and he owns and manages a herd of cattle, sheep and goats.

Researcher: Baba, thank you for granting me the opportunity and time to discuss livestock farming. I will be asking you several questions about your farming business related to challenges and possible needs that can assist you with your daily activities. Is that OK with you?

MB: There is no problem.

Q1: Are you aware of the technology known as the Internet of Things? If yes, in what relation to your business have you seen this technology being applied?

MB: The what? No, I am not aware of it. What is it?

Researcher: OK, I will provide you with a definition of what is the Internet of Things. It is some kind of technology that allows the farmers to tag or install devices on their livestock. These devices can collect information about the livestock, such as their movement within the farm. Farmer can access information about their livestock movement patterns from their mobile phones.

MB: OK, I have heard about it when visiting farming events. They also try and sell us these flying drones for us to use in checking our cattle.

Researcher: That is great.

Q2: What is the list of items that keep you (Farmers) awake at night regarding your business?

MB: The biggest problem or problems that I have, is the loss of animals. In this area, we have high levels of crimes. Sheep and goats get stolen almost daily. If criminals do not steal them, they are eaten by wild animals. So, we spend a lot of time accounting for stock and patrolling the fence, checking for any break-ins into the farm.

Q3: Do you find that the theft incidents are more prominent than that of wild animals hunting your livestock?

MB: There are about two incidents of cattle related theft a month. But the sheep and goats are at high risk for theft as they are small in size and can easily be transported with little notice, even in a small car. The sheep and goats incidents occur two or three times a week. So, in my case, so example, my farm is in the middle, right in the centre of other farms. So, it is difficult for thieves to access my farm as they need to go through the surrounding farms to get to mine and also, other farmers can easily catch them while they are busy jumping from one farm to the next. You see, in my case, the biggest problem is the rooikats and jackals hunting my sheep and goats. Predation is one of the biggest problems in the area. In the year 2020, yeah, it was 2020. Out of 152 sheep, 35 were lost to rooikat and jackals. If you look at those numbers, I lost a lot of money just last year. So, we have to count livestock at least once a day, mostly early in the morning.

Q4: Besides theft and predation, do you experience animal losses due to sick livestock?

MB: No, sick animals are not an issue; for example, I have anti-biotics. Once an animal shows any sign of sickness, I can feed it anti-biotics. But, it does happen in some cases we have an outbreak, but the biggest disease that we get is redwater. It is a tick-borne disease then I call a Vet to come out to assist.

Q5: Do you believe that you have the impact of livestock theft or predation under control?

MB: As farmers, we have hired services from a livestock security company. They have since installed cameras in entry and exit point to keep watch of unknown cars that criminals use to transport livestock. We have had some successes, but other thefts have not been picked up by security. The community works together to try and minimise the impact of theft. Other farmers have bought drones to patrol the area for suspicious people. But the predation situation is a bit difficult to manage or control.

Q6: How is the network coverage in the area? Do you experience challenges with the network?

MB: The network is very bad and unreliable such that we use two-way radio to communicate with security and other farmers. We find that to be more reliable and cheaper. Sometimes calls go straight to voicemail without ringing, and you miss important calls, and at times you cannot even make calls, and you need to move around to get a signal. I ended up buying a booster to use the internet for my business, and the signal is much better.

Q7: Which mobile network provider do you use?

MB: Ha-ha, I have SIM cards for all the network providers, but Vodacom and MTN are much better. When the one gives me problems, I switch to MTN

Q8: Would you consider using technology like IoT in your farm if it could assist in giving you visibility of your livestock?

MB: Visibility? How?

Researcher: if you can see the whereabouts of your cattle or sheep while they move about on your farm and monitor their heart rate all from your phone?

MB: Ha-ha, how would knowing the heart rate help me?

Researcher: For example, if a wild animal or rooikat is chasing a sheep, the device on your sheep or cattle can send you an SMS informing you that your cattle or sheep are moving at an abnormal speed. If the heart for your livestock is no longer visible, it could mean that your cattle have been killed. Another one if someone steals your sheep the moment it leaves your farm, you can be notified of possible theft.

Q9: If you can have such technology, would you consider it for use on your farm?

MB: Ha-ha, I hear you. So, it works like a tracker? A car tracker?

Researcher: Yes.

MB; So, I can track my sheep or cattle?

Researcher: Yes, and which means you could also count your livestock without driving out to them.

MB: OK, that could work because it means I can see all my animals, but I will still need to inspect them to assess their physical condition, but it would be less frequent, maybe once a week instead of every day. Yeah, that could work for me. But the counting is done mainly by the herd boys

Researcher: Thank you very much. I know you had indicated that you are busy, and I would not want to keep you any longer. The information you have shared with me is of great value, and I would like to thank you once again for your time and expertise. It is greatly appreciated.

MB: OK bye, thank you

APPENDIX F1.1: Case study 1: Farm water monitoring

Problem: How do I know if my water tanks need to be refilled?

