LogDynamics
Research Report

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LogDynamics

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Dynamics in Logistics

The complexity of logistic networks and systems is growing in today's globalised world. Individual customers' requirements cause a significant number of product variants and services as well as shorter product life cycles. This implies new technical and economic challenges for logistic systems and processes. In order to meet these challenges we need innovative logistic solutions that adapt flexibly to continuously changing conditions. The ability to control these dynamic aspects is essential for successful manufacturing and transport logistics. Moreover, it guarantees strategic advantages in terms of competitiveness on the world market. Because of this relevance the Bremen Research Cluster for Dynamics in Logistics (Log*Dynamics*) strongly focuses this research area on both fundamental and applied level. The Research Report 2010/2011 provides significant insights into the research topics. It presents interesting examples of the scientific work in the International Graduate School for Dynamics in Logistics.

Prof. Dr.-Ing. Bernd Scholz-Reiter,
Spokesman of Log*Dynamics*

Research and Development in Logistics

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 in and for the state of Bremen implies the respective scientific focus.

The University of Bremen meets the demand for logistic research by linking competences of different scientific disciplines within an interdisciplinary cluster. The Bremen Research Cluster for Dynamics in Logistics (short: Log*Dynamics*) was founded in 1995 as a cooperation between members of the faculties for physics and electrical engineering, mathematics and computer science, production engineering, economics, as well as the BIBA – Bremer Institut für Produktion und Logistik GmbH and the Institute of Shipping Economics and Logistics (ISL). The objective of the cluster was and still is to strengthen interdisciplinary research and development in the competence area of logistics for the benefit of the region Bremen.

The "International Graduate School for Dynamics in Logistics" (IGS) is one of the four pillars of Log*Dynamics*. It offers outstanding researchers from all around the world the opportunity to complete a structured graduate training at the excellent logistic location Bremen. The International Graduate School is closely linked to the demonstration and application centre for mobile technologies in logistics "Log*Dynamics* Lab", as well as to the Collaborative Research Centre 637 "Autonomous Cooperating Logistic Processes – A Paradigm Shift And Its Limitations" funded by the German Research Foundation (DFG) since 2004.

Interdisciplinary Cooperation

The logistic challenges cannot be solved within one single scientific discipline. Therefore the Log*Dynamics* research is based on interdisciplinary cooperation and synergy effects. The 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.

Therefore, Log*Dynamics* makes special efforts to increase the cooperation possibilities between science and industry. Furthermore, it promotes giving small and middle-sized enterprises access to research and innovation. The resulting dialogue of industry and science contributes to a better understanding of the different aspects of problems and possible solutions in logistics. The regional objectives of Log*Dynamics* are to strengthen the field of logistics at the university and its research institutes and take over an active and dialogue-oriented role in the competence network. Focus is placed on ensuring fundamental research, continuing research on applied scientific logistics, and training of young scientists.

Graduate Training at Highest Level

The aim of the IGS is to identify, describe and model the required and feasible intrinsic dynamics in logistic processes and networks. It conducts research on innovative dynamic planning and control methods by using new technologies. In doing so, cross-disciplinary cooperation under consideration of intercultural aspects is the basis for this research. The topics of the International Graduate School focus on:

- Holistic interdisciplinary method toolbox for the modelling, analysis, and simulation of logistics
- Synchronisation of material and information flow
- Adaptive and dynamic control methods for logistics

Research Beyond Boundaries

Faculty 1: Physics / Electrical and Information Engineering

Dynamics in Logistics is intrinsically coupled with the corresponding 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 available 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 that is investigated is the use of information networks to implement dynamic routing algorithms for transport logistics to react to dynamic events that can drastically influence the behaviour of the transport processes. **Prof. Dr.-Ing. Carmelita Görg** is head of the research group Communication Networks.

In the near future it must 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 terms of carriage as 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. That 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 knowledge. 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. He is member of the Collaborative Research Centre 637 "Autonomous Cooperating Logistic Processes" and since June 2010 with Jacobs University Bremen, School of Humanities and Social Sciences as "Professor for Visual Information Technologies".

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

The increasing complexity of production systems and logistic networks requires the development, use, and integration of new methods of planning and controlling based on an interdisciplinary perspective. The research aims at developing and applying new concepts, methods, and ICT solutions which help to enhance the planning and controlling of logistic processes on one hand and improve the understanding and the qualification of people in different socio-technical systems on the other. This

pursues the goal of a sustained optimisation of production and logistic systems. **Prof. Dr.-Ing. Bernd Scholz-Reiter** is managing director of the BIBA – Bremer Institut für Produktion und Logistik GmbH and head of the department "Planning and Control of Production Systems". He is spokesman of the International Graduate School for Dynamics in Logistics (IGS) and of the Collaborative Research Centre "Autonomous Cooperating Logistic Processes – A Paradigm Shift and its Limitations" (CRC 637).

High performing co-operations between independent companies with the aim to develop and to 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 at BIBA – Bremer Institut für Produktion und Logistik GmbH.

Faculty 7: Business Studies / Economics

Logistics research in mobility and elaboration of tools 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) and head of the logistic systems unit. 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 Professors

All professors of Log*Dynamics* are available as supervisors for the IGS. Particularly, there is a close cooperation with the School of Engineering & Science of the Jacobs University Bremen. Two professors are sub-project leaders in the Collaborative Research Centre 637 "Autonomous Cooperating Logistic Processes".

Prof. Dr.-Ing. Katja Windt is Bernd Rogge Professor of Global Production Logistics. Her research focuses on the intrinsically embedded interdisciplinary aspects of logistics in networks:

- Her team *Production Control* develops novel methods for problems pertaining to production control, including appropriate planning strategies. These include auditory display, analysis of production processes and approaches to self-organized control, inspired by abstract model dynamics as well as real-world situations.
- Her team *Systems Design* analyzes and structures logistic environments. It works on comparing decentralized production control methods by using computer simulation models, on the development of models for quantification of emissions, and on flexible and reconfigurable technologies for logistics.

Prof. Dr. Michael Hülsmann is head of the Systems Management Workgroup. His research is addressing questions of

- building and leveraging strategic competences,
- avoiding and managing organisational change and strategic crises,
- designing processes and structures of inter-organisational co-operation, co-ordination, and collaboration, and
- controlling impacts of organisational configurations on corporate value, risk, and sustainability.

International Graduate Training in Logistics

International Graduate Training in Logistics

Since 2005 the International Graduate School for Dynamics in Logistics at the University of Bremen (IGS) 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 enterprises.

The curriculum of the International Graduate School is designed for a three-year full time doctoral study. It bundles interdisciplinary competences and fosters the link between research and industry. Besides the individual doctoral project it covers collective thematic introductions, subject specific courses, interdisciplinary colloquia, dialogue forums, excursions, as well as individual coaching regarding soft skills. The language of the training and the PhD thesis is English. However, a basic knowledge of 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 IGS-graduate 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 Graduate Training

Eight professors from four faculties of the University of Bremen are available as supervisors or as mentors for the graduates at the International Graduate School for Dynamics in Logistics. Additionally, graduates receive a structural supervision form the Managing Director of the International Graduate School 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 graduates 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 graduates learn to use the exact tools of scientific work which are required for their particular project and receive individual support in their research activities.

Courses

Courses are divided into lectures with tutorials, seminars, workshops, practical training, and integrated learning in small groups. The aim of the disciplinary courses is to educate graduates on the level of international standards of the respective

research area. Thematic introductions into the "other" disciplines support the interdisciplinary cooperation at the International Graduate School. In detail the offer includes: time and project management, academic writing, presentation and moderation, rhetoric and communication, intercultural coaching, and language courses.

Interdisciplinary Research Colloquium

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

Dialogue Forum

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

Success Story

From an IGS-PhD Student to the Professorship in Brazil

About a year after successfully graduating from the International Graduate School for Dynamics in Logistics Dr.-Ing. Enzo Morosini Frazzon was appointed to a professorship at the Federal University of Santa Catarina. After four years of doing research at the University of Bremen the Brazilian-born returned to his home country and as of 1st of August 2010 took up the employment in the faculty of Production Engineering.

Within three years Enzo Frazzon finished his PhD thesis on global logistic systems at the IGS. Dr.-Ing. Ingrid Rügge, manager of the International Graduate School, compliments the young researcher: "Graduating in an engineering science within three years is already an enormous accomplishment but doing it yet in two foreign languages is remarkable. I am very proud that the IGS was able to contribute to that!" Enzo Frazzon was the second IGS alumnus; by now there are nine, two of which also finished their PhD within three years. Dr. Rügge points out: "The success of our structured doctoral program is very impressive!"

After his graduation from the IGS Dr. Frazzon held a postdoc position at the Bremer Institut für Produktion und Logistik GmbH (BIBA). During this time he established collaborations with universities

in Brazil and was involved in numerous international projects. "These collaborations mean an important step towards the internationalisation of logistics research. They create a large added value for the BIBA and the University of Bremen and will be continued in the future via the existing networks", says Prof. Dr.-Ing. Bernd Scholz-Reiter, Managing Director of BIBA and supervisor of Enzo Frazzon in the IGS.

Professional Development of Professor Enzo Frazzon

Enzo Frazzon finished his studies at two colleges in Brazil: the Federal University of Santa Catarina and the IBMEC Business School. He holds degrees in Production Engineering with a focus on logistics and transport, Mechanical Engineering and Business Administration (MBA). Furthermore, he has gained ten years worth of experience working in businesses, such as Volkswagen/Audi, Arcelor, Petrobras and in political departments such as the Brazilian Ministry of Transport and the National Agency for Transport. In April 2006 Frazzon came to Bremen to do research as a scholarship holder at the IGS in the field "Dynamics in Logistics". His goal was to gain international and intercultural experience to optimize his professional prospects. And the IGS was just the right place for that.

Logistics is international, interdisciplinary and intercultural – the IGS reflects this tendency and this perspective is also taken up in Frazzon's PhD thesis. His research addressed the question: Which factors drive successful international venturing in the logistic services industry? He examined the relationship between the early recognition and consideration of the contextual gap among nations (i.e. the cultural, administrative, geographic and economic differences) and the sustainability and effectiveness of logistic service providers in international co-operations. He proved that developing an awareness of this and faster learning cycles

at logistic service providers can actually support an improvement of the operating profit and the development of a competitive advantage. For the industry his research generated indications of challenges and opportunities for German logistic service providers doing or planning business in Brazil.

"Brazil is a very important frontier for the development of business and science; therefore holding a professorship in Brazil is both challenging and very motivating" states Frazzon. The Federal University of Santa Catarina is a public university located in Florianópolis, the capital city of Santa Catarina in southern Brazil. The university is one of the leading Latin-American research universities, being the third largest university in Brazil and the fifth in Latin America, noted by its engineering school and technology centre.

The teaching work of Enzo Frazzon is focused on undergraduate and graduate courses in the field of Production and Systems Engineering. For undergraduate students he assumed two courses: "Informatics applied to Production Engineering" and "Guidance for the Degree Dissertation in Production and Systems Engineering". Furthermore, he has been appointed for the board of the Production and Systems Engineering Undergraduate Course. As part of his administrative role, Frazzon was nominated as President of the Department Committee of Infrastructure. He also assumed the role of Associate Editor of the Journal Produção Online. Starting in 2011, he will inaugurate a course on Intelligent Logistic Systems within the Production and Systems Engineering Graduate Program.

Beside his teaching responsibilities Frazzon participates in a number of international research projects which comprise cooperative research activities, exchange of students and researchers, as well as working missions.

Integrated Logistics supported within the PRONEX Program – a framework for supporting scientific research and technological development within outstanding research groups.

Project **Intelligent Logistic Platforms** aims to develop and diffuse a concept of logistic platforms acting as intelligent links along supply chains and intermodal transportation, focusing on the information integration through ICT and exploring the synergy of served production chains.

Project LogGlobal – **Improving Global Supply Chains** is one of the founding projects of the Brazilian-German Collaborative Research Initiative on Manufacturing Technology (BRAGECRIM). The research focuses on improving informational interfaces between globally distributed manufacturing and logistics systems.

Globalisation is normally associated with material and information flows along supply chains, as well as internationally decentralised manufacturing and logistics systems. Within academia and science, globalisation is embodied in the international collaboration among universities and researchers. In Professor Frazzon's view, building resilient networks that can act as framework for fostering scientific cooperation are of central relevance and therefore will be his lasting priority.

"I would like to thank the IGS for the assistance and supervision which strongly contributed to my professional career. The international, intercultural and interdisciplinary experience provided me with valuable skills and influenced positively my scientific work. It gave me also access to important contacts within academia and industry. In particular I will continue the cooperation with my supervisors, project partners and my former PhD colleagues – the alumni of the IGS."

Prof. Dr. Enzo Morosini Frazzon

Alumni

Alumni of the International Graduate School for Dynamics in Logistics

The first alumnus left the IGS in 2008. By now, there are nine young researchers who successfully finished their theses. One of them is Dr.-Ing. Arne Schuldt who was awarded with the Science Award for Logistics by the German Logistics Association (BVL) in October 2010 in the course of the 27th German Logistics Congress in Berlin. His PhD thesis has been selected because of its high relevance for the praxis.

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.-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. 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. 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

Self-organizing Supply Networks: Autopoiesis for Agent Coordination in Autonomous Logistics

Jan Ole Berndt
Prof. Dr. Otthein Herzog

Supply networks are faced with the contradictory requirements of achieving high operational efficiency while retaining the ability to adapt to a changing environment. Decentralized approaches representing logistics entities by autonomous artificial agents must therefore be enabled to structure and operate supply networks efficiently according to the domain's inherent dynamics caused, for instance, by operational failures, changing customer demands, and network participants entering or leaving the system. In this paper, a novel approach to self-organization for multiagent systems is outlined that considers the particular challenges in supply network design and operation.

Introduction >>> Logistics plays a major role in the globalized economy. Industrial production and trade require efficient and reliable supply networks. Growing interrelations between these networks and the inherent dynamics of the logistics domain result in a high complexity of global supply processes [7]. Application of conventional centralized planning and control to these processes suffers from that complexity. Therefore, a need for decentralized methods employing autonomous actors arises [8].

From the artificial intelligence point of view, these autonomous entities can be represented by software agents to model logistics networks as multiagent systems (MAS) [17]. These systems may be used to simulate, evaluate, and actually apply new approaches in autonomous logistics [18].

Coordination and cooperation of autonomous agents is the challenging task that has to be addressed in order to develop such approaches. In the logistics domain, coordination is faced with the contradictory requirements of achieving high operational efficiency while retaining the system's ability to adapt to a changing environment. Supply networks, therefore, need to achieve high performance rates concerning asset utilization, cost reduction and customer satisfaction on the one hand. On the other hand, they are required to employ flexible and robust structures in order to react to unforeseen changes caused by the domain's inherent dynamics.

In this paper, a novel approach to self-organization for multiagent systems in the context of supply network modeling is outlined. Considering particular challenges in supply network structuring and operation, as depicted in the next section, agent coordination mechanisms are investigated as means for structuring decentralized behavior in logistics networks. These considerations form the basis for the introduction of *autopoiesis* in autonomous logistics as an adaptive self-structuring paradigm for supply networks modeled by multiagent systems. <<<

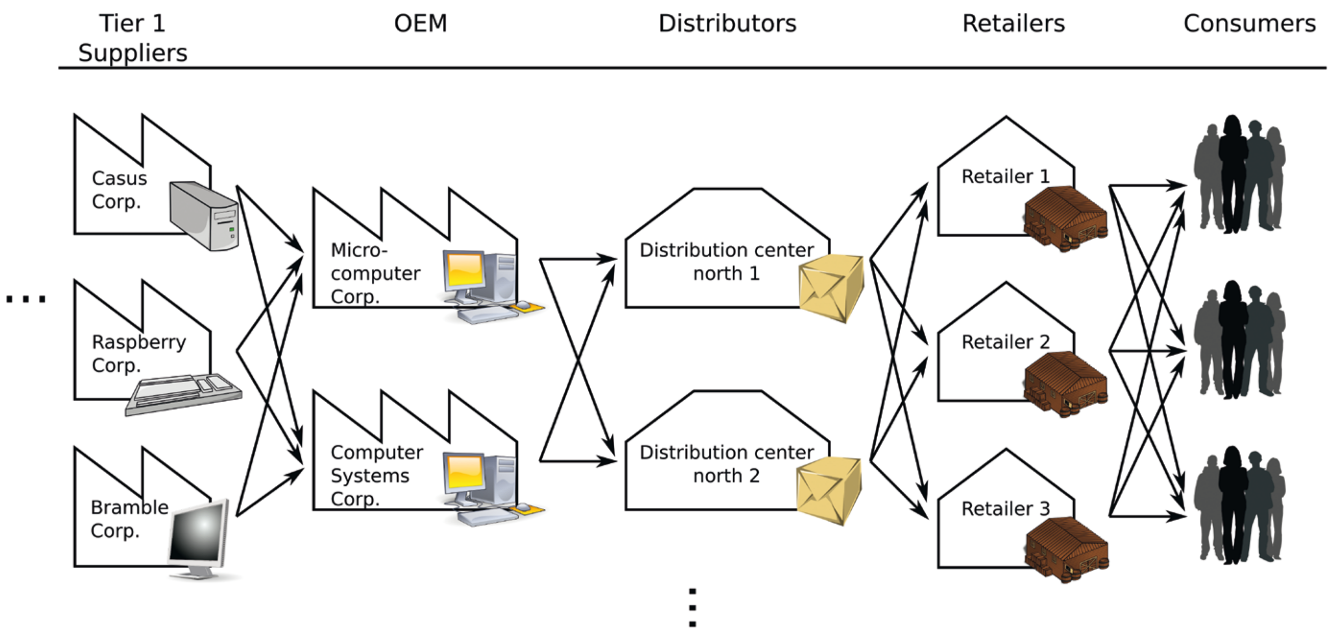
Self-organizing Supply Networks

In order to efficiently solve repeatedly occurring coordination problems in decentralized systems, organizational structures have to be established [6]. Yet, it is unclear which kind of structure is applied best, given a particular coordination problem. Consider, for instance, a supply network as partly shown in Figure 1: In this network, the participants must choose which subset of the depicted possible relationships between each two tiers (pictured as arrows in the direction of material flows) actually to establish. This decision has to take into account cost considerations as well as the responsiveness and reliability of possible business partners in order to enable efficient operations within the network.

Thus, a supply network can be considered a graph consisting of logistics entities as its nodes and their possible business relationships as edges. Establishing an organizational structure refers to the choice of a subgraph restricting the set of edges to a subset of all possible ones. An efficient organizational structure then minimizes the actually instantiated relationships while maximizing the achieved operations outcome according to logistics performance measures.

However, due to the dynamics of logistics processes, conventional design time evaluation and optimization of these organizational structures is not sufficient in terms of flexibility and robustness. Increasing demands of the final consumers, for example, require structural modifications in the distribution part of the supply network in order to fulfill those demands: Additional warehousing capacity has to be allocated and even completely new channels of product distribution must be established. Thus, the structures in that part the supply network need to be refined, i.e., further or other options of business relationships must be instantiated.

Figure 1: Part of an example supply network in the computer manufacturing domain showing all possible relationships between the participants.



This is but an example for the dynamics in logistics that is further aggravated by the *openness* of those systems [1, 15]: Not only consumer demand changes as well as unforeseen failures of scheduled operations may happen (leading to the need of dynamic replanning and reallocation of resources), but the logistics market itself may alter. New competitors as well as new customers may enter, causing further changes in demand, prices, and requirements of products and services. These developments evoke the need for each participant to constantly adapt his relationships to customers and suppliers in order to secure market shares and to fulfill his customers' needs. Such an adaption, furthermore, affects other business relationships within the network, requiring an extended refinement of supply partnerships therein.

Thus, modeling and operating supply networks with multiagent systems requires the agents' ability to establish organizational structures that allow efficient operation, while being flexible enough (i.e., alterable) to cope with the dynamics of logistics processes. Hence, the need arises for self-organizing MAS that autonomously adapt to those dynamic changes. In this context, self-organization is therefore considered as the emergent evolvement and modification of organizational structures defining business relationships between supply network partners.

