LogDynamics
Research Report

Research Report 2012/13

International Graduate School for Dynamics in Logistics

Volume 3 2013

Universität Bremen*

*EXCELLENT.
An Excellence Initiative Success Story

LogDynamics

Research Report

Content

Dynamics in Logistics

Logistics is one of the major fields of activity and creative power in line with the realization of a sustainable and liveable economy. It is characterized by improvements in efficiencies and on-going innovations for products and processes. Due to worldwide distributed production, ambitious customer behaviours as well as new information and communication technologies the complexity in logistics networks and systems increases more and more. Bearing in mind dynamically changing decision situations in daily life, the governing of this complexity can be seen as one of the biggest techno-economic challenges in the operational and strategic management in and between enterprises and institutions. The Bremen Research Cluster for Dynamics in Logistics (Log*Dynamics*) accepts this challenge. Within an international team of researchers and doctoral students new remarkable solutions and scientific results are elaborated interdisciplinary, both from the point of view of fundamental as well as applied research. The Research Report 2012/2013 provides significant insights into the research topics. It presents examples of the scientific work in the International Graduate School for Dynamics in Logistics (IGS).

Univ.-Prof. Dr. Hans-Dietrich Haasis
Spokesman
International Graduate School
for Dynamics in Logistics

Logistics in Bremen

The federal state of Bremen is the second largest logistics location in Germany. This is due to its advantageous maritime position and good hinterland network. Established logistic-related companies are based in Bremen, like for example aeronautics and space technology, automobile construction, food manufacturers, etc. The importance of the logistics industry for the state of Bremen implies the respective scientific focus.

The University of Bremen meets the demand for logistics research by linking competences of different scientific disciplines within an interdisciplinary high-profile area. The Bremen Research Cluster for Dynamics in Logistics (short: Log*Dynamics*) was founded in 1995 as a cooperating network of research groups originated from four faculties: Physics/Electrical Engineering, Mathematics/Computer Science, Production Engineering and Business Studies/ Economics. Recently the logistics focus has been acknowledged by contributing to the title “University of Excellence” awarded by the German Research Foundation (DFG). Besides the four faculties, further partners within Log*Dynamics* are: BIBA – Bremer Institut für Produktion und Logistik GmbH, ISL – The Institute of Shipping Economics and Logistics (ISL), and the Jacobs University Bremen gGmbH.

The activity fields of Log*Dynamics* range from fundamental and applied research to transferring findings into practice. The research cluster collaborates closely with enterprises. The objective is to strengthen interdisciplinary research and development in the competence area of logistics for the benefit of the region Bremen as well as to foster international cooperation.

The International Graduate School for Dynamics in Logistics (IGS) is the structured doctoral training programme of Log*Dynamics*. It offers outstanding researchers from all around the world the opportunity to complete a doctorate at a logistics location of long standing tradition. The objective of the IGS is to foster excellence in research and education by pursuing an interdisciplinary and cross-cultural approach.

Interdisciplinary Cooperation

Most of today’s logistic challenges cannot be solved within one single scientific discipline. Therefore, research in Log*Dynamics* is based on interdisciplinary cooperation to generate synergy effects. The research cluster conducts fundamental and applied research, offers education at the highest level and organises scientific conferences. At the same time the reference to industrial practice is one of the most important aspects.

Log*Dynamics* makes special efforts to feature opportunities for cooperation between science and industry. Furthermore, it promotes the idea of giving small and middle-sized enterprises access to research and innovation. The resulting dialogue of industry and science contributes to a better understanding of different perspectives and possible solutions in logistics.

Doctoral Training

The aim of the IGS is to identify, to describe, to model and to evaluate the required and feasible intrinsic dynamics in logistics processes and networks both on an operational as well as on a strategic level. It conducts research on innovative dynamic planning and control by using new decision support algorithms and methods, new communication and cooperation arrangements as well as new technologies. Special topics are adaptive and dynamic control methods for logistics as well as the synchronisation of material and information flows. Against this background, cross-disciplinary cooperation under consideration of intercultural aspects is the basis for research.

The IGS meets the challenge of globalisation through practice-oriented research within the scope of fundamental and applied research. The research is centred on four topic areas:

- Business models, decision processes and economic analyses of dynamics in logistics
- Holistic interdisciplinary methods for modelling, analysis and simulation of dynamics in logistics
- Synchronisation of material, information, decision and financial flows
- Adaptive and dynamic control methods in logistics

The curriculum includes individual doctorate projects, disciplinary supervision, scientific mentoring as well as specific trainings in the field of complementary skills.

Research Beyond Boundaries

Faculty 1: Physics / Electrical and Information Engineering

Dynamics in Logistics is intrinsically tied to the information exchange of all players in the logistics domain: e.g. suppliers, manufacturers, transport companies, customs authorities. This information exchange is based on an increasing number of fixed and wireless information networks. Access networks usually employ wireless or mobile network technology directly or indirectly connected to infrastructure networks. These networks range from sensor networks to satellite networks. Research topics in this area are related to the performance evaluation and optimization of communication processes. Another related aspect investigated is the use of information networks to implement dynamic routing algorithms for transport logistics. These react to dynamic events that, sometimes drastically, influence transport processes. Head of the research group Communication Networks is **Prof. Dr.-Ing. Carmelita Görg**.

In the near future it will be possible to capture not only the position of each container world-wide, but of any pallet or even each individual piece of goods. The conditions of carriage like temperature or humidity have to be supervised permanently and influence current decisions. Due to the high amount of resulting data a central control will not be possible. Especially during periods of missing radio communication the freight has to react on disturbances and new information correctly. With new mathematical theories and progresses in microelectronics and micro system technologies, it will be possible to integrate low-cost sensors to monitor and control the product quality as well as the environmental parameters. This contains the conception of the ad-hoc sensor network and the communication system. New sensors and wireless communication mechanisms have been investigated under the notion of "Intelligent Container". **Prof. Dr.-Ing. Walter Lang** is director of the Institute for Microsensors, -actuators and -systems (IMSAS).

Faculty 3: Mathematics / Computer-Science

In analogy to conventional logistics, autonomous logistic processes are in need of knowledge to perform their task. Data, information, and knowledge are the key resources which ensure the quality of the logistic process. Knowledge management is required to support autonomous logistic processes by providing context-sensitive information. Furthermore it has to be considered that actors in these processes act in a competitive way. Consequently, information and knowledge should be treated as tradable goods which have a high utility potential for their consumers. Projects by **Prof. Dr.-Ing. Otthein Herzog** include, for example, knowledge management for the planning and scheduling of autonomous logistic processes.

In software engineering as well as in other areas of computer science diagrams and graphs are used in manifold ways for modelling logistic processes, easily describing and visualizing complex structures. Rule-based methods have proven to be extremely effective for capturing dynamic aspects like process and system flow. This inspires the attempt to employ rule-based graph transformation for modelling logistic processes and systems. Since the so-called graph transformation units in particular include a control component, they are an obvious choice for the description of autonomous logistic processes. **Prof. Dr.-Ing. Hans-Jörg Kreowski** is professor for theoretical computer science and member of the Technology Centre Computer Sciences and Computer Technology (TZI).

Faculty 4: Production Engineering

High performing co-operations between independent companies with the aim to develop and realise customised products are an important success factor for the competitiveness of the European industry. So called enterprise networks can be seen in addition to the traditional supply chains. The research unit "ICT applications for production" prepares, develops, and realises methods and tools to support co-operative inter-organisational enterprise networks. The research concentrates on efficient and effective collaborative design and production processes by applying innovative information and communication technologies (ICT). As focus can be seen the collaborative acting of enterprises during distributed design and production processes as well as during the late processes of the product life cycle such as the usage phase or the recycling phase. **Prof. Dr.-Ing. Klaus-Dieter Thoben** is director of this research unit. Since September 2012 he is managing director of BIBA – Bremer Institut für Produktion und Logistik GmbH and spokesman of Log*Dynamics*.

The increasing complexity of production systems and logistic networks requires the development, use, and integration of new methods of planning and control. The research aims at developing and applying

new concepts, methods, and ICT solutions in logistic processes. This pursues the goal of a sustained optimisation of production and logistic systems. Until August 2012 **Prof. Dr.-Ing. Bernd Scholz-Reiter** was managing director of the BIBA, head of the department "Planning and Control of Production Systems" as well as spokesman of Log*Dynamics* and IGS. Now he is engaged in his new function as rector of the University of Bremen.

Faculty 7: Business Studies / Economics

Logistics research in mobility and elaboration of tools which are made for the development and evaluation of an added value orientated system integration of intermodal transport already pick up today's major design options for the realization of sustainable economics. **Prof. Dr rer. pol. Hans-Dietrich Haasis** holds a chair in general business studies, production management and industrial management. He is managing director of the Institute of Shipping Economics and Logistics (ISL), head of the logistic systems unit and from July 2012 on spokesman of the IGS. Advisory service and research of this unit are focused on cooperative systems in and between logistics and production as well as solutions for regions and hubs as well as business concepts for enterprises. These topics also integrate an e-business orientated management of supply chains in relationship to partially conflicting objectives of business operations and transportation.

Supervision in Cooperation with External / Visiting Professors

Prof. Dr.-Ing. Marcos Ronaldo Albertin
Centro de Tecnologia
Federal University of Ceará (UFC), Ceará, Brazil

Prof. Dr.-Ing. Enzo Morosini Frazzon
Department of Production Engineering
Federal University of Santa Catarina (UFSC), Brazil

Prof. Hamid Reza Karimi PhD, MSc.
Faculty of Engineering and Science,
University of Agder, Grimstad, Norway

Prof. Dr. Mônica M. M. Luna
Department of Industrial and Systems Engineering
Federal University of Santa Catarina (UFSC), Brazil

Prof. Dr. Cathy Macharis
Faculty of Economic, Social and Political Sciences and Solvay Business
Vrije Universiteit Brussel, Belgium

Prof. Antônio G.N. Novaes
Universidade Federal de Santa Catarina
Departamento de Engenharia de Producao e Sistemas
Centro Tecnològico
Florianòpolis, SC, Brazil

Prof. Dr. Christian Prins
Head of the Industrial Systems Optimization Laboratory (LOSI)
University of Technology of Troyes (UTT), France

Prof. Dr. Hendrik Wildebrand
Department of Cooperative Studies
Berlin School of Economics and Law, Berlin, Germany

International Doctoral Training in Logistics

International Doctoral Training in Logistics

Since 2005 the International Graduate School for Dynamics in Logistics (IGS) at the University of Bremen has been offering excellent researchers from all around the world the opportunity to complete an efficient, structured graduate training at a logistics location with a long-standing tradition. The IGS is embedded in the Bremen Research Cluster for Dynamics in Logistics (Log*Dynamics*) and collaborates closely with commercial enterprises.

The curriculum of the IGS is designed for a three-year full time doctoral study. It bundles interdisciplinary competences and cross-cultural cooperation and fosters the link between research and industry. Besides the individual doctoral project the curriculum covers collective thematic introductions, subject specific courses, interdisciplinary colloquia, dialogue forums, excursions, as well as individual coaching regarding complementary skills and personality development. The language of training and thesis is English. However, a basic knowledge of the German language and culture is also required. German IGS graduates have the opportunity to participate in a scientific exchange at foreign universities.

All these elements involve the young researchers in a critical dialogue which – instead of presenting a single dominant perspective – encourages discussions beyond scientific boundaries and helps to create a dynamic, issue-related network. A system of concerted-individual measures ensures the well-directed and effective personnel development through the institutional combination of possibilities and obligation to actively exchange ideas. This enables the doctoral candidates of the IGS to receive excellent qualifications and helps the university to gain efficient new insights. Furthermore, the IGS contributes to the transfer of the research results into practice.

Structure of Doctoral Training

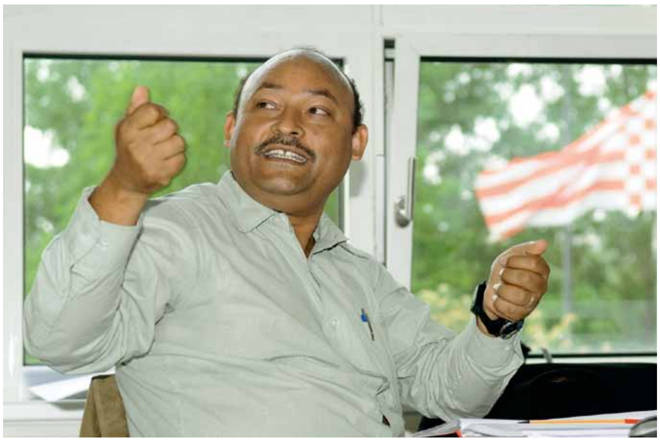
Seven professors from four faculties of the University of Bremen are available as supervisors or as mentors for the doctoral students at the IGS. Additionally, the early stage researchers receive a structural supervision form the Managing Director of the IGS and scientific support from the postdoctoral research fellows in their working groups.

Doctoral Project

Working on the doctoral project is the central research activity in the curriculum. In order to fulfil this work under optimal conditions the doctoral students are integrated in the disciplinary research group of their supervisors. Through this disciplinary assignment they can benefit from the knowledge and the infrastructure of the respective faculty and institute. Furthermore, they learn to use the tools of scientific work which are required for their particular project and receive individual support in their research activities.

Courses and Coaching

Courses are divided into lectures with tutorials, seminars, workshops, practical training, and integrated learning in small groups and individual coaching. The aim of the disciplinary courses is to educate doctoral students on the level of international standards of the respective research area. Thematic introductions into the "other" disciplines support the interdisciplinary cooperation at the IGS. Additional course-offers include project management, research process and methods, academic writing, presentation and communication techniques, cross-cultural co-operation, language courses, and voice development.



Interdisciplinary Research Colloquium

The interdisciplinary research colloquium offers an institutional and issue-related forum to present and discuss the concept and status of the doctorate projects with the whole faculty. The young researchers have the opportunity to exchange research results, develop interdisciplinary research questions, and participate in cross-disciplinary discussion groups. Colloquia with lecturers of Log*Dynamics* or visiting professors ensure targeted impulses for the individual research projects.

Dialogue Forum

A dialogue forum aims at the exchange between industry and academia. The doctoral candidates have the opportunity to present their research results at fairs, conferences, and events and discuss relevant issues with experts to gain different business perspectives and receive new impulses, thus increasing the practical relevance of their research. Furthermore, this direct link to industry improves the career prospects of the young researchers.

Awards and New Faces

Log*Dynamics* contributed to the success story of the University of Bremen in the high-profile area of logistics. The University of Bremen succeeded in the national competition of the Excellence Initiative with an outstanding future concept entitled "Ambitious and Agile: Institutional Strategy for a prominent mid-sized university". The IGS is the educational part of Log*Dynamics* and contributed particularly by its very high degree of internationality and interdisciplinary of research and education. In 2011 the innovative supervision and mentoring concept for doctoral students has already been awarded by the German National Academy of Science and Engineering (acatech), the 4ING faculty conferences, the TU9 consortium (union of the leading technical universities in Germany), and the Working Group of Technical Universities and Colleges (ARGE TU/TH). In a national competition the structured training programme has been chosen as best practice for the internationalisation of an engineering doctoral training programme.

The IGS extended its external funded scholarship base in two ways:

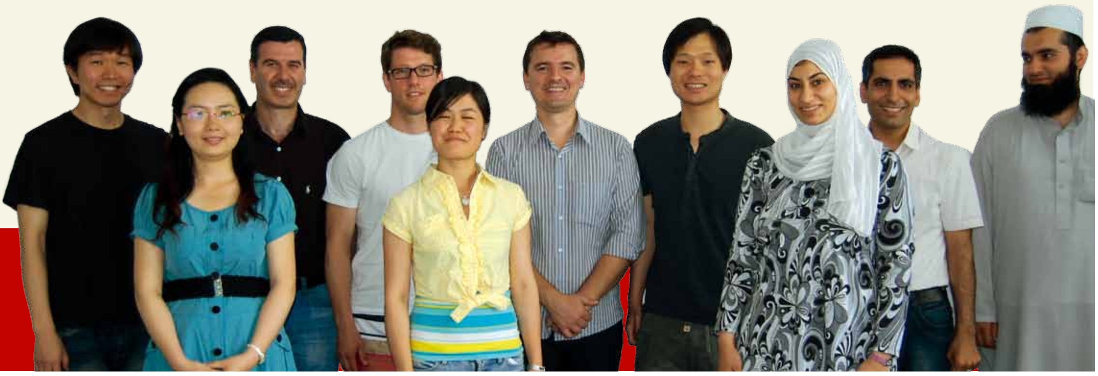
- The IGS succeeded in the competition "GSSP – Graduate School Scholarship Programme" of the German Academic Exchange Service (DAAD). Thus, beginning in 2013, the IGS has been offering four DAAD-scholarships to outstanding international doctoral students.
- Since July 2012 LogDynamics is partner in the EU project "cLINK – Centre of Excellence for Learning, Innovation, Networking and Knowledge". This project facilitates the academic exchange between European and Asian universities. Beyond the University of Bremen the other European universities are in Great Britain, France, Romania and Hungary. cLINK offers scholarships for students and lecturers on all levels of qualification. Promising candidates will stay between one month and two years at the European university. The students will come from Bangladesh, Bhutan, Nepal, Pakistan, China, India, Malaysia and Thailand.

By integrating students from Asia into the academic training programme, the IGS extends and intensifies its international foundation through personal experiences. In this way the alumni, the guest researchers and the cLINK fellows are ambassadors of Log*Dynamics* and the high quality of education and research within the IGS.

To extend the supervision capacities for the doctoral students of the IGS, Log*Dynamics* established a new position of a junior professorship on "Dynamics in Logistics". The doctoral candidates will benefit from the excellence initiative since two further professorships are being implemented. They bridge the gap between the University of Bremen and the external research institutes ISL - Institute of Shipping Economics and Logistics and BIBA – Bremer Institut für Produktion und Logistik GmbH. Additionally, funding is available for the leadership of young research groups.

In the mid of 2012, Prof. Dr. rer. pol. Haasis, Faculty of Economics and managing director of the ISL, was elected as the new spokesman of the IGS. He followed Prof. Dr.-Ing. Scholz-Reiter who is still available but is now busy in his new function as rector of the University of Bremen. The latter will implement the measures of the Excellence Initiative.

Alumni of the IGS support the school from places all around the world. Some stay in Germany and contribute as guest lecturer to the curriculum of the IGS. Others go back to their home countries or are now postdocs/professors in other countries. In these positions, they are sending new outstanding doctoral candidates to Bremen. We love this lively cooperation and exchange between scientific disciplines, cultures and continents!



Visiting Scientists

Prof. Dr.-Ing. Marcos Ronaldo Albertin
Centro de Tecnologia
Federal University of Ceará (UFC), Ceará, Brazil

Prof. Dr.-Ing. Enzo Morosini Frazzon
Department of Production Engineering
Federal University of Santa Catarina (UFSC), Brazil

M.B.A. Seungwoo Jeon
Seoul National University, Korea

Prof. Hamid Reza Karimi PhD, MSc
Faculty of Engineering and Science,
University of Agder, Grimstad, Norway

Dr. Holger Kenn
Europäisches Microsoft Innovations Center GmbH
Aachen, Germany

M. Eng. Sérgio Adriano Loureiro
Universidade Estadual de Campinas (UNICAMP), Brazil

Prof. Dr. Mônica M. M. Luna
Department of Industrial and Systems Engineering
Federal University of Santa Catarina (UFSC), Brazil

Prof. Dr. Cathy Macharis
Faculty of Economic, Social and Political Sciences and
Solvay Business
Vrije Universiteit Brussel, Belgium

Prof. Antônio G.N. Novaes
Universidade Federal de Santa Catarina
Departamento de Engenharia de Producao e Sistemas
Centro Tecnològico
Florianòpolis, SC, Brazil

Prof. Dr. Christian Prins
Head of the Industrial Systems Optimization Laboratory (LOSI)
University of Technology of Troyes (UTT), France

M. Eng. José Benedito Silva Santos Júnior
Laboratory for Logistics and Transport (LALT)
Universidade Estadual de Campinas (UNICAMP), Brazil

M. Eng. Vanina Macowski Durski Silva
Department of Industrial and Systems Engineering
Federal University of Santa Catarina (UFSC), Brazil

M.Sc. Li Xia
Wuhan University of Technology, China

Dr. Xuanguo Xu
Economics and Management School of Jiangsu
University of Science and Technology, China

Junzhou Yan PhD
Zhengzhou Institute of Aeronautical, China

Alumni

Alumni of the International Graduate School for Dynamics in Logistics

Dr.-Ing. Ali Badar Mohamed Alamin Dow, M.Sc.
Design and Fabrication of a Micromachining Preconcentrator Focuser for Ethylene Gas Detection System
Faculty of Physics / Electrical and Information Engineering

Dr.-Ing. Mehrdad Babazadeh, M.Sc.
Plausability Check and Energy Management in a Semi-autonomous Sensor Network Using a Model-based Approach
Faculty of Physics / Electrical and Information Engineering

Dr.-Ing. Salima Delhoum, M.S.I.E.
Evaluation of the Impact of Learning Labs on Inventory Control: An Experimental Approach with a Collaborative Simulation of a Production Network
Faculty of Production Engineering

Dr.-Ing. Enzo Morosini Frazzon, MBA
Sustainability and Effectiveness in Global Logistic Systems – an Approach Based on a Long-Term Learning Process
Faculty of Production Engineering

Dr. rer. pol. Julie Gould
A Decision Support System for Intermodal Logistics under Considerations for Costs of Security
Faculty of Business Studies / Economics

Dr.-Ing. Amir Sheikh Jabbari, M.Sc.
Autonomous Fault Detection and Isolation in Measurement Systems
Faculty of Physics / Electrical and Information Engineering

Dr.-Ing. Amir Jafari, M.Sc.
Development and Evaluation of an Autonomous Wireless Sensor Actuator Network in Logistic Systems
Faculty of Physics / Electrical and Information Engineering

Dr.-Ing. Huaxin Liu, M.Sc.
Modelling Dynamic Production Systems with a Special Focus on Dynamic Bottlenecks
Faculty of Production Engineering

Dr.-Ing. Nicole Pfeffermann, Dipl.-Ök.
An Integrated Management concept of Innovation Communication and its Contribution to a Company's Value
Faculty of Production Engineering

Dr.-Ing. Gulshanara Singh, M.Sc.
Agent-based Clustering Approach for Autonomous Cooperation in Transport Logistics
Faculty of Mathematics / Computer Science

Dr.-Ing. Arne Schuldt, Dipl. Inf.
Multiagent Coordination Enabling Autonomous Logistics
Faculty of Mathematics / Computer Science

Dr.-Ing. César Stoll, M.L.I.
Evaluation of the Application of Automatic Conditions Monitoring of Produce in Fresh Food Warehouses
Faculty of Production Engineering

Dr.-Ing. Que Son Vo, M. Eng.
Modeling and Implementation of Sensor Networks for Logistic Applications
Faculty of Mathematics / Computer Science

Dr. rer. pol. Jiani Wu
Sustainable Freight Village Concepts for Agricultural Products Logistics
Faculty of Business Administration, Production Management and Industrial Economics

Towards Green Logistics in Batch Process Industry Planning

Nagham El-Berishy

Consumers are growingly concerned with environmental issues in general and their own fast moving consumer goods in particular. These are usually produced in batches. This type of production includes a lot of challenges to be met within the global environments. In addition, it is challenging to increase the price of any product, in spite of higher raw material prices and rising energy and water costs. Therefore, it is more important than ever to develop environmentally friendly technologies and processes during the planning phase. This article presents the requirements for designing an integrated planning of production and distribution operations under green logistics aspects by reviewing the related literature. Some important issues are considered here such as the level of integrity and the performance measures. Moreover, it provides a framework to meet the related requirements considering economical as well as environmental challenges. As a going on research an integrated plan between production and distribution is to be developed.

Introduction >>> Being green is crucial nowadays due to the dynamics in supply chain operations and the high competitiveness in the global market. The aim of this paper is to present the requirements for designing an integrated planning of production and distribution operations under green logistics aspects. This work highlights the importance of designing a framework to handle economical and environmental challenges under today's competitive requirements. Green Supply Chain Management (GSCM) is a multifaceted problem, which comprises economic, social and environmental elements. The motivation for the introduction of GSCM may be ethical (e.g. reflecting the values of managers) and/or commercial (e.g. gaining a competitive advantage by signaling environmental concern) [1].

The paper is structured in 4 sections: section 1 is an introduction to the scope of this paper. The description of the requirements of the proposed framework is discussed in section 2. Section 3 describes the important modeling issues for the green logistics oriented framework and discusses the techniques and methodologies which can be used to plan these operations. Finally, conclusions are given at the end of this paper. **<<<**

Green logistics in batch process industry planning

Batching is the clustering of items for transportation or manufacturing processing at the same time [2]. In a batch manufacturing environment, products are released to the production system in groups (batches). Batch products are characterized by short life cycles, large numbers of different product variants and long lead times or delivery times in relation to their life cycle. Such products can be found in many consumer industries, for instance the apparel branch (seasonal and fashion articles), the cosmetics branch (fashion articles), or the food industry (e.g. fruits and vegetables, which take time to ripen, but may rot after a short time). Within this group of products, the proposed research product will focus on products that are manufactured in batch production, such as textiles or apparels.

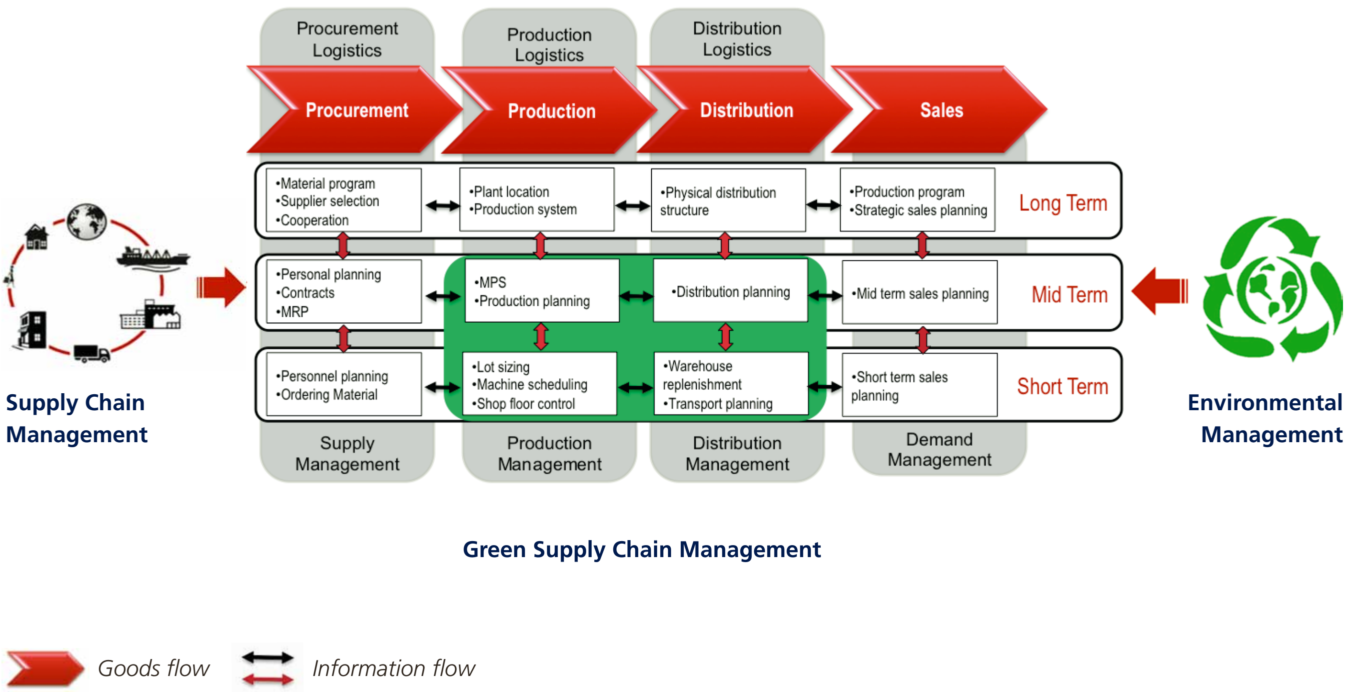
Logistics management is the part of the supply chain process that plans, implements, and controls the efficient and effective flow of goods, services and related information from the point of origin to the point of consumption in order to meet customers' requirements [3]. Merging the concept of green logistics with Supply Chains (SCs) is targeted by enterprises due to the logistics' positive impact on the efficiency of transport systems [4]. Greening SCs aims to balance marketing requirements with environmental issues. In order to meet challenges, such as energy conservation and pollution abatement, enterprises have tried to green their SCs [5].

Today, many companies are required to face these environmental issues due to both regulatory and non-regulatory conditions [6]. In addition, customers take environmental issues more and more into account. Due to this fact; green logistics will become a main focus of companies in the future [7]. These trends are inter-dependent; companies must satisfy the need of their customers and even exceed the environmental expectations of their governments [8]. Evidently, design and management of supply chain activities is a primary factor in promoting environmental impact [9]. The suggested concept of the GSCM framework is shown in Figure 1. The related issues which are required to design this framework are the main work of this research paper.

Sustainability
Economic performance has been the traditional focus for many supply chains. A sustainable supply chain is also socially beneficial. Sustainability in the supply chain is increasingly seen as essential to delivering long-term profitability by helping to maintain the quality of the environment assets for production, thereby supporting the long-term productivity.

Efficiency
Characteristics that will be addressed in the batch process industry include production, inventory, and distribution phases. Therefore, developing a model for production plans and distribution schedules

Figure 1: Suggested green supply chain management framework



The GSCM framework requirements

Production and distribution operations are two key functions in the supply chain. To achieve optimal operational performance in supply chains, it is crucial to integrate these two functions, and to plan and schedule them jointly in a coordinate manner [2]. These decisions are traditionally made separately. However, their integration has a significant impact on the overall system and service performance [10].

Focusing on the previously described requirements, the design of a green logistics oriented framework that integrates production and distribution decisions is investigated. The four elements required to construct this framework are: sustainability, efficiency, flexibility and robustness [11]. This framework addresses economic, social and environmental issues to manage the dynamics in supply chain operations.

which captures all these characteristics together will be achieved via mathematical programming, one of the most convenient tools in modeling production planning and scheduling models.

Flexibility
The increase of structural and dynamic complexity of production and logistics systems is caused by diverse changes. For example, short product life cycles as well as a decreasing number of lots with simultaneously rising variants of a product. As a result, new demands have been placed on competitive companies, which cannot be fulfilled by conventional controlling methods. Conventional production systems are characterized by central planning and controlling processes, which do not allow fast and flexible adaptation to changing environmental influences. Establishing cooperating logistics processes is believed to be an appropriate method to meet these requirements in a flexible way.

Robustness

To manage changes inside and outside a production system, an approach that is decentralized and at the same time controls green logistics is promising. This control would consider the interrelation between the production and distribution processes.

The proposed framework, which satisfies these requirements, is a form of an automated decision support system. Providing this automated decision support system helps decision-makers in determining the optimal master production schedules and the optimal distribution sequences in the batch process industry. It is a systematic approach for production plans and transportation solutions which enables managers to answer "what-if" questions related to the tactical and operational decisions.

Framework modeling issues

The number of issues should be considered when modeling an integrated framework for production and distribution of green logistics in batch process industry. The issues which need to be addressed are:

The level of integrity

Integration within supply chain functions aims to multiply the reduction of environmental impacts. It has much in common with other environmental management concepts, such as life cycle management and green or sustainable supply chain management [12]. The goal of the integrated approaches includes increased cost competitiveness, shorter product life cycles, faster product development cycles, globalization and customization of product offerings, and higher overall quality [13].

On the other hand, the application of conventional centralized planning and control to logistics processes suffers from complexity. Therefore, a need for decentralized methods employing actors arises [11].

To conclude, keeping up a suitable level of integrity insures the benefits of optimizing the total logistics system. It is usually not appropriate to build a model that encompasses the decisions of all functions. For this reason, there has been increased interest on optimization models which integrate smaller sections of the supply chain [14].

Performance measures

Due to the variations of logistics systems, choosing the appropriate supply chain performance measures are difficult [15]. The performance measures have implications for all managerial levels – strategic, tactical, and operational. Performance measures have tangible and intangible characteristics. Many issues must be addressed, such as which to be used, when, and how to measure them [16]. The performance is defined in terms of both economical and environmental effect.

Green supply chain performance measures may be determined through supplier certification processes or surveys completed for current practices among organizations in the negotiation of future contracts [17].The types of environmentally-based performance measures used by an organization will depend largely on the organization's evolutionary stage in environmental management. Thus, the amount of regulated emissions or disposal of hazardous wastes would be core performance metrics.

Techniques and methodologies

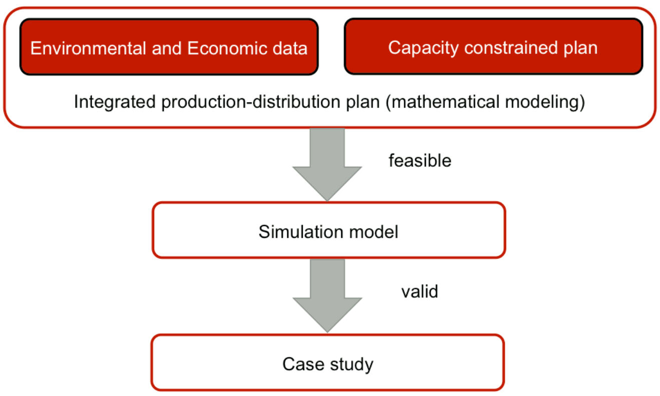
Both exact and approximate algorithms are used in solving production planning and distribution problems. Approximate algorithms (heuristic method) are used to solve problems by finding an efficient solution while exact algorithms can solve the problems easier in this time compared to the past. Optimization packages have undergone a huge development in the last decade [18, 19].

An analytical investigation is a suitable tool for solving small instances of this system in reasonable time, thus, simulative approaches should be used to investigate combined production and transport scenarios for a real time scale [20]. The combination of event-based simulation and mathematical modeling could be realized to consider dynamic aspects as well as environmental aspects.

Available supply chain models do not cover the specific characteristics of the batch process industry. Therefore, this research focuses on identifying how the proposed framework will be considered for modeling and evaluating the processes in the batch process industry [11].

Figure 2 illustrates the concept of the proposed framework. Firstly, the planner introduces the economic and environmental data and the capacity constrained plan. By defining these parameters and modeling using mathematical programming an integrated production-distribution plan could be established. If the plan is feasible, a simulation model validates this model in a larger scale. Finally, the practicality of the developed model should be tested by applying it in a case study.

Figure 2: The concept of the proposed research approach



Conclusion and outlook

In summary, this paper presents an integrated framework design for a production-distribution green logistics system for the batch process industry. The importance of this integration is forced by its direct effect on the overall performance of the system.

The core of this integrated planning system will consider the optimal production and distribution decisions regarding the logistics of batch process products, besides the economic and environmental issues. The model simulates the standard processes for logistics in the batch process industry.

References

[1] Testa, F.; Iraldo, F.: Shadows and Lights of GSCM: Determinants and Effects of These Practices Based on A Multi-National Study. In: Journal of Cleaner Production 18 (2010), pp 953-962.

[2] El-Berishy, N.: An Advanced Production Planning and Scheduling System for Batch Process Industry. LAMBERT Academic Publishing, Germany 2011.

[3] Brewer, A. M.; Button, K. J.; Hensher, D. A.: The handbook of Logistics and Supply-chain Management, Handbooks in Transport 2, Pergamon/Elsevier, London: 2001.

[4] Zhu, Q.; Cote, R.: Integrating Green Supply Chain Management into an Embryonic Eco-Industrial Development: A Case Study of the Guitang group. In: Journal of Cleaner Production 12 (2004), pp 1025-1035.

[5] Beske, P.; Koplin, J.; Seuring, S.: The Use of Environmental and Social Standards by German First-Tier Suppliers of the Volkswagen AG. In: Corporate Social Responsibility and Environmental Management 15 (2008), pp 63-75.

[6] Mintcheva, V.: Indicators for Environmental Policy Integration in the Food Supply Chain (The Case of the Tomato Ketchup Supply Chain and the Integrated Product Policy). In: Journal of Cleaner Production 13 (2005), pp 717-731.

[7] Seuring, S.; Sarkis, J.; Müller, M.; Rao, P.: Sustainability and Supply Chain Management- An Introduction to the Special Issue. In: Journal of Cleaner Production 16 (2008), pp 1545-1551.

[8] Walton, S. V.; Handfield, R. B.; Melnyk, S. A.: The GSC: Integrating Suppliers into Environmental Management Processes. In: International Journal of Purchasing and Materials Management (1998), pp 1-11.

[9] Gupta, S.; Palsule-Desai, O. D.: Sustainable Supply Chain Management: Review and Research Opportunities. In: IMB Management Review 23 (2011), pp 234-245.

[10] Nananukul, N.: Lot-sizing and inventory routing for a production-distribution supply chain. Ph.D. thesis, The University of Texas at Austin 2008.

[11] Scholz-Reiter, B.; El-Berishy, N.: Green Logistics-Oriented Framework for Integrated Production and Distribution Planning: Related Issues. In: The 10th Global Conference on Sustainable Manufacturing, Istanbul (2012).

[12] Fortes, J.: Green Supply Chain Management: A Literature Review. In: Otago Management Graduate Review 7 (2007), pp 51-62.

[13] Seuring, S.; Müller, M.: Integrated Chain Management In Germany-Identifying Schools of Thought Based on A Literature Review. In: Journal of Cleaner Production 15 (2007), pp 699-710.

[14] Sheu, J.; Chou, Y.; Hu, C.: An Integrated Logistics Operational Model for Green-Supply Chain Management. In: Transportation Research Part E 41: Logistics and Transportation Review (2005), pp 287–313.

[15] Beamon, B. M.: Measuring Supply Chain Performance. In: International Journal of Operations and Production Management 19 (1999), pp 275-292.

[16] Hervani, A. A.; Helms, M. M.; Sarkis, J.: Performance Measurement for Green Supply Chain Management In: Emerald Benchmarking 12 (2005), pp 330-353.

[17] Papadimitriou, C.; Steiglitz, K.: Combinatorial Optimization: Algorithms and Complexity, Dover Publications, New York, U.S.A 1998.

[18] Armentano, V. A.; Shiguemoto, A. L.; Lokketangen, A.: Tabu Search with Path Relinking for an Integrated Production-Distribution Problem. In: Computers and Operations Research 38 (2011), pp 1199-1209.

[19] Mula, J.; Peidro, D.; Diaz-Madronero, M.; Vicens, E.: Invited Review: Mathematical Programming Models for Supply Chain Production and Transport Planning. In: European Journal of Operations Research 201 (2010), pp 377-390.

[20] Scholz-Reiter, B.: International Graduate School for Dynamics in Logistics/Production Engineering: Production Logistics Versus Transport Logistics: Similarities and Difference for the Application of Autonomy, URL: http://www.sfb637.uni-bremen.de/, Date of Access 25.09.2009."

Nagham El-Berishy, M.Sc.

Green Logistics Oriented Framework for Integrated Scheduling of Production and Distribution Networks

E-mail: elb@biba.uni-bremen.de
Country: Egypt
Start: 01.04.2011
Supervisor: Prof. Dr.-Ing. Bernd Scholz-Reiter
Faculty: Production Engineering
Research Group: Planning and Control of Production Systems

Best Practices for the Manufacturing Industry in Developing Countries: An Ethiopian Study

Fasika Bete Georgise

Recently, many firms have been focusing on achieving productivity gains in their operations by implementing best practices. However, there is a relatively lack of research and literature about experience of the implementation and initiative for manufacturing industry in developing countries context. This paper explores the best practices implementation and challenges encountered during the process of adoption. A semi-structure interview and questionnaire survey are used to explore the extent of the implementation in Ethiopian manufacturing firms. The research survey was based on SCOR model best practices. The findings show that most of the respondent firms have shown interests and put efforts to implement some of them. But, the results were below the expectations. Therefore, there is a need for developing countries to adapt the best practices that consider their scenarios.

