UNIVERSITY OF LIVERPOOL

MANAGEMENT SCHOOL

EURO Working Group on
Decision Support Systems

WELCOME TO EWG-DSS LIVERPOOL 2012

April 12th-13th 2012

Hosted by The University of Liverpool
Management School

ewgss.wordpress.com

Workshop Proceedings

Proceedings

of the

EWG-DSS Liverpool-2012 Workshop

on

"*Decision Support Systems & Operations Management Trends and Solutions in Industries*"

Liverpool, UK, 12th - 13th April 2012

Editors:

F. Dargam, B. Delibasic, J.E. Hernández, S. Liu, R. Ribeiro, P. Zaraté

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University of Liverpool Management School

Workshop Proceedings

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*Abstracts appear in the same order that they are presented in the program.

Institutional Support

	EURO, The Association of European Operational Research Societies **EWG-DSS, EURO Working Group on Decision Support Systems** (http://www.euro-online.org/web/ewg/10/ewg-decision-support-systems)
	Management School, University of Liverpool, UK (http://www.liv.ac.uk/management/)
	University of Toulouse, France (http://www.univ-tlse1.fr/) **IRIT Institut de Research en Informatique de Toulouse, France** (http://www.irit.fr/)
	UNINOVA - CA3 - Computational Intelligence Research Group (www.uninova.pt/ca3/)
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	University of Belgrade, Serbia (http://www.bg.ac.rs/eng/uni/university.php)
	The Lanner Group (http://www.lanner.com)

About the EWG-DSS

The EWG-DSS is a Working Group on Decision Support Systems within EURO, the Association of the European Operational Research Societies.

The main purpose of the EWG-DSS is to establish a platform for encouraging state-of-the-art high quality research and collaboration work within the DSS community. Other aims of the EWG-DSS are to:

- Encourage the exchange of information among practitioners, end-users, and researchers in the area of Decision Systems.
- Enforce the networking among the DSS communities available and facilitate activities that are essential for the start-up of international cooperation research and projects.
- Facilitate professional academic and industrial opportunities for its members.
- Favour the development of innovative models, methods and tools in the field Decision Support and related areas.
- Actively promote the interest on Decision Systems in the scientific community by organizing dedicated workshops, seminars, mini-conferences and conference streams in major conferences, as well as editing special and contributed issues in relevant scientific journals.

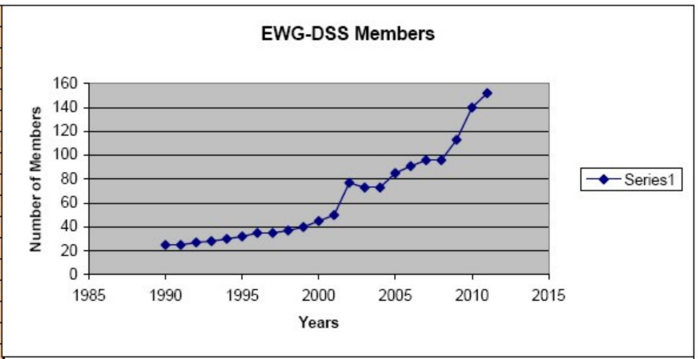
The EWG-DSS was founded during a memorable EURO Summer Institute on DSS that took place at Madeira, Portugal, in May 1989. This Summer Institute was organized by two well-known academics of the OR Community: Jean-Pierre Brans and José Paixão. It counted with the participation of 24 (at that time) young researchers of 16 different nationalities. Most of them still continue nowadays to pursue their goals, working actively in their research areas.

The number of EWG-DSS members has substantially grown along the years. Now we are over 150 registered members (see Fig.1), coming from various nationalities. Since May 2009, the EWG-DSS is also active within the social network LinkedIn, with a group that grows rapidly. At the moment the EWG-DSS LinkedIn Group counts with 125 Members (see Fig.2). The creation of this LinkedIn group goes towards our main goals, as another way to keep us working together and to innovate our interaction approaches.

Through the years, there has been established quiet a few well-qualified research co-operations within the group members, which have generated valuable contributions to the DSS field in journal publications. Since its creation, the EWG-DSS has held annual Meetings in various European countries, and has taken active part in the EURO Conferences on decision-making related subjects. The group is taking care of keeping trace of the research cooperation among the group members via a network analysis project, called EWG-DSS Collab-Net. This project is managed by the EWG-DSS coordinators and implemented by some members of the group.

EWG-DSS EURO Working Group on Decision Support Systems
Number of Members from 1990 up to 2011

#	Year :	Nr. Members:
1	1990	25
2	1991	25
3	1992	27
4	1993	28
5	1994	30
6	1995	32
7	1996	35
8	1997	35
9	1998	37
10	1999	40
11	2000	45
12	2001	50
13	2002	77
14	2003	73
15	2004	73
16	2005	85
17	2006	91
18	2007	96
19	2008	96
20	2009	113
21	2010	140
22	2011	152



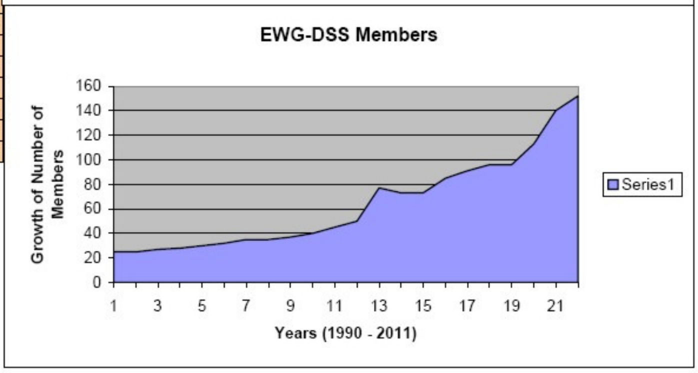


Fig.1: EWG-DSS Registered Members from 1990 to 2011

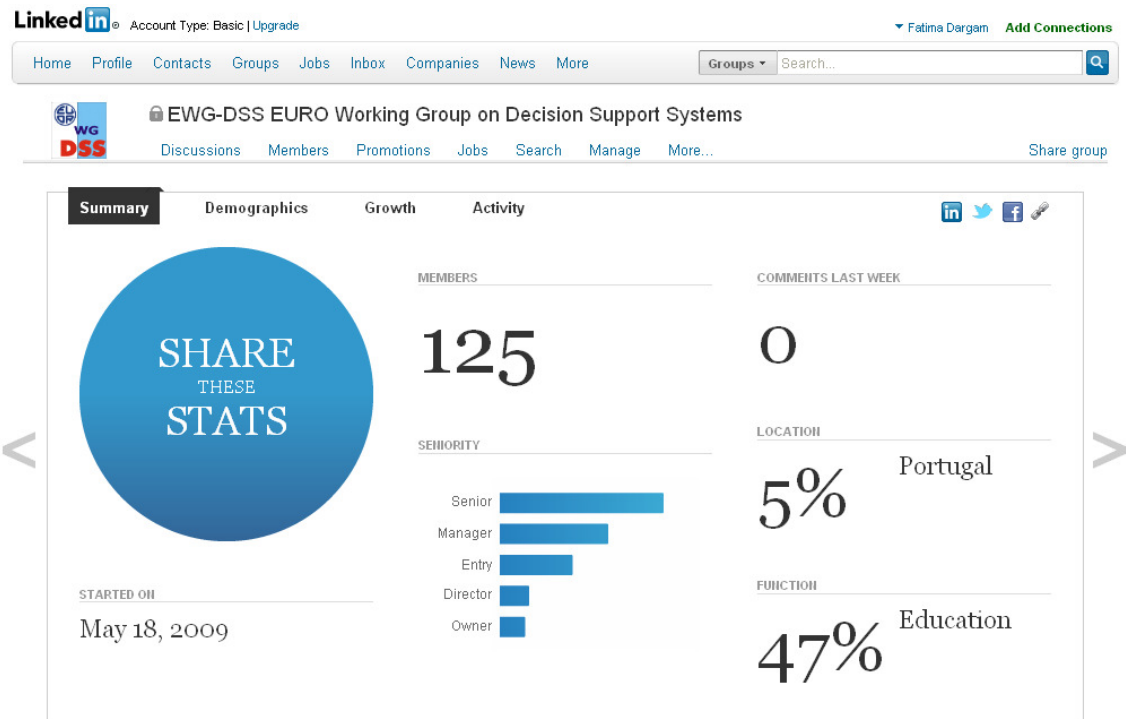


Fig.2: EWG-DSS LinkedIn Group Members (as of March, 2012)

Since 2007 the EWG-DSS has been managed by a coordination board, which main aim is to better promote joint-work among the group members and to encourage more participation of the whole group in DSS related projects and events. In the period of June 2007 to January 2011 the EWG-DSS Coordination Board was composed by: Pascale Zaraté, Fatima Dargam and Rita Ribeiro. Since the beginning of 2011, the EWG-DSS Board has doubled in the number of members.

The current EWG-DSS Coordination Board is composed as follows :

Pascale Zaraté (Coordinator)
Fátima Dargam (Coordinator)
Rita Ribeiro (Board Chair)
Jorge Hernández (Board Assistant)
Boris Delibasic (Board Assistant)
Shaofeng Liu (Board Assistant)

Boris Delibašić, Shaofeng Liu, Rita Ribeiro, Pascale Zaraté, Fátima Dargam & Jorge Hernández.
Photo: London, 2011

Joining the EWG-DSS

The EWG-DSS membership does not cost you anything.
If you wish to join the EURO-Working Group on Decision Support Systems, all you have to do is to send an e-mail to our group at:
<ewg-dss@fccdp.com>, with the following information:

Name, Affiliation, Mailing Address, Phone, e-mail, and Homepage link..

Alternatively, you can also join the EWG-DSS via our LinkedIn Group at:
http://www.linkedin.com/groups?about=&gid=1961459&trk=anet_ug_grppro

Thanks for your interest!
The EWG-DSS Coordination Board

Notes from the EWG-DSS Coordinators

The EURO Working Group on Decision Support Systems (**EWG-DSS**), in cooperation with **the University of Liverpool Management School**, has the pleasure to organize the **EWG-DSS Liverpool-2012 Workshop** on **"Decision Support Systems & Operations Management Trends and Solutions in Industries",** during the period of April 12th to April 13th 2012.

Following the success of both "EWG-DSS London-2011 Workshop on Decision Systems" in June 2011 and the "EWG-/ DASIG Paris-2011 Joint-Workshop on Policy Analytics and Collaborative Decision Making" in December 2011, the main purpose of this Workshop is to provide an informal setting in which the participants can have the opportunity to meet and discuss technical, methodological and social aspects involved in the development of Decision Systems, with focus on industrial solutions and operations management current trends.

The EWG-DSS Liverpool-2012 Workshop has attracted the participation and interest of many professionals in the decision-making research area. It presents a total of 20 research contributions, and 6 special talks. The Workshop is organised in 6 contributions sessions, distributed in its 2 days, which contain presentations in the areas like "Collaborative Decision Making in Industries"; "Knowledge Management and Decision Making"; "Simulation-based DSS"; "Decision Systems applied to SMEs"; "Decision Systems applied to Supply Chains"; as well as "DSS in Design, Management and in Social Networks"**.** The rich diversity of topics and approaches of Decision Making presented in this Workshop is itself an invaluable source of inspiration for further investigations in the area.

The special talks of the EWG-DSS Liverpool-2012 Workshop will be presented by **Dr. Paul Drake**, Head of Marketing and Operations Management Group, Management School, University of Liverpool, UK; by **Prof. Pascale Zarate**, *Professeur a l Universite Toulouse 1 Capitole (UT1C)*. France; by **Mr. Tony Waller**, *Lanner Group*, UK; by **Dr. Stephen Childe**, *senior lecturer in the School of Engineering, Computing and Mathematics, University of Exeter*, UK; by **Prof. Peter McBurney**, from the *Agents and Intelligent Systems Group of the Department of Informatics at King's College London*, UK; and by **Dr. Zenon Michaelides**, from the *Management School, University of Liverpool*, UK. We are extremely proud of having such a highly recognized and competent team of professionals to deliver the special talks. Hence, we can already be sure that this Workshop will be a very interesting event for us all!

Last, but not least, the EWG-DSS Coordinators want to express here our deep gratitude to **EURO** for the financial support directed to the organization of this EWG-DSS Workshop; and also to express our special thanks to our colleague and EWG-DSS Coordination Board Assistant **Dr. Jorge E. Hernandez,** *Lecturer in Operations & Supply Chain Management,* *School of Management, here at the University of Liverpool*, UK, for his great support in organizing this meeting in Liverpool. We are extremely grateful to all the local arrangements and help received from him and his Team at ULMS. ***Many Thanks*!**

Jorge, you did a great job!

We hope you all enjoy the Workshop as much as we will!

The EWG-DSS Coordinators

EWG-DSS Coordination Board: ewg-dss@fccdp.com

Pascale Zaraté	(Coordinator) IRIT / Toulouse University , France
Fátima Dargam	(Coordinator) SimTech Simulation Technology / ILTC, Austria
Rita Ribeiro	(Board Chair) UNINOVA - CA3, Portugal
Jorge Hernández	(Board Assistant) University of Liverpool, UK
Boris Delibasic	(Board Assistant) University of Belgrade, Serbia
Shaofeng Liu	(Board Assistant) University of Plymouth, UK

EWG-DSS EURO Homepage: http://www.euro-online.org/web/ewg/10/ewg-decision-support-systems
EWG-DSS Blog: http://ewgdss.wordpress.com/
EWG-DSS LinkedIn : http://www.linkedin.com/groups?about=&gid=1961459&trk=anet_ug_grppro
EWG-DSS IRIT Server: https://wwwsecu.irit.fr/listes/info/ewg-dss
EWG-DSS Mailing List : ewg-dss@irit.fr (only for Members)

Organizing & Program Committees

EWG-DSS Organizing Committee:

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Fátima Dargam, SimTech Simulation Technology, Austria
Rita Ribeiro, UNINOVA – CA3, Portugal
Jorge Hernández, University of Liverpool, UK
Boris Delibašić, University of Belgrade, Serbia
Shaofeng Liu, University of Plymouth, UK

Special Local Organization Support at University of Liverpool, UK:

Jorge Hernández, Lecturer at University of Liverpool Management School
Katie Neary, Event Coordinator at University of Liverpool Management School

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Ana Respício, **University of Lisbon**, Portugal
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Rudolf Vetschera, **University of Vienna**, Austria
Sean Eom, **Southeast Missouri State University**, USA
Shaofeng Liu, **University of Plymouth**, UK

Workshop Program

Day 1, Thursday – April 12th, 2012

***University of Liverpool Management School,* Seminar Room 5**

8:30: Registration/Distribution of Workshop Material – Management School Atrium
Welcome to the EWG-DSS Liverpool-2012 Workshop at University of Liverpool
Opening Session by the Workshop Organisers

8:50 – 9:00: Session D1-0: "Welcome to the EWG-DSS Liverpool 2012"
Chair: EWG-DSS Coordination Board

9:00 – 9:30: Session D1-1: Invited Talk 1 – Dr. Paul Drake, "Welcome to ULMS"
Chair: Jorge E. Hernandez

9:30 – 10:30: Session D1-2: Invited Talk 2 – Prof. Pascale Zaraté*, "Cooperative Decision Support Systems"* - Chair: Jorge E. Hernandez

10:30 – 10:50: Coffee Break ULMS Cafe

10:50 – 12:10: **Session D1-3: Collaborative Decision Making in Industries**
Chair: Pascale Zaraté

10:50 – 11:10: **Session D1-3.1**: A multi-agent decision support system for the collaborative decision-making in multi-level supply chains
Authors: Jorge E. Hernandez, Andrew C. Lyons, Raul Poler and Josefa Mula

11:10 – 11:30: **Session D1-3.2**: Collaborative Manufacturing Planning and Scheduling Systems
Authors: Leonilde Varela, Rita Ribeiro and Goran Putnik

11:30 – 11:50: **Session D1-3.3**: Decision Support System Prototype for Supply Network Configuration Planning and Operations Scheduling in the Machine Tool Industry: a case study
Authors: Julien Maheut, Juan Manuel Besga and Jone Uribetxeberria

11:50 – 12:10: **Session D1-3.4**: An ahp-multicriteria selection of products in industrial and technological diversification strategies
Authors: José María Moreno-Jiménez, Daniel de Arcocha, Emilio LarrodÉ and Victoria Muerza.

12:10 – 12:30: **Session D1-3.5**: Decision Analysis in Nuclear Decommissioning: Developments in Techniques and Stakeholder Engagement Processes
Authors: Simon Turner and Stephen Wilmott.

12:30 – 14:00: Lunch (served in the Management School Cafe)

14:00 – 15:00: **Session D1-4**: ***Invited Talk 3* – Mr. Tony Waller*, "WITNESS Simulation and its role in Decision Support"* – Chair: Fatima Dargam**

15:00 – 15:50: **Session D1-5: Knowledge Management and Decision Making**
Chair: Rita Ribeiro

15:00 – 15:20: **Session D1-5.1**: Knowledge management competence for ERP implementation success
Authors: Uchitha Jayawickrama, Shaofeng Liu and Melanie Hudson Smith

15:20 – 15:40: **Session D1-5.2**: Considering tacit knowledge when bridging knowledge management and collaborative decision making
Authors: Pierre-Emmanuel Arduin, Michel Grundstein and Camille Rosenthal-Sabroux.

15:40 – 15:50: **Session D1-6: "EWG-DSS 2011-Award",** Pierre-Emmanuel Arduin
EWG-DSS Coordination Board

15:50 – 16:10: Coffee Break in the Management School Cafe

16:10 – 17:10: **Session D1-7: Simulation-based DSS**
Chair: João Costa

16:10 – 16:30: **Session D1-7.1**: The value of simulation and immersive virtual reality environments to design decision making in new product development
Authors: Antony Robotham and Fei Shao

16:30 – 16:50: **Session D1-7.2**: Simulation and Modelling as a Decision Support Tool In Manufacturing: A Case Study
Authors: Hossam Ismail and Lina Wang

16:50 – 17:10: **Session D1-7.3**: Sensor Network Infrastructure for Real-Time Business Intelligence
Authors: Ahmed Musa and Yahaya Yusuf.

18:15: EWG-DSS Liverpool-2012 Workshop Dinner
at **Bistro Jaques Restaurant**
Address: 37 Hardman Street, Liverpool, L1 9AS
0151 709 1998

Workshop Program

Day 2, Friday – April 13th 2012

***University of Liverpool Management School,* Seminar Room 5**

9:00 – 10:00: **Session D2-1: Invited Talk 5 – Dr. Stephen Childe, "Decision Support and Operations Management – viewpoint from an editor" - Chair: Shaofeng Liu**

10:00 – 10:20: Coffee Break in the Management School Cafe

10:20 – 11:20: **Session D2-2: Decision Systems applied to SMEs**
Chair: Pascale Zaraté

10:20 – 10:40: **Session D2-2.1**: The Benefits of Enterprise Systems for SMEs
Authors: Gwendolin Geier, Marion Schulze, Yahaya Yusuf and Ahmed Musa

10:40 – 11:00: **Session D2-2.2**: Operational planning solutions for non-hierarchical networked SMEs
Authors: Beatriz Andrés, Raul Poler and Jorge E. Hernández

11:00 – 11:20: **Session D2-2.3**: Support to the Diagnostic of Portuguese SME using AHP
Authors: Bruno Nunes and João Costa.

11:20 – 12:20: **Session D2-3: Decision Systems applied to Supply Chains**
Chair: José Moreno

11:20 – 11:40: **Session D2-3.1**: A Decision Support System for Delivery Management in a Lack of Homogeneity in Products (LHP) Context. The case of a ceramic tile supply chain
Authors: Andres Boza, Mme Alemany, Faustino Alarcón and Llanos Cuenca

11:40 – 12:00: **Session D2-3.2**: A Supply Chain Model for Integrated Procurement and Production Planning with Multiple Uncertainties
Authors: Wei Xu, Dong-Ping Song and Michael Roe

12:00 – 12:20: **Session D2-3.3**: A knowledge chain management framework for global supply chain integration decisions
Authors: Shaofeng Liu, Jonathan Moizer, Phil Megicks and Dulekha Kasturiratne

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12:20 – 13:20: Session D2-4: *Invited Talk 6* – Prof. Peter McBurney*, "What are models for?"* Chair: Fatima Dargam

13:20 – 14:10: Lunch served in the Management School Cafe

14:10 – 15:30: **Session D2-5: DSS in Design, Management and Social Networks**
Chair: Raul Poler

14:10 – 14:30: **Session D2-5.1**: Swarm Intelligence (SI) for Decision Support in Operations Management – Methods and Applications
Authors: Yi Wang, Lilan Liu and Kesheng Wang

14:30 – 14:50: **Session D2-5.2**: A Case Study on AHP-Based Model for Green Product Design Selection
Authors: Xiaojun Wang, Hing Kai Chan and Dong Li

14:50 – 15:10: **Session D2-5.3:** Decision Making in Credit Granting Process
Authors: Ilmars Purins, Toms Reizins, Girts Braslins and Natalja Svitlika.

15:10 – 15:30: **Session D2-5.4**: Disentangling Online Social Networking and Decision Support Systems Research Using Social Network Analysis
Authors: Francisco Antunes and João Costa.

15:30 – 15:50: Coffee Break in the Management School Cafe

15:50 – 16:50: Session D2-6: Invited Talk 4 – Dr. Zenon Michaelides, "*Using Enterprise Resources Planning (ERP) systems to support Decision Support activities in Operations & Supply Chain Management: The Introduction of SAP into Universities taught Curriculum*" – Chair: Jorge Hernandez

16:50 – 17:50: Closing Session

17:50 – 18:30: EWG-DSS Business Meeting

Note: All EWG-DSS Members are welcome to take part in the Business Meeting.

Workshop Abstracts
Special Talks

Special Talk 1

Dr. Paul Drake
Management School, University of Liverpool, UK.

Paul Drake is Head of Marketing and Operations at the University of Liverpool Management School. He has a BSc in statistics, an MSc and a PhD in systems engineering, and is a Chartered Engineer through the Institution of Engineering Technology. Prior to his academic career, he gained several years experience working in industry on the development of information systems. He has conducted wide-ranging research in operations management in collaboration with industry and the public sector. His early research was mainly into process monitoring. He then supervised several research projects with manufacturing enterprises and developed research into artificial intelligence techniques for decision making and scheduling. His current research has expanded into logistics and purchasing strategy, including novel applications in the area of social care. He has placed much emphasis on the supervision of PhD students, with the total number being well into double figures. He has worked with over 50 businesses and public sector organisations and has reached 100 publications in the open literature. He is a visiting lecturer in e-business strategy at the Ecole des Mines de Nantes, one of France's Grandes Ecoles and an honorary senior research fellow in operations management at the University of Birmingham School of Engineering.

Talk:
"Welcome to ULMS"

Abstract

The University of Liverpool, founded in 1881 is one of the UK's leading research-based universities. It has 27,000 students pursuing over 400 programmes spanning 54 subject areas. There are three faculties: Health and Life Sciences; Humanities and Social Sciences; and Science and Engineering, organized into 35 departments and schools. Around 5,000 people work at the University, including nearly 1,400 academic and 800 research staff. The university places great emphasis on inclusion, welcoming students from a wide variety of backgrounds and from over 100 countries of the world.

The Management School is a 21st century creation having been formed in 2002 from long established research groups in areas such as Economics, Industrial Engineering, Public Sector Management and Latin American Studies and an injection of carefully chosen new staff. The School consists of three subject groups: Ecomomics, Finance and Accounting; Organisation and Management; and Marketing and Operations. Research is driven

strategically through Knowledge Platforms of which Operations and Supply Chain Excellence is one.

The Operations and Supply Chain Excellence knowledge platform aims to drive and support business competitiveness by making an original contribution to the theory and practice of operations and supply chain management. This aim is pursued through the development and application of the methods and technologies that underpin and facilitate the achievement of excellence in the design of operations and supply chain systems.

Research is undertaken at a national and international level on a range of themes that principally concern operations strategy and design (with specific emphasis on lean and agile practices), supply chain and logistics design, mass customisation, enterprise systems, procurement policies and practices, service operations management and tracking and traceability technologies. Since 2008, members of the knowledge platform have attracted about £3M in funding for research and knowledge exchange activities and have established close links with regional, national and international companies in key sectors such as automotive, aerospace, food, pharmaceuticals, transport and software.

Operations and supply chain management research at ULMS employs methods that are concerned with direct observation, intervention and improvement of practice. Research and knowledge exchange activities have led to the implementation of a wide range of business and industrial applications with support having been provided to over 100 businesses since 2007. It follows that practitioners are key beneficiaries and staff have a track record of solving real business problems.

The School has over 100 PhD students and about a quarter of these are in the area of operations and supply chain management. The School has a wide range of taught programmes including an MSc in Operations and Supply Chain Management and a related MSc e-Business Strategy and Systems. These two programmes alone have about 100 students and we are soon to introduce a related MSc in Project Management. We also run on-line versions of these programmes through our partnership with Laureate.

A key feature of our work is to seek the fullest exploitation of the opportunities afforded by contemporary ICT and e-Business at the technology, systems and business strategy levels throughout supply chains. Central to this is the development and application of decision support systems and research into novel approaches

Special Talk 2

Prof. Pascale Zarate

Universite Toulouse 1 Capitole (UT1C), France.

Pascale Zaraté is a Professor at Toulouse 1 Capitole University. She conducts her researches at the IRIT laboratory (http://www.irit.fr). She holds a Ph.D. in Computer Sciences / Decision Support from the LAMSADE laboratory at the Paris Dauphine University, Paris (1991). She also holds a Master degree in Computer Science from the Paul Sabatier University, Toulouse, France (1986); as well as a Bachelors degree Toulouse, France (1982). Pascale Zaraté's current research interests include: Decision Support Systems; distributed and asynchronous decision making processes; knowledge modelisation; cooperative knowledge based systems; cooperative decision making. She is the editor in chief of the International Journal of Decision Support Systems Technologies (Ed IGI Global). Since 2000, she is head of the Euro Working Group on DSS (www.euro-online.org).

She published several studies and works 1 book, edited 2 books, edited 11 special issues in several international journals, 2 proceedings of international conferences, 22 papers in several international journals, 2 papers in national journals, 5 chapters in collective books, 26 papers in international conferences.

Talk:
"Cooperative Decision Support Systems"

Abstract

Decision Support Systems are designed in order to support decision makers in organisations. This support is strictly linked to an improvement of the efficiency of the made decisions rather than the effectiveness. The decision making process is then seen as an interaction between the man and the machine and the automation of this kind of process is not feasible. We show in this work how the introduction of Information and Communication Technologies (ICT) changed the decision making processes in organisations. The decisional context evolves from a mono decision maker to multi decision makers, each of them having to interact and to cooperate with the others. Based on this hypothesis we studied this new decision making processes: multi actors working in asynchronous and distributed situations. These processes are then defined as cooperative. We then show how the Decision Support Systems are not adapted to these new needs and we make the proposal of a new kind of framework called Cooperative Decision Support Systems able to support these processes of decision making. This framework is based on the proposed architecture by Sprague and Carlsson.

Special Talk 3

Mr. Tony Waller

Lanner Group, UK.

TONY WALLER received a BSc (Hons) in Statistics from the University of St. Andrews in 1981 and has worked in the field of Operational Research and particularly simulation ever since. He has worked on many diverse international assignments as a consultant and has helped develop simulation software in a product management role. He is currently the Customer Development Manager at the Lanner Group and is on the editorial board of the Journal of Simulation.

Talk:

"WITNESS Simulation and its role in Decision Support"

Abstract

Tony will speak on the power of simulation modelling to inform decision making in all types of businesses. With many references to real world examples he will illustrate just why this powerful technique is so valuable and why it is vital that management appreciate when and how to apply simulation. Example projects referenced will include Airport planning (including Liverpool John Lennon Airport, Air France and British Airways), Oil Pipeline and Shipping (including Apache Corporation and ILF), Manufacturing (including Nissan, Nemak and Kraft) and Logistics (including Coca Cola and Carrefour). Tony will also outline briefly some exciting research being conducted at a number of UK Universities in the use of simulation, widening the scope of the problems addressed including improvements in sustainability.

Special Talk 4

Dr. Stephen Childe

School of Engineering, Computing and Methematics, University of Exeter, UK

Stephen J. Childe is a senior lecturer in Engineering Management at the University of Exeter. He is a Chartered Engineer and member of the Institution of Engineering and Technology and a member of the IFIP Working Group (5.7) in Integrated Manufacturing Systems. He was formerly a vice chairman of the UK Institution of Operations Management and is the editor of the international journal 'Production Planning and Control: The Management of Operations' which addresses operations management in all sectors, especially focusing on research that addresses or identifies problems experienced in industry.

Talk:

"Decision Support and Operations Management – viewpoint from an editor"

Abstract

In this talk, he will look at the areas of interest of DSS and Operations Management, and identify where overlaps exist. Operations Management consists of many kinds of decisions that provide a basis for contributions from the DSS field. In particular, PPC focuses on research that is motivated by current problems being experienced in industry, and which leads to useful new knowledge for application. The talk will also outline the publication process for a typical journal and specifically PPC from an editor's point of view, including some questions that should be considered by authors when making submissions.

Special Talk 5

Prof. Peter McBurney

Agents and Intelligent Systems Group of the Department of Informatics at King's College London, UK.

Peter McBurney is Professor of Computer Science and Head of the Planning, Agents, and Intelligent Systems (PAIS) Group in the Department of Informatics at King's College London. His research focus is on theoretical and applied aspects of agent-based modeling and simulation, cyber security, and multi-agent software systems, particularly agent communications languages and argumentation. He is co-editor-in-chief of the journal, The Knowledge Engineering Review, and was founder and initial gamemaster for the CAT Market Design Tournament, a crowd-sourced research tournament in computational economics. Earlier in his career, McBurney co-founded a telecommunications marketing consultancy company, which provided advice to the world's leading telecommunications and information technology companies on market planning, market modeling and strategic business programming.

Talk:

"What are models for"

Abstract

Despite the growing popularity of agent-based modeling across the sciences, the social sciences, and in policy domains, domain experts and users only rarely consider what these models are for. Indeed, the same is true for modeling in general; most model-users seem to take the purpose(s) of modeling for granted, and thus not needing any discussion. However, models and modeling activities typically have multiple stakeholders, who often have different and sometimes conflicting purposes in mind. In this talk, I will consider some of the different potential reasons that models are created and used, both in general and for agent-based models in particular. I will explore some of the implications of these different intended purposes, and I will argue for making explicit the stakeholders and goals of modeling activities prior to modeling.

Special Talk 6

Dr. Zenon Michaelides

Management School, University of Liverpool, UK.

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Talk:

"Using Enterprise Resources Planning (ERP) systems to support Decision Support activities in Operations & Supply Chain Management: The Introduction of SAP into Universities taught Curriculum"

Abstract

Universities in the U.K. and internationally have identified a shortfall in the ability of graduates to be effective decision makers. This shortfall is particularly notable in the management sciences, where recent graduates are unable to effectively use techniques and technologies aimed at supporting decision making activities.

Enterprise resources planning (ERP) systems allow practitioners to take important strategic as well as operational decisions based on current and projected enterprise data, in an effective and informed manner. Without a grounded understanding of such systems, practitioners find themselves at a disadvantage, as they are continuously reactive or responding to current events rather than adopting a proactive or informed approach, which is key to the decision making process.

It is well accepted that ERP systems enable visibility and foster integration of disparate resources in an enterprise. Since much of any company's operations are global, including their supply chains, the decision making process relies on key enablers to dynamically link or process data and effectively disseminate resulting information in the extended enterprise.

It can be argued that people lacking the knowledge or capability of such enabling systems are at a significant disadvantage in terms of strategic positioning. Understanding the scope that such systems offer are key in enabling effective decision making.

Higher Education Institutions worldwide are increasingly adapting their curricula by adding ERP-centric subjects, particularly in the management areas. The University of Liverpool Management School joined the SAP University Alliance Programme in 2003. They have been a Steering Group Member since, and have introduced Taught Courses using SAP into their Programmes for Operations & Supply Chain Management and E-Business Strategy & Systems.

The course subject matter is presented through both lectures and seminars or labs, by SAP qualified practitioners/ academics. The focus of the SAP presentations is to enable participants to gain real-time experience in ERP systems, by using current industry-leading software. The teaching experience primarily focuses on Case Studies and the application of ERP and SAP software in the business world.

The learning method used is “guided learning”. The benefit of this method is that specialist knowledge is imparted quickly. Students also acquire applicable skills and competencies on industry leading systems, which are relevant and useful in their work environment. This also enhances their employability and relevance to the Industry, which is struggling under recessionary conditions and often, cannot afford the resources and training traditionally afforded to new graduates.

EWG-DSS Stream on "*Decision Support Systems & Operations Management Trends and Solutions in Industries*"

Abstracts

A multi-agent decision support system for the collaborative decision-making in multi-level supply chains

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ABSTRACT

Planning and management of the firm’s production, inventories and resources have always been an important study themes because it is not always easy to efficiently fulfil customer demand in terms of the quantity, time and quality required regarding to the increasing complex environments, especially in supply chains. Besides, the complexity might be increased when firms attempt to capture a larger volume of external information from other members of the supply chain. From the theoretical perspective, it might appear obvious that establishing collaborative processes in a supply chain must enhance efficiency when facing non-collaborative situations. Nonetheless, demonstrating the goodness of collaborative solutions in practice is not altogether evident, while demonstrating the feasibility of implementing systems that can favour collaborative mechanisms in real, complex settings as opposed to traditional ones is even less evident. Hence, the overall objective of this paper is to propose a generic model that supports the decision-making process in multi-level supply chains from a collaborative and decentralised perspective. This model, which is to be developed to be applicable to any kind of supply chain typology, will be validated for a specific multi-level automotive supply chain in terms of its production planning process. The hypothesis presented herein establish that by collaborating in the information exchange process and by considering a decentralised decision-making mechanism, improvements in terms of profit rate levels will found in every supply chain node as well as the complete supply chain.

Keywords: Collaborative decision-making, decision support systems, supply chain management, automotive industry

INTRODUCTION

For enhancing the decision-making (DM) process in a supply chain (SC) it is important to consider and accept the objectives pursued by each node. This, in the most of the cases, implies an adaptation process on information flows, constraints and requirements from the nodes (customers and suppliers). Thus, many of these goals directly bear the DM processes of the nodes. This means that every node must collaborate in the exchanging of information in order to support its own DM processes independently. Thereafter, in this kind of environments, the concept of collaboration will emerge to cover issues such as: costs reduction, timely deliveries and efficient process management. Hence, it will be possible to address the concept of collaborative decision-making (CDM). In addition, the CDM will be oriented to support an efficient coordination among the nodes in the SC [6]. Thus, the collaboration in the SC will depend on whether the members are willing to share and exchange the information required for the DM, specifically in terms of the planning processes [1].

Therefore, the DM processes of the companies are to be considered as one of the main relevant processes in terms of the information flow in the environment. Hence, in the specific context of SC, the main decision will be seen in terms request and responses ranging from customers to suppliers and from suppliers to customers, respectively. For this, it is important that these flows must be well synchronized within the DM processes and mechanisms at every SC level. Thus, in terms of the DM process, the SC can be considered as a group of members directed to meet their customers demand. Specifically, in a manufacturing environment, functions such as planning and replenishment of materials CDM will support the efficient management of intermediate and finished products in order to support their distributions around SC.

Hence, to model and understand these complex environments such as SC, realistic collaboration mechanisms shall be considered. One valid approach is named decentralised in where each node exchanges some information and execute their CDM processes independently [2]. This will guarantee an independent information exchange between nodes in the SC and the use of independent technologies, as the main decision support system (DSS) to support their internal processes (for example, production planning). Thus, one of the best DSS technologies to support the SC collaboration from a decentralized perspective is the multi-agent systems [4]. This DSS technology, when considers the decentralized approach for the collaborative SC, show up its core skills to support the CDM by considering an efficient communication and coordination process of all the nodes in the SC [5].

Therefore, to cover all this relevant issues this paper addresses briefly a multi-agent decision support system (MADSS) to support the modelling and implementation process of CDM in terms of the SC production planning process. The MADSS is to be tested and validated in hierarchical automotive SC considering the implementation of decentralised mechanism such as multi-level negotiation process supported by standard communication protocols. This automotive SC considers four nodes distributed in three levels, which means that every node from the first level will receive the end-customer demand, the ones at the second level will receive the demand from the manufacturer and a third level which will handle the requirements from the first tier suppliers. Thus, by testing this model in a real automotive SC industry, the aim is to highlight, in a quantitative manner, the advantages of collaborative approach versus non-collaboration by considering a realistic decentralised approach in terms of the CDM.

COLLABORATIVE DECISION-MAKING MODEL IN MULTI-LEVEL SUPPLY CHAINS SUPPORTED BY MADSS

The main characteristic of the CDM processes is regarding to the fact that decision makers build up their decision by considering inputs and outs that adds value to their DM process. This added value is to be seen in terms of sharing precise information, allowing feedbacks and iterative negotiations processes among all the member of the SC. This collaborative perspective is to be supported by technologies which will govern the main DM mechanism. In addition, a decentralised DM is to be considered in order to support the collaboration within independent DM process from all the SC nodes in complex and multi-level SC. Thereafter, for such as complex environments, the main behaviours must be detected within the aim of generically give solutions to the CDM. These behaviours can be seen in three ways: customer, in where the node only request orders (demand) to their suppliers; manufacturer, in where the node might receive requests but also might generate order for their supplier, which can be seen as dual behaviour; and finally the supplier, in where the node only receive request from their customers. Hence, CDM is to be supported by iterative interaction among nodes who might consider any of these three types of behaviours. For this, the MADSS is to give the implementation support of these complex SC environments by implementing these behaviours (Figure 1).

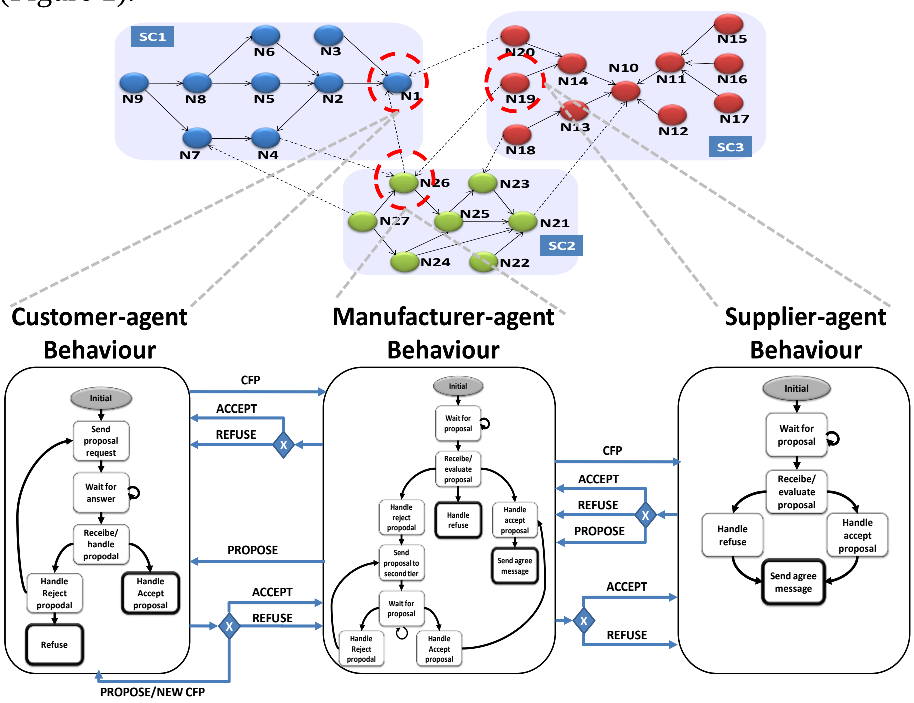

Figure 1: MADSS mechanism to support the decentralised CDM in SC.