Agent Coordination

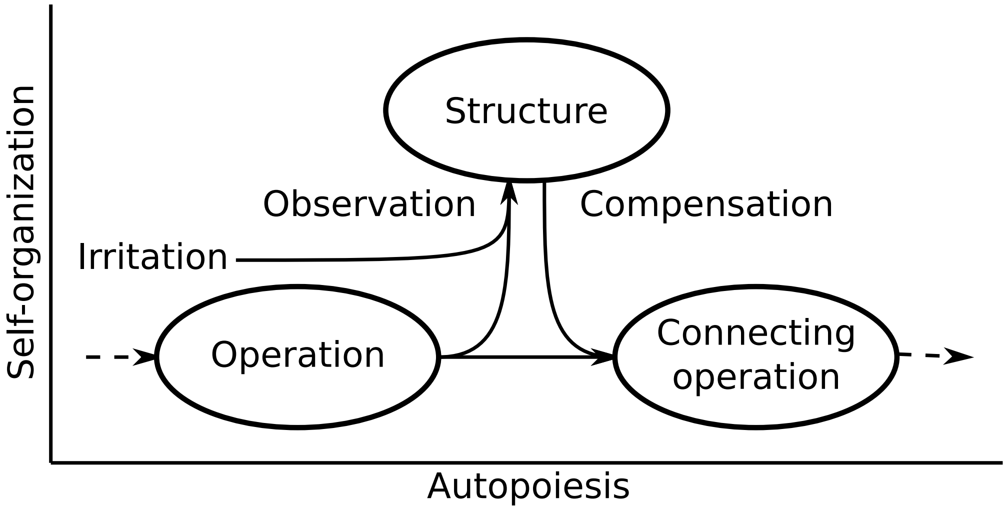
In order to be able to autonomously establish and operate logistics networks consisting of artificial agents, these agents need to interact with each other. For this purpose, agent communication languages that are based on speech acts between agents are commonly used [2, 3]. On the basis of these speech acts, a range of interaction and negotiation protocols have been developed that may be used to coordinate agent behavior. Interaction patterns then reflect relationships between the participants and, thus, express the structure of the multiagent system. In the opposite sense, structuring a supply network modeled as a MAS means to define channels and modes of agent communication.

Consequently, a wide variety of different structuring paradigms for MAS has been proposed (cf. [5] for a comprehensive overview). These structures range from strict hierarchies to market-based methods. While the former use centralized decision-making at the top and distributed processing of concrete tasks at the bottom, the latter are completely decentralized and rely on negotiations for each single task rather than on any middle- or long-term structures. In order to make use of such predefined mechanisms, the expected dynamics of the application domain must be estimated, as they differ in their ability to adapt to changing conditions as well as in their required effort for coordinating the actions of a network's members [16].

However, choosing a prototypical organizational approach for a whole network may not be sufficient. In fact, heterogenous relationships may be required between business partners in different parts of the supply network. Moreover, predetermining agent interaction patterns will neccessarily lead to a compromise between efficient operation and adaptive behavior: While, for example, negotiation-based interaction paradigms are highly adaptive when it comes to changing behavior of participating agents (as they allow to determine the best result given any conditions), they lead to a large overhead of communication and computation effort as every interaction task involves all possible participants among the agents.

In order to overcome that problem, methods have been proposed for subdividing MAS into teams of agents with similar properties and objectives. The model for cooperation [19] provides a formal description of such team building among any number of autonomous agents for distributed problem solving. It includes determination of potentials for cooperative acts, formation of

Figure 2: Conceptual view on autopoiesis and self-organization as correlated perspectives on a system's behavior forming a feedback loop of connecting operations and structural emergence.



teams, distributed planning and the actual processing of plans. In the logistics domain, team formation methods have shown benefits in terms of increased resource utilization efficiency while reducing the communication effort of agents performing similar tasks [17].

Yet, clustering agents in teams usually focuses on short-term behavior and tasks, rather than on middle- and long-term structures in agent interaction. Furthermore, team formation processes rely on the exchange of information about agent properties and goals. Hence, they assume any participating agents to behave benevolently, i.e., to be trustworthy. In an open system, however, agents may be confronted with deceitful behaving participants [1, 13] or others simply not willing to share such information.

Thus, potential interaction partners in open MAS cannot be assumed a priori to exhibit particular behavioral characteristics. In fact, they appear as *black boxes* and, therefore, must be observed by the other agents or the system designer in order to determine their characteristics during runtime of the system. Based on such observations, a structuring approach for MAS has been proposed, using explicit modeling of expectations concerning communication flows [1, 13, 14]. This approach which is inspired by the sociological theory of communication systems [9, 11] establishes a notion of communicative agent behavior that is reflected by the modeled expectations.

Feeding those expectations back into the decision-making process of interacting agents offers a promising foundation for self-structuring MAS, as they not only reflect others' trustworthiness, but also give information about changes in the system's environment. Changing customer demands, for instance, lead to a change of incoming orders on the supplier's side. Observing these changes, the supplier can modify his expectations and then adapt his own behavior based on these refined expectations. Hence, the system as a whole is enabled to react on environmental dynamics by the agents adapting their communication patterns in terms of business relationships; i.e., the system organizes itself.

To summarize, agent coordination refers to communication processes between these agents. Prototypical coordination mechanisms lead to a compromise between operational efficiency and flexibility with regard to dynamic environments while dynamic team formation requires additional behavioral assumptions to overcome these problems. The systems-theoretical perspective of expectations structuring agent interaction (rather than assumptions and commitments), however, provides a promising foundation for self-organization as a paradigm for multiagent coordination.

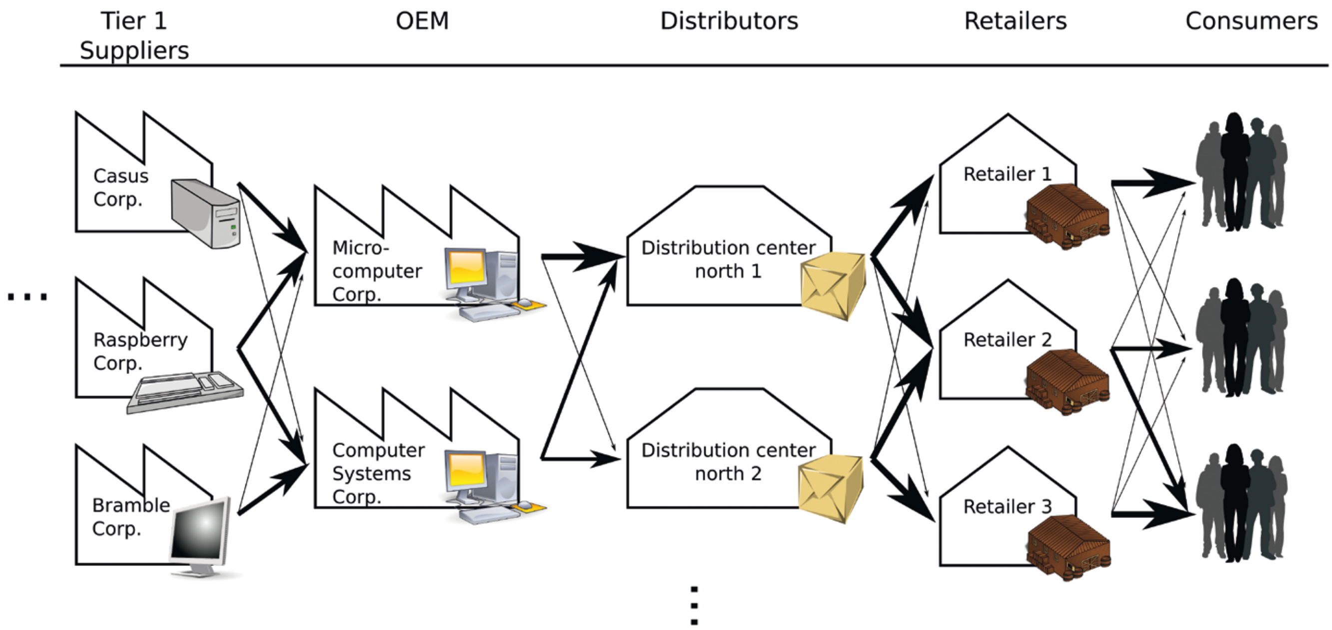
Nevertheless, in the mentioned approach, expectations reflecting and guiding agent behavior are modeled by the system designer as an external observer. Yet, self-organization requires organizational structures to emerge from the system's operations without external intervention; i.e., the mentioned feedback loop has to be closed within the multiagent system. Thus, in the next section, the notion of *autopoiesis* is introduced, complementing and enabling self-organization in a systemically motivated approach to system structure and operation.

Autopoiesis in Autonomous Logistics

Relying on the aforementioned considerations, this section introduces a notion of self-organization for autonomous agents in MAS that is inspired by (social) systems theory. According to that theory, there is no direct causal relationship between a system's environment and its operations. In fact, only the system-internal operations provide conditions for connecting further operations, while the environment can merely irritate this process. The system, in turn, processes these irritations internally. As Maturana and Varela put it, such an *autopoietic system* is "a system of production of its own components, and [it] does this in an endless turnover of components under conditions of continuous perturbations and compensation of perturbations" [12, p. 79].

Modeling logistics networks as agent communication systems, the operations forming them are business processes of order and delivery of products occurring along the network's edges. In order to preserve a system's existence, further order/delivery operations need to be connected to those already processed. In case of environmental perturbations like the aforementioned changing consumer demands, the supply network as a system can only observe these irritations in terms of changing orders and deliveries. Moreover, consisting of these very operations, it can also react only by adapting them according to the observed changes. However, the system's reaction is not causally determined by its environment. For instance, a consumer increasing his demand cannot force the supply network to react in a particular way. In fact, the decision

Figure 3: A possible structure for the example network: The arrows' width reflects the likelyhood of each relationship to be activated while resulting from the experienced outcome of past operations.



of how to adapt its own operations (whose order to fulfill, which storage to use, from whom to order additional raw material for an increase of production rates) is made within the supply network exclusively.

The choice of which operations to instantiate from the set of possible order/delivery options, however, is guided by the organizational structures of such a network, i.e., by the subset of business partners that are taken into consideration as their receivers. As self-organization refers to autonomously evolving network structures, the concepts of autopoiesis and self-organization are closely correlated. While the former focuses on a system's operations and the process of connecting them to previous ones, the latter denotes the emergence of structures that guide this very process. Therefore, the operations "offer the conditions for connecting operations on the one hand [...] and provide the structures necessary for that connection on the other" [10, p. 12; own translation]. By its operations, the system produces and reproduces those structures which, in turn, enable it to choose and process further operations (cf. Figure 2).

Regarding the logistics domain, this means that among the set of all possible operations those are most likely to become connected to former ones that follow well established business relationships. Hence, the choice of order/delivery operations is restricted by the set of actually instantiated agent interaction possibilities. On the other hand, those structures (business relationships, interaction patterns) consolidate, that are supported by most successful operations, i.e., that have proven to provide efficient and reliable operations outcome. Unsuccessful ones, in turn, become less likely to be activated. A possible snapshot of such a network structure is shown in Figure 3. Thus, the correlative autopoiesis—self-organization denotes a control loop that guides a system's behavior regarding environmental dynamics: The system reacts to irritations from its environment in terms of operations effects by observing and adjusting its own behavior in the choice of connecting operations.

Resorting to the aforementioned agent expecations, the structures guiding operations of order and delivery are represented by such expectations regarding the agents' behavior. In case of an order, the choice of an operation implies the selection of order receivers from the set of possible suppliers. The reply to that order, on the other hand, requires a choice of whether to fulfill the order or not. In both cases, the selection of an operation is guided by expectations about the system's reaction to it, e.g., whether an order will be fulfilled or not and whether its fulfillment may induce further orders due to satisfied customers. Both the customer and the supplier cannot gain firm knowledge about these reactions.

Therefore, in autonomous logistics based on autopoiesis, they must establish expectations from their observations of former order/delivery processes. These expectations implicitly represent the relationships between network participants as they emerge from the system's operations and guide the choice of further ones. Thus, the feedback loop is closed as expectations emerge from the interactions among autonomous agents representing logistics entities while these interactions are patterned by those very expectations.

This notion of self-organization contrasts the conventional perspective of a structural design obtained from a source external to the system that determines its operational performance. In fact, autopoiesis in logistics refers to logistics networks that create their structures through their operations and operate according to these structures. Nevertheless, being represented by behavioral expectations, the structures are not fixed, but will be changed in case of repeated disappointments of those expectations. Disappointments occur through observations of unsuccessful processes that are fed back into the decision process. Thus, they lead to a refinement of expectations, making the choice of the same operations less likely and giving rise to the exploration of alternative ones. This enables logistics networks to adapt to environmental changes as both structures and operations alter according to perceived irritations.

Conclusions

In this paper, the need for adaptive yet efficient supply networks has been identified. As multiagent systems provide a means for decentralized modeling of logistics networks, possible coordination techniques have been investigated in terms of their applicability to address the identified challenges in supply network organization. Finally, based on those considerations, *autopoiesis* for autonomous logistics has been introduced as a systemically motivated approach to self-organizing supply networks.

The notion of autopoiesis—self-organization as a correlative of perspectives on a system's behavior regarding its operations and structure provides a framework for self-organizing agent interactions. Using behavioral expectations for guiding their own operations, agents obtain interaction patterns that, in turn, are fed back into further evolving expectations. Thus, the depicted approach to self-organization consists of a control loop of structural emergence and operational execution in multiagent systems, enabling logistics agents to autonomously coordinate supply network performance.

This survey, introducing autopoiesis in logistics as a modeling concept, therefore outlines the foundations of self-organizing supply networks. However, further work needs to be done in order to operationalize the approach and to empirically show its capability of autonomous agent coordination and its applicability to the logistics domain

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Self-organizing Supply Networks: Emergent Agent Coordination in Autonomous Logistics

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Electronic Seals Contribution to the Efficiency of the Global Container System

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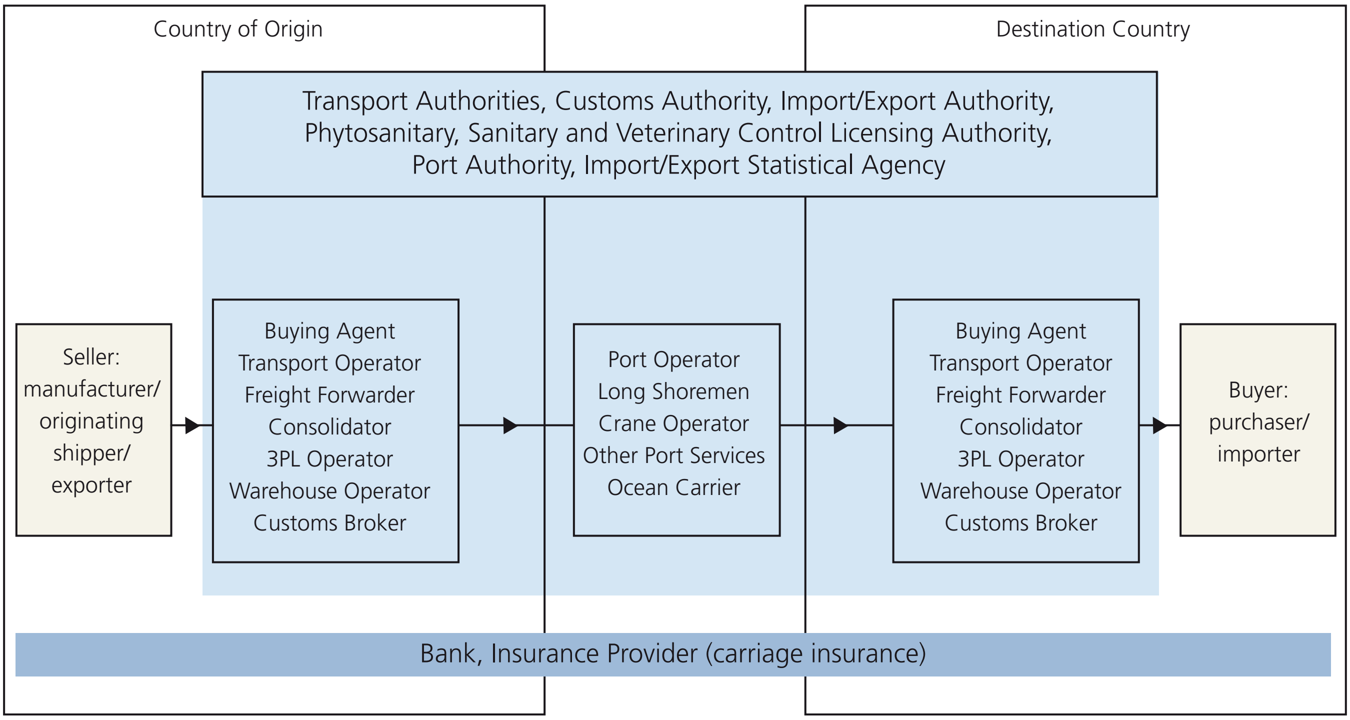
The dynamics inside the global container system and increased post 9/11 security requirements from the government's side force all companies involved in container transportation processes to provide more efficient and cost-effective services. How to balance security and business efficiency in container logistics systems? Smart technologies like RFID e-seals on containers have the potential to add the required level of security to global shipping lines as well as generate a new business value. In this paper we give an overview of new advantages of e-seals implementation in the global container system for service logistics providers, ports and container terminals, container shippers.

Introduction >>> With about 90 percent of the volume of world trade moving by ocean transportation [1], maritime supply chains play an important role in the world economy. And as maritime containers are very popular transport units in the system of global trade more and more international organizations and different private companies are concerned about the safety and security of container flows. After 9/11 US Customs and Boarder Protection (CBP) created the Container Security Initiative (CSI) and Customs Trade Partnership Against Terrorism (C-TPAT) which poses to protect the global container trading system and the trade lanes between CSI ports and the U.S. Under C-TPAT, members sign an agreement to cooperate with Customs and Border Protection (CBP) to protect the supply chain, identify security gaps, and implement specific security measures and best practices. Certainly, the prior aim of the government's acts is the national and international security for trans-national container flows. Hence the attention of each partner in container supply chain is focused now on the problem of finding a solution how to balance the security of container transportation without overloading the international transport systems with additional operational costs [2]. Such trade-off can be found in transformation of a dumb box into a smart one by equipping a container with an e-seal or installing an electronic container security device (smart seal). A smart box will communicate evidence of tampering and register every legitimate or unauthorized opening of the container.

According to the current definition an e-seal is a "Read-only, non-reusable freight container seal conforming to the high security seal defined in ISO/PAS 17712 [3] and conforming to ISO 18185 [4] or revision thereof that electronically evidences tampering or intrusion through the container door". Since October 15, 2008 all maritime containers in transit to the United States are required to be sealed with a seal meeting the ISO 17712 standard. Generally, ISO/PAS 17712 requires that container freight seals meet or exceed certain standards for strength and durability so as to prevent accidental breakage, early deterioration (due to weather conditions, chemical action, etc.) or undetectable tampering under normal usage. ISO/PAS 17712 also requires that each seal be clearly and legibly marked with a unique identification number [5]. E-seals tend to combine physical seals components with RFID technology. This simplest type of electronic seals contains only a seal ID number. The more advanced reusable or permanent active RFID e-seal also includes a seal ID number, a container ID number and can initiate alarm calls and record time/date of container tampering. The smart e-seal or "Container Security Devise" contains additional sensors to indicate environmental status of container content, alarm function to inform in real-time by means of satellite communication systems via GPS/INMARSAT [6].

The functions of e-seals have direct security benefits for container shipments. Nevertheless there are a number of alternative concomitant advantages from investing and using such multifunctional devices (smart seals) for cargo importers, container carriers, service providers and for container port operators. In this paper we expand the list of substantial benefits by proposing to look at e-seal's devices from different perspectives to discover their potential for improving logistics operations through the supply chain as well as at container maritime terminals as huge nodes of cargo transhipment. In the next section we list the number of the most prominent advantages of adding a small "brain" to conventional maritime containers. **<<<**

Figure 1: Actors in Container Logistics Networks, Adapted from [8]



Some Aspects of E-seals Influence on Container Logistics

In the last years the benefits of RFID technology in supply chains have been made clear. However, there is still a lack of research about advantages from application of electronic seals on containers in logistics networks. The general benefit of RFID e-seals in container supply chains seem to be only for securing purposes of customs authorities. However, the container transportation process is characterized by complex interactions of numerous operating companies and organizations. While a container moves from point of origin to destination point, as many as 20 different companies have to coordinate the operations of more than 25 documents with approximately 200 data elements for only one international shipment in the global container network [7]. The companies might include trucking firms, terminal operators, and the shipping company, the manufacturer of the shipped goods, the purchaser, banks, and others (Fig.1).

Currently, based on different types of container security devices, a sophisticated platform that is capable of providing high-end security tasks and elaborated logistics management applications can be developed [9]. Actually, the biggest container ports in the world, namely Singapore, Kaohsiung in Taiwan, Rotterdam in the Netherlands, Pusan in South Korea and the ports of Los Angeles and Long Beach, have already investigated RFID e-seals in projects to test their abilities for cargo tracking [10]. The projects were focused on various advantages from RFID system implementation in port environments, like greater efficiency by shortening the time for container checking and management through the port by using active RFID e-seals [11], the issues of congestion and security in the ports [12] or improving the security of containers destined for the USA, with more stringent security requirements [13]. Their results show that the smart RFID e-seal with its multifunctional ability can be effective for logistics purposes and applications in container supply chains/container ports.