Introduction >>> Production activities in developing countries are facing fierce challenges from both local and international competitors in the marketplace [1] & [2]. For these challenges, manufacturers must be able to understand their customers to better satisfy themthan their competitors and improve their supply chains dynamically. Therefore, companies are pressurized to build their managerial and technical capabilities so that they can retain their markets and integrate themselves into the global business. Recently, academic and practical researches are focused on how manufacturers could use the different management techniques and practices to react to these challenges [1], [3], [4], [5], [6] & [7]. Supply Chain Management (SCM) is one of the foremost solutions to leverage manufacturers' ability to compete and develop a collaborative relationship. Managers focus on SCM practices by classifying them as– the best, the good, the bad, and the worst [8]. The words `best practices´ appear in the advanced SCM because it benefits manufacturing industries in their improvement activities. The Supply Chain Council has developed a Supply Chain Operations Reference (SCOR) model that incorporates the best-practice that helps this paradigm shift [7]. However, manufacturing industries are facing challenges in adopting the best practice to their business processes. **<<<**

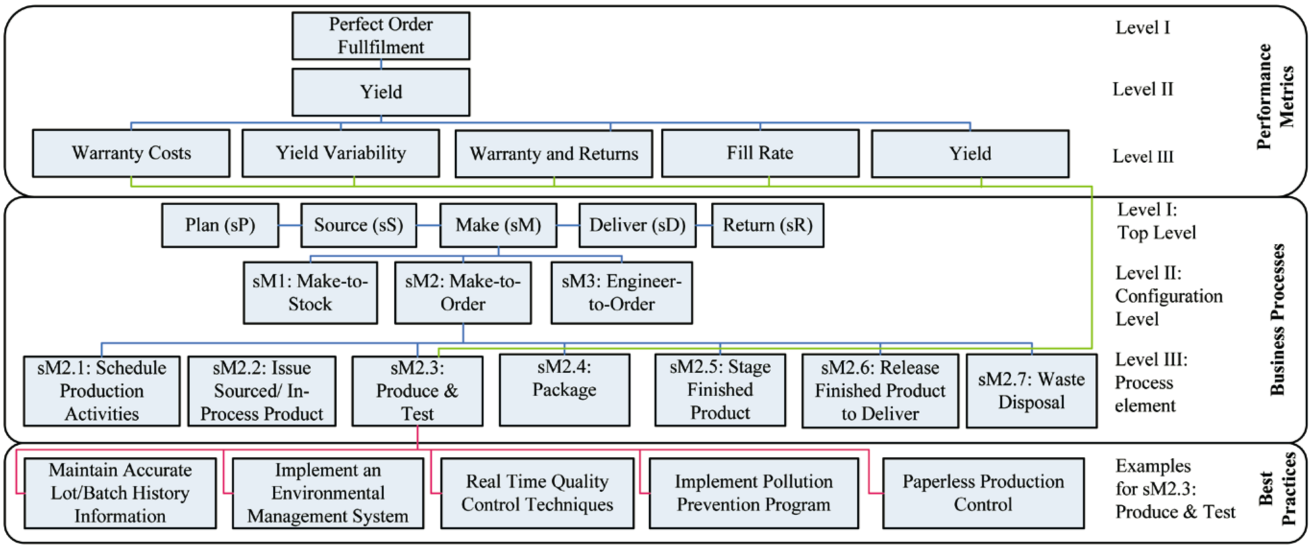
SCOR model as best practices

The SCOR model is generic and a quasi-standard model for the description and analysis of supply chains. The SCOR model uses three well-known individual techniques: business process modeling, benchmarking performance and best practice analysis, turned into an integrated approach. It comprises a complete set of supply chain performance metrics, industry best practices, and enabling systems. The current version (V.10) of this normative model includes more than 200 described process elements, 550 defined performance metrics and 500 leading business practices, which are hierarchically organized on levels [8].

The three elements of the SCOR model are integrated into a single framework. The performance metrics, for example, are linked to the processes to allow root-cause analysis of performance gaps. Similarly, the best practices are linked to the metrics and the processes; this allows users to identify implementation requirements and target performance improvements. For each process in the SCOR model, there are recommended looked-up corresponding best practices for implementation. An example of associations for process template "sM2.3: Produce & Test" is shown in Figure 1. Industry-proven best practices are associated with each activity available in the model.

A best practice is a unique way to configure a process or a set of processes. The uniqueness can be related to issues such as the automation of the process; a technology applied to the process; special skills applied to the process and others. The SCOR model defines "best practice as a current, structured, proven and repeatable method for making a positive impact on desired operational results". SCOR best practices have been collected from diverse industries by SCOR practitioners. SCOR recognizes that several different types of practices exist within any organization: leading or emerging practices; best practices; common practices; and poor practices. What is important to understand, is that different practices have different performance expectations. Best practice analysis follows the benchmarking activity that should have measured the performance of the supply chain processes and identified the main

Figure 1: SCOR model decomposition into process element [8]



performance gaps. It is understood that not all best practices will yield the same results for all industries or supply chains [8].

Transferability of best practices to developing country firms

Research activities have been done by practitioners and academician on the major issues about best practices, its transferability and adaptability to suit developing countries' scenarios [3], [4] & [10]. Technology transfer has been considered as a tool to bypass the lacking growth of industrialization and advancement of developing countries [9]. The recent trends of global integration and collaboration have also encouraged experience sharing and benchmarking against their practice to try to apply some of the practices in their own organizations. However, such activities have been a challenge even for developed countries [1] & [3]. If the best practices' implementation is a challenge even to companies in developed countries, what can be said about organizations struggling in unstable contexts such as those of developing countries?

One way of doing this was copying, adopting, imitating or adapting best practices of widely publicized successes of companies. Unfortunately, such best practice imitation rarely works well because one size does not fit all. Such activities are not simple and results may not be always also successful. Research conducted by different authors verifies the same [1], [3], [10]. Developing countries can learn from practices of developed countries' companies, however, copying them by rote without analyzing the conditions within which they were developed and implemented and then comparing them to one´s own particular situation and making requisite adjustments would lead to mistakes [1] & [3]. The best practices should therefore be perceived more as models to be imitated than ready models to be copied by other companies. The best practice of one company will not automatically become the best practice of another unless it is adapted, successfully implemented and brings the expected results [1] & [3]. The objective of this research is to examine the existing best practices and challenges in a particular context of developing countries - specifically, in Ethiopia.

Research methodology

It aims at describing and understanding the existing phenomena with contextual factors. There is no much research undertaken on the best practices in the developing countries. Therefore, our research fills this gap, by investigating the implementation and use of best practices in Ethiopia, i.e., what types of best practices are adopted and finally implemented, the barriers and challenges faced by developing countries. In order to cover a large number of Ethiopian companies and to ensure a comprehensive view, a survey based on questionnaires and semi-structured interviews was used for data collection. The respondents were chosen from the managing directors, manufacturing and/or production managers and executives, and also quality managers and executives. The items of best practices manufacturing implementation section were adapted from the SCOR model (v.10) [8] and previous studies[10].

Results and analysis

This analysis is based the most frequently identified best practices from the SCOR model and other researches. The research question focus tried to answer the question: to what extent the best practices have been implemented in companies according to the SCOR model and what challenges they have faced.

Best practices implementation level

In order to further verify the extent of best practices implementation in Ethiopian manufacturing industries, the respondent companies were asked to rate the level of adoption of each of the best practices. The questions were set up on a four-point Likert scale to measure the extent of implementation described by each of the items. The scale ranged from 1 to 4, with 1 = never implemented, 2 = poorly implemented, 3 = well implemented, and 4 = extensively implemented.

Table 1 illustrates the distribution of best practice mean scores. Most of the surveyed companies indicate that they use some of the best practices. The result is shown in Table 1 below. Among all

Table 1: The implementation level of best practices

Type of best practices	Mean
Total Quality Management	2.48
Benchmarking	2.39
Available to Promise (ATP)	2.35
Carrier Agreements	2.31
Outsourcing	2.23
Supplier Performance Assessment System	2.03
Lean Production	2.00
Co-located Procurement	1.96
Cross-Docking	1.92
Postponement	1.89
Collaborative Planning, Forecasting and Replenishment	1.61
Six Sigma	1.56
Vendor Managed Inventory	1.56
Bar Coding / Automatic Identification	1.54
Electronic Data Interchange	1.54

of the best practices, Total Quality Management is found to be the leading best practice, with the mean score 2.48. Other best practices that have been extensively implemented are Benchmarking (2.39) and Available to Promise (2.35). However, the least practiced best practices are the Electronic Data Interchange and Bar Coding/ Automatic Identification Practice. Those best practices which need an ICT infrastructure were lower than others.
The interviewed companies also stated that the following are the major best practices implemented so far: business process reengineering, ISO 9001:2008, environmental management system, total quality management, kaizen, benchmarking, balanced scorecard, food quality & safety standard, & outsourcing.

Inventory management practices were also assessed. Table 2 shows the level of inventory management practices. The two frequent inventory management practices were Company-wide coordination and management of inventory (2.59) and Keeping a safety inventory as a consequence of sales variability (2.30). Just-in-time delivery inventory management practices show low levels of use. Inventory management practices used in the supply chain, such as Vendor managed inventory at production sites; Joint inventory by suppliers and manufacturer show even lower levels of use.

Table 2: The implementation level of inventory management

Type of inventory management practices	Mean
Company-wide coordination and management of inventory	2.59
Keeping a safety inventory as a consequence of sales variability	2.30
Regional distribution centers for product distribution	2.25
Lowest inventory driven costs	2.21
Automated warehouse management	2.19
Just-in-time (JIT) delivery	2.04
Vendor managed inventory at production sites	1.71
Joint inventory management by suppliers and manufacturer	1.54

Best practices implementation barriers and enablers

Implementing best practices in manufacturing systems is not an easy task. For any change in an organization to take hold and success, the challenges or barriers need to be identified and understood. The questions were set up on a four-point Likert scale to measure the extent of challenges described by each of the items. The scale ranged from 1 to 4, with 1 = no challenge, 2 = small challenge, 3 = challenge, and 4 = strong challenge. The best practices barriers are analyzed based on the status of best practices' implementation by the respondent companies (Table 3), which are indicated in the previous section. The three main barriers in firms are The excising model specificity to the developed countries' operating environment, Quality of skilled workforce, and Lack of ICT infrastructure.

Table 3: The challenges of best practices implementation

Type of challenges	Mean
The excising model specificity to the developed countries' operating environment	2.97
Quality of skilled and cost effective workforce	2.94
Lack of information & communication technologies (ICT) infrastructure	2.93
Difficulty to implement the models & handle for practical operations	2.79
Non systematic approach to measuring customer requirements	2.78
Management practices and organizational working culture	2.77
Difficult to establish relationships based on shared risks & rewards	2.68
Lack of employee loyalty / motivation / empowerment	2.57
Lack of physical infrastructure	2.45
A lack of willingness to share needed information	2.45

Challenges for interviewed firms also demonstrated similar results. The major challenges are lack of expertise & professional experiences, the best practice ideas come and change without critical thinking about the use, management is only involved in routine production operation and lacks commitment for the innovative ideas and technologies, lack of attention and awareness given for best practice, little attention for research & development activities, financial constraints for such interventions, low level of acceptance & high resistance for new ideas, lack of practical training & support form academic & research institutions, and lack of continuity & follow-up for introduced best practices.
Table 4 exemplifies the use of information and communication technologies as enablers, including both hardware and software in the firms. The questions were set up also on a four-point Likert scale to measure the level of the enablers' status of each of the items. The scale ranged from 1 to 4, with 1 = poor performance, 2 = fair performance, 3 = good performance, and 4 = excellent performance. The Electronic mail service was the dominant enabler available in the respondent companies. The use of new technologies and software, such as Forecast/demand management software; Transport/warehouse software and E-procurement; and Bar coding/automatic identification system are at poor performance

Table 4: The level of enablers for best practices success

Enabler	Mean
Electronic mail system	2.8
Automated material handling system	2.0
Enterprise Resource Planning systems	1.8
Advanced planning and scheduling software	1.7
Electronic data interchange (EDI) capability	1.7
Bar coding/automatic identification system	1.5
E-procurement system	1.5
Transportation/warehouse management	1.3
Forecast/demand-management software	1.2

level. Almost half of the respondent companies did not have such types of enablers at all. However, most of companies were interested to adopt such types of enablers in the future. The firms have already started a program for local software for use.

Conclusion: The need for adaptation

The results show that most of the respondent firms have started to adopt best practices up to a certain extent. The firms should be aware, understand the best practices and their purpose, because the main barriers of these firms are the lack of a real understanding of the best practices concept and employees' attitude. Some of the best practices facilitate the efforts of the developing countries towards supply chain integrations with their partners in developed countries and the overall improvements of supply chains. This finding has implication for the firms, as it provides a mean to help them to search, select, adapt and apply best practices that suit the existing conditions and factors affecting process. The management should understand and emphasise the importance to overcome challenges for the successful implementation of best practices in their firms. The issue of the applicability of the best practices to developing countries should be settled on the basis of the outcomes of such implementations. The search for best practices in developing countries require an appropriate selection, adaptation, application and evaluation of the results above all else.

The major challenge in the future will be in addressing the environmental factors and conditions that challenges the implementation of the best practices in developing country scenarios. This will require new kinds of adaptation mechanisms for best practices that suit the existing scenarios. The field survey and literature review provides the following key insights and lessons: (a) future best practices adaptation should be flexible enough to respond to dynamic manufacturing scenarios and markets; (b)best practices adaptation should favor approaches that provide a number of different technologies and management practices, which firms can search, select, adapt, implement, and evaluate so that they can fit; (c) help closing the gap between those practices observed in the field and those reported in the literature; and (d) some ICT based best practices adaption requires a conducive industrial environment and enhanced linkages with supply chain members.

References

[1] *Lapide, L.: MIT's SC 2020 Project - The Essence of Excellence. In: Supply Chain Management Review 10 (2006) 3, pp 18-24.*

[2] *Kauffman, R. G.; Crimi; T. A.; Best-Practice Approach for Development of Global Supply Chains. In: 90th Annual International Supply Management Conference 2005.*

[3] *Rutkowski, K.: Best practices in logistics and supply chain management. In: Donald Walters (Ed.). Global Logistics: New Directions in Supply Chain Management, 6th Edition. Kogan Page Limited, London UK, Philadelphia, U.S.A. 2010, pp 14-30.*

[4] *Desta, A.: A conceptual framework for assessing the transferability of the Japanese Kaizen Management techniques to manufacturing plants in Ethiopia. In: Asian Journal of Business & Management Science 1 (2011) 6, pp 09-19.*

[5] *Andersen, B.; Fagerhauf, T.; Randmæl, S.; Schuldmaier, J.; Prenninger, J.: Benchmarking Supply Chain Management: Finding Best Practices. In: Journal of Business & Industrial Marketing 14 (1999) 5/6, pp 378-389.*

[6] *Francis, J.: Benchmarking: Get the Gain. In: Supply Chain Management Review 12 (2008) 4, pp 22-29.*

[7] *Díaz, A., Lorenzo, O. & Solís, L.; Claes, B.: Benchmarking Logistics and Supply Chain Practices in Spain. In: Supply Chain Forum International Journal 12 (2011) 2, pp 82-91.*

[8] *Supply Chain Council: Supply Chain Operations Reference (SCOR) model Version 10. The Supply Chain Council, Inc. SCOR. The Supply Chain Reference (binder) 2010.*

[9] *Steinmueller, W.: ICTs and the Possibilities for Leapfrogging by Developing Countries. In: International Labor Review, 140 (2001) 2, pp 193-210.*

[10] *Saenz, M.; Lamban, M.; Garcia, C. et al.: Buenas prácticas en la gestión de la cedena de suministro -estudio empirico.. In: Documento de trabajo – Fundación Economía Aragonesa (FUNDEAR) 33 (2006), pp 1-50.*

Fasika Bete Georgise, M.Sc.
Supply Chain Modeling & Improvement of Manufacturing Industry in Developing Countries

E-mail: geo@biba.uni-bremen.de
Country: Ethiopia
Start: 01.02.2010
Supervisor: Prof. Dr.-Ing. Klaus-Dieter Thoben
Faculty: Production Engineering
Research Group: Collaborative Business in Enterprise Networks

Requirements of Decision Support Models for Collaborative Supply Chain Security

Julie E. Gould
Prof. Dr. Cathy Macharis
Prof. Dr. Hans-Dietrich Haasis

Global supply chains face a great deal of uncertainty due to dynamics in their environments. These dynamics include the pressure organizations face to secure their supply chains against security threats. The selection and implementation of appropriate supply chain security measures are decisions require collaborative decision support, such as that offered by Operations Research and Management Science (OR/MS) methods and approaches. However, scholars have mainly focused on decision-making in hierarchical structures that do not reflect the nature of global, highly collaborative supply chains. Hence, while the study of OR/MS offers opportunities to structure, analyse and evaluate potential solutions for security problems, a solid framework for modelling security decision problems in the context of multi-actor supply chains is still required to incorporate a) various stakeholder perspectives and b) dynamic information, including real-time. Developments in future research in the area of decision support for supply chain security to incorporate these two aspects will support the building of dynamic supply chain management capabilities.

Introduction >>>

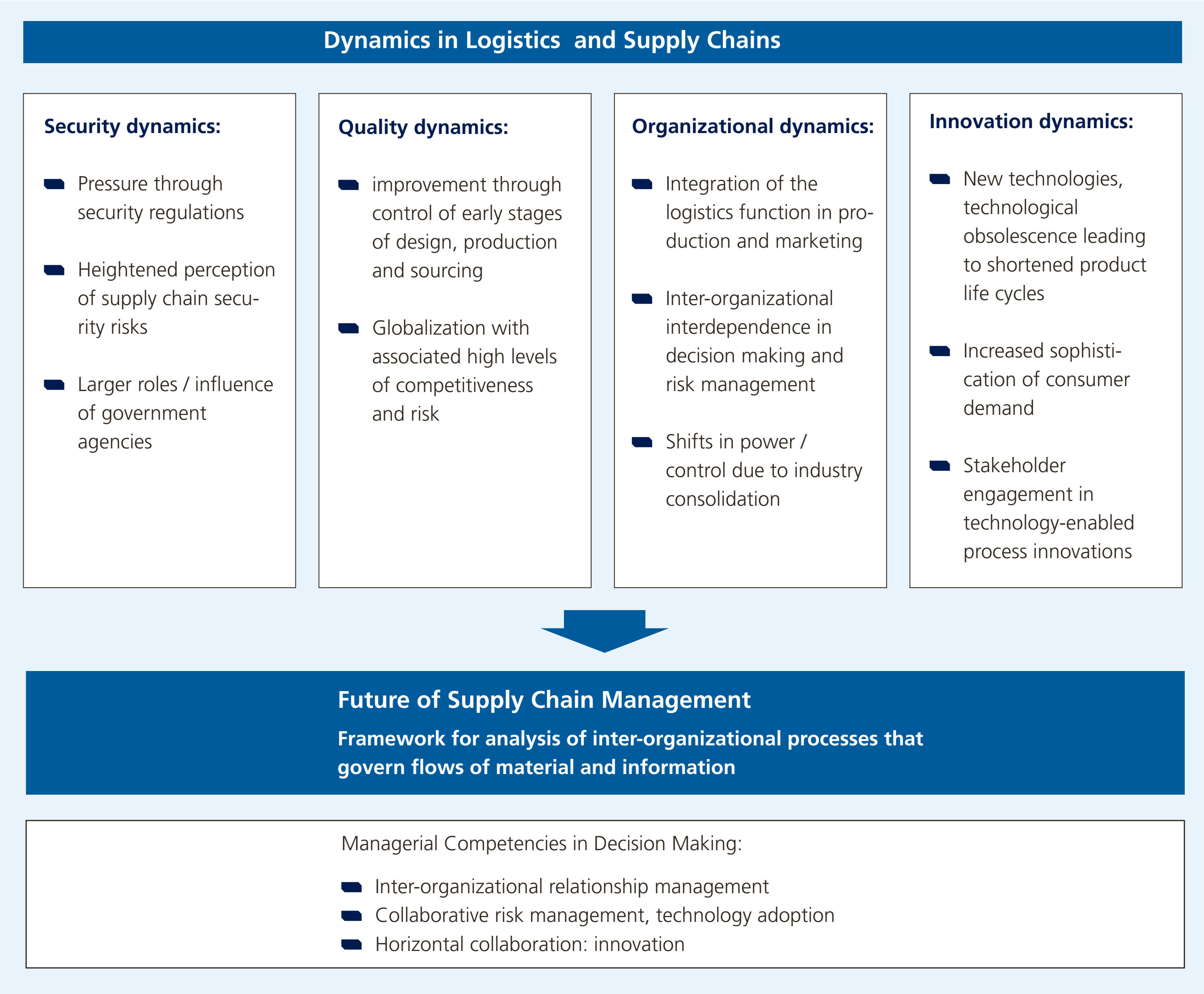
Supply Chain Security Dynamics Pose Challenges for Decision-Making

Supply chains serve an important economic function: they provide the coordination of production, transportation and distribution activities to match demand and supply of products and services; in meeting demand, supply chains create value. Supply chains operate in global, highly competitive environments, and therefore must strive for efficiency and effectiveness in their value-creating activities and processes. In their value-creating role, global supply chains face a great deal of uncertainty due to dynamics in their environments. Shifts in global economics, markets and technology are sources of dynamics for supply (value) chains, and represent strong sources of risk and uncertainty. Currently supply chain dynamics include the pressure organizations face to secure their supply chains against any possible sabotage for the purpose of committing a malicious attack Heightened security threats, awareness of security risks and the requirements of international security regulations contribute to the pressure put on global supply chains to implement a security strategy.

To deal effectively with these dynamic forces – that is, to continue to create value and remain competitive in their demand-fulfilling activities and processes – supply chains must demonstrate the appropriate managerial capabilities, i.e., those that foster effective coordination between actors in the value chain: inter-organizational relationship management – for example, at the dyadic buyer-seller relationship [1] –, collaborative risk management, innovation strategies and technology adoption. Figure 1 highlights some categories of dynamics acting on supply chains, and a number of managerial decision-making capabilities that supply chains must exert in order to deal effectively with associated risks and uncertainties.
Figure 1 Current Dynamic Forces on Supply Chains Requiring Management Capabilities [2]

The risks and challenges associated with requirements for supply chain security (SCS) have led this to become an area of significant interest, specifically over the last decade. Heightened security threats, increased awareness of these security risks and the requirements of international security regulations have put pressure on global supply chains to demonstrate the trustworthiness of their operations. In particular those activities involving cross-border trade are under scrutiny. This has led actors to consider and to implement security measures.

Figure 1: Current dynamic forces on supply chains requiring management competencies [2]



The implementation of supply chain security measures on a strategic or operational level is a decision problem that requires collaboration in decision-making. Specifically, security decisions involve the sharing of costs, change efforts, risks and potential benefits across the supply chain, and hence, need to take into account the multiplicity of objectives and their differing value to the various stakeholders. Quality of decision-making can by supported by analytical support through operations research and management science (OR/MS)

The purpose of this paper is to investigate the applicability of OR/MS methods to collaborative decision-making in multi-actor supply chains towards supply chain security. In considering this question, this paper will look at the selection and implementation of supply chain security measures in the context of a subordinating research question:
What complexities exist in decision-making within collaborative supply chains for selecting implementing security measures in a supply chain? <<<

Strategic and Operational Measures towards Supply Chain Security Objectives

Security for supply chains has risen in the last 10 years in importance for supply chains. SCS looks at the risk of terrorism – and, relatedly, theft and counterfeit risks – and their impacts on supply chain strategy and operations. Besides the risks associated with the threat of terrorism (theft, loss, but, centrally, malicious sabotage involving transported assets), there are additional ones to do with the impacts of security regulations, which result in additional costs, delays and even unpredictability [3]. The pressure to comply with and achieve certification along security regulations (for example, certification as an AEO – Authorized Economic Operator), is itself a challenge for supply chain actors. These risks and their resulting challenges are forces driving organizations to invest into the security of their supply chains. Supply chain security can be defined as "the set of activities, assets, and exchanged information aimed at preventing, detecting and recovering from disturbances and intrusions in the physical flow of materials and the accompanying information" [2].

In response to security risks, organizations can pursue security-related strategies around several key objectives. These include: a) achieving value from security investments through efficiencies in supply chain-related business processes; b) managing security risks; and c) building capabilities in detecting, responding to and recovering from unforeseen events and crises [4-5]. Toward their supply chain security objectives, an organization can choose to employ technical or organizational security measures.

The selection and implemention of appropriate supply chain security measures are decisions that have direct and indirect impacts across organizations in any given supply chain, in particular, additional costs, required change efforts, risks as well as potential benefits. Therefore, a key determinant in the selection of the security strategy and measures are the relationships in the supply chain: with suppliers [6], with governmental bodies [7-8], as well as with customers, who act as drivers for implementing security measures [2].

Five main categories of security measures have been identified in the literature [5]:

1) improved communication in the supply chain,
2) adherence to international regulatory security initiatives,
3) changes in logistics operations or having alternatives to implementation in the case of a security incident,
4) building capabilities in resilience and response to deal with security incidents, and lastly,
5) creating a security culture to define the communication of a security strategy and support the success of the implementation of security measures.

Besides the identification of security objectives and the selection of measures to pursue them, operational planning needs to take place for the objectives to be met. For all of the categories of security measures, an increased level of information sharing and collaboration between organizations and across functions is required to support the operationalization of the supply chain's security strategy.

Collaborative Supply Chain Decision-Making Support Requirements

The organizational complexity represented by such decisions requires collaborative decision support. Decision making is the management task. In supply chains, demonstrating inter-organizational competitive strategies and processes, decision making is being done across organizations [9]. Important areas for collaborative decision making include: selection and application of information systems [10], optimal use of assets, and the provision and sharing of information. Collaboration acts as a catalyst for improving supply chain activities in: improving the successful implementation and acceptance of systems [10-11], building trust for partnerships [9], improving visibility and flexibility in the face of high levels of dynamicity in the environment [11]. Collaborative decision-making, then, must deal with:

- Multiple sets of, potentially dissimilar, objectives;
- Uncertainty and risk, often unforeseen;
- Complexity in incorporating large amounts of data;
- High levels of environmental dynamicity.

Operations Research and Management Science (OR/MS) are dedicated to the study and development of formalized managerial decision-making, offer methods and approaches for modeling decision-making problems in order to provide analytical support to management in selection between alternative courses of action or strategies; however, scholars have mainly focused on decision-making in hierarchical structures that assume a single decision maker and hence do not reflect the nature of global, highly collaborative supply chains. In such a context, how well do current OR/MS methods support supply chains in making efficient decisions regarding their security?

The complexity of managing collaborative supply chains is indeed a point of interest for management scientists [12]. The stages of decision-making involve, generally:

1) identification of the problem, including qualification and operationalization of the problem and specifications of objectives for a solution;
2) the generation and evaluation of alternatives, given the contextual risks and uncertainties;
3) realization of the alternative selection.

Collaborative decision scenarios, then, necessarily involve weighing multiple sets of objectives and risks; hence, the evaluation (or, rating) of the alternatives under consideration will be subjective to the perspective taken, and may certainly vary based on the viewpoint of any one given organization rather than the to-be-optimized "virtual supply chain". Decision support, then, involves the formalization of both the problem and objectives, which are then used to generate and evaluate options. In particular the study of OR/MS offers opportunities to structure, analyse and evaluate potential solutions for security problems.

The complex, inter-organizational nature of supply chains requires that decision support models designed to assist in their management are able to use a decision framework outside of and beyond the scope of a single firm. In the context of a value chain, one embedded in a complex network demonstrating mutual interdependencies, the decision setting is neither hierarchical nor market oriented, but one towards cooperation and collaboration. Decision support for collaborative supply chains must offer analytical support at the level of the supply chain, rather than for any one organization [9].

For operational transport decision making for supply chain security, research is challenged to address these issues by:

- Forwarding modelling methodologies that are closer to the perception of transport policy makers, transport operators and users;
- Incorporating multiple actors and multiple levels of planning in meaningful ways;
- Incorporating qualitative factors in transport planning to support the goals of the supply chains using the transport activities. Some relevant qualitative factors include: a) trust between the shipper and the transport operators and b) security capabilities resulting from characteristics, such as security culture, presence and use of forewarning mechanisms, and contingency and continuity planning.

Besides reflecting objective of multiple decision makers, decision support methods for supply chain security should allow for the incorporation of real-time information, including signals, in the decision-making process [13]. These include signals from visibility technology, such as Track & Trace, that allow for anomaly detection. This is particularly of interest for supply chains facing the threat of terrorism, theft and sabotage. Timely action-taking in response to detection security events represents better decision making through the incorporation of real-time information. This leads further to creating feedback loops to allow for re-evaluation of adjustment [14]. Specifically, inclusion of feedback-loops can significantly increase efficiency and improve performance over time. To summarize, a solid framework for modelling security decision problems in the context of multi-actor supply chains is still required to incorporate a) various stakeholder perspectives, and b) dynamic information, including real-time, and c) feedback-loops that improve performance over time. This has the potential to lead to newer methods of control (such as autonomous cooperation); in any case, co-ordinating structures in a multi-actor chain represent an area for future research [15], especially those incorporating multiple actors and multiple planning horizons [16]. Importantly, such developments in future research in the area of decision support for supply chain security will likewise support the building of dynamic supply chain management capabilities.

Conclusion and Outlook

To deal effectively with dynamics in their operating environment and markets, supply chains have to demonstrate managerial capabilities, i.e., collaborative decision-making capabilities. Security threats and regulations in particular pose challenges for supply chain decision-making on the strategic as well as on the operational level. The key issue continues to be balancing the need to mitigate security risks while maintaining competitiveness through value creation, driving areas for potential gains in business process efficiency, security risk mitigation, and supply chain resiliency. However, the paths toward the achievement of these security objectives are still areas for research. OR/MS can support decision-making between high-level objectives and in support of security strategy, if the methodologies can effectively incorporate real-time, event driven information, non-hierarchical decision-making typologies. Such decision models can then support operational implementation of security measures in the supply chain.

References

[1] *Svensson, G.: Key areas, causes and contingency planning of corporate vulnerability in supply chains: A qualitative approach. In.: International Journal of Physical Distribution & Logistics Management 34 (2004) 9, pp 728-748.*

[2] *Gould, J.E.: A Decision Support System for Intermodal Logistics under Considerations for Cost and Security. Universität Bremen, Bremen, Germany 2010.*

[3] *Wolfe, M.; The Dynamics of Supply Chain Security. In: The Monitor 10 (2004) 2.*

[4] *Gutiérrez, X., et al.: Voluntary Supply Chain Security Program Impacts: An Empirical Study with BASC Member Companies. World Customs Journal 1 (2007) 2, pp 31-47.*

[5] *Gould, J.; Macharis, C.; Haasis, H. D.: Emergence of security in supply chain management literature. In: Journal of Transportation Security 3 (2010) 4, pp 287-302.*

[6] *Rinehart, L. M.; Myers, M. B.; Eckert, J. A.: Supplier Relationships: The Impact on Security. In: Supply Chain Management Review 8 (2004) 6, pp 52-59.*

[7] *Fletcher, T.: Authorized Economic Operator (AEO) Programs: IBM's Perspective. In: World Customs Journal 1 (2007) 2, pp 61-65.*

[8] *Williams, Z., et al.: Why all the changes?: An institutional theory approach to exploring the drivers of supply chain security (SCS). In: International Journal of Physical Distribution & Logistics Management 39 (2009) 7, pp 595-618.*

[9] *Dimitris, F. et al.: Evolution of a supply chain: cases and best practices. In: Internet Research 14 (2004) 4, pp 274-283.*

[10] *Sarkis, J.; Talluri, S.: Evaluating and selecting e-commerce software and communication systems for a supply chain. In: European Journal of Operational Research 159 (2004) 2: pp 318-329.*

[11] *Volkoff, O.; Chan, Y. E.; Peter Newson, E. F.: Leading the development and implementation of collaborative interorganizational systems. In: Information & ; Management35 (1999) 2, pp 63-75.*

[12] *Akkermans, H.; Bogerd P.; van Doremalen, J.: Travail, transparency and trust: A case study of computer-supported collaborative supply chain planning in high-tech electronics. In: European Journal of Operational Research, 153 (2004) 2, pp 445-456.*

[13] *Power, D.J.; Sharda, R.: Model-driven decision support systems: Concepts and research directions. In: Decision Support Systems 43 (2007) 3, pp 1044-1061.*

[14] *Schönberger, J. ; Kopfer, H.: Online decision making and automatic decision model adaptation. In: Computers & Operations Research 36 (2009) 6, pp 1740-1750.*

[15] *Bontekoning, Y. M.; Macharis, C.; Trip, J. J.: Is a New Applied Transportation Research Field Emerging?--Review of Intermodal Rail-Truck Freight Transport Literature. In: Transportation Research: Part A: Policy and Practice, 38 (2004) 1, pp 1-34.*

[16] *Caris, A.; Macharis, C.; Janssens, G. K.: Planning Problems in Intermodal Freight Transport: Accomplishments and Prospects. In. Transportation Planning and Technology, 31 (2008) 3, pp 277-302.*

Julie E. Gould, M.A.

A Decision Support System for Intermodal Logistics under Considerations for Costs of Security

E-mail: jgould@uni-bremen.de
Country: Canada
Start: 01.11.2005
Supervisor: Prof. Dr. rer. pol. Hans-Dietrich Haasis
Faculty: Business Studies / Economics
Research Group: Business Administration, Production Management and Industrial Economics

Calibration of Thermal Flow Sensors by New Test Device for Low Airflow Rates

Safir Issa
Chanaka Lloyd
Prof. Dr.-Ing. Walter Lang

Calibration of flow sensors is a very crucial operation for providing confidence in sensor readings and their uncertainties. However, calibration is a difficult mission in many cases due to the complexity of performing controlled measurements. This paper introduces a calibration method for thermal flow micro-sensors. A new test-device is designed and manufactured for this calibration purpose; it is suitable for the air velocity range from 0 to 7 m/s. The sensor is placed in a long tube in which the air velocity is controlled through a mass flow controller. Sensor results are characterized, modeled by a function-model in MATLAB and then calibrated. The calibration method is based on direct comparison between readings of the sensor under calibration and a reference anemometer. Results of this calibration method show that the maximum uncertainty over the studied range is 0.24 m/s.

Introduction >>> Thermal flow sensors are used for many applications, such as medical, automotive and airflow measurements [1, 2]. One of the relevant fields of the last application is the airflow measurement in transport containers. Such measurements help improve the transport processes by predicting temperature, identifying stagnant zones in containers, and as a consequence, taking preventive actions to maintain products' quality [3]. Container requirements, e.g. narrow accessible holes, low air velocity and the need to send data through wireless network are considerable motivations to use these sensors for such objective. However, these sensors are developed for research purposes, and therefore they need to be characterized and calibrated precisely before using them in real applications.

Sensors used here are thermal flow micro-sensors developed by IMSAS [4]. They consist of a heater and two thermopiles embedded in a low stress silicon nitride membrane, which is 1 × 1 mm^2 in dimensions and 600 nm in thickness. The heater is made of tungsten-titanium, whereas the thermopiles are made of a combination of polycrystalline silicon and tungsten-titanium. The sensing principle is straightforward: as the heater receives power it generates heat that is distributed uniformly in all directions. In a stagnant case, where no airflow passes through the sensor, both thermopiles produce similar output voltages. However, when there is an airflow, part of the generated heat is convected by the air current in the flow direction. As a result, a difference between up- and downstream thermopiles is detected. This difference is related to the flow value, and it is the interested part in the sensor characterization. A constant power circuit is used to operate the sensor during this study. The used sensor has a fast response time of about 3 ms [5].

In literature, it is difficult to find reports about the calibration of this kind of sensors. However, there are many reports about hot wire anemometers calibration, such as by Al-Garni [6] and Özahi et al. [7]. The former reports about a method based on moving hot wire probes in stagnant air for low speed values below 1 m/s, and the latter also reports about in situ calibration and rotating disc methods also for low speed values. However, neither of the above reports mentions uncertainty of measurements for the reported methods.

In this study, a description of a new test device is illustrated in Section 2. After that the calibration method is explained in Section 3. First characterization and modeling of the sensor results are done, and then the calibration of the sensor by comparing its results with those of the reference anemometer is performed. The uncertainties, yielded from different parameters that influence the measurement results, are evaluated in Section 4. <<<

Description of the calibration test device

The test device consists of a Plexiglas tube of 1.5 m in length and 35 mm in diameter (see Figure 1). The inlet is connected to a mass flow controller (MFC) through a pipe of 10 mm in diameter. From this inlet the air flows through a conic section before entering the tube. On the tube entrance, a thin regulator is placed which consists of a plate with many small holes to distribute the airflow uniformly inside the tube. At a distance of 1 m from the inlet a special parallelepiped section is in place to hold the airflow sensor. The sensor is fixed on a special cover of the parallelepiped section. This cover assures that the sensor membrane is placed exactly on the horizontal center line of the tube. A small hole on the cover makes way for the connection wires to connect the sensor signal and power terminals to the constant power circuit outside. A schematic drawing of this test device is depicted in Figure 1.

A second cover for the parallelepiped section is designed for the reference anemometer probe. This cover has a hole that allows the insertion of the anemometer probe from the top and places its sensing probe head exactly in the tube's center. No air leakage was detected with this design during calibration measurements.
In the characterization setup, one mass flow controller (MFC in Figure 1) with maximum capacity of 300 SLM (Standard Liters per Minute) from MKS Company (MKS Instruments, Germany) is used. It is connected through pipes to an air supply source from one side and to the inlet of the testbed from the other side, as shown in Figure 1. This controller is driven by the control unit MKS (model: 147C, MKS Instruments, Germany) where a LabVIEW program is used to set the desired flow inside the pipe. The sensor which is placed inside the pipe detects the changes in the airflow, and its two thermopile's signals are extracted by NI DAQ (National Instruments data acquisition) device. The sensor output data of the related flow values are stored in a PC. From the two thermopile signals, we calculate the output voltage difference as a function of flow. For our application, i.e. airflow measurement in transport containers, air velocity value is of more importance than the flow value. For this reason, we consider it as the basic parameter in this study.