The main novel characteristic of the proposed MADSS is the consideration of distributed messaging protocols based on the standard FIPA-ACL such as the *Call for Proposal* (CFP) protocol. Thus, every type of behaviours is to be addressed to every related node allowing an iterative and multi-level negotiation process amongst them to reach the better solution for the CDM process. Hence, in a decentralised mode, every node will support their DM more efficiently and independently of the SC configuration or typology.

APPLICATION OF MADSS TO A HIERARCHICAL AUTOMOTIVE SUPPLY CHAIN

The analysed SC focuses on a group of medium and small companies which supplies automotive parts and components to one large company known as the manufacturer fort this complex and hierarchical SC. Therefore, the information exchange flow process implies to achieve a suitable and better DM process to allow every member of this SC to interact among each other independently considering their own DSS. Thereafter, by moving from the traditional to the collaborative approach in this hierarchical SC, each DM process in this automotive SC supply chain will consider a negotiation process to generate better information exchange management and also a better DM support for the decision-makers. A fully detailed description of the automotive SC is addressed in [3]. In this context, the MADSS model considers the end-customer, the automotive manufacturer (as customers), first-tier suppliers (as manufacturers) and the second-tier suppliers (as supplier) to be the main elements of this SC. Hence, these elements are willing to share information among them to support the CDM. Then, by adapting the generic definition of the MADSS, the implementation of the DSS is presented in Figure 2.

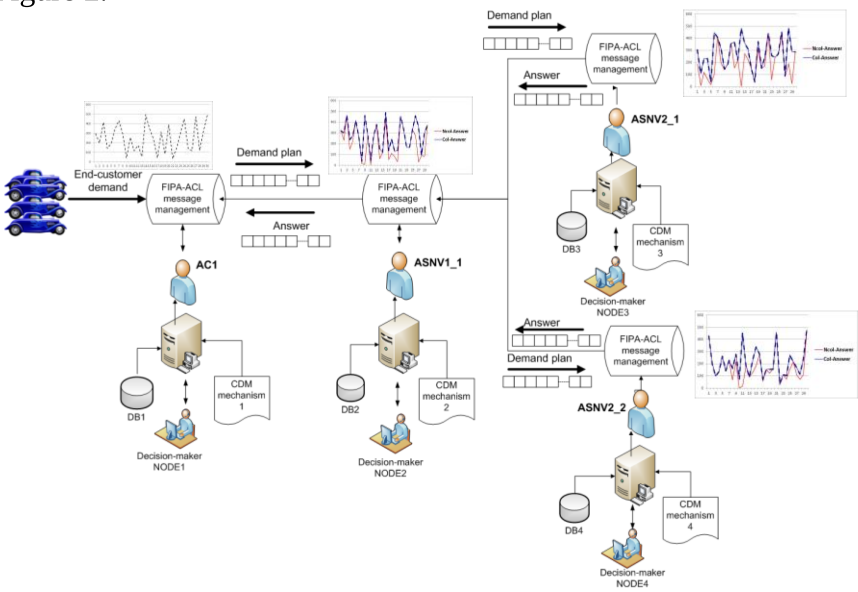

Figure 2: Application of MADSS to an automotive SC

Regarding to demand pattern from the end-customer, there is to be considered a bi-directional informational flow among all the agents who gives the proper information, on-time, to their linked decision-maker. In addition, MADSS is designed to handle collaborative (COLL) and non-collaborative (NCOLL) answers, in which will give the support to execute the multi-level and iterative negotiations' mechanisms in every node, independently. As can be seen in Figure 2, the demand from the end-customer flows from the top to the bottom generating either COLL answer (blue lines) or NCOLL answer (red lines). All the interaction in MADSS considers the decentralised perspective of the DM in terms of technologies and goals of every node. The objective of MADSS is to promote the end-customer demand fulfilment.

For the validation of MADSS, one demand pattern has been considered. Then, by using this information as the starting point, more scenarios have been defined considering different work-loads and demand variability's (see Figure 3). Thereafter, fifteen scenarios were defined, considering the highlighted E_{12} as the starting point.

	Demand variability				
	0%	25%	75%	100%	200%
Level 90	E_{01}	E_{11}	E_{21}	E_{31}	E_{41}
Level 100	E_{02}	E_{12}	E_{22}	E_{32}	E_{42}
Level 110	E_{03}	E_{13}	E_{23}	E_{33}	E_{43}

Figure 3: Validation and scenarios definitions for MADSS

In context, main indicators are defined to measure the impact on the DM considering collaborative. These are the Iterations number, the selling price (SP), costs due delays on demand (DoDC) and profit level.

NCOLL

Node	Iteration	SP	DoDC	Profit	
1	1	66	68	118085.15	Po
2	1.1	21	2.1	37158.5	
6	1.1	3	0.3	5030-4	
5	1.1	3	0.3	5030.4	
2	1.1	21	2.1	35168.7	
1	1	66	68	38913.82	P1

COLL

	Node	Iteration	SP	DoDC	Profit	
	.....	......	.....	.....	.....	
	1	1	66	68	38913.82	P1
	2	1.1	21	2.1	35168.7	
	6	1.2	3	0.3	5030.4	
	5	1.2	3	0.3	5030.4	
	.....	.....	.....	.....	.....	
	.....	.....	.....	.....	.....	
	6	3.1	3.0736	0.3	5030.4	
	5	3.1	3.0736	0.3	5030.4	
Extra Time	6	4.1	3.1105	M	5101.07	
Extra Time	5	4.1	3.1105	M	5101.07	
Extra Time	2	2.4	23.9322	M	44461.89	
	1	2	66	68	110168	P2

Figure 4: Negotiation evolution for NCOLL and COLL DM processes in the SC in E_{12}

From Figure 4 it is possible to highlight a clear positive impact in the profit level evolution once a COLL approach is considered by comparing P_1 against P_2. This is to be reached by increasing in the SP, in where customer nodes, to avoid possible delays on demand are willing to pay more to their suppliers in order to get their desired requested orders. To support this, main consideration from this typical environment has been taken in to account, such as the fact of all the demand must be fulfilled, high penalty cost due to any delay on demand and that every customer node will be able to increase their SP to certain amount in order to maintain the economical equilibrium. Within this, the results highlights that at certain amount of SP the supplier will consider the use of extra time in order to fulfil the customer demand, which can be translated into a better profit and service level for every node.

In addition, regarding to main hypothesis defined at the beginning, MADSS not only will generate a solution for every node, but also to the global perspective of the SC management. For this, a comparative analysis has been done in terms of measuring the difference between the NCOLL and COLL approach (see Figure 5).

	0%	25%	75%	100%	200%
CS-DIF-NCOL-COL-N90	0.000%	0.079%	2.924%	5.558%	8.706%
CS-DIF-NCOL-COL-N100	0.000%	2.253%	5.588%	6.214%	10.218%
CS-DIF-NCOL-COL-N110	0.000%	0.193%	3.586%	5.750%	9.694%

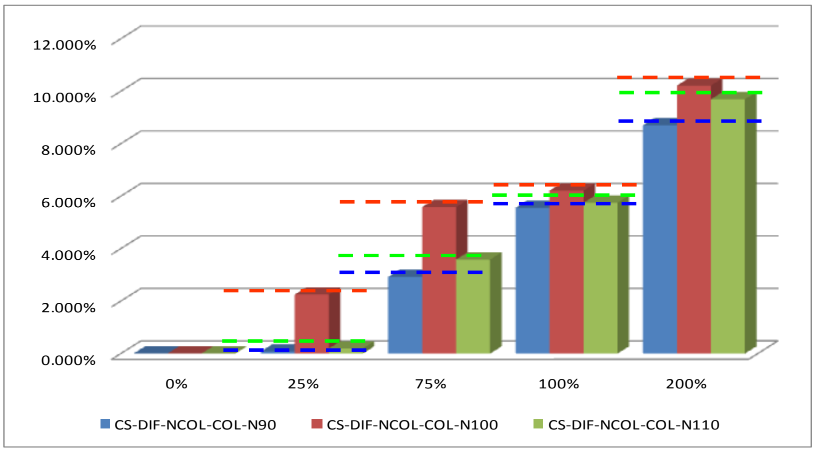

Figure 5: Global SC analysis considering COLL vs. NCOLL

From Figure 5, in the first place, it is possible to observe that at the work-load level of 100 (equivalent to 100% saturation) MADSS provides further improvements over the rest of saturation. Secondly, at the work-load load level of 110 (equivalent to a 110% saturation) MADSS tend to give even better solutions, which means MADSS behave better as soon as more complex the configuration is in to opposite to the 90% saturation level scenario. With these results it is possible to highlight that the automotive SC will benefit from the greatest differences with respect to a situation of NCOLL and COLL, then high percentages of variability will increase the DM process considering the MADSS model.

CONCLUSIONS

The main findings from this paper, considering its theoretical and practical developments, are summarised as follows: the collaborative decision-making will result in an increased level of end customer service level as opposed to non-collaborative scenario; from a collaborative perspective, each node's profits will be greater than the profits obtained from a non-collaborative perspective; the supply chain's total profits will be greater when considering a collaborative perspective rather than a non-collaborative one and; the production planning collaborative perspective will imply reducing the level of backlogging per customer-type node as opposed to a non-collaborative perspective. Thereafter, complex SC environments such as the automotive industry will benefit from this approach in terms of implementing a DSS to support the decentralised DM across the whole network. Further extension of this work will be to apply and test MADSS in non-hierarchical SC in different industries.

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Collaborative Manufacturing Planning and Scheduling Systems

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ABSTRACT

Web-based collaborative systems can make the difference between success and failure and highly contribute to the competitive ability of industrial companies occurring in a ubiquitous manufacturing system (UMS). Specifically, collaborative manufacturing planning and scheduling ensures better customer service, namely through reliable and timely deliveries, as well as improved manufacturing management of available resources. In this work we present an illustrative example to highlight the advantages of such networked-based systems for facilitating information sharing and collaboration among users globally distributed.

Keywords: Collaborative manufacturing planning and scheduling, ubiquitous manufacturing system, web-based system.

INTRODUCTION

Manufacturing systems have been fundamentally changed by globalization and collaboration and have evolved from a traditional transformation model into a network-based relationship. This transformation enables to take advantage of features and resources that are, or can be made available, through the Internet to all company stakeholders. This means that a greater impact on companies' performance can be achieved ensuring better use of manufacturing management resources and thus provide a better customer service, namely through reliable and timely deliveries. Therefore, providing Internet-based collaborative systems can make the difference between success and failure and highly contribute to the competitive ability of industrial companies occurring in a ubiquitous manufacturing system (UMS).

Due to manufacturing planning and scheduling (MP&S) complexity when a company does not have access to good algorithms it usually draws upon simple and empirical procedures whose quality of solutions tends to be poor. This is a situation that can be avoided if companies have easy access to shared information, algorithms and other services. By exploring the Internet facilities in a network of MP&S service providers, users can ensure better management of their industrial tasks. This is because a pool of valuable knowledge on

MP&S, which has been developed by academia and industry over the years, can also be made available to companies and individual users.

Nowadays globally distributed manufacturing scheduling is being constantly enriched, in the context of a Ubiquitous Manufacturing System (UMS), by an intensive replication of integrated resources, processes and software, spread through a globally distributed manufacturing environment. Although several different approaches and frameworks were already put forward [1-4], there is still no single tool or package that can be termed as a Real-time Collaborative Management (RTCM) package.

Moreover, many MP&S solving methods are mainly based on meta-heuristics, as these kind of approaches yield a high performance with relatively small computational time, which makes them interesting ones, as they provide usually a lower bound on the optimal time/cost, and thus guarantee that the solutions found are within a known margin from the optimal solutions [5, 6, 7].

To stay competitive in the dynamic global market of today, companies with distributed factories or divisions require new ways of effective collaboration among all production units and stakeholders including suppliers and outsourced service providers. Among many other factors, flexibility, timeliness, and adaptability are identified as the major characteristics to bring dynamism to collaborative manufacturing environments.

Developing and enhancing MP&S web-based technology is still a promising strategy. In fact, by migrating from conventional applications to a web-based context some important benefits are expected, regarding: 1) Automating the data transactions and eliminating human errors, e.g. by enabling direct XML data transferring; 2) Sharing MP&S resources and services, regardless of distance between peers; and 3) Structuring the system in a decentralized and distributed manner, e.g. including several modules replicable and running on different machines; 4) Support for strategic and tactical decisions between the network of MP&S by providing real-time access to global information, thus facilitating the negotiation processes

Therefore, the main contribution of this work is to show, through an illustrative example, how collaborative MP&S enable better decision support in web-based manufacturing solving processes.

In order to better summarize the underlying work of this paper, it is organized as follows: on the next section, a brief literature review about related work is presented. Afterwards, an illustrative example for supporting inter-manufacturing planning and scheduling, among a set of business partners is provided, in order to better clarify how the system can contribute to enable collaboration among them, when trying to reach appropriate decisions, in terms of a global decision-making context about manufacturing orders assignment and production planning. Finally, the last section presents some main conclusions.

RELATED WORK

Traditionally, MP&S problems were considered to be static and deterministic, but increasingly new approaches were proposed, over the last decades, in order to address the "industrial" dynamic scheduling problem [8-13] and find some kind of better quality solution, namely through the application of dispatching rules or other very fast algorithms.

Approaches to obtain good or at least satisfactory solutions, in acceptable time, within the context of Ubiquitous Manufacturing System (UMS) and Manufacturing Systems Integration (MSI) scenarios [14] are mostly based on local or neighborhood search techniques, namely meta-heuristics. Singh and Hindi, in 1991 [8], already provided a systematic analysis of the hierarchical decomposition of the scheduling problem.

Addressing different time scales in scheduling and on-line control, Duggan and Browne, in 1991, proposed the concept of Production Activity Control (PAC) with an off-line scheduler and an on-line dispatcher to execute the scheduling plan [8]. A similar approach by Chryssolouris resulted in a commercial software package (MADEMA) [8, 9]. Schmidt, in 1996, also considered the need for creating an architecture for reactive scheduling [8] where he applied case based reasoning techniques. Many other researchers proposed other interesting distributed approaches to both, manufacturing scheduling and on-line control (see for example [10-13]).

Nowadays, the MP&S systems scenario is quite different. There is a list of planning and scheduling systems accessible via the Internet, such as the Lekin, a flexible job shop scheduling system [13] and Lisa, Library of scheduling scheduling algorithms (http://lisa.math.unimagdeburg.de/). Other interesting systems include the NEOS Server (http://www-neos.mcs.anl.gov/), the ForthMP by the Mitra's Group (http://www.brunel.ac.uk/depts/ma/research/com) and the IMS-NoE, based on the use of distributed services globally accessible that focus on the needs of each individual context (http://www.imsnoe.org/BENCHMARK/TBA.asp), among others.

In the next section an illustrative example for collaborative manufacturing planning and scheduling is briefly described.

ILLUSTRATIVE EXAMPLE

Let us consider a manufacturing context that includes four different business partners or business, for short (B_1 to B_4), distributed worldwide, each one being able to process a set of four distinct jobs (J_1 to J_4), each one with a same processing time of 1 time unit. Moreover, we will consider four distinct scenarios (R_1 to R_4) where each B_i will produce either 1 or 2 or 3 or 4 jobs (i.e. all possible combinations can be distributed by the businesses B_i). Figure 1 depicts the environment for this example.

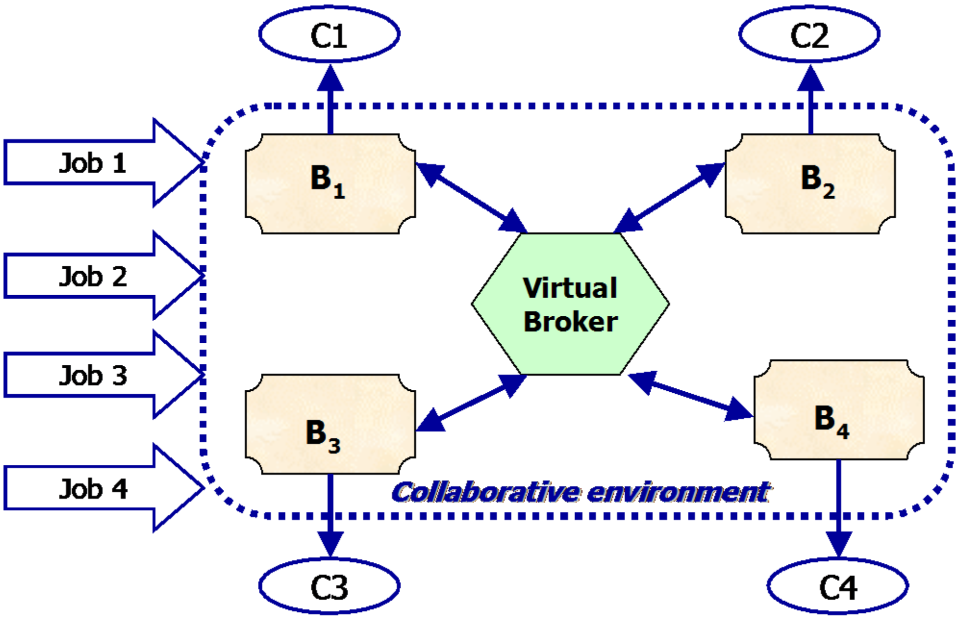

Figure 1: Collaborative example

We will also consider that each job requires a setup cost/time for being processed on a business, which varies according to the number of jobs to be processed on that business, as follows: 0.8 time units if the whole set of four jobs is processed on one of the four businesses available; 1.5 time units if three of them are processed on a given business; 2 time units if 2 of the jobs are processed on a same business; and 3 time units if only one job is processed on a business. Moreover, the jobs also have to be delivered to the final clients and this final transportation cost/time - of each job to the corresponding client - will be 0 time units if the job is processed near the corresponding client location (i) and we assumed that B_1 is located in the same location as Client 1 (C_1) and so forth (e.g. B_2 is located next to Client 2, C_2). Otherwise, if a job has to be delivered to some other location, the corresponding transportation time of job j to location i follows the rule of time = |i-j| time units, for example, the time for transportation of job 2 to business 3 is equal to 1 (|2-3|) time units, and so one.

Under a collaborative context let us now consider the set of all alternative scenarios for jobs allocation for being processed and delivered to corresponding four clients - placed next to each of the four businesses available - as follows:

- Scenarios considering only 1 job per business include 24 situations (R_1^1 to R_1^{24});
- Scenarios considering 2 jobs per business include 36 situations (R_2^1 to R_2^{36}). These occur when two of the 4 jobs will be processed on one of the four businesses available and the remaining two jobs on another available business;
- Scenarios considering 3 jobs include 48 situations (R_3^1 to R_3^{48}) that arise from the context of processing three of the set of the four jobs on one of the four businesses available and the remaining job being processed on another business of the four available;
- Scenarios considering 4 jobs include 4 different situations (R_4^1 to R_4^4), correspond to processing each set of four jobs on one of the four businesses available.

Now that we establish the possible scenarios we can calculate the best inter-scheduling, expressed on time units, for the example, and Figure 2 summarizes these results.

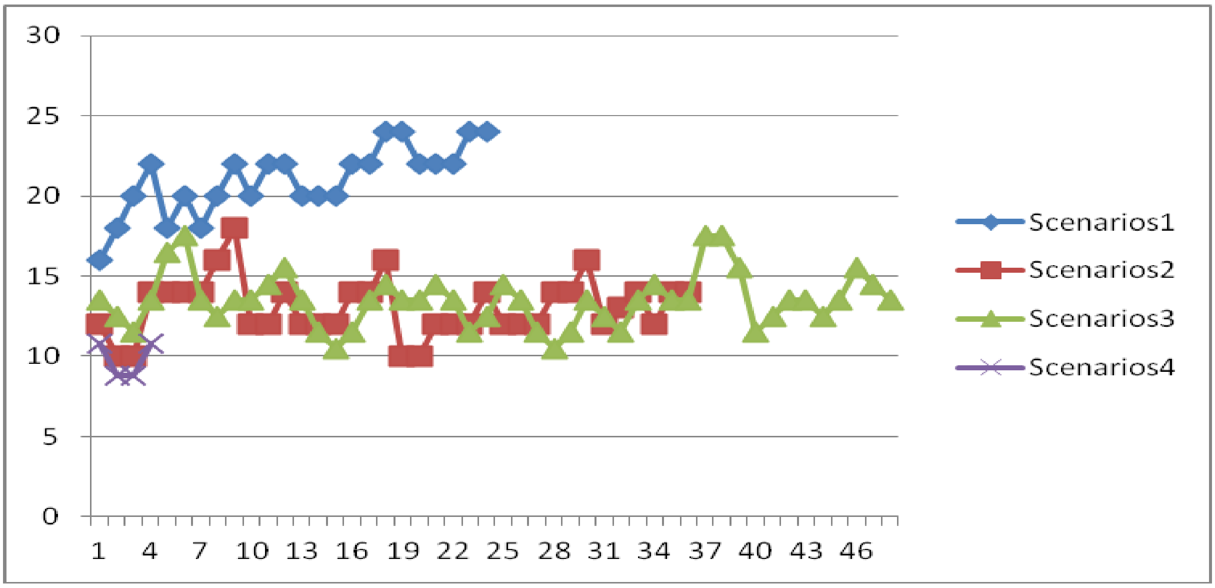

Figure 2: Total result about the alternative 112 scenarios

From the above results we extract the best (minimums) solutions for each scenario:

Scenario R_1^1 = $\{(B_1, J_1); (B_2, J_2); (B_3, J_3); (B_4, J_4)\}$ = 16

Scenario R_4^2 = $\{(B_2, J_1, J_2, J_3, J_4)\}$ = 8.8

Scenario R_4^3 = $\{(B_3, J_1, J_2, J_3, J_4)\}$ = 8.8

Scenario R_2^2 = $\{(B_1, J_1, J_2); (B_3, J_3, J_4)\}$ = 10

Scenario R_2^3 = $\{(B_1, J_1, J_2); (B_4, J_3, J_4)\}$ = 10

Scenario R_2^{19} = $\{(B_2, J_1, J_2); (B_3, J_3, J_4)\}$ = 10

Scenario R_2^{20} = $\{(B_2, J_1, J_2); (B_4, J_3, J_4)\}$ = 10

Scenario R_3^{15} = $\{(B_2, J_1, J_2, J_3); (B_4, J_4)\}$ = 10.5

Scenario R_3^{28} = $\{(B_1, J_1); (B_3, J_2, J_3, J_4)\}$ = 10.5

It is obvious that the best solutions are the ones from scenario R_4^2 and R_4^3 with either B_2 or B_3 (total time = 8.8) producing all the jobs. The worst scenario is R_1^1 (total time 16) where each job is divided per business (mainly due to the set-up times involved).

Now, if we are in a collaborative environment we could expect some negotiation to take place to ensure selection of the best option in terms of members of the "social network" established by the four businesses (solutions of R_4). Since the 2 best scenarios for R_3 (total costs 10.5) present worst results than the 4 best for R_2 (total cost 10) we opt for analyzing these latter 4 possible results. Observing the 4 possible solutions of scenario R_2 we see that B_1 and B_2 are in a stronger position because they can be combined either B_3 or B_4 and still remain competitive in terms of time. Hence in a negotiation process they could agree between themselves which one will keep the job and with whom to "mate". Conversely we could use a multi-criteria model with other criteria such as historic quality of products delivered and also historic timely deliveries and select which B_i will win the contract of producing 2 jobs.

Through this case study it is possible to realise that the decision supported by the brokering web-based service depends on the type of procedure adopted/used for production allocation and scheduling for trying to globally optimize production environment/resources planning, according to the corresponding relevant data for providing inter and intra production environment results considering: setup times for production resources/environments preparation for jobs processing and times of products delivery and transportation to the clients besides the underlying jobs processing times on the corresponding production resources.

Therefore, it is possible to realise that the best solutions provided, vary according to the importance level/degree of the corresponding time type for the global or total time, and will sometimes be a decision based on a trade-off situation in terms of low time but also collaboration between partners. When times approximate - more or less equally - preferable situations tend to occur, as we enter on a collaborative environment.

Therefore, it may be wise to conclude that, in a globally distributed market of resources it turns out to be relevant to pay attention not only to local production scheduling approaches but also to global ones, considering the diverse situations related to inter manufacturing environments planning and scheduling alternative scenarios.

CONCLUSION

In this paper we showed the importance, as a competitive strategy, to explore and use collaborative environments, which are now becoming available through the Internet and Intranets, for solving scheduling problems. An illustrative example was presented, which highlighted how the decision making process could be supported within manufacturing and scheduling collaborative environments. Although the main goal was to highlight scheduling problems resolution decision support, the collaborative system may also be used for historical and referencing information about each different kind of MS problem class, and corresponding methods and its implementation(s).

As future work, we plan to develop a platform for solving MS problems occurring in real-time distributed manufacturing environments, for instance, either for intra or inter cellular manufacturing scheduling scenarios. Concepts, related to problems and solving methods will be modelled through XML and related technologies and methods are put available through an UMS network, where a set of business partners are dynamically integrated.

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Decision Support System Prototype for Supply Network Configuration Planning and Operations Scheduling in the Machine Tool Industry: a case study

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ABSTRACT

This paper aims to present a decision support system to solve the supply network configuration problem and the operations scheduling problem of a company that assembles highly customised machine tools in several European plants. A novel database structure is described, which is able to consider alternative operations (purchasing, production, routing and transport) and alternative BOMs (upgrading, reconfiguring custom products). An algorithm for complete enumeration to determine all the feasible solutions, and also each solution cost and delivery time, is proposed. A multi-agent-based simulator evaluates the different KPIs handled by the company for each alternative solution (e.g., workload plants, plants cost, SN lead time, SN total benefits, etc.) to determine the optimum solution by collaborative decision making.

Keywords: Decision Support System, Case Study, Supply Network Configuration, Operations Scheduling, Mass Customisation, Collaborative Decision Making

INTRODUCTION

Supply networks compete and have to differentiate among competitors and other supply networks in an increasingly globalised world, and are always seeking reduced costs and minimum delivery times by meeting or exceeding customer expectations and by offering high levels of quality and/or services.

Regarding capital goods companies such as manufacturers of machinery for civil engineering and construction, plastic injection machinery or machine tools, the highly competitive environment means that companies are obliged to offer increasingly personalised products to end customers. This customisation entails offering customers a product catalogue with extensive options, renewing it regularly and assuming the complexity of managing a product inventory with increasingly shorter life cycles. This products diversity, increased complexity in operations processes and higher materials costs are critical management keys to consider in order to remain competitive.

The key question that planners often ask is: how can my supply network (SN) serve the desired products to my customers and meet/exceed their expectations in an attempt to minimise my total logistics costs, and to assume short delivery times and to ensure levelled production levels in the various production centres to respond to future orders? This question is fundamental for companies that assemble machines and tools because orders are not regular, but are specific. Given the frequency of orders, the value of electronic components and raw materials, or the variety of options offered, a solution based only on costs or delivery times can prove suboptimal when a new order arrives.

Due to market pressure, companies working in a mass customisation environment have to adapt their inventory management policies to cut their delivery times and to improve customers' service levels. A suitable balance between the products assembled in Build To Forecast (BTF) and those in Build To Order (BTO) has to be find. Generally, because of the need to quickly respond to unexpected demand, a Switch To Order (STO) strategy is preferred. Product skeletons are released to manufacturing based on the forecasts of the most demanded options. By means of allocation rules, product skeletons are assigned to orders placed by customers. In other cases, product skeletons can be partially reconfigured or adapted to meet customers' requirements. However, when there are no suitable skeletons in stock, reconfiguration can prove expensive, so the BTO strategy has to be used; however, delivery times can be important. Managers used to think that the appropriate strategy was BTF. Nevertheless when a new order arrives, it is often appropriate to consider, and not only in the case of the non-availability of this product in stock, the possibility of using alternatives BOM (upgrading or proposing a change to customers) to fill new orders and to also reconfigure the products assembled in BTF by assuming the cost.

Moreover, resources consideration (workforce or machinery) is a concern that must not be treated in an isolated manner because the availability, efficiency and cost of resources can have a great effect on operation scheduling activities [2].

When operations planning has to be done in a multisite context and there is a different way to respond to demand, the SN problem can contemplate various possible configurations because, for instance, raw materials can be purchased from different suppliers [1], products can be produced or assembled on different machines or in different facilities, or can be delivered by different forms of transport. Selecting a configuration implies reaching a compromise between the costs involved and the service levels to be offered to customers by collaborative decision making.

Integrating the supply network configuration problem and the operations scheduling problem to be performed in a multisite context into these cases is a necessity to not only optimise the SN at any given time, but to also anticipate new orders. To answer these questions, decision support systems (DSS) often prove useful decision-making tools because they are based on a set of procedures which are supported by models for the data processing of unstructured problems.

The main contributions of this paper are summarised below:

- A DSS to solve the SN configuration and the operations scheduling of a company that assembles highly customised machine tools in several European plants is proposed.
- A novel database structure that is able to consider alternative operations (purchasing, production, routing and transport) and alternative BOMs (upgrading, reconfiguring custom products) is described.
- An algorithm for complete enumeration to determine all the feasible solutions and to determine each solution cost and delivery time based on a direct hypergraph is proposed.
- A multi-agent-based simulator that evaluates the different KPIs handled by the company for each alternative solution (e.g., workload plants, plants cost, SN lead time, SN total benefits, etc.).

The following section describes the company's SN and the case study in this paper (Section 2). Then, Section 3 describes the proposed tool: the database architecture, the algorithm for complete enumeration and the simulation module. Finally, Section 4 presents conclusions and future research.

THE SUPPLY NETWORK DESCRIPTION

The product and the customers

Milling machines are small machines with a complex structure made up of thousands of different components. These components are grouped together in functional units known as attributes. An attribute can be fixed or can belong to a range of values called options.

The main customers of these products come from very diverse sectors such as aerospace, capital goods, railways, subcontractors or mould & die manufacturers. An extensive catalogue that includes several families depending on machine size, bed type and column type is offered to customers. Customers configure their order by selecting the option best for each attribute suited to the machine they need; thus, a combinatorial problem is generated which can be in the order of billions, as in the case of the family selected.

Variety of end products has increased in recent decades. Nowadays, the number of product variants theoretically includes around 2,548,039,680 possible combinations [3]. Generally, each customer orders one specific product and the overall demand for end products in one year might be higher than 80 products. Products are principally sold in Europe, and the major sales markets are Spain, Germany and Turkey.

This case study includes Spanish SME designs, manufactures, transports, installs and machine tool sales, specifically milling machines and milling centres. In the last few years, increasing market pressure on the company has been continuously detected with demand for greater product customisation capability, shorter delivery times and increasingly competitive costs. An example is what has happened with small milling machines: the market demands delivery times of about 14 weeks, which is clearly shorter than the production time of approximately 30 weeks.

Supply network configuration

In this case study, the SN has three assembly plants distributed in Europe. two in Spain and one in Hungary. Traditionally, the decision-making process was decentralised and led to suboptimal decisions. With the use of the DSS, the company strategy involves creating a synergy among plants via a collaborative planning tool for SN configuration and operations scheduling for all the SN members.

Assembly operations for milling machines can be performed in any assembly plant, but costs differ between each one because of workforce costs, productivity and available capacity. Generally, first-assembly stages are done in Hungary because workforce costs are lower and the facilities have their own local supplier network for cast-iron and machined parts. Having finished the initial assembly, and the machines were assembled in the first stages in Hungary, and products used to be transported to Spain where customisation operations, electrical and mechanical assemblies, careenage, tests and painting were performed. In the same plant, machine inspection and customer approval takes place before shipping to the destination where an in-house final installation is done. Nevertheless, the Hungary plant layout has been recently modified and final assembly can be performed there, thus cutting total costs.

THE REMPLANET DSS SIMULATION-OPTIMISATION TOOL

The REMPLANET DSS is a simulation and optimisation tool for collaborative decision making that can respond to a set of nine issues. For many scenarios and conditions, this tool allows to conduct the systematic testing of the structure and operation of this type of complex SNs, along with their behavioural patterns and properties, and to identify alternative flexible SN structures, as well as those strategies, policies and rules, which better suit their management at both the local and global network levels, at a low cost and with very little risk. However given the scope of this paper, only those features of most interest to understand our problem are dealt with. The tool contains five basic components:

- A database that is able to consider alternative operations
- An optimisation model
- An agent-based simulation model
- A graphical user interface
- A knowledge base

The Database

The global tool comprises tens of tables that structure the data and store them in order to solve nine different problems. However in order to emphasise our contribution, this section presents only those tables required to consider alternative operations and alternative BOMs (Figure 1).

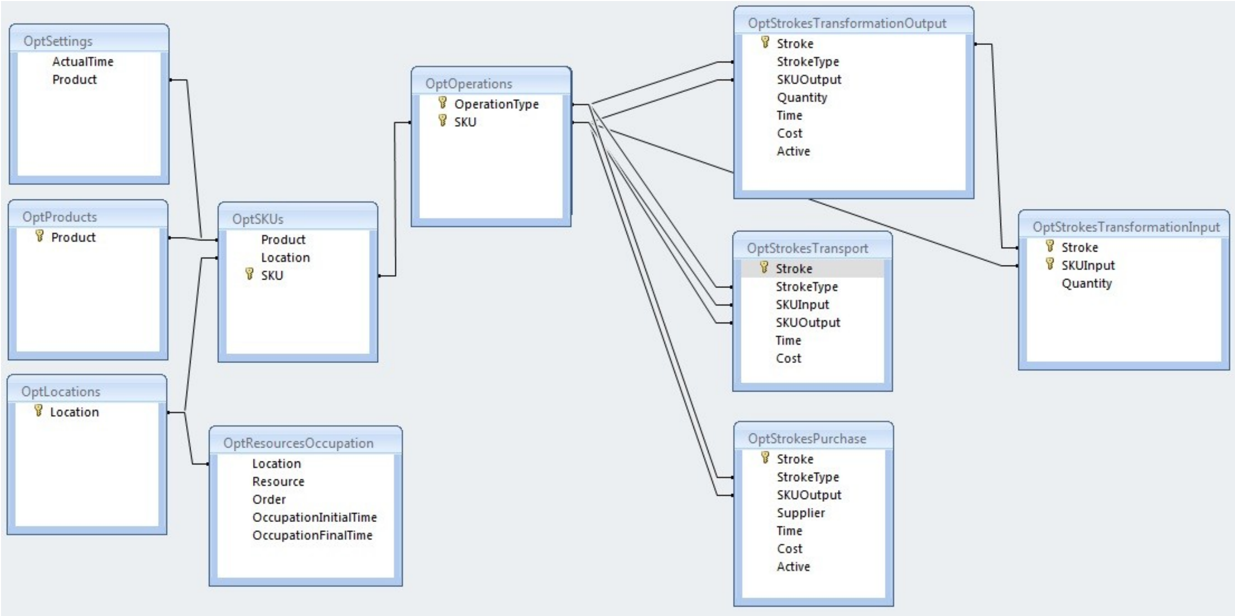

Figure 1: The database structure

Optimisation model: an algorithm for complete enumeration

To determine all the feasible alternative solutions to manufacture the new order, a procedure based on complete enumeration has been implemented via the following steps:

1. The database enables a stroke generated for the order to be transformed into an "Hybrid Database enabled stroke"
2. An AND-XOR hypergraph is created from the Hybrid Database
3. All the feasible solutions are generated by complete enumeration, and the cost and time associated with each one are calculated
4. For each solution, a procedure finds the associated strokes that must be performed

The DSS Simulator

The simulator has been developed in Anylogic®. Different types of agents have been implemented. The following UML sequence diagram shows the interaction of the SN agents over time. Each solution is evaluated in the simulation tool and the optimum solution is selected by the stakeholder in order to fix the SN instance for the order. The KPIs (Key Performance Indicators) proposed for this case study are: lead times, delivery times, service, workload levels, inventory levels, total costs and machine costs.

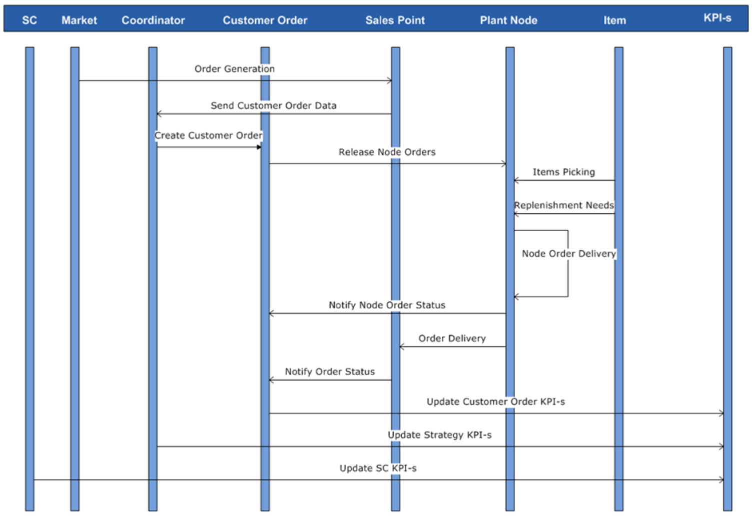

Figure 2: The DSS Sequence Diagram

CONCLUSIONS

In this extended abstract, a DSS to solve the SN configuration problem and the operations scheduling problem of a company that assembles highly customised machine tools in several European plants has been described. A novel database structure that is able to consider alternative operations (purchasing, production, routing and transport) and alternative BOMs (upgrading, reconfiguring custom products) has been introduced and the steps of an algorithm for complete enumeration to determine all the feasible solutions have been presented. Then a simulator based on multi-agent technology evaluates the different KPIs by collaborative decision making.

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An AHP - Multicriteria Selection of Products in Industrial and Technological Diversification Strategies*

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ABSTRACT

The economic recession that has recently immersed the western world, the dynamism and complexity of the markets and the generalised globalisation of the world economy have forced many companies to rethink and reorganise their industrial strategies. Through identifying and taking advantage of the key technologies of a company, this work presents a multicriteria methodology and its corresponding decisional tool (DSS) for the selection of the best product or product portfolio in a process of technological diversification that, along with the key technologies, identifies the sub-levels consonant to the sub-technologies, applications and products. The proposed methodology, based on the Analytic Hierarchy Process, allows the integration of multiple scenarios, actors and criteria, both tangible and intangible; it has been applied to a case study in the Spanish automotive auxiliary sector.

Keywords: Multicriteria Selection, AHP, Industrial and Technological Diversification, Strategic Planning.

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INTRODUCTION

The complex nature of the economic and financial fabric of society at the commencement of the 21st century and the dynamism and competitiveness of the markets in a global and interconnected context are all factors that favour industrial diversification strategies (the development of new products in new markets) as a response to the new challenges that face the entrepreneur. Such strategies can react to changing consumer preferences and make use of the continuous advances in new technologies. In the industrial sector, where the life cycle of a product is often limited, many companies now see diversification as a risk reduction strategy in a business environment of constant innovation and technological adaptation.