Below we describe the main areas of logistics applications of smart e-seals in maritime ports and terminals:

Competitive Advantages to Connect Ocean Terminals into a Global Info-Network

Key factors for a container terminal are the efficiency of the stacking and transportation of this large number of containers to and from the ship's side. Shipping companies ask for reliability regarding adherence to delivery dates and promised handling times [14]. Thus, container ports are forced to provide efficient and cost-effective services. They have to invest heavily to meet the stringent demands for faster service and higher quality. The competition between container terminals has increased due to large growth rates on major seaborne container routes. Terminals are faced with more and more containers to be handled in short time at low cost. Therefore, they are forced to enlarge handling capacities and strive to achieve gains in productivity. At the present time, one more additional factor impacts the efficiency of the maritime ports – the security issue. To secure the cargo containers more innovatively companies use the smart e- seals, instead of simple mechanical seals. How does it influence the port operator? Port and terminal operators, in order to keep their positions on the market, need to adapt to the new security requirements for container systems. Investments in RFID reading infrastructure will bring the ports the benefits by providing a new kind of service for their own innovative customers, that is using e-seals, and open the port gates for new companies looking for the partners that can provide higher levels of security and visibility for their cargo flows. The adaptation of innovative technologies like e-seals is a state in which no player can benefit by being the only one to change his strategy. No player can improve his position by opting out the impact of RFID seals in container systems. Vice versa, no player can improve his position by adopting smart seals alone. The only way to move from the one equilibrium to another is to organize an agreement or consortium between the players [15] to get some of them to adopt the new technology solution (e-seals) for secure logistics processes.

Automation of Containers Passes to the Territory of Port Terminals

E-seals can contain data about goods in a container, ID number of container, shipper's contact information, point of cargo destination etc. By passing port gates, RFID seal transmits container information to the local port network through the reading device fixed on the gate. In this case truck drivers do not have to complete any written formalities to get access to the terminal. This procedure takes much less time, has a higher degree of accuracy, and eliminates technical mistakes (human factor).

Security and Safety of Containers

The security aspect is the strongest side of e-seals. Container terminals are usually not open territories. Nevertheless, the security of the most ports territory is provided by the simplest methods of accident prevention. Containers may stay for a long time without any supervision at a terminal which increase vulnerability of the container in general. E-seals can prevent un-authorized access or theft of the container contents and inform about such accident via an alarm function. Furthermore, container doors with any type of seal could be removed or containers could be cut and opened from the top, bottom and sides. It makes a huge loss for owners of high value cargo and for insurance companies as well. To avoid container intrusion, pilferage, and thefts of containers or goods, it is necessary to combine electronic seal with different sensors (temperature, light, etc.).

Control of Access to the Containers Contents

E-seals possess a useful function to record the time of authorized access to the container contents or unauthorized access at the moment of e-seal breaking. Furthermore, the broken e-seal cannot be fabricated or changed by another one without any damage of the electronic part of the seal. Hence, uniqueness of the e-seal ID number and alarm function of this device provides reliable security of goods and the real time control of access to the container contents.

Identification of Containers and Their Locations

Each ISO container has a unique ID number. Nonetheless, several identification numbers on the same container are the real case for many intermodal containers. In these cases terminal operators should identify which of the ID numbers is correct. Such type of information can be coded to the e-seal memory. Each time a container changes the hands or documents regarding the container are transferred, the potential for miscommunication and human mistakes exists. For instance, a trucker might bring a container to a port but does not inform the shipping company that he has arrived. It causes a container not to be loaded onto a ship. These kinds of inconveniences may cost money to the company waiting for the shipments. Electronic information, transmitted to the local network of the terminal via e-seal can provide companies with authorized access with required data in real time about individual container location.

Monitoring of Containers Movements

The e-seal together with RTLS (Real Time Locating System) allows not only to control the container location, but also to monitor every movement of the container on the port territory. RTLS is indispensable to container operators because container yards and van pools are so extremely large and store so many containers that without the support of locating systems workers cannot find a particular container in the required time limit. This informative function of e-seals can be useful to the forwarding or agent companies to inform them whether the container is loaded or unloaded from the ship.

Improving the Congested Situation in the Ports

The combination of dramatic increases in freight traffic and transportation systems operating at or near capacity has only recently resulted in growing visibility of freight and its role in urban congestion and environmental problems as a symptom of greater supply chain congestion [16]. The waiting time and variability of waiting time at ports can be significant. Delays might happen when containers are waiting to enter the ports as well as during container processing through terminal gates. Almost 44% of operators serving ports reported that their operations were often affected by congestion at the ports [17]. By creating the GreenLane – handling expedition of C-TPAT-compliant cargo at border crossing and port – RFID e-seals can play an important role in paperless information exchange. Time savings in container processing through the container terminal will influence the improvement of situations with truck congestions at the port gates; that also will have a "green" impact on the reduction of port-related truck emissions because of an acceleration of truck-turn-over time at the terminals.

Another series of potential benefits belongs to the logistics applications of e-seals for all businesses (Importers, Carriers, Manufacturers, and Service Providers). Regarding C-TPAT Survey 2007 [18] more than three-quarters (76.5%) of survey participants reported that it is extremely important to "reduce the time and cost of getting cargo released by U.S. Customs and Border Protection (CBP)". Next on the list of the most important motivations for joining security programs are "to reduce the time in CBP secondary cargo inspection lines" and to "improve the predictability in moving goods and services across borders".

Benefits of Security Enhancement for the Private Sector – GreenLane

Membership for U.S. firms operating in the supply chain is becoming the standard rather than the exception [19], especially among service providers who have found it to be a relatively low cost and effective marketing tool. C-TPAT membership has certain benefits: several times less likely to be targeted for physical inspections, resulting in considerable savings in time and money as CBP increases the number of exams overall; priority for cargo inspection ; reduction of handling costs by removing all containers not selected for inspection to their location before CBP has completed its inspection of the entire shipment [19]. At present, the customs service physically inspects only 2 percent to 4 percent of containers arriving at U.S. seaports [20]. The smart-seal program can boost the number of properly inspected containers. Simultaneously, by using smart e-seals or smart boxes the shippers will get the most attractive benefit – the GreenLane advantage – to accelerate their cargo clearance and expedite processing through the port. More than half of C-TPAT Survey participants in 2007 indicated that benefits from enhanced security outweighed the costs (32.6%) or that the benefits and the costs were about the same (24.2) [18].

Smooth Border Crossing and Port Gate Processing

The enhanced security system can also affect the container flows going through the port gates or borders of the countries in another way: a U.S. Department of Transportation program "TransCore" shows that electronic seals were able to help secure containers and reduce border congestion [21]. At the Port of Seattle a reader at the port's gate indicates that the truck has entered/left the port. The truck is tracked at six weigh stations and processing centres along a 300-mile stretch of Interstate 5. When the truck arrives at the Blaine border crossing, the e-seal is read with a handheld reader or a roadside reader. Information on the carrier, vehicle, cargo, location, and time of detection, drivers, and security status is uploaded to a secure Web site. The shipper and carrier, as well as U.S. Customs Service agents and the U.S. Department of Agriculture agents can view the information on a secure Web site. The system requirements to be the most effective is the existence of special lanes for trucks with sealed containers; otherwise, it does not help to reduce congestion at the port terminals or smooth the border crossing [21].

Improve Process Flows

The improvement of process flows in container networks means that the flow of materials and the flow of information are synchronized when the information system continually displays the current status and stream of goods. The information system is thereby not just more accurate but is also up to date. E-Seals that are unaffected by weather which can improve the process flow for containers at the gates (improvement of the operations at port gates by e.g. remote readability of a container number) as well as refine on the matching of the container to the manifest; or avoid typical errors made during issuing and receiving of goods, such as incorrectly logged quantities.

Protect the Brand Name and the Reputation

Looking for rewards from security programs, the huge companies like Procter & Gamble, Boeing, Starbucks, and Kmart with high-value products emphasize that they need to secure the cargo in order to "protect the brand" [7]. Electronic seals with their track-and-trace ability not only ensure the container supply chain, but also gain supply chain efficiency from automatically tracking containers. Damage to intangible assets and the contingent losses which could arise in cases where e-seals are not used are even greater, e.g. damage to reputation (contaminated goods or non-delivery of goods). In some cases the pilferage from the container or theft may lead to the loss of sensitive information or intellectual properties, therefore the container flows have to be under protection of secure environment attached to the particular container in the form of a smart device.

Anti-tamper System for Container Flows

One of the main applications of RFID technologies in the context of shipping containers is their use as e-seals. It is usually active tags that provide efficient, instant notification of container security breaches. An identification number of e-seal is protected by electronic encryption and authentication. Electronic seals have to work in harsh environments under often severe conditions. Active tags contain batteries, have more processing and operating power, and hence appear to be the most promising ones in container logistics. Such devices provide 100% check to ensure the e-seals are not tampered with/replaced and could detect when/where container tampering occurred (this information can be useful for insurers, the police as well as for bankers). Smart seals integrate in itself useful information other than the seal number e.g. container number, destination, and consignee. The shippers get automated monitoring and tracking of containers as well as higher processing level for their shipments through the customs by eliminating human errors in reading or visual inspection or recording of seals on the containers and more effective customs work.

Minimization of Container Loss, Tampering/Theft or Cargo Pilferage

The risk of theft, especially if the goods have a black market value, is very real. Worldwide, the direct cost of cargo theft is estimated at about US$50 billion per year, with an indirect costs many times higher, and US$15 billion of merchandise losses in the United States alone. Cargo theft occurs in freight-forwarding yards, warehouses and during transportation in trucks, and on ships. Cargo is particularly vulnerable in the period of being loaded or unloaded from the trucks, or through documentary fraud [22]. To ensure the process of container operations at its different stages the cargo owner, their service providers, or the carrier and port operators should provide the reliable protection of each container during its transportation. The e-seal is the right key to solve this problem. It combines mechanical mechanism to lock the container with specific electronic components. Therefore, it can provide tamper evidence, physical security and data management as well as indicate electronically whether a conveyance has been opened or tampered with.

Loss of Insurance Claims

Theft and pilferage of the goods from containers lead to insurance claims. If a container seal is checked at multiple points as the container moves through the supply chain, it will help a carrier, a shipper, and an insurer to determine the weak link in the chain. But if a container seal is not checked at different stages as the container moves through the supply chain, they will not be able to pin down the location where the pilferage occurred, and law-enforcement agencies will not be able to deploy their resources effectively [23]. Identifying the location of the breakdown by using of smart e-seals will help determine which party is responsible for the loss and thus to settle insurance claims with them.

Thereby, the range of presented e-seal's advantages for container logistics describe the most attractive and useful functions for large container logistics providers such as port operators, shipping companies, forwarders etc. Nevertheless, there are still some challenges in worldwide adoption of e-seals systems. The first discussion point is what kind of technology should be used as a worldwide standard of e-seals. This discussion has a substantial importance for the next issues: what kind of infrastructure needs to be installed and what kind of functionality one could obtain from the device [24]. The infrastructure for e-seals does not presently exist, and needs to be installed on thousands of different properties. Another issue for the global implementation of e-seals are the international ISO standards for the device. It is still an open question what the product needs to do; what specific events must be captured and recorded; is capturing entry through the doors enough or does it have to detect entry into the container through the walls, ceiling or floor; does the device have to detect conditions other than entry intrusion? Thus, the governments and industry have to archive equilibrium from security requirements and all businesses benefits, before setting all these specifications for e-seals or container security devices.

Conclusion

This research is based on the literature and praxis review to disclose some business-related advantages of electronic security devices (e-seals) for the global container system. The main idea of this approach is to define the contribution of security devices for locking shipping containers to the efficiency and profitability of the global logistic system. The implementation of container security devices in logistic processes provides a wide range of advantages for commercial users of e-seals in supply chains, service providers, cargo carriers, and port operators. In spite of the various challenges that face this implementation in the worldwide container network, there is a sufficient set of competitive advantages of e-seals for the improvement of operating efficiency in the global container system such as control, identification and monitoring of containers; automation and improvement of container processes; providing anti-tamper containers protection with minimization of container losses and thefts; and there is also the indirect impact of e-seals on the competition factor for service providers, protection of brand names and the reputation of companies as well as improvement of congestion and ecological situations in container terminals. Therefore, smart electronic seals do facilitate the achievement of both supply chain security and commercial profit in the global container network.

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Electronic Seals and Their Influence on the Dynamics of Container Logistics

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Adapting the SCOR Model to Suit the Manufacturing Industry in Developing Countries

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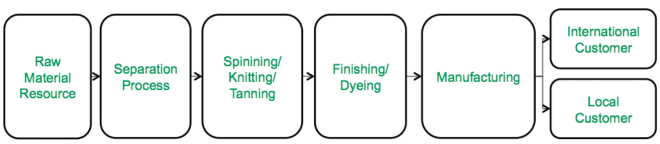
This research focuses on the SCOR model adaptation for the manufacturing industry in developing countries. With a necessary understanding of the characteristics, difficulties and problems of the manufacturing industry in developing countries' supply chain, likewise it designs an adapted model with business process model, key performance indicators (KPI) and best practices. By using a case study about the Ethiopian textile and leather industry, this research will also illustrate the benefits and insights gained with an adapted model.

Introduction >>> The manufacturing industry in developing countries (MIDC) has been part of the global supply chains (SCs) for a long time. Firstly, manufacturing industries have contributed as sources of natural and semi-processed raw materials, for example minerals and semi-processed leather products, such as skin and hides. Secondly, the MIDC has been involved as final products manufacturer to the global market. We can observe this participation in the global supply chain from the typical textile and clothing supply chain shown in Figure 1.

Figure 1: Typical Textile & Leather Industry Supply Chain



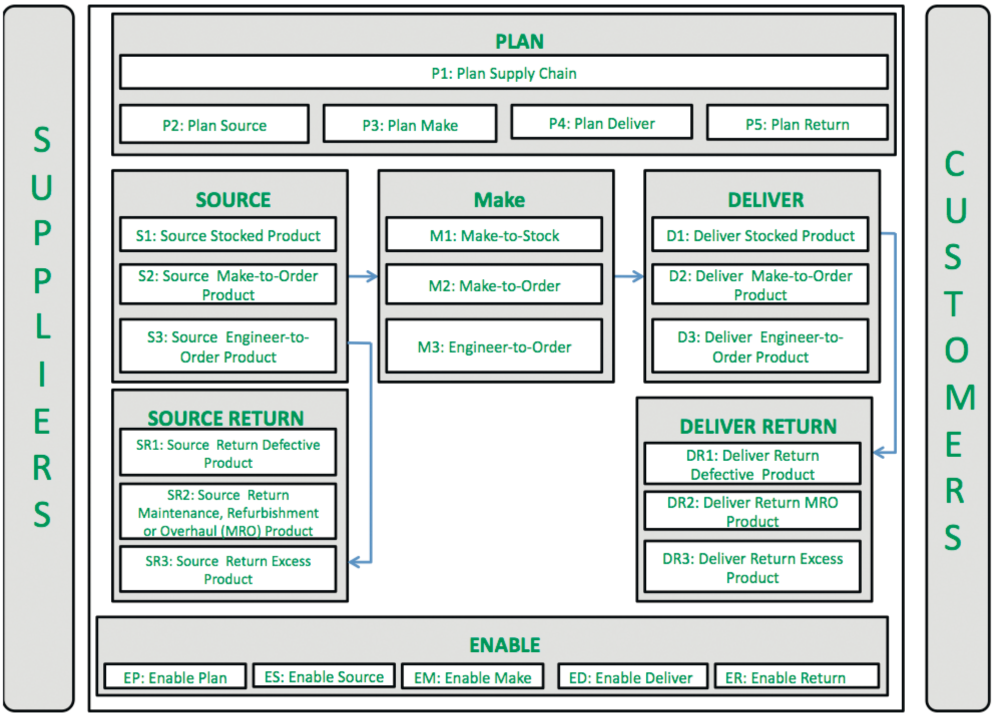
However, it is facing challenges in highly competitive markets because all manufacturers are trying to improve their product quality, reduce costs and product delivery lead time. Even though the MIDC plays an important role as supplier and as producer, MIDC has not got enough attention and has not been studied well so far. Indeed, it seems to be isolated from global research. <<<

Performance Measurement System

Up to now, the MIDC has been practicing a backward and isolated performance evaluation of intra-organizations assessments. Traditionally, the focus of performance measurement has been on process operations within the organizational boundaries. It has been investigated recently that the installation of a performance measurement system facilitates the coordination and improvement activities of a supply chain [1] – [4]. A significant competitive advantage cannot be obtained by improving the efficiency of products and business processes alone; the MIDC needs to improve the efficiency of products, business processes, as well as its supply chains [5] & [6]. Lee and Bilington (1992) suggested that SC performance measurement systems (PMSs) are necessary for firms to successfully improve their supply chains [7]. According to Neely et al. (2002), "A Performance Measurement System is the set of metrics used to quantify the efficiency and effectiveness of past actions" and "it enables informed decisions to be made and actions to be taken because it quantifies the efficiency and effectiveness of past actions through the acquisition, gathering, sorting, analysis and interpretation of appropriate data" [8]. PMSs are considered a tool to gain competitive advantages and continuously react and adapt to external changes [9].

Motives for adapting any performance measurement system are less difficult to justify, particularly in the light of the immense benefits for the improvement of MIDC. A performance measurement system is critical to the success of the supply chain [10]. What is particularly challenging is the successful design, selection and implementation of such a PMS with its business processes, key performance indicators (KPIs) and best practices for supply chain performance improvement. From a range of PMS, the SCOR model is viewed as a powerful tool to evaluate the performance of supply chains. The SCOR model is the first one available, designated to measure supply chain performance and logistics impact [11] across the boundaries of individual organizations. It is in the growing stage of its life cycle and is enjoying the leverage of becoming the industry standard [12]. This process reference model was also integrated within the well-known concepts of business process reengineering, benchmarking and best practice. Thus it is a model that links business processes, KPIs, and best practice. It was developed to be configurable and aggregates a series of hierarchical process components that can be used as a common language for enterprises to describe the supply chains and to communicate with each other [11], [13] & [14]. The SCOR model is structured around five management processes, namely: PLAN, SOURCE, MAKE, DELIVER and RETURN. These management process building blocks can be used to describe very simple or very complex supply chains with one common set of definitions. The SCOR model is revised and adapted by Supply Chain Council members when it is deemed necessary and the SCOR v9.0 model is the eleventh revision of the original SCOR model. An overview of the SCOR v9.0 model is depicted in Figure 2.

Figure 2: Original SCOR V9.0 Model, adapted from [15]



Problem Definition

Managing a supply chain within a single country is complicated due to various types of uncertainties in demand, supply and process. In most developed economies there are limited uncertainties about the availability of basic necessities for the manufacturing industry, such as power, ICT, roads, skilled manpower etc. However, in developing countries infrastructure is weaker and that poses several new types of challenges that developed countries do not have to face. These problems may even cause successful well tested strategies and models that work in developed economies to fail.

A classical example is that of Wal-Mart [16] which has an efficient network of cross docking facilities in the US that store minimal inventory in them while simultaneously enabling more frequent suppliers to the retailer stores. When Wal-Mart went into operation into South America (Brazil) and Korea, it was very difficult to run a logistics system based on such docking facilities and it had to adapt its approach. The biggest challenge that Wal-Mart faced in Brazil was shipping products on time and delivering them to the shelf. Timely delivery of merchandise is an ideal concept in the bumper-to-bumper traffic in Brazil (Sao Paulo) and in Korea (Seoul), where Wal-Mart depends on suppliers or contract truckers to deliver most of its goods directly to stores. As a result, Wal-Mart lost between $20 and $30 million in 1997 on top of an estimated $48 million loss since starting up in South America in 1995. Therefore, operating supply chains in developing nations often requires firms to tailor their existing supply chain strategies and models, or develop newer ones suitable for that particular environment [16] & [17].

Companies in developed countries have implemented the SCOR model successfully with its building blocks: business processes, key performance indicators, best practices and relevant technologies. However, the SCOR model is not a magic tool; it is difficult, resources- and time-consuming to implement the SCOR model within existing manufacturing industries. Manufacturing industries in economically developed countries such as the USA and the EU are well designed and supported by an outstanding infrastructure, which, in turn, enables a smooth flow of information and physical goods among supplier, manufacturer and customers.

In recent years, the lack of process models, KPIs and best practices have been recognized as one of the major problems in process evaluation and improvements of a supply chain in the MIDC [1] – [4]. A direct application of the SCOR model to developing countries is not advisable and may not be wholly satisfactory due to variations in environmental factors and conditions. Shewchuk (1998) says that "one size does not fit all", meaning there is a need to find the most fitting SCM approach & model, depending on the business process and the environmental factors and conditions in which a firm is operating [18].

The MIDC consists of small and medium-sized enterprises which produce Food, Beverages, Textile and Leather products. From a technical perspective, supply chain operations have been manipulated on a manual or semi-automated basis with the support of basic or legacy applications. Lack of connectivity, limited resources, and skilled labor are still challenges for the direct application of the SCOR model. There are often ICT systems with a shortage of qualified and experienced professional employees. The ICT base advanced manufacturing technologies implementation faces several cultural and organizational challenges. Other considerable obstacles are related to the poor supporting infrastructure of the developing countries. Poor infrastructure leads to unresolved issues that are demonstrated in late delivery and material shortage.