To study the flow in the setup, we distinguish between two situations. On the one hand, flow inside the pipe which is characterized mainly by Reynolds number:

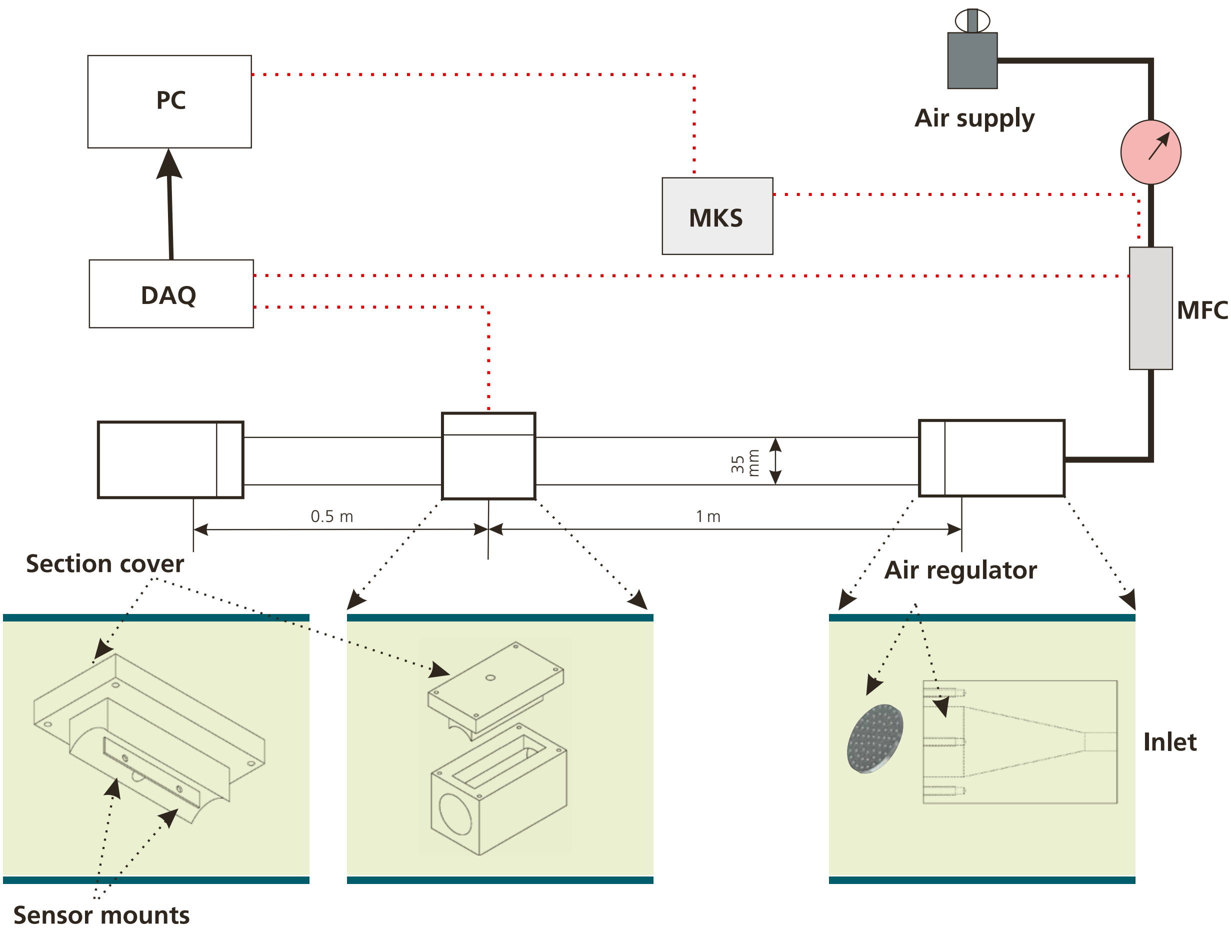
$$Re = \rho \cdot v \cdot D / \mu \qquad (1)$$

where ρ is the air density; v is air velocity; D is the pipe diameter and μ is the dynamic viscosity of air. Calculations show that Reynolds number inside the pipe for air velocities higher than 2 m/s is more than 4000, which implies that we have turbulent flow. Only for the velocity of 1 m/s the Reynolds number is about 2100 in the laminar flow limit, but with the perforated plate acting as a turbulence generator, we assume that the flow inside the pipe is turbulent for the whole range. The entry region for fully developed turbulent flow is about 10 to 60 times the diameter [8]. In our case, this distance is about 30 times the diameter. On the other hand, the boundary layer flow over the sensor is considered according to the flow over the parallel plates as the position of the sensor parallel to the flow in the middle of the test tube. In this case, the critical Reynolds number is 60,000 for laminar flow in the boundary layer over the sensor [9, 10].

$$Re(x) = \rho \cdot v \cdot x / \mu \qquad (2)$$

The distance x from the leading edge of the sensor's PCB is 22 mm which is the characteristic length in this case. Therefore, the calculated Reynolds number is below 10,000 in all measurement cases and it is much smaller than the critical value.

Figure 1: Schematic drawing of the manufactured calibration test device



Calibration method

The relationship between the air velocity v at the pipe center is given in m/s and the flow F delivered by the mass flow controller given by SLM is estimated as:

$$v = \frac{3 \cdot 10^{-3} \cdot F}{2 \cdot 60 \cdot \pi \cdot r^2} \qquad (3)$$

The experimentally obtained parameters – air velocity and thermopiles voltage difference – are plotted to yield the calibration curve, as explained in Section 2; the function-model that best fits these experimental results, is the following:

$$\Delta E = a + b \cdot v^c \qquad (4)$$

where ΔE is the thermopiles voltage difference in mV; v is the air velocity at the sensor position; a, b and c are constants to be determined for the best fit of experimental results through a MATLAB program. The flow range in these experiments is from 0 to 300 SLM; the entire range is covered with flow increments of 2 SLM each step increase. For each flow step, velocity and sensor output voltage are calculated and plotted. Then the MATLAB program determines the constants a, b and c for the best fit. Figure 2 shows the characteristic curve of the sensor where the thermopiles voltage difference is plotted against the air velocity, and how it compares with the fitting curve. This operation is repeated 7 times in several days during one month to check the repeatability of the measurement. For the fitted curve, we adopt the mean value of each constant from all tests.
As a result we found:

$$\Delta E = 0.26 + 5.62 \cdot v^{0.66} \qquad (5)$$

with R-squared value 0.998 which expresses the high agreement between the experimental results and the model. In practice, air velocity is the interested output parameter as a function of the thermopiles voltage difference. Therefore, we rewrite the function-model in the following form:

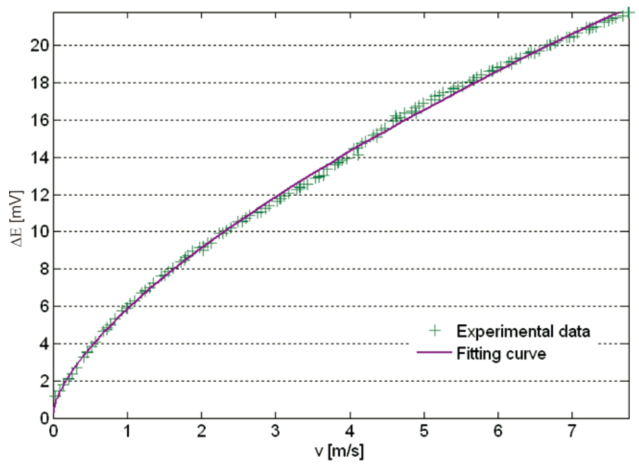
$$v = \alpha + \beta \cdot \triangle E^{\gamma} \qquad (6)$$

where α, β and γ are constants to be determined for the best fit through the same MATLAB program mentioned above. The only difference is that in the first case the air velocity is considered as a variable and the thermopiles voltage difference is the output; inverse is considered in the second case. Previous measurements give:

$$v = -0.01 + 0.07 \cdot \triangle E^{1.35} \qquad (7)$$

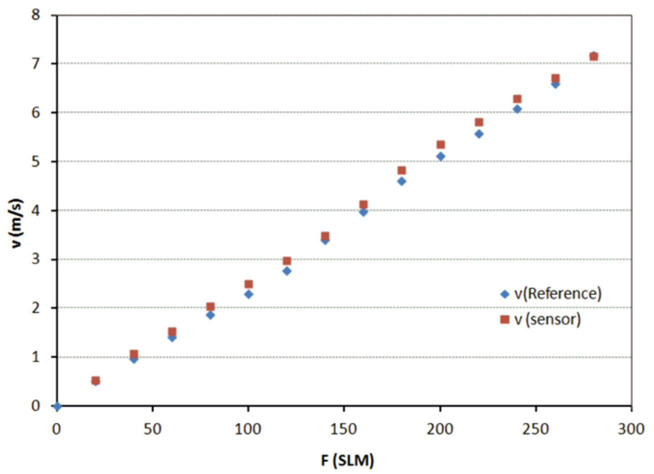
R-squared value is also 0.998. The last equation is adopted as the output characteristic of the sensor. This equation is also validated by the calibration of the sensor explained in the next paragraph.

Figure 2: Characteristic curve of the sensor where the thermopiles voltage difference is plotted against air velocity



We use the calibration setup described in Section 1, shown in Figure 1. The calibration method is based on the comparison between the flow sensor and the reference device readings for the flow range from 0 to 300 SLM. The used reference anemometer is the thermo-anemometer VT200 (KIMO Instruments, France), a calibrated airflow measurement device. We place the probe of the reference device and the sensor under calibration at the same place alternatively, one at a time. In both cases, the sensing element –membrane of the flow sensor and the probe head of the anemometer– is aligned with the horizontal centre line explained in Section 2. The flow inside the tube is controlled by the control unit and the mass flow controller. Sixteen test points are checked, starting from 0 SLM with successive flow steps of 20 SLM. Readings of both the flow sensor under calibration and the reference device are registered. This operation is repeated 4 times on different days to check the repeatability. The equivalent velocity of the sensor under calibration is calculated from Equation (7) as a function of the thermopiles voltage difference for the test points, whereas the reference device gives the air velocity as a direct output. Average values are calculated for results comparison, whereas standard deviations are considered for uncertainty estimation. Figure 5 shows a comparison between the sensor and reference device results. This comparison shows good agreement between both results; this validates the model given to the sensor output. The maximum relative difference is taken as percentage, which is the ratio between the difference (sensor-reference) and the value measured by the reference anemometer, and it is about 9% for the whole range, i.e. 0 to 7 m/s; it decreases to about 5% for the range 3 to 7 m/s. Moreover, the absolute maximum difference over the whole calibration range is about 0.2 m/s. The plots, depicted in Figure 5, show a slight overestimation in sensor readings with respect to the values measured by the reference anemometer, in particular for velocities lower than 7 m/s. These slight differences are most likely caused by the assumed relation between the mean and the maximum velocities in the pipe, and also by the estimated function-model in Equation (7).

Figure 3: Comparison of sensor and reference device readings for different flow values.



Uncertainty of measurement is a basic metrological parameter defined by (VIM 1993) [11] as: "parameter, associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand". It reflects the lack of exact knowledge of the value of the measurand. Quantitatively, uncertainty of a measurand y is calculated by the law of propagation of uncertainty, assuming that all input quantities xi are independents [12]:

$$u_c^2(y) = \sum_{i=1}^{n} \left(\frac{\partial f}{\partial x_i}\right)^2 u^2(x_i) \qquad (8)$$

where the measurand y is a function dependent on all input quantities xi by the functional relationship

$$y = f(x_1, x_2, \dots, x_N) \qquad (9)$$

where $\frac{\partial f}{\partial x_i}$ is the sensitivity coefficient and $u(x_i)$ is the standard uncertainty for the input quantity i.

Analysis of the above described calibration method of thermal flow sensor allows determining the parameters or the input quantities that affect measurement uncertainty. These parameters are: function-model formula, mass flow controller, reference, repeatability of measurements, and ambient temperature. For each parameter, we calculate the standard uncertainty by associating an appropriate probability density function and then the sensitivity coefficients. Multiplying the individual standard uncertainties with the corresponding sensitivity factor and then make the sum as in Equation (8) enables calculating the combined uncertainty. Results show that the maximum uncertainty over the studied range is 0.24 m/s.

Conclusion

A simple calibration method for thermal flow sensors is presented. This method is based on a direct comparison between readings of the sensor and a reference anemometer in a testbed designed and fabricated for this purpose. First, the sensor results are characterized and modeled, then compared with those of the reference device. Further investigations will be carried out after using these sensors in measuring airflow velocity in transport containers to evaluate the calibration method and to take into consideration new parameters raised from field tests.

References

[1] *Silvestri, S.; Schena, E.: Micromachined flow sensors in biomedical applications. Micromachines 3 (2012) 2, pp 225-243.*

[2] *Fleming, W. J.: Overview of automotive sensors. In: Sensors Journal, IEEE 1 (2001) 4, pp 296-308.*

[3] *Issa, S.; Lang, W.: Characterization of thermal flow sensors for air flow measurements in transport containers. In: Proceedings of the 3rd International Conference on Dynamics in Logistics (LDIC 2012). Bremen, Germany 2012.*

[4] *Buchner, R.; Sosna, C.; Maiwald, M.; Benecke, W.; Lang, W.: A high temperature thermopile fabrication process for thermal flow sensors. In: Sensors and Actuators A: Physical 130-131 (2006), pp 262-266.*

[5] *Issa, S.; Sturm, H.; Lang, W.: Modeling of the response time of thermal flow sensors. In: Micromachines 2 (2011) 4, pp 385-393.*

[6] *Al-Garni, A. M.: Low speed calibration of hot-wire anemometers. In: Flow Measurement and Instrumentation 18 (2007) 18, pp 95–98.*

[7] *Özahi, E.; Çarppinlioglu, M. Ö.; Gündogdu, M. Y.: Simple methods for low speed calibration of hot-wire anemometers. In: Flow Measurement and Instrumentation 21 2010, pp 166 -170.*

[8] *Incropera, F. P.; DeWitt, D. P.: Fundamentals of heat and mass transfer, 5th Edition. John Wiley & Sons, Hoboken, NewJersey, 2002.*

[9] *Cubukcu, A. S.; Zernickel, E.; Buerklin, U.; Urban, G. A.: A 2D thermal flow sensor with sub-mW power consumption. In: Sensors and Actuators A: Physical 163 (2010), pp 449-456.*

[10] *Lienhard, J. H. I. V.; Lienhard, J. H. V., A Heat Transfer textbook, 3rd Edition. Phlogiston Press, Cambridge, United Kingdoms, 2008.*

[11] *International Vocabulary of Metrology – Basic and general concepts and associated terms (VIM). 3rd Edition. Joint Committee for Guides in Metreology (JCGM), 2008.*

[12] *Evaluation of measurement data guide to the expression of uncertainty in measurement, 1st Edition. Joint Committee for Guides in Metreology (JCGM), 2008.*

Safir Issa, M.Sc.
Flow Sensors and their Applications to Convective Transport in the Intelligent Container

E-mail: sissa@imsas.uni-bremen.de
Country: Syria
Start: 01.08.2010
Supervisor: Prof. Dr.-Ing. Walter Lang
Faculty: Physics / Electrical Engineering
Research Group: Institute for Microsensors, -actuators- and -systems (IMSAS)

DASH7 Inspired Wireless Airflow Sensing Inside Refrigerated Containers

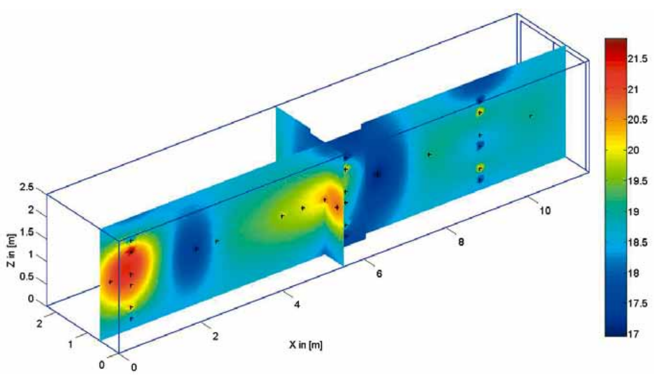
Chanaka Lloyd
Prof. Dr.-Ing. Walter Lang

The inter-continental transportation of bananas is a large industry. It is highly prone to temperature fluctuations within the containers due to internal banana ripening process and inadequate ventilation of cold air within the container. This results in loss of quality of bananas and financial losses. Therefore, proper sensors to measure the air flow within the containers and communication means to tackle the high attenuation of radio signals within bananas are required to ascertain temperature hot spots and relay the sensor data effectively. This paper discusses the usage of thermal flow sensor electronics and a calibration process for measuring the air flow speed, and discusses the design of a new wireless sensor platform based on the new DASH7 technology for added advantage over radio communication in 2.4 GHz frequency.

Introduction >>> Food transport is a large and globally challenging industry. Transportation of perishable food items, such as bananas, avocados, strawberries, etc., present even more challenges due internal ripening processes that take place if the desired temperature is not maintained, especially in intercontinental transports. Therefore, maintenance of the correct temperature using cooling units in containers is of paramount importance.

The work presented in this paper is related to the Intelligent Container project [1]. Therefore, the emphasis is on transportation of bananas in refrigerated containers. The studies have shown that hot spots, or localized high temperature zones, are abundantly prevalent in banana transports (Figure 1) [2].

Figure 1: Air temperature distribution inside a container (with cooling unit) packed with bananas



The freshly packed, raw bananas are shipped from Costa Rica to Germany. Interruptions in the cold chain, i.e. during the loading of the bananas from warehouse to ship and vice versa, and slow ripening processes within the bananas cause the temperature to rise above the desired temperature range of 13 to 14.4 °C. Therefore, the cooling unit takes the additional heat off the bananas to bring the temperature down to the desired temperature. This happens by means of heat transfer between the bananas and the cool air that is circulated in the container.

The studies show that 800 Watt of heat per ton is produced in bananas [3]. As the temperature data obtained within the banana containers show, despite cooling units with enough cooling load, the temperature still rises above the desired temperature range in unpredictable manner in containers; these locations are aptly called hot spots. This is because of the heat transfer process, as discussed above, not taking place due to lack of air flow within and around the identified hot spots. Therefore, the quantifying and logging temporal air flow data within the containers is required for quick identification of possible hot spots. Change of air flow is readily measurable due to very low time constant of air flow change, in contrast to temperature change. The eventual target of the work presented in this paper of measuring the air flow in containers is to correlate them with temperature data, in order to obtain an efficient hybrid model (air flow and temperature) to predict the hot spots much faster than the existing temperature models.

Figure 2: Thermal flow sensor with its 2 thermopiles, heater element, temperature sensor (extra feature) and bond pads

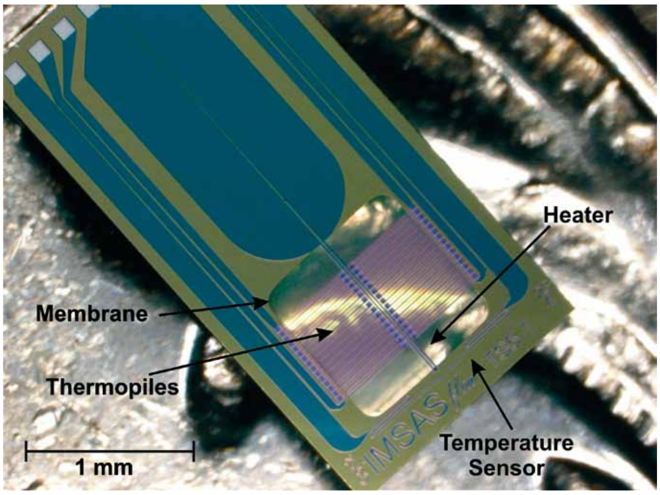
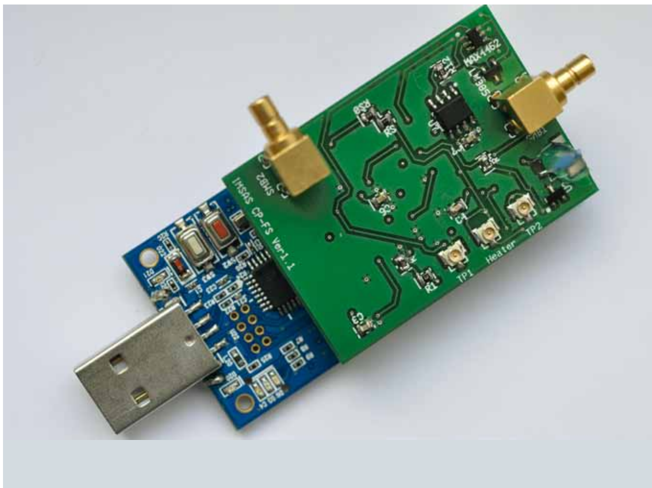


Figure 3: Constant Power (CP) circuit mounted on top of a TelosB wireless node



A thermal flow sensor (Figure 2) [4], using a Constant Power method for reading the sensor, is used to measure the air flow speed. Currently, it is mounted on a TelosB 2.4 GHz wireless node for wireless sensing of the air flow sensor. Due to inherent drawbacks of the 2.4 GHz communication channel, such as low penetration and low range in high water-containing fruits, it is proposed to use the new DASH7 technology.

DASH7, specifically DASH7 Mode 2, is a new technology that is being developed by the DASH7 Alliance. It is an amendment to the ISO/IEC 18000-7:2004 standard [5], and is based on the 433 MHz Industrial, Scientific and Medical (ISM) radio band. DASH7 is suitable for deployment in low and ultra-low power WSNs. In order to keep the maintenance costs, e.g. replacing batteries, low in WSN solutions, the DASH7 technology solutions offer a low energy consuming framework for the nodes, thereby prolonging the battery life.

This paper discusses a) Thermal airflow calibration and technique, and b) Preliminary DASH7 tag design to replace the current wireless platform TelosB. <<<

Wireless airflow measurement

Air flow is measured by using a thermal flow sensor with high sensitivity, to the tune of 0.446 mVK^{-1} in sensors fabricated using a quartz substrate [4]. The flow sensor comprises of 2 thermopiles and a heater element. In operation, the heater element is powered up to a desired power level; the output voltage difference of the 2 thermopiles is a function of the air (or liquid) flow speed over the heater element. In order to translate and condition the voltage signal, a Constant Power (hereon after called CP) circuit is used. Using digital circuitry (Figure 3) and a proportional-control feedback loop, the latter technique maintains a predetermined power level applied to the heater element. Figure 3 shows the CP circuit mounted on top of a TelosB wireless. The sampled data from the flow sensor (not shown in Figure 3) attached to the CP circuit is sent over the radio to a gateway connected to a host PC for processing during calibration tests and in actual operation.

In the tests performed, 5, 10, 20 and 30 mW power levels were applied. Figure 4a shows how the control loop focuses and stabilizes on the power level of 20 mW; it takes 300 ms to do so. On average, it can be narrowed down to approximately 50 ms. Each loop in the control algorithm is performed subsequent to a radio transmit. The radio on the TelosB takes nearly 20 ms per each transmit. Another 10 ms is allowed for other delays such as time response of the flow sensor, ADC conversion time of the TelosB and calculations in the microcontroller. In the final algorithm, the loop-to-loop time will be minimized to 5ms.

Figure 4a: Measured power of the heater element of the thermal flow sensor and how it focuses on the desired power level of 20 mW

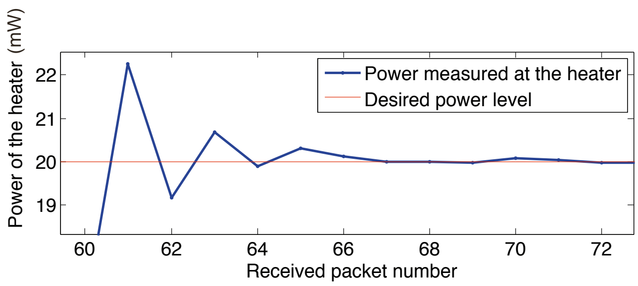
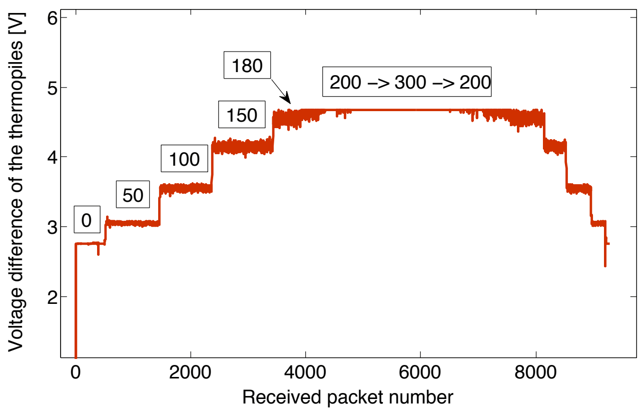


Figure 4b: Thermopile voltage difference against time



The text boxes on each step are the air flow values in SLM.
Each unit on the Y-axis corresponds to 30 ms.

A specially designed testbed was used to simulate different air flow speeds. The air input to the testbed was regulated using a flow controller (model 147C, MKS Instruments). A calibrated KIMO VT200 air flow device was used as a reference. The thermal flow sensor was placed inside the testbed and connected via signal cables to the CP circuit outside. Figure 4a shows a zoomed-in portion of the Power Level vs. Time. It shows how the controller analyzes the existing power level of the heater and compensates to achieve the desired power level. The flow sensor is sampled only when the heater power is at the desired power level.

Figure 4b shows a calibration graph of the Voltage output of the thermopiles vs. Time for gradual, stepwise increments and decrements of air flow input to the testbed. Text boxes in Figure 4b are the air flow values in SLM (Standard Liters per Minute) supplied to the testbed. Above 200 SLM (corresponds to about 3.4 ms^{-1}), the graph is saturated, meaning that the circuit is only capable of handling up to 3.4 ms^{-1}. By controlling the air flow input to the testbed, it is possible to create different air flow speeds at the flow sensor inside the testbed. These tests are still ongoing.

DASH7 wireless sensor node

TelosB wireless platform is based on 2.4 GHz radio frequency. In the field tests that were carried out, it was evident how inefficiently this frequency performed when confronted with metal, concrete and foods with high water content. Therefore, to sample the ambient parameters of a container with sensors distributed within it, hop protocols are required. This means long radio-on times, implying wastage of precious battery power in standalone wireless sensors and nodes.

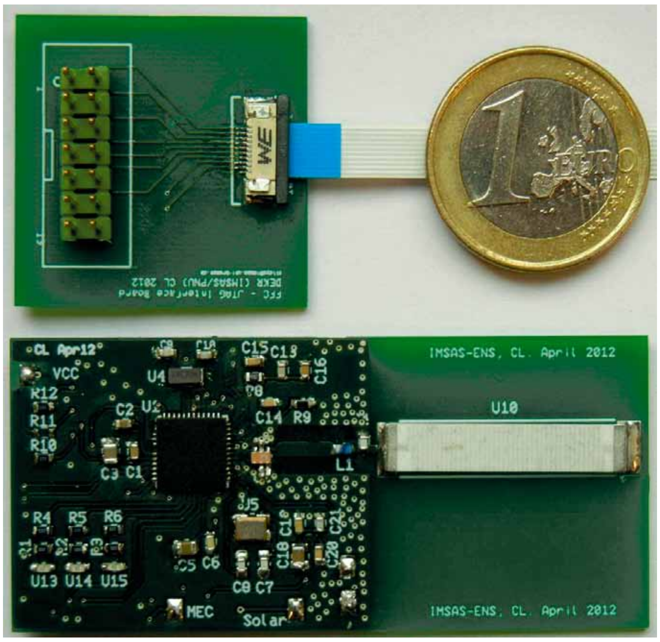
DASH7 technology, with its inherent power saving architecture, can be efficiently used to overcome the disadvantage stated above. DASH7 sensors and nodes, with their long range and superior penetration power, can be effectively used in produce like bananas without too much hopping to relay the data to a gateway. The new DASH7 tag was designed with the latter in mind, with some additional features such as energy harvesting for other uses where solar, vibration and thermal energy can be harvested from the ambience.

Figure 5 shows a finalized prototype PCB of the current DASH7 tag design, which is a first of its kind for a ubiquitous DASH7 tag with energy harvesting capability. The key features of this design are:

- Small form factor chip antenna
- 433 MHz Balun RF circuit
- 8 Mbit flash data logger
- Dual power supply, and
- Energy harvester circuit (with charger/protector chip MAX17710 [6]) with harvesting capability down to 1 µW
- Multiple sensor integration possibility, and
- CC430 SoC microcontroller.

In the case of deployment in containers carrying fresh produce, the tag can be further miniaturized by removing the LEDs, the energy harvesting circuitry and extra oscillator. Miniaturization is required to make sure that the tag is placed as discretely as possible within the produce when taking measurements. The DASH7 tag is programmed with OpenTag [7].

Figure 5: Miniature DASH7 wireless tag with energy harvesting and JTAG programmer interface board



Conclusion and future work

This paper presented ongoing work on a thermal flow sensor calibration using digital circuits and a specially designed testbed. The flow sensor electronics, currently, are capable of measuring up to approximately 3.4 ms^{-1}. The average air flow speeds measured manually and otherwise (using commercially available devices) inside a container are between 0 and 4 ms^{-1}. In order to overcome the drawbacks of the TelosB wireless platform, a new DASH7 platform running on a 433 MHz frequency range was designed.

The future work on the thermal flow sensor is expected to include air flow speeds up to 7 to 8 ms^{-1}. In order to prolong the battery life and improve the communication range, DASH7 tag is to be finalized and deployed in field tests to assess the advantage over 2.4 GHz communication. System tests will be carried out on the DASH7 tag to improve the RF circuitry to achieve maximum range and the circuits will be minimalized for the purpose of measuring air flow and temperature only. Therefore, the CP circuit and the flow sensor are to be integrated on to the DASH7 tag in future work.

References

[1] IMSAS: The Intelligent Container. URL: http://www.intelligentcontainer.com/, Date of access 02.10.2012.

[2] Jedermann, R.; Moehrke, A.; Lang, W.: Supervision of banana transport by the intelligent container. In: Kreyenschmidt, J. (ed.): 4th International Workshop on Coolchain-Management, University of Bonn. Bonn 2010, pp. 75-84.

[3] Kerbel, E.: Banana and Plantain. In: Hardenburg, R.E.; Watada, A.E.; Wang, C.Y. (eds.):

The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks, U.S.

Department of Agriculture/Agricultural Research Service. Washington D.C. 1986, revised

2004, Vol. 66, Agriculture Handbook.

[4] R. Buchner; M. Maiwald; C. Sosna; T. Schary; W. Benecke; W. Lang: Miniaturised Thermal Flow Sensors for Rough Environments. In: 19th IEEE International Conference on MEMS. Istanbul, 2006, pp.582-585.

[5] ISO/IEC 18000-7:2004: Information technology – Radio frequency identification for item management – Part 7: Parameters for active air interface communications at 433 MHz. URL: http://goo.gl/W7td8, Date of access 02.10.2012.

[6] MAXIM Integrated: MAX17710 energy harvesting charger and protector. URL: http://www.maximintegrated.com/datasheet/index.mvp/id/7183, Date of access 02.10.2012

[7] OpenTag: A full-featured communications stack for DASH7 Mode 2 (ISO 18000-7.4). URL: http://sourceforge.net/projects/opentag/, Date of access 02.10.2012.

Chanaka Lloyd, M.Sc.

Airflow Pattern Analysis and Optimization of Quality Degradation Warning Systems with Airflow Parametric Data in Transport Systems

E-mail:	clloyd@imsas.uni-bremen.de
Country:	Sri Lanka
Start:	01.05.2011
Supervisor:	Prof. Dr.-Ing. Walter Lang
Faculty:	Physics / Electrical Engineering
Research Group:	Institute for Microsensors, -actuators- and -systems (IMSAS)

Radio Resource Allocation for M2M Communication in LTE Uplink Scheduling

Safdar Marwat
Dr. Thushara Weerawardane
Dr. Yasir Zaki
Prof. Dr. Carmelita Görg

Logistic processes deeply rely on Machine-to-Machine (M2M) communications. M2M communications require high uplink traffic that is expected to be served by the future mobile networks such as Long Term Evolution (LTE) and LTE-Advanced (LTE-A). The Quality of Service (QoS) provisioning is one of the primary objectives of the wireless network operators. In this paper, the end-to-end QoS performance of the Bandwidth and QoS Aware (BQA) LTE uplink scheduler [1] is evaluated for regular LTE traffic classes. The BQA scheduler is designed to provide efficient allocation of radio resources to users according to the QoS requirements of various traffic classes and the instantaneous channel conditions of the users. The end-to-end QoS performance of the scheduler is analyzed with the help of simulations and the results show that the proposed scheduler guarantees efficient provisioning of the QoS required by users.

Introduction >>> Long Term Evolution (LTE) employs Orthogonal Frequency Division Multiple Access (OFDMA) and Single Carrier Frequency Division Multiple Access (SC-FDMA) transmission schemes for downlink and uplink, respectively. The low Peak-to-Average Power Ratio (PAPR) of SC-FDMA signals reduces the battery power consumption of the User Equipment (UE). Despite the bandwidth allocation flexibility of SC-FDMA, the contiguous subcarriers allocation to a UE and the uplink Power Control (PC) are key uplink constraints. These limitations complicate the resource allocation algorithms and impede the fulfillment of the QoS requirements of different traffic types.

The aim of Machine-to-Machine (M2M) communications is to enable machines to communicate with each other without human intervention [2]. The implementation scenarios of M2M communications include: transportation, production, traffic systems, smart metering and monitoring, and healthcare [3]. The M2M communications can significantly enhance the standards of the logistic processes. The storage period of goods, starting from the departure at the source to the arrival at the destination, requires monitoring of several environmental factors including temperature, pressure, humidity, light intensity and location. Goods are usually sensitive to environmental changes and regular monitoring is required. Based on sensor readings, it is required to take appropriate measures and counteract unwanted situations. The communication of sensor readings and remedial actions has to be facilitated primarily by the mobile radio network infrastructure. The data packets of such messages would undergo the network experience according to their QoS requirements. In logistics industry, the delivery of goods with assurance of time, place, quantity and quality is of immense importance [4]. The hurdles in fulfilling these guarantees are caused by the increasing requirements and expectations of the consumers, and by the limited available resources; which are the causes of "dynamics in logistics". Consequences of these dynamics are rerouting, production strategies alteration, shifting bottlenecks etc. In order to minimize the adverse effects of dynamics, business groups continually strive for devising counteractive measures. The target of M2M communications is to enhance such tactics and fulfill the QoS requirements of M2M messages in logistic processes.

Currently, M2M communications are based on contemporary wireless communication technologies, like General Packet Radio Service (GPRS), which are fulfilling the requirements of certain M2M applications sufficiently. The existing communication technologies offer low-cost deployment of M2M devices with roaming facilities and convenient deployment. However, it is expected that the number of devices based on M2M might undergo an exponential growth. According to [5], the number of connections for embedded mobile M2M applications was recorded as 87 million in 2009 worldwide, and is expected to reach the 428 million mark by 2014. The current wireless systems might run out-of-capacity in the near future and the M2M communications may not be facilitated proficiently.

LTE and LTE-A are promising technologies expected to provide

M2M services in the future [6]. However, the dilemma is that M2M applications are expected to offer a diverse range of services, including narrowband applications transmitting data infrequently; and LTE is primarily developed for broadband data services. With narrowband applications, LTE may not achieve spectrum and cost efficiency. Consequently, it is essential that the architecture of LTE is redesigned in order to conform to the M2M communications requirements. Accordingly, the techniques for resource allocation to regular and M2M users of various QoS classes by LTE network have to be adapted accordingly. <<<

Problem definition

The distinctive characteristics of M2M messages pose serious challenges for wireless network researchers. The most challenging issue is the expectedly large number of M2M messages, since a large number of M2M devices are anticipated to be deployed in the near future. The logistic processes would be supported by M2M devices deployed in the transport vehicles, ships, factories, and storage houses. It requires the mobile networking standard bodies to revise the network designs for efficient support of such messages transmitted and received from these devices. The other major concern are the varying sizes of these messages. The size of M2M messages could be just a few bits as in the case of a simple temperature reading in a container. Likewise, messages of the order of mega bytes could also be transmitted as in the case of a video monitoring device. The smallest resource unit that can be allocated in LTE to a device (or a UE) is the Physical Resource Block (PRB) with a dimension of 180 KHz in frequency domain and 1 millisecond in time domain. Under favorable radio channel conditions, a PRB is able to transmit several kilo bytes of data. If one PRB is allocated to a single M2M device which transmits small messages, the spectral efficiency of LTE system would decline drastically.

In emergency situations like fire and flood, the network may have to deal with simultaneous transmission of emergency messages which can cause degradation of the networks performance and blocking of resources for regular users. For example, in case of fire in a warehouse, the building and vehicle alarms would simultaneously trigger resource requests.

The matter of fulfilling the varying QoS requirements of various types of M2M messages is a challenging problem. Due to this diversity, the designing of low complexity scheduling algorithms would require great effort. All these issues related to M2M communications with LTE networks and supporting logistic processes should be tackled in such a manner that regular LTE services are not hindered.

LTE uplink scheduler design

The BQA scheduler has been designed in accordance with SC-FDMA features with support for multi-bearer UEs. The scheduler is decoupled into Time Domain Packet Scheduling (TDPS) and Frequency Domain Packet Scheduling (FDPS). The information about uplink data in a UE buffer is reported to the eNodeB via Buffer Status Report (BSR). The channel conditions of such user are conveyed to the eNodeB using the Channel State Information (CSI) carried by the Sounding Reference Signals (SRSs). In this work, the SRSs are assumed to be available at the eNodeB at each TTI and for all the PRBs of active UEs. Moreover, it is also assumed that the eNodeB is aware of the Power Spectral Density (PSD) of the active UEs via power headroom reports. The transmit power of a UE is adjusted by PC. Multi-bearer UEs are scheduled in a manner that bearer starvation is avoided. The QoS performance of BQA scheduler is analyzed by simulating a single and multi-bearer scenarios and comparing the performance with other schedulers.

The TDPS and FDPS algorithms are taken from [1,7,8]. The TDPS algorithm is designed to assign priorities to scheduling candidate UEs for a particular TTI in a given cell. A candidate gets high metric value if it has stringent QoS requirements, better channel conditions and/or has been unable to obtain any significant resources in the recent past TTIs (fairness). The TDPS metric values are generated for each active UE by ‚weighted Proportional Fair‘ (wPF) algorithm. In FDPS, only the high priority UEs are selected for allocation of frequency resources within the TTI. The bandwidth is divided into portions called Resource Chunks (RCs). The RCs are allocated to the chosen UEs based on FDPS metric values for each RC of each UE. The FDPS metric values are generated with 'Proportional Fair Scheduled QoS-aware' (PFSchedQ) algorithm. The allocation of RCs is achieved by a search-tree based algorithm named as 'Fixed Size Chunk and Flexible Bandwidth' (FSCFB) algorithm. The FSCFB allocates RCs to UEs by determining the best RC. The best combination should follow contiguity, buffer size, and maximum allowed RCs constraints.

If the multi-bearer candidate UEs acquire RCs, the PRBs are further subdivided among the user bearers. Each user bearer has its own QoS requirements related to delay budget, rate budget and delay threshold. The user bearers require adequate resources to ensure QoS provision and avoid bearer starvation. In this work, the bearers are served according to bearer QoS weight. However, the bearers having reached their packet delay threshold are given strict priority and the PRBs are allocated to them before serving other bearers.

Simulation results and analysis

The OPNET Modeler [9] is used to perform the simulations for analysis of the BQA scheduler for regular LTE traffic. The results for various scenarios are illustrated in [6] and some of these results are revisited in this paper. The QoS and the throughput performance of the BQA scheduler is compared with the performance of other contemporary TDPS schedulers which are commonly used. These schedulers are the Blind Equal Throughput (BET), the Maximum Throughput (MT) and the Proportional Fair (PF) [8]. In FDPS, the Proportional Fair Scheduled (PFSched) algorithm [10] is utilized along with all the TDPS schedulers. The BQA scheduler serves the bearers of multi-bearer users according to QoS weights, whereas the other schedulers serve the bearers by giving strict priority to GBR bearers. The simulation parameters used are given in Table 1. The performance of the schedulers is compared in terms of cell throughput and average traffic delays of the various classes. The cell throughput of MT scheduler with 8 FTP single-bearer users in the cell is approximately 10Mbps, and is considered the target cell throughput. The difference between the target and achieved throughput is defined as the evaluation criteria for scheduler throughput performance. The schedulers strive to minimize the size of their respective spider web shape in the diagrams in Figure 1 and Figure 2.