The Council for Industrial and Technological Diversification of the University of Zaragoza was created in 2007 as a result of an agreement between the Ibercaja Bank, the University of Zaragoza and the Regional Government of Aragon. The Council carries out research into production and technological evolution of industries in the area of the Ebro valley. One of its recent innovations is a methodology for assessing the possibilities for the industrial diversification of a company [1]; in short, the methodology comprises two stages or steps: (i) the *evaluation of suitability*, a stage that includes the formulation of the problem and the selection, through multicriteria techniques, of companies that have the potential to undertake a diversification process; (ii) the *technological diversification process*, in which the diversification suitability of the company is confirmed, the most appropriate technological diversification strategy is chosen, a business strategy is designed and its implementation process is established.

Once the diversification suitability of a company is confirmed, the technology trees are designed, the most appropriate alternative technology is selected and then the company must decide on the best product or portfolio of products that will be the cornerstone of the diversification strategy. The objective of this work is to develop a multicriteria tool, based on the Analytic Hierarchy Process (AHP), for the selection of the best product or portfolio of products for achieving the goals pursued by the company.

BACKGROUND

Technological diversification

Diversification is a commercial strategy that emphasises the role of the management of the company in the search for new business opportunities and activities. In this context, diversification can be defined as a strategy in which the company adds new products and markets to its commercial portfolio. This strategy implies the amplification of the competitive environment, the appearance of new industrial techniques, technological development and a management shift; factors that oblige the company to design a new organisational culture and prepare solid foundations for good leadership and the correct execution of strategic decisions [2].

One of the most significant figures in the study of diversification strategy is Igor Ansoff who proposed the four-strategy, product-market matrix [3], more specifically, diversification is defined as the combination of new markets and new products. Ansoff identifies different types of diversification, depending on the relationship between products (old and new) and markets (existing and potential) and further differentiates between horizontal, vertical, concentric and conglomerated diversification.

The Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a methodology created by the mathematician Thomas Saaty in the 1970s. The technique involves a multicriteria resolution of 'discrete' alternatives: the number of alternatives is considered as discrete and each of them can be dealt with in an explicit manner.

AHP [4, 5] is made up of the following stages: (i) *Modelling the problem* – a problem hierarchy must be constructed, and this involves the identification of the mission, the criteria relevant to its execution, the sub-criteria for each criteria, the actors and the alternatives; (ii) *Evaluation* – the establishment of paired comparisons between the elements of the hierarchy that hang from the same node (this process uses Saaty's fundamental scale [4]); (iii) *Prioritisation and synthe*sis - the local and global priorities for the elements of the hierarchy are determined, as are the totals for the alternatives of the problem. Saaty's Eigen Vector Problem EGV [4] and the Row Geometric Mean Method (RGM) are commonly used as the prioritisation procedures.

AN AHP MULTICRITERIA SELECTION OF PRODUCTS

The Analytic Hierarchy Process (AHP) is used to select the best product or portfolio of products for a commercial diversification strategy. After the company has been recognised as suitable for a diversification strategy there then follows an analysis of its technological capacity and the drawing up of the company's technology trees (as many trees as the key technologies possessed by the company). A technology tree identifies new alternatives for a product or service derived from a technology of the company which is usually a key technology [1]. The roots of the tree present the generic technologies, the trunk is the technological and industrial potential developed by the firm, the branches are the industrial activity sectors and subsectors and products are represented by the fruit [6].

A parallel study identifies a sub-technology or application (a branch) for each of the technology tree graphics and this determines the optimum diversification line to be followed. There will be a group of sub-products for each technology; the objective of this paper is to design a AHP based tool that can be used for the selection of the best product, in other words, the most effective, efficacious and efficient strategy [7].

Product selection is made according to multiple criteria (tangible and intangible) related to both technology and market. This approach differs from the classical one which considers two criteria (mean- variance model) representing profitability and risk.

To achieve this objective, a group of criteria, organised into four blocks, must be satisfied, the blocks are: Economic (E), Social (S), Technological (T) and Environmental (A). The subcriteria for the first block are relative to the economic structure of the organisation: Production (PR), Financial (FI), Human Resources (RH) and Commercial (CO); the subcriteria for the social block are: Socio-demographic (SO), Cultural (CU) and Political (PO); Technology sub-criteria are Capacity (CA) and Adaptability (AD); Environmental sub-criteria are Environment (ME) and Environmental policy (PA).

Once the problem has been hierarchically structured, it is necessary to know the preferences of the decision-makers. The Council for Industrial and Technological Diversification was able to turn to a group of experts that, by means of a series of interviews with the company management team, were able to propose a specific value or priority for each criterion. The experts act as a single entity (group decision making) and provide their judgments by consensus. From this data, five pairwise comparison matrices between the criteria and subcriteria were constructed using Saaty's fundamental scale. Four of the matrices made reference to the paired comparisons between the sub-criteria and each criterion; the other compared the criteria among themselves (with regards to the mission). The next stage is an evaluation of the alternatives (the products). Saaty's fundamental scale is again used to create matrices that, in relative terms, compare one alternative with another, based on the sub-criteria.

After the construction of the decision-makers' preference matrices, the local and global priorities can be calculated. With these results and the valuations of the alternatives, the total priorities are obtained and the optimum product is determined: this is the alternative (product) with the highest total priority.

CASE STUDY AND RESULTS

The methodology was applied to a Spanish company working in the automotive auxiliary sector. The company's main activity is the production and development of water pumps and the distribution of automotive components such as fuel pumps and filters.

The first step was an AHP multicriteria analysis that concluded that the company was suitable for a diversification strategy. This was followed by a technological study that identified three key technologies: i) the capacity for process automation; ii) research and development (R+D); iii) aluminium smelting. This information was used to design the technology trees.

Following the methodology, an optimum sub-technology was selected for each tree. This process limited the number of alternatives, focusing on three sub-technologies and a series of products from which the best alternative (product) was selected. This procedure was undertaken with the Analytic Hierarchy Process (as a methodological support) and the EXPERT CHOICE software package as a calculation support.

The hierarchical structure of the criteria was used to collect information relative to the preferences of the company and to design the paired comparison matrices. The group of experts then analysed and evaluated the alternatives (products) which were: Automated Guided Vehicles (AGV), Mini wind-power generators (MIN) and Diaphragm pumps (BOM). After the prioritisation of the alternatives and calculations made with EXPERT CHOICE, the alternative that obtained the highest total priority was that of Diaphragm pumps and it was therefore selected as the best product for the development of an industrial and technological diversification strategy.

CONCLUSIONS

The objective of this study was to design a multicriteria methodology using the Analytic Hierarchy Process for the selection of the best product for a company diversification strategy. The methodology selected the best alternative through the introduction of a hierarchical structure, the aggregation of the judgements that encapsulated the preferences of the decision-makers with reference to the criteria (economic, social, technological and environmental) and the prioritisation of the alternatives.

The methodology is of a cognitive character - its application gives companies greater knowledge of their strategic options, particularly with regards to diversification projects. This means that companies will be able to have a much greater understanding of their structure, business environment and commercial opportunities.

The methodology is clearly a tool of great potential for growth and expansion, it can be applied to many contexts concerning the selection of a product or portfolio of products and other types of business strategies, it can also be used in a variety of business sectors.

Decisional tools are becoming more and more important in organisations seeking to optimise their processes. In highly competitive markets and sectors these tools can be very efficacious in the selection of more competitive strategies; they do not require a great use of resources and may generate significant benefits for the company or organisation.

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Decision Analysis in Nuclear Decommissioning: Developments in Techniques and Stakeholder Engagement Processes

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ABSTRACT

This paper provides a brief background to the history of the use of Multi-Attribute Decision Analysis (MADA) optioneering tools in Magnox Limited for the purposes of waste management decision-making and stakeholder engagement, and how Magnox Limited have developed new assessment techniques that deliver a more open, transparent, and proportionate approach.

Keywords: Multi-Attribute Decision Analysis, Nuclear Decommissioning, BPEO Screening Analysis, Stakeholder Engagement

OPTIMISATION OF RADIOACTIVE WASTE MANAGEMENT IN THE NUCLEAR INDUSTRY IN THE UK

Following the end of electricity generation, the decommissioning of nuclear plant will involve dealing with a variety of radioactive wastes, determined by various thresholds – Intermediate Level Waste (ILW), Low Level Waste (LLW) and Very Low Level Waste (VLLW). There is a requirement on the industry to ensure that its waste management plans are optimised at strategic and detailed levels. The former is undertaken by high-level optioneering within a framework called Best Practicable Environmental Option (BPEO), and the latter within a framework called Best Practicable Means (BPM)[1].

BPEO is usually defined as (Ref. 1),

> *"…the outcome of a systematic and consultative decision-making procedure which emphasises the protection and conservation of the environment across air, land and water. The BPEO procedure establishes for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as in the short term".*

BPM can be defined as (Ref. 2),

> *"Within a particular waste management option, the BPM is that…level of management and engineering control that minimises, as far as is practicable, the release of radioactivity to the environment whilst taking into account a wider range of factors, including cost effectiveness, technological status, operational safety and societal factors…"*

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[1] Within England and Wales, the introduction of the Environmental Permitting Regulations 2010 has replaced these terms with Best Available Techniques (BAT), although both BPEO and BPM processes continue to be used, and are acknowledged by regulators as useful steps in determination of BAT by identifying high level strategy and implementation optimisation respectively.

HISTORY OF DECISION MAKING IN MAGNOX LIMITED

Prior to the Aarhus Convention (1998) and the European Council Directive on Public Access to Environmental Information (2003)[2], regarding access to information and encouraging greater stakeholder participation in the decision making processes on matters concerning the environment, there was some use of decision analysis techniques in the company but little evidence of them being used as a means of stakeholder engagement.

However, with the introduction of these requirements, the company recognised the need for greater openness and transparency in its decision-making processes, and with Multi Attribute Decision Analysis (MADA) tools already being practised in some arenas, and being available in "simple-to-use" off the shelf packages such as "HiView", it soon became clear that such tools could be used as the means for engagement.

For demonstration primarily of BPEO for decisions relating to waste management for ILW and LLW wastes, so workshops began to be held with representation from a variety of stakeholder interests (including Site Stakeholder Groups (SSG), regulators and non-governmental organisations) to assess alternative options to support development of strategy for each waste. This is illustrated in Figure 1 below.

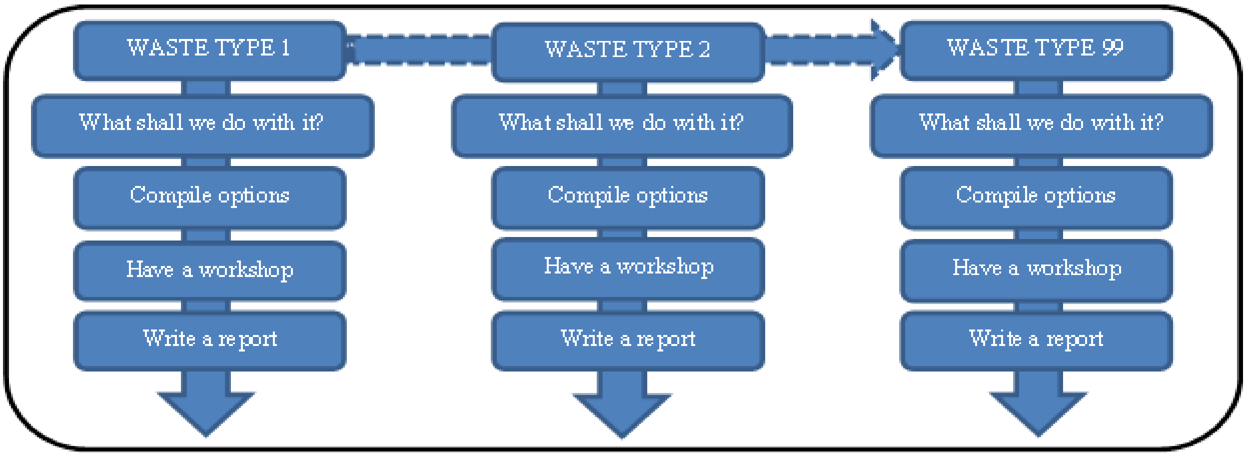

Figure 1: The Standard Process of Decision-Making (and Stakeholder Engagement) for Individual Waste Streams.

THE NEED FOR CHANGE

However, the change to a more stakeholder led decision making process resulted in a number of problems:

- Magnox Limited has some 500 different radioactive waste types, identified by their characteristics and location. Each of these wastes could require their own BPEO assessment.
- The MADA assessments were often carried out by external organisations who were not well practised in understanding the theory behind the available software packages, such that reports would contain many figures showing weighted scores and sensitivity analyses, but with little underpinned justification for outcomes; for example, weighting factors being averaged, or misunderstanding of the differences between swing and preference weighting.

[2] This was introduced in the UK through the Environmental Information Regulations (2004).

- Sensitivity analysis became restricted to effects of weighting factors on attribute scores.
- The process was resource intensive. Workshops and associated work cost the organisation between £10,000 and £2 million, with typical costs around £15-20,000 – in addition to this would be staff costs, both in support of the workshop but also in review and verification of the outputs from workshops.
- Changes in technology, in an industry where technological advancements are continually being made, could result in large studies needing to be regularly repeated.
- Waste streams were being assessed individually, when in reality what happened to a waste stream could be dependent on what happened to a variety of other wastes.
- Strategy and detailed optimisation became intertwined, so that small changes could invalidate the BPEO.
- Regulators were losing faith in the process. The outputs of reports would vary from site to site for similar waste streams, dependent on the quality of facilitation, understanding of the process, and the workshop attendees. Responding to the summary reports of 2005, the Environment Agency (EA) commented, "*there was much paper produced…with little evidence of it being useful to either party*."
- The process was disengaging stakeholders. Stakeholders were fatigued by the process, leading to dwindling numbers of participants and hence reducing the value input of the engagement.
- Magnox staff were becoming disengaged, with decisions seemingly being wholly stakeholder led rather than by those considered to have expertise in such arenas; for example, one study was scored and weighted solely by non-expert members of the public.

It was clear that simply applying MADAs to every decision on waste management strategy, notwithstanding the high cost of doing so, was not an effective way forward, either in terms of delivering well underpinned decision making or engagement with stakeholders.

DEVELOPMENT OF A NEW PROCESS OF DECISION ANALYSIS

To address these issues, the authors developed a three step process of decision analysis (see Figure 2):

a. Establish a site waste baseline strategy by application of the MADA ("Meaning of Ten") approach. Stakeholders were involved in the process to assign attribute weightings, recognising that different people have different views as to the relative importance of the various issues involved.
b. For each waste, using a screening matrix, compare the site baseline to identify the availability of other technical options and whether such options would deliver improvements in terms of waste disposal volume or management solution along the waste hierarchy.
c. Review the BPEOs on a periodic basis.

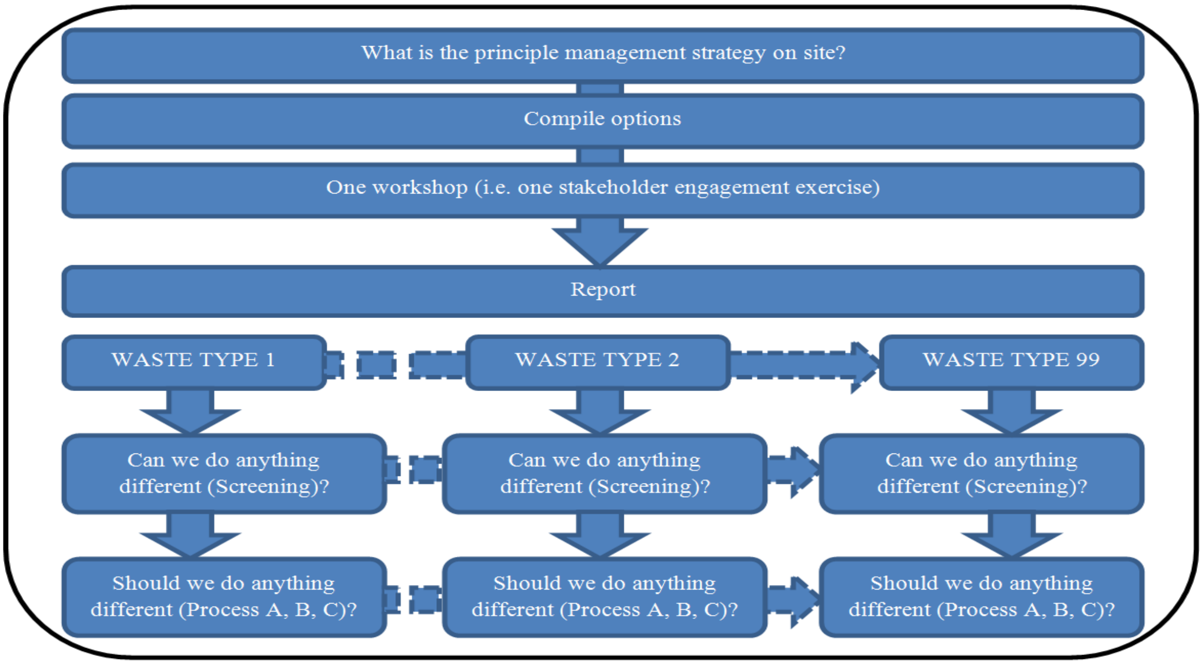

Figure 2: The New Process of Decision Making Based on Establishing a Site Baseline and Screening Analysis.

ESTABLISHING THE SITE BASELINE STRATEGY – THE "MEANING OF TEN" APPROACH TO MADA

For the site baseline studies, options providing the widest contrast in concept were considered in order to understand the underlying drivers. That said, a wide range of options did not necessarily result in a large number of options as the number of appropriate technologies are relatively limited – the baseline is therefore not especially sensitive to technology change.

An approach we call the "Meaning of Ten Approach" was developed and used, with attributes largely related to impacts (e.g. tonnes of carbon dioxide emitted) rather than the mechanisms which give rise to impacts (e.g. transport). This allowed for clarity of reasoning when assigning weighting factors to attributes and also facilitated subsequent sensitivity analysis (e.g. because a new mechanism resulting in carbon dioxide emissions, for example, can be later included in the analysis if required). The authors also believed that this helped external stakeholders understand the magnitude of the actual consequences of adopting particular strategies.

In the Magnox site baseline strategy studies, an absolute scoring scheme was used (based on factual information on the whole), as against a relative scheme or a scheme based on differences between the best and the worst options. In this scheme, a score of zero would mean that an option had "no impact" on an issue and a score of 10 represented the maximum impact of any option on that issue. In this system, the "swing" element, that is, the difference in performance between the options, is accounted for within the scoring scheme rather than the weighting scheme. If options perform similarly on a particular issue then all options would have a similar score, e.g. between 9 and 10 (out of 10). However, if there is a large range in performance between the options then there will be a large variation in score, e.g. from 1 to 10.

Accounting for the "swing" element in the scoring scheme rather than in weighting factors has two advantages:

a. It minimises the risk that small, unreliable differences in option performance could (mathematically) have an undue influence in the outcome by being “stretched” between scores of zero and 10; and,
b. It allows for attributes on which options have a reliable performance difference (as represented by scores over a larger range) to have a greater influence, depending on weighting factors selected by stakeholders.

The weighting factors in the Magnox studies were chosen taking account of the importance of the issues and the maximum possible impacts. The scoring and weighting system allowed people to recognise the absolute magnitude of an issue (the worst an impact could be, i.e. the meaning of 10) and to amend the weighting factor if they so wished to account for the importance of the issue to them, notwithstanding the actual level of impact. This was apparent, for example, when stakeholders consciously gave a higher weighting factor to what they recognised was a small maximum impact, e.g. radiological discharges.

In these ways, the scoring and weighting process took into account differences in option performance, the absolute levels of impact concerned, the potential for error due to uncertainties, and subjective preferences in terms of importance of the issues notwithstanding actual impacts. The process also allowed for analysis of alternative scenarios, given the parameters and constraints identified by stakeholder views of potential impacts.

CONSIDERATION OF INDIVIDUAL WASTE STREAMS

With the site baseline established, the screening process is applied, using a matrix approach. This process compares at a high level, for each waste stream at each site, the site baseline option against other management technologies to identify the availability of technical solutions (a process which took a 1-day workshop for 39 waste streams at Hinkley Point A site with no need for external facilitation). Technologies are assessed to determine whether they deliver improvements in opportunities along the waste hierarchy, or if requiring disposal, substantial reductions in the waste volume to be disposed, from that identified by the baseline option. A simple triage approach can then be applied to the outcome of the process for the purpose of options comparison (see Figure 3):

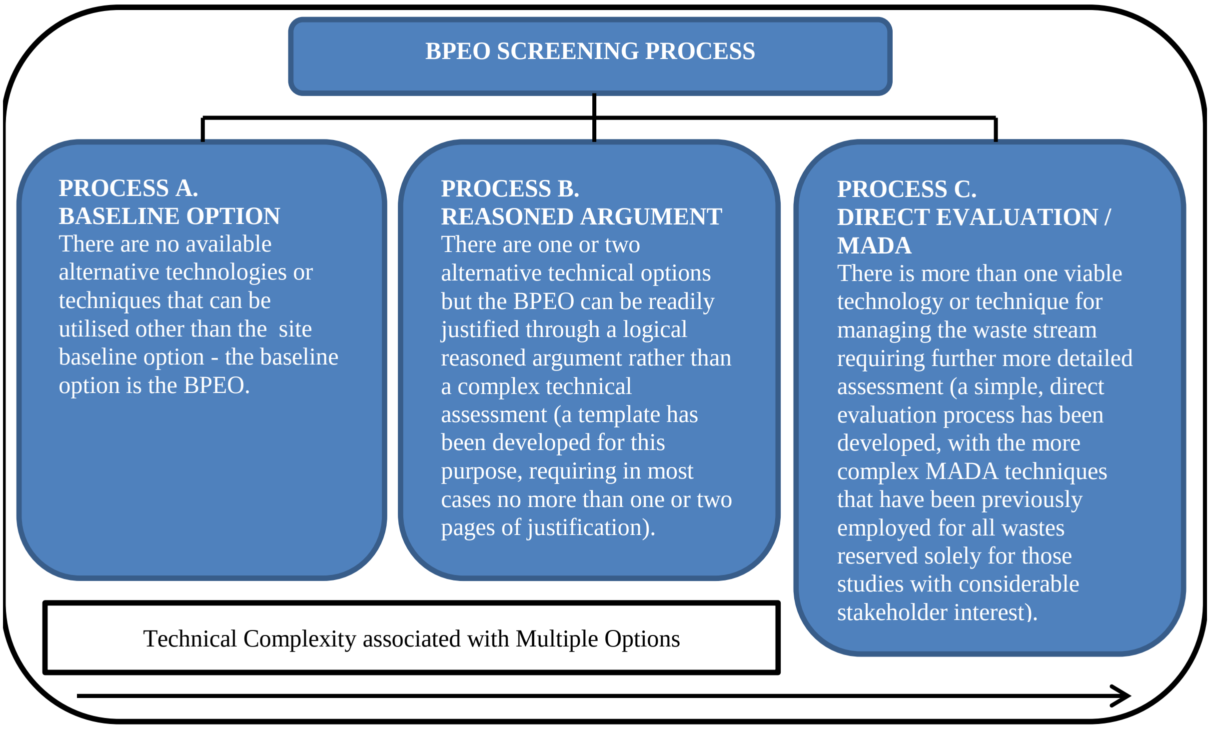

Figure 3: Post Screening Outcomes for Options Comparison.

In other words, the process employs a proportionate approach to decision making and identification of the BPEO. Experience thus far has demonstrated that over 99% of the waste streams evaluated can be dealt with using either Process A or B, presenting a considerable cost and time saving to the Company.

STAKEHOLDER INVOLVEMENT IN THE NEW PROCESS

The approach to stakeholder involvement has also been given consideration and a proportionate approach to involvement and engagement developed. The principle of participation does not necessarily mean that all potential stakeholders need to be involved in every BPEO study. Instead stakeholders input into the "big picture" for the site, but in general do not need to be involved with the detail of hundreds of individual waste streams (see Table 1).

Table 1: Stakeholder Engagement in the Decision Making Process

	INTERNAL	EXTERNAL	
BPEO SCREENING PROCESS	Involvement of technical specialists with knowledge of the waste streams and possible technical solutions.	External stakeholders briefed with outcome of screening process.	EXTERNAL STAKEHOLDER ENGAGEMENT
PROCESS A **BASELINE OPTION**	Baseline option further justified through internal expertise.	Presentation of outcome of BPEO Screening Process to external stakeholders.	
PROCESS B **REASONED ARGUMENT**	Logical argument developed by internal expertise.	Presentation of outcome of reasoned argument made to external stakeholders.	
PROCESS C **DIRECT EVALUATION / MADA**	Direct evaluation process undertaken by internal expertise to compare options. ***OR***	Presentation of outcome of direct evaluation made to external stakeholders but with opportunity for stakeholders to participate in a weighting exercise to identify issues of concern. ***OR***	EXTERNAL STAKEHOLDER INVOLVEMENT
	MADA assessment held to compare options involving internal and external stakeholders, where choice of option is likely to impact significantly on the local environment, e.g. on-site disposal.		

PERIODIC REVIEW OF BPEOS

The developed process has also recognised the need for ensuring that the outputs of these assessments are updated regularly to reflect changes in waste characterisation and analysis, or new technologies, or even changes in regulation and timescales for decommissioning. The success of this process is that a simple review of the screening process means that individual screening forms can be reviewed quickly and usually simply revalidated rather than necessarily reconvening workshops to determine the MADA output for each and every waste stream that is affected.

All of the BPEO documentation is kept on a database which links all documents to individual waste stream identifiers for all sites, and employs a simple “traffic-light system” to raise awareness that a periodic review is required.

The outcome of the review can then be recorded on the BPEO Requirements Form and also recorded on the database. In other words, the whole process from start to end is fully transparent and auditable, with each step clearly documented along the way.

COMMENTS AND FEEDBACK

The BPEO Screening Process and the BPEO Database have been introduced to the Environment Agency Inspection Team and both have been well received. The Environment Agency has commented,

> *"We always welcome developments that make our job as well as the sites' easier and more efficient. We are able to check rapidly if a site has the structure in place to demonstrate compliance in this area and it reassures us that best practice is being applied…Over the coming years it will be critical in ensuring wastes go to the right disposal route allowing decommissioning that gives optimised protection of the environment."*

Magnox Site experience of the process has also been very favourable, with interest generated now amongst other nuclear operators:

> *"Prior to the implementation of the new BPEO methodology, the process would typically involve several months of effort and costs to deliver an outcome. The new methodology is much more efficient and less times consuming, and also allows comparison with similar wastes at other sites which allows a generic approach to be taken to managing our wastes."*
>
> Head of Environment, Hinkley Point A

> *"Having employed this novel process at the recent Hinkley Point A Site ILW BPEO Workshop, it is clear that this technique facilitates decision making by presenting information in a clear, tabular format that can be easily understood and discussed by panel members (including non-experts)."*
>
> Head of Waste, Hinkley Point A

> *"At Berkeley we are undertaking BPEO reviews for over 100 different ILW streams that need to be retrieved and made safe prior to entry into care and maintenance. With previous approaches this would have required generation of lots of supporting information for each waste stream and each option to support MADA workshops. With the revised approach…this will result in both a significant cost and time saving, whilst still maintaining regulator and stakeholder engagement and support for a robust process and outcome."*
>
> Berkeley ILW Project Design Authority

> *"The development of the BPEO Screening Process and BPEO Database has produced a process that is already attracting interest from other SLCs. By simplifying the process it allows all those involved to think more about the outcome than being immersed in the process. This should improve the outcome and involvement in the process."*
>
> Magnox South Head of Environment.

CONCLUSION

The development of this new, innovative and multi-award winning approach to BPEO management across Magnox Limited has opened the way for a more open, transparent and proportionate approach to BPEO regulation with the Environmental Agencies, which has been welcomed on all sides.

This has had, and will continue to have, enormous savings (running into millions of pounds) in terms of both time and ongoing costs for the organisation as we move forward, and has further cemented a positive working relationship with the Environment Agency and the Scottish Environment Protection Agency and their inspection teams.

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Knowledge management competence for ERP implementation success

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ABSTRACT

In today's dynamic and unpredictable business environment, organisations face the tremendous challenge of expanding markets, rising customer expectations and developing their intellectual capital. Therefore, many companies are turning to Enterprise Resource Planning (ERP) systems in order to accomplish above goals. Literature had extensively discussed the key issues, challenges and current status of ERP selection, implementation and use in industries. Knowledge Management (KM) has been identified as one of the key success factors for ERP implementation and has received considerable attention in the last decade, and is continuously gaining interest from industry and academia. KM for ERP implementation is however a challenging task because of the complexity of ERP packages which requires holistic consideration of different types of knowledge across its life-cycle stages. Existing work has not adequately addressed the KM support for ERP implementation from an integrated perspective.

This paper aims to identify the research gap on KM competence for ERP implementation success (KM competence-ERP success), and proposes a conceptual framework on KM competence-ERP success, in order to guide ERP projects towards success by eliminating failure points. The KM competence-ERP success framework integrates three key perspectives. The knowledge management life-cycle perspective provides insights into knowledge flow from k-creation through k-retention and k-transfer to k-application. Knowledge types considered include project management knowledge, business process knowledge, organizational cultural knowledge, and ERP package knowledge. Knowledge layer perspective will discuss not only know-what and know-how but also know-why and know-with, so that ERP implementation decisions will be adequately informed and justified. Next step will consolidate the KM competence-ERP success framework with feedback from colleagues in KM and ERP and evaluate the framework with industrial empirical studies.

Keywords: knowledge management competence, enterprise resource planning, conceptual framework

INTRODUCTION

The global business environment has changed dramatically in recent years, as competition in complex knowledge based economies has increased. Enterprise Resource Planning (ERP) systems have been viewed as a way to manage increased business complexity, leading to the rapid adoption and implementation of such systems, as ERP can support enterprises to improve their competitiveness [1, 2]. ERP is a strategic tool that helps a company to gain competitive advantage by integrating business processes and optimizing the resources available [3]. Over the past two decades, ERP systems have become one of the most important implementations in the corporate use of information technology. ERP implementations are usually large, complex projects, involving large groups of people and other resources, working together under considerable time pressure and facing many unforeseen developments [4, 5].

Despite the benefits that can be achieved from a successful ERP system implementation, there is evidence of high failure in ERP implementation projects [6]. Too frequently key development practices are ignored and early warning signs that lead to project failure are not understood.

More recently, knowledge management (KM) has emerged as a discrete area in the study of organizations, to the extent that it has become recognized as a significant source of competitive advantage. Effectively implementing a sound KM strategy and becoming a knowledge-based company is seen as a mandatory condition of success for organizations as they enter the era of the knowledge economy [7]. The prospect of synergies between these two areas makes it an attractive area for current research, using KM to help face the challenge of increasing the success rate of ERP and reducing the risk of the implementation. Hence, this paper investigates current work in this domain and proposes a conceptual framework on KM competence-ERP success, to guide ERP projects toward success by eliminating failure points with regard to knowledge management aspect.

KNOWLEDGE MANAGEMENT COMPETENCE FOR ERP IMPLEMENTATION SUCCESS

The majority of research in ERP system implementation is focused on critical success factors, critical failure factors, risk factors and effective factors relating to ERP implementations [8, 9, 10, 11, 12]. However, there are relatively few studies which specifically focus on knowledge management competence for ERP implementation success (KM competence-ERP success). This section mainly discusses the various KM competence-ERP success related literature.

Vandaie [13] identifies two major areas of concern regarding the management of knowledge in ERP projects; managing tacit knowledge and issues concerning the process-based nature of organizational knowledge. Further, he identifies that facilitators are able to moderate these negative effects. The structure of team interactions and the atmosphere of the team help to moderate negative effects that are due to the tacit nature of ERP knowledge. Similarly, powerful core ERP teams and hiring in external consultants help to moderate the negative effects of the process-based nature of ERP knowledge and organisational memory. There is a large, significant and positive relationship between knowledge management competence and enterprise success, according to the quantitative study by Sedera and Gable

[14]. The study also demonstrates the equal importance of the four phases of the KM-competence i.e. creation, retention, transfer and application. Further, Sedera et al. [15] revealed that information quality, system quality, satisfaction, individual impact and organizational impact as variables in order to measure ERP success. Jones et al. [5] examined eight dimensions of culture and their impact on how the ERP implementation team is able to effectively share knowledge during implementation. This study shows ways to overcome cultural barriers to knowledge sharing. Further, it develops a model that demonstrates the link between the dimensions of culture, and knowledge sharing during ERP implementation. Maditinos et al. [16] introduced a conceptual framework that investigates the way that human inputs are linked to communication effectiveness, conflict resolution and knowledge transfer. They also showed the effect of the above factors on successful ERP implementation. Moreover, they found that knowledge transfer is positively related to user support and consultant support. These findings are largely based on the phases of knowledge management i.e. k-creation, k-retention, k-transfer and k-application.

O'Leary [17] investigated the use of KM to support ERP systems across the entire life cycle, with particular interest in case-based KM. Organisation culture, business framework, ERP package and project were the knowledge types identified by Alavi and Leidner [18]. Chen [19] divides empirical knowledge into four different layers of “know-what”, “know-why”, “know-how”, and “know-with” based on the empirical knowledge characterization.

The common feature of the past studies discussed in this section is that most of them are case based qualitative studies or purely literature reviews. Although effective KM has been identified as one of the key drivers for successful ERP implementations, there has been a significant shortage of empirical research on management of knowledge related to ERP implementation [20]. Understanding this, it is quite evident that KM competence-ERP success domain demands more research, particularly in the form of quantitative, rather than purely qualitative, studies.

A CONCEPTUAL FRAMEWORK ON KM COMPETENCE-ERP SUCCESS

A tentative conceptual framework has been developed from the literature in the KM competence-ERP success domain and it identifies the research gap in this particular area. Further, it comprises the components as can be seen in Figure 1 with the arrows indicating the relationship between each component.

A positive relationship between KM Competence and ERP Success (measured by information quality, system quality, satisfaction, individual impact and organizational impact) and the significant contribution towards KM Competence by k-creation, k-retention, k-transfer and k-application were incorporated to this framework based on the Sedera and Gable [14] and Sedera et al. [15] quantitative studies (denote by the hash lined area). K-types and K-layers have been introduced to the framework based on the studies of Alavi and Leidner [18] and Chen [19] respectively.

The k-creation determined by tacit nature of ERP knowledge [13], nature of individual interactions [21], k-centred culture and k-oriented leadership [22]. The k-retention determined by ERP features for KM, KM automation and practice of document management [23]. Moreover, k-transfer determined by project team power and culture [5], top management support [24] user support and consultant support [16] during ERP system implementations have also been identified and incorporated to the framework. Unfortunately, k-application (use, re-use and learning) lacks a sound research base. It appears that k-application has a significant research gap as far as the KM competence-ERP success domain is concerned.

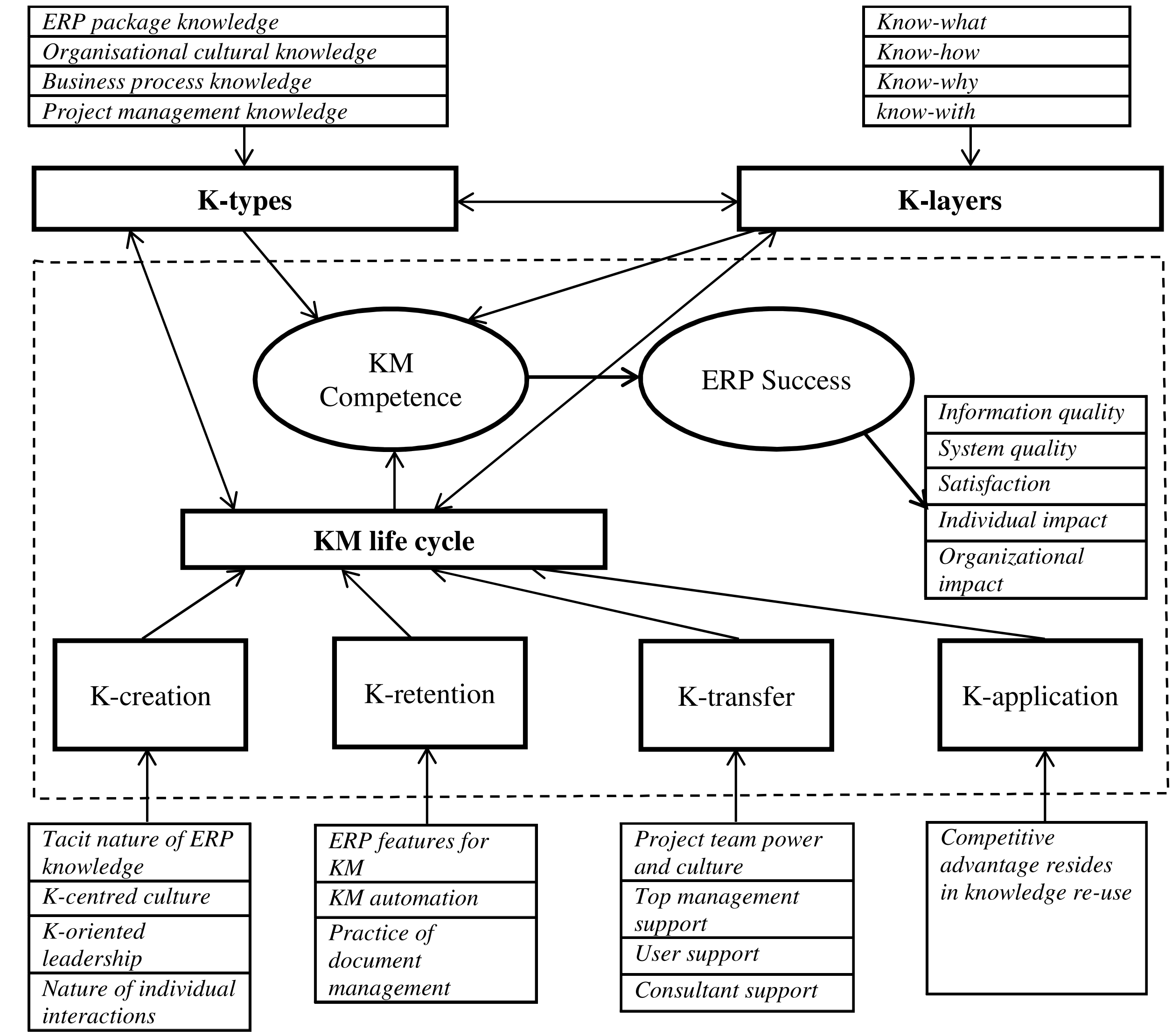

Figure 1: Conceptual framework on KM competence-ERP success

DISCUSSION AND CONCLUDING REMARKS

The conceptual framework focuses on several areas that have had limited research exposure. First, the positive relationship between KM Competence and ERP Success and the significant contribution towards KM Competence by k-creation, k-retention, k-transfer and k-application were found only for SAP package and public sector organisations in Queensland, Australia. This framework, however, suggests that it may be possible to generalise these relationships for other ERP packages such as Oracle, J. D. Edwards and Baan, as well as across various other sectors such as financial, telecommunication, transport, manufacturing, etc. and across alternate geographical areas, for instance, the UK.

Second, k-types and k-layers, with the inter-relationships between the three components (KM life cycle, k-types and k-layers) towards KM Competence, have not been tested in the ERP context before. Therefore, this would be a new research area as far as the KM competence-ERP success domain is concerned.

Third, the determinants of k-creation were found through literature, but have not been validated through any empirical work. Therefore, this framework could be used to examine this through empirical research.