Customers	• Farmers
Needs to address	• Water availability for animals. This is particularly relevant in dry lands (e.g. certain areas of Africa)



Technologies

Feature	Requirement	Comment
Network Area	▪ Wide	Extended fields in remote locations can require significant signal coverage
Spectrum	▪ Shared / Dedicated	Quality of service of transmission is not a crucial factor
Battery life	▪ Long	The sensors may be placed in remote points of the field and need to have long battery life. Solar panels may contribute to extending battery life
Connectivity cost	▪ Low	Associated to the low bandwidth requirement
Module cost	▪ Medium	Price may be an issue in developing countries
Bandwidth	▪ Low	Data needed to monitor water level is limited

Technologies: LPWA | 2G |

Source: (Chaabane, 2017)

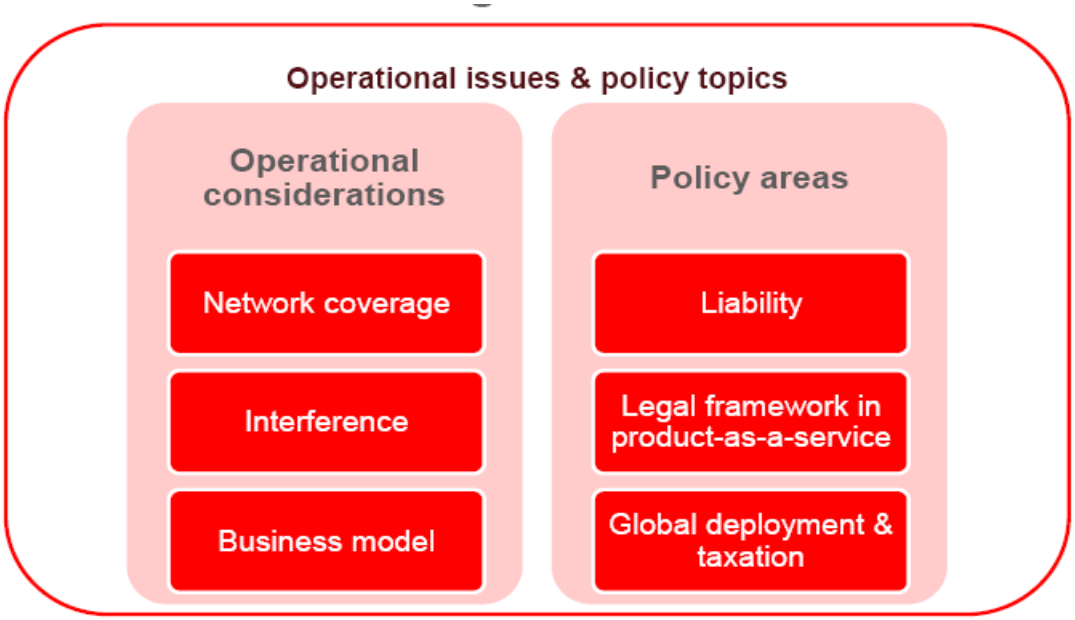
APPENDIX F1.2: Case study 1: Farm water monitoring – most likely business models

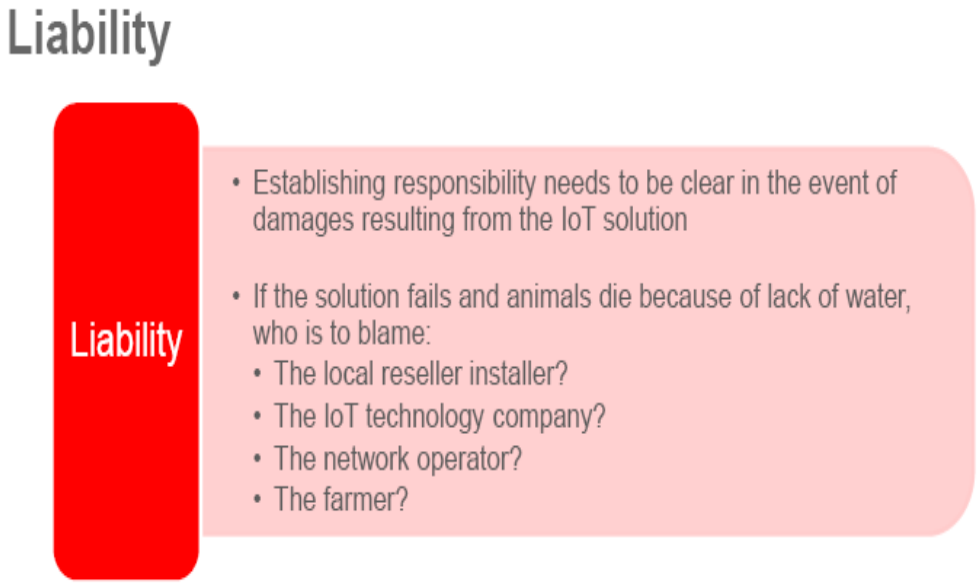
Business models	Revenue of the IoT company	Device ownership
Revenue-sharing	Recurring	IoT company
Cost-savings sharing	Recurring	IoT company
Product-sharing	Usage	IoT company
Product-as-a-Service	Recurring	IoT company
Performance-as-a-Product	Usage	User
Transactional	Upfront	User

Most likely business models

Source: (Chaabane, 2017)

APPENDIX F1.3: Case study 1: Farm water monitoring





Source: (Chaabane, 2017)