A MULTIDISCIPLINARY AND COLLABORATIVE PROBLEM SOLVING ARCHITECTURE FOR HIGH-LEVEL COMPUTER AIDED PROCESS PLANNING IN DISCRETE MANUFACTURING

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A thesis submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in fulfillment of the requirements for the degree of Doctor of Philosophy.

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DECLARATION

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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(Signature of candidate)

___________ day of ______________________ (year) 2006

ABSTRACT

One of the most daunting challenges in Computer Integrated Manufacturing (CIM) is bridging the gap between Computer Aided Design (CAD) and Computer Aided Process Planning (CAPP). Past research into CAPP, considered one of the most important and most complicated computer aided systems, resulted in a wealth of knowledge but unresolved problems still exist. The actual CAPP systems are considered large, complex, and monolithic, with limited extensibility, low-level of integration with other applications, and high development and maintenance costs. Consequently, this thesis develops a new framework that focuses on a CAPP architecture for problem solving that manages complexity through simplicity, and applies principles and strategies used in manufacturing enterprise management, automation, robotics, and software engineering, that finally leads to a system of systems which is human-centric, architectural-centric, process-centric, and in line with the IT (Information Technology) infrastructure trends. Thereafter, the framework is used to develop a number of software applications that apply object-oriented programming as a new way of thinking about solving CAPP problems and as a promising alternative to other techniques. Then, the capabilities of the new approach are demonstrated through the use of examples. The thesis ends with conclusions about the new CAPP approach, and finally highlights its theoretical and practical implications.

To my family

Ionel Botef

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LIST OF SYMBOLS

¦ ¦	conditional OR
¦	unconditional OR
/	division
= =	equal to
!	not
!=	not equal to
&	unconditional AND
&&	conditional AND
^	exclusive OR
\n	linefeed
\r	tab

NOMENCLATURE

AI	Artificial Intelligence
AM	Agile Manufacturing
AMT	Advanced Manufacturing Technology
BFU	Basic Fractal Unit
BOM	Bill of Materials
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CAPP	Computer Aided Process Planning
CAR	Corrective Action Request
CASE	Computer Aided Software Engineering
CBR	Case-Based Reasoning
CIM	Computer Integrated Manufacturing
CE	Concurrent Engineering
CNC	Computer Numerical Control
CSG	Constructive Solid Geometry
DIC	Drawing Issue Controls
ERP	Enterprise Resource Planning
FMS	Flexible Manufacturing System
FrMS	Fractal Manufacturing System
GRN	Good Received Note
GA	Genetic Algorithms
GT	Group Technology
GUI	Graphical User Interface
IMS	Intelligent Manufacturing Systems
IWO	Internal Works Order
JIT	Just In Time
KBS	Knowledge-Based Systems
LM	Lean Manufacturing

M	Machining
MS	Manufacturing Systems
NC	Numerical Control
NNs	Neural Networks
QA	Quality Assurance
RR	Rectification and Replacement Request
RUP	Rational Unified Process
SABS	South African Buro of Standards
SADwO	South African Design with Objects
SACAPP	South African CAPP
SAE	South African Estimation
SAEM	South African Engineering Management
SAM	South African Management
SAS	South African Sales
SASM	South African Sales and Marketing
SMEs	Small and Medium Enterprises
STEP	STandard for the Exchange of Product model data
TQM	Total Quality Management
TPM	Total Productive Maintenance
UML	Unified Modeling Language
UoD	Universe of Discourse
VM	Virtual Manufacturing
YTTJC	It indicates the name for a hypothetical industrial company (see page 188 – Project Vision) for which the system "YTTJC" was developed.