Fourth, the determinants of k-retention were tested only for Taiwan companies. Therefore, this framework could be used to validate the applicability of these determinants for other contexts in order to generalize the results.

Fifth, the determinants of k-transfer i.e. project team power and culture, top management support, user support and consultant support, were found largely via case based qualitative research studies. Hence, there is the potential for confirming these outcomes by use of quantitative approach in order to generalise the results across a wide range of ERP packages and industry sectors.

Sixth, the k-application phase currently lacks research outputs. Therefore, this conceptual framework could be extended to discover determinants for this phase of knowledge management with respect to ERP implementations.

Though this conceptual framework contributes to the existing knowledge, there are some clear limitations. There may be difficulties in using a single research approach across the framework i.e. either quantitative or qualitative. Moreover, there may be difficulties in testing and generalizing the framework across all the available ERP packages on the market and across all industry sectors.

In conclusion, this paper has discussed the background of KM and ERP, the literature on KM competence-ERP success domain and the importance of fulfilling research gaps in above domain. It has offered a significant contribution in terms of the proposed conceptual framework on KM competence-ERP success, whilst highlighting its limitations. The proposed conceptual framework on KM competence-ERP success should be a useful guide for ERP projects toward success, by helping to eliminate failure points with regard to the knowledge management aspect.

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Considering tacit knowledge when bridging knowledge management and collaborative decision making

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ABSTRACT

This paper introduces ways for considering tacit knowledge when bridging knowledge management and collaborative decision making. The presented approach relies on unexpected theories in the area of collaborative decision making such as ethnographic workplace study and incommensurability of interpretative frameworks seen as the source of communication breakdown within collaborative decision making.

The bridge between knowledge management and collaborative decision making can now be considered as accepted as a source of improvements by the organizations. Collaborative tools or ontologies, several things are done to promote collaborative decision making through knowledge management.

However, knowledge management is not reduced to its technological approach, which rests on the codification of explicit knowledge and neglects its tacit dimension.

We propose in this paper to discuss three view points for considering tacit knowledge when bridging knowledge management and collaborative decision making, which have been developed relying on the presented background theories. These view points are currently tested within several large companies, and could be improved in future works.

Keywords: Knowledge Management, Collaborative Decision Making, Tacit Knowledge, Incommensurability, Interpretative framework, Ethnographic Workplace Study.

1 INTRODUCTION

Economical investments since the 1970's in computers, information technologies, and collaborative tools are important. Over the last twenty years, as remarked by Landauer in [10], productivity in the services at which they were aimed are stagnating everywhere in the world.

At the same time, several authors warn the organizations about the possible lost of knowledge when neglecting tacit knowledge within them. If authors as Tsuchiya in [18] propose to improve knowledge creation, others as Liebowitz in [7] propose methodologies to retain it.

We consider that knowledge management should be an integrated part of collaborative decision making as it enables knowledge creation, knowledge sharing and knowledge retention. Collaborative decision making is a process always followed by a decision engendering actions. During this process, knowledge is created. We have to prevent the loss of this knowledge, and to improve its sharing. When knowledge is shared, the decision is more easily accepted, collaborative decision making is improved. This was already discussed by us in [1].

In this paper we highlight the importance of tacit knowledge when bridging knowledge management and collaborative decision making and give directions in order to take into account tacit knowledge. Because of being immaterial, tacit knowledge is often (not to say always) neglected. After remembering our vision of knowledge within the organization, we present unexpected background theories in the area of collaborative decision making: the ethnographic workplace study introduced by Jordan in [8] and the concept of *incommensurability* through the study of communication breakdown introduced by Kuhn in [9]. These background theories consolidated our own research works and brought us to highlight three key view points for considering tacit knowledge, which will be presented at the end of this paper.

2 BACKGROUND THEORY

2.1 Our vision of knowledge within the organization

When Tsuchiya in [18] introduces the concepts of sense-giving and sense-reading, we simply observe that we continuously appropriate information which is not ours. As the authors of this paper, we have got tacit knowledge that we have structured into information during a process of sense-giving. As the readers of this paper, you have interpreted this information perceiving forms and colours, integrated words, data, during a process of sense-reading possibly creating new tacit knowledge for you (see Fig. 1).

When a person P_1 structures its tacit knowledge and externalizes it, he creates information. A person P_2 perceiving some data from this information and internalizing it, possibly creates new tacit knowledge. Thus knowledge is the result of the interpretation of information by someone. This interpretation is done through an interpretative framework that filters data contained in the information and the use of previous tacit knowledge as presented by Tsuchiya in [18] and by Grundstein in [6].

If the probability that two people will give the same meaning to the same information is high, it is said that their interpretative frameworks have a strong commensurability or are commensurable. On the contrary, if this probability is low, it is said that their interpretative frameworks have a low commensurability or are incommensurable. Many of our studies aim at setting a mean to measure this commensurability. We will see in section 2.3 how Kuhn in [9] introduces the concept of incommensurability relying on the observation of communication breakdown between individuals. Is the observation of individuals, of stakeholders of a collaborative decision making process, a way to estimate this commensurability and to prevent the risk of communication breakdown? What kind of observation should it be?

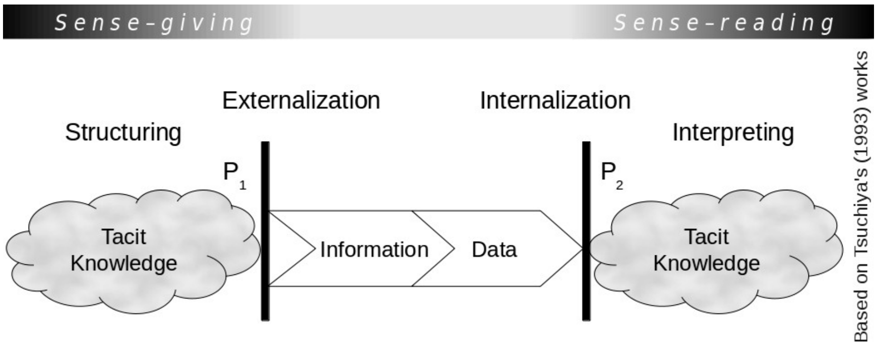

Figure 1: Tacit knowledge transfer

2.2 Ethnographic workplace study: the participation as a mean to observe

Historically, collaborative tools as the Computer-Supported Cooperative Work (CSCW) are the result of information technologies whose design was polarized around the individual user (Schmidt and Bannon in [15]). Individuals are users and as such they are all individually connected to a system.

According to Standing and Stockdale (p.1091 in [17]), neglecting social activity leads to “meaningless conclusions”. So we cannot be satisfied only with a technological approach and Jordan insists when she reminds that knowledge is not only based on the group but is also tacit, embodied in individual minds: “We believe that there is yet another dimension that needs to be explored and that is the knowledge that is not only group-based but also tacit, implicit, embodied, and not articulated.” (p.18 in [8]). Thereby knowledge can be:

1) explicit, it is socially constructed and then can be supported by CSCW or similar technologies
2) tacit, it is not always articulated, relying on Polanyi [13] notably : “we can know more than we can tell”.

The creation and the use of explicit knowledge within a group have been studied by Lave and Wenger in the chapter 4 of [11]. The transfer of knowledge has been characterized by Davenport and Prusak in [5], page 101 notably: “Transfer = Transmission + Absorption (and Use)”. However there are very few works known about tacit knowledge and its use within a group, when bridging knowledge management and collaborative decision making for example. The immaterial nature of tacit knowledge often leads people to neglect it or to take it into consideration only from a local point of view. Using and sharing tacit knowledge is rarely a part of organizations' strategy. Jordan, with this in mind and relying on her anthropologist background, presents ethnographic field methods in order to highlight tacit knowledge within a group.

Early in the twentieth century, the anthropologists studied exotic tribes and communities. They were away from civilization and from its rules, even the spoken language was not known in many cases. As said by Jordan in [8]: “Anthropologists learned to learn not by explicit instruction but by *participating* in the routine activities of people’s daily lives and by immersing themselves in the events of the community [...]”. They learned to see the world from the point of view of “the natives”. This was the creation of ethnography: a methodology to understand complex functioning systems.

Every ethnographic field work involves what Jordan calls “participant observation”. A “participant observer” is not only the novice who tries to fit right into a community, but also the observer who needs to maintain a distance, to record his observations and to reflect his evolving understanding of the situations he encounters. Lave and Wenger in [11] present the apprentice as the “legitimate peripheral participant”: he can ask questions, “get into interesting situations” and is thus powerful to assimilate tacit knowledge within organizations.

Participant observation can thus be a mean to consider tacit knowledge when bridging knowledge management and collaborative decision making. The participant observer learns to become a part of the community and doing so, he assimilates the tacit knowledge which was only known by “the natives”. We can notably refer to Roy [14] who introduces the “analyst” as the person who makes explicit the problem for the decision-maker. The analyst is living the processes, he interferes in them, he is a participant observer. Jordan in [8] presents more precisely her field work notably with the use of cameras, in-situ question asking, etc. We deduce from the work done by Jordan [8] that doing together is a way to share tacit knowledge. We agree with this idea and we presented a similar approach in [1].

2.3 Incommensurability: when communication breaks down

As a philosopher of science, Kuhn in [9] introduced the term “incommensurable” to characterize two theories whose transition “change their meanings or conditions of applicability in subtle ways” ([9], p.266). Such theories are, he said, incommensurable. In [9] Kuhn was the first to tackle the problem of “partial communication” which will become “communication breakdown”. He identified the source of this communication breakdown as being a problem of incommensurable points of view.

In collaborative decision making, and more generally in a group, individuals talk. They all learned a language which attaches terms to nature, what is outside them. This language is constructed imprint of their own view of the world. It is the same mechanism that makes specialists interpret Newton's Second Law $f=ma$, for example, as $mg=\frac{md^2 s}{dt^2}$ for the pendulum or $mg\sin(\theta)=-ml\frac{d^2\theta}{dt^2}$ for coupled harmonic oscillators. So even this physical law has different interpretations. Language, whether natural or scientific, can be interpreted differently. Depending on what?

Kuhn proposes to study the sources of communication breakdown, which are “extraordinarily difficult to isolate and by-pass” ([9], p.276). Differences are not only in the terms or the language, but also and inseparably in the nature. Two men, even if they see the same thing in the nature, even if they hold the same data, can interpret them differently. The differences between what is in the nature and what they perceive as being in the nature are correlated to the corresponding differences in the language-nature interaction. The two men are processing the same data differently. They see the same thing differently. For Kuhn their general “neural apparatus” is differently programmed.

According to him, this programming should be the same if the stakeholders share a history (except the immediate past), a language, an everyday world, and sciences. Given what they share, they can highlight more about how they differ. They can discover the area where occurs the communication breakdown. Often the root of the problem are terms such as “element” or “compound” used by both men but attached to the nature in a different way (see Fig. 2). For every identified term they can found another in a basic vocabulary, which sense in an intra-group use will elicit no discussion, no request for explication, no disagreement. With time, these men will become good predictors of each other's behaviour. They have learned to talk each other's language, they have learned to see the world from each other's point of view.

Consideration to tacit knowledge is for us obtained through these efforts to understand each other by transcending itself. It is a way to avoid communication breakdown, which is one of the difficulties encountered in collaborative decision making.

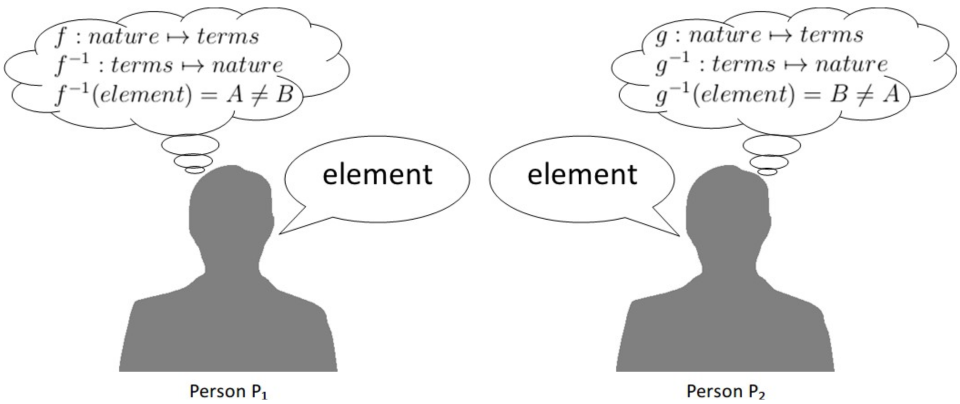

Figure 2: Communication breakdown: when terms are attached to nature in different ways

3 PROPOSITION

In this section, taking into consideration the background theories discussed above, we point out the importance of tacit knowledge during collaborative decision making processes. Regarding the man as a component of a collaborative initiative and not only as a user of a collaborative system, we present three view points as essential when considering tacit knowledge. For each of them we suggest some axis of analysis. These axis of analysis are currently tested within industrial environments and will be refined in future works.

The view points have been formed around the statements that (1) even when collaborative decision making implied knowledge management activities (document management system, ontologies, etc.) it sometimes (2) neglects tacit knowledge held by individuals. However, collaborative decision making processes are not always (3) aware of the conditions and limits allowing explicit knowledge, formalized and codified, to be correctly interpreted by all the stakeholders.

Relying on these statements, we propose to consider tacit knowledge within collaborative decision making processes from the analysis of three view points: (1) implementation of new activities enabling to retain and to use knowledge created during the collaborative decision making process, (2) awareness that knowledge is not an object (it results of the interpretation of information by someone, see section 2.1) and (3) analysis of the conditions and limits so that codified and formalized knowledge will have the same meaning regardless who is receiving it.

3.1 View point 1: implementation of new activities enabling to retain and to use knowledge created during the collaborative decision making process

This view point is naturally leaded by the necessity to consider knowledge as a resource for every process, including a collaborative decision making process. Moreover, knowledge being created in the action and collaborative decision making processes implying actions, they create knowledge. One should maintain, retain and use the knowledge created through collaborative decision making processes. One should manage these resources.

First of all, the stakeholders of collaborative decision making processes should be aware that activities in order to retain or to use knowledge are necessary. These activities can then be introduced in a local, informal and no hierarchized way. At best, they should be integrated parts of every collaborative decision making initiative.

3.2 View point 2: awareness that knowledge is not an object

The second view point relies among others on Tsuchiya's works [18] presented in section 2.1. Knowledge resulting of the interpretation by an individual of information, the sense taken by this information can diverge from person to person. That is the reason why knowledge management is not only the management of an "object knowledge", but also the management of the activities creating, retaining and using knowledge (view point 1). We are sure then, that we are not loosing the tacit dimension, often neglected when knowledge is regarded as an object.

First of all, the stakeholders of collaborative decision making processes should not use the terms "information" and "knowledge" equally. Neglecting that these words have different meanings shows that the stakeholders are not aware that knowledge is not an object. Once this distinction is done, they can implement some activities aiming at highlighting and sharing, in the sense of Davenport and Prusak [5], tacit knowledge. At best, collaborative decision making processes should consider knowledge as resulting of the interpretation by someone of information and should integrate individual and collective learning and tacit knowledge transfer.

3.3 View point 3: analysis of the conditions and limits so that codified and formalized knowledge will have the same meaning regardless who is receiving it

The last view point for considering tacit knowledge when bridging knowledge management and collaborative decision making has been leaded by the statement that collaborative decision making processes can integrate knowledge management activities (view point 1), they can consider that knowledge is not an object (view point 2), nevertheless it is possible that they do not know the conditions allowing an individual to be able to interpret correctly the information disseminated within the collaborative decision making process, able to interpret the pieces of information sources of knowledge.

First of all, individuals should not be simple users of collaborative decision making technologies. They should be actors of collaborative decision making, create their own knowledge by interpreting information and validate these interpretations through interactions with others individuals. These interactions can be limited, rare, not maintained, or hierarchically imposed. At best, every interpretation should be validated through interactions with others individuals without any hierarchical intervention. The validity of the interpretations being then ensured.

So our approach involves three view points for considering tacit knowledge when bridging knowledge management and collaborative decision making. These view points are currently discussed and confronted to industrial environments. We are also refining and characterizing the axis of analysis in order to improve more practically the consideration devoted to tacit knowledge during collaborative decision making processes. In the final document we will propose a precise characterization of the three view points. Relaying on industrial fieldwork studies and regarding from these proposed view points, we will also compare collaborative decision making processes considering – or not – tacit knowledge.

According to Jordan's works [8] presented in section 2.2, we suggest to people applying our approach to try to do ethnographic field work. Indeed we observed at the beginning of our investigations that individuals are often not aware of how they consider tacit knowledge when we only ask them questions. Sometimes they are convinced to take tacit knowledge into account whereas all the tacit dimension is neglected, otherwise they are convinced not to take it into account whereas knowledge management activities are inherent in collaborative decision making processes. When it concerns tacit knowledge, every investigation should be done as closely as possible from the workers, who, let us remind it, hold tacit knowledge.

CONCLUSIONS

In this paper, we began presenting several background theories unexpected in the classical area of collaborative decision making such as knowledge seen as an individual interpretation, ethnographic workplace study or incommensurability through communication breakdown study. We finally explain the approach we have developed relying on these theories in order to improve the consideration to tacit knowledge when bridging knowledge management and collaborative decision making.

Collaborative technologies have all the same weakness: they consider the collaborative group as a network of individual users. Every single user is a simple user and as such, the given opportunities to highlight, to share, and to assimilate tacit knowledge are extremely rare. We then propose, through the presented theories and the discussed approach, to focus at least a bit more on tacit knowledge, which is our richer resource, the most effective, the most singular and the hardest to disseminate.

The anthropologists were the first to learn, in spite of themselves, without "explicit instruction but by *participating* in the routines activities" as said by Jordan in [8]. Doing so, they create a kind of methodology in order to assimilate tacit knowledge and to understand complex systems, as organizations and collaborative decision making processes are nowadays. They learned to see the world from the point of view of "the natives".

Knowledge resulting of the interpretation by someone of information, Kuhn [9] introduced the concept of incommensurability, which is encountered when communication breaks down, when stakeholders' language attaches terms to nature in different ways. They see the same thing but interpret it differently. To bypass communication breakdown, individuals should be able to see the world from each other's point of view, to understand how each other's language attaches terms to nature. This can be done using ethnographic field work study as introduced by Jordan [8] and presented in section 2.2.

Background theories converging into this idea of transcending individual's point of view, we proposed an approach in order to improve tacit knowledge consideration within collaborative decision making processes. Our approach involves three view points which are (1) implementation of new activities enabling to retain and to use knowledge created during the collaborative decision making process, (2) awareness that knowledge is not an object and (3) analysis of the conditions and limits so that codified and formalized knowledge will have the same meaning regardless who is receiving it. Regarding from these three view points, we can say when collaborative decision making considers tacit knowledge.

Our approach is currently tested within several large companies. A weakness of this work is that it is only a work-in-progress: no data can for the moment be shown in order to support the proposed view points. Perspectives are thus to sum up and aggregate collected data through ours axis of analysis for each view point on the one hand and to refine the axis of analysis and the view points relaying on these collected data on the other hand. We also should try to use this work in order to evaluate the commensurability of interpretative frameworks. We could then prevent the risks of communication breakdown within collaborative decision making.

Knowledge management gives a scientific background in order to improve collaborative decision making. Moreover it gives today methodological answers to old technological weaknesses: began to see the man not only as a collaborative system user, but also as someone who creates knowledge, who shares knowledge and who uses knowledge. Decisions are created, decisions are shared, and finally, decisions are collectively accepted.

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The value of simulation and immersive virtual reality environments to design decision making in new product development.

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ABSTRACT

In response to the need to develop more sophisticated, higher quality products product developers are more and more expecting engineering simulations to provide them with the data, information, and knowledge required to make design decisions.

Engineering simulations provide insight into the behaviour of virtual product designs and have the capacity to be executed many thousands of times to provide a comprehensive coverage of the solution space being explored. However, engineering simulations are only representative of a reduced set of product properties and are bound by the constraints imposed by the fidelity of the underlying physics of the simulation tools being used. .

In this paper, we will briefly explore a number of different types of engineering simulation that the Virtual Engineering Centre has been involved in creating and consider the value that the data, information and knowledge that each creates to the decision making process.

We will also explore how different visualisation methods being used at the Virtual Engineering Centre support decision making by individuals and groups of people in a design review context. Specifically, we will discuss the use of immersive virtual reality in reviewing simulation results and highlight the limitations of using this technology in group decision making using a case study taken from our work with Bentley Motors.

We will conclude that whilst virtual technologies provide opportunities to generate data and information early in the product development process, the ever increasing demands for accuracy and fidelity in representation in mature product sectors outstrips the capability of the technology to fully support decision making in a complete virtual world.

Keywords: Simulation, Virtual Reality, Immersion, Decision Making

INTRODUCTION

Product development is an ongoing cycle of new product development projects that seeks to maintain, if not enhance, the competitive advantage of a company. Successful companies, e.g. market leaders, recognise that the competitive advantage they have over their rivals is due to superior product quality, value for money, service and closeness to their customer.

In order to achieve competitive advantage in product quality, a cornerstone of new product development should be life cycle oriented design. Whilst a full argumentation for this approach will not be detailed here, the principles are outlined below. Life cycle oriented design is a foundation of design for quality, which focuses upon creating high quality products with appropriate quality properties that satisfy the needs of everyone who has a stake in the product during its life cycle.

Product quality and life cycle oriented design

During the "cradle to grave" life of a product, many different people will interact with the product, each in a different context and with a purpose different to the others. These people are known as stakeholders and each will have a set of needs to be satisfied. The work of Mørup in "Design for Quality" [1], fully describes the relationship between product quality, the product life cycle, and stakeholders.

Product quality starts in the design process with the design team. In life cycle oriented design, the design team must anticipate all the life cycle demands made of the product and create design solutions that will have the appropriate properties to fulfil the quality expectations of all the stakeholders. The failure to consider or anticipate a likely mode of use, context of use, or type of user may result in the product being used in a manner that had not been considered and where failure could have considerable consequences on product quality and acceptance.

In order to create a model of the product life cycle, it is necessary to determine each of the discrete meetings, which will occur between the product and the stakeholders. Scenarios are a highly relevant means for describing what occurs in these meetings and, if organised in a sequence, can be used to map the product passing through all the phases of its life.

Understanding of the events which occur in each meeting enables the needs of the stakeholder to be identified, the functions of the product to be determined, and what properties the product should have to satisfy, and even delight, the customer. The level of abstraction used to describe a meeting will vary depending upon the design context. However, if a meeting is sub-divided into smaller, more discrete events, then a larger number of functions (or rather sub-functions) and properties will be identified.

With this detailed understanding of the product life cycle, functions, needs and properties, the design task is then to create a solution that best satisfies all of these requirements. During the design process, the performance of new ideas should be evaluated for all life phases, and successful solutions for one function synthesised with solutions for other functions. By continually comparing design results with life cycle needs, it is possible to maintain a check upon whether a design solution is emerging with the appropriate quality properties.

However, despite all the efforts that can be made during the product development process to validate the design solution, the true quality of the solution can only be verified when the product is realised and each stakeholder can interact with it. In summary: *The totality of product quality is achieved only when all life cycle phases have been thoughtfully considered, and all stakeholders delighted by their interaction with the product*

Scenarios

"Scenarios are not formal; they are not scientific in any fancy sense. We know that they can be used because they already do play many roles in the system lifecycle. Perhaps the time has come to consider how a more integrative scenario perspective for system development can be constructed" [2]

"Multiple scenarios allow us to explore different visions of the future – "cover the field" as much as possible." [3]

Scenarios have become a popular vehicle in a problem area central to all design efforts: management of change. By offering a down-to-earth middle-level abstraction between models and reality, scenarios promote shared understanding of the current situation and joint creativity toward the future [4,5].

The main purpose of introducing scenarios in design is to stimulate thinking, e.g. scenarios are *"a creative tool that facilitates the leap from observation to invention"* [3]. This is also apparent in Carroll's definition of the concept:

"The defining property of a scenario is that it projects a concrete description of activity that the user engages in when performing a specific task, a description sufficiently detailed so that design implications can be inferred and reasoned about" [2].

People use scenarios for a variety of different tasks and to accomplish a variety of specific goals, for example: in requirements analysis to embody the needs apparent in current work practice [6] in user-designer communication as a mutually understood means of illustrating important design issues or possible designs [7] in software design as a means to identify the central work domain objects that must be suitably included in the system; in documentation and training as a means to bridge the gap between the system as an artefact and the tasks users want to accomplish using it; and in evaluation as a means of defining the tasks the system has to be evaluated against [8].

Scenarios take many forms with respect to form, contents, purpose, and life cycle issues. Some use narrative text to produce extensive descriptions of how the system interacts with its environment, and use these descriptions in a range of activities throughout the development process. Others use diagrammatic notations to produce dense descriptions of interactions among internal system components, and use these descriptions to ensure agreement among partial views at a few clearly defined points in the development process [5].

Scenarios are, however, not simply available for use, they have to be managed. The need for scenario management increases, as scenarios become increasingly pervasive artefacts used throughout the product life cycle. Scenario management involves: capturing/generating scenarios; structuring and co-ordination of scenarios; evolution and traceability; reviewing scenarios; and documenting scenarios.

Engineering simulations

In response to the need to develop more sophisticated, higher quality products, product developers are more and more expecting engineering simulations to provide them with the data, information, and knowledge required to make design decisions. Engineering simulations provide insight into the behaviour of *virtual products* and have the capacity to be executed many thousands of times to provide a comprehensive coverage of the solution space being explored.

However, engineering simulations are only representative of a reduced set of product properties and are bound by the constraints imposed by the fidelity of the underlying physics of the simulation tools being used. Therefore, hundreds of different simulation models may be required to represent all the scenarios identified in the product life cycle. Additionally, each scenario requires an accurate representations of the way products are likely to behave, the influence of the active environment, and of human operator involved in the task being undertaken.

Consequently, developing a new product using virtual engineering technologies demands several thousand of simulations being devised. The questions asked here are:

"Can engineering simulations provide complete coverage of all the scenarios that represent the life cycle of a product to ensure the totality of product quality is achieved?"

"Can engineering simulations enable all stakeholders to be delighted by their interaction with the virtual product?"

VIRTUAL ENGINEERING

Virtual Engineering (VE) is concerned with integrated product and process modelling, where product models embody the design data, developed through process models. A product model embedded within a synthetic environment of the relevant life cycle phase is described as a virtual prototype. A virtual prototype has three elements: technical system; active environment; and human operator, which together enable a process to carried out (Figure 1). Virtual prototypes can be used to optimise the design of the product to meet the multitude of requirements across the product life cycle.

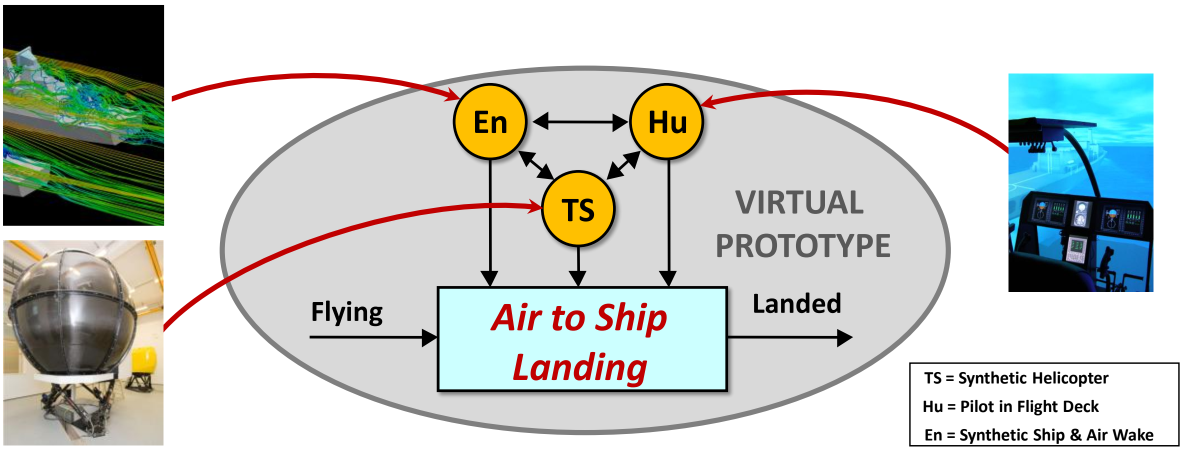

Figure 1: Example of a Virtual Prototype

The expected value to be derived from VE allows credible design decisions to be pulled forward to the earliest point where they *can* be made, based on the outputs from high fidelity virtual prototypes, rather than left until they *must* be made.

The elements of the VP are derived from engineering simulations that seek to represent the behaviour of an engineering system in the context of the active environment and user operations. The Virtual Engineering Centre has developed many different types of simulation model to demonstrate the value of VE in different product life cycle scenarios.

The common feature of all these engineering simulations is that a specific functionality of the product is numerically represented with models that depict the geometric configuration of the system, its material properties, and the physics that determine its behaviour to external stimuli. The outcome of the simulation is usually a vast array of numeric data that is then used to create visualisations of the behaviour of the product (Figure 2).

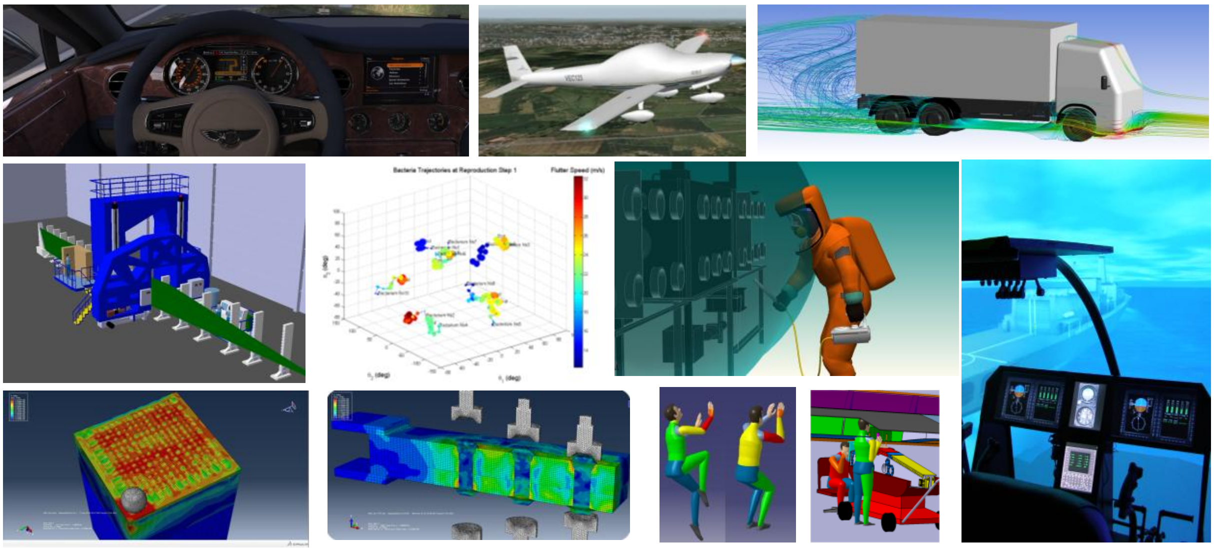

Figure 2: Examples of Engineering Simulations

Design decisions will be made on the basis of interpretation of the information these visualisations provide and selective interrogation of the underlying data where necessary. However, to achieve the coverage necessary to reflect the totality of the solution space for just one scenario requires thousands of such simulations to be performed to allow for variability of all the driving parameters.

Immersive Virtual Reality

The Virtual Engineering Centre is also exploring the value of immersive virtual reality (VR) technologies to support design making decision. The opportunity that immersive VR offers designers is real-time interaction with a virtual product design, which requires the underpinning engineering simulation responding to real-time changes in external stimuli.

Figure 3: Immersive Virtual Reality - First Person Perspective Vehicle Interior

In an evaluation project with Bentley Motors, immersive VR (Figure 3) has been adopted to represent the driver experience of a vehicle interior. The challenge has been to ensure that the visualisation of the vehicle interior is completely representative of what would be experienced if sitting in a real car. This has required a number of physics based functions to be represented in the engineering simulations, whilst ensuring that the image that is displayed can be refreshed in real-time to the satisfaction of the observer.

The primary advantage of the immersive virtual reality environment over "traditional" visualisations of engineering data is the ability to interact with the virtual product in real-time. This enables designers to explore many different aspects of a scenario and instantly obtain information about the variability of their own stimuli on the functionality of the virtual product. However, to achieve real-time interaction often requires engineering simulations to be simplified and limited to tasks that can computed very quickly.

In working with design teams from Bentley Motors is was apparent that immersive virtual reality provides: a design environment for the design team; an information resource shared by all; a means of communication; a means for visualising life cycle events and maintaining a high level of awareness of stakeholders' needs during design; a stimulus for creativity and synthesis; a means to monitor the progress of design work; and a means to support quality assurance efforts in design.

CONCLUSIONS

Whilst virtual technologies provide opportunities to generate data and information early in the product development process, the ever increasing demands for accuracy and fidelity in representation in mature product sectors outstrips the capability of the technology to fully support decision making in a complete virtual world for the many thousands of scenarios that are representative of the product life cycle. Virtual scenarios demand management: capturing/generating scenarios; structuring and co-ordination of scenarios; evolution and traceability; reviewing scenarios; and documenting scenarios.

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Simulation an Modelling as a Decision Support Tool In Manufacturing: A Case Study

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ABSTRACT

Simulation Modelling has long been used in the manufacturing environment to enhance the design, planning and decision making processes. It is a valuable tool for studying the dynamic behaviour of manufacturing systems through experimentation. With simulation modelling technology, business managers can model, analyse and optimize processes in a risk-free environment and gain deeper insights into the complexities of corporate functions. This research explores how simulation modelling technology can, in manufacturing industry, be used as a decision making support tool. Specifically it investigates how simulation modelling techniques can be integrated into other (software) applications/packages and how it can be used to assist company decision makers on a daily basis. This study also proposes an implementation framework to explore how simulation can be applied as a dynamic online decision support tool.

Keywords: Modelling, Simulation, Optimization, Decision Making

INTRODUCTION

Manufacturing enterprises are facing considerably more complex and difficult conditions than ever before owing to unpredictable market demand and fluctuating production environments. As a result manufacturing has tended towards gradual change and adjustment in response to prevailing market conditions. Furthermore, modern manufacturing processes and systems such as those in the electronics, semiconductor, aerospace, and automotive industries, as extremely complex and are not as easy to manage and optimise under such external pressure [1]. Under such circumstances, simulation as an approach becomes an attractive method able to provide a powerful and flexible approach for the analysis of complicated processes. The simulation provides the most comprehensive evaluation of the likely future performance of the system, particularly in relation to the dynamic behaviour of the system, and allows the decision maker to make reliable and credible decisions. From an application point of view, although simulation is widely used to aid management, it has only been used actively for decision support over the last 10 years [2]. This is a result of the relatively high cost for developing a simulation model [3], high complexity of the process being modelled [3], long experiment running time [5], lack of modelling flexibility [4], lack of history data [3] and lack of simulation. However, the dynamic characteristics of manufacturing industry have determined that the industry decision makers are “less interested in technology and a lot more interested in getting a solution out as fast as possible” [6]. Therefore, most of the simulation packages now commit to offer predefined building blocks or modules which help simulation practitioners to obtain a high level simulation model in a short time period.

Earlier researchers [7] and practitioners explored decision support system (DSS) that are described as “model-based information systems”. The main characteristics of such DSS is that it uses data obtained from a spread sheet or database; models the process using that data; processes and analyses it using problem specific methodologies; and assists the user in the decision-making process through a graphical user interface (GUI) [8]. For instance [9] proposed a generic simulation model that describes the system structure while the system parameters are stored in a database whereby the data is only accessed when each individual simulation model is generated. Similarly, [10] proposed data-driven template-based models as a means of providing greater model accessibility for non-simulation user to experiment with different scenarios. Later research [11] demonstrated the development of software that integrated simulation using virtual reality technology where the virtual environment is applied to provide a better understanding of the activities on the shop floor. User-friendly software was developed using a Visual Basic Excel based controller and Graphic User Interface that allow users who do not have a good knowledge of simulation modelling techniques and programming to develop dynamically and reconfigurable simulation models of the manufacturing system and create a virtual environment to simulate the activities of the manufacturing system. Work by [12] demonstrated how to put “state-of-the-art problem-solving technologies” into the hands of decision makers by effectively integrating simulation models with optimization algorithms to aid planners and shop floor managers in their decision-making processes. The system required very little knowledge of advanced engineering methodologies and tools, such as simulation and optimization. A proposed framework by [13] for the development and optimization of simulation models in manufacturing environments which aimed to provide realistic possible models that have the potential to be used as an operational tool to support operational decision making. The framework focused on delivering an experimentation tool for operations personnel like production managers and shop floor supervisors to test different scenarios and parameters before making any decisions when a problem arises in a short span of time. Recently, [14] has discussed a system that assesses based on commercial package performance from a simulation run, identifies problem area(s), and automatically works on these problem area(s) to enhance performance. The developed expert mechanism receives outputs from the simulator, assesses system performance, and, based on operational rules embedded in it effects changes to the input variables to enhance performance in the subsequent simulation run.

THE PROPOSED FRAMEWORK

Manufacturing systems consist of various types of machines (processing or assembly machines, material handling equipment, inspection stations, etc) and operating control procedures used to determine how the equipment is to be operated. The complexities of manufacturing systems make optimum planning and controlling effort difficult to achieve. This is specifically true when the system is faced with a varying business environment and when the process performances are less deterministic. The core concept of the proposed framework is that simulation models enable system developers to experiment with alternative scenarios to identify the optimum parameters and configuration for operating the system. In this research, a simulation model is only a test bed for experiments and not an optimizer.

Improvements and Extensions to the Framework

The integrated framework focuses on the use of simulation modeling and experimentation for the purposes of supporting day-to-day operational decisions. This framework illustrates both the flow of material and the flow of information. Furthermore, it accounts for the effects of machine degradation and variations in operator competency in the evaluation of system performance. It is developed focusing on how to build a decision support tool around the use of simulation. The proposed new framework is different from other researchers [9;11,12,13 14] framework in that it concentrates on assisting operational management personnel in identifying fluctuations in the performance of production systems, and helps them to make "better" operational decisions. More specifically, it is able to capture both static and dynamic information and allows for incorporation of performance variation to assist the user in making quicker and more reliable decisions. In the proposed framework, both static and dynamic stochastic behavioral characteristics are captured by automated systems. The data can then be imported and analyzed through simulation modeling. The results of the modeling can then be fed into models relating to forecasting, risk analyses etc. These form the basis on which decision makers operate. Decision makers or domain experts are able to obtain a better understanding of system performance and performance fluctuation as well as an understanding of the impact of planned events. In this way, decision makers could obtain more reliable information available for decision making.

Model Accuracy Requirements

The accuracy of the simulation model and experimentation is directly related to the credibility of the decision. There are two key factors that are related to the accuracy of the simulation modeling and experimentation.

- The first factor is the accuracy and reliability of the collected data. Data collection and classification comes after identifying the type and boundaries of the model but before the process mapping and simulation work starts.

- The second factor is the prediction of performance fluctuation tendencies. The definition of a manufacturing system's performance includes both machine performance (e.g. efficiency, unplanned downtime etc.) and labour performance (e.g. skill level, motivation etc.) in addition to general material handling and workflow problems. Considering this aspect, the performance of a manufacturing system is not static or fixed. On the contrary, it changes as operators vary and the machines' working condition shifts.