Table 1: Main simulation parameters

Parameter	Setting
Cell Layout	3 Cells, 1 eNodeB
System Bandwidth	5 MHz (~25 PRBs)
Frequency reuse factor	1
Cell radius	375m
UE velocity	120kmph
Max UE power	23dBm
Path loss	128.1+37.6log10(R), R in km
Slow fading	Log-normal shadowing, 8dB standard deviation, correlation 1
Fast fading	Jakes-like method [11]
Mobility Model	Random Way Point (RWP)
Power Control	FPC, α = 0.6, P0 = -58dBm
Traffic environment	Loaded
Max FDPS UEs	5
RC size	5
VoIP silence/ talk spurt length	Exponential(3) sec
VoIP Encoder scheme	GSM EFR
Video frame size	1200 bytes
Video frame inter-arrival time	75ms
HTTP Page size	100Kbytes
HTTP Page inter-arrival time	12 sec
FTP File size	20Mbytes
FTP File inter-request time	Uniform distribution, min 80s, max 100s

In the single-bearer scenario, the BQA scheduler and the reference schedulers (BET, MT and PF) are compared with 8 FTP UEs, 10 VoIP UEs and 10 video UEs. The graphs in Figure 1 depict the average cell throughput difference, VoIP end-to-end delay, video end-to-end delay and FTP file response time results for the schedulers (MT results do not fit into the given scale). The PF scheduler achieves lower throughput difference and FTP response time compared to the BQA because the PF scheduler is not QoS aware as opposed to the BQA. The VoIP average end-to-end delay for the BQA scheduler is better than for the PF. Similarly, the video end-to-end delay result also illustrates that the BQA performs better compared to the PF. The QoS provisioning of delay sensitive traffic is guaranteed by the BQA scheduler.

In the multi-bearer scenario, 8 multi-bearer UEs with VoIP, FTP and HTTP traffic are simulated and the performance of the schedulers is compared in terms of average cell throughput difference, FTP average upload response time, HTTP page response time and VoIP packet end-to-end delay. As in Figure 2, the PF scheduler achieves better cell throughput and FTP response time. On the other hand, the BQA scheduler provides better results in terms of average packet end-to-end delay for VoIP, and average page response time for HTTP, hence guaranteeing QoS.

Conclusion and outlook

In this paper, the research issue of facilitating M2M communications across the LTE network was discussed and the LTE uplink constraints were pointed out. The challenges faced by the current and future mobile technologies for the transmission of M2M messages, especially those related to dynamics in logistics, were highlighted. The performance of the BQA scheduler was evaluated for regular LTE traffic. The BQA scheduler can handle regular LTE traffic quite efficiently, however, still requires enhancements to support the scheduling of M2M traffic more efficiently. Furthermore, the scheduler capability of dealing with dynamics in logistics is an interesting prospect for future investigations.

Figure 1: Single-bearer scenario results

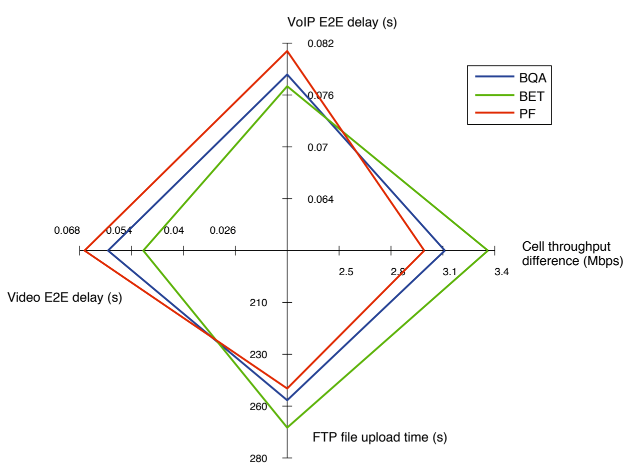
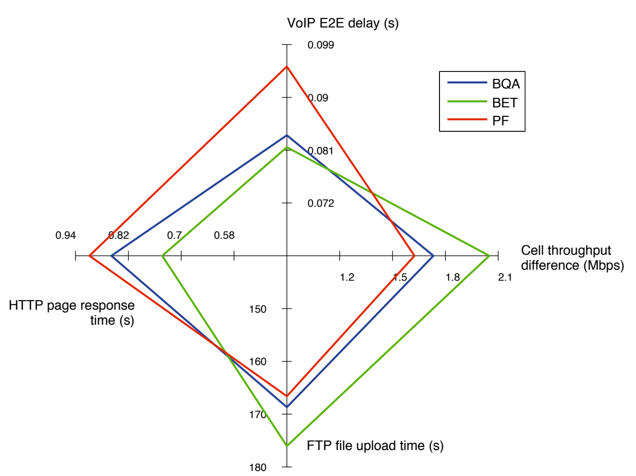


Figure 2: Multi-bearer scenario results



References

[1] Marwat, S. N. K.; Weerawardane, T.; Zaki, Y.; Goerg, C.; Timm-Giel, A.: Design and Performance Analysis of Bandwidth and QoS Aware LTE Uplink Scheduler in Heterogeneous Traffic Environment. In: 8th International Wireless Communications and Mobile Computing Conference. Limassol, Cyprus 2012.

[2] Lawton G.: Machine-to-Machine Technology Gears up for Growth. In: Computer 37 (2004) 9, pp 12-15.

[3] EXALTED, EXpAnding LTE for Devices: Home. URL: http://www.ict-exalted.eu/fileadmin/documents/EXALTED_WP2_D2.1.pdf, Date of access 26.03.2012.

[4] Scholz-Reiter, B.; Mehrsai, A.; Görges, M.: Handling Dynamics in Logistics - Adoption of Dynamic Behaviour and Reduction of Dynamic Effects. In: Asian International Journal of Science and Technology in Production and Manufacturing Engineering 2 (2009) 3, pp 99-100.

[5] Infonetics Research: Embedded mobile M2M modem market on track to more than triple in 2010. URL: http://www.infonetics.com/pr/2010/Embedded-Mobile-M2M-Modem-Market-Highlights.asp, Date of access 26.03.2012.

[6] Marwat, S. N. K.; Weerawardane, T.; Perera, R.; Goerg, C.; Timm-Giel, A.: Impact of Machine-to-Machine (M2M) Communications on Disaster Management in Future Mobile Networks. In: General Sir John Kotelawala Defense University Annual Symposium. Ratmalana, Sri Lanka 2012.

[7] Marwat, S. N. K.; Weerawardane, T.; Zaki, Y.; Goerg, C.; Timm-Giel, A.: Performance of Bandwidth and QoS Aware LTE Uplink Scheduler Towards Delay Sensitive Traffic. In: Roer, P., (Ed.): Mobilkommunikation - Technologien und Anwendungen, Vorträge der 17. ITG-Fachtagung vom 9. bis 10. Mai in Osnabrueck. Osnabrueck, Germany 2012.

[8] Marwat, S. N. K.; Weerawardane, T.; Zaki, Y.; Goerg, C.; Timm-Giel, A.: Performance Evaluation of Bandwidth and QoS Aware LTE Uplink Scheduler. In: 10th International Conference on Wired/Wireless Internet Communications. Santorini, Greece 2012.

[9] Zaki, Y.; Weerawardane, T.; Goerg, C.; Timm-Giel, A.: Long Term Evolution (LTE) model development within OPNET simulation environment. In: OPNET Workshop, Washington, D.C., USA 2011.

[10] Anas, M.; Rosa, C.; Calabrese, F. D.; Pedersen, K. I.; Mogensen, P. E.: Combined Admission Control and Scheduling for QoS Differentiation in LTE Uplink. In: IEEE 68th Vehicular Technology Conference. Calgary, Canada 2008, pp 1 - 5.

[11] Cavers, J. K.: In: Mobile Channel Characteristics. Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow, 2002.

Safdar Nawaz Khan Marwat, M.Sc.

Link Level Scheduling for Future Mobile Communications

E-mail: safdar@comnets.uni-bremen.de
Country: Pakistan
Start: 16.11.2011
Supervisor: Prof. Dr. rer. nat. Carmelita Görg
Faculty: Physics / Electrical Engineering
Research Group: Communication Networks

Autonomous Control in Fully Modular Production Systems with Contribution of Cloud Computing

Afshin Mehrsai

The phenomenon of globalization has been influencing all kind of industries, in particular, manufacturing branches. Thereby, introducing a wide range of opportunities as well as threats to the enterprises that make them become entrepreneurs in their businesses or partially fail in the narrow competition among such. Employment of new business models, technologies, methodologies, and systems can assist enterprises to survive in the fully dynamic environment, i.e., volatile market, expansion of scale and scope, mass-customized demands, scarce resources, growing complexity in processes, cost competition, etc. Indeed, the challenges facing manufacturing industries have forced them to reconfigure their business structures. They need to form new models of closed cooperative and collaborative networks to fulfill their requirements and to achieve market goals. Accordingly, by means of state of the art technologies, isolated enterprises aimed together at configuring new forms of supply networks, particularly in virtual environments.

Introduction >>> The current circumstances of the market contest [1] forces companies not only to smartly react to the changes, but also to proactively deal with them. Internal and external influences on the building-blocks of manufacturing enterprises have to be monitored and controlled, so that these units can get more precise impressions about their on-time roles in the entire performance. Every unit must reflect its exact merit in the symphony of production and delivery to continuously reduce costs and to increase productivity. This notion develops the new idea about moving enterprises towards a new performance atmosphere, where the building-blocks can smartly cooperate with each other and make expert recommendations in a real-time manner. The units concerned may span from macro-scale objects, like single enterprises within supply networks (SN), to micro-scale ones, like individual product-parts or single carriers in shop-floor logistics.

In this regard, the flow of materials and information, as the major task at manufacturing enterprises, which engages most of logistic activities (i.e., planning and control, handling, procurement, and delivery), has achieved a very high importance in real-time involvements. In order to precisely manage and control the flow of information and materials throughout an enterprise/SN, it is required to solely monitor and locally control them, so that less energy, more efficiency, and higher effectiveness can be realized. However, exclusive tracking and control of materials and their respective information is by itself a very complex, time-consuming, and costly duty; if not impossible in practice, since the related scope and scale is radically large.

Therefore, material flow control is conventionally not achievable in real-time by means of a central organizer, which can cover every required detail in practice; but distributed approaches are promising [2]. This problem can be positively solved by introducing self-organized engaged units with intelligence, decision-making, and negotiation capabilities in a distributed structure. The new achievements in communication and information technology (ICT) have fostered the idea of self-organizing objects within manifold systems with heterarchical control and decentralized structure. This concept shifts the mission of material flow control from a global centre to decentralized objects with local control capabilities. Thanks to state of the art ICT, realization of such units in manufacturing enterprises is getting possible, by means of cloud computing within a digitally interconnected environment [3]. <<<

New generation of manufacturing enterprises

The new generation of manufacturing enterprises offers virtual shop-windows with shelves full of various products, despite hardly any physical finished-product in the store. However, in their embraced digital environment with cloud computing the knowledge of producing most of these final-products is available. Indeed, cloud computing is a new upcoming and assisting tool in mass-customization environments [4] [5], as a success key in the near future. The concept of mass-customization with regard to custom-made products is not a new phenomenon in manufacturing; however, realization of highly engineered customized products with complexity in their design and manufacturing processes is still challenging. A major difficulty is: decreasing delivery time as well as increasing productivity and product quality [6]. However, one prominent way to handle this complexity is to develop modular solutions for customized products. Such systems with modularity include products, processes, and resources. The discussion about the modular manufacturing system that encompasses all engaged units in a manufacturing procedure was initiated in the early nineties [7].

Such enterprises are configured out of several smart blocks and self-organized objects that actively cooperate and collaborate with each other to fulfill the final customer demand. Once any specific expertise regarding a new order is required by any of the interconnected objects in a digital enterprise, it can be either derived from its own intelligence or be extracted from the cloud to be directly employed. If the necessary information is not directly available, intelligent objects may derive it based on their own know-how (which was already learned), together with comparable expertise available on the cloud.

Therefore, intelligence, learning, and expert decision-making are the attributes of these autonomous objects (units, blocks) as modules of new enterprises under extreme dynamic conditions (supply and demand) and with high expectations on product variants. However, the main focus of this paper resides on autonomous equipment objects which are classified in the resource category. The product and process modularity are taken for granted. In particular, out of several potentials, the role of goods' carriers for logistics with the mentioned competencies is highlighted in this study.

In this prospective manufacturing environment all autonomous modules perform independently, but in cooperation with each other to broaden the scope of adjustability and flexibility. However, decision-making of autonomous objects with local perceptions about their surroundings may lead to a performance globally not optimum or, in some cases, can result in chaos, in the general context. Above the technological problems in practice, a huge impediment of realizing autonomous objects, in this collaborative and cooperative modular environment, is their competition for common resources. In other words, how to plan and control their behaviors for competing in a global framework, since they are independent in decision-making?

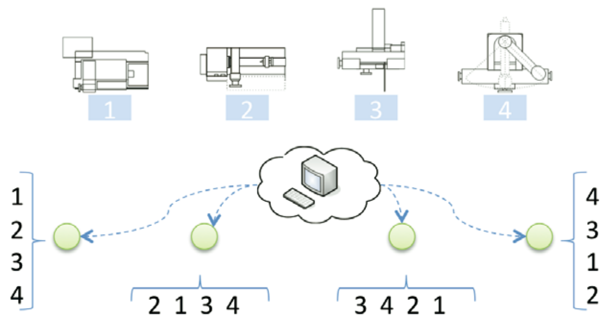
For that reason, autonomous objects in complex systems not only require being intelligent themselves as well as rendering decisions, but also need to be informed about the others' intentions. This matter provides the single units with competent information for decisions on a unique resource. For instance, two full pallets with the same destination compete for a common assembly-station to proceed their products. Each wants to reach it as soon as possible, whereas both have an identical global target, as fulfillment of final customer's order. Correspondingly, if two single units compete for a common resource, while they are intelligent and have enough information about their alternatives, they can change the individual plan (one of the competitors), so that less interventions takes place throughout the production steps. Thus, full interconnectivity via cloud in such environments is necessary to mobilize all effective players in the system with heterogeneous local interests and homogeneous global goals.

Alternative control structures for carriers

On this basis, two important structures, i.e., the control structure of autonomous objects and the structure of cloud computing, must be described and their adjustabilities have to be defined. Among several potential objects for autonomy in logistics and production operations, pallets (fixtures, bins, etc.) as the closest transport means to single products in assembly shop-floors are selected to be explored for autonomous control. The control structure of such objects in a complex environment of material flows can be chronologically classified into seven formats as following.

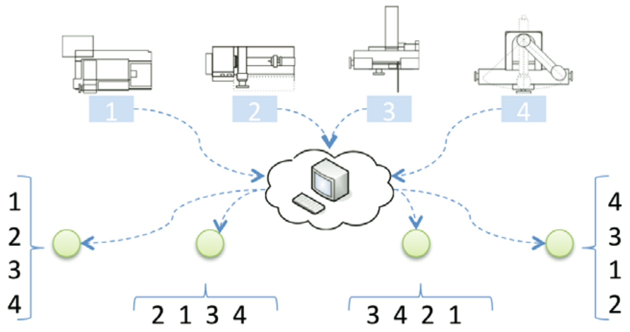
First, the simple conventional control structure with each single pallet following the preplanned schedule, done by a central controller in an offline manner. In this structure, the center is responsible for controlling the accurate execution of the plan. Here, unseen events and rescheduling are time-consuming and problematic occasions which is not suitable for mass-customization with real-time flexibility, see Figure 1.

Figure 1: Conventional, hierarchical, and central scheduling and control



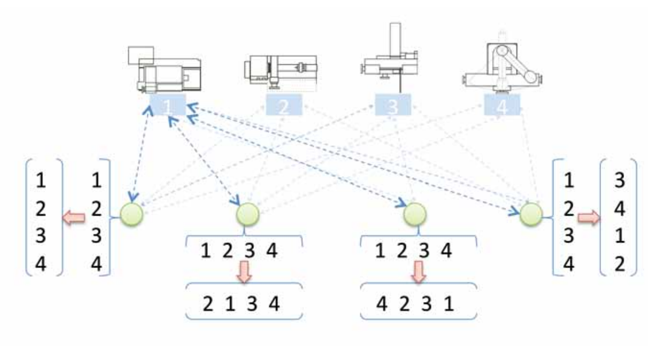
Second, the interconnectivity of engaged objects, i.e., pallets and machines, causes a better control structure by means of the central controller. In this case, the center has real-time information about the condition of stations and pallets. Once an unseen event happens in the pre-scheduled operations or in the state of the machines, it can be centrally controlled and rescheduled. Through control and monitoring the required rescheduling takes place regarding the real-time state of machines, see Figure 2.

Figure 2: Real-time monitoring of conditions, prompt scheduling with hierarchy and centralized control



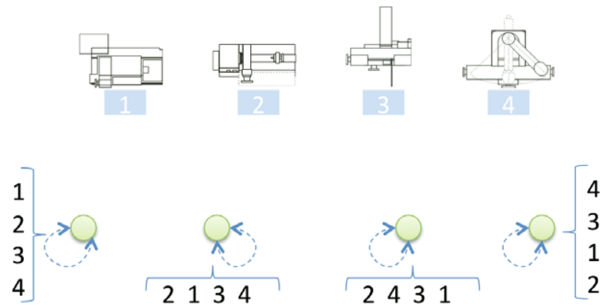
Third, realization of decentralized control done by each single pallet, based on bilateral negotiations. In this type, the initial schedule of each pallet for operations can be rendered by itself or be given from a center. But the final real-time schedule (control) is done thanks to a fully interconnected structure among pallets and machines. Derived from the existing knowledge inside each object or given from a center, a primary operations' sequence is generated. However, bilateral negotiations in real-time between the service-provider (machines) and service-consumer (pallets) cause subjective rescheduling between the conflicting plans, although being coordinated by single machines. In this type, there is no need to distribute the knowledge or control means to distributed pallets, but the fixed machines can take on this responsibility; so that less technological impediments occur. Indeed, the mission of the central controller is distributed to the stations, so that each decides on the feasible schedule regarding its current state and communicating pallets, see Figure 3.

Figure 3: Real-time agent-based negotiation between service-provider and service-consumer



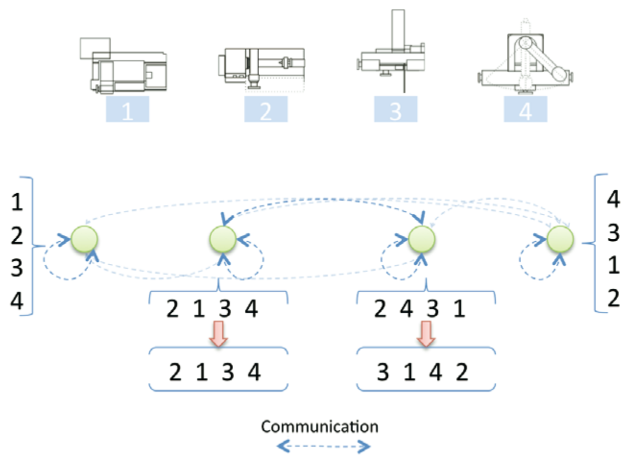
Fourth, totally autonomous plan and control just by pallets, based on own knowledge and without any consideration of others' intentions. This type reflects fully self-organized objects with learning and, thereupon, real-time decision-making capabilities in a totally heterarchical and decentralized circumstance. Distributed processors with fairly huge computation capability between pallets are the technical disadvantage of this model, while real-time awareness from counterparts is missing as well. The only resource for decision-making in this case is the self-knowledge derived from learning, see Figure 4.

Figure 4: Self-organized objects with learning, real-time decision-making under heterarchy and decentralization



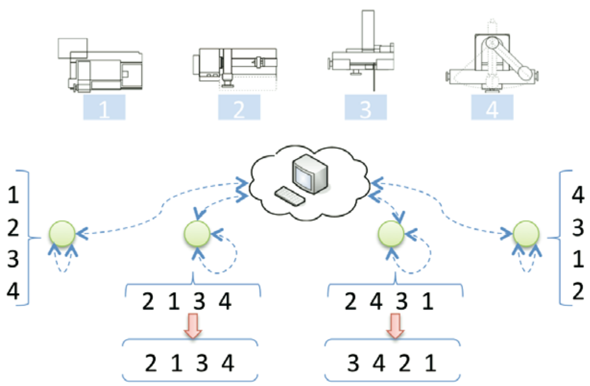
Fifth, self-organized objects with learning and negotiation capability for real-time decision-making. Here, the autonomous pallets have the possibility to negotiate with other autonomous objects, so that a common consensus about unique resources can be achieved. Despite positive awareness of the others' intentions, realization of this model requires a very precise regulation in the negotiations, see Figure 5.

Figure 5: Self-organized objects with learning and negotiation for real-time decision-making



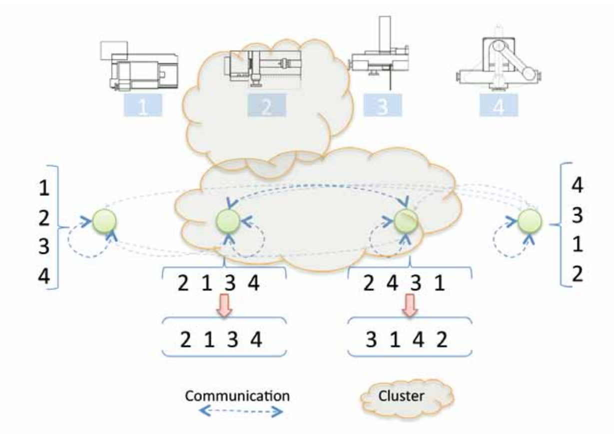
Sixth, a nonconventional central controller for distributed and autonomous objects. In this structure, the problem of realizing decentralized control with autonomous objects can be solved via cloud computing. The model of the central controller is kept from conventional systems, but the roles of objects and center are different; the center is a cloud. Here, the major computational loads are allocated to the cloud as a central computational resource, while each distributed autonomous object has just the minimum requirement for processors (e.g., digital tag) to transact with the center. Autonomous objects are fully self-organized in this model, but the advantages of a conventional central controller can be achieved as well. The central cloud has the information of all connected objects and can be used not only as a computational resource, but also as a common platform for coordinating heterogeneous targets. See Figure 6.

Figure 6: Autonomous objects with suggestion-making and negotiation (coordination) via cloud central controller



Seventh, realization of decentralized control done by each single pallet, based on clusters and constructive recommendations. This model is twofold; it facilitates and can be facilitated by modular systems. While every autonomous unit makes its own decision about how to proceed in the complex system to achieve its temporal objective, some federations seem beneficial to reduce diverse performances for a common transient target of interrelated objects. Meanwhile, making constructive suggestions by autonomous objects about their upcoming processes contributes to the reduction of complexity in controlling and handling material flows. Thanks to full interconnectivity, autonomous objects with similar procedures and goals, instead of competing ones, collaborate with each other; by means of building temporal clusters. For instance, pallets with similar semi-finished products and comparable orders can contribute to a common cluster and render an optimal schedule for the clusters' members. Local experience of each unit in the cluster and purposeful exchange of information between objects reduces the decision- making time and increases productivity. Consequently, autonomous units in the swarm of modules have to be connected to their stakeholders. Here, the role of the cloud is quite positive in a model, where modules and autonomous units can collaborate with each other for building clusters and consensuses, see Figure 7.

Figure 7: Realization of virtual cooperation clusters regarding common temporal resources



Cloud computing and future modular enterprises

Generally, in case of full interconnectivity, autonomous objects can make their own priority list, based on their knowledge from learning, and build some transient collaborative clusters to achieve their temporal targets. These objects in such clusters either need to compete with each other (e.g., two pallets) for a common resource or like to cooperate (e.g., a pallet and a CNC machine) to proceed on to further steps. For realizing this scenario, on the one side, the merit of learning and decision-making for each engaged object and, on the other side, mobile connectivity to the other players are crucial. The state-of-the-art ICT has facilitated access to respective expertise via real-time connection to the cloud [8]. Cloud computing provides the required platform for distributed computations and assists realization of modular systems in enterprises. Modular enterprises are built out of several intelligent and autonomous units. In doing so, cloud computing has several service and deployment models which can be employed for modular and autonomous systems.

Some regular services are the following [9]:

- Infrastructure-as-a-Service (IaaS): to provide a large scale of required hardware (e.g., in modular and distributed form) to install a stack of modular software on them or realized distributed processors with no need to proliferate processors (fewer technological problems),
- Platform-as-a-Service (PaaS): to provide a set of modular software and Program languages that can be combined to build a complete form of an applicable software, methods, and algorithms for distributed autonomous objects,
- Software-as-a-Service (SaaS): to provide computational software required for individual modules in a remote and seamless way.

These three main service models are required to bring the concept of autonomous logistic objects closer to practice. Additionally, several deployment models of clouds for logistics and production environments can be imagined, as shown below [10]:

- Private cloud: this type is locally managed and is usually allocated to an organization,

- Community cloud: this type covers several shared infrastructures between some organizations, e.g., in the form of small consortiums,
- Public cloud: available for public sectors or big industries, which is offered by a third-party organization professional in this branch,
- Hybrid cloud: a fusion between different models (private, community, or public) by means of standard interfaces or portability.

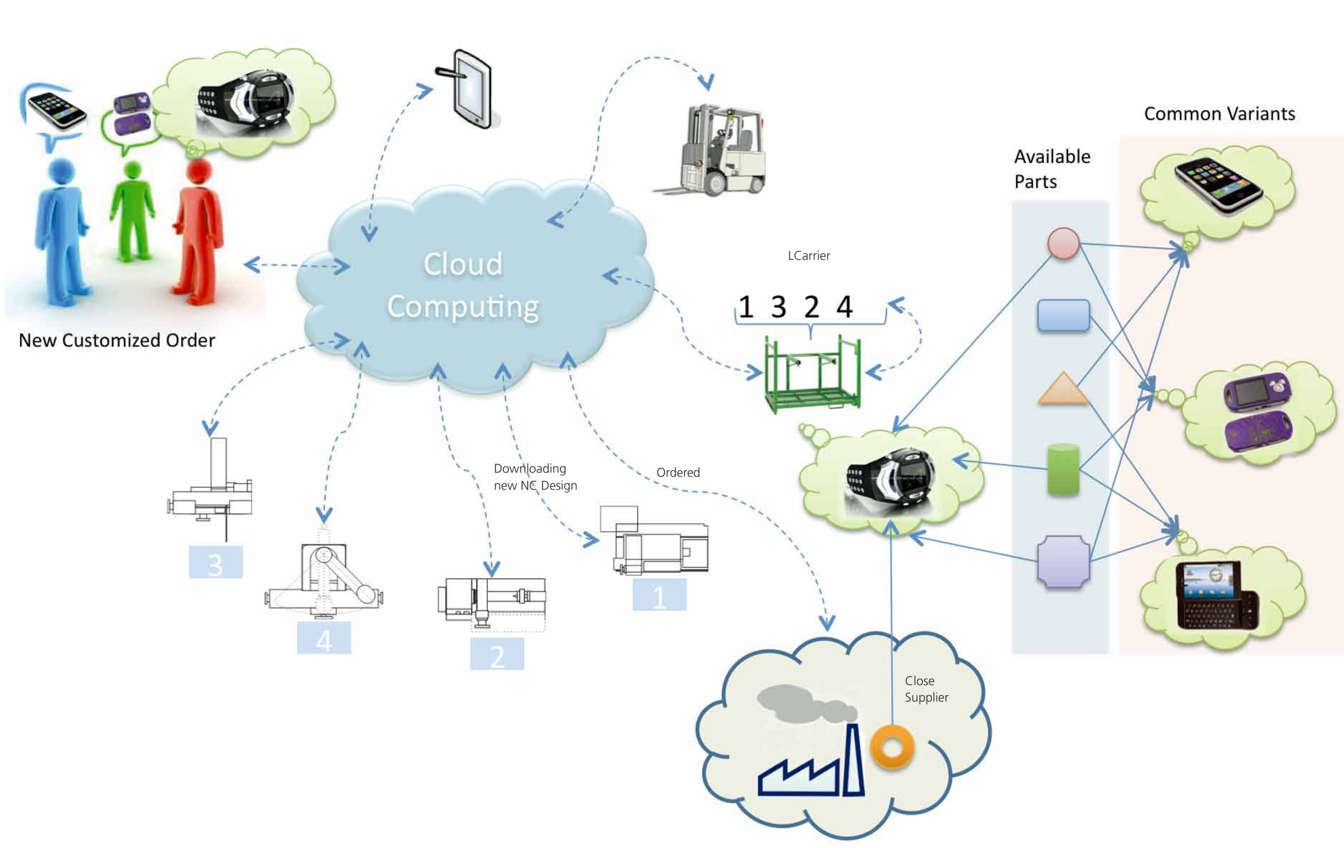
In conclusion, for moving from the conventional control system for optimizing logistic processes towards autonomous objects with decision-making and proactive suggestion-making capabilities, cloud computing can span from the private cloud model for small shop-floors to hybrid clouds in a global context for outbound logistics and supply networks.

As a prospective framework for applicability of autonomous objects in production and logistic environments, the concept of a modular system seems quite promising. In other words, combination of autonomous objects, like pallets, with a modular system in producing mass-customized products leads to superior flexibility in manufacturing operations. For instance, in such a modular manufacturing system every engaged object is smart or autonomous, so that they can exchange their actual competence in real-time with other modules to fulfill an upcoming customer's order. In this case, an autonomous pallet is responsible for deriving the required list of processes, resources, and product modules to deliver the ordered individualized product on-time, see Figure 8.

Negotiation with the other modules and extraction of specific procedure for assembling the final product has to be done by the pallet via accessing the cloud and thereupon expert systems. Intelligent machines with flexible performances grasp their operation method from their own as well as from cloud expertise. When a new order comes with some similarities to the current final products, its availability-to-promise has to be checked and the customer must be informed about the positive or negative answer within an acceptable waiting-time (customer lead-time). This can be done through the cloud by checking the closest and the most authentic supplier for the missing product module.

This new application area of autonomous objects in logistics and production is configured in the form of a prospective research project in the field of new enterprises with digital connectivity and modular structure for realizing mass-customization and consequently competitive advantages.

Figure 8: Realization of mass-customization with flexibility through cloud



References

[1] *Abdelkafi, N.: Operations and Technology Management 7: Variety induced complexity in mass customization: concepts and management. Erich Schmidt Verlag GmbH, Berlin 2008.*

[2] *Minhas, S.U.H.; Halbauer, M.;Berger, U.: A Multilevel Reconfiguration Concept to Enable Versatile Production in Distributed Manufacturing. In: Proceedings of DET2011 7th International Conference on Digital Enterprise Technology, Athens, Greece 2011, pp 28-30.*

[3] *Luo, Y.L.; Zhang, L.; He, D. J.; Ren, L., Tao, F.: Study on Multi-View Model for Cloud Manufacturing. In: Advanced Materials Research 201-203 (2001), pp 685-688.*

[4] *Che, J.H.; Ma, B.; Zeng, Q.: Parallel Processing of Product Configuration for Cloud-Based Mass Customization Service Platform. In: Advanced Materials Research 532-533 (2012), pp 1196-1200.*

[5] *Tien, J.: Manufacturing and services: From mass production to mass customization. In: Journal of Systems Science and Systems Engineering 20 (2011) 2, pp 129-154.*

[6] *Hvam, L.:Mass customisation of process plants. In: Int. J. of Mass Customisation 1 (2006) 4, pp 445–462.*

[7] *Tsukune, H. et al.:Modular manufacturing. In: Journal of Intelligent Manufacturing 4 (1993) 2, pp163-181.*

[8] *Kumar, S.: Strategic management system for academic world: Expert system based on composition of cloud computing and case based reasoning system. In: Digital Content, Multimedia Technology and its Applications (IDCTA), 7th International Conference on. Busan, Korea 2011, pp 16-21.*

[9] *Van der Molen, F.: Get Ready for Cloud Computing – A comprehensive guide to Virtualization and Cloud Computing. Van Haren Publishing, Zaltbommel, Netherlands 2010.*

[10] *Chandrasekaran, M.; Muralidhar, M.; Dixit, U.: Online optimization of multipass machining based on cloud computing.In: The International Journal of Advanced Manufacturing Technology 170 (2012), pp 1-12.*

Afshin Mehrsai, M.Sc.

Feasibility of Autonomous Logistic Processes by Reconfiguration of Business Processes

E-mail:	meh@biba.uni-bremen.de
Country:	Iran
Start:	01.07.2008
Supervisor:	Prof. Dr.-Ing. Bernd Scholz-Reiter
Faculty:	Production Engineering
Research Group:	Planning and Control of Production Systems

Machine-to-Machine Communications and Intelligent Objects in Refrigerated Containers

Javier Palafox-Albarran
Alexander Dannies
Bala Krishna Sanjeeva
Prof. Dr.-Ing. Walter Lang
Dr. Reiner Jedermann

The application of Machine-to-Machine (M2M) communication can largely improve the supervision of logistic processes; especially if not only global mobile communications are included but also short range wireless sensor nodes, however it has been rarely implemented. We implemented M2M global and local communications by using only off-the-shelf hardware. We demonstrate the advantages of ubiquitous M2M communication on a laboratory scale with an example setup. New software features can be deployed, either to the gateway-device in the form of OSGi-bundles or to the sensor nodes in the form of MIDlet-suites, by using M2M-technology. As example we programmed an algorithm for predicting temperature curves and the therefore required mathematical libraries. A gateway bridges the local and the global network. Sensor messages can be forwarded via email and SMS or be provided by a web server. The advantages of such a supervision system would allow global and pervasive traceability not only of the location but also of the quality state of the assets..

Introduction >>> Machine-to-Machine communication (M2M) is the automatic communication between machines without human interaction allowing direct access to real-time data. A sensing device transfers its readings to a remote central system on a daily or hourly basis to be either reviewed or to act on the collected data. The communication system for transferring data from the remote facility may be, for example, wires, the cellular network and communication satellites. The selection depends on the cost and connection availability.

Wireless Sensor Networks (WSN) on the other hand is an emerging technology to monitor ambient conditions. However, they are commonly considered to be stand-alone; the sensor nodes communicate with other sensors and the gateway, but are in principle unable to communicate with the outside world.

The combination of M2M and WSN technologies brings the opportunity to benefit from their respective advantages. Real world data, collected in the environment, can be integrated into the information world by sending data to the Internet. Furthermore, the system may become ubiquitous, which conceptually means "existing or being everywhere, especially at the same time". The benefits of such integration of sensor data in logistics have already reached commercial interest. In a commercial system called Smart Trace [1] M2M is used as an online cold chain monitoring system where temperature changes inside the container are measured by wireless smart tags and uploaded to a server. However, intelligent data processing and remote deployment of new software components are not considered.

Intelligent Information about the cargo, provided by intelligent objects, will help a human operator or a machine to take efficient logistics decisions. By using M2M technology, such information should be sent via radio to a gateway which generates a notification either via SMS or e-mail. **<<<**

Differentiation between M2M and WSN

M2M is a technology that allows communications-enabled remote devices to exchange information automatically without human interaction. The basic four stages according to this are: data acquisition or collection, transmission of data through a communication network, assessment of data, and response to available information. In general, local devices with missing or only limited intelligence and computing capabilities are used for data acquisition. Their task is to transmit data periodically or to send alarms when a threshold is exceeded or a malfunction is detected. Data is sent to the telemetric system via wired or wireless communication. The assessment of data and the response to it are made through human interaction due to the fact that the local devices are unable to do it autonomously.

Wireless Sensor Networks (WSN) on the other hand is an emerging technology to monitor ambient conditions. The sensor nodes communicate with other sensors and the gateway, but are in principle unable to communicate with the outside world.

WSNs and wireless M2M devices are equipped with sensors, a radio transceiver, an antenna, processing capabilities and an energy source. However there are differences: wireless M2M covers applications involving longer range and the node will typically be powered from the machine itself; WSNs consist of several sensors interconnected, usually powered by batteries and cover applications involving shorter range.

M2M are deployed when power consumption is not critical, the size/weight of the devices is not an important factor and a range of kilometres is required. Additional features may include for example bidirectional communication.

WSNs are to be deployed in short/medium range areas where human intervention is not possible – either because it is too dangerous, like in a battlefield or a forest fire, or too remote to send people, as is the case of monitoring glaciers and mountains. The system must replace human intervention with spatially distributed sensor nodes. The desired characteristics of an autonomous WSN deployment include high lifetime and robustness as well as fault tolerance and self-configuration [2]. Furthermore it cooperatively monitors physical or environmental conditions, such as temperature, humidity and pressure, at different locations.

The impact of combining M2M with WSN in logistic practice

In conventional transport logistics it is required to have the right product, in the right quantity, at the right place at the right time. An instant identification of the assets in the supply chain is possible by reading RFID tags.

Cold-chain, is a special case of supply-chain, requires, in addition to traceability, environmental data monitoring to provide complete information about quality of the goods. The temperature of frozen and chilled goods must be monitored continuously. Data management becomes dynamic; it is conditioned by the quality data, which determines the dynamic of the other aspects. For instance, the right time, quantity and place may vary during transportation. As the quality of the goods decreases, new routes and suppliers/buyers have to be found, according to the actual price of the cargo, with the aim of increasing the profitability.

At the same time, this quality data is susceptible to fluctuations in environmental parameters such as relative humidity or temperature. The deteriorations can lead to a decrease in the aesthetic appeal, as well as a reduction in nutritional value. The information about the quality/temperature of the product must be available at any time, everywhere in order to have valuable information that allows taking proper decisions. As a result the amount of goods that arrives at the costumer in non-acceptable conditions decreases. This leads to further advantages such as reduction of transport volume and greenhouse gas emissions. Actions against faulty cooling conditions can be taken as soon as a problem arises. Goods can be sorted in the warehouse by their actual quality condition. It requires the deployment of more sophisticated technologies to include the mentioned dynamic fluctuations in the supply chain.

Combining M2M and WSN in logistic practice has the potential benefit of the reduction of waste, which is achieved by a greater amount of and more accurate just-in-time information.

Uckelmann, Harrison and Michahelles [3] describe the requirements for the future Internet of Things. In a broader vision, the possibility of including embedded devices such as Wireless Sensor Networks (WSN) is mentioned. M2M and WSN will fill the gap between autonomous logistics and the Internet of Things. M2M will allow us to access information in a ubiquitous way at a reasonable price by sending the right e-mail or SMS with the condition information to be readable for human interaction. WSN may use sensor information to detect signs of degradation of condition at an early stage with the help of intelligent data processing.

Implementation using off-the-shelf components

Figure 1 displays the developed implementation in which only open software is used. It consists of the three categories: WSN, gateway and end-user. Conventional remote monitoring is possible by using conventional M2M communication. However, the implementation differs to that in deploying intelligent objects on the sensor boards to predict the temperature change.

