NETWORK FIELD MAINTENANCE AND DATA COLLECTION IN DEVELOPING COUNTRIES – A CASE FOR LOCATION-BASED SERVICES TECHNOLOGY

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Abstract: In South Africa and other developing countries there is a major drive to expand infrastructure. Over the past 10 years millions of South African households in both rural and urban areas have been provided with electricity, water and telephone services. Once new networks have been installed the challenge is to maintain them. Maintenance personnel typically have a lower level of experience and skill than their counterparts in Western Europe and the USA. This paper describes the potential benefits of the application of Location-based Services [LBS] technology to support field work teams responsible for collecting information on, and maintaining, network-based utilities in developing countries. By providing these work teams with mobile hand-held computing devices linked via a communication network to a central geospatially-based data server, information about the network can be provided as required. In addition the proposed system compensates for the work team's lack of familiarity with computers by providing a context aware human-computer interface. This limits the amount of data input required from the operator. The principles explored are applicable to electricity, telecommunications and water networks in under-developed areas. Our University participating in Intergraph's Registered Research Laboratory (RRL) programme has made the research possible. We are pleased to acknowledge Intergraph's generosity in this regard.

INTRODUCTION

In 2002 most African countries came together to form a new political and economic bloc called the "African Union", or AU. The economic and developmental aspirations of the AU are encapsulated in a strategic plan called "NEPAD" (New Economic Plan for Africa's Development). One of the key aspects of NEPAD is infrastructural development. Bridging the infrastructure gap in Africa has been identified as an important element of promoting regional integration on the continent [NEPAD, 2002]. This strategy envisages massive investments in the construction of new electrical, water and telecommunication networks.

Infrastructural growth has also been a key feature of the development of South Africa since the early 1990's. More than 2 million households in both urban and rural areas have been supplied with grid electricity and piped water over the past 10 years. Fixed-line and cellular telecommunications networks are being rapidly rolled-out. The impressive rate of growth of network-based utilities in South Africa has, however, brought with it many challenges. It is these same challenges that many African and other developing countries are bound to face in the years ahead.

This paper deals with one of these challenges – namely the task of operating and maintaining hundreds of thousands of kilometers of new network infrastructure.

NETWORK MAINTENANCE – THE CHALLENGE

Maintenance personnel in developing countries typically have a lower level of experience and skill than their counterparts in Western Europe and the USA. In bridging this skills gap, modern information and communication technologies have the potential to make a significant contribution. One such technology relates to geospatial information systems (GIS).

In developing countries GIS technology has the potential to empower the mobile workforce. The appropriate use of computer applications based on geospatial information will improve the ability of inexperienced and relatively unskilled field personnel, allowing them to reduce costs, improve productivity and accuracy, and be more responsive to customers and clients. However, great improvements in productivity will be unlikely unless workers have the level of education and skill needed to handle the new (advanced) technologies. For this reason it is important also to ensure “ease-of-use” of the technologies proposed.

The application of GIS technology, whether in the developed or developing world, is however pointing the way to a need for enterprise-wide access to spatial data embedded in the corporate database. The implication of the demand for user access to spatially related data (asset maps, geocoded networks, field workprints and orders, dispatch, and topographical maps), requires that the corporate relational data model includes two simple additional attributes, namely "x" and "y" map co-ordinates, for any outside plant, personnel and customers.

Almost all utilities have to face the challenge of capturing and maintaining field asset records, which are required in an "as-built" format to supply accurate information to work teams in the field. With geospatial information content now more easily available it is possible to capture, maintain and access field asset data with the assistance of personal digital assistants (PDAs) and wireless communications technology, thus enhancing the productivity of field operational work-crews. The dramatic growth in business demand for mobile computing is a direct result of the natural synergy between PDAs, wireless technology, and data-driven workstyles [Intel, 2002]. Multiple studies of this synergy confirm productivity gains of between 15 and 25% per week when the mobile workforce is equipped with mobile PDAs and wireless access.