The SCOR model has been developed for the environment of developed countries and may not be suitable for the MIDC. We need to find a solution for adapting to environmental and local factors of developing countries. For the intended task we need to adapt the SCOR model to the environmental factors and conditions of the developing countries' manufacturing industry. These factors have different impact on the model that have not experienced in the environment of developed countries . These environmental and local factors, explained above, with supply chain relationship level, culture, infrastructure, human and ICT capabilities issues should be considered for our adaptation. The MIDC should adapt the SCOR model with its elements: business processes, KPIs and best practices to their local scenarios and conditions for their supply chain performance improvement.

Research Objective and Question

The research objective is to adapt the SCOR model and apply it for evaluating and improving manufacturing industry supply chain operations in developing countries.

In fulfilling this objective, this research addresses the following basic research question: What are the differences between SCs characteristics in developing countries and developed countries with an effect on SC process modeling and evaluation? Addressing this basic question is at the heart of this research. The research will apply its findings to the Ethiopian textile and leather industry supply chain.

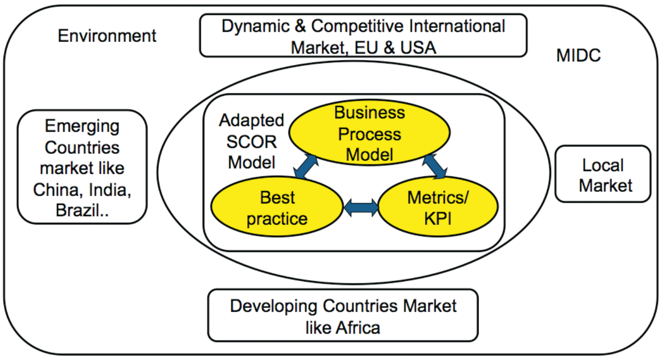
Based on this research objective, a literature review and formal talks with different practitioners, the following research questions have been proposed. They are listed as follows:

- What are current practices and characteristics of the manufacturing industry supply chain in developing countries?
- What type of key performance indicators and best practices are currently available in the developing countries' manufacturing industry supply chain?
- What type of performance indicators or metrics and best practices are applicable in the DCMI supply chain in the future according to different market maturity conditions and scenarios (see Figure 3)?

Methodology

A study will be carried out by reviewing the available literature on SCM concepts, PMS, SCOR model which help in encapsulating various research outcomes in a structured manner. An industrial analysis will be carried out to assess how SC is managed, measured, evaluated and improved in the manufacturing industry. Moreover, detailed site investigation studies will be carried out in different organizations.

Figure 3: Performance Measurement System



The industrial analysis and mapping with a thread diagram of the MIDC will be used to evaluate the manufacturing industry supply chain. The industrial analysis results will then be compared to the existing SCOR model process elements. Corresponding process elements will be chosen to regenerate manufacturing industry supply chain process elements which will be based on SCOR model concept. Then, there will be also a corresponding selection of suitable performance metrics and best practices for each process element to adapt the existing metrics or add new ones and similarly best practices to suit with the product characteristics. Finally, the result of adaptation will be the establishment of a business process model, KPI and best practices for MIDC. At the same time, each process element includes suitable performance metrics to evaluate supply chain performance.

Industrial Implications

This research potentially has implications for the manufacturing industry in developing countries which need to assess its supply chain performance in terms of management and operation. From a managerial aspect, this research provided quantitative measurements in the stipulation of performance metrics in each process element. On the other hand, the operational measurement will take into account qualitative measurements. Consequently, the specific research outcome will be a supply chain performance measurement framework, specifically for the manufacturing industry. Companies participating in the framework validation process will receive feedback in return for their input, after assessment.

Conclusion and Outlook

This study begins with an emphasis on the need for an effective and efficient supply chain performance measurement for improving the manufacturing industry supply chain performance in developing countries. The research aims in improving manufacturing industry by optimising current processes/new designs, process monitoring and decision support during operation. It will create further opportunity to modeling, evaluating and improving supply chain of developing countries with adapted SCOR model. Hopefully, this will give a more comprehensive approach to performance measurement within the supply chain management domain in the developing countries scenario.

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A Robust Multiple Logistic Objectives-oriented Manufacturing Control (RMLOO)

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RMLOO is a manufacturing control system for job shop environments aiming at, on one hand, obtaining a robust manufacturing system to react adequately to the disturbances including internal disturbance (e.g. equipment failures, rework) and external disturbance (e.g. variations in customer demand) and, on the other hand, optimizing multiple logistic objectives, short throughput times, low Work in Process (WIP) and high schedule reliability by applying feedback, adaptive and distributed control technologies to release process and order routing process. To verify RMLOO, simulation experiments are conducted using industrial data making it possible to assess RMLOO with respect to the target performance criteria. RMLOO is afterwards compared both with an uncontrolled process and with the manufacturing control systems Constant WIP Control (CONWIP) and Autonomous Control with a Queue Length Estimator (AUTO-QLE). The simulation results indicate that RMLOO can effectively cope with the disturbances, while optimizing the target logistic objectives.

Introduction >>> Conventional manufacturing control systems which are characterized by non-feedback, non-adaptive and centralized control methods show a wide range of weaknesses especially regarding a lesser robustness against the internal and external disturbances. This creates the need for robust manufacturing control systems that are able to manage the disturbances effectively. Moreover, to achieve business success in a globalised market, todays' enterprises are trying to distinguish themselves from their competitors not only by manufacturing at low costs which is demonstrated by the logistic objectives, low WIP level and high output rate, but also increasingly with a superior logistic performance which is demonstrated by the logistic objectives, short throughput times and high schedule reliability [1]. Consequently, there is not just one logistic objective which needs to be optimized, but multiple logistic objectives that have to be considered simultaneously. Although there is no possibility to reach all of the four logistic objectives to the highest level because of the conflict between high output rate and the other three logistic objectives due to the existence of the scheduling dilemma [2] [3], the logistic objectives, low WIP level, short throughput times and high schedule reliability might be simultaneously optimized due to their mutual support relationship. Therefore, to overcome both challenges, this paper proposes a hybrid control system in which the logistic objectives, short throughput times, low WIP level and high schedule reliability can be optimized in an environment full of these disturbances. <<<

RMLOO Concept

It is not easy to optimize the target logistic objectives while coping with the disturbances. Firstly, Logistic Operating Curves [4] imply that no matter which objective oriented control of individual workstations is used, it is able to possibly optimize at most two objectives. Moreover, even if different logistic objective-oriented control tasks are assigned to individual workstations, i.e. distributed control of workstations, the contradiction between local objectives will lead to non-optimal global performance. Therefore, aiming at optimizing the target logistic objectives, it is necessary to assign different objective-oriented control tasks not to individual workstations but to the whole logistic system or individual orders. Secondly, the reason that conventional manufacturing systems show a wide range of weaknesses regarding the flexibility and adaptability to the disturbances is that they are characterized by non-feedback, non-adaptive and centralized control approaches. To overcome this problem, it is necessary to shift the ongoing paradigm from non-feedback control towards feedback control, from non-adaptive control towards adaptive control, and from centralized control towards distributed control.

On the basis of the combined consideration of the above-mentioned two necessities, optimizing the target logistic objectives and coping with the disturbances might be realized by assigning a low WIP level-oriented feedback control task to the whole manufacturing system and assigning a high schedule reliability-oriented, distributed control task to the individual orders. Hence, we propose a RMLOO which consists of three control components: a feedback WIP control aiming at reducing WIP level and throughput times of the manufacturing system; a distributed routing control aiming at increasing schedule reliability by reducing due date deviations of individual orders, and an adaptive backlog control aiming at further improving schedule reliability by adaptively reducing order backlogs. In the control process, the three control modules function and interact together to accomplish the targeted logistic objectives and react adequately to the disturbances (Figure 1).

Feedback WIP Control

The previous research findings have shown that releasing mechanisms have a significant effect on the performance of manufacturing system, reducing WIP and throughput times. Because of the direct relation between WIP level and throughput times, both of them could be minimized simultaneously under the condition that the WIP level of manufacturing systems reach a desired level. In accordance with the Manufacturing System Operating Curves (MSOC)[5], the ideal minimum WIP of the manufacturing system ($WIPI_{\min,MS}$) level represents the WIP level necessary to run the system assuming that no arriving order has to wait and no interruption occurs in the material flow. As a result, the minimal attainable throughput time is able to be achieved by maintaining total WIP at $WIPI_{\min,MS}$ level. In order to achieve both short throughput times and low WIP level, a WIP controller has thus been developed to remain the total WIP of job shop at $WIPI_{\min,MS}$ (t) level calculated by Equation (1).

Equation 1

$$\mathrm{WIPI}_{\mathrm{min,MS}}(t) = \sum_{i=1}^{W} \frac{\dfrac{\mathrm{ROUTO}_{\mathrm{max,BN}}(t)}{\mathrm{MFC}_{\mathrm{BN}}(t)}}{\dfrac{\mathrm{ROUTO}_{\mathrm{max,i}}(t)}{\mathrm{MFC}_{\mathrm{i}}(t)}} \cdot \mathrm{WIPI}_{\mathrm{min,i}}(t)$$

Where

$\mathrm{WIPI}_{\mathrm{min,MS}}(t)$: Ideal minimum WIP of the manufacturing system [Hrs]

$\mathrm{WIPI}_{\mathrm{min,i}}(t)$: Ideal minimum WIP of workstation i [Hrs]

$\mathrm{ROUTO}_{\mathrm{max,BN}}(t)$: Maximum output rate of the bottleneck workstation in number of orders [1/SCD]

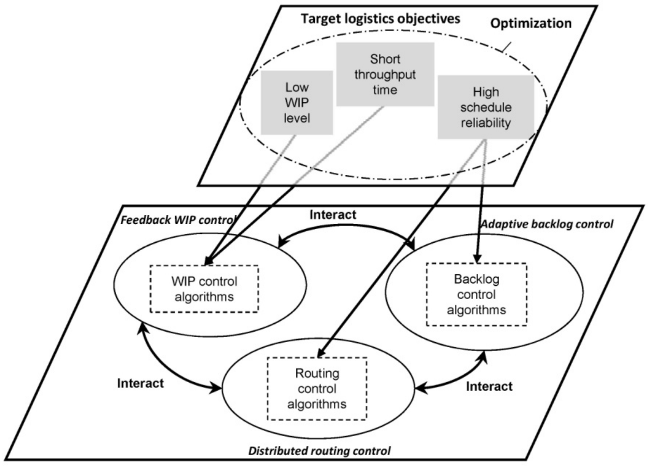
$\mathrm{ROUTO}_{\mathrm{max,i}}(t)$: Maximum output rate of workstation i in number of orders [1/SCD]

$\mathrm{MFC}_{\mathrm{BN}}(t)$: Material flow coefficient of the bottleneck workstation [-]

$\mathrm{MFC}_{\mathrm{i}}(t)$: Material flow coefficient of workstation i [-]

W : Number of Workstations [-]

Figure 1: Concept of RMLOO



The Equation (1) is developed using the same idea of deriving MSOC, i.e. the higher the workstation's utilization is, the more its ideal minimum WIP contributes to the ideal minimum WIP of the manufacturing system. The essential difference is that the ideal minimum WIP of the workstation is expressed not in number of orders but in standard hours so that the complex conversion between the $WIPI_{\min,MS}$ in number of orders and in standard hours can be avoided. The workstation with the maximum WIP level is detected as the bottleneck workstation; the material flow coefficient describes the workstation's relative proportion of the manufacturing system's material flow and is determined from the material flow matrix [6]; the ideal minimum WIP level of the workstation is calculated according to [6].

In the control loop, if the deviation between the total WIP and the $WIPI_{\min,MS}$ level arises, the WIP controller prevents a further release of orders into the job shop until the deviation is eliminated completely or negative. In contrast to conventional manufacturing control methods, the proposed approach has significant potential for improving the robustness of the manufacturing system thanks to the integration of the feedback control loop. Furthermore, in the proposed approach only the direct load is measured by the individual workstations without considering the indirect load (i.e. work at all upstream or downstream workstations). In this way, both inaccurate accounting for the total workload (e.g. Workload Control [7]) and complex processes of deriving control reference variables (e.g. Load Oriented Order Release [8] and Decentralized WIP-oriented Manufacturing Control (DEWIP) [9]) can be avoided and bypassed, respectively.

Distributed Routing Control

Aiming at achieving high schedule reliability in the production area, manufacturers generally strive to avoid completing orders before or after the due date by minimizing due date deviations of individual orders. A distributed order routing control has thus been developed in which schedule reliability can be optimized by minimizing due date deviations of individual orders, whereas the negative influence of the disturbances on system performance can be reduced by introducing the heterarchical structure into the manufacturing control system.

It is widely agreed that the distributed control systems tend to be less complex while improving flexibility, adaptability and fault tolerance (e.g. [10] [11] [12]). However, they also suffer some drawbacks, the most significant being the difficulty in optimizing system performance [13]. To overcome this drawback, a hybrid scheduling approach has been developed for the distributed order routing control component. The proposed hybrid scheduling method consists of two components: a centralized, daily scheduling, using a backward algorithm; and a distributed, real-time scheduling, using a forward algorithm, both of which are lumped together and support each other. The centralized scheduler is responsible for providing individual orders with expected due dates of operations (i.e. minimal global information), so as to optimize global performance. In the meantime, the distributed scheduling delivers expected completion times of operations by taking current local situations of the shop floor into consideration, so as to respond to the disturbances in real time. The hybrid scheduling method is summarized in the following algorithm, and steps 1 through 3 are repeated as long as output events occur.

Step 1: After operation j-1 of order i ($1 \leq j \leq n$) is completed, order i obtains the due date of operation (i, j) ($d\leftarrow i,j$) by gaining access to the centralized scheduler. At the centralized scheduling, the expected throughput time of each work system is estimated daily according to the PPC data. According to the processing plan of order i, the expected throughput time of each operation of order i ($TTPi,j$) can be determined as the expected throughput time of its corresponding work system. Based on the expected throughput times of individual operations of order i and the due date of order i (di), the due dates of individual operations of order i ($d\leftarrow i,1,\ d\leftarrow i,2\ldots,\ d\leftarrow i,j$) can be given by:

Equation 2

$$\underset{1\leq j\leq n}{d\leftarrow_{i,j}} = d_i - \sum_{j+1}^{n} TTP_{i,j+1},\ \text{if } j = n,\ \sum_{j+1}^{n} TTP_{i,j+1} = 0$$

Step 2: Order i searches the alternative workstations ($Mi,j,1, Mi,j,2\ldots,\ Mi,j,k, 1 \leq k \leq m$) which can process operations (i, j) and checks if there is a breakdown at the alternative workstations. Numbers of breakdowns and available workstations are given by Nb and Na, respectively. Order i requests all the alternative workstations to conduct forward scheduling.
The scheduling process starts with the present time (pt) and takes into account the expected durations of operation (i, j) executed on the alternative workstations ($Di,j,1,\ Di,j,2\ldots,\ Di,j,k$) and the shift calendars of alternative workstations ($SCi,j,1,\ SCi,j,2\ldots,\ SCi,j,k$), so as to obtain the expected completion times of operation (i, j) on alternative workstations ($d\rightarrow i,j,1,\ d\rightarrow i,j,2\ldots,\ d\rightarrow i,j,k$) as follows:

Equation 3

$$\underset{1\leq k\leq m}{d\rightarrow_{i,j,k}} = \text{Distributed scheduling}\left\{pt,\ \underset{1\leq k\leq m}{D_{i,j,k}},\ \underset{1\leq k\leq m}{SC_{i,j,k}}\right\}$$

In Equation (3) the expected durations of operations (i, j) are calculated based on the work content of operations (i, j) (WCi,j), the expected mean repairing times (MTTRi,j,1, MTTRi,j,2..., MTTRi,j,k) and the current WIP levels (WIPi,j,1, WIPi,j,2 ..., WIPi,j,k) of alternative workstations. If there is no breakdown at the workstations, the expected durations of operation (i, j) can be given by:

Equation 4 and 5

$$\underset{1\leq k\leq Na}{D_{i,j,k}} = WC_{i,j} + \underset{1\leq k\leq Na}{WIP_{i,j,k}}$$

$$\text{Otherwise, } \underset{1\leq k\leq Nb}{D_{i,j,k}} = WC_{i,j} + \underset{1\leq k\leq Nb}{WIP_{i,j,k}} + \underset{1\leq k\leq Nb}{MTTR_{i,j,k}}$$

Step 3: The expected due date deviations of operations (i, j) on the alternative workstations ($ddi,j,1,\ ddi,j,2\ldots,\ ddi,j,k$) are given by Equation (6). The alternative workstation with minimum due date deviation is selected to process the next operation j.

Equation 6

$$\underset{1\leq k\leq m}{dd_{i,j,k}} = \left| d\leftarrow_{i,j}(t) - \underset{1\leq k\leq m}{d\rightarrow_{i,j,k}} \right|$$

Adaptive Backlog Control

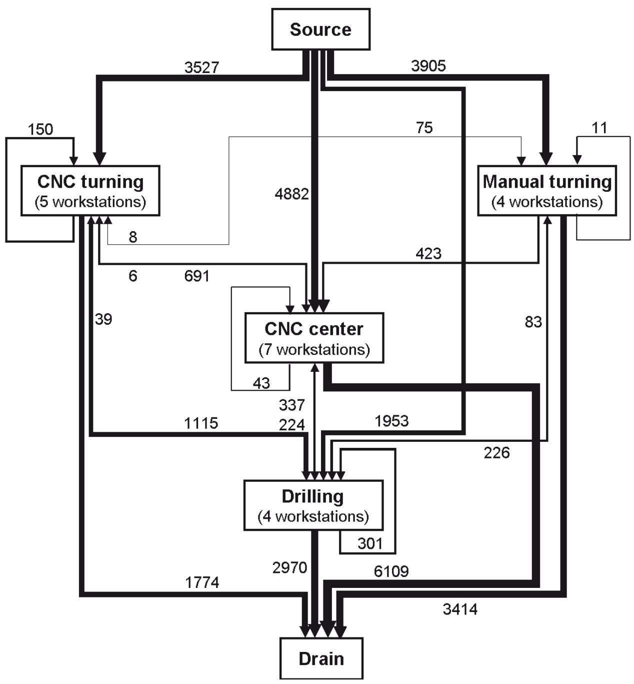
Due to the integration of the WIP controller, there might be an amount of orders waiting for release in the order release pool. Apparently, if the waiting orders are released in random sequence without considering their backlog situations, it will lead to a further decrease in schedule reliability. An adaptive backlog controller has therefore been developed to increase schedule reliability by reducing order backlogs. Once an order is released or new orders arrive, the current backlogs of the unreleased orders will be recalculated in real time. According to the current backlogs the backlog controller rearranges the release sequence; and the order with maximum backlog will be released first. In contrast to the conventional backlog control mechanisms (e.g. CONWIP [14] and DEWIP), the adaptive backlog controller has the ability to respond to changes in backlogging condition in real time and compensate for order backlogs during the release process.

Simulative Experiments and Evaluations

Simulation Model Description

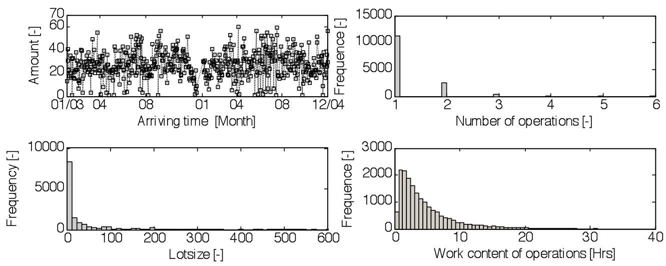
The simulation model describes a partial manufacturing system of a German hanger manufacturer and consists of four work systems which represent different processing steps (Figure 2). Each work system consists of several alternative workstations and works in the given shift calendars.

Figure 2: A Partial Manufacturing System



The manufacturer is a typical MTO enterprise and produces a wide range of customer-related products (i.e. manufacturing in an environment full of the external disturbances). From 2003 to 2004, the completed orders have diverse quality in terms of quantities, lot sizes, numbers and work content of operations (Figure 3).

Figure 3: Diverse Quality of Production Orders



Moreover, to create the internal disturbances in simulative experiments, the operational availability and the mean repairing time of each workstation are set at 95 % and 10 minutes, respectively. The simulation experiments will be conducted in the environment full of the above-described internal and external disturbances. For simplicity, the following simulation runs are merely carried out for 128 SCD.

Evaluations

To comprehensively assess RMLOO, its performance is compared both with that of uncontrolled processes and with those of manufacturing control systems CONWIP and AUTO-QLE as shown in Table 1.

Table 1: Performance Comparison

	Mean throughput time [Hrs]	Mean WIP [Hrs]	Schedule reliability [%]	Output rate [Hrs/SCD]
Uncontrolled	29.55	436.82	93.39	152.82
CONWIP	19.23	285.19	95.13	150.37
AUTO-QLE	16.06	284.30	95.21	155.28
RMLOO	9.01	163.37	96.50	149.15

*The employed algorithms of CONWIP see [14]; by getting access to practical dada, the number of Conwip cards is determined as 49 according to [15]. The employed algorithms of AUT-QLE see [16].

*Schedule reliabilities are calculated by setting schedule tolerance and mean value of due date distribution at +/- 10 and 0 days, respectively.