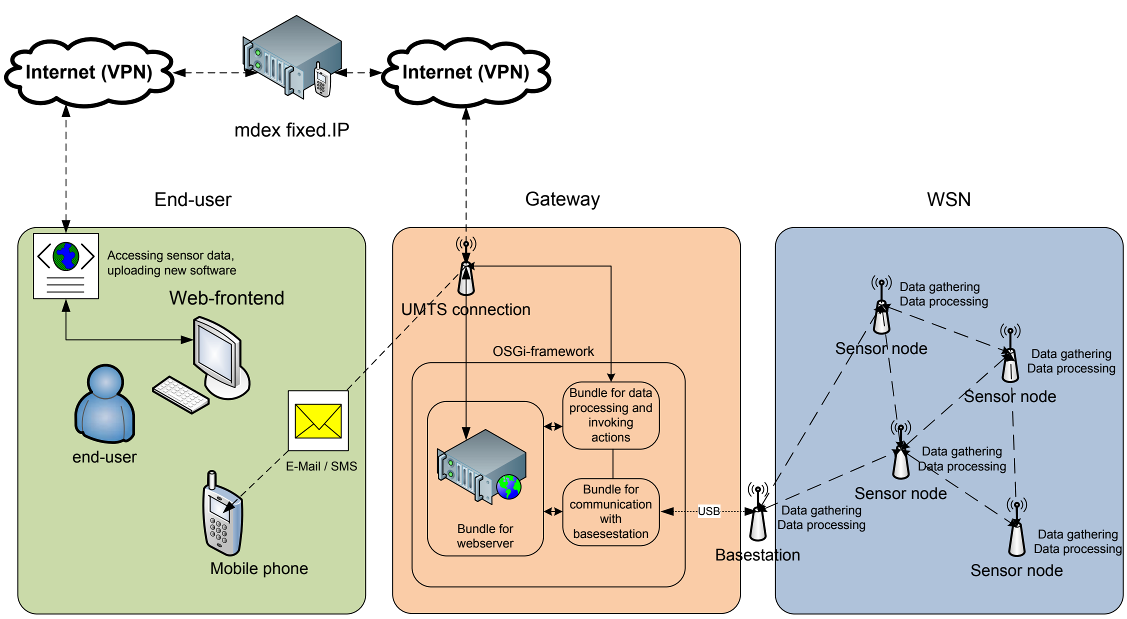


Figure 1: Developed implementation

The task of the WSN is the gathering of environmental data – here temperature values – and local data-processing. The processed data is transferred wirelessly and can be received by the base station – the juncture between the WSN and the gateway.

In the gateway, the Equinox OSGi-framework is installed on top of the Linux OS, to allow dynamic updates software modules remotely during runtime. An OSGi-bundle contains a web-server and servlets for generating dynamic web-pages – this is for displaying data and altering of software on the sensors. Furthermore, another bundle encloses an implementation for sending notifications via SMS or e-mail.

From the different types of wireless sensor modules, we selected the SunSPOT[4] because it provides the option to update or deploy new Java applications without physical access to the sensor. One or more applications, so called MIDlets, can be combined to a MIDlet suite and transferred via a radio link to the sensor node. To avoid human interaction and the dependency to a fixed internet connection, the deployment process must be fully automated and executable over multi-modal networks. In our solution the sensor network is linked by a gateway to a GPRS or UMTS cellular network for global communication.

Application in refrigerated containers

As demonstration of how intelligent objects and M2M may be applied to improve cold-chain logistics, temperature changes during transportation is selected as the quality of the goods mainly depends on this environmental parameter.

The goods within a refrigerated container are not exposed to a uniform temperature profile. The temperature deviations within a single container can vary significantly as of ±2 °C [5].The temperature profile depends on the ambient temperature, the total air circulation rate and distribution, external environmental conditions, and the respiration heat of the goods. Packing mistakes can either block or short-circuit the circulation of cooling air. In this case, temperature deviations can rise to up to 10 °C.

After gathering the data of each sensor node, it can either send the record of the temperatures to the gateway or to the end-user; however, transmission of raw data would result really expensive. If data processing algorithms are deployed in the sensor nodes, these can be treated as Intelligent Objects that send only a reduced amount of data that gives more useful information

As an example, the future temperature values inside the container can be calculated by using system identification techniques, which estimate the missing parameters for a given model structure. A Single-Input Single-Output (SISO) grey-box model is used to predict the temperature inside the container under the presence of perishable goods with the aim of reducing the complexity and preserving the accuracy. The proposed, so called Feedback-Hammerstein with white noise, model is shown in Figure 3. It provides a meaningful description of the factors involved in the physical system including the effect of transporting living goods such as fruits and vegetables.

The difference equation of the model presented in Figure 3 is described by Equation 1.

$$a_1^*(q^{-1})\mathrm{y}(\mathrm{t}) = b_1\alpha u(t) + b_1\beta(e^{\gamma y(t)} - \gamma y(t)) \qquad (1)$$

In the model γ is a key parameter that characterizes the heat production in Watts; it is a constant, which is fixed for a certain type of fruit and ripening-state, β is a scaling factor, which depends on the amount of food and is given in kilograms, b_1 is the zero of the first-order linear system and a_1^* is the pole of an equivalent pseudo-linear system. The algorithms to calculate the required parameters of the resulting system are presented in [6]; they have lower order matrix dimensions and do not need any matrix inversion. In total, three parameters for the equivalent system are estimated $(a_1^*, b_1\alpha \text{ and } b_1\beta)$ and are updated after each measurement.

Figure 2: Implementation of the platforms in a refrigerated container

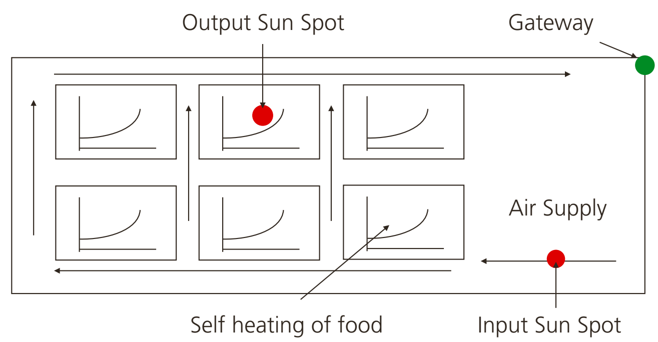
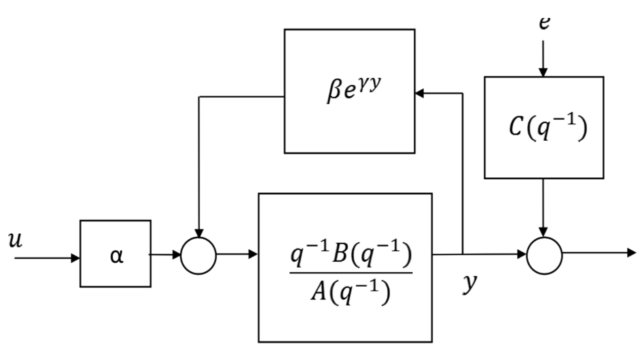


Figure 3: Feedback-Hammerstein model



The data of the air-supply and on the boxes containing the goods is gathered and processed on the SunSPOT sensor nodes. The sensor located near the cold-air-supply samples the local temperature periodically and broadcasts it to the rest of the sensors located inside the boxes. These sample the local temperature in the boxes every time a measurement from the air-supply sensor arrives. This process is similar to data gathering in conventional M2M communications.

After the data processing in each SunSPOT is performed, the three resulting model parameters and the last supply and output parameters are forwarded to the base station.

One OSGi bundle in gateway receives data from the base station that may also run a prediction algorithm. Based on the calculations in correspondence with a defined threshold value, an event can be triggered in the OSGi-context. To be able to react on these events, additional bundles can be installed. One application, which can be connected to the environment, is a web-interface for displaying data in form of a table or graph. It can also be used for remote configuration, e.g. to change the threshold value for notifications. M2M related bundles can be added to the environment, which sends notifications via SMS or e-mail when receiving an event.

Conclusion

Recently, the necessity of much more interactive and intelligent features has been recognized in the field of cold-chain logistics. They should allow an efficient management of dynamic data as required, for example, during the transport of perishable goods. Sensing, interaction with the environment, mobility and local intelligence are trends, which will optimize the information flow.

The combination of the respective advantages of the technologies RFID, wireless sensor networking (WSN) and Machine-to-Machine communication in transport logistics explores a new technical horizon. This leads to a breakthrough, which will allow a global and pervasive traceability of the location and quality state of the assets.

This paper presented how the pervasiveness of M2M combined with intelligent objects and wireless sensor technologies will impact the management of the dynamic behaviour on food transportation.

Feedback-Hammerstein training and prediction algorithms were used as an example of the intelligent features that can be deployed in wireless sensor nodes. M2M was demonstrated by sending the prediction results from the sensor node to a telemetric system that sends an SMS or an e-mail to be read by a human operator.

It also demonstrated additional advantages of dynamic updates supported by Java and OSGi by allowing MIDlets that may contain intelligent algorithms required to deal with the actual cargo condition to be deployed remotely onto the sensors in real time.

References

[1] Ceebron Pty Limited: Smart-Trace – Online Monitor. URL: http://www.smart-trace.com/index.php, Date of access 28.08.2012.

[2] Verdone, R.; Dardari, D.; Mazzini, D.; Conti, A.: Wireless sensor and actuator networks: technologies, analysis and design. Elsevier Ltd.- Academic Press, London, United Kingdoms 2008.

[3] Uckelmann, D.; Harrison, M.; Michahelles, F.: An Architectural ApproachTowards the Future Internet of Things. In: Uckelmann, D.; Harrison, M.; Michahelles, F.(Eds.): Architecting the Internet of Things. Springer, Berlin, Heidelberg 2011, pp 1-24.

[4] Sun Labs.: Sun™ Small Programmable Object Technology (Sun SPOT) -Theory of Operation. URL: http://sunspotworld.com/docs/Purple/SunSPOT-TheoryOfOperation.pdf, Date of access 19.08.2012.

[5] Jedermann, R.; Moehrke, A.; Lang, W.: Supervision of banana transport by the intelligent container. In: Kreyenschmidt, J. (Ed.): Coolchain-Management, 4th International Workshop. University Bonn, Bonn, 2010, pp 75-84.

[6] Palafox-Albarrán, J.; Jedermann, R.; Lang, W.: Energy-Efficient Parameter Adaptation and Prediction Algorithms for the Estimation of Temperature Development Inside a Food Container. In: Cetto, J.A.; Ferrier, J.-L.; Filipe, J.,(Eds.): Informatics in Control, Automation and Robotics 89. Springer, Berlin, Heidelberg, 2011, , pp 77-90.

Javier Palafox-Albarrán, M.Sc.
Analysis and Prediction of Sensor and Quality Data in Food Transport Supervision

E-mail: jpalafox@imsas.uni-bremen.de
Country: Mexico
Start: 01.10.2010
Supervisor: Prof. Dr.-Ing. Walter Lang
Faculty: Physics / Electrical Engineering
Research Group: Institute for Microsensors, -actuators- and -systems (IMSAS)

Performance Evaluation of CoAP Using the RPL Routing Protocol

Thomas Pötsch

The use of web services for sensor networking applications is an important part in emerging M2M communications. The Internet Engineering Task Force (IETF) proposed the Constrained Application Protocol (CoAP) to optimize the use of the RESTful web service architecture for constrained nodes and networks, for example Wireless Sensor Networks.
In this paper, we present a performance evaluation of the CoAP protocol implemented for the embedded operating system TinyOS. The CoapBlip implementation has been deployed on 20 TelosB motes forming a multi-hop network using the Routing Protocol for Low-power and Lossy Networks (RPL) with the two objective functions of MRHOF and OF0. The results of the experiments show that RPL performs better when using MRHOF instead of OF0.

Introduction >>> In Wireless Sensor Networks (WSNs), like IPv6 over Low power Wireless Personal Area Networks (6LoWPANs), energy usage, bandwidth, storage capabilities and computing power of the utilized battery operated computers are limited in most cases. Additionally, those networks mostly consist of IEEE 802.15.4 [1] compliant nodes with a maximum packet size of 127 byte. Resulting from this, such kind of networks can be seen as constrained networks. Therefore, the currently available Internet Protocol (IP) based application protocols, such as the Hypertext Transfer Protocol (HTTP), are not suitable for 6LoWPANs. This led the IETF Constrained RESTful Environments (CoRE) working group recently to propose a Working Group Internet-Draft called Constrained Application Protocol (CoAP) which fulfills the requirements imposed by the limitations of constrained nodes and networks. In [2] and [3], an implementation for TinyOS, named *CoapBlip*, has been presented by the authors. The implementation provides several resources to access, for example temperature and humidity sensors.

The IETF Routing Over Low power and Lossy networks (RoLL) working group developed a routing protocol for targeting IPv6-based low-power and lossy networks, called Routing Protocol for Low-power and Lossy Networks (RPL) [4]. RPL is used to create multi-hop connectivity in WSNs.

CoAP, 6LoWPAN, RPL and IP – as standardized protocols – are of high interest for logistical applications. In this field of application, many parties (e.g. producer, transporter, consumer) are involved with a need to inter-operate. The authors are therefore interested in using the IETF suite of protocols in a project, termed the *Intelligent Container* [5], where a cargo container is equipped with a WSN to supervise goods during transport. In this application, the Internet Engineering Task Force (IETF) protocols are used to retrieve sensor data from the goods. This solution is implemented and evaluated on TinyOS, a widely researched embedded system architecture.

This work has been published at [6] and evaluates the performance of CoAP using the IETF RPL routing protocol. The motivation for these tests is to see the feasibility of using those protocols for Machine-to-Machine (M2M) communication in logistical applications for supervision of the environmental conditions during transport.

An indoor testbed, consisting of 20 TelosB sensor nodes is used to evaluate CoAP and RPL protocols with different parameters. RPL relies on the two objective functions OF0 (Objective Function 0) and MRHOF (Minimum Rank Objective with Hysteresis), which represent two different metric computation schemes. Both are evaluated in this testbed setup, in order to decide the optimal setup to be deployed in the *Intelligent Container* while using CoAP as the application protocol.

The next section of this paper gives an overview of the evaluated protocols (CoAP and RPL). Then the testbed setup used to compare the performance of CoAP in a single-hop and a multi-hop network is described. The single-hop setup is used to compare the CoAP performance in terms of resource retrieval time and number of bytes used in different CoAP resources. The multi-hop network is used to evaluate the CoAP performance when running over RPL. The analysis of the results and the conclusion are given in the last two sections. <<<

Constrained Application Protocol (CoAP)

CoAP [7] is a lightweight web protocol which is specifically designed to meet the requirements of constrained networks and nodes. Its main focus lies in providing an M2M application protocol, implementing low message overhead, simplicity and limiting the use of fragmentation. Furthermore, it provides reliable and asynchronous message exchange using the User Datagram Protocol (UDP), Uniform Resource Identifiers (URI) and content-type support as well as multicast support and built-in resource discovery. By providing a stateless mapping to HTTP by use of proxies, the interaction with existing web applications is given.

CoAP is based on the same client/server model as HTTP and represents its interaction model in a similar manner. Resources are requested and identified by URIs using the Representational State Transfer (REST) [8] methods GET, PUT, POST and DELETE, whereas response codes (e.g. 201 Created) indicate success or failure. In contradiction to HTTP, CoAP exchanges messages asynchronously over UDP. To provide a lightweight reliability mechanism, it makes use of an exponential back-off with the common stop-and-wait retransmission scheme. Furthermore, it implements detection of duplicate messages by using randomly generated, unique message identifiers.

Currently, CoAP is available as a CoRE Working Group Internet-Draft of the IETF in version 11 [7]. In this work, the application installed on the nodes is based on the C implementation *libcoap* [9] and uses version 03 of the draft.

CoAP is mainly used in the WSN part of the *Intelligent Container* to manipulate resources (e.g. temperature, humidity) by using the following methods:

- The GET method is used to retrieve resources from WSN nodes or the telematic device. The resources are identified by the requested URI.
- The PUT method is used to modify an existing resource on a sensor node or the telematic device.

Both, the methods and the requested URI are carried in a Confirmable (CON) message wich represents the request.

The following resources are used to evaluate the performance of the CoAP protocol during the initial tests.

- */r:* Retrieval of sensor data (temperature, humidity, voltage) from the sensor nodes in the *Intelligent Container*. Here, the sensor nodes act as a CoAP server.
- */rt*: Retrieval of routing table from the sensor nodes to log the routing table information.
- */ni*: Sending of configuration information to the telematic device. A newly joined sensor node sends a PUT to the */ni* resource to inform the telematic device about the joining of the WSN. Here, the sensor node acts as a CoAP client.

The total size of the CoAP server and client implementation on a sensor node with typical sensor resources, including the operating system and the remainder of the radio stack, is about 45 430 bytes using a recent compiler.

RPL

RPL [4] has been designed for low-power and lossy IPv6 networks and relies on source routing by making use of the distance vector mechanism to calculate the routing paths. The RPL protocol is used to create a multi-hop network in the WSN part of the *Intelligent Container*. In TinyOS, the objective function OF0 [10] or MRHOF [11] are implemented for selecting the parent node and calculating the ranks.

OF0 is a basic objective function where nodes select their default route considering only the link quality to the possible parent together with its rank. Contrary, the path costs in MRHOF are obtained by summing up the link cost (e.g. in terms of expected number of transmissions (ETX)) to the possible parent and also considering the parents' link cost to the root node. This allows the use of MRHOF to select a parent considering the characteristics of a path rather than only considering an individual link quality. Both objective functions additionally use a hysteresis to limit ping-pong parent selection.

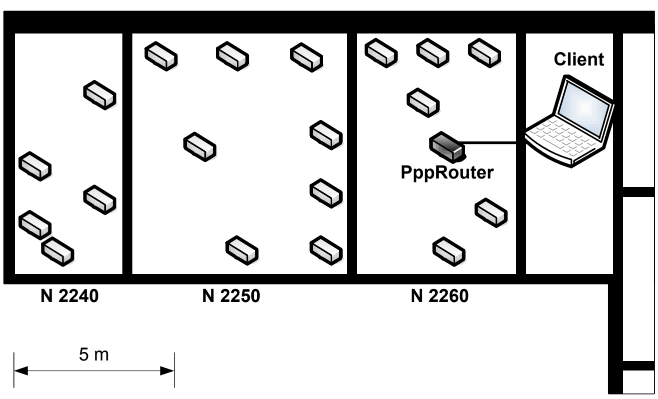
TinyRPL [12] is an implementation of the IETF RPL draft version 18 in TinyOS. It provides both OF0 and MRHOF routing metrics and updates the ETX values after each unicast transmission.

Testbed setup

For the experiments presented in this work, a set of 20 TelosB nodes, operating at the 2.4 GHz ISM band with IEEE802.15.4 based radio chips, are used. All sensor nodes are configured to run on the TinyOS operating system including the Berkeley Low-power IP stack (Blip 2.0) stack with IPv6 and 6LoWPAN [13], RPL and *CoapBlip*. The global addresses of each node are preconfigured, e.g. fec0::3.

We evaluate the performance of our CoAP implementation in terms of Round-Trip Time (RTT) and number of bytes transmitted by using two testbed setups. The single-hop consists of two nodes, where one node runs as a *CoapBlip* server and one as a *PppRouter*. The multi-hop testbed is setup with 20 TelosB sensor nodes, spread over 3 office rooms of the university (cf. figure 1). It consists of 19 *CoapBlip* server nodes and one *PppRouter* node. In both scenarios, the *PppRouter* is used to connect the local computer to the WSN and acts as a border router. This setup is similar to a real deployment scenario of the *Intelligent Container*, since the sensor nodes are not moving once they are loaded to the container. A standard cargo container consists of 20 pallets, where usually 4 pallets are equipped with 4 sensors each. In total, there are at least 16 nodes required to have an appropriate connectivity inside a standard cargo container completely filled with goods.

Figure 1: Testbed setup: mutli-hop network



In our testbed setup, the transmit power is set to the minimum value of -25dBm in order to enforce multi-hop connectivity in our indoor testbed setup. The test is used to compare how the performance of RPL (with OF0 and MRHOF) affects the application layer. The root node (i.e. *PppRouter*) starts the RPL operations immediately after booting. Once the routes are established, the CoAP client starts retrieving */r* resource from each node, regularly at 5 minute intervals.

Each test lasts for 12 hours, resulting in a total number of 2508 */r* requests generated by the CoAP client. Additionally, the client requests */rt* every hour from all nodes. The details of */rt* are used to generate the routing topology and also for further debugging. In total, there were 2 test runs, in which both objective functions of RPL were used. The mentioned tests were carried out using USB powered nodes.

In the multi-hop setup, the following parameters are used for the evaluation.

- RTT: The application layer resource retrieval time to receive an Acknowledgement (ACK) for a */r* GET request generated by the client. The ACK message carries the temperature, voltage and humidity values piggy-backed in a Time-Length-Value (TLV) structure. The RTT includes the time taken for any retransmissions (triggered by the CoAP layer) in case of lost packets.
- Retransmissions: This shows the total number of retransmissions done at the CoAP layer. The CoAP retransmission timeout has been set to 6 seconds based on experience with the topology. CoAP tries 5 retransmissions for each GET request and each retransmission is done with an exponential back-off, as specified in [7].
- Packets lost: This shows the total number of packets lost due to not receiving a successful ACK at the application layer although retransmission have been tried.

Analysis of results

This section details the evaluation of CoAP and RPL that are proposed to use in the *Intelligent Container* project.

Single-hop evaluation

In this section, the RTTs and the total number of bytes transmitted in a single-hop scenario are measured by using the CoAP implementation described above. Both, CoAP client and server nodes, are connected wirelessly via IEEE 802.15.4 using channel 26. The measurements of the mean and standard deviation values are calculated out of 100 measurements. In the CoAP header, only the URI-Path option is included and the payload is carried piggy-backed as an immediate response.

Since this scenario is a single-hop network, the payload for requesting the */rt* resource carries only one entry (default route) of the servers routing table.

Table 1 shows the resulting RTTs, as well as the number of transmitted bytes (CON and ACK messages) for requesting both resources on the *CoapBlip* server.

Table 1: Single-Hop Evaluation

Resource	Mean RTT (Standard Deviation)	# of bytes CON/ACK
/r	331.32 ms (4.03 ms)	70/77 bytes
/rt	61.16 ms (3.74 ms)	71/96 bytes

According to Table 1, requesting the resource */r* shows higher values for the RTT. This is due to the fact that the sampling of the temperature itself takes ≈ 280 ms.

Multi-hop evaluation

Next, we present the results taken with 20 sensor nodes forming a multi-hop network. Table 2 shows the overall results taken for 4 test cases each running for 12 hours.

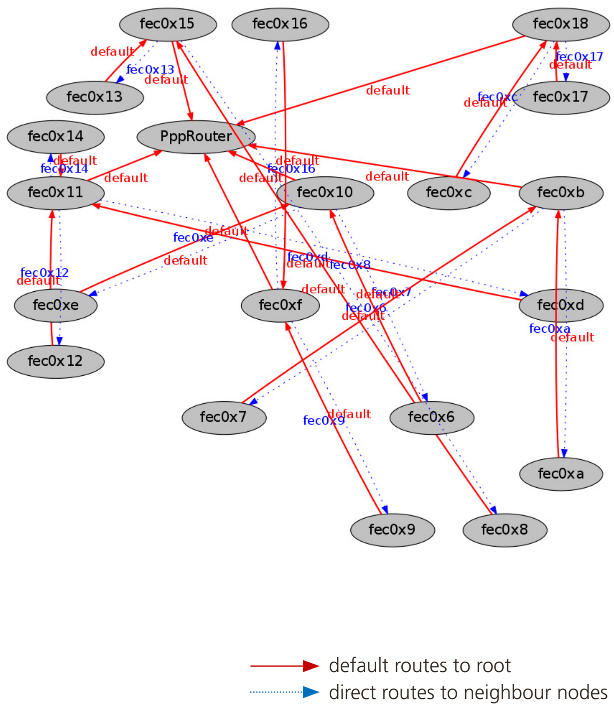
Table 2: CoAP performance when using OF0 and MRHOF

	OF0	MRHOF
Mean RTT	549.11 ms	362.43 ms
Std. Deviation	4216.26 ms	733.02 ms
Retransmissions	46	15
Packet losses	0	0

Table 2 shows that using MRHOF leads to lower values for the mean RTT and that fewer packets are lost and retransmitted when compared to OF0.

Figure 2 shows one instance of a routing topology when using the OF0. This topology is created using the */rt* details. The analysis of the routing topologies at different time instances shows higher numbers of single-hop connections to the RPL root node, when using MRHOF. Those higher numbers of single-hop connections lead to lower RTT values and less retransmission compared to the use of OF0.

Figure 2: Routing topology of multi-hop network (Objective function of RPL: OF0)



When using OF0, the number of two-hop connections exceeds the number of single-hop connections to the RPL root node. Since the OF0 algorithm considers only the individual link quality between a node and its neighbors (and their rank) to determine a parent, this algorithm tends to construct more two-hop connections than MRHOF. For example, Figure 2 shows a two-hop connection between node fec0::12 and the RPL root node (notified in the figure as *PppRouter*) over node fec0::11 when using OF0, whereas the node fec0::12 selects a direct connection to the RPL root node when using MRHOF. This means MRHOF sees that the direct connectivity to the *PppRouter* is better than using a 2 hop path over node fec0::11. Furthermore, the ETX metric, based on the individual link quality, varies frequently and child nodes with OF0 start to switch between different parents. This causes instability of routes resulting in higher packet losses in the network and triggering retransmissions at the CoAP layer. In contrast to OF0, MRHOF shows a more stable connectivity due to choosing a parent considering the quality of the complete path.

Conclusion

The main objective of the experiments was to evaluate the CoAP protocol in combination with the other lower layer IETF protocols which are planned to be deployed for M2M communication in logistical applications for supervision of the environmental conditions during transport. The resources of the CoAP protocol, which should be deployed in the *Intelligent Container* project, have been implemented and tested. The results of the experiments show that RPL performs better when using the MRHOF objective function instead of OF0. Furthermore, the results presented here show the feasibility of deploying CoAP, RPL (with MRHOF) and 6LoWPAN protocols together in the project, though care has to be taken to adapt the parameters of CoAP to the protocols/settings that have been chosen in the lower layers.

Acknowledgments

This research project ('The *Intelligent Container*') is supported by the Federal Ministry of Education and Research, Germany, under reference number 01IA10001.

References

[1] *IEEE Computer Society: Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs). In: IEEE Standard for Information technology- Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements. IEEE Std 802.15.4-2006. 2006.*

[2] *Kuladinithi, K.; Bergmann, O.; Pötsch, T.; Becker, M.; Görg, C.: Implementation of CoAP and its Application in Transport Logistics. In: Proceedings of the Workshop of Extending the Internet to Low power and Lossy Networks (IP+SN 2011). Chicago U.S.A. 2011.*

[3] *Becker, M.; Pötsch, T.; Kuladinithi, K.; Görg, C.: Deployment of CoAP in Transport Logistics. In: Proceedings of the 36th IEEE Conference on Local Computer Networks (LCN). Bonn Germany 2011.*

[4] *Winter, T.; Thubert, P.; Brandt, A. et al.: IPv6 Routing Protocol for Low power and Lossy Networks. Internet-Draft (work in progress). URL: http://tools.ietf.org/ html/draft-ietf-roll-rpl-19, Date of access 29.08.2012.*

[5] *Lang, W.; Jedermann, R. et al.: Intelligent Container. URL: http://www.intelligentcontainer.com, Date of access 13.09.2012.*

[6] *Pötsch, T.; Kuladinithi, K.; Becker, M.; Trenkamp, P.; Görg, C.: Performance Evaluation of CoAP using RPL and LPL in TinyOS. In: Proceedings of the 5th IFIP International Conference on New Technologies, Mobility and Security (NTMS). Istanbul, Turkey. 7 - 10 May 2012*

[7] *Shelby, Z.; Hartke, K.; Bormann, C.; Frank, B.: Constrained Application Protocol (CoAP). Internet-Draft (work in progress). URL: http:// tools.ietf.org/ html/ draft-ietf-core-coap-11, Date of access 18.09.2012.*

[8] *Fielding, R.: Architectural Styles and the Design of Network-based Software Architectures. Ph.D. Dissertation. University of California, Irvine, USA 2000.*

[9] *Bergmann, O.: libcoap: C-Implementation of CoAP. URL: http://libcoap.sourceforge.net, Date of access 13.09.2012.*

[10] *Thubert, P.: RPL Objective Function 0. Internet-Draft (work in progress). URL: http://tools.ietf.org/ html/draft-ietf-roll-of0-20, Date of access 13.09.2012.*

[11] *Gnawali, O.; Levis, P.: The Minimum Rank Objective Function with Hysteresis. Internet-Draft (work in progress). URL: http://tools.ietf.org/ html/ draft-ietf-roll-minrank-hysteresis-of-04, Date of access 13.09.2012.*

[12] *Ko, J.; Eriksson, J.; Tsiftes, N.; Dawson-Haggerty, S.; Terzis, S.; Dunkels, A.; Culler, D.: ContikiRPL and TinyRPL: Happy Together. In: Proceedings of the Workshop on Extending the Internet to Low Power and Lossy Networks (IP+SN 2011). Chicago, U.S.A. 2011.*

[13] *Dawson-Haggerty, S.: Design, Implementation, and Evaluation of an embedded IPv6 stack. Master's thesis. URL: http://code.google.com/ p/ tinyos-main/ source/ checkout, Date of access 13.09.2012.*

.

Thomas Pötsch, M.Sc.

The Efficiency of Machine-to-Machine Protocols in Current and Future Mobile Networks for Logistical Processes

E-mail: thp@comnets.uni-bremen.de
Country: Germany
Start: 01.05.2012
Supervisor: Prof. Dr. rer. nat. Carmelita Görg
Faculty: Physics / Electrical Engineering
Research Group: Communication Networks

Applying the Monte Carlo Method in Delivery Time Uncertainty in Supply Networks

Mehdi Safaei

The value-chain concept has been extended beyond individual firms, and so it is now applied to entire supply chains and supply networks. Today's research has recognised the importance of analysing the delivery time uncertainty in supply networks. The delivery time uncertainty of each supplier influences the final delivery time differently according to the complexity and the type of the supply network. A method to calculate this uncertainty is needed to reach a reliable delivery time. The aim of this paper is to calculate the accumulation of the individual delivery time uncertainties and estimate the combined uncertainty, transmitted to the OEM. In this paper, an adapted Monte Carlo Method (MCM) algorithm is applied to calculate this accumulation. The presented method can be applied to calculate the accumulated uncertainty for a supply network with considering different probability density function of individual delivery time uncertainties.

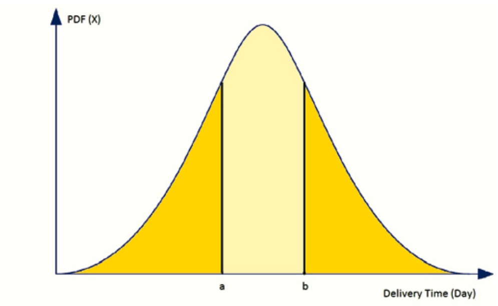
Introduction >>> Today's business has rapidly changed and has become more competitive. Companies more and more realized the effective role of supply networks to compete in the global market and networked economy. Since a supply network is considered as the collaboration between suppliers and an OEM with the objective to realize a product, the management of quality, cost and time is not the issue of one single organization any more [1].

Time plays an important role for every participant of a supply network because of the need to ensure internal efficiency, and because of external pressure of time based competition [2]. Quantities, delivery times, due dates, start times, etc., in the network may change at any time. Hence, the supply network is a dynamic system where these quantities are changing continually. Consequently, supply network systems must be updated accordingly so that decisions are based on dynamic information [3]. Nowadays, a company in the supply network can outsource different functions and signifies different degrees of commitment and integration between the company and the contractor. Outsourcing in the supply network creates a new source of uncertainty in delivery time and other quantities and qualities factors. This uncertainty has an impact on supply network performance by affecting delivery time reliability [4]. The importance of delivery time as a strategic weapon has been recognised in the arena of global competition [5] [6]. The strategic importance of delivery time uncertainty (DTU) has been recognised (introduced) by many researchers and practitioners, and it has emerged as a key competitive factor in a supply network. Thus, many manufacturers are adopting the use of delivery-time guarantees as part of their market positioning strategy [7].

Each supplier in the supply network has uncertainty in their delivery time and when they work with other suppliers in a network, accumulation of DTUs gains importance for supply networks managers and production planners to make more efficient and effective decisions. Safaei in 2012 proposed a method based on the GUM methodology, and calculated this accumulation for the networks when the DTU of each supplier follows as a normal probability density function (PDF) [8]. Moreover, he mentioned that types of networks have an influence on this accumulation. Calculating the accumulation of uncertainties when the PDF of each supplier is not followed as a normal function and the PDFs of the suppliers are different, is still a challenge in the supply network and production planning area.

In this paper, we adapt the Monte Carlo Method (MCM) and extend it to calculate the accumulation of the delivery time uncertainties that are transferred to the OEM, when the PDFs of suppliers are not normal, and they are different with each other. The paper is organized as follows. In section 2, the probability density function is explained, and we try to show what our understanding of PDF is in this research. The categorization of basic types of supply networks is following in section 3 to indicate what the supply network is in this study. In the next section, we will discuss the delivery time uncertainty. The methodology of MCM to calculate the accumulated uncertainty in supply networks is introduced and the advantages of this method are discussed in section 5. In the final section, we will discuss the application and conclusion. <<<

Figure 1: Normal probability density function



Probability Density Function

Probability density function (PDF) is a statistical measure that defines a probability distribution for a random variable and is often denoted as PDF(x). When the PDF is graphically portrayed, the area under the graph will indicate the interval under which the variable with fall. For example, if X is a continuous random variable, then the probability density function, PDF of X, is a function PDF(x) such as that for two numbers, a and b with a ≤ b [9].

That is, the probability that X takes on a value in the interval [a, b] is the area under the density function from a to b.

$$P(a \leq x \leq b) = \int_a^b PDF(x)\partial x \qquad (1)$$

A most popular probability density function is the normal distribution, whose PDF is given:

$$PDF(x) = \frac{1}{\sigma \times \sqrt{2\pi}} \times \left(e^{\frac{-1}{2}\times\left(\frac{x-\mu}{\sigma}\right)^2}\right) \qquad (2)$$

Table 1, illustrates the most important PDFs and their feature, which is more likely in the real world.

Type of network

The supply network concept appears to be more complex than the supply chain concept. Supply networks encompass the mess and complexity of networks involving lateral links, reverse loops, and two-way exchanges, and include a broad, strategic view of resource acquisition, development, management, and transformation [10]. Various classified types of a supply network have been introduced in the literature. Formally, a supply network can be described by nodes, which represent the companies and the links (relationships) between these nodes. From this perspective, a network type is defined as the structure of how the different nodes are linked with each other. Figure 2 depicts basic types of a network [11]. Generalised networks can be described as a combination of these basic types. In this paper, supply networks are considered as networks with an OEM and its suppliers.

In Figure 2, in the Linear-type, the partners' interaction pattern mainly follows a chain. Maximum in and out degree for any node (firm) in the network is one and multiple tiers exist but every firm has exactly one supplier below it. The processed juice industry, where the plantation supplies the factory, which in turn supplies the end market, and natural resource industries are mostly a good example of linear topology [12].

Where all members of the supply network communicate to a single firm is called "star-type". In the star topology all suppliers interact with one central node (OEM). Maximum depth of it is one, and it has included of single tier where all suppliers go to a single central firm. The best example of this network type is eBay [12], [8].

Figure 2: Basic network types ([8], [12])

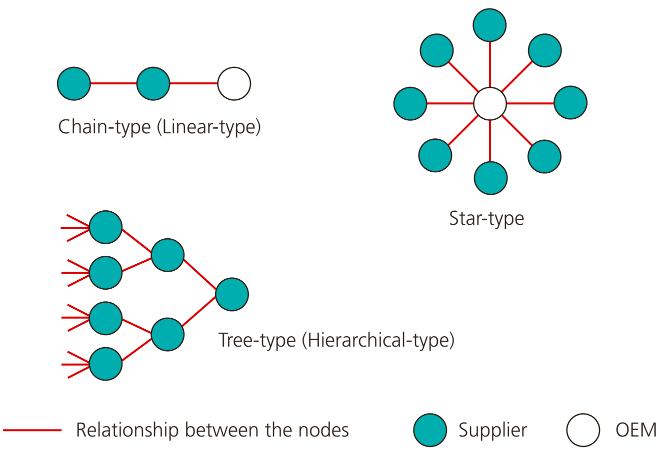
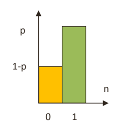
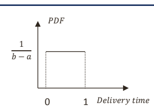
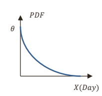


Table 1: Most important PDFs in supply networks

Name of PDF	Function	Indexes	Shape	Conditions
Bernoulli	$PDF(x) = \begin{cases} p & n = 1 \\ 1-p & n = 0 \end{cases}$	B(1,p) P: probability of success (n=1)		There are only two modes of delivery and non-delivery of the order.
Uniform	$PDF(x) = \begin{cases} \frac{1}{b-a} & a \leq x_{DT} \leq b \\ 0 & \text{Otherwise} \end{cases}$	U(a,b)		Probability of order's delivery is the same at every time in the specified timeframe.
Exponential	$PDF(x) = \theta e^{-\theta x_{DT}} \quad x_{DT} \geq 0$	EXP(θ)		There is a regular time between every two successive orders.
Normal	As described before.			

Delivery time uncertainty

For estimating the delivery time uncertainty of the entire supply network, the influence of individual supplier uncertainties on the overall uncertainty must be understood. How the individual uncertainties need to be accumulated depends on the network type [13]. The type of the supply network directly effects the final accumulation of the uncertainty of the delivery time. The way to calculate this accumulation is our discussion in this paper. Moreover, we explain an algorithm to calculate this accumulation regarding the Monte Carlo Method (MCM). In the next section, we will further discuss this algorithm.

Adapted Monte Carlo Method

The Monte Carlo Method (MCM) was coined in the 1940s by John von Neumann, Stanislaw Ulam and Nicholas Metropolis, while they were working on a nuclear weapon projects (Manhattan Project) in the Los Alamos National Laboratory. It was named after the Monte Carlo Casino, a famous casino where Ulam's uncle often gambled away his money [14]. The Monte Carlo Method is in the computational algorithms' level, which depends on repeated random sampling. The MCM is often applied in computer simulations of physical, mathematical systems, risks assessment of business. Nowadays, researchers have recognized the MCM as a practical alternative method to analyse the uncertainty of measurement in calibration laboratories in comparison to (Guide to the Expression of Uncertainty in Measurement) GUM.

GUM is based on the mathematic methods, and the accuracy of the GUM is higher than that of the MCM, but it has some limitations. Some advantages of the MCM to the GUM are listed below:

- MCM is able to consider nonlinear relationship functions between the delivery times of suppliers in the supply network.
- MCM is appropriate, also when the probability density function of DT of each supplier is not normal.
- MCM is simple for analysis in more complex networks.
- MCM can consider unsymmetrical PDFs.

The schematic process of the MCM to calculate the accumulation of DTUs in supply networks and the research problems which the MCM is able to solve , are illustrated in the figure 3.

In adapted MCM, there are four main steps to calculate the accumulation of uncertainties, which are as follows:

Inputs section:
In this part, we need to identify the probability density function of delivery time of each supplier separately, according to the type of network; the mathematical relationship function between suppliers must be determined. Probability density functions (PDFs), will be estimated by the sampling of the past delivery times, and mathematical relationship functions demonstrate how the suppliers relate with each other to obtain the product. The confidence coefficient (p) is the next input of the MCM and introduces the percentage of confidence which a manager has to deliver the order in the specified timeframe. As we mentioned before, the MCM is an algorithm, which depends on repeated random sampling, the number of MCM trials (m) must be determined in the final part of section one.

Process section:
In this section, MCM algorithm according to the number of Monte Carlo trials (m), and PDFs of each supplier's delivery times, will generate m vector of delivery time for each supplier separately. Now we have 'n' vector (if n suppliers are in our supply network), and each vector has m member. The MCM will generate 'm' value as a result of mathematical relationship functions by putting the generated delivery time on this function.