To deal with the key challenge of network data collection our University is carrying out research focused on developing appropriate business processes to achieve more productive data capture. This research involves the measurement of existing data capturing productivity within South Africa’s telecommunications company, Telkom, and the national power utility, Eskom. The "quantifiable increase in productivity" will be measured by applying the proposed business process and technology to a pilot site and then assessing productivity gains over the baseline. In a similar way data accuracy improvements will be quantified. These measurements will be conducted in an “over-the-shoulder” fashion with Telkom’s and Eskom’s own personnel to minimise duplication and to ensure that the measurements are not “skewed” by introducing alien processes through the usage of only non-Telkom or Eskom field personnel for the data capture implementation.

Standard COTS (commercial-off-the-shelf) software is being used in the new data collection process proposed, and where appropriate, the field personnel has been trained in its use. This software is Intergraph’s package called Intelliwhere OnDemand, software that operates on a standard Personal Digital Assistant (PDA) device to location-enable a mobile workforce and which has been made available to the University through the Intergraph Registered Research Laboratory programme in which Witwatersrand University is a participant. IntelliWhere OnDemand has been customised to accommodate the specific requirements of the data sourcing application. Standard data collection templates, see example in the appendix to this paper, have been programmed into the OnDemand PDA application, and have been tested satisfactorily for the field data sourcing process.

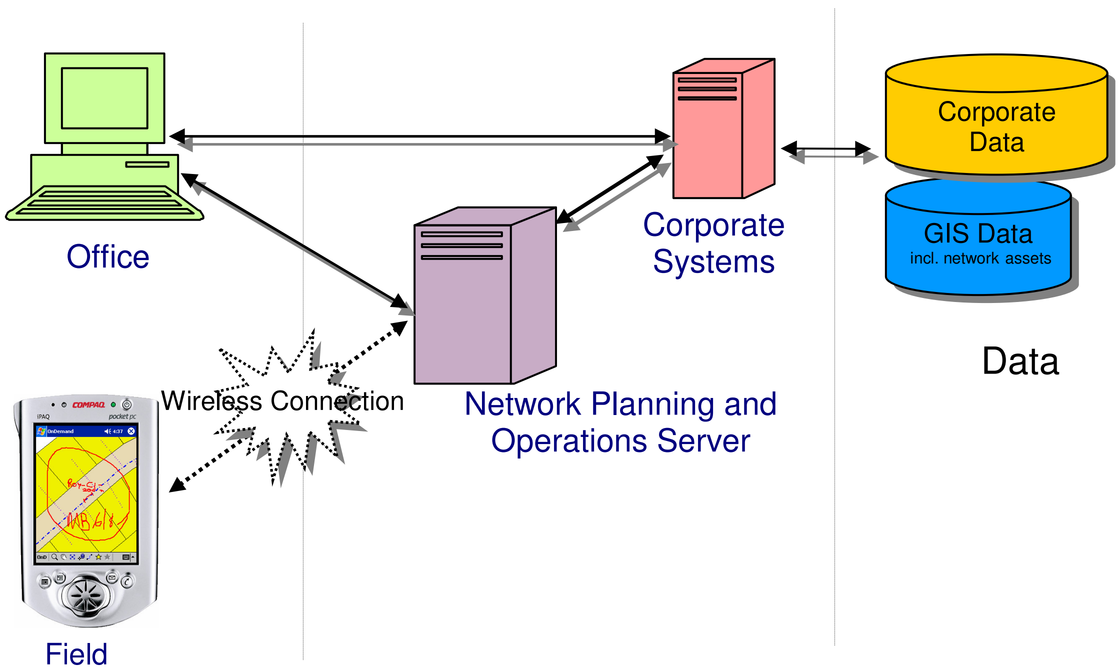

FIGURE 1: The Network Data Collection Process

HUMAN COMPUTER INTERACTION (HCI)

By suggesting the use of GIS as one means of compensating for the lack of skill and experience amongst field personnel in developing countries, we bring another significant challenge to the fore. This is the low level of familiarity with computers amongst field personnel. In this regard our research is addressing three additional questions:

1. *How and when should network information be presented to the maintenance teams on site, given their low levels of computing knowledge and skill?*
2. *To what extent can a mobile computing device, that typically has limitations in terms of its user interface and data processing capabilities, replace the roles of maps and paper-based schematics in distribution network maintenance?*
3. *Will the proposed personal digital assistant technology together with wireless actually improve the productivity of the mobile utility workforce?*

The concept of an "adaptive context" HCI is proposed as an approach to meet some of theses challenges. The objective behind the concept is to implement a mobile user interface that presents the user with the correct and necessary information at any location with minimal user intervention. This information is specific to the actual location of the user as well as being specific to the context in which this information is to be used. [Schmidt, 1999].