Performance fluctuation is a dynamic activity and, there is a degree of variability over time. For instance, a machines' working condition shifts with time, and while regular maintenance improves, it reduces the rate of degradation, although degradation still occurs. Additionally, if the operators get to know the machine better, they can become more proficient at operating it. This would also improve the manufacturing system's performance. The two key issues are represented in the framework, which is illustrated in Figure 1.

As shown in Figure 1, the overall system structure comprises four main components, i.e. dynamic model database, conceptual simulation model, experimentation for performance evaluation and operational decision applications. Visual Basic programming is used to integrate various components through a user-friendly graphical user interface. Object oriented (OO) approaches are adopted in the system development process to define the materials, products and processes information used in the MS Excel, Visual Basic, and simulation model components. These tools enable the development of data structures and methods apply inheritance and allow for a greater deal of the code to be reused.

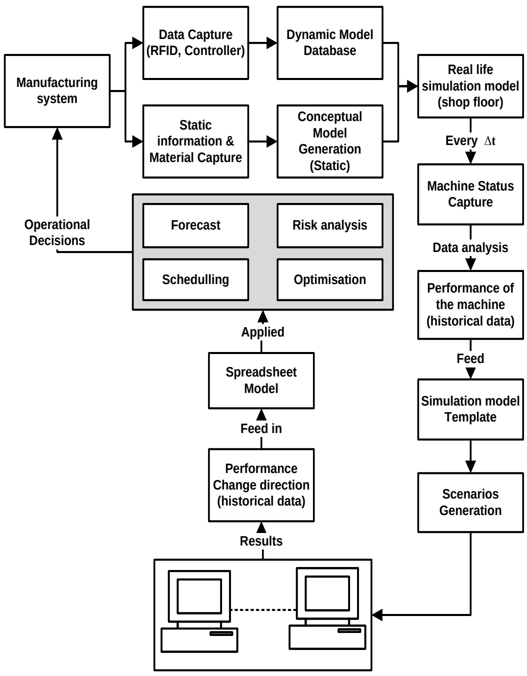

Figure1: Proposed Operational Model Framework

Implementation of the Proposed Framework

Manufacturing simulation models have traditionally focused on the flow of material and more recently the flow of basic information, but they often miss evaluating fluctuations in system performance. These issues prompted the development of an operational model framework that allows a unified representation of the manufacturing system with a physical material focus as well as system performance fluctuation focus to support both information management and operations improvement. The operational framework in **Figure 1** focuses on exploration of system performance fluctuation for the purpose of supporting operational level decisions. It also focuses on delivering a testing tool for operational personnel, such as production managers and shop floor supervisors, to obtain the a more accurate manufacturing system performance before making any final decisions on forecasting, risk analysis, rescheduling etc.

CASE STUDY

To demonstrate the applicability of the proposed framework, a case study is employed. The company analyzed in this case study is one of the manufacturing sites of an international manufacturing group. It is responsible for combining raw materials into granules of different sizes that are then used in the manufacture of products elsewhere in the group. The manufacturing processes modeled are iterative where one set of granule sizes are used as input to generate another set of sizes. The level of complexity arises from the fact that each stage of the process generates a variety of output sizes. This necessitates exploring new tools for production planning to meet the significant operational, handling and scheduling challenges it will face. The product range is also to be expanded to offer a degree of flexibility in terms of its specification and alternative ‘mixes’ and ‘recipes’ may result in better stock utilization.

The main aim of this application is through analysis, to model the manufacturing performance of current activities; and to test and evaluate the production capacity in terms of different process routes. This involves generating either long-term or short-term operational schedules to meet the various product demands of customers whilst maintaining minimum stock. With extensive software development of the planning / data management tool, a decision making support system for scheduling and stock managing is established.

As a demonstration, the whole system consists of three main parts: a data management tool that manages the system information, an optimization model that is able to generate optimized schedule and weekly products recipes and a simulation template model that acts as a test bed for various scenarios.

Data Management System

To cover all elements of the manufacturing system, a large data collection exercise was undertaken. A majority of the data was obtained from the company’s database system and process identification. The collected data is then saved in a pre-defined MS Database. The MS Database is designed for data structure management and to act as a data repository. Its role in the system is similar to a data library, whose main function is to allow a user to update and retrieve information through interaction with a Visual Basic designed user interface.

The data management tool, which is highlighted in the dashed box in Figure 2, consists of two main parts. One is the MS Database system that acts as an information repository, whose primary function is in storing system information. The other is a Graphical User Interface that is based on a Visual Basic Programme. The purpose of developing this data management system is to develop a software with a Graphic User Interface that provides non-expert users with the flexibility to optimize production, as well as generate production schedules to meet different demand patterns. The generation of a Data Management Tool provides the production manager with a new method to manage production planning and control the stock of materials/finished products.

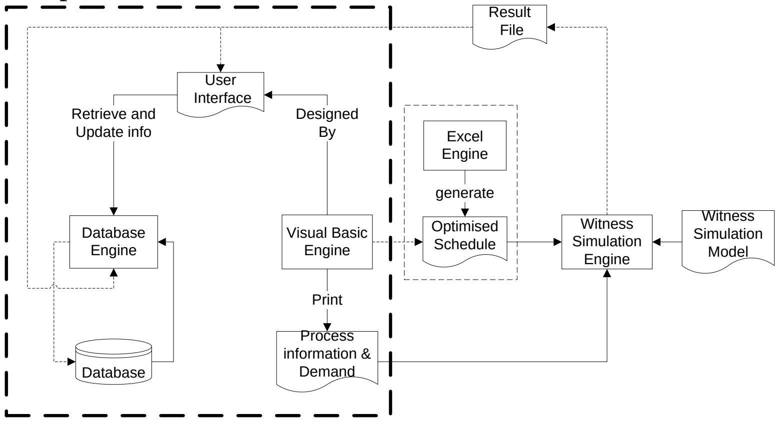

Figure 2: System Architecture

After the user has loaded the required system information through the graphic user interface, a series of production scenarios can be created for any configuration by selecting the relevant processes plans and product demands. The appeal of this approach is that all the information relating to the scenario can be fully loaded as a data object and exported to an external text file whose format has already been defined in advance. This template information file contains all the pre-defined process information, number of batches needed to be run and finished stock level on completion of the run. Then, based on the optimized summary sheet information and given production rules (e.g. some processes can share the same input ingredients etc.), this programme is able to generate efficient schedules that will satisfy customer's demands. The production planning function also enables the user to generate an optimized schedule by entering the expected demand for each final product. From this perspective, the programme can also be used to evaluate production capacity. For instance we can test whether production capacity can meet customer demand in a limited time. Additionally, the impact of specification and product mix changes can also be quickly and easily assessed in terms of their impact on capacity. These calculations were previously fairly crude and time consuming.

Optimization Model

The biggest problem faced by the operational team is that the process continues to produce granules that cannot be used as either finished products or intermediate input granules. By employing efficient optimization techniques we can generate an optimized schedule that maximizes output and minimizes unused granule stock levels.

Optimization is used in this project for a simple reason. It assists the scheduler to generate an operational schedule that allows targets to be met and without stocks of materials that cannot be used in subsequent production stage. In fact, two levels of optimization are considered in an Excel prototype, which are process optimization and product recipe optimization. They are not independent as they fully interact with each other as the optimized schedule should be generated based on the process and production optimization results. As the production system is typically an iterative process system where every productive process requires input granules that come from a previous process. External demand triggers new internal demands from processes below. Internal demand also triggers additional internal demands. If there is insufficient supply of granules to a process, a further production run takes place to provide them to these and inter running processes. Therefore, a bubble recursion pull technique is carried out for process optimization. This bubble recursive technique is shown in Figure 3.

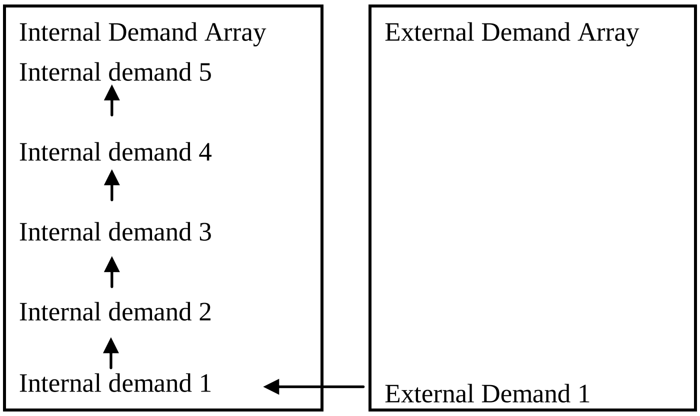

Figure 3: Bubble Recursive Technique

Product recipe optimization is a stochastic search problem. Simulated Annealing (SA) is chosen as quick demonstrations algorithm as it is a direct and fast way to optimize our problem in here. The final optimized schedule and weekly product recipes are exported via a readable text file into a WITNESS Model so that robustness testing of the system can take place.

Simulation Model

The models are initialized using the initialize action function within WITNESS. The initial values of variables that are involved in processing information and scheduling are set by reading the information from specified external text files. Modules are created to represent activities and operations carried out in the manufacturing system including the machining processes. This provides for easier model development and model reconfiguration/redesign. The process of manufacturing the granules is triggered by an (internal) customer demand. A production schedule is generated according to it. As soon as the necessary raw material or stock has been properly prepared, the granulator is able to start its batch processing.

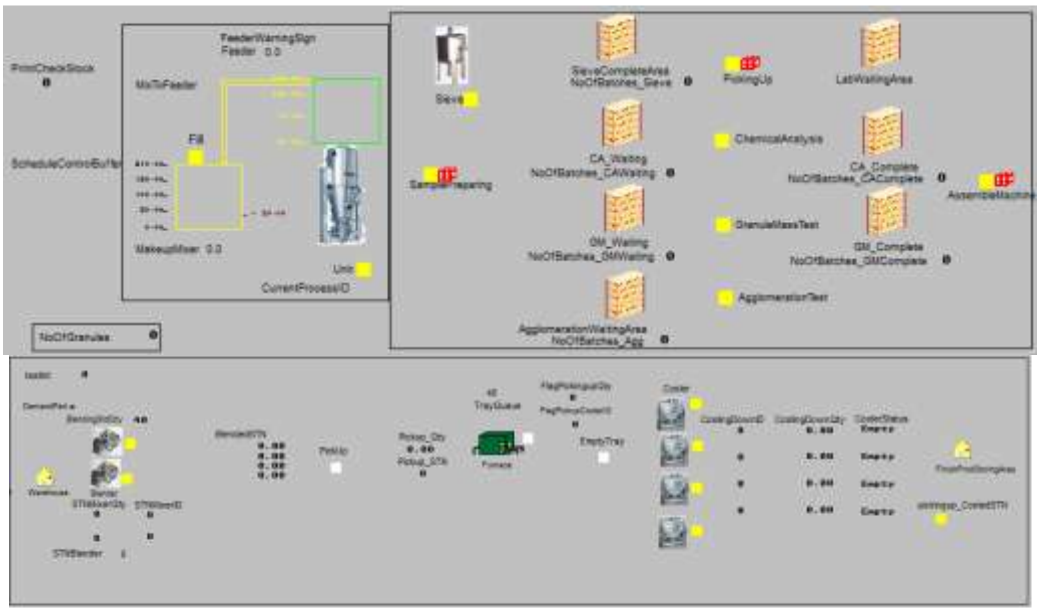

Figure 4: Snapshot of Simulation Model

There is only one main granulator machine in the granulation process stage. The granulator process starts with seeds and through a continuous series of batch/process stages increases their size to meet final product requirements. Once the granules have been produced to the required granule mass in the granulator, the product will be batched together in a number of runs for heat treatment. The granule production process uses a binding agent, which has to be removed before the granules are vacuum packed and dispatched to the customer. As soon as all the granules meet the necessary gas and chemical specifications, they need to be cooled down to room temperature. The cooling process usually takes 12 hours before they can be vacuum packed. The layout presented in Figure 4 of the simulation model is not the actual factory layout but one that makes monitoring of the production process easier. It provides a graphical representation of the flow of material, indicates the amount of labor needed, and the amount of materials required.

DISCUSSION

The simulation model developed has achieved its objectives in terms of its technical aims of providing an assessment of the performance of the system under various scenarios. It successfully demonstrates that the proposed framework works. The proposed framework focuses on accounting for the effects of machine performance in the evaluation of system performance. It helps the user identify the critical point where the system cannot deliver what it is supposed to deliver.

First, it is a test bed for experiments and not an optimizer. Whatever the solution generated from the optimization model, the simulation model can run based on it. It can be used to test different scenarios involving the production schedule and fluctuations in process performance. For instance, Figure 5 shows that the system cannot meet the customer demand (based on running condition and demand level in Table 3) if the process output varied, even by only 1% variation. It means the decision maker either has to adjust the product granules' mixing recipe to ease the system performance variation or they have to strictly control their production process to ensure the process output granules percentage match with the process specification.

Second, the simulation model in this case study can be used for validation purposes. It is able to validate the solutions that are generated by the optimization model. The WITNESS model is run on the basis of a schedule. Whilst the schedule is generated by a demand-driven Excel capacity model, it ensures that it will not produce more than the customer requires. Therefore, it is important to test system robustness against performance fluctuation. If the system fails to meet demand when system performance fluctuates beyond a certain range, it means that the proposed solution is only valid within that range. For instance, the experimentation result (Figure 5) shows the schedule solution that is employed in Table 3 is only valid when the process is not varied. In this way, the WITNESS model is used as a validation mechanism to validate each proposed solution.

Third, it can be used to explore and test the robustness of the solution and inform the scheduler when they should go back to change the scheduling and optimization foundation– "process information". For example, it can be used to test the robustness of the schedule against process performance variations. If system performance fluctuates beyond a given range, it will result in a yield that is not adequate to meet customer demand. This is due to the fact that the schedule is generated on the basis of unreliable process information. In this situation, it requires the scheduler to go back to the original process information database and excel capacity model and update the process information. The model can then be re-run to obtain a more accurate schedule.

Finally, it can be used to test the maximum capacity of the system and check variations in system performance against fluctuations in demand. As explained above, the schedule is generated by a demand-driven Excel capacity model. The demand that is contained provided by the optimization model is a weekly average demand. In the real world, however, the customer does not always maintain a stable level of demand. Therefore, it is necessary to test the model's capability in dealing with demand variations.

In order to provide the scheduler with a more comprehensive understanding of system robustness, the main target of the WITNESS model developed is to test the manufacturing system's robustness on several levels. Key features of the model can be summarized as follows:

- Scalability that allows the user to simulation various process scenarios
- Central control of process information and schedules allows changes to be made easily
- Central control of the weekly product recipe allows changes to be made easily
- Data driven with minimum need for coding in WITNESS model to allow for changes and reconfiguration of recipes, schedule and operating parameters.
- Stochastic operational elements (process variation function and demand fluctuation function) involved in the model to enhance applicability to real life situations.

CONCLUSIONS

This research focuses on the use of reconfigurable simulation techniques used within management decision making. A proposed framework is proposed which integrates a number of tools to assist the decision making process. The proposed framework is demonstrated in a real industry case to show how a decision support system framework based on simulation models could be used in the managing of complex manufacturing systems. The framework explores many current and emerging technologies to deliver an integrated platform for developing and implementing manufacturing simulation models. The case study discussed in this research demonstrates how a commercial software model can be easily controlled and maintained by non-expert users through a data driven user interface. It can also be used for scenario generation and testing in order to determine decision for daily operations or to support and enhance decision making.

The majority of the data was obtained from the company's database system and process identification. The collected data is then managed and updated in a pre-defined MS Database through a Visual Basic defined user interface. Optimization is a major component of the whole framework. A bubble recursive technique and simulated annealing are applied to generate optimized schedules and weekly product recipes. The design of the simulation model is modular, flexible and scalable. The separation of information flows from model physical entities facilitates easy experimentation and model reconfiguration. The manufacturing system considered here is a dynamic system because the process contains dynamic characteristics such as "time", "volumes", "capacities" and "quality". This study takes into account stochastic elements such as process variation and demand variation. The involvement of these stochastic elements allows robustness of the model to be checked against practical uncertainties

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Sensor Network Service Infrastructure for Real-Time Business Intelligence

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ABSTRACT

RFID and sensor network technologies together with distributed application services for supply chain planning and execution enable and support real-time operational visibility and intelligence in supply chains. End-user adoption of RFID and related technologies is not increasing as rapidly as predicted in the last decade but application developers, systems integrators and hardware manufacturers continue to develop new products and services. The adoption obstacles include challenges in configuring and managing devices, deriving and deploying business intelligence from RFID events, absence of uniform standards, the availability of a diversity of medium access control protocols, and challenges of scaling RFID events and linking them with enterprise backend systems (ERP systems, warehouse management systems, etc.), the perceived cost of adoption (especially at the item level), lack of industry or customer mandates, and the assumption that the available technologies have not yet matured. Evolving standards, technologies and procedures have the potential to lower, or even eliminate, most of the barriers to adoption in the near term. This paper highlights some of our findings from extensive case studies of existing infrastructure for identification and location of items both indoor and outdoor of the supply chain, identifies some research gaps, and then describes our current attempt at using system dynamics and distributed processing to build event-based decision models for supply chains. The devices considered in our study include RFID and other wireless sensors and generic visibility information sources. Sensor network devices are only one of several and different sources of data and information for real-time business intelligence. We indicate other sources of data, especially ontological information.

The challenge is that existing technologies have yet to address the following issues, which provide opportunities for research:

a) Efficient and effective enterprise system scalability and decomposition of business logic between the backend and the enterprise edge. For instance, a large retailer that uses RFID across its network on most of its merchandize might require an annual throughput rate of up to 60 billion items. When replicated across retailers and supply chains, this has the potential to put severe stress on network resources. Performing process logic on the mobile thin client, at the enterprise edge, reduces communication costs and computational overheads at the backend: only aggregated data needs to be forwarded to the backend. However, in order for this to be realized, there is a need for algorithms that scale sufficiently well in terms of bandwidth, energy and computational power requirements with respect to client typology and topology. Products such as DASH-7-compliant thin clients can communicate peer-to-peer and

execute simple logic locally. DASH-7 products are likely to become cheaper and much more widespread in the future; much as local processing capacities of thin devices are likely to increase, and their energy budgets shrink, in the medium term.

b) Event-based communication and reaction can relieve bandwidth requirements. In this case, optimal models and automatic (or even semi-automatic) systems for handling exceptions in real-time are needed. For example, if there is a sudden breakpoint (a natural disaster, an accident, or missed performance target) in the supply chain, how is the chain able to re-organize itself in real-time so as to minimize the negative consequences of the break?

c) If decisions are taken at the strategic or tactical levels of the supply chain to address an identified break, how are these decisions communicated and turned into concrete actions at the operational levels of the chain or enterprise in real-time? If actions are not taken quickly at the operational level to resolve identified system deficiencies or failures, then the spirit of urgent data acquisition at the enterprise edge and its transmission to managerial levels will be defeated.

Our ongoing research focuses on item (b), designing effective real-time control mechanisms for event-based management systems. This paper will report the methodology we have taken in the investigations. Results are yet to mature.

Keywords: RFID, sensor networks, enterprise systems, system dynamics, business intelligence.

The Benefits of Enterprise Systems for SMEs

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ABSTRACT

The aim of our study is to identify the current body of knowledge about the benefits of Enterprise Systems for small and medium sized enterprises (SMEs). A new affordable generation of Integrated Enterprise Systems is now available for SMEs and makes this topic highly significant. Our systematic review identified only seven journal articles in this area. Two of those articles focus on the manufacturing industry and one on the public sector. The latter article is also system specific, focusing on only SAP software. The identified small body of primary research confirms the benefits of Enterprise Resource Planning (ERP) systems for SMEs. Also having analysed the benefits of ERP for large enterprises in connection with a broader study, it can be established that only a part of the identified benefits are relevant for small and medium sized enterprises. SMEs mainly gain operational and managerial benefits from ERP systems in contrast to large enterprises, which can take advantage of a greater range of benefits (operational, managerial, strategic, IT infrastructure and organizational benefits). However, the extent to which these benefits can be realised is still unclear and only limited focus is on a specific industry or specific software system. This paper explores the typology and dimensions of potential benefits of Enterprise Systems. It also suggests key decision support areas for optimal implementation of Enterprise Systems by SMEs.

Keywords: Enterprise Systems, Enterprise Resource planning, SMEs

INTRODUCTION

Enterprise Systems (ES) are "commercial software packages that enable the integration of transaction-oriented data and business processes throughout an organization (and perhaps eventually throughout the entire inter-organisational supply chain)" [1]. This advanced software has Enterprise Resource Planning (ERP) as a foundation, but it has to be noted that throughout the literature different related modules and definitions can be found. Weston Jr [2] stated that this software consists of ERP, customer relationship management (CRM), and supply chain management (SCM). According to Seddon et al. [3] ES are comprised of ERP, CRM, SCM and data warehousing (DW). How the ES is comprised depends on the components the individual software has to offer and the components a company selects for implementation. Another widely used term for an ES is 'ERP II'.

Each of the ES components could be combined with products from other vendors (e.g. SAP CRM with Oracle ERP) but ES vendors argue that supply chains are most flexible when suppliers use the same ES vendor and enable a plug-and-play system. Therefore we call such approaches Integrated Enterprise Systems (IES instead of ES or ERP II) meaning that all ES components are from the same supplier. We will use the term ES for all information system landscapes in enterprises including those supported by different ES vendors.

Older IES versions (e.g. SAP Business Suite) were successful in large organisations but too expensive for many SMEs. As a result, SMEs carried on using legacy systems or less complex ERP systems (e.g. Sage). The idea of a plug-and-play supply chain with only one IES version did not work. Therefore IES market leaders (SAP, Oracle, Microsoft) work on overcoming this hurdle by developing cheaper IES solutions for SMEs that fit with their versions for larger enterprises. SAP recently launched Business ByDesign, an affordable solution for SMEs with 10 SAP users minimum, usually an equivalent of 100 employees. SAP claims that Business ByDesign can be implemented in four to eight weeks and has affordable user licensing fees.

But would smaller SMEs benefit from IES? Benefits of ERP have been researched since more than two decades. Some ERP research addressed them for SMEs. However, there is no overview of benefits of IES for SMEs. This paper intends to close some of this gap. A systematic literature review investigates what we know about ERP benefits for SMEs. Benefits for other components should be reviewed in subsequent papers.

In the following section we will provide more background regarding the nature of ERP systems for SMEs. Based on this understanding we will systematically review literature on benefits of ERP in SMEs. After describing how the literature review was conducted we will summarise its results followed by a discussion. Finally we will conclude to what extent our aims were reached.

THE NATURE OF ERP SYSTEMS FOR SMES

Before investigating the benefits we will explore the nature of ERP systems and define ERP within the new generation of IES for SMEs. ERP can be defined as a "method for the effective planning and controlling of all the resources needed to take, make, ship and account for customer orders in a manufacturing, distribution or service company" [4]. However, ERP systems as commercial software packages support more than ERP.

Firstly, they integrate all business processes, not only planning and controlling but also execution. They "…provide cross-organization integration through embedded business processes … [usually using different modules for several functions,] … including operation and logistic, procurement, sales and marketing, human resource and finance" [5]. ERP systems allow a company to “automate and integrate the majority of its business processes…” [6]. The new generation of IES for SMEs offers an ERP core with the above functions. They are intended to be more flexible and less difficult to understand. User training is available online for saving implementation costs. The systems are therefore less complex compared to ERP systems for large enterprises.

Secondly, users can “… share common … practices across the enterprise…” [6]. An ERP system is configurable standard software. Standard software means that business process support is pre-defined, meaning that programmes for transactions are available. Configurable means that organisations can decide which transactions are to be used, determine detailed features of chosen transactions, define organisational structure and create more reports if the standard is not sufficient. Configuration has been a costly task for traditional ERP systems. Common practices are pre-defined by the IES vendor and therefore speedy to configure.

Thirdly, users can “… share common data [and] … access information in a real-time environment” [6]. This feature is possible, because of the common database of ERP systems. This database is the condition for building an ERP system and therefore also a feature of the new generation of IES for SMEs.

We can summarise that ERP systems within the new generation of IES for SMEs are configurable standard software that automate and integrate the majority of SMEs’ business processes. An integrated database allows sharing and accessing data in a real-time environment. ERP systems for SMEs are to be implemented quickly, thus should be simple, intuitive, and mainly pre-configured. Aftercare and technical support are often outsourced.

The implementation of an ERP system in SMEs would replace software currently used to support business processes or obtain planning and controlling data. Assuming that costs for the newly developed IES are not lower than those of legacy systems we review in the following chapter what benefits can be obtained by implementing ERP in SMEs.

THE BENEFITS OF ERP SYSTEMS FOR SMES

Methodology of Literature Review

This article intends to identify benefits SMEs can achieve with an ERP system. We decided to carry out a systematic literature review and evaluate the current body of ERP knowledge. For this purpose the SciVerse Scopus database was researched. The focus was on existing literature reviews of ERP in SMEs and relevant new articles concerning benefits of ERP for SMEs [7]. It could be established that only a limited amount of research has been carried out on ERP benefits solely focused on SMEs. A variety of articles focus on critical success factors (CSF) SMEs should account for when implementing an ERP system and the implementation itself [e.g. 8, 9, 10, 11] . Only seven articles focus on benefits realised by SMEs after implementing an ERP system [12, 13, 14, 15, 16, 17, 18]. Three of those articles are industry specific - two focus on the manufacturing industry and one on the public sector [15, 17, 18]. The latter article is also system specific, focusing on SAP software. It has to be noted that the identified benefits are for ERP systems, as no research has been conducted for IES in SMEs yet. The findings of the three most recent articles only will be described in the following sub section, due to length regulations of this extended abstract. Most research on ERP benefits has been conducted for large and medium sized enterprises. We reviewed this literature to compare findings with SME research. Results will be pointed out in the discussion if they are relevant for ERP benefits in SMEs.

Results of Literature Review

Federici [14] studied five benefits of ERP systems for SMEs. It was evaluated to what extent the benefits could be reached and if they were related to company size and economic sector or the extent of organizational change, number of updated processes and type of ERP producer. The result showed that SMEs of every sector and size are able to benefit from ERP. Furthermore, it was displayed that SMEs may obtain the same benefits as large enterprises.

Unlike Federici's [14] study, Mathrani and Viehland [12] did not select benefits beforehand. 10 organisations were selected and the viewpoints of ES vendors, ES consultants and IT research firms on ERP implementation practices and benefits expected from an ERP system were researched. The qualitative data analysis program Nvivo was employed and as a result, key benefits expected by SMEs could be established, as shown in Table 1.

Kale et al. [13] selected SMEs from one industrially advanced city in West India. Questionnaires and interviews aimed at identifying reasons for implementing ERP systems, prioritising benefits after ERP implementation and distinguishing CSF. The authors provided a list of benefits and CSF with the possibility for expansion. Frequency analysis was used to evaluate the collected data. The results show reasons for implementing ERP systems as well as the importance of benefits and CSF.

Table 1 summarises the results of the three studies. It focuses on benefits that have been achieved. The two benefits in Table 2 were expected by SMEs but have not been confirmed yet by ERP research.

Table 1: Realised ERP benefits mentioned in SME research

Benefit	Author
Cost and inventory reduction	12, 13, 14, 15, 18
Cycle time reduction	12, 13, 15
Productivity improvement	13, 14, 16, 18
Quality improvement	13, 15, 16, 17
Customer service improvement	12, 13, 16
Increased customer relationship	15
Increased supplier relationship	15
Improved decision making and planning due to real-time information and transparency	12, 13, 14, 15, 16
Better resource management through transparency	16, 17
Business Growth	18
Performance improvement	13, 14, 18
Building business innovation	18
Generating or sustaining competitiveness	13
Changing work pattern with shifted focus through streamlined communication and standardised processes	12, 13, 14, 15, 16, 17, 18

Table 2: Expected ERP benefits mentioned in SME research

Benefit	Author
Support business alliance	11
Business flexibility	11

Kale et al. [13] also rated the importance of benefits for SMEs, as seen in table 3.

Table 3: Ranking of ERP benefits in SMEs

Ranking	Benefit	Frequency*
1.	Changing work pattern with shifted focus through streamlined communication and standardised processes	38
2.	Customer service improvement	37
3.	Improved decision making and planning due to real-time information and transparency	36
4.	Productivity improvement	35
5.	Generating or sustaining competitiveness	33
6.	Quality improvement	21
7.	Cost and inventory reduction	21
8.	Cycle time reduction	18
9.	Performance improvement	12

*Number of companies, which think this benefit is most beneficial

Discussion

Even if there is only a small amount of SME specific research it seems to confirm that there are ERP benefits for SMEs. We compared the results with general ERP research using Shang and Seddon's benefits framework [19]. Compared to other benefits frameworks as for example from Schubert and Williams [20] or Murphy and Simon [21], this framework has been adapted by other researchers [e.g. 21, 22] and therefore seems the most accepted. The framework distinguishes between operational, managerial, strategic, IT and organizational benefits of ERP systems.

The ranking in Table 3 indicates that operational benefits are the most important for SMEs. In comparison to this, large enterprises put more emphasis on benefits related to strategic business development and IT [9]. It can be established that in comparison to large enterprises, SMEs were only able to take advantage of a limited amount of benefits provided by the ERP system. It can be said that the emphasis is on operational and managerial benefits, because all benefits in those categories could be achieved. In opposition to this, only one benefit each from the categories organizational benefits and IT infrastructure benefits could be realised by SMEs. Strategic benefits could be realised to a medium range, noting that business growth and worldwide expansion were not achieved.

Existing research is mainly of qualitative nature. It would be interesting to investigate quantitative variables to get a better picture of the significance of the ERP benefits in SMEs. Considering that new IES are targeting SMEs with as little as 10 users, the mentioned cost reductions might not be as significant as described within the studies. Savings depend largely on how often business processes are carried out. The smaller the enterprise is, the smaller the achievable cost reductions. Apart from this, we must not forget the effect of cognitive dissonance, which may influence the outcome of the research.

CONCLUSIONS

The results are useful for SMEs and researchers who are evaluating IES or just ERP systems. They indicate that SMEs gain mainly operational and management benefits from implementing ERP systems. There is still little evidence how significant these benefits are and therefore the need for more research arises. Considering that new IES for SMEs are said to be as expensive as legacy systems, SMEs might benefit from implementing IES.

However this recommendation needs to be handled with caution, because we only focussed on ERP, the core of IES, not on CRM and SCM. The scope of our study was limited to benefits; it excluded potential risks and disadvantages of ERP systems. There is a lot of additional research necessary to shed more light on the evaluation of IES.

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Operational planning solutions for non-hierarchical networked SMEs

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ABSTRACT

Non-hierarchical manufacturing networks consider, generally, a multi-level and multi-directional information flow among the parties, which might consider a collaborative or non-collaborative relationship with their partners to support their operational planning solutions. Regarding to the amount of agreements and standardisation processes, the collaborative solutions might turn in one of the most complex ones. Moreover, when partners are defined by a SME’s characteristics, decentralised decisions are required to manage the collaborative processes in these Non-hierarchical manufacturing networks. In light of this, this paper reminds the most relevant existing problems when networked SME’s belongs to a non-hierarchical network. Regarding to this, a matrix to classify the main collaborative processes problems and solutions is proposed for hierarchical and non-hierarchical networks. Amongst all the identified problems and solutions, this paper focuses on the operations planning issues. The objective is to address the operational planning problem in non-hierarchical networks considering the solutions from the *Supply Chain Agent-based Modelling Methodology that supports a Collaborative Planning Approach*.

Keywords: Non-Hierarchical Networks, operational planning, collaboration, inter-organizational barriers

INTRODUCTION

A growing number of organizational forms in collaborative networks are emerging as a result of the information and communication technologies (ICT) advances and the market and society needs to increase the research progress to cope the main enterprise collaboration issues. Moreover, issues such as the increasing on competition, customer requirements, use dispersed knowledge, the need to address global-scale issues and the globalization requires an SMEs joint efforts and global collaboration [1].

Traditional Hierarchical Manufacturing Networks (HN), based on centralized decision models (CDM), imply significant inefficiencies for the entire network due to the fact they only consider constraints defined by the minority of dominant firms. Thereafter, the HN performance can be improved by establishing a decentralized decision-making (DDM). Non-Hierarchical manufacturing Networks (NHN) are based on DDM where all the networked partners are involved in the business processes management in a collaborative way [1].

The paper presents an overview of the SME's needs arising from non-hierarchical collaborative relationships to support DDM. Amongst the problems affecting network collaborative processes, the operational planning problem is specifically considered. Furthermore, considering the previous researched from [2], this paper analyses how the novel SCAMM-CPA approach [18] adapts to non-hierarchical scenarios to deal collaboratively with operations planning within a DDM perspective.

COLLABORATIVE PROCESSES PROBLEMS

Considering the previous work from [2], the most relevant problems associated with collaborative processes are shown in Table 2. Hence, the matrix already defined in [2] reveals the existence of many problems affecting the inter-enterprise collaboration and provides some brands in order to identify a collection of solutions that supports collaborative processes, in where the most of them considers the HN perspective. In addition, the degree of coverage is analyzed for each problem which can be adopted to address the problems from the NHN perspective. In this way, if the solution is provided specifically for NHN it is possible to say there exist a good degree of coverage to support NHN (●). On the other hand, if the solution is oriented for HN, then it must be determined how the provided solution can be implemented in NHN. Regarding to this, from the Table 1, the matrix provides the following classification and notation to identify the degree of coverage: poor (○), unsatisfactory (◔), acceptable (◑) or satisfactory (◕).

Table 1: Solutions Degree of Coverage (adapted from [2])

Degree of Coverage		Description
Poor	○	The solution cannot be applied to NHN
Unsatisfactory	◔	The solution concept or idea can be implemented in NHN but the solution itself cannot be applied because it is subject to a HN features
Acceptable	◑	The solution is outlined for the HN scenarios but it can be applied to NHN
Satisfactory	◕	The majority solution lines are adaptable or defined for NHN
Excellent	●	The solution has been specifically designed for NHN context

The identified problems are conceptually arranged accordingly to the decisional level, such as strategic, tactical and operational (S/T/O) and according to the used criteria for the solutions classification: models, guidelines and tools (M/G/T). Table 2 shows the classification scheme of problems affecting networks collaboration, both from the HN and NHN perspective.

Table 2. Collaborative Processes Problems Classification (adapted from [2])

Models
Guidelines
Tools

Level	Strategic		Tactical		Operational	
Collaborative Problems	(1) Network Design	◕	(1) Forecast Demand	◕	(1) Scheduling	◑
	(2) Decision System Design	◑	(2) Operation Planning	◕	(2) OPP	◕
	(3) Partners Selection	◑	(3) Replenishment	◕	(3) Lotsizing Negotiation	◑
	(4) Strategy Alignment	◔	(4) Performance Management	◕	(4) Inventory Management.	◑
	(5) Partners Coordination	◑	(5) Knowledge Management.	◑	(5) Information Exchange	◕
	(6) Product Design	◑	(6) Uncertainty Management.	◑	(6) Process Connection	◑
	(7) PMS Design	◕	(7) Negotiation Contracts among partners	◔	(7) Interoperability	◕
	(8) Coordination Mechanisms Design	◑	(8) Share costs/profits	◔		
			(9) Coordination Mechanisms Management	◑		

Degree of Coverage: ○ poor ◔ unsatisfactory ◑ acceptable ◕ satisfactory ● excellent

OPERATIONAL PLANNING PROBLEM

Amongst all the collaborative process problems identified, the operational planning problems, classified at the tactical decision level, are selected regarding to their relevance for establishing collaborative processes among networked partners. At this decisional level, as studied in [18], the collaborative approach will imply the sharing of information in terms the planning process, which is oriented to support the implementation and evaluation of joint activity programs to achieve common goals. This means sharing information in terms of risks, resources, responsibilities and rewards, for instance. Hence, the collaboration can be seen as the mutual participants' commitment to jointly solve problems.

Operational planning, such as production, inventory management and distribution processes, is a key factor in network management. Given the complex management of the network and different goal-based objectives among partners, it is desirable to develop scenarios to integrate all the nodes through the network planning [4].

Collaborative planning is defined as an interactive process in which partners, continuously collaborating and sharing demand information to jointly plan their activities [5]. This collaborative planning, in terms of its linked decision-making process, can be seen as centralized or decentralized. In centralized planning, one partner performs the plan that is transmitted to others. Then, this partner is meant to make the best solution on behalf the whole network. On other hand, in the decentralized scenario, each node is responsible for exchanging its own information and taking their own decisions [24]. Decentralized planning has closer behaviour to real environments and need coordination mechanisms [7] and pre-agreed business rules. Non-hierarchical networks are characterized by establishing decentralized mechanisms.

Operational Planning Solutions

In the context of the operational planning, solutions for collaborative processes are collected in HN and NHN context. Table 3 illustrates a classification scheme from the literature review on operational planning solutions. The classification scheme is based on the type of solutions. Three major operational planning solutions categories are defined: models (M), guidelines (G) and tools (T).

Table 3. Operational Planning Solutions

Operational Planning Solutions	***MODELS*:** planning domains [6], decentralized planning, Partially centralized SCMP [7], SC Planning matrix, APS [5], e-constraint method [8], planning models under uncertainty [4], network decentralized planning [5][9], Fuzzy Goal Programming [10], conceptual modelling of planning processes [11]
	GUIDELINES: iterative collaborative planning [12], non-hierarchical negotiations based on compensation schemes [13], ADSCP, Decentralized supply chain planning framework [14], interoperability [15], OPS [16]
	TOOLS: ACI [17], SCAMM-CPA [18], MASCOPP [19], MASCOT [20], eXPlanTech, ProPlanT [21], DGRAI [22], COC PLAN TOOL [23]

Application of SCAMM-CPA to NHN

Multi Agent Systems (MAS) is a robust tool to deal with the decision-making, information flown and simulation modelling process, especially in supply chain environments. This technology is commonly used to overcome the operational planning management process in networks ([18], [19] and [20]).

The use of agent-based, such as MASCOT [20] - *Multi-Agent Supply Chain Coordination Tool*, MASCOPP [19] - *Multi-Agent System for collaborative production planning* -, which lets us synchronize decentralized production plans and SCAMM-CPA methodology [18] - *Supply Chain Agent-based Modelling Methodology that supports a Collaborative Planning Approach*-, support the collaborative planning process in the network.

Amongst all the identified solutions, the novel SCAMM-CPA approach is considered particularly interesting. This approach, also extended by [24] for more complex and generic environments, is oriented to support the design and implementation of the most important collaborative supply chain processes, such as forecasting, order management, production planning, replenishment and product-distribution by considering a novel implementation of collaborative mechanisms among companies based on distributed agents. From the extension of [18] to [24], it has been possible to generate a novel architecture structured over the standard perspectives and dimensions of the Zachman Framework in where the main data, functions, people, motivations, temporal and spatial relationship are identified and defined. Within this, it is possible to support the design and implementation of the collaborative network processes, especially NHN. Although, SCAMM-CPA is validated by applying it to an automotive supply chain from where the architecture has been generated in order to be as generic as possible to make it adaptable to any kind of network typology.