Firstly, as shown in the first column of Table 1 the mean throughput times have been gradually decreased from uncontrolled system to CONWIP, AUTO-QLE and RMLOO. Moreover, by applying RMLOO the standard deviation of throughput times was significantly reduced as compared to those of the other control systems as well (Figure 4).

Figure 4: Distributions of Throughput Times for Individual Orders

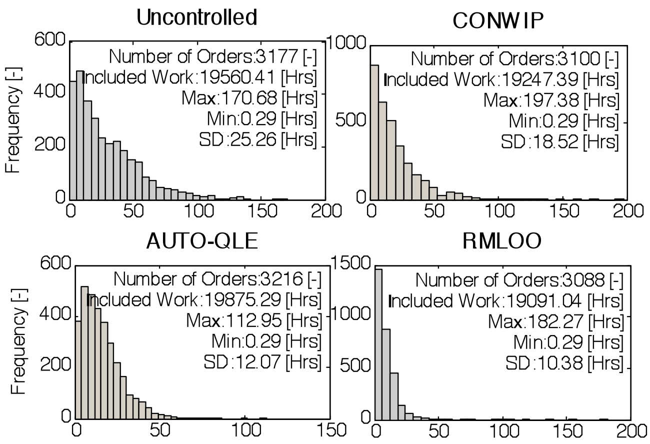
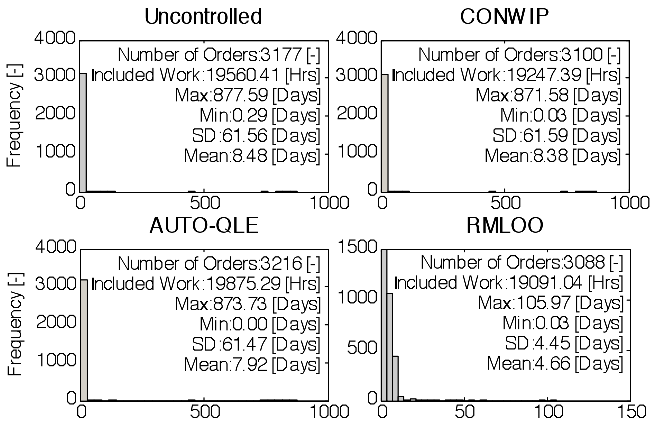
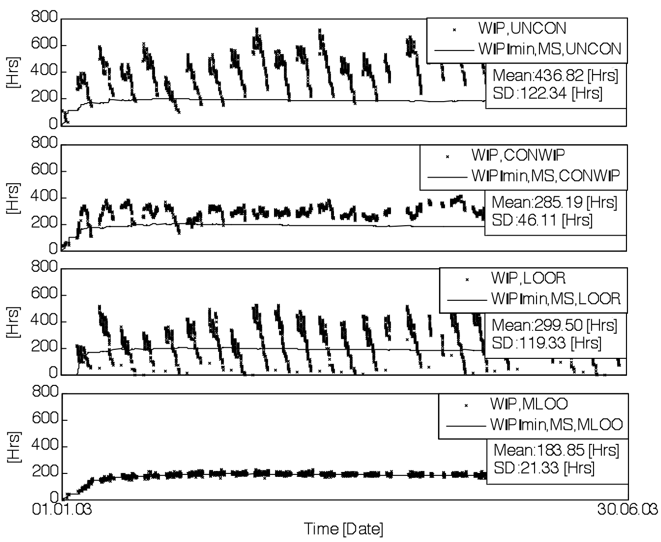


Figure 6: Distributions of Due Date Deviations for Individual Orders



Secondly, as shown in the second column of Table 1 the mean WIP levels have been gradually decreased from uncontrolled system to CONWIP, AUTO-QLE and RMLOO. Furthermore, as shown in Figure 5 the WIP levels of the comparative control systems strongly deviate from their respective $WIPI_{\min,MS}$ levels. In contrast, the WIP level strictly fluctuates around the $WIPI_{\min,MS}$ level in RMLOO. Consequentlly, RMLOO also led to significant decreases in the standard deviation of WIP levels as compared to the other control systems as can be seen from the data in Figure 5.

Figure 5: Fluctuating Actual and Ideal Minimum WIP Levels



Thirdly, as compared to other control systems in the sequence of uncontrolled system, CONWIP and AUTO-QLE, RMLOO leaded to 3.11 %, 1.37 % and 1.29 % increases in the schedule reliability, respectively. Because the schedule reliability does not reflect how late or early orders are completed in accordance with due dates, the (absolute) due date deviation as a second performance measure is utilized so as to comprehensively evaluate the due date performance of RMLOO.

As shown in Figure 6, the mean due date deviations have been gradually decreased from uncontrolled system to CONWIP, AUTO-QLE and RMLOO and the standard deviations of due date deviations of uncontrolled system, CONWIP and AUTO-QLE are 13.83, 13.84 and 13.81 times as great as that of RMLOO, respectively. However, as compared to the control systems in the sequence of CONWIP, uncontrolled system and AUTO-QLE, RMLOO led to 0.81 %, 2.40 % and 3.95 % decreases in the output rate, respectively.

To sum up, by applying RMLOO, almost all the performance measures have been optimized. Among them, the mean throughput times, the mean and standard deviations of WIP levels as well as the mean and standard deviations of due date deviations have been significantly reduced. Even though RMLOO yielded the less improved schedule reliability, it has significantly decreased the mean and standard deviation of due date deviations. That indicates that RMLOO is a both effective and efficient manufacturing control system to improve the due date performance. Furthermore, although RMLOO resulted in a decreased output, yet the amount of decreased output is acceptable. Even compared to AUTO-QLE which obtained the highest output, the corresponding workload of the decreased output (784.25 hrs) (Figure 6) could be finished by RMLOO in about 5.26 SCD which as compared to the reference period (128 SCD) can almost be ignored.

Summary and Outlook

In this article, we have shown that RMLOO can not only effectively cope with the internal and external disturbances but also result in the optimized multiple logistic objectives, short throughput times, low WIP level and high schedule reliability as well as an acceptable decrease in output. However, RMLOO has also some shortcomings. For instance, in the feedback WIP control the control reference variable $WIPI_{\min,MS}$ is derived under the assumption that no interruption occurs in the material flow. Consequently, RMLOO could not perform very well any longer when crowd internal disturbances occur (e.g. high-frequency equipment failure with long recovering time). To overcome this shortcoming, the WIP controller could automatically adjust the $WIPI_{\min,MS}$ with regards to the frequency and amount of the internal disturbances in future work.

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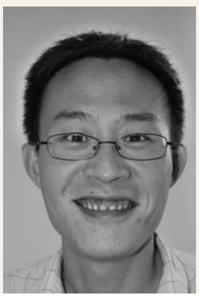

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Modelling Dynamic Production Systems with a Special Focus on Dynamic Bottlenecks

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Assuring Strong Termination of Controlled Graph Transformation by Means of Petri Nets

Melanie Luderer
Dr. Renate Klempien-Hinrichs

Termination is an important problem for graph transformation systems, but in general it is undecidable. In this paper we propose an algorithm that searches for sufficient conditions to ensure termination of graph transformation controlled by regular expressions. The main idea is to make use of the recursive structure of regular expressions and compute for each considered expression a finite set of upper bounds with respect to what is deleted and added by derivations permitted by the expression. Elements of this set may interact when iterating the expression. This is analysed by means of a Petri net: Non-repetitiveness of the net implies termination of the considered control expression. Finally, we show that the findings can be transferred to regular expressions extended by *as-long-as-possible*.

Introduction >>> In rule-based graph transformation (see [Roz97,EEKR99,EKMR99] for an overview), graphs are transformed step-by-step through applications of rules that usually come from a finite set. When using graph transformation as a programming paradigm, termination is an important issue - which is studied, e.g., in [Plu98,Aßm00,BHPPT05,EEdL+05,VVGE+06,LPE07], [HKK08]. In general, termination is undecidable for graph rewriting systems [Plu98]. But for many systems termination can be guaranteed. A sufficient criterion is to find a termination function, i.e. an evaluation function $eval\colon \mathcal{G} \to \mathbb{N}$ that associates a natural number $eval(G)$ with each graph $G \in \mathcal{G}$ so that the value decreases whenever a derivation step is done: $eval(G) > eval(G')$ for $G \Longrightarrow G'$. However, requiring a single termination function to work for *every* rule in a system is very restrictive, at least from a practical point of view.

A control condition may, e.g., express a property of a whole rule application sequence (hence 'condition'), or reduce in each derivation step the number of choices for the next rule. Typical conditions are regular expressions over rules (and imported transformation units [KK99,Kus00b]), regular expressions together with *as-long-as-possible*, and priorities (see, e.g., [Kus00a], [HKK08]). In [BHPPT05], the concept of termination function is developed for expressions with *as-long-as-possible*.

The research we report on in this paper started with the observation that a derivation controlled by applying an expression C_0 *as-long-as-possible* is infinite, i.e. does not terminate, only if C_0 itself admits a non-terminating derivation or C_0^* admits infinitely many derivations (of finite length). Therefore, we first study regular expressions over rules as control conditions and propose a notion of strong termination for such expressions, meaning that only finitely many derivations are admitted. Then we show that our approach transfers easily to regular expressions with *as-long-as-possible*. **<<<**

Preliminaries

This section introduces the basic terms used in this paper and due to space limitations cites their references.

Graph transformation approach. The considerations in this paper are independent of a specific graph transformation approach; we only have to define some basic requirements for such an approach.

The terms *derivation step* ($G \underset{r}{\Longrightarrow} G'$), *derivation* ($G_0 \underset{r_1}{\Longrightarrow} G_1 \underset{r_2}{\Longrightarrow} \ldots \underset{r_n}{\Longrightarrow} G_n$ as well as the abreviation $G_0 \overset{*}{\underset{P}{\Longrightarrow}} G_n$ if $r_1, \ldots, r_n \in P$ for some set $P \subseteq \mathcal{R}$), and *rule application sequence* ($r_1 \cdots r_n$) are defined as usual. For detailed information see e.g. [Roz97].

Assumption 1 *1. For each rule $r \in \mathcal{R}$, there is at least one graph $G \in \mathcal{G}$ to which it can be applied, i.e. its derivation relation $\underset{r}{\Longrightarrow}$ is not empty. 2. Each rule $r \in \mathcal{R}$ can be applied to a graph $G \in \mathcal{G}$ only in finitely many ways, i.e. the set $der(G)_r = \{G \underset{r}{\Longrightarrow} G' \mid G' \in \mathcal{G}\}$ is finite.*

Control Conditions. A major purpose of control conditions is to regulate the derivation process by enforcing some kind of order on rule applications. A very natural kind is a regular expression over $\mathcal{R}$.

The set $REX(\mathcal{R})$ of regular expressions over $\mathcal{R}$ is defined as usual, as well as the language of a regular expression e, $L(e) \subseteq \mathcal{R}^*$. A regular expression is *star-free* if it does not contain a subexpression of the form (e^*).

Let $G \in \mathcal{G}$ be a graph. For a rule sequence w over $\mathcal{R}$, the set of derivations permitted by w (*w-runs* for short) starting in G is defined as $der(w)_G = \{G \underset{w}{\Longrightarrow} G' \mid G' \in \mathcal{G}\}$. For a regular expression e over $\mathcal{R}$, the set of permitted derivations (*e-runs* for short) starting in G is $der(e)_G = \bigcup_{w \in L(e)} der(w)_G$.

When programming with graph transformation, one usually does not need to specify the empty set of derivations or the set containing only the empty derivation. Therefore, we will from now on ignore regular expressions $\emptyset$ and λ.

The set of regular expressions is extended by the operation *as-long-as-possible*, denoted by !, to a set of expressions as follows: $(e!)$ is an expression if e is an expression. The meaning of $(e!)$ is to iterate derivations permitted by e as often as a complete derivation permitted by e can be executed.

The set of permitted derivations $der(e!)_G$ contains all finite concatenations $d_1 d_2 \cdots d_n$ of derivations $d_1 \in der(e)_G$ and $d_{i+1} \in der(e)_{end(d_i)}$ for $i \in [n-1]$ so that $der(e)_{end(d_n)} = \emptyset$, and all infinite concatenations $d_1 d_2 \ldots$ built analogously if $der(e)_{end(d_i)} \neq \emptyset$ for all $i > 0$.

Petri Nets. Petri nets are a well-known modelling tool for nondeterministic concurrent systems. A concise introduction can be found in, e.g., [Mur89].

A Petri net is *partially repetitive* if there exists a marking M_0 and an infinite firing sequence $w = (t_i)_{i \in \mathbb{N}}$ starting from M_0. Partial repetitivity can be characterised with the help of the incidence matrix (see [Mur89, Theorem 31]).

Theorem 2. *Let $N = (P, T, F, B)$ be a Petri net and A its incidence matrix. N is partially repetitive if and only if there exists a $|T|$-vector $x\colon T \to \mathbb{Z}$ of non-negative integers such that $A \cdot x \geq 0$ and $x \neq 0$.*

Computing a Sufficient Condition for Termination

The section starts with the defintion of a notion of strong termination for regular expressions. Subsequently, measures for graphs and upper bounds for the changes in measures through derivations controlled by regular expressions are defined. On this basis, Petri nets whose analysis may yield a sufficient condition for a starred expression are constructed. Finally, the reflections of this section are condensed into a checking algorithm and expanded to deal with control conditions that are regular expressions over rules together with *as-long-as-possible*.

Termination of Regular Expressions. In any computation model, a computation does not terminate if some loop construct – such as *do X as-long-as-possible* – requires infinitely many computation steps. If X is controlled by some regular expression C and starts in a graph G, this means that the regular expression C^* admits infinitely many derivations starting in G. This is exactly the situation that we forbid in our notion of *strong termination* for regular expressions.

Definition 3 *Let C be a regular expression over $\mathcal{R}$ and $G \in \mathcal{G}$ a graph. 1. C* terminates strongly *for G if $der(C)_G$ is finite. 2. C* terminates strongly *if it terminates strongly for all graphs in $\mathcal{G}$.*

Due to Assumption 1, we have the following observation, where point 2 is just point 1 rephrased since for a regular expression C that contains neither $\emptyset$ nor λ, the language $L(C)$ is finite if and only if C is star-free.

Observation 4 *Let C be a regular expression over $\mathcal{R}$. 1. If $L(C)$ is finite, then C terminates strongly. 2. If C is star-free, then C terminates strongly. 3. $C_1; C_2$ terminates strongly if and only if C_1 terminates strongly and for all $G \in \mathcal{G}$ and $d \in der(C_1)_G$, C_2 terminates strongly for $end(d)$. 4. $C_1|C_2$ terminates strongly if and only if C_1 and C_2 terminate strongly. 5. If C^* terminates strongly, then C terminates strongly.*

Lemma 5 *Let C be a regular expression over $\mathcal{R}$. 1. If $C = r \in \mathcal{R}$, then C terminates strongly. 2. If $C = C_1; C_2$ or $C = C_1|C_2$ and both C_1 and C_2 terminate strongly, then C terminates strongly.*

C_0^* will terminate strongly if for every start graph an intermediate graph is reached after some C_0-runs so that C_0 cannot be applied anymore. This case is investigated in the following sections.

Measure Sets for Graphs. A measure maps graphs to natural numbers, so that for each rule - its application yields the same change in the measured value, independently of the graph to which the rule is applied.

Definition 6 *A* measure *on graphs is a mapping $\mu\colon \mathcal{G} \to \mathbb{N}$, so that for all graphs $G, G', \bar{G}, \bar{G}' \in \mathcal{G}$ and every rule $r \in \mathcal{R}$, $G \underset{r}{\Longrightarrow} G'$ and $\bar{G} \underset{r}{\Longrightarrow} \bar{G}'$ implies $\mu(G') - \mu(G) = \mu(\bar{G}') - \mu(\bar{G})$. We will write a set of k measures $\mu_1, \ldots, \mu_k$ ($k \in \mathbb{N}$) as a vector $\vec{\mu} = (\mu_i)_{i\in[k]}$.*

Upper Bounds for C. Define a set $\mathit{Change}(C) \subseteq \mathbb{Z}_\infty^k$ of vectors for each regular expression C, so that each vector has k entries in $\mathbb{Z}_\infty = \mathbb{Z} \cup \{\infty\}$ that serve as upper bounds for the change in measured values whenever a derivation admitted by C is executed.

Definition 7 *Let C be a regular expression over $\mathcal{R}$ and $\vec{\mu}$ a measure set.*

1. *For $C = r \in \mathcal{R}$, let $\mathit{Change}(C) = \{x\}$, where x is the unique vector $x = \vec{\mu}(G') - \vec{\mu}(G)$ for all $G, G' \in \mathcal{G}$ with $G \underset{r}{\Longrightarrow} G'$, and vector difference is computed component-wise.*
2. *For $C = C_1; C_2$, let $\mathit{Change}(C) = \{x + y \mid x \in \mathit{Change}(C_1),\ y \in \mathit{Change}(C_2)\}$, where vector addition is computed component-wise.*
3. *For $C = C_1|C_2$, let $\mathit{Change}(C) = \mathit{Change}(C_1) \cup \mathit{Change}(C_2)$.*
4. *For $C = C_0^*$, let $\mathit{Change}(C) = \{(x_1, \ldots, x_k) \mid x_i = \infty$ if $\exists (y_1, \ldots, y_k) \in \mathit{Change}(C_0) : y_i > 0$ and $x_i = 0$ otherwise, for $i \in [k]\}$.*

For an expression C_0 that terminates strongly, C_0^* admits rule application sequences where C_0 is iterated arbitrarily often. Any decrease in a measure through a C_0-run does not occur if C_0 is iterated zero times. In contrast, an increase in a measure may lead to arbitrarily large values of that measure, indicated by ∞.

Lemma 8 *Let C be a regular expression over $\mathcal{R}$. 1. For all $G, G' \in \mathcal{G}$ and $w \in L(C)$ with $G \underset{w}{\Longrightarrow} G'$ there exists $x \in \mathit{Change}(C)$ with $\vec{\mu}(G') - \vec{\mu}(G) \leq x$. 2. $\mathit{Change}(C)$ is finite.*

Constructing a Petri Net from $\mathit{Change}(C_0)$. Now we are aiming to provide a sufficient condition for strong termination of a regular expression $C = C_0^*$, i.e. for the case that is missing from Lemma 5.

Definition 9 *Let C_0 be a regular expression over $\mathcal{R}$ that terminates strongly, and let $\vec{\mu} = (\mu_i)_{i\in[k]}$ be a measure set. Construct the pure Petri net N_{C_0} as follows. The set of places is $P_{C_0} = \{l \in [k] \mid x_l \neq \infty$ for all $(x_1, \ldots, x_k) \in \mathit{Change}(C_0)\}$, the set of transitions is $T_{C_0} = \mathit{Change}(C_0)$, the incidence matrix A_{C_0} has as columns the vectors in $\mathit{Change}(C_0)$ restricted to the entries selected for P_{C_0}.*

Since C_0 is assumed to terminate strongly, we now know the following: If $C = C_0^*$ does not terminate strongly, then there is a marking M of N_{C_0} and an infinite firing sequence starting in M, i.e. N_{C_0} is partially repetitive. By contraposition and using Theorem 2 we get the desired sufficient condition for strong termination of C.

Lemma 10 *Let $C = C_0^*$ be a regular expression over $\mathcal{R}$. If C_0 terminates strongly and there is no vector $x\colon T_{C_0} \to \mathbb{Z}$ of non-negative integers so that $A_{C_0} \cdot x \geq 0$ and $x \neq 0$, then C terminates strongly.*

A Termination Check. Putting Lemmas 5 and 10 together, we obtain the following test, where the function NoNnSolution returns $\mathbf{true}$ for an input matrix A over integers if and only if the only non-negative solution x for $A \cdot x \geq 0$ is $x = 0$:

Check(C : regular expression over $\mathcal{R}$) : $\{\mathbf{true}, \mathbf{false}\}$
case $C \in \mathcal{R}$:
    return $\mathbf{true}$;
  $C = C_1; C_2$ **or** $C = C_1|C_2$:
    return Check(C_1) **and** Check(C_2);
  $C = C_0^*$:
    return Check(C_0) **and** NoNnSolution(A_{C_0})
endcase

Theorem 11. *Let C be a regular expression over $\mathcal{R}$. If* Check$(C) = \mathbf{true}$ *then C terminates strongly.*

Regular Expressions with *as-long-as-possible*. Let us consider the extension of regular expressions over $\mathcal{R}$ to include the operation *as-long-as-possible*. Then an expression C *terminates strongly* if for all graphs $G \in \mathcal{G}$, $\mathit{der}(C)_G$ is finite and contains only derivations of finite length. By induction on the structure of nested *as-long-as-possibles* we can show the following, where the mapping rex turns an expression C into a regular expression $\mathit{rex}(C)$ by replacing every occurrence of '!' with '*':

Lemma 12 *Let C be an expression. Then C and all its subexpressions terminate strongly if and only if $\mathit{rex}(C)$ and all its subexpressions terminate strongly.*

Consequently, the algorithm above can be used to search for a sufficient condition for expressions with *as-long-as-possible*, too:

Theorem 13. *Let C be an expression over $\mathcal{R}$. If* Check$(\mathit{rex}(C)) = \mathbf{true}$ *then C terminates strongly.*

Conclusion

In this paper we have proposed an algorithm to search for sufficient conditions that ensure (strong) termination of graph transformation processes restricted by a control condition in the form of a regular expression. Strong termination for a regular expression C follows from strong termination for all subexpressions C_0^* of C. The basic idea is that, given strong termination of C_0, C_0^* terminates strongly if every derivation permitted by C_0 deletes something, and during iteration of C_0 at least one type of deleted elements cannot be balanced by other derivations permitted by C_0 that add elements of the same type. This is assured by constructing a set of upper bounds for the differences of measured elements resulting from a derivation permitted by C_0. This set is interpreted as the incidence matrix of a pure Petri net. If linear-algebraic analysis shows the Petri net to be non-repetitive, strong termination of C_0^* is implied. Moreover, we have shown that regular expressions extended by as-long-as-possible can be treated analogously.