The development of mobile computers able to communicate via wireless technology has brought a completely different perspective and approach on how humans communicate with computers. Interaction with mobile computers is vastly different as compared to desktop computers. Desktop computing takes place in a static environment where the user is presented with a large high-resolution user interface and information is stored either locally on the computer, or may be accessed via a data network. [Cobb, 2002] states that "usability" is important for any mobile computing application or device, but it's even more important with capability-constrained devices with limited display or input.

In contrast, mobile computing has associated with it specific constraints and restrictions which result in the design of very different user interfaces. Two of the most important limitations of mobile computing are:

- *heterogeneous environments* – e.g. mobile devices operate in environments containing different mobile communication network infrastructures affecting the connectivity of the device;
- *limited mobile device resources* – e.g. the mobile device screen size, processing power, network bandwidth, battery power, etc., impose constraints on the design of mobile software applications.

It is planned to utilise this human-computer interaction principle as one of the underlying concepts for the network data collection process currently being investigated. It is crucial to the success of the deployment of new technologies for data collection, that they are accepted and effectively used by the Network Operator's existing field workers.

THE BUSINESS CASE FOR MOBILE COMPUTERS

Mobile application technology enables significant structural change in how organisations perform their tasks and accomplish business goals by moving existing business processes, whether automated or manual, beyond the organisation's office to where-ever and when-ever those can be tasked are carried out efficiently. In the recent past, one of the key obstacles to the successful deployment of mobile applications was the high cost to co-ordinate these tasks out in the field. Practice is already demonstrating that this obstacle has been overcome.

The pay-off for mobile computing comes about through lowering the Total Cost of Ownership (TCO) of the technologies deployed and lifting the Total Benefit of Ownership of the mobile application.

<u>Lower Total cost of Ownership:</u> Five years ago it was estimated by Intel Corporation [Intel, 2002] that the total cost of ownership difference between a notebook computer and a desktop was approximately $4000. By the year 2000 it had declined to less than $1000 and so the question was posed as to how much extra value does one need from a mobile computer user to make up this $1000 TCO differential. Depending upon the total cost of employment of the user itself, Intel estimated that only one extra hour of production per week to justify that TCO difference. With PDAs it could be the same, or less, so lowering the total cost of ownership is definitely feasible in this application. The reader can easily calculate the TCO applicable to its mobile application under consideration. In "Tapping the Power of the Mobile Enterprise", a white paper from Extended Systems, some tips for determining the TCO are provided, covering direct costs of the necessary software licences and their maintenance, hardware costs, data security and access measures, and staff training and device deployment costs.

<u>Higher Total Benefit of Ownership:</u> A key assumption is that mobile users are more productive. When Intel management investigated its mobile computing initiative, it had learned that mobile users realise productivity improvements of between three and eight hours per week. This analysis is borne out in most utility industries as well. According to a study conducted by the Gartner Group, business users with a mobile computer, and who spend 20 % of their time out of the office, realise a minimum annual benefit of 20 to 25% of their annual cost of employment through increased productivity and efficiency. Other benefits of this deployment, but incorporating PDAs and wireless access are quantitative (e.g. cost savings) and provide better responsiveness, better accuracy and better timeliness of, for example, network asset information. Also by having access to the corporate databases from field remote locations, the mobile user is assured of accurate and reliable information as stored in the Corporate repository. This ensures that the mobile worker can be certain that he/she has the correct tools and information (geospatial and other) for the task at hand.

CONCLUSIONS

Although the research described in this paper is still in progress, much insight has already been gained into the challenges of network information collection and field maintenance within utilities. Certainly the largest challenge by far is obtaining the “buy-in” by the field personnel themselves. However, the pay-offs for mobile computing applications are clear and for this reason the University has embarked on many different research projects, particularly involving the mobile workforce for utilities. It is anticipated that this work will assist African governments too in their dream of NEPAD and the task of bridging the infrastructure gap on the continent of Africa.

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