First output:
After generating 'm' value for the final delivery time by using two software like EXCEL 2007 and EASYFIT 5.5, we will find the diagram and mathematical function of the PDF of the accumulated of delivery time uncertainty.

Final results:
According to the probability density function of delivery time, the combined uncertainty which is transmitted by suppliers to the OEM is calculated and shown. By considering the confidence coefficient (p), and final delivery time (which is estimated in this section), a coverage distance for delivery time is shown. This timeframe presents the interval for delivery time of the order, which take place on it with the specified confidence.

Figure 4, shows the adapted algorithm of MCM to calculate the accumulation of delivery time uncertainty according to the presented four steps.

Figure 3: MCM process framework to calculate the accumulation of DTUs in supply networks

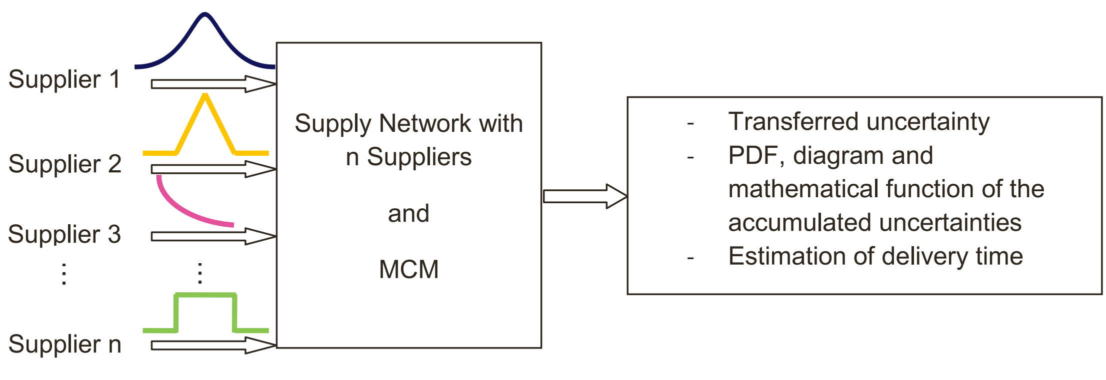
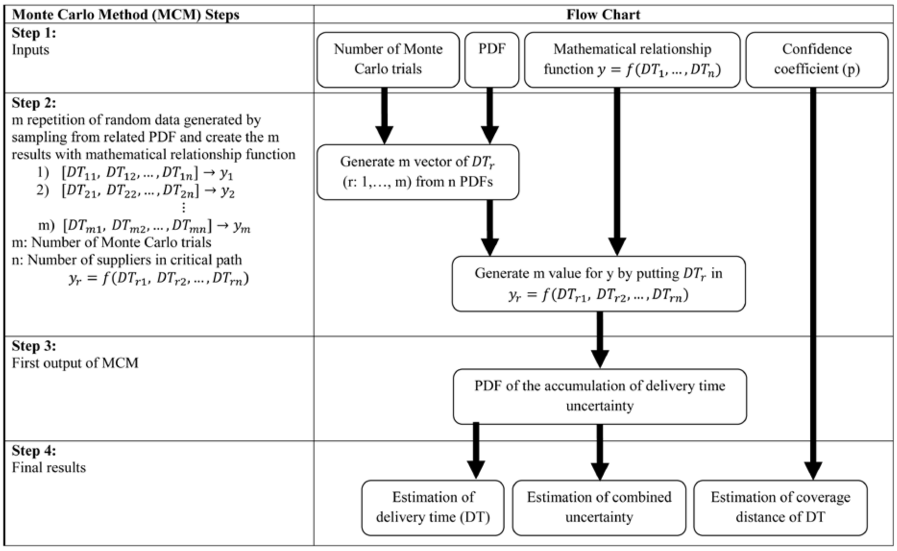


Figure 4: Adopted MCM flowchart to calculate the delivery time uncertainty in supply network



Application and conclusion

The presented algorithm can calculate the accumulated delivery time uncertainty of the supply networks, in which the PDFs of their suppliers are not exactly normal. In addition, it is able to consider different PDFs for each supplier in the network. This accumulated uncertainty, creates high confidence for decisionmakers, to speak about the delivery time of orders, and they are able to have more control on their delivery time uncertainty in the supply network. Moreover, this method gives some information about those parts of a network, which have the highest influence on DTU, in consequence, managers are able to make a decision about their suppliers. Therefore, it helps network planners to find the best design for their supply networks with high efficiency and effectiveness according to less uncertainty in DT.

References

[1] Safaei, M.; Seifert, M.; Thoben, K.D.: Toward a better understanding of the network type impact on delivery time uncertainty in supply networks.In: MITIP 2011, Proceedings of the 13th International Conference on Modern Information Technology in the Innovation Processes of industrial enterprises. Trondheim, Norway 2011, pp 1–11.

[2] Sule, E.: The role of time in supply chain. In: Acta Technica Jaurinensis Series Logistica 2 (2009) 3, pp 325-336.

[3] Barker, J: Using dynamic information in the supply network. In: Proceedings of the 8th International Conference on Manufacturing & Management: Operations Management & Advanced Technology: Integration for Success. Gold Coast, Australia 2004, pp 1-10.

[4] Vanany, I.; Zailani, S.; Pujawan, N.: Supply chain risk Management: Literature review and future research'. In: International Journal of Information Systems and Supply Chain Management 2 (2009) 1, pp 16-31.,

[5] Lerderer, P.J.: Pricing, production, scheduling, and delivery-time ompetition. In: International Journal of Operation Research 45(1997) 3, pp 407-420.

[6] Christopher, M.: The agile supply chain: competing in volatile markets. In: Industrial Marketing Management 29 (2000) 1,, , pp 37-44.

[7] Urban, T.L.: Establishing delivery guarantee policies. In: European Journal of Operational Research196 (2009), pp 959–967.

[8] Safaei, M.; Issa, S.; Seifert, M.; Thoben, K.D.; Lang, W.: A method to calculate the delivery time uncertainty in supply network. LDIC 2012, Proceedings of the 3rd International Conference on Dynamics in Logistics. Bremen, Germany, 2012.

[9] Montgomery, D. C.; Wiley, J.; Sons, I.: Introduction to statistical quality control', 3. Edition. John Wiley & Sons, New York 1997.

[10] Harland, C.M.; Lamming, R.C; Zheng, J.; Johnsen, T.E: A taxonomy of supply networks. In: The Journal of Supply Chain Management (2001), pp 21-27.

[11] Thoben, K.D.; Jagdev, H. S.: Typological issues in enterprise networks.In: Production Planning & Control 12 (2001), pp 421-436.

[12] Pathak, S.D.; Dilts, D.D.; Biswas, G.:On the evolutionary dynamics of supply network topologies.In: IEEE Transactions on Engineering Management54, 4 (2007) 4, pp 662-672.

[13] Guiffrida, A. L.; Jaber, M. Y.: Managerial and economic impacts of reducing delivery variance in the supply chain'. In: Applied Mathematical Modeling32 (2008), pp 2149–2161.

[14] Binder, K.: Toppics in Applied Physics 71: The Monte Carlo Method in Condensed Matter Physics. Springer, New York 1995.

Mehdi Safaei, M.Sc.
Delivery Time Uncertainty in Dynamic Supply Networks

E-mail: saf@biba.uni-bremen.de
Country: Iran
Start: 01.11.2009
Supervisor: Prof. Dr.-Ing. Klaus-Dieter Thoben
Faculty: Production Engineering
Research Group: Collaborative Business in Enterprise Networks

A Periodic and Real-time Event-driven Rescheduling for Dynamic Job Shops: Using Shifting Bottleneck Procedure

Yi Tan

Due to the increasing market competition, manufacturers currently pay more attention on due date related production objectives and scheduling in order to fulfill the customers' demand on punctuality. However, two types of dynamics in manufacturing increase the uncertainty in production scheduling. They are continuous production processes with on-going incoming jobs as well as unexpected events or disturbances during a production process. In order to consider and react to these two dynamics, this article presents a hybrid rescheduling policy combining periodic with event-driven sub-policies for job shop production processes, considering the due date related optimality criterion total weighted tardiness. For the rescheduling method, which is responsible for solving the concrete rescheduling problems for the policy, this research extends the shifting bottleneck procedure originally developed for static job shop problems to dynamic job shops. As a result, this article presents the appropriateness of using this procedure for the designed rescheduling policy.

Introduction >>> Former research in the scheduling literature has paid a lot of attention to the static job shop scheduling problem (i.e. job shops with a finite set of jobs). In this article I focus on the rescheduling of job shops under the consideration of dynamics in production processes. Two types of dynamics are under consideration:

1. A continuous production process with on-going incoming jobs describes the first dynamic. The rescheduling framework [1] defines a production process with infinite set of jobs as dynamic rescheduling environment and a job shop in this environment as a dynamics job shop.
2. Unexpected events and disturbances in the production environment during the production process are the second dynamic. They may invalidate the currently used production schedule.

To consider and react to these two dynamics we require two different rescheduling policies. In the following sections, I present firstly the design of a hybrid rescheduling policy consisting of periodic and event-driven sub-policies. Secondly, I focus on the job shop rescheduling problems with the optimality criterion total weighted tardiness (TWT) and demonstrate the formal definition of the dynamics job shop problem. Afterwards, I extend the shifting bottleneck (SB) procedure originally developed to the static job shop problem to dynamics job shops. Furthermore, I present the appropriateness of using this procedure as the rescheduling method, which is responsible for solving the concrete rescheduling problems for a rescheduling policy [1], for the designed policy. <<<

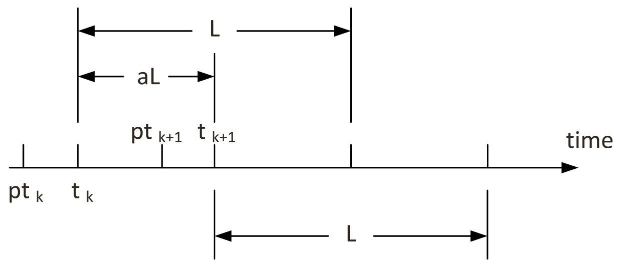
A hybrid rescheduling policy – periodic and event-driven

To consider and react to the two types of dynamics mentioned in the introduction we require two different rescheduling sub-policies. The first one is the periodic rescheduling policy to consider the production process with on-going incoming jobs and the second one is the event-driven rescheduling policy to react to the unexpected events.

The periodic rescheduling policy reschedules jobs periodically for the next period by means of the rolling time horizon method [2][3][1]. This method decomposes the overall scheduling problem into smaller and static (i.e. infinite set of jobs) scheduling problems.

I adapt in my research the rolling horizon method. Figure 1 illustrates the rolling time horizon method for the periodic rescheduling policy. For the date t_k the scheduling system considers the jobs ready for the next period from t_k to $t_k + L$, where L is the length of each period (e.g. 8 hours), and generates a tentative production schedule for this period. The schedule in the area from t_k to $t_k + aL$ is permanent, i.e. the schedule will not be changed during the production process, where a is a parameter between 0 and 1 (e.g. a = 0.5 and aL = 4 hours). As time goes on, new jobs will arrive. At the date $t_{k+1} = t_k + aL$ the production process should execute a new schedule considering the jobs in the next period from t_{k+1} to $t_{k+1} + L$. This new schedule will overwrite the tentative schedule of the last planning period for the time between t_{k+1} and $t_k + L$.

Figure 1: Periodic rescheduling policy and rolling time horizon method



pt_k	the k[th] planning date
t_k	the start date of the k[th] schedule
L	length of a planning horizon for a tentative production plan
a	parameter between 0 and 1
aL	permanent production plan
t_{k+1}-pt_{k+1}	planning time for the (k+1)[th] horizon

In order to have a schedule at date t_{k+1} the scheduling system has to start the calculation of the schedule at an earlier time pt_{k+1}. At that time the scheduling system has to collect the information of jobs in the next horizon t_{k+1} to $t_{k+1} + L$ and estimate the production system environment (e.g. the machine release dates) at the date t_{k+1} depending on the current permanent schedule and its execution. The larger the distance between pt_{k+1} and t_{k+1} is, the more time the rescheduling approach will have to generate a schedule for the next period. Especially for difficult problems like job shop problem (proved to be NP-hard) it is necessary for the scheduling system to make a large computational effort to achieve a plausible schedule. However, the later the pt_{k+1} is, the more information about jobs the scheduling system will obtain and the more precise the estimation of the system environment at the date t_{k+1} will be. Hence, there must be a trade-off between computational time and precise information. Nevertheless, in general a periodic rescheduling approach has relatively enough time to generate the schedule for next period.

The second policy, which reacts to the unexpected events during the production process, is the event-driven rescheduling. If an unexpected event (like machine breakdown or a significant supplier delay) occurs, the event-driven rescheduling will immediately react to this event, collect the current system states, update the scheduling problem, and generate a new schedule for the current period (i.e. until $t_k + L$). This process has to be done in real-time (i.e. within some seconds), because the whole production process has to stop during the calculation of a new schedule and each break in the manufacturing causes cost. Related to the periodic rescheduling, if the event-driven rescheduling occurs between t_k and pt_{k+1}, it is not necessary to do a new periodic rescheduling. If the event-driven rescheduling is between pt_{k+1} and t_{k+1}, a new periodic rescheduling for the period k+1 is necessary.

Job shop total weighted tardiness rescheduling problem

In respect of the rescheduling problem to be investigated, my research focuses on the job shop rescheduling problem. Generally, the job shop scheduling problem is formulated as follows (c.f. [4][5]):

- There is a set of n jobs $j = 1, \ldots, n$ to be scheduled.
- There is a set of m machines $i = 1, \ldots, m$.
- Each job j consists of a predetermined sequence of n_j operations $O_{i,j}, i \in \{1,\ldots,m\}$, where $O_{i,j}$ denotes the processing of job j on machine i. In addition, $n_j \le m$ and $i \ne i'$ for each $O_{i,j} \ne O_{i',j}$.
- $p_{i,j}$ is the processing time of the operation $O_{i,j}$.
- d_j denotes the due date of job j.
- w_j denotes the weight of job j.
- The problem is to find a feasible schedule which minimizes some objective function depending on the finishing times C_j of the last operations $O_{n_j,j}$ of the jobs.

Two constraints are considered in this problem:

- At a time, a machine can process at most one operation.
- No pre-emption, it means an interruption of a processing of an operation on a machine is not allowed.

Two additional parameters in respect of rescheduling are required to the problem definition. In dynamic job shops jobs arrive in the production system at different dates. Hence, each job has a release date. Furthermore, in consideration of the rescheduling situation occurring during a production process, some machines cannot be available at the beginning time of the scheduling problem, because they are still processing jobs at that time. Hence, it is necessary to define a machine release date to describe this situation.

- r_j denotes the release date of job j.
- mr_i denotes the release date (or available date) of machine i in the production process.

The optimality criterion for the rescheduling problem considered in my research is the total weighted tardiness. On-time delivery has gained significant importance for the manufacturers. A manufacturer has to pay a customer a penalty if he delays the agreed delivery date of the product ordered by this customer. According to the delivery dates of the customer orders, each job j associated with a customer order has a due date d_j in production. The penalty mentioned above depends usually on a penalty weight w_j (defining a penalty for one time unit) and the delayed time called tardiness $T_j := \max\{0, C_j - d_j\}$ for each job j, where C_j is the completion time of job j in production. The weighted total tardiness (denoted as $\sum w_j T_j$) is as follows:

$$\sum w_j T_j := \sum_{j=1}^{n} w_j T_j$$

Shifting bottleneck procedure as rescheduling method

To solve the static job shop TWT scheduling problem Pinedo and Singer [5] present a SB-TWT procedure, which can be briefly described as follows:

Phase 1: The job shop is decomposed into a number of one machine problems ('subproblems') that have to be scheduled.

Phase 2: The subproblems are solved according to some specified 'subproblem solution procedure' (SSP).

Phase 3: A performance measure 'machine criticality measure' is computed in order to rank the machines in order of criticality. The schedule of the most critical machine, among the machines of which the sequences still have to be determined, is fixed.

Phase 4: Calculate the interactions between the machines already scheduled and those not yet scheduled.

Phase 5: Those machines that already have been sequenced are rescheduled using the new information obtained in Phase 4. If all machines have been scheduled, stop. Otherwise go to Phase 2.

In phase 1, all operations $O_{i,j}$ construct the one machine problem for machine i . Each operation $O_{i,j}$ has a release date $r_{i,j}$ derived from the job release date r_j and n due dates $d^k{}_{i,j}$ as subject to the due dates of all n jobs (derived from $d_k, k=1,..,n$. In phase 2 Pinedo and Singer [5] developed the following priority rule to schedule the operations on a machine:

$$I_{ij}(t)=\sum_{k=1}^{n}\frac{w_k}{p_{i,j}}\exp(-\frac{(d_{ij}^k-p_{i,j}+(r_{i,j}-t))^+}{K\overline{p}})$$

Where the parameter $\overline{p}$ denotes the average processing time of all operations and the K is a scaling parameter that has to be determined empirically by computational experiments. However, if we consider the rolling time horizon method for dynamic job shops, we determine that this rule depends on the chosen time horizon and is therefore not applicable for dynamic job shop scheduling.

Proof: Let L is the length of a time horizon. The same operation in the next time horizon has the following priority index given by the rule:

$$I_{ij}(t)=\sum_{k=1}^{n}\frac{w_k}{p_{i,j}}\exp(-\frac{((d_{ij}^k+L)-p_{i,j}+((r_{i,j}+L)-(t+L)))^+}{K\overline{p}})$$

$$=$$

$$I_{ij}(t)=\sum_{k=1}^{n}\frac{w_k}{p_{i,j}}\exp(-\frac{(d_{ij}^k+L-p_{i,j}+(r_{i,j}-t))^+}{K\overline{p}})$$

Hence, the priority index depends on L .

In order to avoid this dependence, I investigated the Apparent Tardiness Cost (ATC) rule [6], which is the basis of the Pinedo and Singer rule, and developed three further rules, which are L independent (see Table 1).

As already described in the rescheduling policy section, the periodic rescheduling policy usually has enough time to generate a schedule for the next period. Thus, the objective of the rescheduling method used for this policy is to achieve a near optimal schedule quality according to the optimality criterion TWT, while the computational time of the rescheduling method still has to be realistic in the practice (i.e. maximum several hours). Former research and the preliminary computational results of my research determine that the SB procedure can achieve near optimal schedules by using some time-consuming control structures (e.g. the reoptimization described in phase 5 of the SB procedure or the backtracking algorithm). In contrast to the periodic policy, for the event-driven policy the SB procedure can balance the schedule quality and the computational efficiency by deactivating some complex control structures and make a real-time rescheduling possible.

Table 1: Dispatching rules as SSP for dynamic job shops

Rule	Definition	Comment
sumATC	$I_{ij}(t)=\sum_{k=1}^{n}\frac{w_k}{p_{i,j}}\exp(-\frac{(d_{ij}^k-p_{i,j}-t)^+}{K\overline{p}})$	
sumATC_RP	$I_{ij}(t)=\sum_{k=1}^{n}\frac{w_k}{p_{i,j}}\exp(-\frac{(d_{ij}^k-p_{i,j}-t+(r_{i,j}-t)^+)^+}{K\overline{p}})$	consider the release date penalty
sumATC_R_2T	$I_{ij}(t)=\sum_{k=1}^{n}\frac{w_k}{p_{i,j}}\exp(-\frac{(d_{ij}^k-p_{i,j}+r_{i,j}-2t)^+}{K\overline{p}})$	consider the release date and its relative distance to the current time t

Conclusion and outlook

In this article, I introduced a periodic and event-driven rescheduling policy for production processes. Afterwards, I demonstrated the formal definition of dynamic job shops with the consideration of rescheduling aspects. Then, I extended the SB procedure to solve the dynamic job shop scheduling problem regarding the optimality criterion TWT and presented its appropriateness as rescheduling method for the designed rescheduling policy.

As the next steps of my research, I will investigate the different control structures of the SB procedure in the literature and develop new control structures. Afterwards, I will evaluate the variants of SB procedures with different control structures by applying them to solve the benchmark test problem instances of job shops and by simulation. The objective of the evaluation is to determine the most promising variant of SB procedure for each of the sub rescheduling policies (periodic and event-driven).

References

[1] Vieira, G. E.; Herrmann, J. W.; Lin, E.: Rescheduling manufacturing systems: A framework of strategies, policies, and methods. In: Journal of Scheduling 6 (2003), pp 39–62.

[2] Harilaos, H. P.: Dynamic vehicle routing problems. In: Golden, B. L.; Assad, A. A. (Eds.): Vehicle Routing: Methods and Studies. North-Holland 1988, pp 223–248.

[3] Ovacikt, I. M.; Uzsoy, R.: Rolling horizon algorithms for a single-machine dynamic scheduling problem with sequence-dependent setup times. In: International Journal of Production Research 32 (1994) 6, pp 1243–1263.

[4] Brucker, P.: Scheduling Algorithms, 5. Edition. Springer-Verlag, Berlin Heidelberg 2007.

[5] Pinedo, M.; Singer, M.: A shifting bottleneck heuristic for minimizing the total weighted tardiness in a job shop. In: Naval Research Logistics (NRL) 46 (1999) 1, pp 1–17.

[6] Vepsalainen, A. P. J.; Morton, T. E.: Priority rules for job shops with weighted tardiness costs. In: Management Science 33 (1987) 8, pp 1035–1047.

Yi Tan, M.Sc.

A Periodic and Real-time Event-driven Rescheduling Approach for Dynamic Job Shops in Manufacturing

E-mail: tan@biba.uni-bremen.de
Country: China
Start: 01.10.2010
Supervisor: Prof. Dr.-Ing. Bernd Scholz-Reiter
Faculty: Production Engineering
Research Group: Planning and Control of Production Systems

Freight Villages in China: Current Developments and Future Prospects

Jiani Wu
Prof. Dr. Hans-Dietrich Haasis

The fast development of the Chinese economy has had a tremendous impact on the growth of the logistics market. Freight villages (FVs) increase the logistics efficiency and decrease freight traffic in central cities through clustering logistics-related activities and facilities. Therefore, nowadays the Chinese government promotes FVs as key projects for the country's logistics sector. This paper reviews the FVs development in China as well as analyzes the obstacles and offers a number of solutions. As a result, it points out two prospects for China's FVs future development: one is the sustainability orientation, and the other one is a feasibility study considering current situations before adopting a new FV project.

Introduction >>> Freight village (FV) has evolved over the last 20 years, which is a promising logistics solution in most countries at present.

The concept of FV is developed to offer "common" services to various transport and logistics companies located within its site, as well as to other external users. The common infrastructure, equipment and services can benefit transport and logistics companies, allowing them to use these without heavy and risky investments [1]. The main functionality of a FV is to act as a node in a node-link system. The FV concept has often been utilized in order to point out major concentration of traffic flows in the transport network. Nowadays, a FV is perceived as an "integrator" of various transport modes, able to promote intermodal transport [2]. A FV is typically characterized by an intermodal terminal. It is the principal component of the intermodal transport chain, constituting the node where the transshipment of goods from one mode (road, railway, waterway, air) to the other takes place.

Due to the fast economic progress and a manufacturing-centered economy, China's logistics sector has grown persistently throughout recent years. In addition, rising demand for international trade and a large geographical spread have also resulted in the development of logistics services. Through a major shift from dispersed logistics activities to the integrated logistics process during these years, the logistics sector has received considerable attention from policy makers. In order to improve the logistics efficiency, an integrated logistics system is in need in China nowadays. As a fundamental facility of the logistics system, FV has become one of the major methods to promote the logistics industry and its positive effect will continuously grow for a long period of time.

Since the first FV was founded in Shenzhen Pinghu in 1998, the FV concept has been spreading across China, especially in the Pearl River Delta and the Yangtze River Delta. FVs in China have increased in number over the last two decades. However, some problems and obstacles have arisen during this development process. Hence improvements are needed in such areas, including FV projects standards, planning method, FVs development strategy and functional positioning. This paper discusses the current developments of China's FV. It summarizes the evolution process of the FVs development and introduces the organization structure for the logistics sector and FVs in China. Furthermore, the current obstacles and solutions are analyzed. Finally, the future prospects on sustainability orientation and the feasibility of FV projects at the Planning stage are proposed. <<<

Basic concept

"Nodal centre" or "freight nodal terminals" are very widely used in the processes of trade and transport in Western Europe, South-east Asia and the U.S. In international literature, "nodal centre" or "freight nodal terminal" is encountered with various names: "Freight Villages" (United Kingdom), "Platformes Multimodales/ Logistiques" (France), "Interporti" (Italy), "Gueterverkehrszentren" (Germany). FV is perceived as the unified name describing a defined area within which all the activities relating to transport, logistics and distribution of goods, both for national and international transit, are carried out by various operators. It offers basic services to the enterprises located within its site, as well as to external users.

Enterprises are enabled a faster and easier realization of logistics location (buy or rent), thus decreasing transit times and improving quality [3].

Nowadays, despite traditional warehousing function of storage, a wide range of services are available in FV, such as shipping, receiving, storage, materials handling, break bulk, cross-docking, freight consolidation and containerization, as well as value-added logistics, including total logistics management, inventory control and tracking, packaging, labelling, procurement and vendor management, customer service functions [4].

DGG (Association of German FVs) identifies three key characteristics of a FV: (1) settling of transport-oriented (independent) companies, logistics service providers and logistics-intensive trade and production enterprises in a commercial area; (2) containing an intermodal road/rail or inland waterway/road/rail terminal with open access to every potential user; (3) to support synergy potentials, the establishment of suitable organisational structures (i.e. FV development company) is recommended [5].

As a freight integrator, FV is able to combine the specific strengths of each mode at country, continent and world level to offer their clients and, consequently, society at large the best service in terms of efficiency, price and environmental impact in the broadest sense (economic, ecological, energy, etc.) [6]. Consequently, the FV concept trends to be associated with consolidated logistics and city logistics with sustainability adaption.

FVs are opportunities because they: (1) Leverage freight operations to create local economic value; (2) Create shared value-support businesses that serve the village and the surrounding community; (3) Use primarily private funds to achieve local community development goals; (4) Reuse Brownfield properties; (5) Encourage multimodal freight use [7].

Current developments

Evolution process of the FVs development in China

In 1998, Shen zhen Pinghu FV was initiated, which was the starting point for China's exploration of FVs. After that, from 2001, the trend of FV projects emerged in various regions of China. In 2003, there was a great upsurge. Through a range of reforms, the FVs' development in a growing period hopefully brings broad benefits to the logistics sector and the industrial fields. Until now, the evolution process of the FVs development in China can be summarized in the following four periods (see Fig.1):

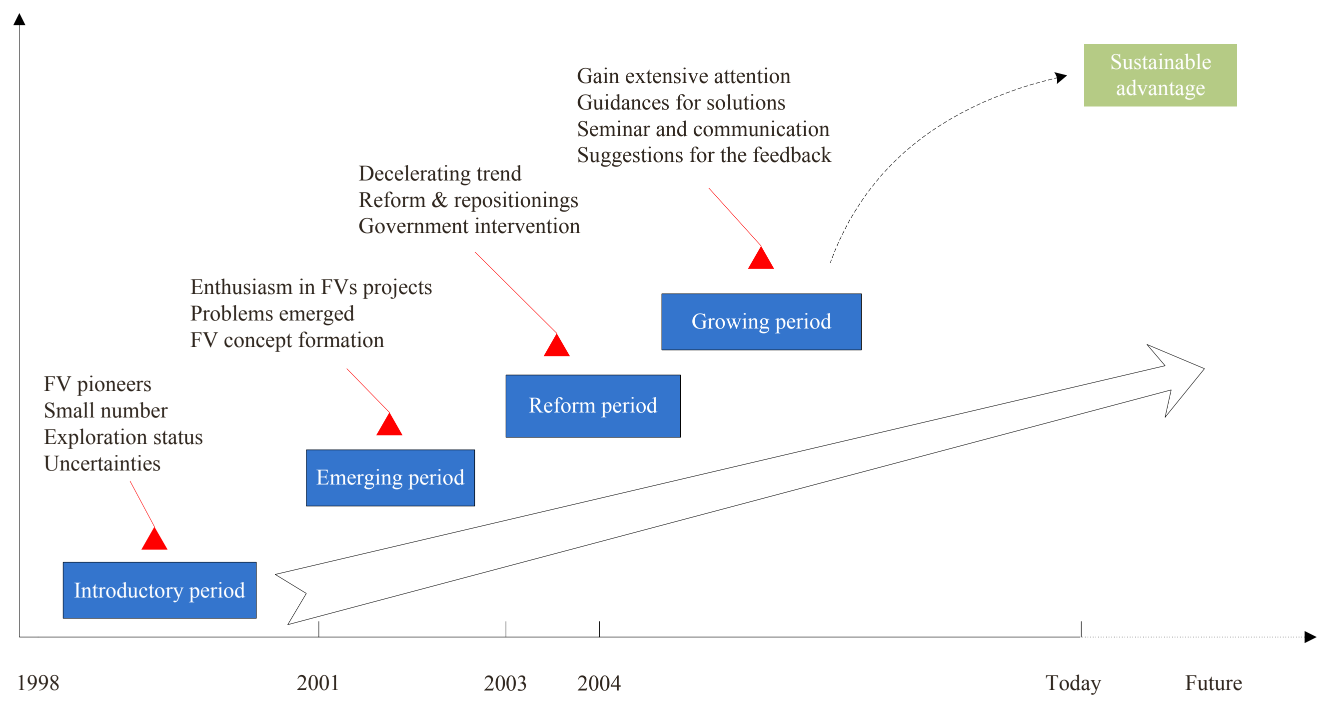
Introductory period (1998-2001)

During this period, the FV concept was spreading in economical developed areas where the logistics market has large potentials. At that time, a small number of FV pioneers appeared in coastal areas of China, especially Pearl River Delta and Yangtze River Delta. Due to the confusions with several other concepts, like industrial park and technological park, non-unity-based understandings about FVs resulted in lots of uncertainties.

Emerging period (2001-2003)

This period was characterized by a fast growth of FVs in China, but accompanied by many problems. The FV concept became to be accepted by various fields, especially logistics emprises and local authorities. Successful cases began to draw wide enthusiasm for FVs projects. Developers tended to invest in a large area for FV projects at that time. In some areas, FV projects were even mistaken for vanity projects by local officials without feasibility studies. Some established FVs could not involve adequate logistics enterprises which led to a high vacancy rate in these FVs.

Figure 1: Evolution process of the FVs development in China



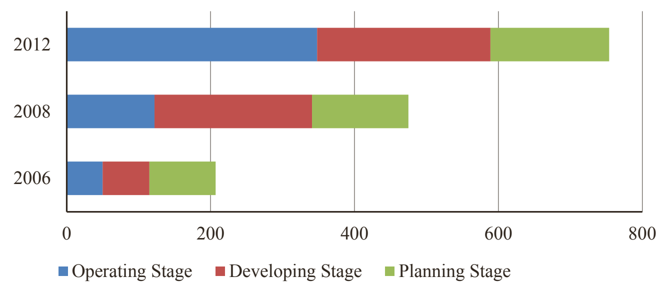
Reforming period (2003-2004)

During this period, a range of problems were recognized and needed reforming, e.g., limited understanding of FVs theories, misleading strategic orientation, unscientific planning. Therefore, a set of reforming policies were carried out to avoid difficult situations of FV projects. According to the guidance of national governments and professional associations, some early established FVs in Shanghai, Shenzhen, and Nanjing began to adjust their strategies and positions. In addition, Shanghai Waigaoqiao Tax-bonded FV was authorized during this period. After that, bonded FVs became a special group within the field of FVs in China.

Growth period (2004-now)

FVs have increased in recent years. According to the data in 2012, the number of FVs in China is 754, among which, 348 are in operation accounting for 46%, 241 are in construction accounting for 32%, and 165 are in planning accounting for 22%. Fig. 2 compares the number of China's FVs in 2006, 2008 and 2012, and a rapid growing trend is indicated. Growth of number cannot mean a super performance of the FVs development. Therefore, sustainable advantage should be the orientation of China's FVs in the next periods.

Figure 2: The increasing number of FVs in China (2006-2012)



Top 10 FVs in China

"2009-2010 China FVs top 50" was a project relating to FVs ranking in China. This project was jointly sponsored by China International Logistics Committee and Jones Lang LaSalle [8]. It aims to introduce and recommend FVs with high market performance and investment potential. The survey of the project involves more than 300 FVs covering Tier I, II, and III cities in China. The appraisal project relied on questionnaires following series processes of design, answer, collection and analysis. The evaluation index system mainly consists of economic foundation, market proximity, suppliers, constructions and facilities, demand-supply status, project quality and development planning. Table 1 lists the top 10 FVs in China according to this survey project. Several of them were rewarded due to their distinguished performance.

Organisational structure for the logistics sector and FV development in China

Logistics has been an important feature of industrial and economic life for many years. The fast development of the Chinese economy has brought tremendous impact on the growth of the logistics market in the country. However, being one of the world's largest logistics markets, logistics costs in China are high at 17.8% of GDP compared with 8-9% for developed countries. FVs rely heavily on the logistics environment, thus this paper introduces the organizational structure for both the logistics sector and FV development in China. Since the development of the logistics sector depends on a nation's economy, public traffic (road, railway, waterway, and air), foreign trade, etc, the logistics policy environment in China involves the following official units and social organization:

- National Development and Reform Commission
- National Energy Bureau
- Ministry of Foreign trade and Economic Operation
- Ministry of Transport
- Ministry of Railway
- Ministry of Information Industry
- Professional Associations

Professional associations assist government agencies to standardize logistics activities and improve logistics performance. Among numerous professional associations relating to China's logistics sector, China Federation of Logistics and Purchasing (CFLP) is a leading one. CFLP is the only legal logistics association authorized by the State Council.

Table 1: Top 10 FVs in China (2009-2010)

Rank	FVs	Distinguished award
1	GLP Park Suzhou	Best developer award
2	Shanghai Waigaoqiao Bonded Logistics Park	
3	Goodman Fengxian Distribution Centre, Shanghai	Best environmental awareness award
4	Vailog Songjiang Logistics Park, Shanghai	
5	Blogis Park Tianjin	Best service award
6	Juncho Logistics Park, Shangha	
7	Xindu Logistics Centre, Chengdu	
8	GLP Park Lingang, Shanghai	
9	Southern Logisics Center, Guangzhou	
10	Plainvim Kunshan Industrial Park	Best strategic planning award

The Specialized Committee for Logistics Park (SCLP) of CFLP is newly established in response to the FVs development needs. It specializes on the following aspects:

- promote the sustainable advantage of China's FVs
- serve the members (e.g., FVs, logistics enterprises, related government departments, research institutions, universities);
- integrate FVs projects into government supports;
- ensure common benefits of logistics sector and the lawful rights of the members;
- promote the communication and cooperation among FVs;
- strengthen standardization administration;
- provide feedback of the demands and reasonable suggestions for the logistics sector;

Obstacles and solutions

Nowadays the obstacles to the FVs development can be found in the following areas: prerequisites of establishment, strategic positioning, operational ability, regional synergy effect, management system, and green logistics. Solutions are suggested in the following table (Table. 2).

Future prospects

Sustainability orientation

Compared to general industrial clusters, the double nature of FVs has brought to attention the potential effects yielded in both public configurations consolidation and commercial acceleration, while general industrial clusters behave more in their own business affairs. Supporting this view, C.D. Higgins and M.R. Ferguson point out the two different ways of thinking about FV functionality: first is the transportation infrastructure and second is the promoter of business and economy activity. Therefore, FV is expected to become a pivotal element contributing to the three dimensions of sustainability in China.

Economic dimension

FVs are often pointed to as a means for promoting intermodality, integrating spatial planning, and reducing the cost of services by facilitating synergies among tenants. Thus, logistics operative costs can be reduced by their most important features - the combination of various modes of transport and logistics services. To date, many FVs have added a number of value-added services, including total logistics management, inventory control and tracking, packaging, labelling and bar coding, procurement and vendor management, and customer service functions, such as returns, repair, rework and assortment promotional assembly [4]. These value-added services have provided broad sources for the income of FVs. Furthermore, the settled companies can maintain long-term competitiveness through the cooperation. This cooperation is based on the industry chain cooperation of these settled companies, as well as the stable relationship with customers. Meanwhile, FVs are connected with the consequences on the economy of the areas affected. These consequences include the leverage of freight operations to create local economic value, the revival of economic activity, the optimization of regional economic structure, the attraction of new investments or the expansion of existing industries.

Table 2: Obstacles and solutions to the FVs development in China

Current obstacles	Solutions
Prerequisites	Vaguest FV concept should be avoided; Needing adequate scientific feasibility study before building; Motivations should be in line with FV orientations and functionality; Be in need of a set of standards for new FV projects; Effective rules of endorsing land for FV projects;
Strategic positioning	Seeking big scale is reasonless; Must learn more about local logistics demand; Indiscriminate copy of experiences is inadvisable;
Operational ability	Expand logistics service and value-added services; Centre on enhanced IT-based system and its application; Increase occupancy rate of logistics enterprises; Improve employee's skills and deal with the lack of logistics professionals; Utilize efficient facilities and equipments; Attach importance to traffic access and intermodal connections;
Regional synergy	Prohibit redundant FV projects at local scale; Concerning regional industry and try to establish a link with them; Formulate and establish a nationwide logistics network in China; Well-prepared site selection;
Management	Build a managerial organization combining individual FVs; Establish an independent management sector in each FV; Management sector performs the responsibilities of FVs promotion, supervisor and evaluation, not merely limited to land leasing;
Green logistics	Make transport routing and select transport modes considering the ecological environment; Reduce no-load ratio and recommend consolidated shipment; Encourage clearer and renewable energy using in FVs.

Environmental dimension

Due to the intermodality feature, FVs are recommended as environmentally adapted solutions in implementing green logistics and supply chain management. It has been pointed out that FVs by nature care for the environment since they allow for less warehouse dispersion around the country, less adverse side effects of transport on the environment, including air and water pollution, noise, as well as reduction of pollution emissions of vehicles to the central cities. In reality, most medium-sized and small enterprises refuse to invest on the technologies and equipment for environmental protection because of the high cost. Based on the concentration investment of logistics facilities and services, it becomes easier for FVs to realize reverse logistics and adopt the advanced waste disposal equipment [9].

Social dimension

The industrial development is the backbone of a community's development, and therefore the local community development goals are becoming dependent on the logistics services quality in a community. It also can be regarded as "use of primarily private funds to achieve local community development goals". To some extent, FVs can be viewed as Economic Zones by potentially creating jobs for the society. Increase in local employment results from the attraction of new businesses to FVs and on the valuation of this increased employment at the level of the existing per capita regional product [10]. Multimodal freight use is encouraged for FVs, thus the intermodality of FVs can significantly reduce congestion on the roads. By reducing the road congestion and triggering business activities, FVs can improve the living quality of local people. In addition, the FVs' concentration of transportation in proximity to consumer centres offers convenience and enhances accessibility for people's social and business activities. Most importantly, FVs interact with the existing public facilities, which probably consolidate regional or national logistics networks.