Thereafter, the architecture implements a MAS-based tool to support any kind of supply chain typology. Specifically in the NHN context, the tool is to be installed in each supply chain node in order to provides an automated system to negotiate demand plans between any pair of supply chain nodes and enables the consideration of restrictions in all the nodes involved to generate an efficient response to the supply chain`s customer demand. Hence

NHN are to be implemented by considering their own behaviours and decision-making mechanisms in collaborative and decentralised perspective, which can be considered as novel research solution.

CONCLUSIONS

The literature review reveals the existence of many problems affecting the inter-enterprise collaboration, most of them treated for the HN context. Andrés and Poler [2] relate both relevant problems and solutions in collaborative context. The degree of coverage is determined for each problem as the extent to which the provided solution can be implemented in NHN.

Amongst the relevant collaborative processes problems that affect the collaborative relationships within a network this paper particularly addresses the operational planning problem. To deal with the operational planning problem a solution based on the SCAMM-CPA is analysed to determine the applicability at NHN.

The future research lines are focused on building a "Collaborative Framework for Non-Hierarchical Manufacturing Networks" that will focus on problems which current solutions do not provide satisfactory degrees of coverage in NHN context. In addition to provide models, guidelines and tools for supporting collaborative processes, specifically in the non-hierarchical context. The framework has the goal of achieving a better understanding how SMEs deal with collaborative problems.

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Supporting the Diagnostic of Portuguese SME using AHP

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ABSTRACT

In this paper we suggest the use of the Analytic Hierarchy Process (AHP) to evaluate intervention measures in Portuguese Small Medium Enterprises (SMEs). These intervention measures result from an external diagnostic performed under the QREN program (“*Quadro de Referência Estratégico*” – Strategic Reference Frame). QREN aims at the development of Portuguese economy and is financed by the European Union. The AHP application enables to rank the intervention measures and to focus on the most promising ones.

SMEs (with less than 100 employees) are the dominant type of companies within the Portuguese enterprise structure, sharing many types of problems. The QREN framework aims (among other objectives) at enhancing SMEs through the improvement of management quality, the introduction of new organizational structures and technology, the access to new markets and the incorporation of social responsibility. The idea is to follow an instruction-action attitude where (external) consultants develop their activity around the following vectors: company diagnostic, suggestion of intervention measures and training of companies' collaborators (including entrepreneurs).

We present the results of applying the AHP over two cases. The results show that this application adds consistency and focus to the interventions in the framework of QREN.

Keywords: AHP – Analytic Hierarchy Process, SME – Small Medium Enterprises, Intervention Measures Management.

INTRODUCTION

The QREN program (“*Quadro de Referência Estratégico*” – Strategic Reference Frame) aims at developing the Portuguese economy and is financed by the European Union. The AEP (“*Associação Empresarial de Portugal*” – Enterprise Association of Portugal) is the organization baring management responsibilities within this framework. For this matter, the AEP developed a guidebook (“*Manual de Organização e Funcionamento”* – MOF – [1]) structuring and guiding the application of economic and management measures, taking into account a set of specific requirements and constraints imposed by the European Union.

Although being the most common type of enterprise in Portugal, Small and Medium Enterprises (SMEs) (enterprises with less than 100 employees), they are plagued by several types of problems: lack of management skills, poor market positioning, low quality control, absence of marketing plans, poor productive organization and low motivation among their employees[2].

The project FPME (“*Formação Pequenas e Médias Empresas*” – Instruction for SMEs) is encompassed by the QREN framework and aims at enhancing SMEs performance through the improvement of management quality, the introduction of new organizational structures and technology, the access to new markets and the incorporation of social responsibility [1]. This project follows an instruction-action attitude where (external) consultants develop their activity around the following vectors: company diagnostic, suggestion of intervention measures and formation to the company collaborators (including entrepreneurs). According to the MOF [1] the diagnostic must encompass:

- the characterization of both company and overall business;
- the identification of objectives;
- the analysis of the business context;
- a SWOT (Strong points, Weak points, Opportunities, Threads) analysis;
- a list of the current versus the desirable situation;
- a hierarchical structure (a tree) of aims (objectives).

Using the objective tree, consultants and management staff develop the intervention measures and define the instruction plan. By including the social responsibility component, a strategic plan of medium-long term is concluded.

We suggested the use of the Analytic Hierarchy Process (AHP), as defined by Saaty [3], in order to evaluate the intervention measures according to the objective tree. This enables to rank the intervention measures and to focus on the most promising ones. As a byproduct of this evaluation, the consistency of the objective tree is also tested and the hierarchical structure of aims can be rebuilt in case of inconsistency.

When searching the internet to find suitable software for AHP implementation, we found a large amount of possibilities. We selected a small amount of implementations, ranging from simple Microsoft Excel templates to more sophisticated systems, and used them in SMEs diagnostic cases. Two of them were specially preferred by the users: a Microsoft Excel template (http://bpmsg.com/) and the system “Make it Rational” (https://makeitrational.com/). The users are the consultants and the SMEs management staff responsible for the development of the SME diagnostic.

In this paper we present the results of applying AHP over two cases. The results show that this application adds consistency and focus to the interventions of the FPME in the framework of QREN. We will start by briefly present the AHP, then we will present the two cases. Finally, we will give some clues on future work on developing a helping system not only for the application of AHP but also for supporting the selection of intervention measures according to the current situation found in a SME.

AHP METHOD

The AHP is a multi criteria decision support method initially developed by Saaty [3]. The AHP starts by structuring the decision problem, according to a hierarchy of objectives and sub-objectives: a tree of objectives. The sub-objectives of each level (or children) are pair-wised compared, according to their predecessor (or father). The comparisons use a scale that usually range from 1 ('A have equal importance to B according to objective C') to 9 ('A is extremely more important than B according to objective C'). The reciprocals of the numbers 1–9 are used when the first element is not as important as the second (1/9, for instance, meaning that 'B is extremely less important than A according to objective C'). A matrix of pair-wised comparisons is built and its principal right eigenvector is computed. The normalized values of this vector correspond to the impact, or importance, weights of each sub-objective on their predecessors. The evaluation of the alternatives follows the same process. In order to compute the impact weights of the alternatives on the main objective (the root of the tree), the obtained weights in each path from, the main objective to the alternative, are multiplied. After that, the path values that correspond to the same alternative are added.

Some degree of inconsistency is expected among pair-wise comparisons of the elements (objectives or alternatives), mostly due to some possible intransitivity. If A is 3 times more important than B and if B is 3 times more important than C, for instance, it is expected that A is 9 times more important than C. Saaty [4] proposes to measure that inconsistency using a ratio (the consistency ratio – CR) which results from dividing the normalized difference between the maximum eigenvalue of the matrix and the number of rows (and columns) of the matrix (in consistent matrix this eigenvalue is equal to the number of rows and columns) by the average normalized difference found in matrixes randomly generated. Godinho et al. [5] provide a detailed description on the application of the AHP.

The AHP is a well known and accepted method, though it also presents some application problems:

- rank reversal – in some cases (usually by misuse) it is possible that the rank of existing alternatives is changed when an irrelevant alternative is added;
- difficulties in comparing three or more very different elements – in some cases we can have, for instance, that A is 9 times more important than B and that B is 9 times more important than C, so A should 81 times more important than C;
- a high number of comparisons to be made – if, for instance, we have to sort out 10 alternatives we will have 90 pair wise comparisons to make.

Saaty [4], also based on other authors, suggests ways of dealing with these problems.

APPLICATION OF AHP TO SME DIAGNOSTIC

Case I – Printing Company

This small company prints documents and other material for institutional communication and marketing. It has three main sections: the accounting section; the pre-printing section, where the materials are prepared to the printing machines; and the production section, where the materials enter the machines to be printed.

After analyzing the current economic and financial state of the company and the business context, a SWOT analysis was performed. This analysis enabled to identify the current issues that needed intervention, in order to increase the revenues.

The identified elements needing intervention were the following:

- disorganized billing process,
- printed and delivered works where not billed to customers, because the accounting section did not know about them;
- communication breaks between the pre-printing section and the production section;
- incorrect filling of the production forms;
- difficulties in finding technical information about previous works;
- urgent requests disrupted pre-printing section workflow, causing delays;
- there was a general feeling that the employees where not listen when problems arise;
- production employees where under motivated, as they felt that they work harder than the employees from the other section.

A small tree of objectives was built, where the main objective of increasing the revenues was identified, as well as two sub-objectives, namely, to improve the billing process and to improve productivity. This late sub-objective was also divided into other sub-objectives, namely: to improve production effectiveness; to reduce nonproductive times; and to raise employees' satisfaction. This small tree is presented in Table 1.

The identified intervention measures were the following:

- IM-1: To re-design the billing process, possibly by introducing billing software;
- IM-2: To introduce a better communication channel between production and accounting sections, in order to control deliveries and billing;
- IM-3: To improve the communication channel between pre-printing and the production sections, in order to avoid breakdowns, thus reducing lead times;
- IM-4: To emphasize the need for documenting the different works, preferably using digital documenting;
- IM-5: To improve the archive system, by introducing a database management system;
- IM-6: To avoid urgent requests;
- IM-7: To improve internal communication;
- IM-8: To find ways for employees' acknowledgement.

The management staff, along with the consultant, evaluated these intervention measures according to the tree of objectives, using a software package implementing AHP. Table 1 presents the results (the consistency ratio of AHP was considered acceptable).

When analyzing the results, it is obvious that management changes must focus on improving the billing system, including the coordination between the production and the accounting section, for a proper billing procedure. These measures have 67% of impact on improving the company revenues. Documenting the different works produced at the company also presents a high impact on increasing revenues. In conclusion, a successful implementation of these three measures will have a high impact on increasing revenues.

Table 1: Tree of Objectives and Evaluation Results for Case I

<table>
<tr><td colspan="8">Increase Revenues (100%)</td></tr>
<tr><td colspan="2" rowspan="2">Improve Billing (67%)</td><td colspan="6">Improve Productivity (33%)</td></tr>
<tr><td colspan="2">Production Effectiveness (20%)</td><td colspan="2">Reduce Unproductive Time (5%)</td><td colspan="2">Employees’ Satisfaction (8%)</td></tr>
<tr><td>IM-1 (50%)</td><td>IM-2 (17%)</td><td>IM-3 (7%)</td><td>IM-4 (13%)</td><td>IM-5 (4%)</td><td>IM-6 (1%)</td><td>IM-7 (4%)</td><td>IM-8 (4%)</td></tr>
</table>

Case II – Civil Engineering Company

The main activities of this company consist on the analysis, verification and validation of construction projects, the management of construction contracting, as well as the inspection or management of constructions sites.

The analysis of the company enabled to identify the current main objective: raising operational results up to a positive level, as their numbers were in the red. The current issues requiring intervention were also identified:

- difficulties in finding new contracts;
- due dates of some of the contracts in the current portfolio were expiring;
- employees felt difficulties in managing their individual time, especially on work overload;
- communication breakdowns from higher to lower hierarchy (though there were several meetings with clients, the employees were not aware of them neither of the resulting information);
- there were problems managing documents and archives;
- several employees reported difficulties in using office applications;
- there was not enough expertise inside the company to do internal quality audits;
- there was not enough expertise inside the company for fire security inspection (the company was sub-contracting other companies for this issue).

A small tree of objectives was built (presented on Table 2) and the identified intervention measures were the following:

- IM-1: To reinforce the sales team;
- IM-2: To improve marketing strategies;
- IM-3: To improve internal communication between management staff and employees through regular meetings;
- IM-4: To improve the archives, by introducing a database management system;
- IM-5: To teach employees about techniques for personal time management and office applications;

- IM-6: To teach quality control techniques to employees;
- IM-7: To contract experts on fire security systems and inspections;
- IM-8: To reduce financing costs by changing short term debt to long term debt.

Table 2 presents the results of the application of AHP (the consistency ratio of AHP was considered acceptable). From Table 2 it is easy to conclude that management must focus on reducing costs by reshaping the debt, contracting experts on fire security and teaching quality control techniques to employees. Management must also improve the expertise of employees on personal time management and office applications.

Table 2: Tree of Objectives and Evaluation Results for Case II

Positive Operational Results (100%)							
Improve Sales Effectiveness (9%)		Improve Productivity (35%)			Reduce Costs (56%)		
		Reduce Unproductive Time (9%)					
IM-1 (8%)	IM-2 (1%)	IM-3 (2%)	IM-4 (7%)	IM-5 (26%)	IM-6 (11%)	IM-7 (34%)	IM-8 (11%)

CONCLUSIONS

We presented the application of AHP to evaluate intervention measures in two Portuguese SMEs. These intervention measures result from external diagnostics performed under the QREN program. The AHP application enabled to rank the intervention measures and to suggest focusing on the more promising.

The AHP was applied to several other Portuguese SMEs, but the results were not presented in this paper. The presented cases are deemed enough to understand the advantages of the AHP use and also to start the assessment of which are recurring cases. This observation enabled us to start the design of an information system for helping on SMEs diagnostic process. By documenting several cases, it is possible to select groups and sub-groups of intervention measures along with groups and sub-groups of issues that require intervention.

The general idea is to build an interactive web application where managers could have access to SMEs cases and related extracted information. In this way, managers (without the help of hired consultants) can choose the intervention measures that better fits their particular case.

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A Decision Support System for Delivery Management in a Lack of Homogeneity in Products (LHP) Context. The case of a ceramic tile supply chain

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ABSTRACT

Uniform product deliveries are required in sectors like ceramic, wood or textile, where customers require this homogeneity, and lack of homogeneity in products (LHP) becomes a problem for them. Raw materials or other factors in the manufacturing process can be reasons for LHP. Industries that manufacture with LHP cannot avoid the occasional arrival of non uniform finished products at their warehouses and, consequently, the fragmentation of their inventories. In these cases, final uniform product amounts do not match the planned production and promise orders have to be reassigning with real inventory. This work proposes a multi-objective model-driven decision support system (DSS) to help the person in charge of delivery management to reassign the real inventory available to orders. The identification of such problems in a ceramic tile supply chain has enabled us to validate the DSS.

Keywords: Lack of homogeneity, Delivery Management, Decision Support System, Supply Chain

INTRODUCTION

In certain industrial sectors like ceramic, marble, wood or textile, customers usually require uniform products; however final products sometimes present differences. This may happen when the raw material used is directly obtained from nature itself [1], and/or some product characteristics depend on specific factors that cannot be controlled during the manufacturing process (pressure, humidity, temperature, meteorology, etc.). These differences imply lack of homogeneity in the product (LHP) [2]. This may become a considerable problem when customers acquire several units of a given product and expect product homogeneity to use, present, arrange or consume them together. The problem of LHP can be visible in products like parquet strips, leatherwear, floor tiles or pearl necklaces.

Companies that manufacture with LHP cannot prevent non uniform finished products incoming to their warehouses and the fragmentation of their inventories. Thus, managing customers' orders is particularly complicated. In this task, the order promising process has an important role. This process involves checking if there are enough uniform product available (real or planned) which have not been previously promised (ATP – available to promise) to meet the requirements set out in the order for the foreseen delivery date [1][3].

Traditional ATP assignment systems may accumulate the current not promised stocks in the warehouse (real ATP) and the planned amounts of one same product (planned ATP) originating from different manufacturing lots and periods since they assume product homogeneity. Products can be prepared and delivered according to the ATP assignments. However, companies with LHP obtain not uniform lots; so frequently, some ATP-based orders cannot be met because there is not enough amount of homogeneous product. This situation causes problems in orders with immediate delivery date. In these cases, in order to deliver the promised orders, reassigning the inventory available in the warehouse (real inventory) is possible prioritizing those orders with immediate delivery dates. The correct assignment must guarantee both the delivery dates and the homogeneity in the delivered products. For instance, two orders with 700 and 900 units of the same product can be promised with a planned lot of 1800 units. Initially, the planned lot has enough quantity and even ATP for 200 units. However, if the real production for this lot is 1200 homogeneous units and 600 homogeneous units, it is possible to deliver only one of these orders with homogeneous quantities.

Thus, this is a critical and complex decision. In order to achieve a feasible reassignment, the decision maker has to manage a considerable volume of data: a large number of orders with different delivery dates, several products in each order, and the fragmentation of the inventory because of LHP, which entails identifying, locating and managing subtypes of products.

Several works have proposed the use of model-driven designs to assign ATP to orders. Some models attempt to deal with the customers' orders in real time [4][5][6] [7] according to the order in which orders arrive. Other models group the order proposals received during a certain time interval (batch interval), after which they assign an ATP to them [5][8][9][10][11][12]. Although it has been verified that batch models offer better results than on-line models, there are environments in which it is necessary to respond immediately to customers' demands. Nonetheless, these models are not valid for contexts with LHP because they involve new restrictions on ATP management systems not considered to date. Thus, a good assignment of an ATP with LHP should ensure product homogeneity in each order.

A model-driven DSS is appropriate in LHP contexts as it can help managers to make a decision. This work proposes a multi-objective model-driven DSS to optimally reassign an inventory to LHP-characterized promised orders in MTS environments. The solution of the model allows knowing that product must be served in the current inventory conditions and which subtype of uniform product will be delivered following two objectives: 1) to maximize profits and 2) to maximize the number of orders served with an earlier delivery date.

MULTI-OBJECTIVE MODEL-DRIVEN DSS ARCHITECTURE FOR DELIVERY MANAGEMENT IN SCS WITH LHP

Context

With regards the physic-organizational aspects, this proposal works with three kinds of nodes in a supply chain: production plants, a central warehouse and selling points. Production plants follow an MTS strategy and manufacture in lots. One same product may be manufactured in any production plant. Each manufactured lot may give rise to different product subtypes (owing to the LHP), which should be unified in the central warehouse with other equal subtypes (from the same production plant or from others). The orders to be dispatched and delivered to selling points are prepared in the central warehouse according to the orders they have sent. Customers place orders in selling points. An order includes several order lines of various products, and there is a single delivery date for the whole order.

When preparing orders for delivery, there are some limitations: 1) partial orders are not allowed, that is, all the order lines will have to be served on the same date. 2) the customer requests an amount of product type and it is necessary to decide the subtype that will be delivered. In order to guarantee the homogeneity, it is not possible to mix different subtypes to serve an order line. 3) A policy of not accumulating the planned ATP of different periods and lots of product in anticipation of LHP to reduce the number of future inventory reassignments. However, final products manufactured from different periods and lots can be accumulated in subtypes according to their actual features in the central warehouse. Compromising stock to an order line requires enough planned ATP (a planed lot of product) or real uniform ATP (a subtype in the central warehouse). This fact may lead to a situation in which some orders with longer delivery dates will have to be compromised with real ATP because only this real ATP ensures the sufficient amount of a uniform product to serve the order. This will lower not only the real ATP but, consequently, the possibilities of covering orders with earlier delivery dates. On the other hand, and as a result of the previous situation, some orders with early delivery dates could not reserve the real ATP and will have to be reserved from the planned ATP.

As manufacturing lots are received, they are classified into the corresponding subtypes. At this time, checks are made to see if there is a sufficient amount of the uniform subtypes obtained to serve the promised orders. Owing to LHP, sometimes orders with immediate delivery dates cannot be served completely because the amount of the uniform product available is not enough, and it is not possible to release production orders to be delivered on time. Thus the only alternative to avoid delays consists in reassigning the current inventory in the warehouse from orders with no immediate delivery dates to those orders with immediate delivery dates. This decision can be made: a) periodically and whenever necessary for product delivery management and, b) when urgent orders arrive to transfer real inventory from less priority orders to the urgent orders.

For the purpose of providing support to the person in charge of delivery management tasks, a model-driven DSS is proposed. The DSS includes a mixed integer linear programming model which contemplates all those promised orders. It is assumed that orders with delivery dates within a delivery horizon require immediate delivery and they will have priority in the reassigned of the current inventory.

Model

This model help to decide which promised order must be served using the current inventory following two objectives: 1) to maximize the profits of orders delivered and 2) to maximize the number of orders served with early delivery dates. The decision maker can assign a weight between 0 and 1 between these objectives and the sum of both weights must be 1.

The constraints included in the model deal with:

- Orders, whose dispatch date is in the delivery horizon, have to be served. That is, priority is given to reserving the inventory available for these orders.
- A specific order could be served, whenever all the order lines have assigned to real inventory.
- The amount of each subtype of product assigned to the different order lines, must be equal to the amount of that subtype of product available in the warehouse.
- Every single order line is completed with only a subtype of product. This constraint ensures the required uniform product.
- ATP in the current period (real inventory not assigned to any order) of product and subtype must be non negative.

Owing to the first constraint, the model solution may not be feasible because there is not enough amount of the uniform product available in the warehouse to cover all the requirements of the orders in the delivery horizon. This situation means it is not possible to serve all the orders within the delivery horizon on time. In this case, the elimination of the first constraint from the model and running it again are recommended to find a solution to optimize the objective. Nonetheless, although the first constraint is eliminated from the model, priority is given to assign the current inventory to orders with closer delivery dates. This procedure implies defining two models, one with the first constraint (MPM-1) and other without this constraint (MPM-2).

Usage details

The usage details of the proposed DSS are described in accordance with the blocks presented in Figure 1 (extraction, pretreatment, solver, post-treatment, analysis):

Extraction:

In the proposed DSS, the information about customers' orders is extracted from sales information systems. Only orders with order lines compromised with current stock (previous stock + new stock received from planned lots in the period) are considered. This information includes: the delivery date for each order, the profits obtained and the amount requested of product for each order line. Information about the amounts of products and their subtypes in all the production plants is extracted from the information systems of each production plant. The transport time from the production plants to the central warehouse and the central warehouse to each selling point is obtained from the logistics information system.

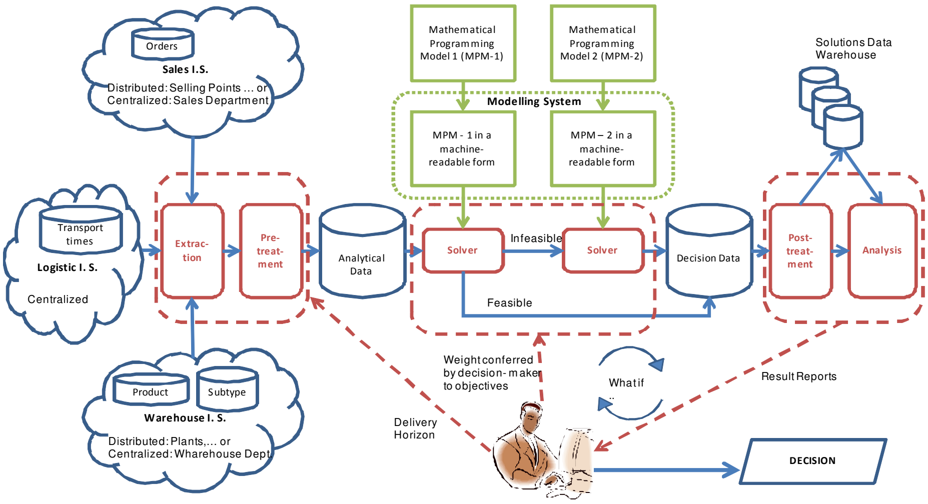

Figure 1: Usage details

Pre-processing:

Before running the model, it is necessary to perform a previous data processing. This involves calculating the number of order lines in each order, the number of orders whose delivery date is in the delivery horizon, the dispatch date of each order from the central warehouse as the difference between the order delivery date and the transport time from the central warehouse to the selling point, the maximum and minimum profit of the orders processed to scale the profit, and finally, the total amount of subtypes of products as the sum of the amounts of subtype of products in the production plants.

Solver:

Before the solving stage, the decision maker must introduce the weights assigned to each objective considered in the mathematical programming models. Firstly, the MPM-1 model is solved; if a solution is obtained means that all the orders in the delivery horizon are served. In case of an unfeasible solution, the model MPM-2 is run which always provides a feasible solution but some orders will not be served. The solution data obtained includes information on: if one order is completely reserved or not, the subtype of product reserved for each line and, the amount of the physical stock of subtype of product unreserved; that is, ATP. The decision maker may run the corresponding model several times and confer different values to the weights of each objective.

Post-processing:

A post-processing is proposed to provide additional information to compare different solutions (the decision maker may run the model modifying the weights of the objectives). It calculates certain performance parameters for each solution which will allow the decision maker to compare various solutions.

Analysis:

As previously mentioned, the decision maker may run the model several times and confer a different weight to the objectives. The analysis of the results must enable the decision maker to consult the results of the model with as much detail as possible for each solution generated in such a way that the decision maker may analyze how sensitive is the solution.

Decision:

Finally, and depending on the analysis of the results, the decision maker should choose a solution. The decision taken will be valid for the defined delivery horizon. Once this horizon has passed, the decision maker will necessarily have to decide about the next delivery horizon. Therefore, the decision maker will have to run this decision process with the same frequency as the delivery horizon (period-driven). Additionally, this process will have to be carried out when an urgent order arrives (event-driven).

THE CASE OF A CERAMIC TILE SUPPLY CHAIN

The validation of the multi-objective model-driven DSS has been carried out in an SC which manufactures, stores, distributes and sells ceramic products. LHP is characteristic in the firms that manufacture ceramic products where different factors relating to the production process and raw materials, like humidity, temperature or clay properties, unpredictably affect the final aspect of the product in question. This product varies given the lack of homogeneity of its colors (variety of tones) and thicknesses (different calibers), giving way to different subtypes (a combination of product-tone-caliber). For this reason, the subtypes making up each manufactured product lot must be identified according to the different combinations of tones and calibers actually obtained. With this classification, each subtype is identified, stored and managed separately.

A suitable management of subtypes is crucial for customer satisfaction. Delivering a product with different tones or calibers carries inevitable esthetic and functional problems.

The ceramic SC in which the developed model-driven DSS has been validated is made up of 3 production plants, a central warehouse and 28 selling points. The production plants follow an MTS strategy owing to high setup times and costs. One product can be manufactured in any production plant and each manufactured lot may give rise to different product subtypes (because of LHP), which are unified in the central warehouse with other subtypes of the same kind. Orders are prepared in this central warehouse to be dispatched and delivered to the selling points in accordance with each selling point's orders.

The person in charge of managing the delivery of products to customers may reassign inventories and decide the way to manage those orders with closer delivery dates. For this purpose, using the DSS every week enables decisions to be made as to which orders are delivered the following week. The DSS prioritizes the preparation and delivery of those orders within the delivery horizon (1 week). For the purpose of offering a vision of the considerable volume of information managed by the DSS, some relevant data of one of its executions are presented: there were 2,274 orders in the order book, with an average of approximately 4 lines per order (some had more than 100 different order lines) with a total of 9,389 lines. There were 6,426 different products and 18,133 subtypes.

The modeling language used to translate the model into an algebraic, machine-readable form was MPL 4.2 and the solver employed was CPLEX. A Microsoft Access database was created in accordance with the analytical data and decision data structure. This structure was extended to include the data required for the pre- and post-processing. The decision maker may carry out a "what-if"-type analysis by running the model several times, by varying the weight conferred to each objective and by comparing the results of the different executions based on the post-processing of these executions. Then, the decision maker selects the most suitable solution. In short, the decision maker determines what orders are to be reserved from the current stock, and what subtypes and, consequently, what orders with immediate dispatch dates are to be delivered.

CONCLUSIONS

This work describes a multi-objective model-driven DSS developed to support the decision making involved in the delivery management in supply chains that manufacture make-to-stock with lack of product homogeneity. The differences that LHP introduce to assign ATP to customers' orders have been presented in comparison with a uniform product context, a situation which may entail having to reassign the current inventory for delivery management purposes.

Pursuing various objectives during the reassignment, the considerable volume of processed data and the difficulty in obtaining feasible assignments, all justify a model-driven DSS. The DSS is designed to help and support the person in charge of delivery management (the decision maker) to periodically assign the real inventory available to orders with immediate dispatch dates and to ensure that the delivered products are uniform. Furthermore, before making a definite decision, the decision maker may perform different "what-if" simulations by modifying the weight assigned to each objective, and by assessing and comparing the different solutions. The DSS presented herein may be used directly by the decision maker without necessarily having any technical knowledge.

This multi-objective model-driven DSS has been validated in a ceramic tile supply chain where lack of product homogeneity is materialized in the form of different tones and calibers of the ceramic tile floorings and coverings. It has been verified that the DSS adequately supports the problems involved when the decision maker is faced with a wide range of possible solutions to choose from..

CONCLUSIONS

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A Supply Chain Model for Integrated Procurement and Production Planning with Multiple Uncertainties

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ABSTRACT

This paper develops a supply chain model based upon two case studies to assist decision making for integrated procurement and production. The model consists of four sub-models: Customer Order Model, Manufacturing Model, Raw Materials Procurement with Transportation Model, and Finished Goods Satisfying Customer Order with Transportation Model. From the data of two studies, multiple types of uncertainties are identified and modeled, which include information flow and material flow uncertainty, information and material delays, supply uncertainty, customer demand uncertainty, and production quality uncertainty. The supply chain performance is measured by total cost and customer service level. The supply chain model is simulated using MATLAB. The usefulness of the model is illustrated by experimenting two strategies, Just-In-Time and JIT with safety stock, in comparison with case companies' original strategy in a range of scenarios with different degrees of uncertainty and different levels of cooperation.

Keywords: Decision Making, Multiple-stages supply chain, Uncertainties, Simulation, Raw material procurement and Production planning

INTRODUCTION

The importance of integrated operations in supply chain systems has been increasingly recognised. Many Integrated Decision Support Systems (IDSS) have been developed to improve system performance through better information exchange (e.g. data mining) and operation coordination between agents and users (e.g. [1-4]). Procurement and production integration planning is one of the most important functional integrations in supply chain management (SCM). For example Power [5] found that the integration of supply chains (SC) can potentially benefit multiple trading partners. Stadtler et al. [6] illustrated the advanced planning in SC using integrated systems (applications). A number of studies in the literature have addressed the issues related to procurement and production integration, e.g. imperfect production processes[7], integrated purchasing-production in centralized SC and decentralized SC [8], effectively integration analysis [9], and optimal procurement and production quantity [10, 11]. However, few are based on real case studies and consider the integration of operations in the presence of multiple uncertainties. Uncertainty is an inherent characteristic of most supply chain systems. Common types of uncertainties include customer demand ([12-14]), material supply ([15]), production process and machine reliability ([11, 15]).

This paper aims to develop a supply chain (SC) model based upon two case studies to assist decision making for integrated procurement and production planning. Through interviews with managers in two case studies, multiple types of uncertainties are identified and modeled, which include information flow and material flow uncertainty, information and material delays, supply uncertainty, customer demand uncertainty, and production quality uncertainty. The model is able to evaluate the SC performance under different types of procurement and production strategies, and quantify the impacts of different levels of cooperation between supply chain members on the SC performance in uncertain situations.

MODEL DEVELOPMENT

The two case companies are medium-sized manufacturers located in Shandong province (north of mainland China) and Jiangxi province (south of mainland China). Company A produces four types of products requiring four main types of raw materials, and in Company B, we select a supply chain which produces one type of product requiring three main types of raw materials. Although the two case companies are in different industries and the activities and processes associated with other SC members differ slightly, the two case companies' supply chains have the similar supply chain structure, e.g. both include suppliers, raw materials (RM) transportation company, RM warehouse, manufacturer, finished goods (FG) warehouse, FG transportation company and customers. The data from these two cases interview, a supply chain model is generated as shown in Figure 1.

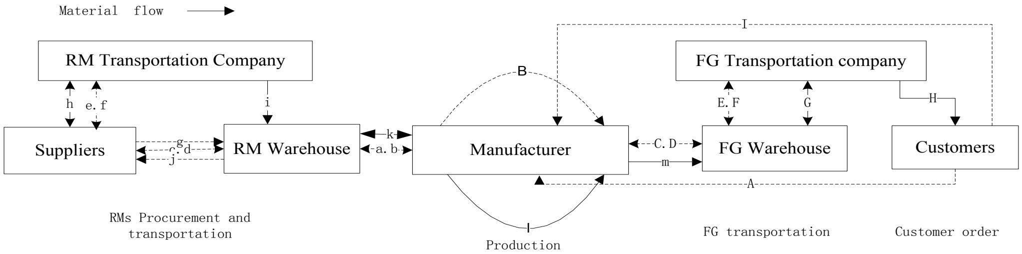

Figure 1: A generalised supply chain model with information and material flows based on two cases

The supply chain model in Figure 1 consists of two major processes: RM procurement and transportation process, and FG production, transportation and satisfying customer demand process, which are described in more details below.

The RM procurement and transportation process includes the following 13 activities:

a. Manufacturer shares the production plan to RM warehouse
b. RM warehouse reports the RM on-hand inventory information to manufacturer
c. RM warehouse places order (RM) to suppliers
d. Supplier gives feedback incorporating inventory availability to RM warehouse
e. Supplier contacts RM transportation company to arrange the delivery
f. Transportation company confirms the delivery requirements with suppliers
g. Supplier provides delivery information to RM warehouse
h. RM transportation company picks up RM from supplier
i. RM transportation company ships RM to RM warehouse
j. RM warehouse gives feedback to supplier and makes the payment
k. RM warehouse updates inventory and deliver RM to manufacturer workshop
l. Manufacturer produces FG
m. Manufacturer delivers FG to FG warehouse

The process of FG production, transportation and satisfying customer demand includes the following 9 activities:

A. Customer places the order to manufacturer
B. Manufacturer receives the order with internal checking
C. Manufacturer shares the customer order information with FG warehouse
D. FG warehouse reports inventory information to manufacturer
E. FG warehouse contacts FG's transportation company to arrange delivery
F. Transportation company confirms the delivery requirements with FG warehouse
G. Transportation company picks up FG from FG warehouse
H. Transportation company ships FG to customer
I. Customer makes payment and gives feedback to manufacturer

The above activities are categorised and consolidated into four sub-models: (i) Customer Order model (*A,B,C*); (ii) Manufacturing (Production) model (*a,k,l,m*); (iii) RM Procurement with Transportation model (*b,c,d,e,f,g,h,i,j*) and (iv) FG Satisfying Customer Order with Transportation model (*D,E,F,G,H,I*). The main decisions in the underlying supply chain is placing raw material orders to suppliers and determining production quantity for the manufacturer in order to meet customer demands efficiently and effectively.

The system is subject to various uncertainties. They may be classified into three categories according to their sources: (i) information flow uncertainty, (ii) material flow uncertainty, and (iii) customer demand uncertainty. On the other hand, according to the nature of uncertainty, they can also be classified into three types: lead-time, quantity, and delay. Table 1 summarizes the classifications of those uncertainties within four sub-models. All types of uncertainties given in Table 1 have been represented in our model by different input parameters (e.g. the distribution types, the uncertain levels)

Table 1: Classifications of uncertainties in four sub-models

		Uncertain types		
		lead-time	Quantity	Delay
Sub-Model I	Demand	Customer contracted delivery date	Customer demand	
	Information flow	Customer order information lead-time	Inaccurate order quantity	Information delay lead-time of inaccurate order
Sub-	Material	Production lead-time	Defective products	Remanufacturing lead-time

Model II	flow			
Sub-Model III	Information flow	RM order information lead-time/ booking transportation lead-time		RM order information delay lead-time/ Transportation arrangement delay lead-time
	Material flow	RM availability/ RM transportation lead-time	A fraction of RM being delayed	RM transportation delay lead-time
Sub-Model IV	Information flow	Arranging FG transportation lead-time		FG Transportation arrangement delay lead-time
	Material flow	FG availability / FG transportation lead-time	A fraction of FG being delayed	FG transportation delay lead-time

MODEL EVALUATION

Due to the complexity of the supply chain system in Figure 1 in association with multiple types of uncertainties in Table 1, we turn to the simulation method to assist the decision-making. We have developed a simulation tool using Matlab, which offers a great flexibility to evaluate specific procurement and production strategies in various scenarios representing different degrees of uncertainties and different levels of cooperation. For example, the degree of quantity uncertainty can be characterised by a set of parameters, and the level of cooperation between supply chin members can be partially represented by the lead-time and its variability. In general, higher level of cooperation will lead to shorter average lead-time with lower degree of variation.

To illustrate the usefulness of the model, we evaluate two strategies, Just-In-Time (JIT) and JIT with safety stock, in comparison with the case companies' original strategy in a range of scenarios with different degrees of uncertainty and different levels of cooperation. The company’s original strategies are the combination of regular orders and emergency orders. We have collected company’s annual historical ordering data as input data to represent its original strategies. We use LT to represent the upper bound of lead-time or delay. The default lower bound is 0. The actual lead-time and delay follow uniform distributions within the bounds. The lower value of LT represents higher level of cooperation in case SCs. Although this is a simple treatment of the cooperation, it is reasonable because higher level of cooperation may adopt advanced technologies such as EDI between channel members, which can speed up the information flow and also improve the information accuracy (i.e. reduce lead-time and its variability). Quantity uncertainty is denoted as DoU (degree of uncertainty), which represents the upper bound of the fraction of raw materials being delayed, the fraction of defective products, and the fraction of FG being delayed. The default lower bound of DoU is equal to 0. The actual quantity uncertainty follows a uniform distribution (partially based on interview results) between the lower bound and the upper bound. For example, the fraction of defective products follows a distribution U(0, DoU).

In this experiment, we consider two levels of lead-time and delay uncertainty (LT) and two levels of quantity uncertainty (DoU). For case company A, LT takes 3 weeks and 1 week, which means the lead time or delay follows a uniform distribution U(0, 3) and U(0, 1) respectively; for case company B, LT takes 7 days and 3 days, which indicates the lead time or delay follows distributions U(0, 7) and U(0, 3) respectively. The quantity uncertainty (DoU) takes two levels: 0.1 and 0.3.

Strategy I is a JIT strategy, in which the manufacturer makes RM ordering and production decisions based upon received customer orders at each period in attempt to keep zero RM and FG inventory level. Strategy II is a JIT with 30% safety stock strategy, in which the manufacturer makes production decisions based upon received customer order plus extra 30% of received customer order quantity as safety stock, meanwhile manufacturer makes RM ordering decisions based on FG production plan plus extra quantity of RM that can be used to produce extra 30% of FG (based upon production plan) as RM safety stocks. Strategy III is the company original strategy. Total cost and CSL (customer service level on average) have been used to measure the supply chain performance. The total cost consists of the following components: customer order delay penalty cost, FG transportation cost, FG backorder cost, FG shipping delay and inaccurate quantity penalty cost, production cost, setup cost, defective product penalty cost, FG inventory holding cost, RM inventory holding cost, RM transportation cost, and RM transportation delay penalty cost. The CSL is defined as the average ability of the manufacturer to fulfill periodic customer demands over the planning horizon. Here the period is on weekly and daily basis for Case A and Case B respectively, and the planning horizon is one year for both cases.

Table 2 gives the results of the two SC performances in total costs. The impacts of customer service levels, under three strategies in all scenarios for two case studies. The performance in bold corresponds to the best strategy in each scenario. It can be seen that from the customer service level perspective, the second strategy (i.e. JIT with safety stock) is the best in all scenarios for both cases; whereas from the cost perspective, the best strategy varies in different scenarios. When the average lead-time decreases (which indicates a higher level of cooperation), the supply chain performances are generally improving, which is in agreement with intuition. When the degree of quantity uncertainty increases, the total cost is generally increasing under a given strategy. However, it can be observed that strategy II is fairly robust with respect to quantity uncertainty, whereas strategies I and III are very sensitive. More importantly, the model is able to quantify the relative difference between different strategies in any given scenario and quantify the impacts of system parameters on the supply chain performance under a given strategy. Therefore, it can help the decision-maker to evaluate and select appropriate strategies for integrated procurement and production planning in complicated dynamic and stochastic situations. In the full paper, the impacts of different types of uncertainties given in Table 1 on the strategies and supply chain performance will be extensively investigated.