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Graph Transformation as a Modelling Method in Logistics

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Feasibility of Autonomous Logistic Processes; Introduction of Learning Pallets

Afshin Mehrsai
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The current material supply and flow configure complex logistics networks rather than isolated companies in the past. This intricacy is a direct consequence of product diversity and individualization as well as supply challenges. These make planning and control of material flow quite tough tasks of supply chains and networks. Switching from a holistic approach to a distributed vision to the planning and control duties is reported as a promising foresight. This tactic is complemented by autonomy merit. However, there are some requirements in terms of effectiveness and feasibility of autonomy in logistics processes which should be investigated. This research tries to combine this new research topic with existing strategies in production logistics.

Introduction >>> Supply chains (SCs) consist of several aligned suppliers, manufacturers, distribution centers and retailers which configure cooperative chains to meet customer demands at the right time, place, quantity and quality. This could be extended to a supply network with more interdependencies between suppliers and producers within a network format rather than in a series of suppliers. However, there are more extended definitions that cover recycling of consumed materials and corresponding re-logistics as a chain of supply networks.

In general, those entire activities that transform raw materials to final products from the point of origin to the point of consumption are defined as logistics. Nowadays, it is not possible to separate logistics from supply chain management (SCM) though in some contexts SCM dominates logistics and in some vice versa.

Supply chain management duties include: information and material flow planning & control, procurement, inventory and transportation management, mid-term and short-term scheduling, and other relevant business processes to coordinate and manage them in a proper manner. In other words, SCM is "the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole" [1].

Coordination of all the mentioned tasks of SCM seems to be a hard task in the current logistics environment. For dealing with that, a decentralization approach to this task has become an interesting research topic in the last decade. By means of decentralization, the planning and control mission is directed toward autonomous systems as well as objects. Autonomy is defined as independency of an entity in decision-making by means of interactions and information exchange between the elements of a system [2].

In the context of logistics, autonomy may cover logistics members, processes, and objects which seek to make them autonomous. Following this research topic at the Bremen University, which is defined as Cooperative Research Centre 637 "Autonomous Cooperating Logistics Processes – A Paradigm Shift and its Limitations" (see: www.sfb637.uni-bremen.de), this doctoral research topic is configured to make the concept of autonomy in logistic come closer to the practice. The rest of the paper is organized respectively as sections of centralized and decentralized control, strategies in logistics, application of learning pallet, and general concept and methods of Lpallets. <<<

Centralized and Decentralized Control

Coordination and integration of all activities and processes throughout an entire network of suppliers, producers, distribution centers, and retailers appear extremely complex and difficult. The mission is particularly hard in the current dynamic business environment with high customized requirements. However, the coordination and integration tasks are significantly included in SCM to realize its target value adding activities. By increasing the scope as well as the scale of trades and SCs, the necessity of reducing the complexities of SCM is strongly requested.

Along the concept of decentralization some solutions have been introduced to realize this perspective. Autonomous control for logistics objects (with a semi-hierarchical or heterarchical structure) is disseminating its application into internal and external logistics processes. The meaning of autonomous control according to Scholz-Reiter et al. is "a decentralized coordination of intelligent logistic objects (parts, machines etc.) and the routing through a logistic system by the intelligent parts themselves" [3]. Nonetheless, autonomy has its own constraints i.e., technological, feasibleness, effectiveness, and efficiency in practice.

Strategies in Production / Logistics Systems

Several strategies for material flow and production systems have been taken by SCs that facilitate meeting the customers' (internal/external) requirements. Mostly, customers' needs arise in terms of smoother flow, less cost, and shorter delivery time. Those strategies are based on two concepts of material push and pull. Based on the fulfillment and inventory strategies the type of material flow is chosen [4]. In this regard, make-to-stock or forecast (MTS/ MTF), make-to-order (MTO), assemble-to-order (ATO), and engineer-to-order (ETO) are the most popular strategies. However, some hybrid approaches of them are taken by SCs as well. Usually, the chosen strategies depend on product diversity or type, stock keeping, customer requirements and lead time, network distances, demand volume and other characteristics of the system.

Nevertheless, application of decentralized decisions concerning the type of taken strategies differs. In fact, because of the complexities accompanied with integration and coordination of information / material flow in logistics processes (i.e., MTO system), decentralized control can be a solution [5]. Nonetheless, the decentralized structure doesn't satisfy the aims of full integration of members (regarding the unavailability of all global information, but local one). Therefore, the members as well as logistics objects must be flexible enough to meet any kinds of sudden changes in plans and schedules. It means agility and flexibility of the SC elements reduce the need of integration for global data exchange between them. As a strong alternative, the elements of a dynamic system can learn and adapt themselves to the new situation. Learning elements (SC members, logistics objects, etc.) is a new approach to decentralized control, by local information, in order to realize global targets of SCs.

Application of Learning Pallet

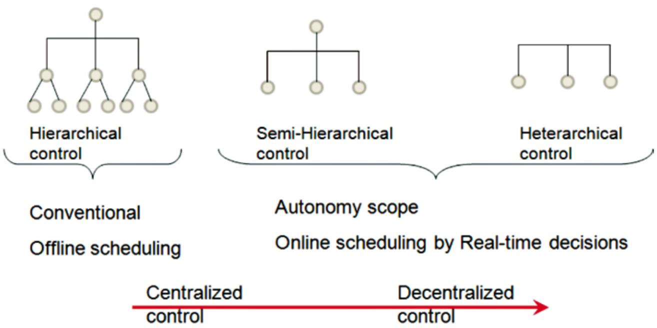
Generally, logistics may be divided into two scales. Firstly, external (outbound) logistics which, by the globalization phenomenon, has become inseparable from production businesses. The main task of external logistics is to transfer materials/ products from point of origin to consumption, according to the plan and demands. Secondly, internal (inbound) logistics which is used to transport materials/ products between working stations within shop-floors, based on the requirements and schedules. Internal logistics has become popular since the mass production system was introduced. However, its working scope and scale have been changed through the time horizon.

By introduction of novel technologies such as wireless networks, and specifically, RFID for tracking and identifying instead of barcodes, a new ability has been given to logistics processes to improve their real-time e-connectivity. Application of ICT is integrated into logistics and is continuously expanding its field. The intelligent pallet with the capability of recording, analyzing, and exchanging data is going to become a step toward decentralization of logistics tasks. To dispense the responsibilities of a central planning and scheduling system to distributed objects in a customized manner, intelligent (Learning) pallets for inter-logistics processes can undertake the following tasks:

- Routing with less processing time between several plants (nodes of network) to reach its destination
- Estimation of completion time and delivery date according to previous experiences
- Proactively performing to reduce the deviation of lead time
- Increasing the flexibility of mass customized systems by individualization of measures and operations
- Tracking as well as identifying of batches (mixture of products)
- Defining unique lot-sizes according to some metrics and current requirements

All in all, by using intelligent pallets some or their entire capabilities and controlling tasks could be customized according to the requirements of the specific industry.

Figure 1: A General Control Stuctures



General Concept and Methods for Lpallets

Pallets as transportation and conveying units are maintained during their lifecycle in logistics systems. Accordingly, they move from point to point regarding supply and delivery needs. Regarding the new concept of customizing products [6] and the mentioned importance of pallets within inbound and outbound logistics, pallets themselves can take over more effective roles to facilitate smooth flows. It means freedom in routing, respectively bottlenecks reduction, flexibility in lot-sizes and batching, even forecasting ability (i.e., each pallet can define its own destination, delivery date and lot, and even release time derived from its knowledge), all bring agility to the system performance. Meanwhile, by using pull system more advantages can be given to pallets for operating more closely to the real-time and react to any changes on time [7].

Respecting the individualization of pallets by each order in pull systems their autonomous functionality dominates the performance of pallets in push systems. Actually, the pull concept facilitates the aim of decentralized control for logistic modules [8] which is a prerequisite of autonomy [2]. This could be done by manipulation of local information instead of global ones by pallets. However, the notion of global and local is quite proportional, so that they vary regarding the scale of concern.

Now for the reconfigurable and flexible manufacturing system (FMS) [6] it is necessary to be agile overall in such an environment. Agility, in the sense, could be described as prompt responsiveness to changes in demand, breakdowns as well as resources availability concerning real-time [9]. As explained before, integration and coordination of all processes (i.e., operational, managerial, and supporting) in a dynamic system seem quite complicated. The alternative for that complexity is to distribute the tasks within a heterarchical structure, so that the results enhance the global targets. Now decentralization of control task could vary from independent chains within a supply network, on a major scale, to autonomous logistic objects, on a minor scale. It is totally dependent on the considered system's scale. For this purpose, one between several appropriate logistic objects is pallet or any similar carrying object.

Accordingly, here the superiority of the learning pallets expresses itself. These pallets have the ability to become independent modules in logistic systems; the pallets, inspired by intelligent methodologies and using local data, do the duties by learning and analyzing information as well as rendering decisions. In addition to handling materials, pallets can even be used as pull signals in a decentralized manner.

However, it should be noticed that, in manufacturing and logistics systems there has been a vast study in the field of integration and coordination of data exchange as well as synchronization of operations based on global performance [1][10][11][12]. All the researches address integration and incorporation of information and processes of SC and logistics, but mostly it is mentioned that implementation of this target is complex in terms of information handling and data exchange. For example, Carter et al. at the beginning of their new book "Supply Chain Integration: Challenges and Good Practices" explained fourteen challenges for integration of supply chain operations of which analyzing data and exchange of data could be the major ones [13]. In most studies data collection and exchange relies on new achievements in internet, electronic data interchange (EDI), and ERP systems. On the other hand, they are aware of the existing challenges for information collection from every entity. That is why production planning and control (PPC) covers the mid- and long-term planning, but detailed scheduling is typically done based on current and immediate situations which is revised very often (see Figure 2). Requirements of detailed information make the control of the system very complicated, yet in a highly varying environment it is almost unrealistic to meet any details.

Usually there is a center which is responsible to get all the information and analyze it to make an integrated decision for global activities. However, a new approach to overall integration is being developed.

This all means we are trying to solve the problem by a decentralized method that is responsible for its details while the key information should be still collected by a center to coordinate the global processes. Integration and exchange of all data is not considered, but details can be controlled locally. Nevertheless, this does not reject the requirements of global awareness and exchange of key information in inbound and outbound logistics. If we want to map the level of (de)/centralization into the architecture of advance planning systems for logistic systems (see Figure 2) [14], the long- and mid-term planning should be done centrally, but some parts of the short-term planning like detailed scheduling and vehicle scheduling can be done by decentralized decisions. As stated before, the proportion of decision types depends on the scale of the entire system and planning horizon.

Here it should be mentioned that by several simulation experiments it is concluded that lack of key information within a production system leads to chaos or undermined performances.On the contrary, for the last decade there has been escalating studies in the field of decentralization of logistics activities to reduce complexity [15][16][17]. Those studies try to distribute the tasks of operations to reduce centralism whose end effect may be yet integration in terms of more profits for everyone.

If a system is controlled in a decentralized manner, entities of the system (e.g., agents, members, objects) must be able, to some extent, to decide about their tasks. In fact, there is no center to command the operations, thus, this inspires autonomy on some level to them. Talking about autonomy in a dynamic environment such as production or inventory systems does not occur in a straightforward manner. The dynamic nature of these systems necessitates continuous adaption to the new condition, so that delays are trivial. This required aptitude is frequently given to learning algorithms and objects. Despite the intelligence of an entity, without the ability of learning, adjustment to new conditions seems ineffective. However, learning can range from just reactively

Figure 2: Architecture of Advanced Planning Systems for Logistic Systems, [14]

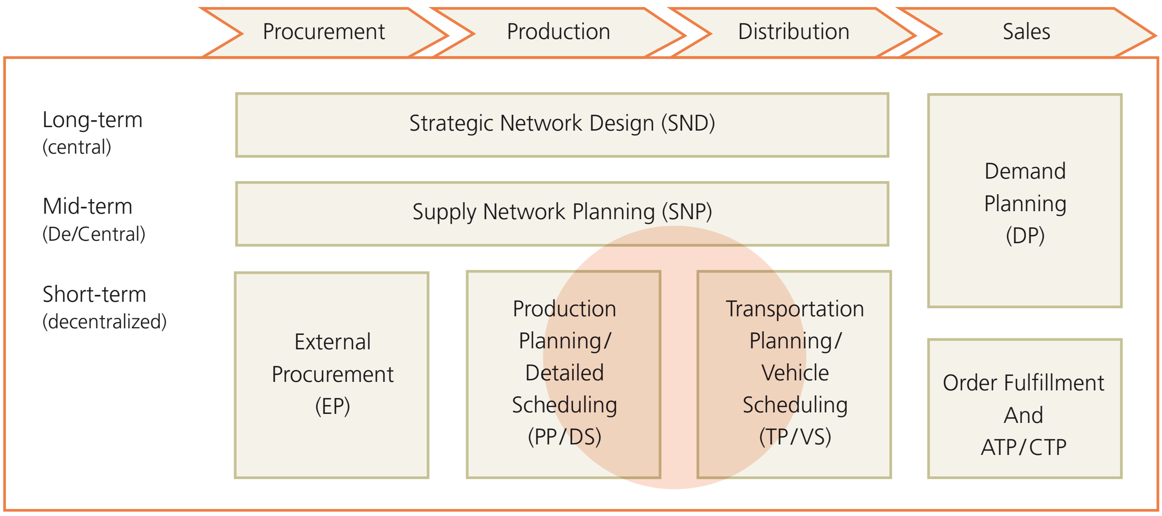
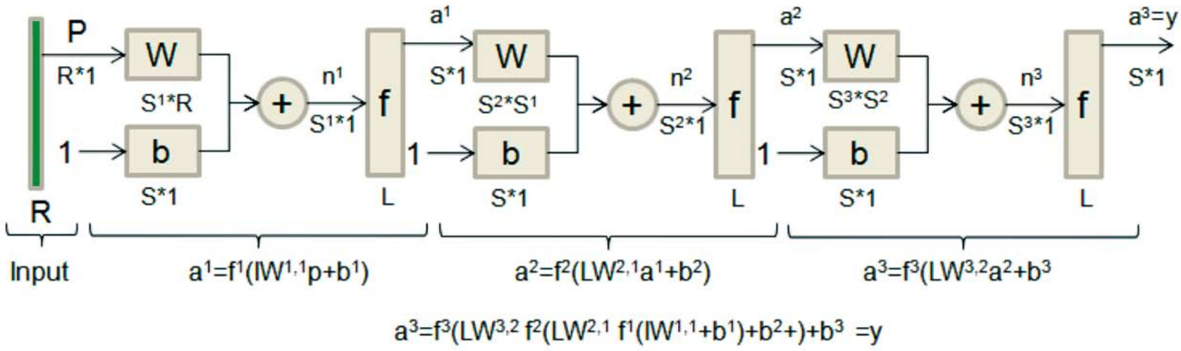


Figure 3: Exemplary Feedforward Neural Network With Input Layer, 2 Hidden Layers, and Output Layer



analyzing feedbacks to proactively forecasting and operating based on analysis. Alternatively, to avoid delayed adaptation that leads to bullwhip effect in the system, supervised learning for some decision making tasks seems suitable.

Nonetheless, exploitation of the learning merit requires permanence and experience of the object (like pallets) to learn the patterns. Artificial intelligence that is associated with machine learning is a common field in this area. Other relevant disciplines that contribute to machine learning are: statistical learning, decision tree, data mining, brain models, adaptive control theory, evolutionary models, and psychological models [18][19]. Among the mentioned disciplines the prominent ones, which are more pertinent to this work research, are artificial neural network (ANN), and Genetic Algorithm (GA)/ programming (GP). To clarify their contributions to learning pallets some explanations are given in the following:

ANN is defined as a mathematical computing paradigm that can model the behavior of biological neural networks [20]. It can be used for modeling complex and non-linear systems. Some common applications for ANN are clustering, data classification, pattern recognition, and data or function approximation that all other applications can be extracted from (for example see Figure 3). For instance, in practice ANN can be used in: industrial process control, sale forecasting, resource allocation and scheduling, optimization and scheduling [21]. The capabilities of ANN make it an appropriate tool for the learning pallets. A learning pallet, regarding its field of application, could have several tasks like: choosing of lot-size, batching of products, estimation of completion time, and selection and sequence of processes (routes) etc., each of which requires either classification of input data or approximating a pattern.

GA is a stochastic search technique based on the evolution and immortality of genes in natural systems. This specification of GA makes it suitable for optimization, adaptation, and learning problems with complex and time consuming calculations [22]. Usually GA is categorized as a global optimization technique. This is, on the one hand, inconsistent with the notion of decentralization. On the other hand, this makes it appropriate for some global monitoring and some discrete optimum decisions based on available inferred data. Data extracted from ANN can be used as input for GA for making a global perception and performance of the system and an approximation map. Although GA can be used in some stationary points for global monitoring of autonomous objects, depending on the calculation capability of the objects, it might be used for every

Figure 4: Routing of Lpallets in a Shop-Floor With Pull System

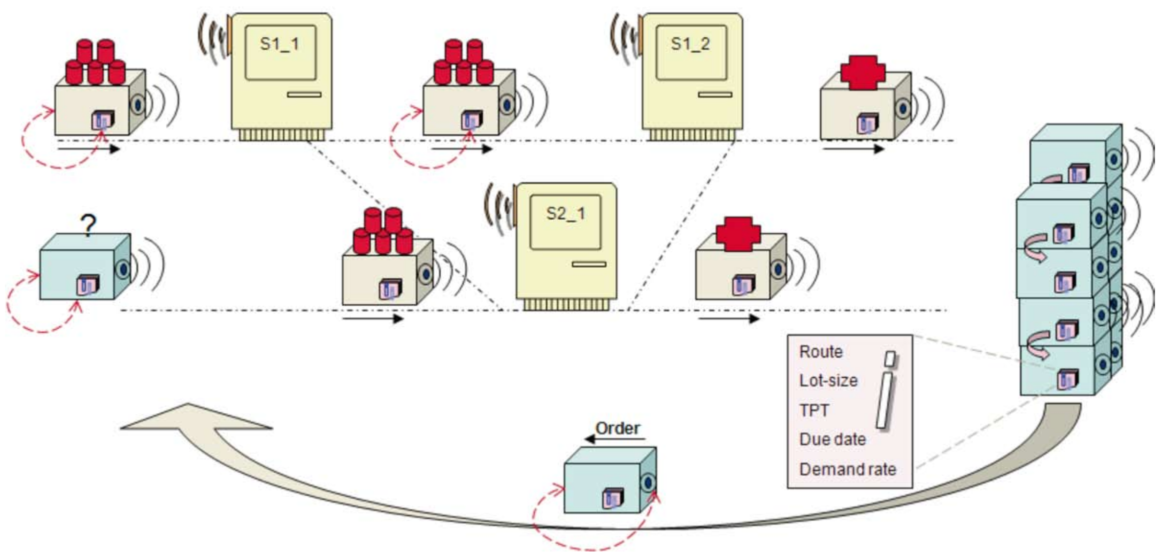
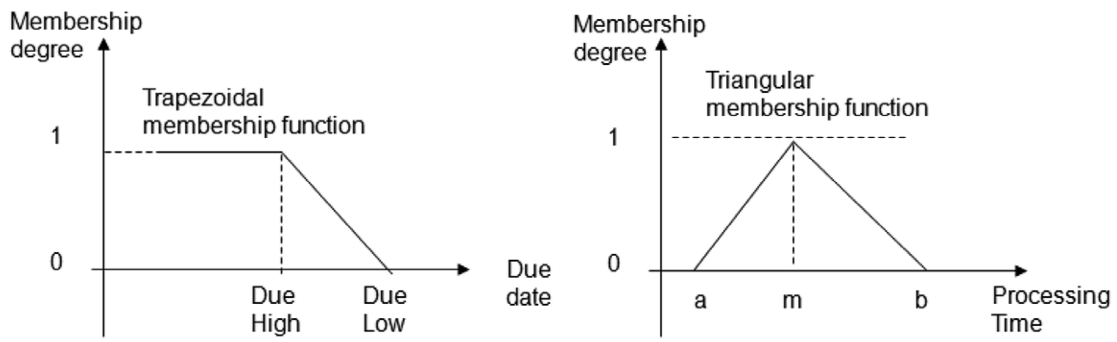


Figure 5: Exemplary Fuzzy Membership Functions for Due Date and Processing Time



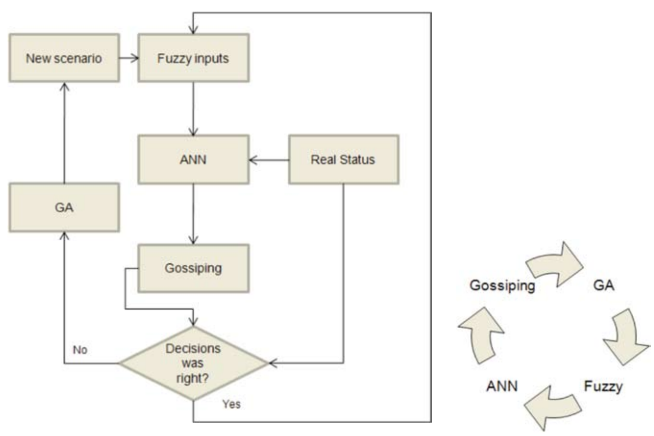
one's decision optimization. Within inbound logistics, Lpallets can undertake some parts of shop-floor problem like: minimizing the throughput time, number of tardy jobs, total idle time of machines, inventory, etc (for example see Figure 4). These can be optimized by employing the advantage of cyclical pallets (closed-loop), applying the outputs of ANN (and the same), and optimization of GA.