Ensure the feasibility of FV projects at the planning stage

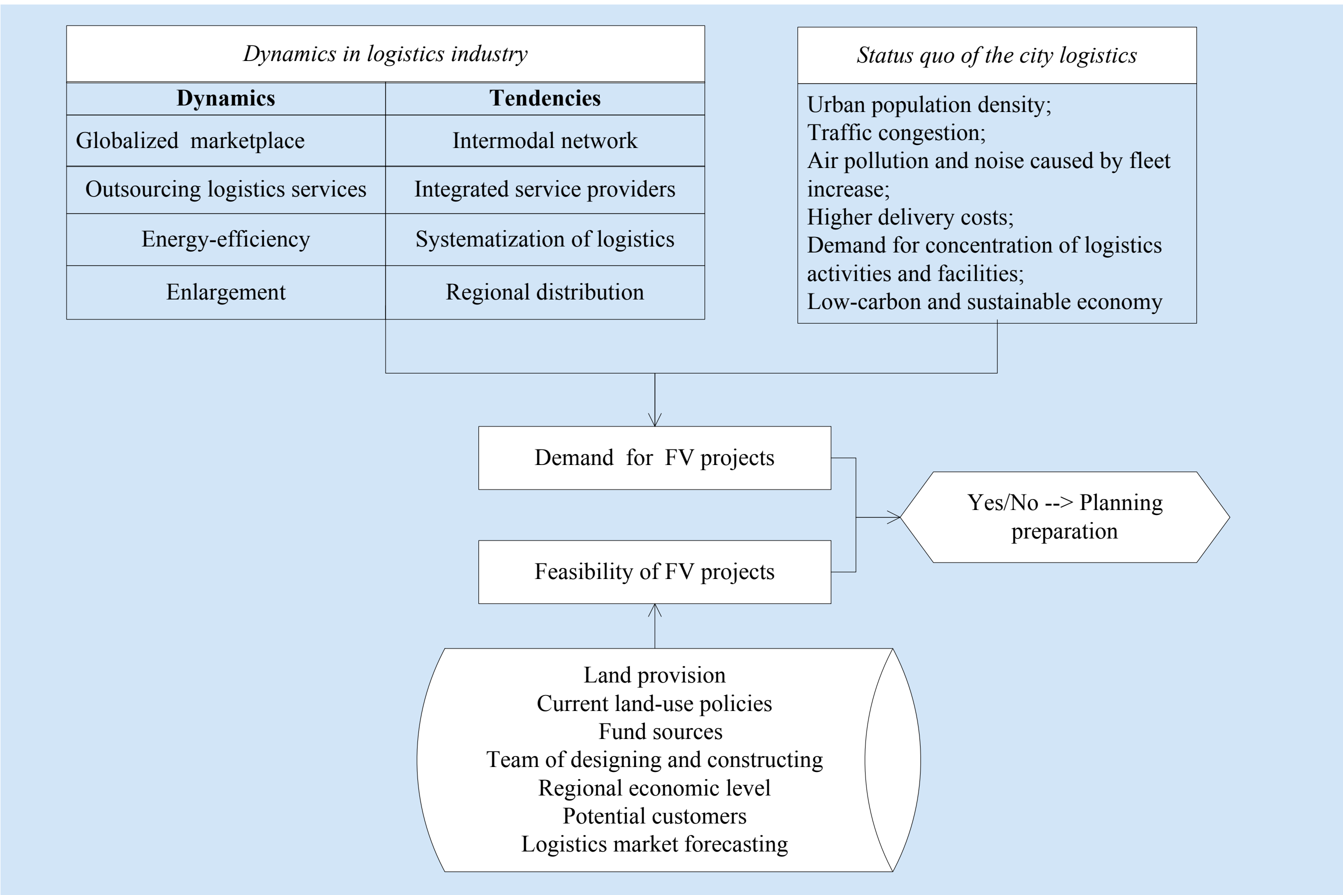
According to the 3rd National FVs Survey report in 2012, the problem of inadequate planning is still greatly hindering the development of FVs in China. FVs projects are usually large-scale projects with long construction periods and large investment demands. Inadequate planning easily leads to the deviation from the FVs' objectives, and the typical "symptoms" of inadequate planning are listed in the following:

- Constructions of unnecessary FV projects
- FVs are mistaken for "Economic Development Zone" or "Industrial Centre"
- Unsuitable sites
- Disturbance to local residents
- Extremely pursuing bigger size and quantity
- No consideration of "intermodal connection"

A well-organized planning is the first step to realize the sustainability effects of FVs, e.g., urban logistics optimization, coordination with regional or national traffic network, meeting requirements of customers, industrial development, traffic journeys minimization, logistics cost savings, intermodality access, etc.

In order to ensure the feasibility of FV projects at the planning stage, this paper provides a framework as guidance (see Figure 3).

Figure 3: Guidance framework for the initial stage of FV projects



Firstly, the developers should make the dynamics in logistics industry clear. FVs are the results of tendencies in logistics industry, such as, intermodal network, integrated service providers, systematization of logistics, regional distribution. Based on the knowing of dynamics in logistics and their corresponding tendencies, the developers are able to find the reasons to build new FVs. Secondly, the status quo of the city logistics in local area decides the demand of FVs projects. The status quo is considered from such aspects, including urban population density, traffic congestion, air pollution and noise caused by fleet increase, higher delivery costs, demand for concentration of logistics activities and facilities, low-carbon and sustainable economy. Thirdly, the feasibility of FV projects is determined by overall basic conditions, e.g., land provision, current-land policies, fund source, qualified designing and constructing team, regional economic level, potential customers, and logistics market forecasting. The next steps of designing and constructing FVs can continue only if a FV project is needed and feasible.

Conclusion

The main goal of this paper was to discuss the concept of FV and its current developments as well as future prospects in China. FV is gaining worldwide attention due to the services (customs clearance, modal transfer, container stuffing and destuffing, and container and cargo storage provides) provided by them and can benefit lots of logistics enterprises and customers.

Huge opportunities of China's logistics market require various efficient logistics solutions, and FV is one of the most important solutions. The evolution process of the FVs development in China is not long, and lots of challenges should be faced. In order to create more FVs with sustainably effects, this paper pointed out the sustainable advantage as an orientation of China's FVs in the following developing process.

References

[1] Tsamboulas, D. A.; Kapros, S. (2003): Freight village evaluation under uncertainty with public and private financing. In: Transport Policy 10 (2003) 2, pp 141-156.

[2] Ye, S.; Tiong R. : NPV-Risk Method in Infrastructure Project Investment Evaluation. In: Journal of Construction Engineering and Management 126 (2000) 3, pp 227-233.

[3] Europlatforms FV-2000: Quality of Freight Villages Structure and Operations. European Commission Directorate General for Energy and Transport. Brussels, 2000.

[4] Rimienė, K.; Grundey, D.:Logistics Centre Concept through Evolution and Definition. In: Engineering economics 54 (2007) 3, pp 87-95.

[5] Deutsche GVZ-Gesellschaft mbH (DGG): about DGG. URL: http://www.gvz-org.de/index.php?id=48&no_cache=1&L=1 , Date of access 14.08.2012.

[6] Commission of the European Communities: White paper-European transport policy for 2010: time to decide.. Office for Official Publications of the European Communities, Luxembourg, 2010.

[7] A. Strauss-Wieder Inc.: Freight Villages and Integrated Logistics Centers in the US - Opportunities for Freight Operations to Create Economic Value and Be Good Neighbours. Presentation Slides, A. Strauss-Wieder, Inc., 2008.

[8] Jones Lang LaSalle: China Logistics Parks 50 Star Performers in an Emerging Market. China, 2009.

[9] Taniguchi, E.; van der Heijden, R. E. C. M.: An evaluation methodology for city logistics. In: Transportation Reviews 20 (2000) 1, pp 65-90.

[10] United Nations - Economic and Social Commission for Asia and the Pacific: Policy Framework for the Development of Intermodal Interfaces as part of and Integrated Transport Network in Asia. (2008).

Jiani Wu, M.A.

Sustainable Development of Freight Villages Based on Knowledge Management

E-mail: wu@isl.org
Country: China
Start: 01.11.2009
Supervisor: Prof. Dr. rer. pol. Hans-Dietrich Haasis
Faculty: Business Studies / Economics
Research Group: Business Administration, Production Management and Industrial Economics

Collaborative Transfer Operations between Drayage Companies and a Container Terminal

Sanghyuk Yi
Prof. Dr. Bernd Scholz-Reiter

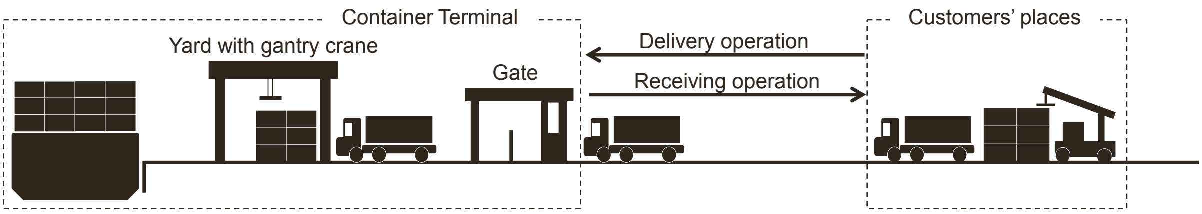
Continuous growth in container traffic has laid a heavy burden on the limited capacity of terminal resources which increases delays of truck deliveries which transfer containers to drayage companies. However, terminal operations depend on drayage operations responding to unexpected truck arrivals. This paper addresses a question of how companies coordinate these joint activities. For the collaborative transfer operation, I suggest the postponement strategy. In this strategy, each company develops a plan with categorized information on containers in advance and postpones decisions on the transfer of specific containers until a truck arrives at a terminal. This approach will alleviate workloads of terminal resources as well as decrease waiting time of trucks.

Introduction >>> A container logistics system can be defined as the transportation of containers from its origin to its destination by various carriers such as shipping liners, drayage companies and a container terminal. For example, a drayage company transports containers between a terminal and customers' places by trucks. A container terminal temporarily stores containers to load them onto drayage trucks or container ships. The transfer operations between the players are divided into two operations as shown in Figure 1. In the receiving operation, a truck transports an outbound container after loading it in a customer's place. After arriving at a terminal, the truck has to pass a gate, and then a yard crane picks up the container from the truck and release it on a block at a yard. In contrast, in the delivery operation, a yard crane retrieves an inbound container from a block at a yard and drops it off onto a truck. Then, the truck delivers the container to its destination. In addition, these operations often occur simultaneously to reduce empty travels of trucks.

Nowadays, these carriers are using information communication technologies (ICTs) (i.e. radio frequency identification, global positioning system, etc) in logistic operations to improve efficiency of their own systems. Consequently, companies can increase productivity and utilization of their resources, as well as reduce delivery time to complete orders. However, in spite of advanced technologies, inefficient transfer operations between carriers still exist in the container logistics system. Especially, constant growth in the volume of containers has strained the capacity of intermodal operations through a container terminal. Moreover, it causes significant delays of drayage trucks waiting at a container terminal, which raises truck emissions in port neighbourhoods and increases the total operation time of trucks. This is because limited capabilities of terminal resources have to handle a heavy amount of work on the pick-up and drop-off transactions with trucks. For instance, if a large number of drayage trucks rushes to a container terminal with limited resources in a short time, congestion of trucks must severely occur. Many trucks have to wait at a gate for driving into a terminal, and then wait for a yard crane's order again to receive or deliver containers at a yard.

These transfer activities cannot be improved by themselves, thus it is not avoidable to synchronize drayage operations and terminal operations. Therefore, this research proposes a collaborative transfer operational approach and methodologies to enhance intermodal operations between drayage companies and a container terminal. <<<

Figure 1: A flow of transfer operation between drayage and terminal operations

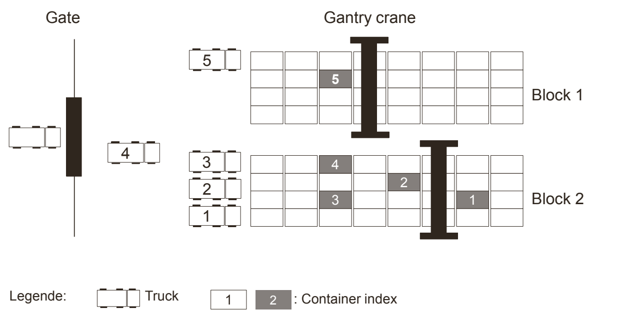


Problem statement

It is essential to identify the causes of truck congestion and inefficient terminal operations . First of all, the transfer operations are joint activities between interrelated players, but drayage operations are actually pushing terminal operations. In other words, since drayage trucks are allowed to deliver containers at any time of terminal operating hours, a terminal operator controls terminal resources responding to unexpected arrival of drayage trucks. Actually, according to transportation demands of drayage companies, a container terminal supplies its resources where shortage or surplus of supply capability can occur. For example, when many trucks demand numerous transfer operations, a terminal cannot provide enough supply capacities for all the trucks, which inevitably leads to waiting of trucks. On the other hand, if a small number of trucks arrive, a terminal remains surplus capability of resources to handle trucks.

Furthermore, operations in a yard need more time than those in a gate. This is because a yard crane spends considerable time to retrieve or receive containers on a block. Additionally, a terminal operator has little knowledge of the arrival of drayage trucks to pick-up or drop-off specific containers before trucks arrive. According to the arrival of a truck, a yard crane could be overloaded or idle. For example, in Figure 2, the yard crane on Block 2 should handle three trucks, but the other one on Block 1 would be idle after finishing one task. Thus, the difference of workloads between blocks inevitably causes waiting of trucks.

Figure 2: Top view on an example of transferring containers at a yard



The yard crane needs additional activities to retrieve the container stacked under other containers in a yard. For example, to pick up container 2 in Figure 3 the yard crane has to relocate two containers on top. Thus, the uncertain sequence of truck arrival worsens the operations of yard cranes as well as the truck turnaround time.

State of the art

There has been much discussion about the collaboration planning and the synchronization between players or inter-related logistic decisions in supply chain and production systems [4], [8], [11]. Nevertheless, most of the previous studies about the container transportation have focused on isolated decision-making problems within a container terminal [6]. Few previous studies have addressed the collaboration of the decision-making problems between different players or planners. Consequently, in the case of container logistics area, the synchronization of the information offers research challenges related to improve the collaboration of operations between independent players [2].

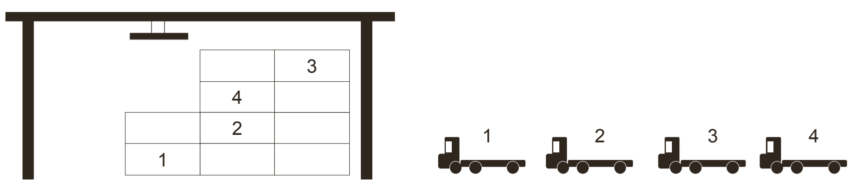
Many papers about the optimization for the drayage problem have focused on the static case. A truck scheduling problem for the transportation of containers has been addressed as the multiple travelling salesman problem with time window (m-TSPTW) as well as types of containers (i.e. inbound full, outbound full, inbound empty and outbound empty movements) [15], [16]. In addition, dynamic planning for drayage operations considering uncertain transit times, vehicle breakdowns, flexible tasks with not defined origin or destination, and time windows has been discussed [3], [7], [14]. Moreover, the distributed routing concept was proposed for dynamic vehicle routing scenarios [10], [13]. In this concept, packages and vehicles as autonomous objects have intelligent capabilities to get their information and make their own decisions through a changing and large network without a central perspective. Furthermore, cooperation between freight carriers has been handled to improve their operations by combinatorial auctions of transportation requests [1], [12]. However, it targets the drayage operation, but does not consider the terminal operation to deal with efficient transfer activities at a terminal.

Some works have addressed synchronizing terminals and drayage operations. Container retrieval operations of a yard crane with the use of truck arrival information revealed reducing container rehandles in yards of terminals [17]. However, it focuses on terminal operations and cannot influence truck schedules. To control truck congestion at a gate, the terminal gate appointment system was suggested by restricting port access of trucks during certain time slots [5]. Namboothiri and Erera [9] also developed a drayage operations planning method based on a port access control system and investigated the impacts of this system on drayage firms. Nevertheless, this gate appointment system deals with an outside terminal and provides little incentive to drayage companies.

Research definition and objective

A truck dispatcher and a terminal operator are decisionmakers of a drayage company and a terminal, respectively. In general, a truck dispatcher receives the requests from shipping liners and load-information from a terminal operator. The initial location of trucks and the distance between a terminal and customers' places are known beforehand. Then, a truck dispatcher makes a truck schedule with the minimum costs or travel time to complete the set of transportation orders.

Figure 3: Cross sectional view on an example of transferring containers at a yard



A terminal operator prepares pick-up or drop-off transactions for drayage operations. In the case of delivery operations, retrieval containers are stacked on yards beforehand. For receiving operations, temporal spaces are reserved to receive containers in advance. Then, as a truck arrives at a terminal, the operator controls yard cranes on blocks to transfer containers.

New ICTs allow operators to track the location of trucks and estimate expected arrival time of trucks in real-time with a reflection of dynamic situation. In addition, a terminal operator and a drayage dispatcher can monitor the expected supply capacities of bottleneck resources at a terminal. Furthermore, those operators can adjust their schedules to balance the supply capacities of those resources, which leads to avoiding useless waiting time of trucks within a terminal.

Therefore, this research determines as follows:

- Scheduling trucks to complete orders of the container transportation.
- Scheduling terminal resources to transfer containers.

For satisfying orders of inbound and outbound containers, this work decides how to schedule trucks and terminal resources considering a real-time situation of a terminal.

The objective of the suggested work is as follows:

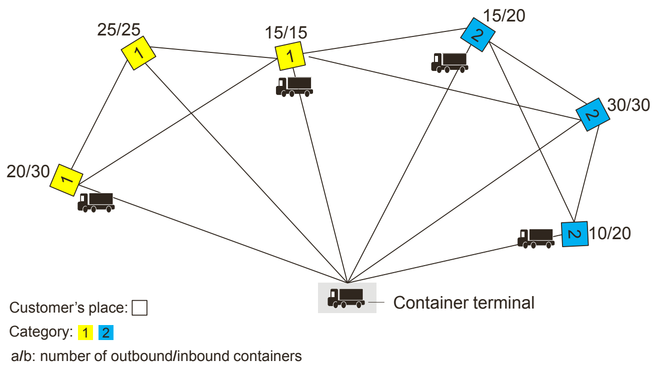
- Minimizing the truck turnaround time at a terminal and total operation time of trucks.
- Balancing the supply capacities of critical terminal resources and minimizing the number of rehandling movements of yard cranes.

The target of drayage companies is to minimize truck turnaround time at a terminal and total operation time of trucks. On the other hand, the aim of a terminal is to balance its supply capacities of resources such as yard cranes as well as to minimize the number of useless rehandling movements of yard cranes.

Solution approaches and methodologies

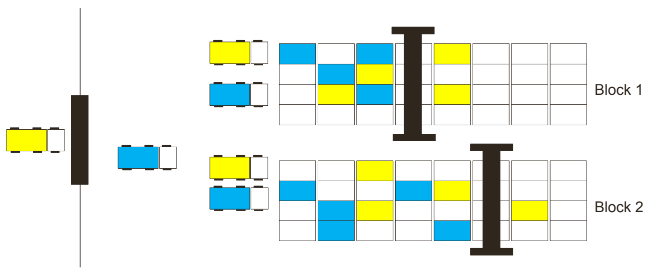
This research proposes 'categorized transportation' where a truck is able to deliver any containers of the same category. In other words, a truck dispatcher postpones the decision on a container that a truck transports until the truck arrives at a terminal. Moreover, a terminal operator puts off the decision on an inbound container that a yard crane should retrieves as well as a location where an outbound container should be stacked until the operation occurs. For instance, it assumes that adjacent customers' places are categorized as a category of containers as illustrated in Figure 4. The category of containers can be assigned to a truck. Then, a terminal operator retrieves any inbound containers with the same category onto the truck. The outbound container can be stacked on any spaces with the same category at a terminal. Thus, drayage companies and a terminal can take advantages of postponing the decision to reduce the truck turnaround time at a terminal and balance workloads of terminal resources. In addition, since truck drivers may not prefer new delivery or pick-up points, the categorized transportation can flexibly change containers in a schedule without route disruption.

Figure 4: An example of the categorized transportation



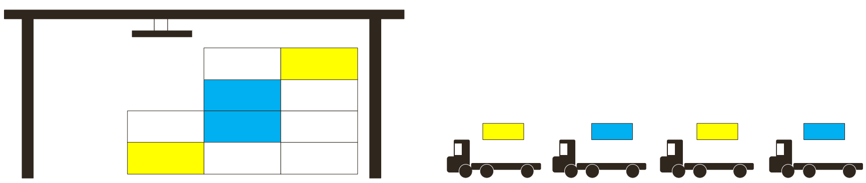
As mentioned above, a truck does not deliver a predetermined container, but satisfies the category of a container. Hence, both players can take benefits in transfer activities by postponing the decision until a truck appears at a terminal. For example, when a truck comes into a terminal, a terminal operator can check the real-time situation of blocks and retrieve a container of the identical category and the minimum queue. As a result, the number of trucks in queue of blocks in Figure 5 are distributed as compared to the example in Figure 2. Moreover, the turnaround time of trucks would be reduced.

Figure 5: Top view on categorized transferring containers at a yard



In the operation of a yard crane, the categorized transportation can reduce the number of rehandling movements to pick up the desired container. A yard crane can transfer a container having not only the same category, but also the minimum number of relocating activities. For instance, in Figure 6, the yard crane must relocate two white containers on top of yellow and blue containers, but in Figure 3, one more relocation of containers would be needed to satisfy the sequence of trucks.

Figure 6: Cross sectional view on an example of categorized transferring containers at a yard



The research suggests the categorized decision-making structure for the collaborative transaction of containers. First of all, a truck dispatcher develops a categorized truck schedule putting off the decision on a specific container until a truck moves into a terminal. Next, during transfer operations, a terminal operator decides which inbound container to retrieve onto a truck or where an outbound container is stacked.

For the proposed decision-making structure, players should be able to exchange information and negotiate decisions responding to dynamic information. Thus, this research will apply a distributed decision-making framework. The distributed framework needs less data exchange and is able to react quickly compared to the centralized framework.

Container transportation orders usually come from many consignors who pay the delivery cost to a drayage company. If a lot of consignors participate in the categorized transportation, then the number of containers included in the same category could increase, which could lead to maximized effects of the proposed approach. Therefore, this work firstly suggests a truck scheduling methodology for the case of an individual company, then extends it for the case of multiple companies. It should be required to have a reasonable computation time from the practical perspective. Consequently, this project will apply heuristic approaches, in particular metaheuristics (e.g., genetic algorithm), as well as Lagrangian relaxation such as a decoupling method [4]. For the case of multiple companies, negotiation or auction approach will be applied. To control terminal resources, heuristic rules will be proposed and evaluated by a simulation study. The developed simulation model will test and analyse the proposed methodologies and decision-making framework. By using simulation, experiments will deal with realistic problems under uncertainty.

Conclusions

The proposed work will identify the impact of the collaborative decision-making approach for the synchronized container logistics. It is expected to show the decrease of the waiting time of trucks at a container terminal. Moreover, distributed workloads of resources at a terminal will help ease the burden on terminal operations. Furthermore, it is difficult to share and split benefits among players in a system and to motivate them to take part in the collaboration. However, this research anticipates that the effects of the synchronization by the collaboration will provide incentives for players and encourage them to reveal their information.

References

[1] *Ackermann, H.; Ewe, H.; Kopfer, H.; Kufer, K-H.: Combinatorial Auctions in Freight Logistics. In: Lecture Notes in Computer Science 6971 (2011), pp 1-17.*

[2] *Crainic, T.G.; Kim, K.H.: Intermodal Transportation. In: Handbook in OR & MS 14 (2007), pp 467-537.*

[3] *Escudero, A.; Raicu, R.; Muñuzuri, J.; Delgado, M.: Dynamic Optimisation of Urban Intermodal Freight Transport with Random Transit Times, Flexible Tasks and Time Windows. In: Procedia Social and Behav-ioral Sciences 2 (2010), pp 6109-6117.*

[4] *Fumero, F.; Vercellis, C.: Synchronized Development of Production, Inventory, and Distribution Schedules. In: Transportation Science 33(1999) 3, pp 330-340.*

[5] *Giuliano, G.; O'Brien, T.: Reducing Port-related Truck Emissions: The Terminal Gate Appointment System at the Ports of Los Angeles and Long Beach. In: Transportation Research Part D 12 (2007), pp 460-473.*

[6] *Kim, K.H.; Günther, H.O.: Container Terminals and Cargo Systems: Design, Operations Managements, and Logistics Control Issues. Springer. Berlin 2007.*

[7] *Li, J.Q.; Mirchandani, P.B.; Borenstein, D.: Real-Time Rerouting Problems with Time Windows. In: Euro-pean Journal of Operational Research 194 (2009), pp 711-727.*

[8] *Muckstadt, J.; Murray, D.; Rappold, J.; Collins, D.: Guidelines for Collaborative Supply Chain System De-sign and Operation. In: Information Systems Frontiers 3 (2001), pp 427-435.*

[9] *Namboothiri, R.; Erera, A.L.: Planning Local Container Drayage Operations Given a Port Access Appoint-ment System. In: Transportation Research Part E 44 (2008), pp 185-202.*

[10] *Rekersbrink, H.; Makuschewitz, T.; Scholz-Reiter, B.: A Distributed Routing Concept for Vehicle Routing Problems. In: Logistics Research 1 (2009) 1, pp 45-52.*

[11] *Scholz-Reiter, B.; Tervo, J.T.; Freitag, M.: Phase-Synchronization in Continuous Flow Models of Production Networks. In: Physica A 363 (2006), pp 32-38.*

[12] *Sheffi, Y.: Combinatorial Auctions in the Procurement of Transportation Services. In: Interfaces 34 (2004) 4, pp 245-252.*

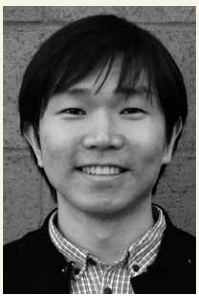
[13] *Wenning, B-L.; Rekersbrink, H.; Timm-Giel, A.; Görg, C.; Scholz-Reiter, B.: Autonomous Control by Means of Distributed Routing. In: Hülsmann, M.; Windt, K. (Eds.): Understanding Autonomous Cooperation & Con-trol in Logistics - The Impact on Management, Information and Communication and Material Flow. Springer-Verlag, Berlin Heidelberg 2006, pp 325–336.*

[14] *Zhang, G.; Smilowitz, K.; Erera, A.: Dynamic Planning for Urban Drayage Operations. In: Transportation Research Part E 47 (2011), pp 764-777.*

[15] *Zhang, R.; Yun, W.Y.; Kopfer, H.: Heuristic-Based Truck Scheduling for Inland Container Transportation. In: OR Spectrum 32 (2010), pp 787-808.*

[16] *Zhang, R.; Yun, W.Y.; Moon, I. K.: Modeling and Optimization of a Container Drayage Problem with Re-source Constraints. In: International Journal of Production Economics, 133 (2011) 1, pp 351-359.*

[17] *Zhao, W.; Goodchild, A.V.: The Impact of Truck Arrival Information on Container Terminal Rehandling. In: Transportation Research Part E 46 (2010), pp 327-343.*



Sanghyuk Yi, M.Sc.
Developing Collaborative Decision Making Methods for Synchronized Container Logistics

E-mail: ysh@biba.uni-bremen.de
Country: Republic of Korea
Start: 01.09.2011
Supervisor: Prof. Dr.-Ing. Bernd Scholz-Reiter
Faculty: Production Engineering
Research Group: Planning and Control of Production Systems

Weather Prediction Error Analysis for Route Optimization

David Zastrau

The economically reasonable application of wind ancillary propulsion technologies depends on properly incorporating weather forecasts into current route optimization models. Aside from expensive ensemble calculations, which are not always available, uncertainty in weather forecasts is modeled by probability distributions that are generated from empirical data. Forecasts often refer to heights that differ from the height of the ancillary propulsion drive. If atmospheric air stratification and surface roughness are unknown, the wind speed profiles may be approximated by the logarithmic wind profile, which depends on surface roughness length. We evaluate the optimal roughness length with respect to the time of the year by comparing weather forecasts to measurements from research stations in the Northern Sea. It shows that the roughness length varies during a year.

Introduction >>>

Wind ancillary propulsion for cargo ships

Currently the continuously rising prices for fossil fuels and increasing tax loads as a preventive measure against climate change are boosting the scientific research into wind ancillary drives. Wind ancillary technologies aim at facilitating wind energy to save conventional fuel reserves. While technologies such as the Flettner Rotor have been invented almost a hundred years ago it has not been economically reasonable to apply green propulsion techniques so far. With the beginning paradigm shift, shipping companies intend to provide the same reliability in shipping times to their customers as with conventionally powered ships. Therefore, route planning algorithms have to compute probability density functions instead of discrete values that outline the uncertainty in arrival time and energy consumption for a certain route. Those probability density functions require the forecast prediction error as input. We estimate forecast accuracy by comparing forecasts with measurements and evaluate the error between approximated and actual wind profile. <<<

Wind profiles for FINO wind measurements in the northern sea

Since 2003 German BSH (Bundesamt für Seeschifffahrt und Hydrographie – eng. ministry for maritime navigation and hydrography) has established three measurement stations in the North and Baltic Sea. The collected data contains highly accurate wind speed and direction measurements. However, the measurements are taken in heights between 31 and 106 meter while the forecast values from German Weather Service apply to a height of 10 meter. The logarithmic wind profile is a reliable method to convert the values, provided the surface roughness length is known. The basic idea behind this is that wind speeds logarithmically increase within the atmospheric surface layer (up to 100m). Unfortunately, offshore the roughness length varies depending on the state of the sea and thus this parameter is one reason for conversion error.

Figure 2: Conversion error (*mean absolute error* (MAE)) with logarithmic wind profile for different roughness lengths within one year

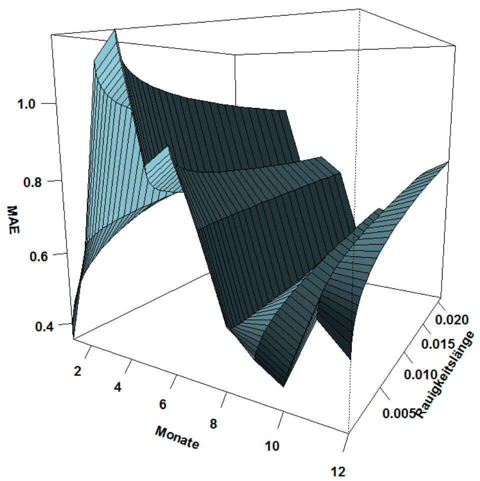
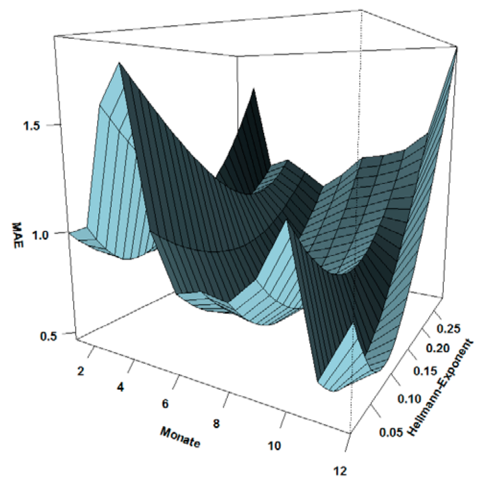


Figure 3: Conversion error with wind profile power law for varying Hellmann Exponent within one year



Estimating surface roughness length for wind profiles

The surface roughness length varies depending on environmental conditions. [4] adduces non-linear wind-wave dependencies, the delayed heat exchange between air and sea and turbulences in coastal regions as reasons. Beside the logarithmic wind profile we also apply the wind profile power law by Hellmann [1] for comparison. Both methods depend on a single parameter that approximates surface roughness and atmospheric air stratification. [2] and [3] approximate values for different terrains but not for varying seasons or wind speeds. Offshore deviations from the logarithmic wind profile are modeled by [6].

Conclusion and outlook

The preliminary results give an overview about the varying error from height conversion depending on the parameter value. Figure 2 and 3 show the conversion error with the logarithmic wind profile and with the wind profile power law. It shows that the logarithmic wind profile tends to be more robust to external perturbations.

Surface roughness varies at least between 0.02 cm and 1 cm within a year. Future research must develop models that reliably estimate surface roughness length for ships under various environmental conditions.

References

[1] Touma, J.S.: Dependence of the wind profile power law on stability for various locations. In: Journal of the Air Pollution Control Association 27 (1915) 9, pp 863-866.

[2] H. Schlichting: Boundary layer theory, 6. Edition. McGraw-Hill, New York 1968.

[3] Meliß, M.; M. Kleemann. Regenerative Energiequellen, 2. Edition. Springer, Berlin, Heidelberg 1993.

[4] Lange, B.;Larsen, S.; Højstrup, J.; Barthelmie, R.: Importance of thermal effects and sea surface roughness for offshore wind resource assessment. In: Journal of Wind Engineering and Industrial Aerodynamics 91 (2004) 11, pp 959-998.

[5] Monin, A. S.Yaglom, A.M: Statistical Fluid Mechanics. In: Lumley, J. L. (Ed.): Mechanics of Turbulence. MIT Press, Cambridge, Massachusetts, 1971.

6] Diaz, Pena; Gryning, Alfredo and Sven-Erik: Charnock's Roughness Length Model and Non-dimensional Wind Profiles Over the Sea. In: Boundary-Layer Meteorology 128 (2008) 2, pp 191-203.

David Zastrau, Dipl.-Inf.
Uncertainty in Route Planning for Cargo Ships with Wind Accessory Drives

E-mail: davidz@tzi.de
Country: Germany
Start: 15.11.2011
Supervisor: Prof. Dr. Otthein Herzog
Faculty: Mathematics / Computer Science
Research Group: Artificial Intelligence

Business Process Oriented Knowledge Management in Third Party Logistics

Hongyan Zhang

Nowadays, the growing importance of logistics as well as the increasing dynamic complexity of markets, technologies, and customer needs has brought great challenges to logistics. Third party logistics (3PL) have played an important role in managing logistics processes within the supply chain management. In order to provide professional logistics services, knowledge in business processes is crucial. This paper analyzes the main business processes of 3PL, defines the process knowledge and describes the key activities of knowledge management (KM) with logistic concepts. A case study of KM in the business process of contract logistics at a leading 3PL provider demonstrates these aspects accordingly. The business process oriented implementation of KM contributes to project accomplishment and process improvement.

Introduction >>> In the current environment of dynamic customer preferences and changing technological development, the network of supply chains is frequently restructured to respond to such environmental changes. Intensified globalization and consequent competitive pressures have reemphasized the importance of third party logistics (3PL) in managing logistics processes as well as customer and supplier relationships within the supply chain management [1]. Through innovative ways to improve logistics effectiveness, 3PL providers provide strategic and operational value to many shippers all over the world [2].

3PL business is emerging and developing rapidly to fulfill the demands for advanced logistics services, in such fields as transportation, warehousing, freight consolidation and distribution, product marking, labeling and packaging, inventory management, cross docking, product returns, order management, and logistics information systems [3].

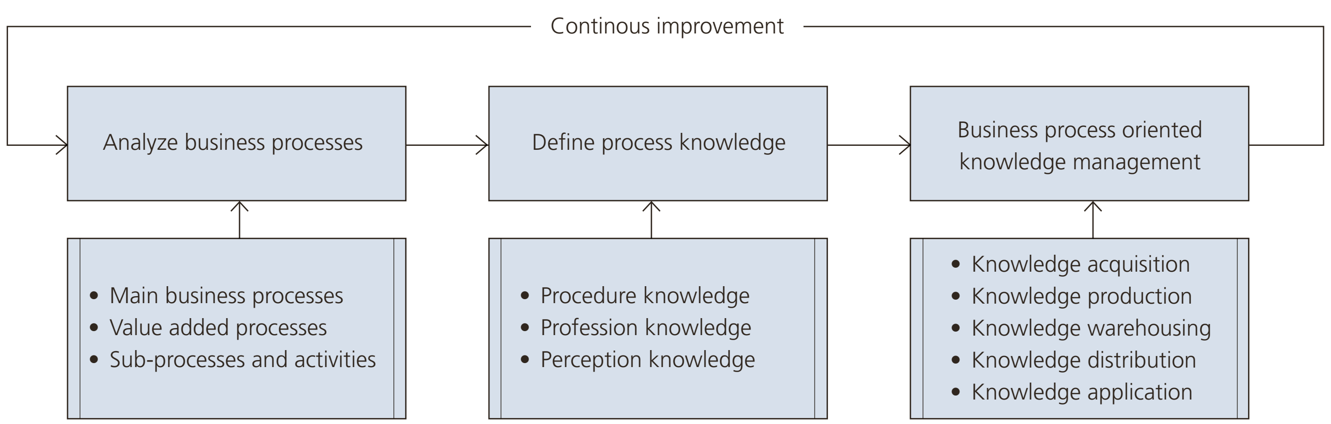
In order to provide these logistics service with professional solutions, logisticians should master the required knowledge in business processes. It is easier for them to learn and share knowledge when the business is simple, the company size is small, and all people work together. However, with the fast development of businesses, processes have become more crucial and complex, companies grow larger with more branches, some people retire and leave, and some new people join. Therefore, knowledge management (KM) is increasingly necessary.

How to effectively manage knowledge is another critical question both in academia and industry. A major part of organizational activity (exceeding 90% in some cases) can be described in terms of processes [4]. Business process involves the knowledge creation, distribution, using and innovation [5]. In the business process of 3PL, knowledge flow is another value chain along with material and capital flow. Effective management of the process knowledge will provide employees with task-related knowledge in the business processes enhance the adaptability to external environment, reduce time and cost, and better allocate resources [6]. <<<

Research procedure

In order to effectively integrate KM into business processes, clear objective and methods are essential from the beginning. The target of this implementation is to continuously improve business processes, which leads to better and innovative logistics service. Process is a key element of implementing KM. It is the carrier of knowledge as well as knowledge producer and user [5].
Figure 1 shows the main steps to implement KM in business processes of 3PL.

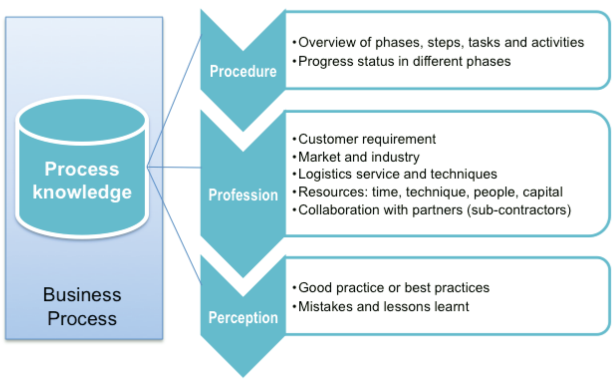
Figure 1: Procedure of implementing KM in business processes of 3PL



First, 3PL providers should analyze the main business processes, identify the key value-added processes, and describe the sub-processes and activities. According to the St. Gallen process management model, there are management processes, business processes and support processes in an organization. The typical business processes in 3PL are: transport, e.g. road, rail, see, air freight, or intermodal transport; warehousing or contract warehousing, e.g. building a distribution center; consultancy, e.g. process reengineering; value-added services e.g. packaging, bar coding, etc. The starting point of all these processes is customer requirement and the goal is customer satisfaction.