Table 2: Experiment results

Case Company		Case Company A				Case Company B			
Cooperative level		LT = 3 weeks		LT = 1 week		LT = 7 days		LT = 3 days	
Objectives		Cost	CSL	Cost	CSL	Cost	CSL	Cost	CSL
Strategy I	DoU = 0.1	**510.28**	0.0071	475.67	0.0048	**2.67**	0.7986	**1.79**	**1.0000**
	DoU = 0.3	663.59	0.0049	651.24	0.0037	10.21	0.4945	**2.51**	0.9016
Strategy II	DoU = 0.1	564.29	**0.6796**	**411.28**	**0.8580**	5.59	**0.8092**	4.31	**1.0000**
	DoU = 0.3	**549.92**	**0.5012**	**428.85**	**0.6632**	5.89	**0.8092**	4.80	**1.0000**
Strategy III	DoU = 0.1	545.28	0.3783	495.84	0.2445	3.12	0.8047	2.53	0.9983
	DoU = 0.3	611.04	0.0682	647.15	0.0063	**3.93**	0.7263	3.61	0.8705

CONCLUSIONS

Based upon two case studies, this paper develops a supply chain model for integrated procurement and production planning in dynamic stochastic situations. Multiple types of uncertainties are identified and modeled, which include information flow and material flow uncertainty, information and material delays, supply uncertainty, customer demand uncertainty, and production quality uncertainty. The supply chain model consists of four sub-models: Customer Order Model, Manufacturing Model, Raw Materials Procurement with Transportation Model, and Finished Goods Satisfying Customer Order with Transportation Model. We develop a simulation tool to simulate the supply chain system.

Numerical experiments illustrate the application of the simulation tool, e.g. evaluate the relative performance of different strategies, and quantify the impact of different levels of uncertainty and cooperation on supply chain performance. Further research is to investigate the optimal integrated procurement and production strategy in given scenarios considering multiple conflicting objectives.

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A knowledge chain management framework for global supply chain integration decisions

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ABSTRACT

Knowledge management (KM) has been identified as a major enabler for integrated decision making in the context of global supply chains. Key characteristics of global supply chains include multiple international participants with varied product and service delivery capabilities, diversified global markets with constant demand fluctuation, and the need for integrated decisions to achieve overall supply chain performance. These key characteristics have fundamentally influenced the KM process, from knowledge creation and retention to its transfer and application. In a global supply chain, KM has evolved from individual activities to joint ventures involving a number of international participants. Global supply chains have, therefore, presented fresh challenges to KM academics and practitioners. Knowledge chain management (KCM) has recently emerged aiming to support integrated decision making in global supply chains.

This paper proposes a KCM framework that identifies and prioritizes critical knowledge that a global supply chain can focus on to achieve competitiveness in a global setting. The framework defines three new knowledge models for a global supply chain: a global market knowledge model (i.e. demand side customer dimension), a global capacity knowledge model (i.e. supply side capability dimension), and a global supply networks configuration knowledge model (i.e. supply side organizational dimension). The inter-relationships between the three knowledge models have been defined. Empirical study has been undertaken to evaluate the KCM framework in the manufacturing industry. An analytic network process has been employed to assess the importance of the global context knowledge constructs from the supply chain and operations managers' viewpoints, and how the valuable context knowledge that global supply chains obtain can enhance their global supply chain integration decisions. A key contribution of the work is that it advances the accepted knowledge chain model that stresses the KM issue within one organization, to include the context knowledge applicable to global manufacturing. Therefore the extended KCM framework can help knowledge flow through the identification and prioritization of critical knowledge, so that KM strategy and activities can be aligned with the global supply chain's value proposition, to further support global supply chain integration decisions.

Keywords: knowledge chain management, global supply chains, decision making, integration support, analytic network process

INTRODUCTION

Knowledge is an essential theoretical construct for understanding organizations, and the co-relation between a firm's knowledge capital and its capability has now been widely accepted. Literature has extensively discussed the evolution of classic resource-based view to emerging knowledge-based view for studying organizations' competitive advantages in recent years [1]. However, less publication has addressed the issue of how to manage the joint activities of knowledge creation, retention, transfer and application along supply chains. In the context of global supply chains, knowledge management has become an even more challenging task due to a number of characteristics resulting from global supply chains, including international participant's reliance on global supply networks for global market and capacity knowledge, partner interaction behavior in the knowledge exploration and exploitation process, and heterogeneity and opaqueness of the knowledge [2]. This paper discusses a knowledge chain management (KCM) framework that addresses the knowledge support issue for decision making in the context of global supply chains. This paper is organized as follows: the next section surveys the literature on knowledge management and supply chain management. Then a conceptual KCM framework is proposed, which comprises three knowledge models that capture the context knowledge which are crucial for global supply chain integration decisions. Afterwards, the paper discusses case studies that have been undertaken in the manufacturing industry to evaluate the conceptual framework, and to provide empirical evidence to the application of the KCM for decision making in global supply chain integration. Finally, conclusions are drawn from the evidence provided, and managerial implications and limitations of the KCM framework are discussed.

RELATED WORK

The knowledge-based view (KBV) is the evolution of the well-developed resource-based view, emphasizing that knowledge rather than resources is the ultimate competence of an organization. KBV stresses that firms can extract maximum value from the knowledge they possess, acquire and create towards their sustenance and survival in the face of increasingly fierce competition [1]. In the context of business globalization, many scholars realize that supply chains can be a cradle of knowledge because they involve multiple networked players with varying insights into global markets, varying production capabilities, and varying roles in global supply networks. In order to take account of the above characteristics of global supply chains, knowledge management approaches and practices have been extended from within and inter- organizational context to the whole value chain perspective [3,4]. The first knowledge chain model was proposed a decade ago which identified five primary (acquisition, selection, generation, internalization and externalization) and four secondary (leadership, co-ordination, control and measurement) KM activities [5]. A basic premise of the knowledge chain model is that how an organization learns and how well it projects are important determinants of the organization's viability and success in a competitive environment. However, the knowledge chain model has not addressed the issue of decision support for global supply chain integration. The extended KCM framework proposed in this paper aims to fill this research gap, and provide insights into knowledge support for integrated decision making in global manufacturing. The extended KCM framework introduces three new knowledge dimensions (demand side customer dimension – global market; supply side capability dimension - global capacity; and supply side organizational dimension - global supply network configuration) to highlight the context knowledge requirement for global supply chain integration. It is believed that KM in global supply chains creates value only when it enables the creation and flow of the truly crucial knowledge. Identifying and prioritizing critical knowledge has therefore been regarded as one of the most important steps in formulating a KM strategy for global supply chains.

RESEARCH METHODOLOGY

The research approach for this study comprises two components: (1) in-depth interviews combined with an analytic network process for data collection and analysis; and (2) System Modeling Language (SysML) for knowledge modelling. Three SysML models have been created using dedicated software Enterprise Architect©: a global market knowledge model, a global capacity knowledge model, and a global supply network configuration knowledge model. The knowledge models have provided theoretical foundation to design the interview guide for the empirical study. The companies solicited for the empirical study operate at an international level with a global manufacturing focus in the automotive sector. Participants in the interviews were supply chain and operations managers. All the individuals who were interviewed have direct responsibility for, or link with, international supply chain functioning and regularly make global supply chain decisions. The interview questions were composed of two main parts: part one focused on what, how and why the global context (market, capacity and network configuration) knowledge have been used to support global supply chain integration decisions in practice; part two asked participants to quantify how much they value the knowledge in terms of its contribution to the decisions. A pilot study was undertaken with six supply chain professionals in order to refine the interview questionnaire. Data collection and analysis also used the analytic network process proposed by Saaty [6], facilitated by the dedicated software Super Decisions ©, in order to identify the core knowledge constructs that supply chain and operations managers value the most in their decision making practices.

A KCM FRAMEWORK FOR GLOBAL SUPPLY CHAINS

The features of global supply chains require new dimensions to consider the exploration and exploitation of not only the global market and capacity knowledge, but also the global supply network configuration knowledge in their decision making process. The global KCM framework therefore extends the existing knowledge chain model defined by [5] to include three new knowledge dimensions to support integrated decision making in global manufacturing. Together with the five primary and four secondary knowledge management activities for organizational learning and projection, the global KCM aims to achieve global competitiveness in supply chains, as shown in Figure 1. The following sections discuss the details of the three context knowledge models in order to address the three new knowledge dimensions.

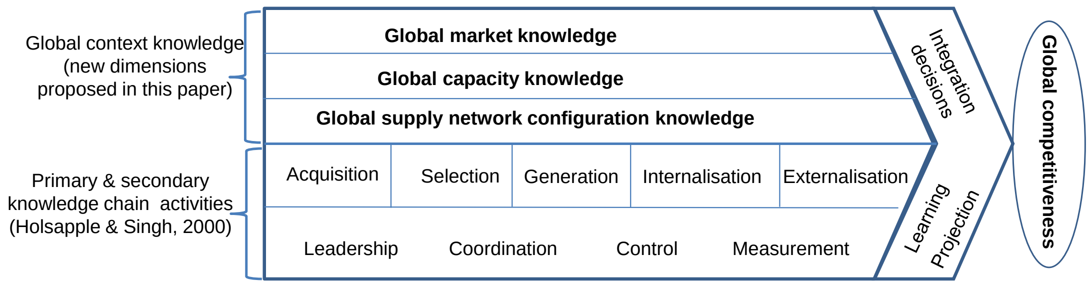

Figure 1: Global knowledge chain management framework

Global market knowledge model

The 21st century marketing has moved away from traditional mass-marketing and broad market segmentation to a more customer-centred approach. It is thus important for global businesses to build up an extensive market knowledge base. Business decision makers can then use the global market knowledge model to better understand the changes in markets as a source of opportunity, to forecast market demand and determine which markets to enter, to identify potential customers and their preferences in relation to products and prices, to invent new distribution channels, and to develop an effective overall competitive positioning [7]. The global market knowledge model includes knowledge for, from and about markets, customers and competitors.

Global capacity knowledge model

The global capacity knowledge model contains knowledge about how to manage global demand (aggregated demand from different markets), especially under uncertainty (i.e. with demand fluctuations). Three capacity strategies to cope with the demand fluctuation have been explored: level capacity, chase demand, and manage demand. In the context of global supply chains, demand fluctuation is much more significant than that of a company with access to local resources and local markets only. Global capacity strategies also closely depend on manufacturing strategies that supply chain participants have adopted, for example, make-to-stock, assemble-to-order, make-to-order, or engineer-to-order [8]. Therefore, the global capacity knowledge model will provide the knowledge about supply chain participants' manufacturing strategies in order to support the global capacity decisions.

Global supply network configuration knowledge model

This model captures the knowledge about the shape of the global supply network, roles of each participant (dominant or weak partners), responsibilities of participants (source, make, deliver, use or return according to the SCOR model defined by the Supply Chain Council [8]), joining or leaving the supply network (procedure and consequences), network re-configuration (to cope with the dynamics of other participants joining and leaving). Typical modes for participants to enter a global supply network include exporting, licensing, franchising, off-shore outsourcing, joint venture and wholly-owned subsidiaries.

Inter-relationships between the three knowledge models

Literature has extensively discussed supply chain integration through the study of material, information, funds and human capital flows [9]. This paper however is focused on knowledge flow through global supply chains by exploring the inter-relationships between the three global context knowledge models. Figure 2 illustrates the key inter-relationships between the knowledge models, which enable the smooth flow of knowledge to support global supply chain integration decisions.

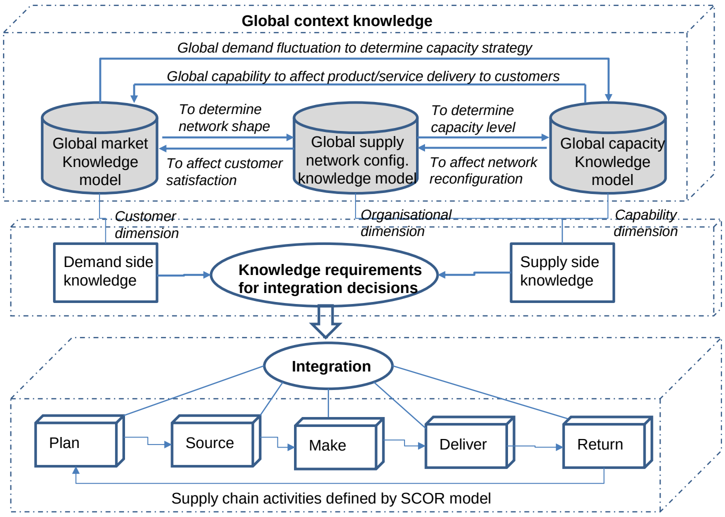

Figure 2: Inter-relationships between the three knowledge models

APPLICATION OF THE KCM FRAMEWORK AND CASE STUDIES

An empirical investigation was undertaken with global supply chain and operations managers, as decision makers from the automotive manufacturing sector. In total over forty supply chain and operations managers participated through multiple case studies. Based on the data collected using interviews with supply chain and operations experts, knowledge constructs that are crucial for global supply chain integration decisions have been identified using the analytic network process [6]. Pairwise comparison and calculation of overall priorities have been conducted with facilitation from the dedicated software Super Decisions©.

Main findings from the empirical data analysis include that:

- All participants reported that they integrated global market knowledge into their global supply chain management decisions for planning, sourcing, making, delivering and returning activities. Knowledge about customer needs and preferences has the highest calculated global priorities among all market knowledge elements.
- Over three quarters of the participants (78%) actually use the global capacity knowledge when making global supply chain management decisions (either they are aware of or understand the capacity knowledge beyond their immediate upstream and downstream partners);
- Less than half (44%) of the participants use the global network configuration knowledge when they make supply chain decisions, such as changing or bypassing some suppliers (either because they are not aware of the global network shape or do not want to use it to constrain their decisions);
- There has been consensus that integrating the global context knowledge can significantly improve their decision performance.

DISCUSSION AND CONCLUSIONS

This paper discussed a KCM framework focusing on context knowledge that is crucial for global supply chain integration decisions. Three knowledge models have been defined to capture and represent the context knowledge about global market – demand side, customer's dimension; global capacity – supply side, capability dimension; and global network configuration – supply side, organisational dimension. Inter-relationships between the three knowledge models have been explored. A key contribution of the work is the empirical demonstration that it advances the knowledge chain model theorised in the literature stressing the knowledge management issue within one organisation [5], to include the context knowledge applicable to global manufacturing, and therefore that the extended KCM framework supports global supply chain integration decisions.

Managerial implications include that context knowledge from both demand and supply side is important for global supply chain management, especially in the integration of planning, sourcing, making, delivering and returning decisions. It suggests that companies involved in global manufacturing should invest in obtaining global market, capacity and network configuration knowledge, capturing the knowledge in appropriate forms, so that their supply chain and operations managers can use the knowledge to improve their judgement and reach integrated decisions for the global supply chains.

The limitations of the work are that: (1) The empirical study undertaken was restricted to companies in the automotive manufacturing sector, which have developed mature supply chains which makes it difficult to generalise the findings into other organisational settings. (2) The main instrument used for empirical data collection was in-depth interviews. Future research will extend the work to include companies in wider manufacturing sectors, especially those belonging to more nascent, dynamic global supply chains. Exploratory research through observation of supply chain and operations managers will also help to triangulate the empirical data for more precise and detailed knowledge about how the decision makers integrate the global market, capacity and network configuration knowledge into their everyday work decision making process.

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Swarm Intelligence (SI) for Decision Support in Operations Management – Methods and Applications

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ABSTRACT

With many successful applications in a variety of complex problems, nature-inspired Swarm Intelligence (SI) has been proved to be very flexible, robust, self-organized and simple to implement. Operations management (OM) is an important process for the competitiveness and profitability of enterprises. OM systems contain a large and complex network of components such as suppliers, warehouses, production, retails and customers, which are connected in different ways. The goal for the enterprise is to find decision support systems for optimizing the components of the complex networks to get maximum profits. This paper summarizes the current state of the art of the SI solution applied in OM. Several successful techniques of SI are also discussed in this paper, such as Particle Swarm Optimizations (PSO), Ant Colony Optimization (ACO), Bee Colony Algorithms (BCA) and Behaviour Swarm Intelligence (BSI). The impact of this implementation will be a significant improvement in operations, service, production, forecasting and marketing in OM systems. The ultimate goal is to develop a self-organizing manufacturing enterprise that could adapt quickly to a fast-changing environment.

Keywords: Operations Management (OM), Optimization, Swarm Intelligence, Decision support system

INTRODUCTION

An individual ant has low level of intelligence, but as a team, they demonstrate remarkable intelligent abilities such as the effectiveness of finding and sorting of food, or the cemetery formation without any kind of supervisor or controller. Other biological species, such as bees, wasps, termites, birds and fishes, can present similar intelligent collective behaviour. The increased intelligence is based on the shared information discovered individually, which are communicated to the other members of the colony by different mechanisms of social interaction. In this way, intelligent solutions to problems emerge from this self-organizational communication between individuals.

Operation management (OM) is an important process for the competitiveness and profitability of enterprises. OM systems contain a large and complex network of components such as suppliers, manufacturer/producers, warehouses, wholesalers, retailers and customers, which are connected in different ways. The goal for the enterprise is to optimize the components of the complex networks to get maximum profits. OM systems, such as scheduling, routing and decision-making problems, are also complex interacting sub-systems organized to reach a common set of goals. For example, a supply chain system in a manufacturing plant could be viewed as an ant colony, with many single and non-intelligent components, that are properly connected into the supply chain system and can, as a whole, yield smart results (to get maximum profits, find a shortest routing, etc.).

Modelling, analysing and optimising these complex interacting sub-systems using traditional analytical and mathematical approaches has proved to fail to overcome complexity and uncertainty. [1]. Agent-based approaches are more suitable for modelling such systems. Swarm Intelligence (SI) is a typical agent-based intelligent paradigm, in which a system is composed of decentralized individual “agents” and each agent interacts with other agents according to localized knowledge or some simple rules. Special kinds of artificial agents are the agents created by simulating social insects. Their behaviour is primarily characterized by self-organized, distributed, flexible and robust features. We can learn from social insect colonies that these very simple individuals can form a system that is able to perform complex tasks by interacting with each other. [2]

SWARM INTELLIGENCE (SI)

Swarm Intelligence (SI) [3] is a sub-branch of Computational Intelligence (CI), see Figure. 1. SI describes the collective behaviour of decentralized, self-organized systems, natural or artificial. The concept of SI is employed in work on Artificial Intelligence. The expression was introduced by Beni and Wang [4], in the context of cellular robotic systems.

SI systems consist of a group of simple interactive agents. The agents follow very simple rules, and although with no centralized control structure, Interactions between these agents lead to the emergence of perfect global behaviour unknown to the individual agents. Examples of SI include ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling. Social insects have evolved so successfully due to the following characteristics [5]:

- ***Flexibility***: The swarm can quickly respond to internal perturbations and external challenges.
- ***Adaptability:*** The swarm can adapt to a changing environment.
- ***Robustness***: The swarm can still complete its tasks even with one or more individual fail.

- ***Self-organization***: The paths to solutions are emergent rather than predefined.
- ***Decentralization:*** The swarm requires little supervision or top-down control. In other words, there is no central control in the swarm.
- ***Scalability:*** The control mechanisms used are independent on the number of agents in the swarm.

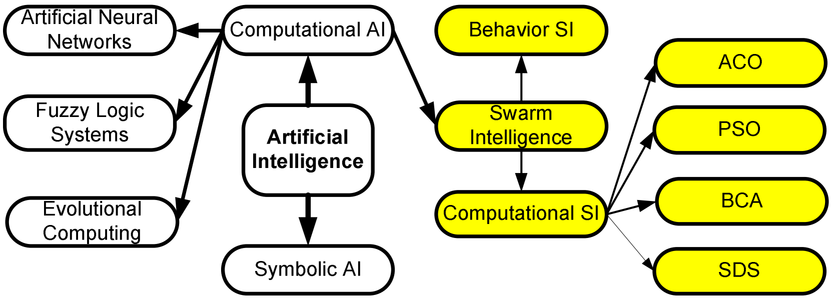

Figure 1: The Category of Swarm Intelligence (SI)

Most enterprise executives have included the first three characteristics in their management, but they often ignore the last three, which are perhaps of the most importance. Through self-organization, decentralization and scalability, the behaviour of the swarm emerges from the collective interactions of all the individuals. One of the currently observed tendencies in operation management systems is that swarm behaviour is one of the most promised solutions among a variety of modelling solutions.

Fig. 1 shows the classifications of Swarm Intelligence. Based on the function of SI, Wang [6] has classified SI into two groups:

1. ***Behaviour SI*,** where the individuals follow simple rules and the resulting swarm behaviour can be surprisingly complex and remarkably effective;
2. ***Computational SI*, which is a computational algorithm to solve complex optimization problems. It consists of several algorithms, such as Ant Colony Optimization (ACO) [7], Particle Swarm Optimization (PSO) [8], Bees Colony Algorithms (BCO) [9] and Stochastic Diffusion Search (SDS).**

OPERATIONS MANAGEMENT (OM)

Operations Management is an area of management concerned with overseeing, designing, and redesigning business operations in the production of goods and services. It involves the responsibility of ensuring that business operations are efficient in terms of using as little resources as needed, and effective in terms of meeting customer requirements. It is concerned with managing the process that converts inputs (in the forms of materials, labour, and energy) into outputs (in the form of goods and services). Generally, operations management aims to increase the content of value-added activities in any given process. Fundamentally, these value-adding creative activities should be aligned with market opportunity (through marketing) for optimal enterprise performance.

A wide range of approaches has been applied to solve optimization problems in OM. However, traditional mathematical methods have proven insufficient in tackling the requirement rising from the development of marketing competition [10]. Computational Intelligence (CI) and Swarm Intelligence (SI) offer effective techniques for modelling, analysing and optimizing operations in the uncertain and complex environment of OM, especially since these techniques are capable of handling complex interdependencies. The main characteristics of these methods is the imitation of the way natural system function and evolve in order to deal with real-world situations. In the following section, we will describe how to solve OM optimization problems using different SI techniques.

APPLICATIONS OF SI TO OM

Kordon [11] gave an introduction about how to apply SI to solve the problems in OM. The main fields which SI are applied for OM are:

- Scheduling
- Routing
- Optimization (Decision Making)
- Clustering

CASE STUDY

Manufacturing Grid (MG) is an integrated system not only with the purpose to share and integrate resources in factories but also provide support for collaborative operation and management on Business groups. In MG system, various manufacturing resources, including design, simulation, information, machine equipment, intelligence and software resources, distributed in multiple sites can offer numerous services to users in a transparent way. And at the same time, there are many tasks submitted by customers, which can be divided into multiple sub-tasks and should be accomplished by many resources. MG should search, select and assign resources with low-cost, short-time, high-quality and good-service to these sub-tasks. The process of resource searching, selection and assigning for specified tasks and sub-tasks is called resource allocation.

The case study shows how to use PSO to solve a multi-objective resource allocation and network evolution problems considering economics and robustness in Manufacturing Grid.

With the tools of JAVA and MATLAB 7.0, MG evolution model is set up and the evolving process is simulated in case of the number of tasks evolving from 0 to 5000.

The results of objectives and parameters are given in Table 1, under the circumstance that the task number is $500, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000$ respectively.

FUTURE TRENDS OF SI IN OM

SI captures the emerging wisdom from the social interactions of biological species and translates it into powerful tools and algorithms. SI is especially effective, flexible and robust when operating in a dynamic and changing environment. The total cost-of-ownership of SI tools and algorithms is relatively low due to their simplicity. SI opens a new way of thinking and new solutions to problems in manufacturing systems scheduling, telecommunication and data network routing, optimization, like American Air Liquid saving more than $6 million dollars per year for one of their 40 plants, Dow Chemical using PSO for optimal colour matching, foam acoustic optimal parameter estimation, crystallization kinetics optimal parameter estimation, and optimal neural network structure selection for day-ahead forecasting of electricity prices, Southwest Airlines estimating that annual gain is more than $10 million, France Telecom and British Telecom proving SI to be very robust and in most cases better than the competitive solutions, and General Motors saving at least $3 million per annum.

Probably the most relevant aspect of further research is the mathematical justification of SI-based technology. The other interesting aspect of the future research could be agents' homogeneity, information sharing mechanisms and collaboration mechanisms.

The possible applications of SI are unlimited. An interesting field related to manufacturing systems is Swarm Robots (SR), which can assemble themselves into vacuum cleaners and other home appliances. Another potential application of SI could be cluster data mining methods, which originate from the way ants group their colony's dead and sort their larvae. Future studies of SI will likely yield additional provocative insights.

Table 1: Results of Objectives and Parameters in different task number

Tasks / Parameters	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
Tasks running	499	996	1491	1984	2454	2924	3379	3814	4243	4613
Number of resource types	294	596	926	1236	1545	1834	2134	2436	2725	3009
Number of resources	1204	2290	3391	4381	5269	6059	6769	7428	7999	8549
Number of factories	243	460	684	910	1091	1264	1396	1525	1636	1720
Minimizing average processing cost P_r	184.70	180.74	177.45	175.66	175.07	174.49	173.47	172.94	171.19	169.78
Minimizing average logistics cost P_t	83.90	87.85	89.47	91.42	96.25	98.02	100.11	103.34	104.88	107.03
Average Output value P_s	762.00	444.01	441.87	441.38	437.77	443.45	443.50	443.72	444.41	443.18
Average shortest distance L	2.56	2.67	2.66	2.67	2.72	2.67	2.66	2.64	2.62	2.60
Clustering coefficient C	0.77	0.70	0.68	0.67	0.66	0.66	0.64	0.63	0.63	0.62
Task economics objective F_1	2.84	1.65	1.66	1.65	1.61	1.63	1.62	1.61	1.61	1.60
System robustness objective F_2	0.23	0.26	0.25	0.25	0.24	0.25	0.24	0.24	0.24	0.24
Evaluation function F	0.85	0.44	0.42	0.42	0.39	0.40	0.39	0.39	0.39	0.38

CONCLUSIONS

Swarms, such as ants and other insects have the ability to collectively solve very complex problems in the nature. The insects must quickly respond and adapt to changes in the environment in order to survive. Similarly, the future operation management systems must be able to quickly adapt to new conditions to have competitive advantage in the global economy. The main motivation for using SI in SCM is their flexibility, robustness, self-organization and success for a variety of hard optimization problems.

This paper provides a view of SI applications in OM with a specific focus on optimization problems for better decision support. A case study is used to show how we can improve the decision making for resource allocation using Particle Swarm Optimization (PSO).

The future research should focus of the development of perception-based modelling, integrated systems, and universal role of intelligent agents, models/rules with evolved structure and self-organized production, schedule and control. Since single SI technique has limited ability to handling complex problems, hybrid intelligent approaches should be considered in order to effectively integrate advantages of different methods in complex and uncertain OM problems.

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A case study of AHP based model for green product design selection

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ABSTRACT

Designing environmentally friendly products has become a tighter requirement in the marketplace because of both the increasing trend in awareness of consumers and the obligations from legislation requirements. Unfortunately, this is not a straight forward decision for designers to evaluate whether their design options are satisfactory or not. This is partly attributed to the fact that there is no universally accepted approach for conducting such analysis. In this connection, this research makes reference to a European Union (EU) directive as a reference model and makes use of Analytic Hierarchical Process (AHP), which is a useful tool to help designers to make decision, for evaluating eco-design options. The AHP model is developed based on two case studies on consumer electronic products. Pairwise comparisons, one of the key steps in AHP, are conducted with the expertise gained from the case studies and the help from the software package Expert Choice. The paper also reveals how design options can be evaluated, or be screened out. The proposed method does not require the designers to conduct detailed analysis (life-cycle assessment for example) for every new product options and hence can save their time. This is particularly important when they are facing shorter and shorter product life cycle nowadays.

Keywords: Eco-design, AHP, Electronic products, Case.

INTRODUCTION

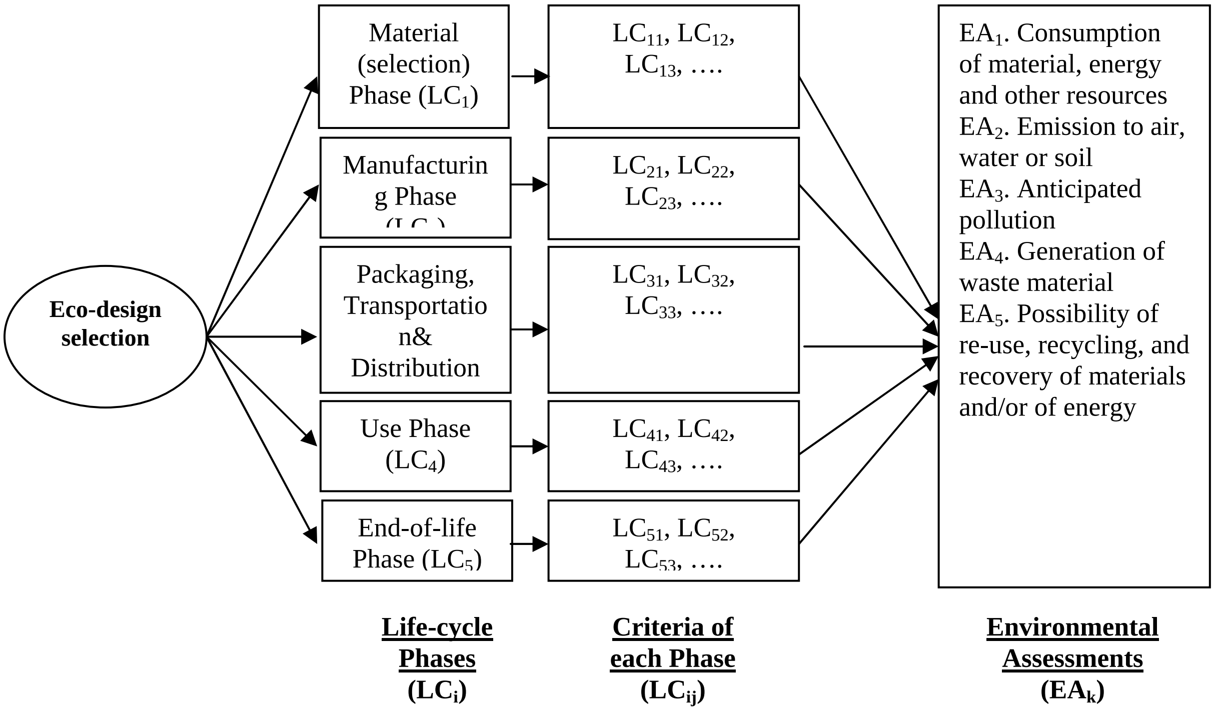
Design and manufacturing of environmental conscious products are of vital importance to the society as they affect the depletion of virgin materials, and consumption of natural resources [1]. There is also an increasing scientific awareness of the cumulative and synergistic effects of some of the environmental impacts over space and time. For instance, some activities at the manufacturing stage may not have an immediate effect to the environment but may have a negative effect on environment during its usage or disposal when it reaches its end of life. In this connection, any decisions made at the design stage could have a profound environmental impact throughout its entire product life cycle. This is reflected in the recently adopted directive by the European Council on energy using products (EuPs) [2]. This Directive provides for the setting of requirements which the EuPs covered by implementing measures must fulfill in order for them to be placed on the market and/or put into service in European Union. According to the EuP directive, preventive actions should be taken as early as possible during the design phase of EuPs, since it appears that the pollution caused during a product's life cycle is determined at this stage, and most of the costs involved are committed then. However, before any improvement or preventive actions are taken, environmental issues must be assessed in a holistic way, alongside technical, financial, and other criteria. Among the environmental management tools that enable to quantify the environmental burdens and assess their potential impacts, Life Cycle Assessment (LCA) is the one gaining wider acceptance in many sectors.

LCA is a comprehensive technique that can be used to analyse the environmental impact of a product design. This can be reflected by numerous studies in this area [3-4. Facing shorter product life cycle [5], firms, however, do not normally have the leisure time to conduct LCA for each new product alternatives. Despite this restriction, developing a green design should take the whole life cycle of the product into consideration [6]. Therefore, a simplified, easy to use approach is desired for quick assessment and initial screening of new product development from environmental conscious perspective, particularly from the EuP directive point of view. This paper addresses these issues by proposing an AHP enabled novel approach to perform structured analysis of LCA. It provides a practical solution without going through the tedious process required for conventional LCA, which can be easily adopted by businesses. The analysis results could be used to support the decision making process when designers or engineers consider improving the design or screening out design options in order to reduce the negative environmental impact while maintaining operational and economic efficiency. Details will be discussed in this paper.

2. The Hierarchical Model

As discussed earlier in this paper, the EuP directive is employed as this is the main source of reference model in the field. A generic illustration is depicted in Fig. 1. According to the EuP directive, a product life cycle is divided into 6 main phases, namely material (selection) phase, manufacturing phase, packaging, transportation and distribution phase, installation and maintenance phase, use phase, and end-of-life phase [2]. Since the focus of this study is on consumer electronic products, and thus the installation and maintenance phase is omitted in Fig. 1. However, the same philosophy can be applied equally well to other products including this phase. The model is then divided into sub-criteria under each phase (i.e. the main criteria of the AHP model), and then each criterion and sub-criterion will affect the environmental assessments attributes that are monitored.

Development of the AHP model (the criteria and sub-criteria) of the case is based on the case study of two electronic products described in Yung et al. [3-4]. Although the above two papers discuss two different types of product, they share a similarity: they are both consumer electronic products. In fact, the LCA results also reveal this feature. This is not the intention of this paper to discuss the LCA results again and hence readers are referred to the above papers for detailed discussions in that regard. On the other hand, based on the experience of conducting the LCA by one of the authors of this paper, a generic AHP model is thus developed based on the LCA results for this type of product. This is illustrated in Fig. 2.



where:
i is the index of life-cycle phase (i = 1 to 5 in this case)
j is the index of the criteria of each phase
k is the index of the five environmental assessment attributes

Figure 1: Hierarchical structure for eco-design selection

After constructing Fig. 2, the next procedure is to determine the relative importance of the criteria based on a *posteriori* assessment (like the LCA experience in the case studies). Weightings for individual criterion and environmental assessment attributes are calculated based on the case information. Fig. 3 summarises the overall weightings of different life-cycle phases. These figures not only serve to exemplify the results but act as a validation method to verify that the output of the proposed model is in line with the results from the LCA results obtained by Yung et al. [3-4] in a broader sense. Refer to Fig. 3, it can be concluded that LC_1 (the material selection phase) contributes most to the environmental assessments followed by LC_2 (the manufacturing phase). To probe further (details of the analysis on the breakdown is omitted in this paper due to the limitation of page length.), LC_{15}

(PCB) and LC_{12} (special types of plastic) are the two most important criteria under LC_1. The former contributes more than 50% of that phase (LC_1), whereas the second one contributes almost 30% to that phase. Another important life-cycle phase is LC_2 (the manufacturing phase). Among the criteria under this phase, LC_{25} (plastic processing) and LC_{24} (metal processing) ranked at the top which contributes over 50% and 20% of the environmental assessments respectively. Nevertheless, other phases should not be overlooked, of course. It is very obvious that LC_{33} (manual), LC_{41} (operating), and LC_{52} (extend of reuse) are the core factors of their respective life cycle phase (all over 50% with respect to their life-cycle phase). These results are in fact all in line with the studies of Yung et al. [3-4].

Life Cycle Phases	Criteria	Environmental Assessment Attributes
LC_1. Material (selection)	LC_{11}. Plastic: general (ABS, PE, etc.) LC_{12}. Plastic: special (rubber, high impact, etc) LC_{13}. Metal LC_{14}. Electronic component (resistors, capacitors, LCD, etc) LC_{15}. Printed Circuit Board (PCB)	EA_1. Consumption of material, energy and other resources
LC_2. Manufacturing	LC_{21}. Surface mount LC_{22}. Die bonding LC_{23}. General assembly LC_{24}. Metal processing (stamping, etc) LC_{25}. Plastic processing (injection, etc)	EA_2. Emission to air, water or soil EA_3. Anticipated pollution
LC_3. Packaging, Transportation & Distribution	LC_{31} Packaging: product level LC_{32}. Packaging: carton level LC_{33}. Manual	EA_4. Generation of waste material
LC_4. Usage	LC_{41}. Operating LC_{42}. Standby	EA_5. Possibility of re-use, recycling, and recovery of materials and/or of energy
LC_5. End-of-life	LC_{51}. Extend of recyclability LC_{52}. Extend of reuse LC_{53}. Extend of recovery	

Figure 2: The hierarchical structure for LCA-based green design selection in the case study

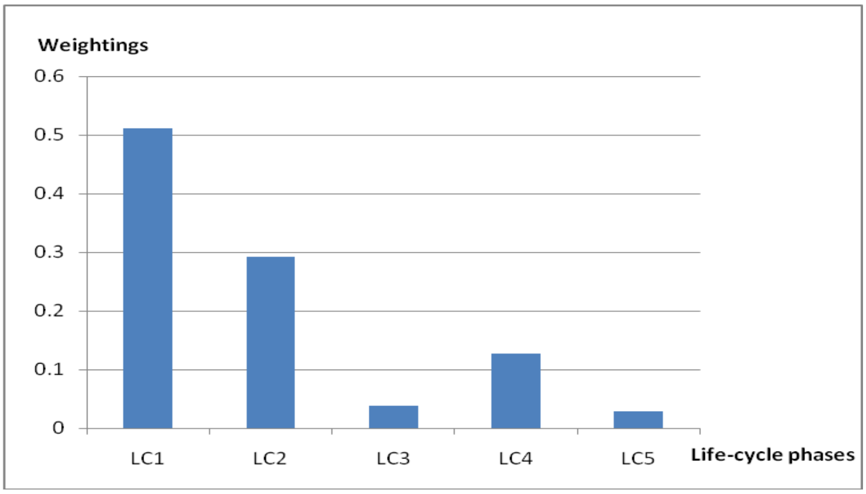


Figure 3: Overall weightings of different life-cycle phases

3. Screening New Operations: Scenarios Analysis and Managerial Implications

The next question, however, is that, how to evaluate a new design (with different options on different criteria) without going through the LCA. This is also the rationale of conducting this research; otherwise, there is no need to construct the AHP and to determine the above weightings. This section will demonstrate that how designers can evaluate design options based on the AHP model and the associated weightings (obtained from a LCA of a similar product type).