Another tool for characterizing the uncertainty and stochastic nature of practical applications in logistics is the fuzzy set theory. It is obvious for practitioners that very often processes and due dates are stochastic with imprecise information. This induces uncertainty into material flow systems which is usually neglected in off-line planning and scheduling. Fuzzy logic, by profiting from fuzzy rules, compromises the existing uncertainties and ambiguity in available data of processes. Fuzzy logic suits to vague or ill-defined problems which is an inevitable characteristic of distributed and imprecise information for autonomous objects. Usually a fuzzy system has fuzzy inputs and fuzzy outputs, each of which is associated with a fuzzy set. The fuzzy sets could be linguistic terms or the same that represent no crisp value in the sets. Since most controlling features require crisp values for other calculations, two filtering processes, called fuzzification and defuzzification, are used in input and output of the system to transform the crisp values to fuzzy ones and vice versa. The fuzzy system is commonly a combination of (fuzzy) rules. The rules have two parts: antecedent and consequent that in antecedent fuzzy operators (And or Or logics) are used. Mapping inputs to outputs is the duty of them. In summary, fuzzy inference process is a combination of five sections: fuzzification of inputs, implication from the antecedent to the consequent, aggregation of the consequents across the rules, and defuzzification of the outputs [23]. For example, to promise to an incoming order with a fuzzy due date (due date with tolerance), called (ATP), the agreement index of the respective due date's membership function with the membership function of production process can be calculated (see Figure 5). This index shows whether we are capable of accepting this order with a due date or not.

However, a supply network consists of inbound and outbound logistics that affect processes of each other. For instance, production sequencing in inbound logistics requires integration with outbound logistics to eliminate long waiting time after production and before delivering products [25]. As explained, integration of all processes is a controversial issue in supply networks. Rather, the members are willing to work autonomously and not integrating all processes based on the plan of a center. Nonetheless, the proposed solution for this problem is to benefit from an integrated optimization modeling by mathematical programming for long- and mid-term planning as well as decentralized controlling by autonomous entities for detailed scheduling. This strategy is accountable when the mathematical model can apply constraints with "unknown-but-bounded coefficients" and "probabilistic constraints" [26]. This gives an interval to each constraint or parameter which resembles the boundaries of fuzzy values. Of course, bounded freedoms to constraints or parameters facilitate planning of uncertain processes in detailed control and schedules. In addition, fuzzy values can be used directly to optimization models in order to cover vagueness in information. For solving such models, they are transformable to forms of integer programming. Regarding [27], real situations are mostly not deterministic with crisp values. This is because of incomplete perception of required detailed data by human beings. Accordingly, within a logistic system with existing autonomous units lack of information about the performance manner of the units is common, but predictable and controllable.

In conclusion, combination of fuzzy sets with GA and ANN enhances the process of learning and improves the perception of the practice, while decreasing the errors of decisions (see Figure 6) [22] [24]. This study is being continued by the author at the Bremen University as a part of PhD research.

Figure 6: Flow of Information Between Methods and Techniques to Render the Best Decision



This algorithm may be changed regarding new findings and practical experiences.

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Feasibility of Autonomous Logistic Processes by Reconfiguration of Business Processes

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Temperature Prediction Inside a Refrigerated Food Container

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Perishable goods in transportation are at risk of suffering quality degradation during transportation. The preservation of their quality is more critical when they have to be shipped overseas, which is very common nowadays due to international trade agreements. During such a long trip the main concern of logistics companies is to control and monitor the ambient conditions of goods inside the containers which determine the ripening state. The present paper is an excerpt from the winner of the Best Paper Award in the area of Intelligent Control Systems and Optimization at the 7th International Conference on Informatics in Control, Automation and Robotics (ICINCO); it proposes an alternative method to predict the temperature profile in a spatial point of the interior of a refrigerated container with the aim of improving the logistics of perishable goods.

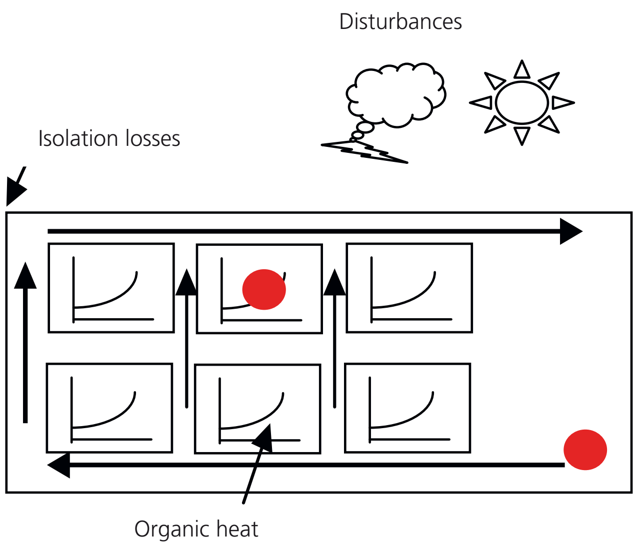
Introduction >>> Research has been done in the past to estimate the temperature profile inside refrigerated containers; usually the focus is put on the cold air flow as the main factor governing the temperature pattern inside a container and the effects due to the cargo presence are estimated. In this paper an alternative Single-Input Single-Output (SISO) grey-box model is presented 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 model provides a meaningful description of the factors involved in the physical system including the effect of transporting foods such as fruits and vegetables. The starting point is based on the physical relations; subsequently, a tuning parameter for the specific case of bananas is found via simulations. <<<

Model of the System

The factors affecting the temperature distribution inside a refrigerated container are illustrated in Figure 1. The cold air flows from bottom to top through the gratings in the floor and through the spaces between the pallets, and is eventually drawn off the channel between the pallets and the container ceiling.

A naive representation of the container can be done via a SISO linear dynamic system in which the input is the air supply and the output is the spatial point of interest. However, in reality it is only a simple model of the main contributor to the temperature pattern, the air flow. Several other factors affect the speed of the cooling . To improve the accuracy of the model, other contributors are considered as well: first is the heat, produced by respiration of foods such as fruits and vegetables; second is the thermal loss, affecting the correct cooling of the goods; finally, unpredictable temperature variations due to highly changing external climatic conditions during transportation.

Figure 1: Factors Affecting the Temperature Inside a Refrigerated Container

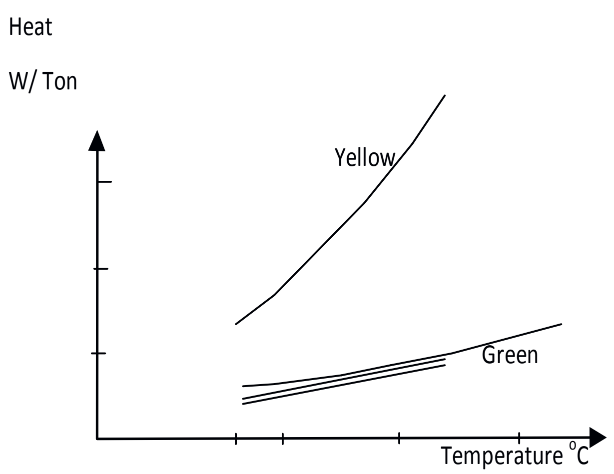


A linear SISO black-box model H represents the air flow. An attenuator, α models the isolation losses of the air supply temperature and is modeled to affect the input of the dynamic system. The external climatic conditions are unknown in advance, and are therefore considered a Moving Average (MA) process.

To model the organic heat, it is necessary to use experimental data. Figure 2 (Mercantila, 1989) shows the curves for organic heat in the case of bananas. A proportional relationship between the organic heat and the rippening state is observed.
Equation 1 represents the organic heat relation with respect to the temperature. P_{fruit} is the heat production in Watts, γ is a constant which is fixed for a certain type of fruit and rippening-state in 1/°C, T is the fruit temperature in °C, and β is a scaling factor which depends on the amount of food and is given in kilograms.

$$P_{fruit} = \beta e^{\gamma T} \qquad (1)$$

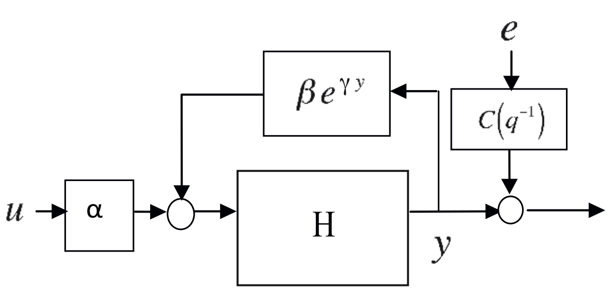
Figure 2: Heat Production of Bananas



Finally, the block diagram to represent the input-output relations of all the factors is built. It is shown in Figure 3. The air flow dynamics are represented as a feed-forward block as it is the most important contributor. The isolation losses affect the correct cooling of the goods before the dynamic system and the noise effect have an additive effect on the output.

The contribution of the organic heat depends on the cooling temperature inside the container. Simultaneously, it has a small additive effect on the input of the linear dynamic system as the air flows through the pallets and is slightly warmed. It is represented by a static exponential feedback. The resulting block diagram, in which a linear dynamic system has a non-linear feedback, corresponds to a Feedback-Hammerstein (FH) configuration (Guo, 2004).

Figure 3: Model of the System



Parameter Adaptation Algorithm

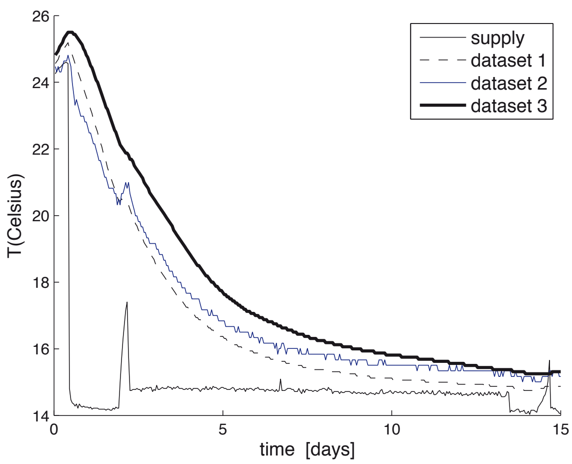
In missing word (Guo, 2004) a Parameter Adaptation Algorithm (PAA) was developed to identify the parameter setting of a FH system. It considers the non-linearity as a polynomial order; however, the dimensions of the matrices in the algorithm would be significantly too large to be applied on platforms where power consumption is an important figure of merit.

To reduce the dimensions of the matrices, it was proposed to use the exponential Equation in Equation 1 instead. γ is to be determined and it remains constant, while β is a parameter to be identified as it depends on the amount of fruit being transported.

Prediction Algorithm

The predictions are made using the estimated parameters in the model. Figure 4 shows experimental datasets from a container transporting bananas. It can be observed how the air supply is kept constant after some days. For the prediction algorithm, $u(t)$ is set to the value of the last sampled input temperature of the parameter adaptation process. Similarly, the initial predicted output value is set to the last acquired value of the output.

Figure 4: Banana Datasets

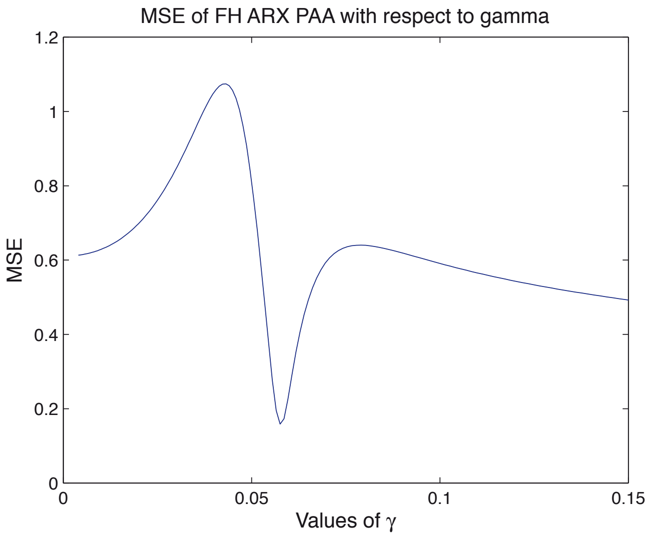


Determination of γ

To find a trustworthy γ parameter that characterizes the respiration heat of bananas. The presented Feedback-Hammerstein model of linear order one and the FH parameter adaptation and prediction algorithms are run using given experimental datasets. The Mean Squared Error (MSE) of the prediction over n samples, equivalent to fifteen days, is stored for several values of γ and a fixed number of training days. If the stored values of the MSE are plotted, the local minimums are determined by the observation of the MSE vs. γ curves. In Figure 5, it can be seen that in the above-mentioned plot for five days of training and for the dataset 1, a local minimum exists for a value γ of 0.0587.

$$MSE = \frac{1}{n}\sum_{t=m}^{n}\left(y_{real}(t) - y_{pred}(t)\right)^2$$

Figure 5: Prediction Accuracy vs. γ

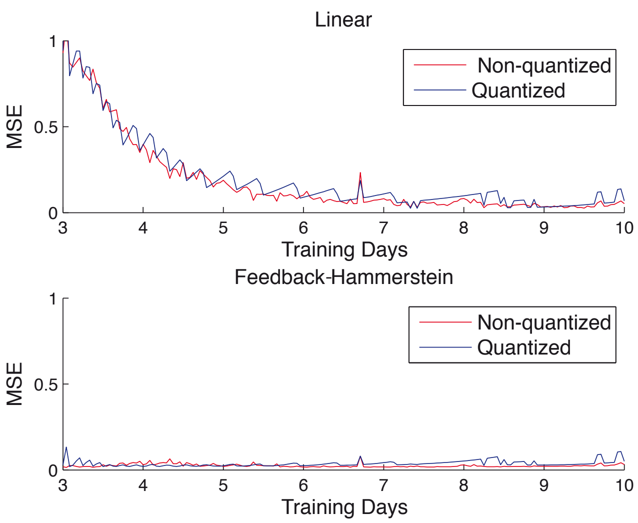


Results

For validation of the model and the algorithms several figures of merit are considered. The accuracy and the speed of convergence are of paramount importance; however, quantization robustness is also highly desirable. To observe the speed of convergence and the accuracy of the predictions with respect to the number of training days, parameter estimation and a prediction in Matrix form are done for a fixed number of training days. Subsequently, MSE vs. Training days graphs are plotted.

Simulations were done for two types of datasets. First, the experimental data of bananas were used to include the presence of organic heat. Secondly, the datasets corresponding to a cheese experiment, which does not present organic heat, were considered.

Figure 6: Comparison of FH and Linear Methods in the Presence of Organic Heat.



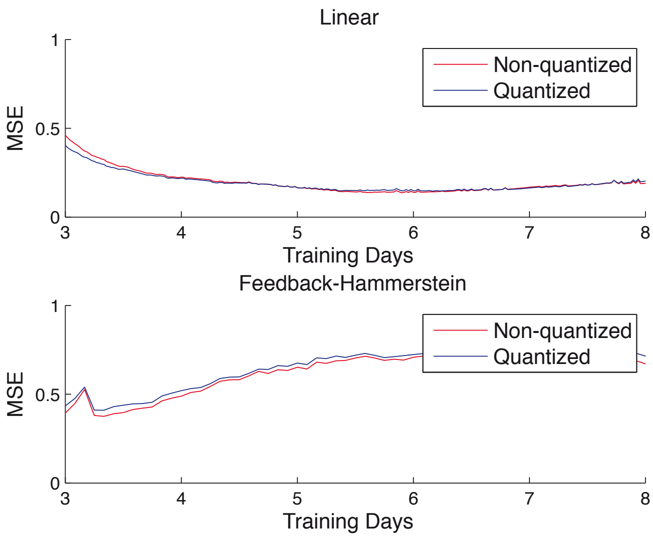
FH vs. Linear Models in the Presence of Organic Heat

From the simulations it can be observed in Figure 6 that if linear methods are applied to the banana datasets, the accuracy of the results for different sensor positions of are not sufficient. It can also be observed that FH identification algorithms are the best way to achieve fast convergence speeds. In the best cases, less than 3 days of training are sufficient to achieve good predictions.

FH vs. Linear Models in the Absence of Organic Heat

In the case of a cheese dataset, the linear methods accuracy results are better than those of the Feedback-Hammerstein as can be observed in Figure 7.

Figure 7: Comparison of FH and Linear Methods in the Absence of Organic Heat.



Prediction Improvement

The described approach was originally developed based on an experiment in 2008 with records for 3 sensors (dataset A). Two new datasets with 16 sensors each, which were recorded in 2009 (Jedermann, 2010) in two separate containers (data set B and C), were used to cross validate the approach.

The previously obtained value of γ equal to 0.0587 is used to predict the temperature inside the containers for many spatial positions. The results are summarized and compared in Table 1. A good average is observed for the three containers; however, in some positions the predictions are not as accurate as can be seen in the Maximum column.

A second approach is to select γ according to the position of the pallets inside the container. The method to find γ, previously described, is applied to all the new container datasets. It can be observed that an improvement in the accuracy of the predictions can be made if two different values of γ are selected: one for pallets close to the door-end, and one for pallets close to the reefer supply. In Table 2 the prediction results are summarized if values of 0.0525 and 0.055 are set respectively.

Table 1: MSE Prediction Results for a Unique Value of γ

Container/Result	Maximum	Minimum	Average
Dataset A	0.1893	0.0173	0.0778
Dataset B	1.4558	0.0550	0.4130
Dataset C	0.8888	0.0101	0.2798

Table 2: MSE Prediction Results for Values of γ According to the Position Inside the Container

Container/Result	Maximum	Minimum	Average
Dataset A	0.1893	0.0173	0.0778
Dataset B	0.4767	0.0279	0.0946
Dataset C	0.5747	0.0201	0.1743

Conclusions

A model to represent the factors affecting the temperature inside a refrigerated container transporting perishable goods was proposed. It models the effect of organic heat using a static non-linear feedback system, the refrigeration via a linear dynamic feed-forward system, and the disturbances by stochastic processes. This complex model can provide an accurate description of the factors involved in the physical system.

The non-linear exponential function is used instead of a polynomial one to preserve the simplicity of the parameter adaptation and the prediction algorithms. The disadvantage of the simplification is that depending on the kind of fruits to be transported, it is required to tune the algorithm via a correct selection of γ which has to be known in advance. An improvement can be observed in the accuracy of the predictions if γ is set according to the position of the pallets inside the container.

From the simulation results it is concluded that the FH identification algorithm is efficient when the cargo emits organic heat. The method of FH is optimal to achieve all figures of merit. However, if the linear method is applied to the banana datasets, a comparable accuracy can only be achieved after more than five days of training. Also, it is concluded that when the goods to transport are free of organic heat, such as in the case of cheese, it is preferable to use a linear system instead.

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A Methodology to Control the Delivery Time Uncertainty in Dynamic Supply Networks

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Supply network management adopts a systematic and integrative approach to managing the operations and relationships of various parties in a supply network. The objective of the manufacturers in their supply network is to reduce inventory costs and increase customer satisfaction levels. One way of doing that is to synchronize delivery performance. A supply network can be described by nodes representing the companies and the links (relationships) between these nodes. Uncertainty in delivery time depends on type of network relationship between suppliers. The problem is to understand how the individual uncertainties influence the total uncertainty of the network and identify those parts of the network which has the highest potential for improving the total delivery time uncertainty. This paper could highlight the problem in this area and explain the whole methodology for solving this problem.

Introduction >>> Today, companies are persuaded to collaborate with each other in a collaborative manner. Isolated companies may not be competitive any more in the current business environment. They may configure several types of networks in order to become successful and survive in the market.