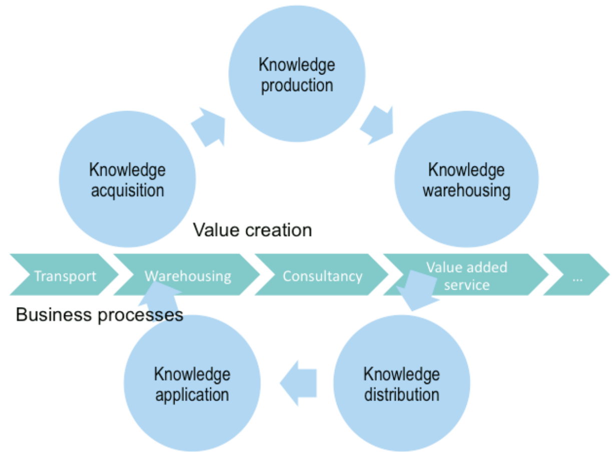
Second, it is necessary to define the process knowledge for business processes. Process knowledge can be explicit knowledge and tacit knowledge possessed by individuals, groups, organizations and inter-organizations. This paper classifies process knowledge in three types: procedure knowledge, profession knowledge, and perception knowledge. Figure 2 describes each type.

Figure 2: Classification of process knowledge in 3PL



Third, management of the process knowledge is a continuous process of knowledge acquisition, production, warehousing, distribution and application. It is an important value chain along with material, capital management in logistics. Knowledge is acquired from the practice of business processes, produced in forms of information and data, stored in different repositories (document, intranet, wiki, or video), distributed to the right people in time, and applied in the current and future business processes. Figure 3 shows these main activities of KM in business processes of 3PL.

Figure 3: Main activities of KM in business processes of 3PL



Finally, feedback and results about the application will contribute to improving new processes. This step can produce valuable knowledge that is helpful to optimize business processes, update old knowledge, avoid same mistakes, and offer innovative solutions, etc.

With this method, the following case study will analyze the practice of KM in contract logistics of a 3PL enterprise. The knowledge source for this case study is a combination of interviews and web research. The face to face interviews are based on questionnaires sent in advance.

Case study

This research takes the practice of a 3PL service provider (company A) as a case to demonstrate why, what and how KM has been applied in the process of contract logistics.

Company background

Company A is a modern logistics service provider with a long tradition. It was founded in 1853 in Bremen Germany. Company A has about 30 branches, e.g. Hamburg, Cologne, Mannheim, etc. It is one of Europe's leading service providers in the areas of transport and contract logistics. In 2009, it was ranked 58 in the top 100 logistics enterprises in Germany [7]. Company A serves customers from such industries as aerospace, automotive, mechanical engineering, steel, renewable energy, chemistry, industrial, and paper.

Contract Logistics is a core business for Company A. They have successfully managed many projects of in-house logistics, e.g. spare-parts warehouse in Lohmar, stand-alone logistics, e.g. service centre (DLZ) in Cologne, as well as transport logistics e.g. service centre (DLZ) in Neuwied. Company A also provides a wide range of freight forwarding services. In addition, it has been offering some 4PL services since 2007, e.g. consulting, value-added services and special projects.

Drivers of KM

Company A has had experience of KM for more than 7 years. There are some factors that drive Company A to start KM and integrate KM into business processes.

First, in the era of knowledge economy, knowledge has been a strategic resource besides land, labor, and capital. In order to keep sustainable competitive advantage in a dynamic market, logistics service providers need to better meet customer demands.

Second, the company size is becoming larger due to business development. 20 years ago and earlier, there were only several employees. Usually they worked in the same office and did the same project. It was easier for them to exchange their ideas and learn from each other. Nowadays, many branches are located in different places, it has become more difficult to meet and talk frequently. They work on different projects and have different experience. Knowledge sharing is important to provide better service to customers.

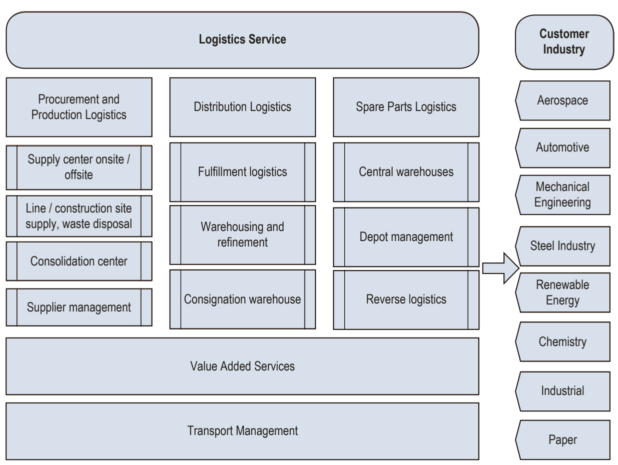
Third, with the expanding of the company, more and more new people join it. They know little about the management of old projects at the beginning. It is difficult to learn from old people in the company since some have left due to retirement or changing jobs, and some are too busy or too far away. Therefore, it is necessary to create knowledge, and store knowledge in organization memory, so that people can learn from good practice or mistakes in the past.

Moreover, logistics service, especially contract logistics is process oriented, so knowledge management must consider the process: plan, design, implement and review. This can provide the required knowledge in time, which will highly improve business efficiency and effectiveness.

Business processes

Business processes at Company A include contract logistics, transport logistics, value-added services and consultancy. Figure 4 describes the logistics service and customer industry.

Figure 4: Logistics service provided by company A



Contract logistics is the most important service at Company A. This service includes procurement and production logistics, distribution logistics, and spare parts logistics.

The business process of contract logistics is essentially a knowledge intensive project. The main phases in contract logistics are plan, operation, and review, which is a continuous KM process. The key processes are tender, CTI (Customer Transmission Integration), operation, and review.

First, the tender center needs to offer the price to obtain an project. They compete with many other logistics service providers. It is the most difficult step. They need to calculate the basic price, and plan time as well as steps to manage the project. For building a spare parts distribution center, e.g., they allocate all the resources of manpower, capital, and location, meanwhile they estimate the cost (Euro/m2) for warehouse renting in Munich. In addition, they have time pressure to produce such a professional plan.

Then, in the process of CTI, the main task is documentation. Based on the calculation, they organize a project team with qualified employees from different departments. After obtaining the project, they communicate with customer to produce the contract between them. They need to discuss the price and process in detail to write a feasible plan.

In the operation process, they implement the planned project into the real world. They organize the project team in a mixed and flexible structure. Usually, there is one team leader, and the members come from different unit functions. The project team in this phase is the same as that in the operation phase.

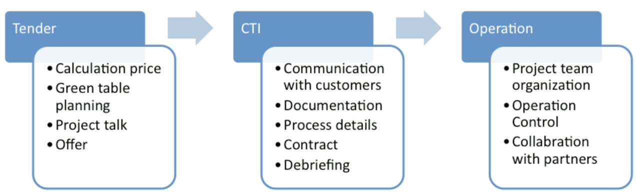
A further phase is the project review. They evaluate the project performance and check good as well as bad experience during the business process. There is a saying in Company A: one mistake only once. This phase is a critical way to review the past project and support guidelines for future projects.

Process knowledge in contract logistics

Procedure knowledge

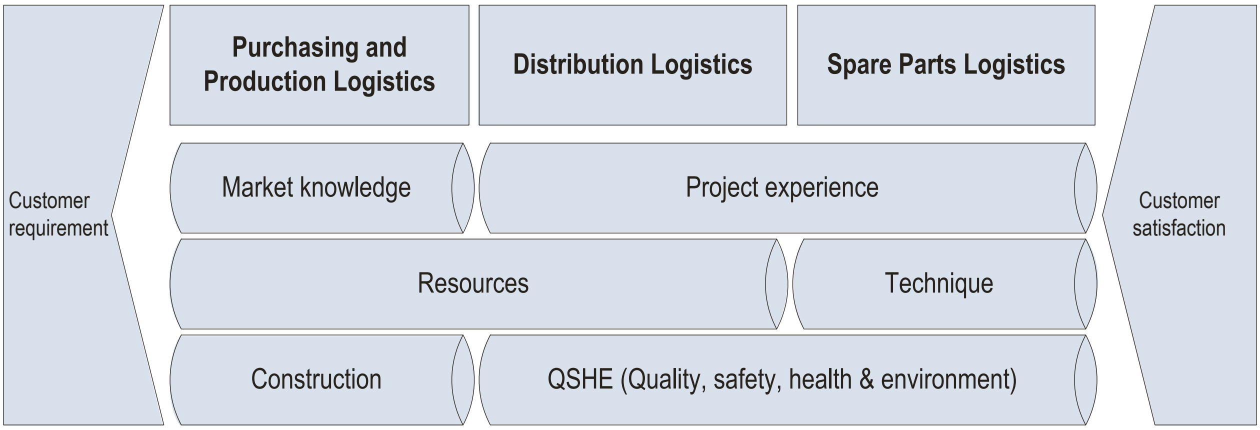
Procedure knowledge is about the overall phases, steps, tasks, and activities to manage a project. The team sets a clear target for all, under it they define tasks for each part and break them into specific activities so that it is clear and concrete to work and evaluate the progress. Figure 5 describes the key activities in each phase.

Figure 5: Process of contract logistics at company A



Another dynamic part of procedure knowledge is the real time progress of project operation. Each member knows the current situation of the project, whether it is going well or not. This kind of knowledge covers many aspects, such as the use of time, quality, and resources.

Figure 6: Knowledge in contract logistics at company A



Profession knowledge

Profession knowledge covers various aspects, e.g. business service expertise and experience, customer requirements, market and industry, logistics, sub-contractors, logistics performance, etc. Contract logistics services require professional planning, development and implementation of integrated logistics solutions. These solutions need knowledge and expertise in the fields of project experience, resources, techniques, IT, and construction . Figure 6 describes the profession knowledge in contract logistics at Company A.

Customer knowledge includes customer requirements and the specific industry. Knowledge and understanding of customer requirements are the basic consideration. Extensive knowledge of the industry is the premise to offer the best business solutions tailored to customer requirements.

Logistics knowledge: The specific knowledge of logistics contains procurement and production logistics, distribution logistics, and spare parts logistics. The primary business activities include the storage, supply and delivery of production components, finished goods, semi-finished goods and spare parts, as well as customized value-added services and personnel acquisitions.

A good project plan and its implementation also need updated *market knowledge*. When the tender center calculates the price of renting a warehouse, they should know the latest prices and compare them with different offers.

Project experience: Professional planning and effective implementation of the proposed solution are extremely important. During the planning phase, knowledge from past projects will enable the team to quickly identify weak points and avoid potential dangers. Meanwhile, collaboration with customers to define the processes and responsibilities from startup, as well as to design the plan and put it into operation is crucial.

Resources in contract logistics include physical assets, human resources, capital, time, collaboration, and so on. The assets, e.g. an own warehouse or a truck, are the foundation to manage a project. Human resources may be employees within the company or people from an outsourced company. Different qualified employees need to be coordinated and incorporated in a very short time to quickly create a strong team so that smooth operation and optimum results are ensured. Sub-contractors are important partners of 3PL to support some parts of business processes, e.g. construction, or transport. Knowledge about the collaboration plan and progress contributes to the fulfillment of the project.

Techniques: Customer demands are diversified and dynamic. The use of appropriate storage technology, trucks, machinery and facility as well as a lot of other technical equipment are one of the prerequisites for the successful handling of logistics. The success of logistics solutions depend significantly on the implemented IT infrastructure. Advanced warehouse management system and modules to choose proper IT systems are necessary supports for logistics service.

There are some key questions before *construction*. Is it an existing property or a new construction? What is the predominant mode of transport links? How close is the object located to the facility? Knowledge about the answers to these questions will pave the way for a smooth project implementation. In addition, the time availability, plan flexibility, technical equipment, and the legal requirements are also of crucial importance.

The issues of quality, safety, health and environment *(QSHE)* in the context of the whole process of planning and operation always come first.

Perception knowledge

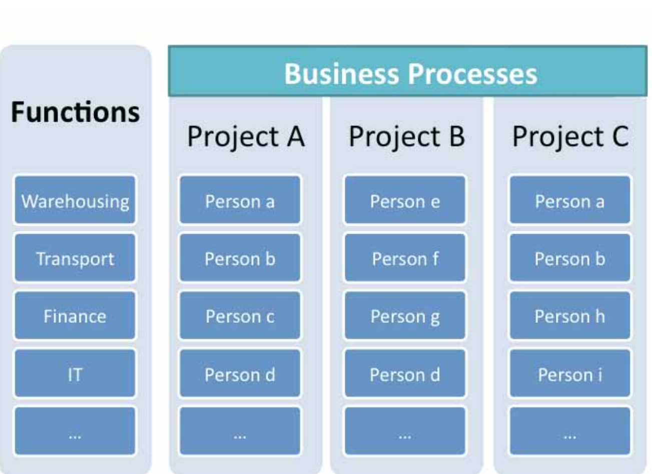
Perception knowledge comes from the experience in business processes. It will enrich both procedure knowledge and profession knowledge. Some ideas or methods contribute to optimize the processes or activities, e.g. improved procedure of CTI. While some knowledge supplements or updates the market development, or logistics service.

There are generally two parts. On the one hand, good practice includes dos, e.g. checklist for contract, improvement of customer claim management, innovation of knowledge sharing systems. On the other hand, lessons learnt include don’ts, e.g. mistakes to avoid in calculation, problems of QSHE to consider during construction, etc.

Implementation of KM in contract logistics

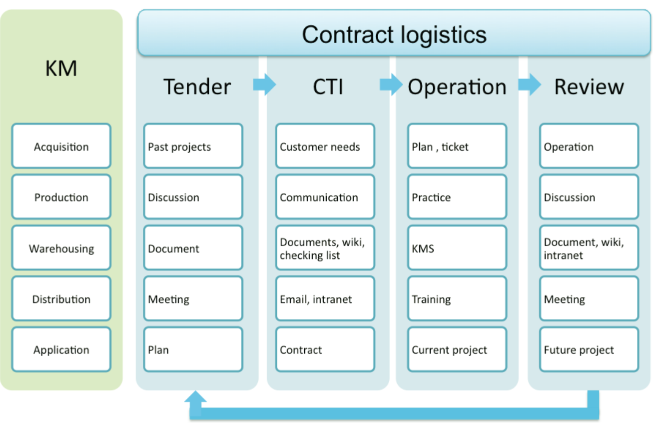
Professional logistics planning with innovative ideas and experience from many successful implementations of logistics solutions is crucial to the success of the project but also a trouble-free operation. In order to guarantee customer-specific concepts and continuous care with efficient, flexible and feasible solutions for long-term success and satisfaction, each project has a tailor-made team of specialists. Figure 7 shows the mixed structure of project teams at Company A.

Figure 7: Mixed structure of project team at company A



Knowledge management is along the whole process of project management, from plan to operation. Figure 8 illustrates some important activities and approaches of KM in different phases of contract logistics at Company A.

Figure 8: Approaches of KM in contract logistics at company A



Tender phase

In order to calculate a competitive price, the tender center needs to know the way of calculation for different projects, thus they must learn from the past, as well as from market and industry. Moreover, they should be familiar with the tools that support the calculation. The GCT (global calculation tool), e.g., covers the resources of people, figures, processes, ideas, etc. within the excel system.

The required knowledge is produced through discussions, e.g. brainstorming, as well as via professional tools, i.e. GCT (Global Calculation Tool).

Such knowledge is stored in documents that must clarify operation procedure, basic prices, exact time and steps, human resource allocation, etc.

After generating the initial plan, there will be a special meeting to discuss it: project talk. The project team explains their plan, and the other employees challenge it. They may ask such critical questions as "Why do you provide this price but not another?" or "How do you know the cost of renting such a warehouse?" They exchange their ideas and improve the plan. This project talk is a process of knowledge distribution. During the meeting, the project team presents the plan, and distributes knowledge to other people. Then the participants challenge the plan by asking critical questions. Through this process, knowledge is transferred to the project team members, which will stimulate valuable knowledge for the plan improvement. During the exchange, both parts also contribute to knowledge acquisition and knowledge production. After this project talk, the project team applies the new knowledge in the updated plan.

CTI phase

After they have successfully obtained the project from the customer, they actively meet and talk with the customer to directly acquire more important information or knowledge. During the meeting and communication, they produce further and more precise knowledge about the customer needs in detail.

Moreover, they document the knowledge in the contract with the customer. The contract provides detailed and specific knowledge about the project, e.g. price calculation. They also describe the process, activities and content of communication with the customer. Additionally, the description clearly shows how the process goes. When it is going well, the process is in green. When there is any problem, it is in red.

When the contract is formed, they have further discussion with the customer to review the details. The exchange between them is knowledge distribution. Knowledge from the interaction with the customer will be applied in the final contract. A practical application is the checking list, which will instruct future CTI processes.

Operation phase

In the operation phase, they acquire knowledge from the well organized plan and apply it into the real world. Meanwhile, they also acquire knowledge from the current practice.

The knowledge from plan and practice can generate new ideas for a better operation. Knowledge from operation processes can produce dos and don'ts for future projects. Since the project team at this operation step is the same as that at the planning stage, it is easier for them to produce new knowledge based on their teamwork. There is the OCS (Operation Control System) that stores very specific knowledge in the operation process, e.g. unloading a truck. The system shows every step and the result. There is also the DOR (Documentation Requirement System) for knowledge warehousing.

In order to distribute the right knowledge to the right people, they use emails, intranet, and reports to share and transfer the progress. As it is a continuous improvement process, they also conduct training to new people. Knowledge from the operation process will be applied for improvement in current and future projects.

Review phase

After these three phases, the project team has a review of the whole business process. They discuss both improvements achieved and lessons learnt. This step is another process of KM. Knowledge is acquired from the operation of contract logistics, produced through discussion, stored in documents, wikis, or intranets, distributed by meetings and forums, and will be applied in future projects.

Implications

The first global Delphi investigation about knowledge management development organized by the Fraunhofer Competence Center (IPK) and Humboldt University in 2002 showed that the combination of KM and business processes is the most urgent research problem [8].

From the case study, we can learn that the objective of KM is to provide better service to meet customer demands by avoiding the same problems and promoting better solutions in business processes. On the one hand, they integrate KM into a real context so that KM practices are more effective. On the other hand, they incentive people to share knowledge in daily work, so that KM activities are more efficient. Examples of the applied approaches are: centralized meetings, documentation, checking lists, CIP (continuous improvement process), idea cards, knowledge tickets, Lotus Notes, Wikis, Intranets and email.

Business process oriented implementation of KM can benefit 3PL directly or indirectly in these aspects: better service, more value-added, less time, lower cost, higher quality, and process standardization. However, there are some great challenges to manage knowledge, especially tacit knowledge in business processes. Open and friendly organizational cultures, effective motivation measures, and process oriented structures are important enablers for knowledge sharing and transferring, which are the crucial foundations of KM.

References

[1] *Xiao, H.; Li, H.; Yang, Y.; Tang, X.: Knowledge-based logistics system of 3pl in p. r. china. In: Proceedings of the international Conference on Management and Service Science (MASS 2009) , Wuhan, China 2009, pp 1–4.*

[2] *Terry, L.: 2012 third-party logistics study. URL: http://www.outreach.psu.edu/programs/hadly-waters/files/2012_3pl_study.pdf, Date of access 10.04.2012.*

[3] *Rabinovich, E.; Windle, R.; Dresner, M.; Corsi, T.: Outsourcing of integrated logistics functions: An examination of industry practices. International Journal of Physical Distribution & Logistics Management 29 (1999) 6, pp 353–374.*

[4] *Amaravadi, C.; Lee, I.: The dimensions of process knowledge. In: Knowledge and Process Management 12 (2005) 1, pp 65–76.*

[5] *Yu, L.; The practice research of process-oriented knowledge management. In: International Conference on E-Business and E-Government (ICEE 2011). Shanghai 2011, pp 1–4.*

[6] *Wu, P.; Hu, K.; Li, X.: Research on the knowledge management in third-party logistics. Journal of Information 2 (2007), pp 15–17.*

[7] *Klaus, P.; Hartmann, E.; Kille, C.: Die Top 100 der Logistik (2010/2011): Marktgroessen, Marktsegmente und Marktfuehrer in der Logistikdienstleistungswirtschaft. DVV Media Group, Hamburg, 2010.*

[8] *Scholl, W.; König, C.; Meyer, B.; Heisig, P.: The future of knowledge management: an international delphi study. Journal of knowledge management 8 (2004) 2, pp 19–35.*

Hongyan Zhang, M. A.

Applying Business Process Oriented Knowledge Management in Third Party Logistics

E-mail:	zhang@isl.org
Country:	China
Start:	01.11.2009
Supervisor:	Prof. Dr. rer. pol. Hans-Dietrich Haasis
Faculty:	Business Studies / Economics
Research Group:	Business Administration, Production Management and Industrial Economics

Modelling the Sourcing Process in the Mineral Raw Materials Industry by Using Supply Chain Frameworks

Raul Zuñiga Arriaza
Prof. Dr. Klaus-Dieter Thoben

The application of the supply chain management to other industries often results in implementations that do not meet the needs and specific characteristics of the companies involved. An industry that needs a standard is the mineral raw materials industry. The current problem this industry is facing is the inability to adapt the existing supply chain frameworks to its sourcing process. This work examines how the sourcing process of the mineral raw materials industry can be represented in today's supply chains frameworks. Most of the concepts, variables, and factors related to supply chain and supply chain management, mineral raw materials industry, and the extraction process are obtained from literature review. The extraction process is presented by using the existing Supply Chain Operation Reference (SCOR) model. The results show how to extend the SCOR model to this process. Therefore, further research is needed for the SCOR model extension to the exploration and development processes of this industry.

Introduction >>> Supply chain models have been implemented nowadays in several industries [1]. However, as most of the supply chain models were originally designed to fit in a manufacturing environment, few related research has focused on the mineral raw materials industry [2, 3]. This industry and its sourcing process in particular present many atypical characteristics, which are challenging to comply with existing supply chain models, and very limited research has covered this early part of the supply chain. A better understanding about the complexity and characteristics of the processes in the mineral raw materials industry can contribute to improving the early supply chain processes, and thereby improve the entire supply chain performance. For this reason, it is relevant to examine how the sourcing process works in this industry. The problem is that the current modelling approaches to supply chains consider raw material industry as an infinite source, a black-box with unlimited resources. Therefore the supply of mineral raw materials has been more or less excluded from existing models so far [4]. This research examines how the sourcing process of this industry is currently represented in supply chains. In addition, it identifies how this process fits into the existing SCOR model. **<<<**

Characteristics of the industry

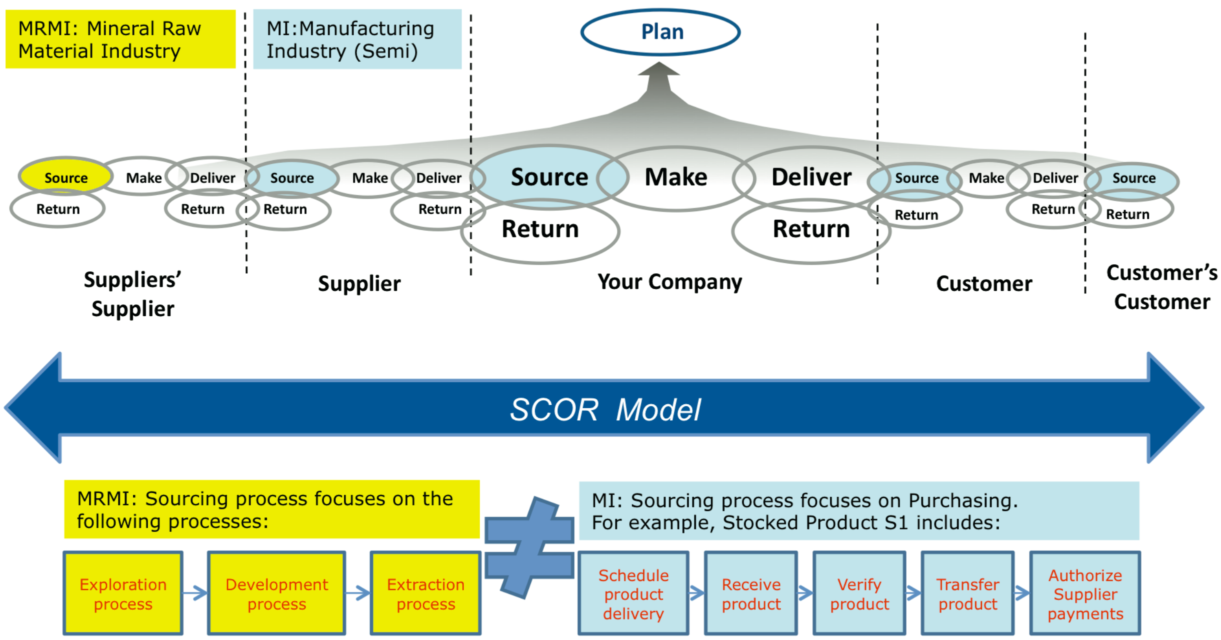
The special features of mineral resources deposits, initially unknown, fixed in physical size and location, and variable in quality, result in characteristics of this industry that create both problems and opportunities [5]. The following aspects characterize the mineral resource deposits.

Mining activities involve high-risk investments [4]. Mineral deposits have to be located and delineated. This entails large exploration costs, before considering normal industrial development and production decisions. Consequently mineral exploration is an integral part of the mineral raw materials industry. In fact, successful exploration is essential for mining companies to survive over time [6]. Also, mineral deposits once they are discovered are of fixed size determined by nature, and therefore they are subject to depletion during the normal course of mining production. Consequently, it is necessary to engage in continuous and successful exploration efforts in order to maintain existing production levels.

The inherent variability in quality and other geological parameters can also result in the variability of mine site revenue, the operating and capital costs that ultimately affect the returns on investment [7]. For this reason, one of the most important competitive advantages of a mining company is the high quality of its mineral deposits. To avoid the cost of transporting non-mineral waste rock with the product, companies decide to process ore adjacent to the mineral deposit. For that, mineral deposits cannot be moved to a convenient location.

There is always a level of uncertainty and estimation errors in geologic modelling and geostatistics systems, in estimated ore quality parameters, such as mineralogy, granulometry, metallurgical and chemical grades. These parameters will only be determined after the exploitation, already in the production process. Also, the uncertainties are in the production process and it is necessary to work with stockpiles of intermediate and final products. Therefore, mining companies normally produce raw materials to stock, not to order [2].

Figure 1: The coverage of SCOR model



Supply chain frameworks – The SCOR model

There are different supply chain frameworks, among them the framework receiving the most attention – the SCOR model. This model evolves from a company's effort to introduce efficiency to the Supply Chain. The SCOR model describes a simple or complex supply chain by using five primary processes (see Figure 1): Plan, Source, Make, Deliver, and Return [8]. These processes are Level 1 processes within the SCOR hierarchy. Level 2 processes describe three process types; Planning, Execution and Enablement. Level 3 are the standardized operations of the Level 2 processes. Level 4 enhances each of the Level 3 processes specific to the organization's needs.

The processes in the early part of the supply chain in the mineral raw material industry are (see Figure 2): Exploration, Development, Extraction, Processing, and Distribution. The question is, how to describe these processes by using the existing SCOR model? In this particular case, how does the SCOR describe the sourcing process? The problem is that the Source process of the SCOR model focuses on purchasing which is different to the sourcing process in mineral raw material industry (see Figure 1). In this case, the sourcing process focuses on exploration, development and extraction processes. Therefore, there is a gap between what the SCOR model defines for the source process and how the sourcing process works in this industry. For this, it is necessary to identify the processes that the SCOR model needs to include for describing the sourcing process of this industry. The extraction process is used as an example.

The extraction process with SCOR model

The sourcing process includes the exploration, development and extraction processes. As an example, the extraction process is described by using the SCOR model.

Figure 3 illustrates the extraction process modelling. This process can be explained as follows. The processing plant (customer) requests a specific quantity of ore from the extraction process. Information starts to flow from the customer to the extraction process. This process then searches the warehouse (stockpile) for

Figure 2: Processes of the minaral raw materials industry

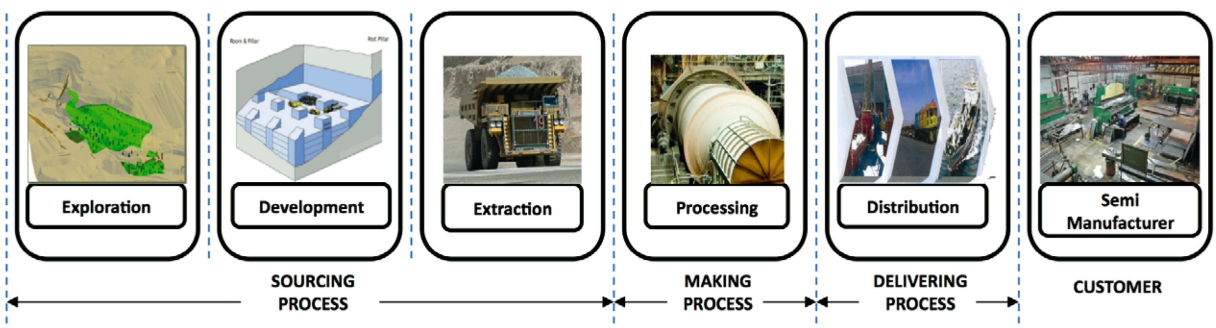
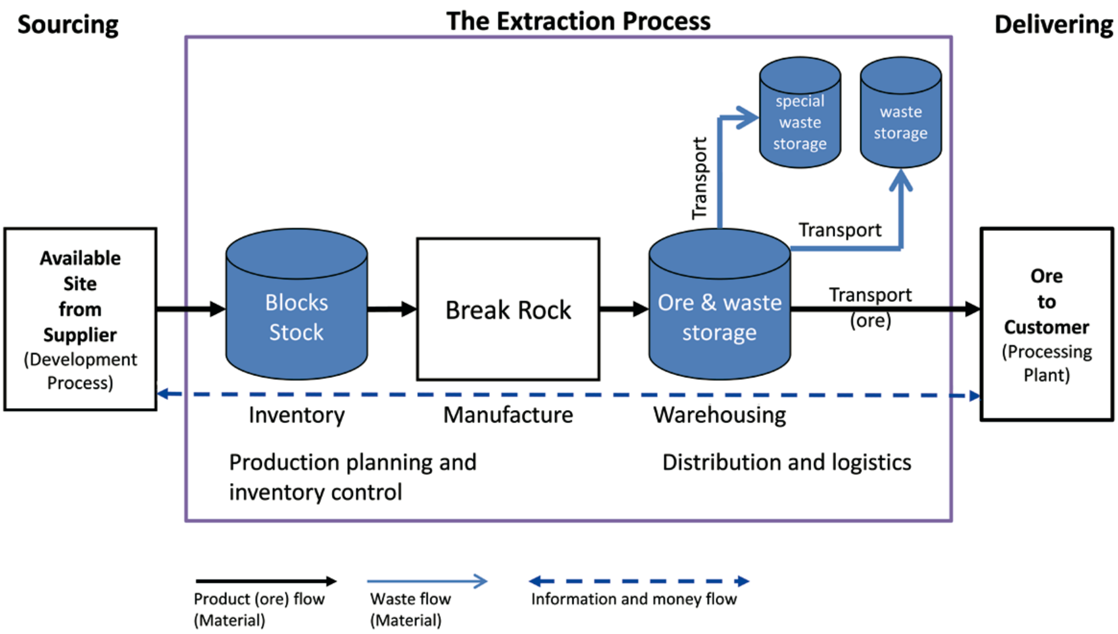


Figure 3: The extraction process supply chain



ore stock, which would be an ore storage stockpile, to examine whether the ore is available or not. If available, the ore is sourced from the stockpile and delivered to the customer via a transport system. The delivery mechanism is the logistics of how to distribute the product (ore). The infrastructure is part of the distribution planning. The name of this delivery process is "remove rock", which includes classifying, transporting, and stockpiling the broken material.

When the ore is not available in the stockpile, it has to be manufactured by extraction process. The manufacture is the "break rock" process, which includes mining the ore body (drill and blast), and extending any necessary infrastructure. The extraction process then plans the ore and sends information to interrogate the inventory for ore blocks stock. Some of the ore blocks stock needed for the ore are held in inventory. The sourcing request is sent out to the supplier, the construction process, which is part of the development process. Then, the supplier delivers an available site with the ore blocks requested. The extraction process keeps blocks in inventory until they are needed to extract the ore. This part is known as production planning and inventory control. Once the ore has been completed, the extraction process delivers ore to the customer via the stockpile as described above. In addition, it also shows the flow of information and money between the different processes. Thus, a product (ore) produced by the extraction process can be managed using supply chain management.

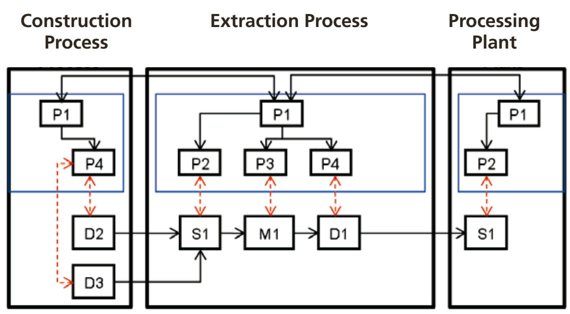
Figure 4 depicts the extraction process by using the SCOR Model. The Source Stocked Product, S1, is the process category that describes the activities involved in obtaining products that are stored for future use by the extraction process and include the receipt of the site with some quantity of ore blocks stock. There are only four process elements within this process category which include the scheduling of product (the site) deliveries, the receipt of products, the verification of products, and the authorisation of supplier payments. The supplier is the construction process, which is part of the development process. This process delivers the site with some quantity of ore blocks stock. The product in the construction industry is different to the typical product of manufacturing industry [9, 10]. The customers should come to the place and use the product (the site) because there is no possibility to transport the final product to another place. Therefore, there is a need to adapt the process elements of the SCOR model because the "transfer of the product" is not possible in this context.

The Make-to-Stock process category, M1, includes all the activities related to the manufacture of a product (ore broken rock) with the intent to store the product in a finished goods state before delivering it to a particular customer (the processing plant). Products that are made to stock are manufactured before an actual customer order from the processing plant is received.

The Deliver Stocked Product process category, D1, includes all the activities involved in the delivery process of a finished product (ore broken rock) from storage.

In addition, there are some results about how to describe the exploration and development processes by using supply chain frameworks. These processes need to be integrated into the extraction process and then, the sourcing process of this industry can be described by using an extension of the SCOR model.

Figure 4: The extraction process by using SCOR model



Conclusions

This work showcases how the SCOR model may be extended in order to model the extraction process of the sourcing process of the mineral raw materials industry. Based on the results shown in this paper, the following conclusions can be obtained.

- The SCOR model, which is a quasi-standard in manufacturing industry, can be extended to model the extraction process.
- The SCOR model shows a high potential to describe the sourcing process of the mineral raw material industry. To improve the results it requires the analysis of Level 3 processes to identify the Key Performance Indicators and Best Practices, which are more suitable to this sourcing process.
- The SCOR model allows companies to model the earliest processes of the sourcing process by the integration with other new processes to use for the exploration and development processes.
- There is a promising potential to extend the SCOR model to the rest of the processes in the early part of the supply chain in this industry

References

[1] Lambert, D. M.; Stock, J. R.;Ellram, L. M.: Fundamentals of logistics management. Irwin/McGraw-Hill, Boston 1998.

[2] Tardelli, P.; Barbin, F.; Cesare de Tomi, G.: ERP in mining industry: Studying the software functionality and the value chain. In: Second World Conference on POM and 15th Annual POM Conference. Cancun, México 2004.

[3] Guoqing, L.; Nailian, H.; Xuchun, H.: Study on the application of supply chain management (SCM) for jiaojia gold mine. In: Applications of computers and operations research in the minerals industries. South African Institute of Mining and Metallurgy, South Africa 2003.

[4] Vial, J.: Modelling commodity markets in the global economy: familiar findings and new strategies. In: Working Papers Series 18 (2004) - Center on Globalization and Sustainable Development, The Earth Institute at Columbia University.

[5] Maksaev, V.: Introducción a la economía minera: definición y aplicación. URL: http://www.cec.uchile.cl/~vmaksaev/ECONOMIA%20MINERA.pdf, Date of access 04.10.2010.

[6] Prospectors and Developers Association of Canada: Mining Information Kit for Aboriginal Communities: Exploration, development, operation and closure. URL: http://www.pdac.ca/pdac/advocacy/aboriginal-affairs/2006-mining-toolkit-eng.pdf, Date of access 10.06. 2011.

[7] SAP AG: The SAP mining solution. URL: http://www.scribd.com/doc/57568973/SAP-Mining-Solution, Date of access 10.05. 2011.

[8] Supply Chain Council: Supply chain operations reference (SCOR) model version 10.0. The Supply Chain Council, Inc. SCOR: The Supply Chain Reference.(binder) 2010.

[9] Morris, P.W.; Pinto, J.K.: The wiley guide to project technology, supply chain & procurement management. John Wiley&Sons, Inc., Hoboken, New Jersey, U.S.A 2007.

[10] Hue, X.; Wang, Y.; Shen, Q., et al.: Coordination mechanisms for construction supply chain management in the internet environment. In: International Journal of Project Management 25 (2007), pp 150-157.

Raul Zuñiga Arriaza, M.Sc.
Modelling and Evaluation of the Early Part of the Supply Chain in the Mineral Raw Materials Industry

E-mail: zun@biba.uni-bremen.de
Country: Chile
Start: 05.05.2009
Supervisor: Prof. Dr.-Ing. Klaus-Dieter Thoben
Faculty: Production Engineering
Research Group: Collaborative Business in Enterprise Networks

Imprint

Log*Dynamics* Research Report
ISSN 1867-0210
Volume 3, 2013
Research Report 2012/13
International Graduate School for Dynamics in Logistics (IGS)

Statutory Declaration

Place of Publication
Bremen, Germany

Publisher
Bremen Research Cluster for Dynamics in Logistics (Log*Dynamics)*
Universität Bremen

Responsible
Prof. Dr. rer. pol. Hans-Dietrich Haasis (IGS)
Prof. Dr.-Ing. habil. Klaus-Dieter Thoben (Log*Dynamics)*

The sole responsibility for the content of the named articles lies with the authors.

Editors
Dr.-Ing. Ingrid Rügge
Aleksandra Himstedt

Contact
IGS, Universität Bremen
Dr.-Ing. Ingrid Rügge
c/o BIBA
Hochschulring 20
28359 Bremen, Germany
Phone: +49 421 218 50139
Fax: +49 421 218 50031
Email: info@IGS.Log*Dynamics*.de
Internet: www.Log*Dynamics*.com

LogDynamics
Research Report

Design
Gudrun Feilcke, Grafik-Design

Picture Credits
Log*Dynamics*, BIBA
Page 3: "Logistikbahnhof" printed with permission of the photographer Ludwig Kay, selected from the photo competition of Log*Dynamics* in 2011
Page 8: Printed with permission of the photographer David Ausserhofer, Deutsche Akademie der Technikwissenschaften (acatech)

Article
The article on page 45 has already been published as Pötsch, T.; Kuladinithi, K.; Becker, M.; Trenkamp, P.; Görg, C.: Performance Evaluation of CoAP using RPL and LPL in TinyOS. In: Proceedings of the 5th IFIP International Conference on New Technologies, Mobility and Security (NTMS). Istanbul, Turkey. 7 - 10 May 2012.

The article on page 41 is an excerpt of the paper: Palafox-Albarran, J.; Dannies, A.; Krishna Sanjeeva, B.; Lang, W.; Jedermann, R.: Combining Machine-to-Machine Communications with Intelligent Objects in Logistics. In Proceedings of the ImViReLL'12 – The Impact of Virtual, Remote and Real Logistics Labs. Bremen, Germany, 28 February – 1 March 2012, pp 102-112.

Bremen Research Cluster for Dynamics in Logistics

International Graduate School for Dynamics in Logistics

Universität Bremen
Postfach 330 440
28334 Bremen, Germany
Email: info@Log*Dynamics*.com
Internet: www.Log*Dynamics*.com

ISSN 1867-0210