Since the outputs of the LCA (or environmental assessments to be precise) are dependent on all the criteria, which means each individual criterion contributes to each environmental assessment differently as illustrated in the complexity of the AHP model. In other words, if one changes the design from environmental point of view, it is not easy to access the effects of the combination of different possible options. Conducing LCA for each individual combination is fine but time required is unaffordable (like Yung et al. [3-4]). This is also the reason why we propose to construct an AHP based on one LCA and then design options can be screened out quickly. This is possible based on the fact that the overall EA_k values (k = 1 to 5) in the AHP model is in fact a sum of all $EA_k(LC_{ij})$, which is the EA_k value of each criterion LC_{ij}. Mathematically

$$\mathrm{EA_k} = \sum_{\mathrm{i}} \sum_{\mathrm{j}} \mathrm{EA_k}\left(\mathrm{LC_{ij}}\right)$$

In this connection, a small disturbance ΔLC_{ij} (i.e. design change) on LC_{ij} will introduce deviation of the corresponding EA values. Basic calculus allows us to find an approximate of the new EA $'_k$ values that can be estimated as:

$$\mathrm{EA'_k} = \sum_{\mathrm{i}} \sum_{\mathrm{j}} \left(\mathrm{EA_k}\left(\mathrm{LC_{ij}}\right) + \Delta \mathrm{LC_{ij}} \frac{\partial \mathrm{EA_k}(\mathrm{LC_{ij}})}{\partial \mathrm{LC_{ij}}} \right)$$

Since Each EA value has a linear relationship to each LCij in this case (which is either dependent on the weight or volume of the input parameter), new EA'_k values can thus be estimated very easily. Employing the case discussed in Section 2 as an example, LC_{12} and LC_{15} have been identified as improvement options because of their high contribution to the EA values. Assume that we can radically change the PCB size by a reduction of 20% (New Design 1), or reduction in the usage of special plastic by 20% (New Design 2), but not both due to technical limitation. However, the designer can accept a compromise that both changes are limited to 10% (New Design 3). This is further demonstrated in the radar diagram as shown in Fig. 4. It can easily be seen that if we compare New Design 1 and New Design 2, the former can further reduce (i.e. optimise) the EA4 value but the latter performs better in EA_5 relatively. Unfortunately, they cannot be taken on board at the same time. The compromise, New Design 3 can achieve a relatively good result on various EA values. Of course, each of which is not the best compared to New Design 1 and New Design 2.

4. CONCLUSIONS

Eco-design is increasingly important for designers to consider during new product development. Prioritizing design alternatives becomes more applicable in the case that a comprehensive environmental impact assessment may not be easy to conduct while the product development is often tight. This research proposes an effective and systematic decision support approach to help designers to evaluate and select new design options. It highlights key critical factors that contribute to the environmental performance throughout the product life cycle and help the designers to analyse design options in order to lessen negative environmental impact while maintaining operational and economic efficiency. Compared to conventional LCA, the AHP approach proposed in this paper provide a practical LCA solution, which is simple, being less demanding with respect to the computational power and time needed to make a decision.

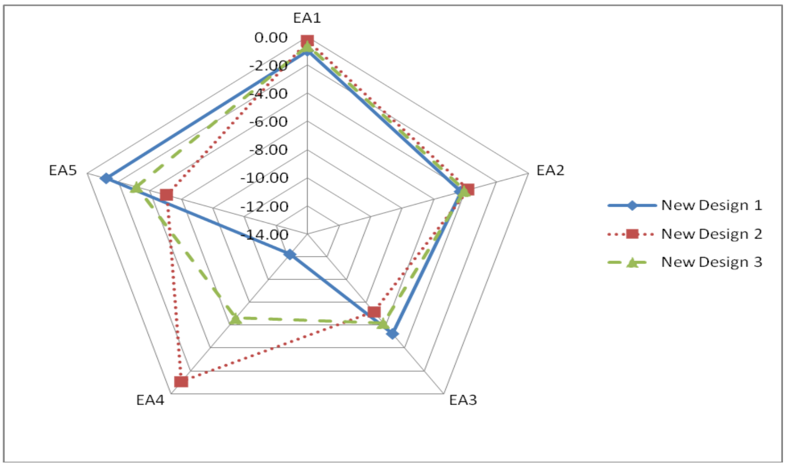


Figure 4: Comparison of different designs (in terms of percentage improvement)

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Decision Making in Credit Granting Process

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ABSTRACT

Many countries have experienced stagnation over the recent years. Some countries have even declined in the granted amount of mortgage credits to households. The credit-granting process itself has become significantly complicated, less transparent and excessively time consuming in this period. This particular study seeks to define the opportunities to sophisticate credit granting process through creation of a simple, transparent and accountable framework of decision-making process of credit granting. To achieve this purpose the authors used a qualitative method – a structured interview – and a graphical tool – a decision tree. The developed framework is a flexible and transparent model of the decision making process of credit granting, which provides the possibility to identify areas of the credit granting process that might be considerably improved. The reflection of decision-making process of credit granting using a decision tree creates an opportunity for the authors to identify inadequately and unreasonably long-duration of alternative solutions of decision-making and suggests the optimal time that each branch of alternative solutions should take. The empirical results of the study indicate that implementation of the developed model in commercial banks is an opportunity to improve customer satisfaction as well as gain better control over expenses via cutting the time managers spend on decision making in branches of credit granting decision tree that results in negative response. This research elaborates on the first empirical study in the field of decision-making in the credit granting process and introduces a valuable framework of a transparent and accountable model of the decision-making process of credit granting. The authors anticipate that in addition to commercial banks the elaborated framework should be beneficial for wide range of organizations that have complicated and multi-stage decision making processes.

Keywords: lending, credit granting, process analysis, decision making

INTRODUCTION

In recent years many countries, including USA [1], United Kingdom [2], Germany [3] as well as Latvia [4], experienced stagnation or the granted amount of mortgage credits to households has even declined. Households similarly to bank officials admit that the credit-granting process has become more complicated, excessively time-consuming, and non-transparent compared to previous years. This paper seeks to define opportunities to sophisticate credit granting process in commercial banks through creation of a simple, transparent and accountable framework of the decision-making process. The developed framework is meant to help commercial banks to improve quality and efficiency and reduce the cost of their decision-making processes in credit granting.

The authors define the following objectives to reach the purpose of the study: to transform complicated household mortgage credit granting process into a simple, transparent and accountable framework by using a graphical tool – a decision tree; to identify problem areas of decision-making process in credit granting; to develop practical recommendations for commercial banks on how to improve the decision-making process in credit granting; to assess the potential of the developed framework.

In the framework of this research the authors have elaborated on a decision-making tree that provided an opportunity to analyse and evaluate the whole credit granting process. The carried out experiment demonstrated that the provided methodology of transformation of the complicated credit granting process into a decision tree is appropriate and relevant. The conducted verification of the developed decision-making tree proved that this way of reflection of the credit granting process was credible and valuable for practical implementation in commercial banks.

BACKGROUND OF THE RESEARCH

The authors' intention is to research decision-making issues of the credit granting process because this component is often neglected by commercial banks. Reverting to the decision-making process of credit granting the authors observed lack of proper analysis and documentation of it in the procedures of commercial banks. Lack of proper reflection and documentation of decision-making process in credit granting implies that commercial banks have not paid detailed attention to that and might, therefore, have little control over the process. Efficiency of the credit granting process could be measured by the time and labour cost spent on processing of a credit application. Knowledge and clear understanding of the decision-making process in credit granting could enlarge the range of tools used by commercial banks to increase customer satisfaction by achieving better efficiency and quality of the credit granting process.

The empirical study of this paper is limited to the development of the framework of credit granting process that relates only to granting mortgage credit to households. The aim of this paper is to examine the decision-making process in the credit granting process as a set of consistent and sequential actions that is carried out to reach decision on approval or denial of granting a credit and state recommendations for its improvement.

THE EXPERIMENT

Techniques used by commercial banks for the reflection of the decision-making process such as flow-charts or the entity-relationship model are useful for training new employees and introducing them to the general perception of the credit granting process. The authors find that graphical tools – decision trees, in particular – are the tools that might be used to overcome the weaknesses of the previously mentioned techniques. The main purpose of creating a tree is that afterwards the decision makers can easily decide how to act in each decision node and follow their decisions throughout the tree.

To achieve the task of the research the authors carried out an experiment. Taking into account that the adopted methodology required qualitative methods – structured interviews with experts – the authors interviewed experts with more than 10 years of experience in the credit granting field [5]. The formulation process was finalized with the development of a decision tree, which brought transparency and accountability into the decision-making process of credit granting. The accomplished experiment adduces clarity and complete understanding of the decision-making process in credit granting. The obtained knowledge allowed the authors to develop a decision-making tree that emphasizes transparency and accountability of the decision-making process of credit granting, as well as defines execution time of each particular outcome.

RESULTS FROM THE CREDIT GRANTING DECISION TREE

The analysis of the developed credit granting decision-making tree was based on the investigation of the alternative solutions of the decision-making process. From the results of the statistical analysis of the developed credit granting decision tree presented in Table 1 the authors found that a positive outcome – a credit is granted – only takes place in 14.60% of cases. A negative outcome – a credit is denied – takes place in the remaining 85.40% of cases.

Table 1: Groups of alternative solutions of the credit granting process

Indicator	Results
Positive decisions (credit is granted)	14.60%
Negative decisions (granting of credit is rejected)	85.40%

Implementation of the developed decision-making tree in the credit granting process would help commercial banks to identify irrational and time-consuming alternative solutions (branches) in the decision making process of credit granting. The results demonstrate that a negative decision of alternative solutions can be reached faster that a positive decision of the alternative solutions. (See Table 2)

Table 2: Decision-making duration of alternative solutions in credit granting

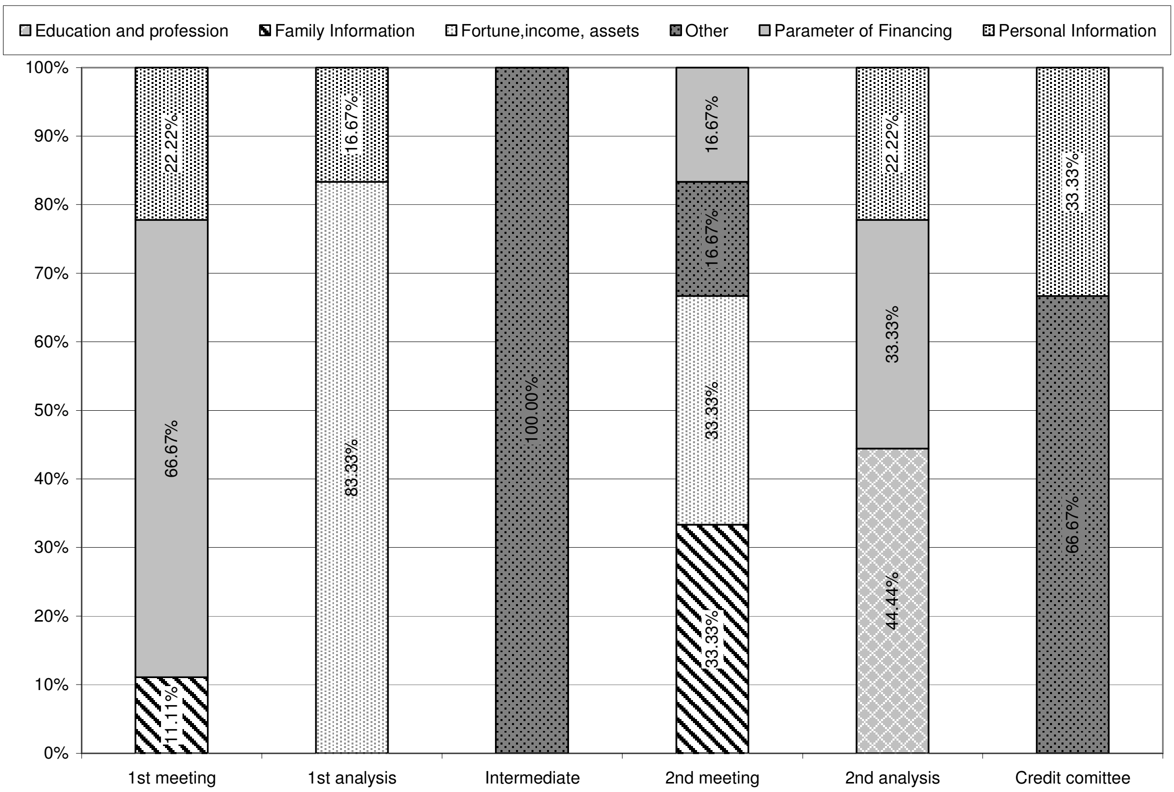
Groups of alternative solutions	Variable	Value	
		minutes	Working days
Overall in the credit granting process	Maximum duration	4064	8.47
	Minimum duration	3	0.01
	Average duration	2512	5.23
Positive decisions	Maximum duration	4064	8.47
	Minimum duration	564	1.18
	Average duration	2412	5.03
	Mathematical expectation	782.07	1.63
	Median	2441	5.09
	Mode	1591	3.31

Groups of alternative solutions	Variable	Value	
Negative decisions	Maximum duration	3764	7.84
	Minimum duration	3	0.01
	Average duration	2130	4.44
	Mathematical expectation	107.28	0.22
	Media	2081	4.33
	Mode	2431	5.07

The main agenda of the suggested analysis is to determine reasons that cause an increase of decision-making duration and to develop recommendations for overcoming those challenges. This should be considered as a reasonable approach because each minute spent to come up with a decision generates expenses and can be defined as a waste of time for both participants of the credit granting process: commercial banks and credit applicants. A negative decision of the alternative solutions does not generate income for commercial banks and does not bring resources to the credit applicants. Therefore, the duration time of alternative solutions with a negative decision should take as short time as possible to ensure efficiency of the credit granting process.

A collateral result of the credit granting process formulation was the ability to find the profile of the whole process in the aspect of field where the interaction between commercial banks and credit applicants is taking place. Based on another recent research of credit granting process [8] authors find the profile of each sequent sub-stage of credit granting process very interesting. (See Figure 1) Results show that the whole process is intermittent that should provide opportunities for process optimization.

Figure 1: Profiles of sub-stages of credit granting process



CONCLUSIONS

The applied approach of reflection of the credit granting process made it possible to express a decision-making duration of each alternative solution in time units. This opportunity ensures accountability of the whole credit granting process and lets one compare and evaluate the decision-making durations of alternative solutions in different profiles. The authors suggest comparing the decision-making duration of alternative solutions to the value of the mathematical expectation. An alternative solution whose cumulative time exceeds the value of the mathematical expectation for the particular group of alternative solutions (positive or negative outcomes) most likely contains opportunities for improvements. Therefore, improvements in the credit granting process can be achieved by finding, scrutinizing, and understanding the cause of the decision-making duration of the particular alternative solution that exceeds the mathematical expectation.

The main benefit of the elaborated framework is the achieved transparency and accountability of the credit granting process and the identified opportunities for improvements. Time component of the credit granting process introduced by the authors is the key indicator in assessment of the cost to commercial banks caused by the process. The cost of the credit granting process can also be expressed in labour cost per hour. Adding the labour cost component to the credit granting decision-making tree makes it possible to calculate and set boundaries for costs that alternative solutions can generate within the credit granting process.

This study presents the first research in the field of decision-making process analysis in credit granting and provides material for further analysis and research. The authors find that the presented framework of the credit granting process is a helpful tool to overcome at least a part of challenges present in the credit granting process.

The authors recommend using the introduced approach not only for the transformation of the credit granting decision-making process in commercial banks, but also in other types of organizations that have multiple stage decision-making processes and interaction of at least two parties, for example, insurance and auditing companies and universities.

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Disentangling Online Social Networking and Decision Support Systems Research Using Social Network Analysis

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ABSTRACT

In order to understand state-of-the-art of online social networking and decision support systems research and their actual interconnection (both technically and socially) we underwent a large study of these research fields, using a thorough analysis of four major bibliographic resources, over a time-span of eight years (from 2003 until 2010).

This paper presents the most relevant concepts of both research fields based on both manual and automatic text extraction procedures. As the interconnections of online social networking and decision support systems concepts were encompassed within a text-based form, we resorted to network text analysis theory as it assumes that language and knowledge can be modeled as networks of words. In addition, knowing that within the context of semantic network analysis, a concept is a single idea represented by one or more words, we used social network analysis tools to process and represent the obtained network of concepts. The relevance of the obtained concepts was determined using the eigenvector centrality measure, as it determines the relative influence of concepts within the network.

The main result of this study was the obtained clustering of research themes that represents the contact points of both fields of research, namely: the technical infrastructure, online communities, network analysis and knowledge management.

Keywords: Decision support systems, online social networking, concept analysis, concept clustering, network analysis.

INTRODUCTION

Most people agree that online social networking is full of potential, with an expectable positive effect in consumer world. However, recent research has revealed that such effect is barely penetrating, or even felt needed, in contexts such as business-to-business [1]. The problem is that the term “Web 2.0” has become such a commonplace that companies are now pasting it on, as a marketing buzzword, with no real understanding of what it really means [2]. Regarding decision support systems (DSS) research field, it also suffers from the previous problem, as many research papers embed Web 2.0 as the mere use of internet-related technologies (HTML, protocols, XML, etc.) with little concern (or none) to online social networking and its possible interconnection with DSS.

In order to understand state-of-the-art DSS literature and its actual interconnection with online social networking (both technical and social related issues and not only the former ones), we underwent a large study of these research fields, using a thorough analysis of four major bibliographic resources: ISI WOK, SCOPUS, SCIRIUS and EBSCO. To the best of our knowledge, no other study of this extent has been performed until now.

This paper presents the most relevant concepts of the analyzed online social networking and decision support systems research literature, based on both manual and automatic text extraction procedures from the above-mentioned bibliographic resources. As the interconnections of online social networking and decision support systems concepts were encompassed within the text, we resorted to network text analysis theory as it assumes that language and knowledge can be modeled as networks of words and relations, encoding links among words to construct a network of linkages, analyzing the existence, frequencies, and covariance of terms or concepts. Baring in mind that, within the context of semantic network analysis, a concept is a single idea represented by one or more words, we used social network analysis tools to process and represent the obtained network of concepts [3].

The relevance of the obtained concepts was determined using the eigenvector centrality measure, as it determines the relative influence of concepts within the network. The underlying reason is that it assigns relative scores to all nodes in the network, based on the concept that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes [4-5]. After ranking the nodes we represented the network of concepts to provide an overall view of the interconnection of concepts within the research of online social networking and DSS. Nevertheless, the main result of this study was the obtained clustering of research themes that represents the contact points of both fields of research.

METHODOLOGY

Time frame

The time-span of published research chosen for this project is 2003–2010. As online social networking research, as a domain, is still relatively young when compared to, the initial year for this study was the one when the first publication explicitly dedicated to online social networking occurred, according to Boyd & Ellison [6], though a significant body of related research has been generated since then.

Articles sample

In order to obtain a broad insight on the subject, we needed to cover several scientific domains. Although the DSS research field has "classic outlets", namely journals and conferences (see, for instance [7]), there are other scientific domains, such as health/medicine, whose common publication outlets differ from the previous ones. Nevertheless, such research is directly related to DSS and internet social networking.

To reduce data-gathering time and workload we decided to use four major bibliographic indexing resources, from the available ones at Beira Interior University. Those were, namely: ISI Web Of Knowledge (Science Citation Index Expanded; Social Sciences Citation Index; Arts & Humanities Citation Index; Conference Proceedings Citation Index – Science and Social Science & Humanities –; Current Chemical Reactions; Index Chemicus); SCOPUS (Life Sciences; Health Sciences); SCIRIUS; and EBSCO (Academic search complete).

These bibliographic sources provided us the necessary grounds for searching information with scientific indexation across distinct scientific domains (as opposed to internet free content, such as commercial sites and blogs, whose validity is, most of the times, author dependent).

Another consideration for choosing such resources was that their search engines allowed multiple Boolean expressions to combine the intended search attributes.

Search attributes

As we knew that using a "([DSS] AND [Web 2.0])" approach would lead us to the many (though mere) technical papers on DSS and internet technology, we decided to opt for a different approach, combining key concepts from both DSS [8] and online social networking [6, 9-10].

DSS concepts:

- Decision support system (Personal Decision Support System/Group Decision Support System): A system developed to support (a) decision task(s);
- Group Support Systems: the use of a combination of communication and DSS technologies to facilitate the effective working of groups tangled with (a) decision task(s);
- Negotiation Support Systems: DSS where the primary focus of the group work is negotiation between opposing parties;
- Intelligent Decision Support Systems: the application of artificial intelligence techniques to decision support;
- Knowledge Management-Based DSS: systems that support decision making by aiding knowledge storage, retrieval, transfer and application by supporting individual and organizational memory and inter-group knowledge access;
- Data Warehousing: systems that provide large-scale data infrastructures for decision support;
- Enterprise Reporting and Analysis Systems: enterprise focused DSS including executive information systems, business intelligence, and more recently, corporate performance management systems. Business intelligence tools access and analyze data warehouse information using predefined reporting software, query tools, and analysis tools.

Online social networking concepts:

- Internet social networking: refers to the phenomenon of social networking on the Internet. As such, the concept subsumes all activities by Internet users with regard to extending or maintaining their social network.
- Social network sites: web-based services that allow individuals to construct a public or semi-public profile within a bounded system, articulate a list of other users with whom they share a connection, and view/traverse their list of connections and those made by others within the system. The nature and nomenclature of these connections may vary from site to site.
- Social software: wikis, micro-blogging and social bookmarking services are types of social software. In an enterprise context, feature-wise, social software is closely related to groupware, though social software originates from the public Internet and is heavily shaped by its users.
- Enterprise 2.0: it describes the adoption of social software in an enterprise context. Much as internet social network denotes the phenomenon and refers to the application of social network software as its main enabling technologies, Enterprise 2.0 refers to the phenomenon of a new participatory corporate culture (with regard to communication and information sharing), which is based on the application of various types of social software technologies. It describes a wider approach that advocates a new organization culture of participation, inclusion, and sharing, rather than simply adopting social software.
- Enterprise social networking: refers to the phenomenon of social networking in an enterprise context, whether using intranet social network or referring to the organizational usage of public social network sites.

Database building

As expected, distinct data sources provided us different output formats for our queries.

Building the dataset

After retrieving each data set from the selected data sources, it was then necessary to create a common database structure to include all the necessary fields to perform a union of the obtained data sets, for common processing. Having performed this step, the resulting database presented almost 1.000 records, which needed additional processing.

Procedure

This process was achieved using SQL (structured query language) procedures and changes to the database structure, in order to perform:

- The removal of duplicates;
- The repairing of fields' data types;
- A re-classification of books into conference books;
- The removal of abstract books:
- The removal of author and subject indexes, references lists and poster sessions;
- The removal of indexed news;
- The removal of web pages;
- The removal of book reviews;
- The removal of product reviews.

After completing these steps, the dataset was reduced to 499 records, which needed manual processing.

Manual processing

The first step was to read all the abstracts in order to eliminate papers that were completely out of the scope of this study. Although our search keywords widely narrowed the search within each data source, their data extractors did not differentiate the body of the papers from their references section. This situation determined that even a research paper without any actual connection to our research subject could be selected (*e.g.*: a paper regarding political influence networks – not online ones –, including any description of social consequences – but not in terms of online social networking – and having a reference source such as the Decision Support Systems journal). After reading all the abstracts, the list of papers was reduced to 326. These ones underwent a thorough reading, in order to assess their contribution to our study. At the end of the process, only 89 papers were selected as an actual interconnection of the decision support systems and online social networking research.

The described process is summarized in Table 1.

Table 1: Research filtering process

Initial	Phase I	Phase II	Final
	Abstract reading	Full paper reading	
499	326	241	89

Network analysis

Though traditionally used to examine social phenomena in such diverse areas as understanding communities, business processes or international organizations [11], researchers in artificial science and data mining have also recognized that an organization can benefit from the interactions within the informal social network [12].

In the recent years a considerable number of social network analysis software has been developed in order to identify, represent, analyze, visualize and simulate nodes (*e.g.*, agents, organizations, or knowledge) and edges (relationships) from various types of input data [13]. In consequence, the main goal of social network analysis is to describe and understand network structures in quantitative terms. When compared to the traditional sociological applications, the key technical challenge for the emerging application areas is the ability to construct social networks through the analysis of large volumes of data. Constructing and analyzing networks from large-scale data has never been the focus of traditional social network analysis (SNA) (where data was primarily acquired through constrained and well defined surveys) [14]. The technical advances (development of algorithms and software technologies) and availability of enhanced tools to perform network analysis has attracted considerable interest from the research community of multiple domains, thus leveraging the full potential of SNA application.

As the basis to ascertain the influence of online social networking on DSS was the above-mentioned bibliographic resources, it implied that the required information was text-based and that the interconnections of online social networking and DSS concepts were encompassed within the text. To extract and analyze such relationships, network text analysis theory stands on the assumption that language and knowledge can be modeled as networks of words and relations, encoding links among words to construct a network of linkages, analyzing the existence, frequencies, and covariance of terms or concepts. Knowing that within the context of semantic network analysis, a concept is a single idea represented by one or more words, concepts are equivalent to nodes in SNA [3]. Consequently, SNA metrics are applicable to our study.

Text processing

As complex socio-technical systems, online social networking and decision support are dynamic systems. Analyzing such complexity require tools that go beyond traditional SNA and link analysis [15], namely through Dynamic Network Analysis (DNA), which combines the methods and techniques of SNA and link analysis with multi-agent simulation techniques. To that purpose we used the Automap CASOS[1] (Computational Analysis of Social and Organizational Systems) toolkit to extract the relationship network among concepts of online social networking and decision support systems. AutoMap is a text mining tool that enables the extraction of network data from text, namely four types of information: content (concepts, frequencies and meta-data such as sentence length); semantic networks (concepts and relationships); meta-networks (ontologically coded concepts and relationships – named entities and links); and sentiment and node attributes (attributes of named entities). Network Text Analysis (NTA) enables parts of speech tagging, machine learning techniques and proximity analysis. It also encodes the links among words in a text and constructs a network of the linked words.

Due to the number of involved papers we pre-processed the involved text files, manually removing the references and acknowledgments sections. We also created a personalized thesaurus from all the abstracts, in order to replace possibly confusing concepts with a more standard form (e.g. web 2.0, became "web_2d0"; decision support systems, became "dss"; business intelligence, became business_intelligence; etc.) to be applied to all papers. The identification of Named-Entities was also performed using the corresponding Automap tool, in order to create a "delete-list" to remove the references to authors. In addition, all numbers were removed from the text, as well as special characters. Pronoun resolution was also performed using Automap.

Network analysis and visualization

To calculate the network metrics, as well as its visualization, we used the open source Gephi 0.8 (beta)[2] software that is easily integrated with Automap and DNA, as the Automap software creates the network representation, namely the concept nodes and edges needed in Gephi. This software has been used in extensive peer-reviewed scientific research (journals, conferences, workshops and thesis), providing a powerful, free-of-charge, intuitive and easy-to-use analysis tool.

RESULTS

The idea of distance between nodes within a network represents how close they are to one another. Where distances are great, it may take a long time for information to diffuse across a population. It may also be that some nodes are quite unaware of and influenced by others [16]. Rather than characterizing the overall structure of the obtained concept network (in terms of density and centrality for instance), we wanted to determine the relative importance of

[1] http://www.casos.cs.cmu.edu/projects/automap/
[2] http://gephi.org/

concepts, in order to assess the actual interconnections of online social networking and DSS research.

Although several centrality measures can be used to identify key members playing important roles in a network (such as degree, betweenness, and closeness, see, for instance, [11] for further details), we chose Eigenvector centrality as the measure to determine the relative influence of concepts within the network. The underlying reason is that it assigns relative scores to all nodes in the network, based on the concept that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes [4-5].

If we rank nodes by Eigenvector centrality, we can determine the key nodes (concepts) in the network. At the top of the list these may be obvious, but we can also determine nodes which have a high eigenvector centrality, even though they are not obviously important.

Concept ranking

After determining the Eigenvector centrality to all obtained nodes, it was obvious that further processing was required, as different nodes, though baring similar concepts, possessed different values that should have been aggregated into a single node (e.g. concepts like information-based, informational, information-related, etc., were aggregated into a single concept named information). To this purpose we had to manually review all the concepts found with the help of the filtering tools in Gephi 0.8 (beta), as well as the automatic procedure for merging the nodes and their connections.

In order to obtain an understandable network representation and due to the large number of involved concepts, we limited (filtered) the concepts to those baring an Eigenvector centrality greater or equal to 0.15 (reminding that the values were encompassed within 0 and 1). As many of the concepts presented near-to-zero values, even if they were aggregated to similar others and at this stage we decided only to merge those concepts whose aggregated values would be greater than 0.01. Figure 1 represents the obtained network of concepts, in which node diameter and letter size represent the relative importance of the concepts.

Table 2: Higher and lower ranked concepts

Higher ranked concepts		**Lower Ranked concepts**	
Concept	**Value**	**Concept**	**Value**
data	1.000	space	0.155
information	0.883	items	0.154
social	0.832	reports	0.153
network	0.798	description	0.152
users	0.764	accuracy	0.152
system	0.758	variables	0.152
group	0.671	sna	0.152
knowledge	0.657	specialization	0.151
representation	0.613	concept	0.151
research	0.559	range	0.151
decision-making	0.536	anonymity	0.150
support	0.525	queries	0.150
organization	0.506	doctors	0.150
community	0.502	web 2.0	0.150
individual	0.499	adaptation	0.150

In *Table 2* we also present the higher and lower ranked concepts. Though we removed speech connectors such as “which” or “such” from the table, we opted to show them in the network representations to preserve existing edges[3].

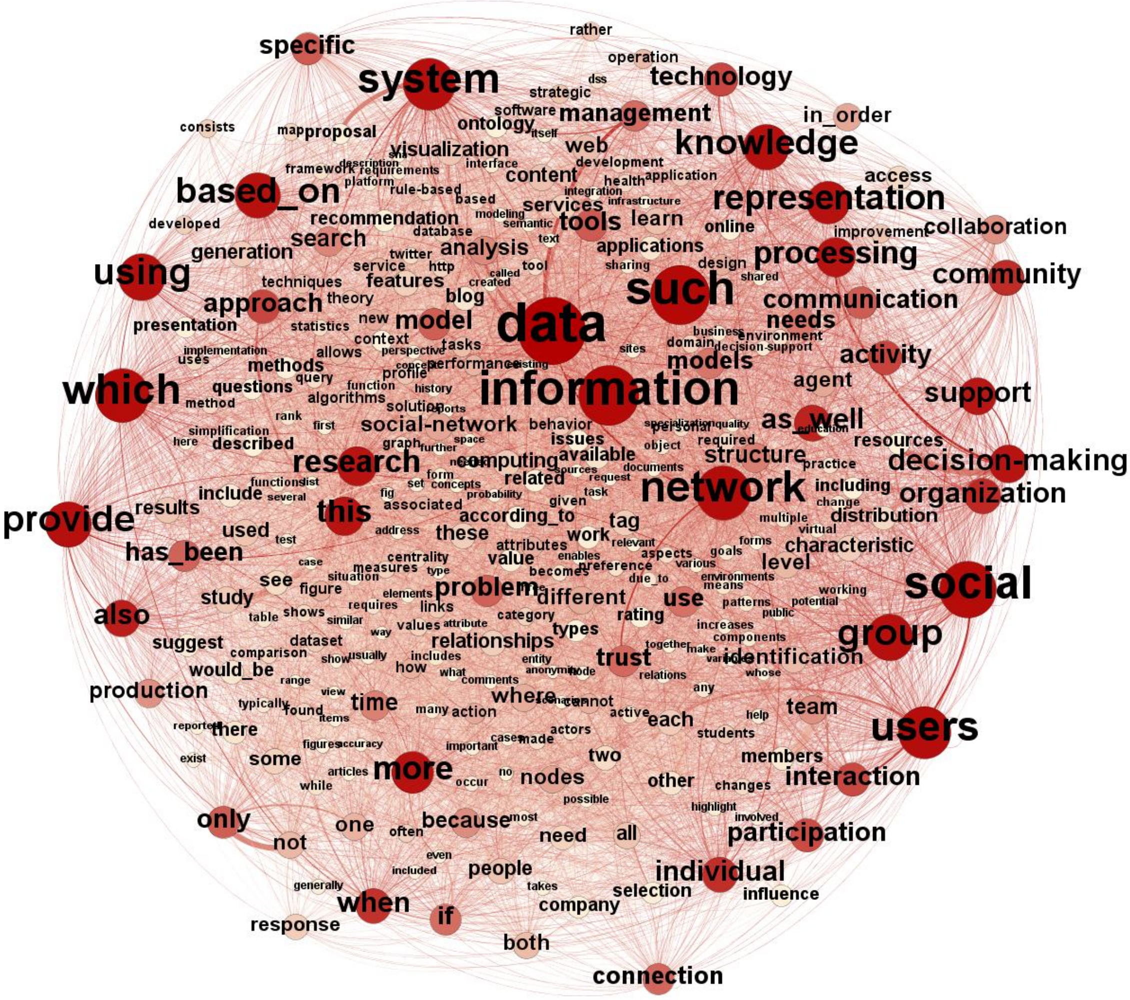

Figure 1: Network of concepts

Concept clustering

In spite of the fact that the concept network presents an interesting overview of the overlapping concepts of online social networking and DSS research, it is quite poor at revealing the thematic interconnection of the research field, which is, after all, the main purpose of this paper. To obviate this problem, we ran a modularity analysis of the concepts, in order to detect and study underlying concept clusters (communities), based on the Louvain method implemented on Gephi 0.8 (beta), which is specially fit for very large networks [17]. The results returned four concept clusters visually represented in Figure 2, in which the division into four axes (clusters) and the order of concepts according to their eigenvector centrality is shown.

[3] The process of eliminating still existing speech connectors and the analysis of its implications for each individual concept Eigenvalue is under current development.

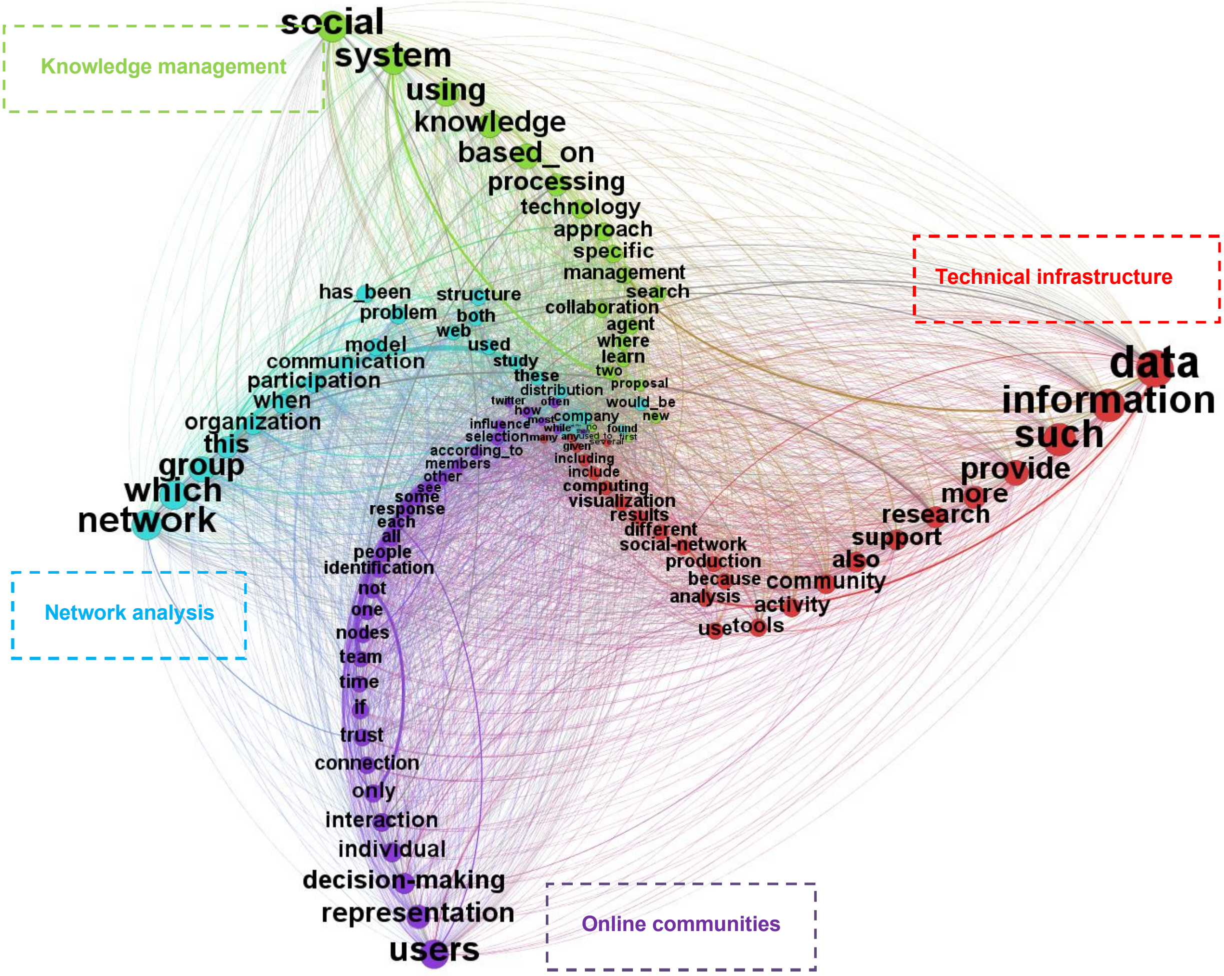

Figure 2: Concept clustering

Technical infrastructure

This cluster represents the concepts which stand for involved technical elements. The technical infrastructure encompasses research that elaborates, develops, proposes and analyzes social networking infrastructures, for distinct underlying purposes (data-gathering purposes, information extraction, taxonomy building, web-computing, consumer support, decision automation, etc.).

Online communities

This cluster focuses on people, users, teams, which points to community interaction. Instead of focusing on the network topology, it provides a focused view on the effects of online social networking among established online communities, baring distinct decision purposes or options (academic, acquaintance, leisure, etc.). In addition, research is directed towards group dynamics (formation, cohesion, behavior, etc.) and its effects (actual or perceived) among specific online communities.

Network analysis

This cluster encompasses a networked analysis of organization, companies and distributed structures. Although directly related to online communities, the main focus of this research lies on the description, community detection, visualization of social networks, to provide interpretation and decision support according to the social network topology, by means of social network analysis measures (centrality, betweenness, closeness, degree, etc.).

Knowledge management

Finally, this cluster represents knowledge management activities, especially around collaboration. The main focus of this theme is to address online social networking (and the so-called "wisdom of the crowds"), using the lens of knowledge management, namely its use (actual and perceived), usefulness and setbacks towards the objectives of knowledge creation, sharing, encoding, retrieval and representation.

CONCLUSIONS AND FUTURE RESEARCH

In this study it was interesting to ratify expected outcomes, namely some of the higher ranked concepts (e.g. data, information, social, network, system, decision-making, for instance). Another expected outcome was the bottom position of the concept "Web 2.0". In spite of the fact that this may seem a wee bit strange or even contradictory, since the so-called Web 2.0 paradigm is inextricably connected to online social networking, we need to remind that we did not search for a direct connection between Web 2.0 and the decision support systems research, but rather a concrete application of these range of technologies (internet social networking, social network sites, social software, enterprise 2.0 and enterprise social networking). This consideration did not, of course, eliminate all the technical concepts around the study scope, but it did considerably reduce the number of mere technical paper with no interest to studying the overlapping points of the research of online social networking and decision support systems.

To our opinion, the main contribution of this paper regards those overlapping points, providing a clear picture that decision support systems research is not only made of quantitative algorithms, but that research and decision support are directed towards social questions, meaning that online social networking enriches and broadens the scope for decision support systems beyond the "classical" purposes of efficient resource allocation, providing research opportunities, in order to aid decision-makers in perceiving the social impacts of implemented (or to be implemented) decisions, as well as the propagation rate of such decisions along an established social network with involved stakeholders (employees, business partners, clients, etc.).

Having determined which are the interconnection themes between online social networking and decision support systems, we intend, in future research, to present whether the developed research has actual implications in improving the tasks that are encompassed by each of the decision process phases (as defined by [18]), namely the identification and listing of all the alternatives (intelligence phase), the determination of all the consequences resulting from each of the listed alternatives (design phase) and the comparison of the accuracy and efficiency of each of these sets of consequences (choice phase).

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