By creating supply chains companies have established their primary format of working together to achieve a unique target. This target has been preferably the profitability of the original equipment manufacturer (OEM). In order to achieve the competitive benefits of more shares from the transmit market, the manufactures have to work in flexible forms of networks with their suppliers and customers.

A supply network (SN) can be viewed as a network of facilities in which customer orders flow through various business processes, such as procurement, supply, and production. Ultimately, it achieves the target of delivering the right products to the right customers in the right quality on time. In other words, the supply network adopts a systematic and integrative approach to managing the operations and relationships of the various parties in a supply network. One of the objectives of SN planning is to reduce inventory costs and increase the customer satisfaction levels.

A supply network consists of a specific number of suppliers and a manufacturer which represent nodes in a network. Hence, SNs interconnect companies such as suppliers, and a manufacturer to produce and sell desired products to customers.

One of the important goals of supply network coordination is to synchronize all processes to improve delivery performance. Thus, appropriate modeling and analysis techniques are important aspects of improving supply networks. For example, accurate supply network lead time and order-to-delivery time are important. In this paper a method for increasing the delivery performance with decreasing the uncertainty in delivery time is introduced. <<<

Literature Review

Modern markets are competitive business environments where customers require their suppliers to be dependable in delivering on-time. One of the important goals of a supply network is to improve delivery performance [2], [14]. Results from recently published empirical studies have identified delivery performance as a key management concern among supply network practitioners (see for example [8], [13]). A conceptual framework for defining delivery performance in a supply network is found in Gunasekaran et al. in 2001. This suggested framework classifies delivery performance as a strategic level supply network performance measure while delivery reliability is viewed as a tactical level supply network performance measure. The framework of Gunasekaran [7], [10] also advocates that to be effective, supply network management tools, delivery performance and delivery reliability need to be measured in financial (as well as non-financial) terms.

The failure to financially quantify delivery performance in a supply network presents both short-term and long-term difficulties. In the short term, the buyer–supplier relationship may be negatively impacted. A norm value of "presumed" performance is established by default when delivery performance is not formally measured [9]. This norm value stays constant with time and is generally higher than the organization's actual delivery performance.

It has been demonstrated that supplier evaluation systems have a positive impact on the buyer – supplier relationships and these relationships ultimately have a positive impact on financial performance [1]. In the long term, failure to measure supplier delivery performance in financial terms may impede the capital budgeting process which is necessary in order to support the improvement of supplier operations within a supply network.

Delivery time is defined to be the elapsed time from the receipt of an order by the originating supplier in the supply network to the receipt of the product ordered by the final customer in the supply network. Delivery time is composed of a series of internal (manufacturing and processing) times at each stage plus the external (distribution and transportation) times found at various stages of the supply network [6].

Early and late deliveries introduce waste in the form of excess cost into the supply network; early deliveries contribute to excess inventory holding costs, while late deliveries may contribute to production stoppages costs, lost sales and loss of goodwill. To protect against untimely deliveries, supply network managers often inflate in process inventory levels and production flow buffers. These actions can contribute to excess operating and administrative costs [5], [15].

An extensive review of available delivery evaluation models by Guiffrida (1999) identified several shortcomings in modeling delivery performance. These concerns are threefold. First, delivery performance measures are not cost-based. Second, delivery performance measures ignore variability. Third, delivery performance measures often fail to take into account the penalties associated with both early and late deliveries. The inability to translate delivery performance into financial terms which incorporates uncertainty as well as realistically quantifying delivery timeliness (early as well as late delivery) hinders the management's ability to justify capital investment for continuous improvement programs which are designed to improve delivery performance.

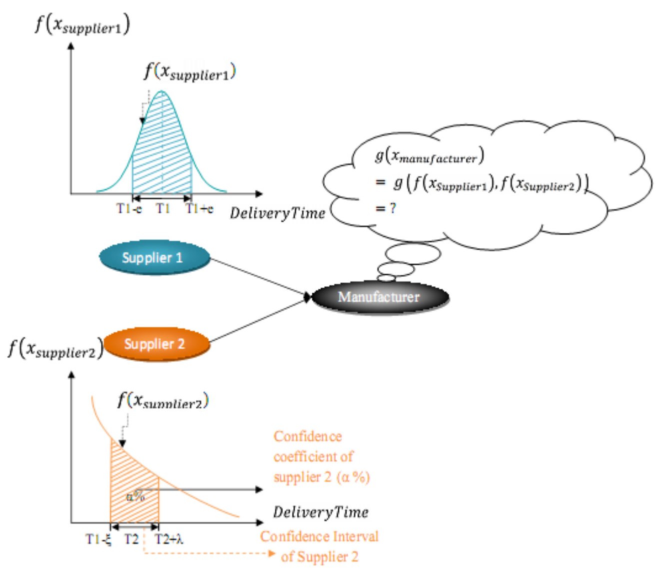
Problem

Delivery time uncertainty within a supply network can be understood as the ability of the network to guarantee a certain percentage of deliveries within a defined time frame. In Figure 1 the delivery uncertainty is presented in a qualitative way.

The delivery time uncertainty of a supply network is caused by the individual delivery time uncertainties of the members of the network. To be able to estimate the delivery time uncertainty of the entire supply network, the impact of these individual uncertainties on the total uncertainty level has to be understood. The way how the individual uncertainties need to be accumulated depends on the network type.

Formally, a supply network can be described by nodes representing the companies and the links (relationships) between these nodes. From this perspective, a network type is defined as the structure how the different nodes are linked with each other. Figure 2 depicts the possible basic types of a network. Generalized networks can be described as a combination of these basic types.

Figure 1: Delivery Time Uncertainty



The problems are:

- To identify how the individual delivery time uncertainties of the members in a supply network need to be accumulated to the total delivery time uncertainty for different network types.
- To understand how the individual uncertainties influence the total uncertainty of the network.
- To identify those parts of the network which have the highest potential for improving the total delivery time uncertainty

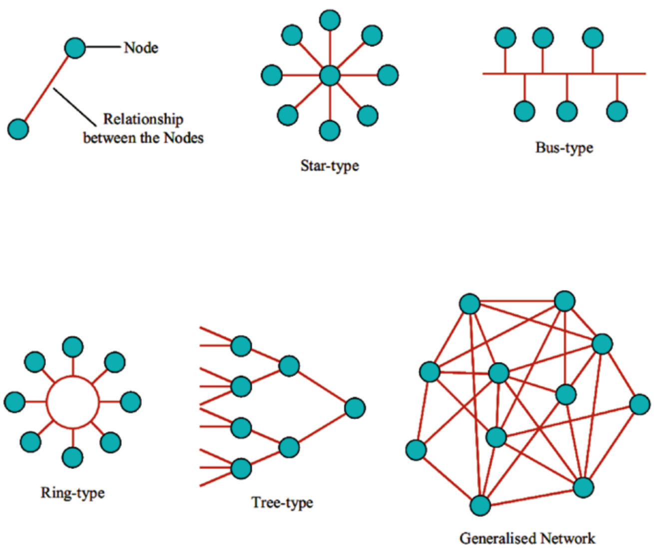
Methodology

The proposed method tries to identify how the individual delivery time uncertainties of the members in a supply network need to be accumulated to the total delivery time uncertainty for different network types.

Considering the description given, uncertainty in delivery time depends on the type of network. The manufacturer may evaluate the individual delivery time uncertainties of each single constituent (supplier); the problem is to understand how the individual uncertainties influence the total uncertainty of the network. The knowledge about the interdependency between a network type and the accumulation of the individual uncertainties is important to identify those parts of the network which have the highest potential for improving the total delivery time uncertainty.

The suggested methodology and procedure is based on the following steps. First, the causes and effects of "time uncertainty" in each supply network will be studied. Second, introducing the distribution functions definitions, interval confidence and confidence coefficient of delivery time for each supplier of the network while paying attention to the past information. Third, identify the shape of curve for each statistical distribution functions of each supplier in the supply network. By choosing different types of relationships between suppliers and manufacture find the best type of relationships for the supply network while paying attention to sensitive analysis on delivery time.

Figure 2: Basic Network Types [11]



Conclusion

The objective of this paper was to introduce a methodology to control the delivery time uncertainty of supply networks considering different types of networks. Superposition rules for the different basic network types will enable an estimation of the delivery time uncertainty also for more general network types. To achieve this objective, the following aspects should be solved:

- Identification of effects of each node in a supply network on the final uncertainty in delivery time dependent on the network type.
- Identification and mathematical description of typical statistical distributions of delivery time of each supplier
- Calculation of the interval confidence and confidence coefficient for delivery time uncertainty for each supplier in the network (local uncertainty) and its accumulation to the total uncertainty level

The further contribution of the study was the development of a methodology to identify those parts of a network where local improvements have the largest effect on the total uncertainty level.

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Data Collection and Management of Wireless Sensor Networks

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Currently, many specialized tools used to monitor and control sensor networks are addressed separately. In this paper, a framework of a component-based tool, named WiSeCoMaSys, is presented to combine the data monitoring from sensor networks, network management and measurements in one system. WiSeCoMaSys helps developers debug their network deployments easily in many scenarios, especially in logistics by leaving an open architecture for modification and integrating a set of special configuration in logistic services such as localization techniques and context-awareness. For monitoring data, this tool provides operators a user-friendly GUI to collect data, analyze the results and visualize the understandable reports in tables, and charts for their applications. Meanwhile, operators can change a variety of parameters at any layer of the sensor node architecture to response to network changes or optimize the performance. Moreover, a set of statistic functionalities are also integrated in this tool to measure the real time status of the entire network for management. With an open based architecture, WiseCoMaSys is believed to be a promising tool for evaluating the performance of sensor networks

Introduction >>> With the development of digital electronics, low-cost, low-power, distributed processing sensor nodes have been proposed for use in a wide range of applications such as environmental monitoring and environment observation. Sensor nodes are electronic devices which typically contain sensors, a microcontroller, a radio communication chip and other peripherals. They can communicate with other nodes to form self-organizing WSNs. Featuring sensing, computation and communication capabilities, such as ad-hoc networking and distributed processing, WSNs allow telemetry, information collection and information management which can be suitable for many applications.

Different from other networks, the monitoring of WSNs involves monitoring both network state and sensing parameters. Besides, controlling WSNs includes controlling the network configuration and the settings of sensing applications. Hence, the need of an integrated powerful tool to monitor the whole sensor network and also manage their configuration is indeed necessary.

Much research has been done to develop the tools to monitor the status of sensor networks and also control network configuration. MViz [2] is a TinyOS v.2 [18] tool which is used to display the data visually. However, this tool can not configure the deployed networks. Surge [3] is another tool which is only used in TinyOS v.1. It allows users to display the connectivity of networks and does some simple configuration, such as putting sensor nodes in sleep mode and changing the data sampling frequency. Octopus [1] is an advanced solution to address the disadvantages of MViz and Surge. It supports three operation modes for sensor nodes. Users can log the data packets for analysis or reconfigure the network with new parameters. However, Octopus is a general tool, so it can not support context-aware sensing application and localization configuration which are useful for logistic services [6] [7]. Moreover, statistics parameters of the deployed networks, such as packet reception rate (PRR) or end-to-end delay, which are necessary for performance optimization and evaluation, are also not supported. SWAT [4] is integrated with SQL server to enable users to measure the performance of sensor networks and visually display the results in reports. PermaSense [18] is a web-based application which allows users to view the live data from their deployments without network management.

Borrowing ideas from SWAT and Octopus, this paper develops a component-based tool which allows users to collect the data packets from sensor network for analysis. It also measures the statistic parameters such as PRR, end-to-end delay which Octopus does not support. Although this tool is designed to target the requirements of logistic services, developers can easily add or modify this tool based on their applications because it is designed in separated and open components.

This paper is structured in 5 sections: section 1 is the introduction to the scope of this paper, the description of the WiseCoMaSys architecture is discussed in section 2. Section 3 describes the functionalities and formats of packets. Finally, conclusions are given at the end of this paper. <<<

Wireless Sensor network Collection and Management System (WiSeCoMaSys)

WiSeCoMaSys, as its name, is a tool which can be used to pull the data out of sensor networks, visualize the received data and manage the networks over the air from the user's side. In order to integrate the monitoring, measurement and management in one system, the goals of our design are the following:

- Modularizing components of the design software for easy modification
- Visually viewing the live network topology and related metrics, such as link quality and hop count.
- Collecting distributed data from network and analysis.
- Supporting context-aware sensing applications.
- Centralized management and control per sensor node in each layer. All the decisions of changing network parameters have been made by WiSeCoMaSys which has a comprehensive view of the whole network.
- Visualizing collected data in tables, graphs at any time scale.
- Logging data to file for complicated analysis.
- Measuring statistics parameters such as packet reception rate, message rate, etc …
- Running at the gateway or via internet. The gateway is a device which bridges the information between sensor network the outside world (e.g. IP network).
- Supporting alert to users by e-mail or SMS.

WiSeCoMaSys has a high-level tool developed in Java and an embedded nesC-based [15] application uploaded onto the sensor nodes and the gateway. The architecture of WiSeCoMaSys is shown in Figure 1.

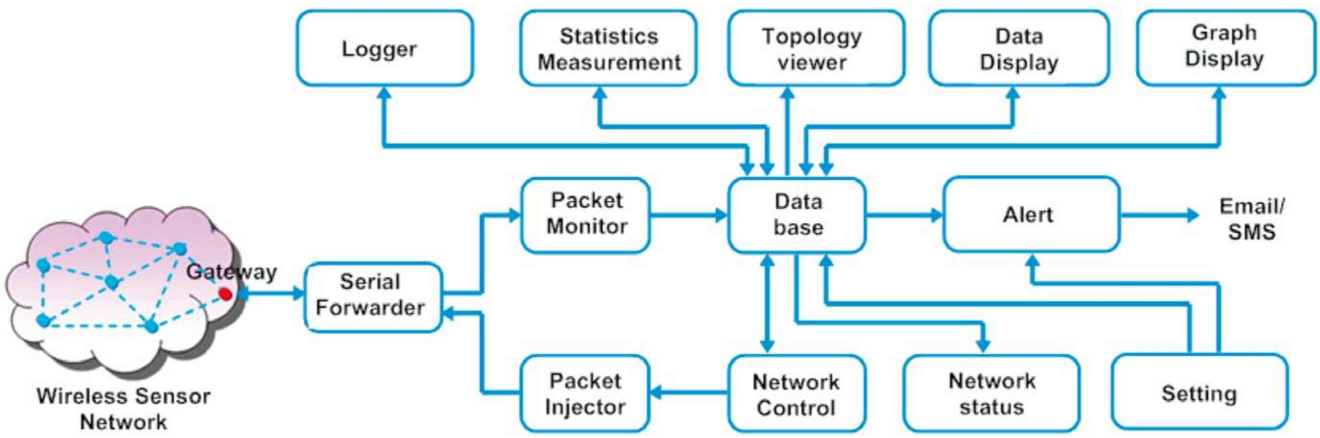
This architecture includes the following main parts :

- Packet Monitor component which listens to the serial port for incoming packets from a sensor network. When it receives a packet, it will update the database based on the type of the packet (data packet or control packet).
- Packet Injector component which puts the required command from Network Control in a request packet and sends this packet to the destination node.
- Database component which stores all information of nodes and interfaces with other components.
- Alert component which checks the pre-defined conditions and sends warning messages to users when a condition is matched.
- Logger component which records all pre-defined values of nodes to a file after the database is updated.
- GUI has many panels to provide the interface between users and network. It includes the following parts:
  - Statistics Measurements contains processes which calculate packet reception rate, message rate, etc…
  - Topology Viewer displays the topology of network with related metrics.
  - Data Display shows all the information extracted from packets and measurement in a table.
  - Graph Display shows the user-understandable values after analysis, such as temperature, humidity or battery of each node in charts. The open source library JFreeChart [19] is integrated to our tool to provide an advanced graph display.
  - Network Control allows users to manage each node by sending specific commands to that node.
  - Network Status displays the status of network and configuration of nodes
  - Setting is the interface where users can change the parameters of logging process; customize display parameters of network topology, etc …

WiSeCoMaSys can be used in many applications, such as:

- Habitat monitoring [14]
- Environmental condition monitoring in data warehouses or storages or harbors [5].
- Tracking and monitoring logistic items inside containers [10][16].

Figure 1: Architecture of WiSeCoMaSys



Collection, Measurement and Management

Data collection

Data collection is an important feature because most sensing applications need to transmit sensing physical parameters from a node located in a specific place to the gateway (base station). The embedded application running in sensor nodes uses the multi-hop opportunistic routing protocol in [5] to forward packets from originating nodes to the gateway via intermediate nodes and these packets will be captured by WiSeCoMaSys. It also supports configuring context-aware sensing applications in [6] and the localization techniques in [7]. There are two kinds of messages used for data collection in networks: data packet for collecting the sensing values from sensor nodes and control packet for replying a request from users. These packets contain both the sensing values and the management information for WiSeCoMaSys to build the network state.

Data Packet

The format of data packet includes the three following parts:

- Routing information has several fields for routing:
  - Sink (2 bytes): the address of the destination sink
  - TTL (time-to-live) (1 byte): used to eliminate loop problems in the network.
- Application information contains the following fields:
  - Mote (2 bytes): the address of sensor node which originates this packet. This field is also used by routing layers for cycle suppression.
  - Sequence (2 bytes) is used to recognize and avoid duplicated packets.
  - Time (4 bytes) is a time stamp embedded in each message to indicate the global sending time.
  - Type (1 byte) indicates if the receiving packet is a data packet or control packet.
  - Reading (8 bytes) is used to transmit temperature, humidity, light and internal voltage of sensor nodes. This field is based on four sensors of TelosB mote [10].
  - Position (6 bytes): the location of the sender, which is given by the distributed localization process in [7].
- Management (10 bytes) contains the information for building the view of network topology, such as hop count, next-hop node; receive signal strength [5].

Control Packet

Because the direction of data packets and control packets are the same (from sensor nodes to gateway), control data can be put in the data packet format with a specific reply mask. When a node receives a request, if the command in this request needs a reply, it will put the corresponding information in the data packet and a specific value of that request in the Reply field to complete a control packet. Then it sends this packet to the gateway using routing protocol. Based on the Reply field, WiSeCoMaSys can extract the information in the receiving control packet correctly.

Data collection can be also used for debugging, such as tracing a variable in a process of a node. Traditionally, LEDs (integrated in motes) and JTAG interfaces are used for debugging. However, these methods are difficult to perform in a large network deployment. With WiSeCoMaSys, developers can declare any field in the header of data packets to carry debugging information. At the gateway, WiSeCoMaSys will capture and display this debugging information easily.

Statistic Measurements

In order to have a deep understanding of the running network, besides the real time status information collected from the network, the Statistics Measurement module also provides some useful statistic parameters that need to be measured over a longer period. These parameters are necessary for users to evaluate the performance or optimize the configuration. Table 1 shows the explanation of these statistic metrics.

Management

In flat WSNs, WiSeCoMaSys can access WSNs via a gateway which bridges the information between WiSeCoMaSys and the WSN. Looking from the outside, each sensor node in a network has a management service which is responsible for managing the node configuration (shown in Figure 2). This service communicates with WiSeCoMaSys using requests and replies and it works as a part of the application in a sensor node. The management information could be local node status, link quality, node configuration, etc…

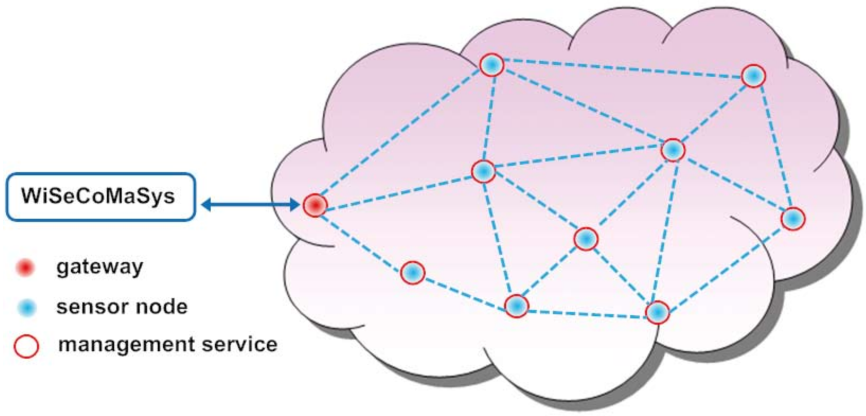
Command Dissemination

Reconfiguration of the network requires sending information from the gateway to nodes inside sensor network. The configuration is put in a specific command for dissemination. To send a command from WiSeCoMaSys to the network, the request packet is used for this purpose to carry a command from the user's side to a specific

Table 1: Parameters Measured by WiSeCoMaSys

Metric	Explanation
Packet Reception Rate (%)	The ratio between the number of successful receiving packets over the number of sent packets
Packet rate (message/s)	The number of packets received in a second
End-to-End delay (ms)	Delay between the time of sending this packet and the time of receiving this packet at WiSeCoMaSys
Hop count	Number of intermediate nodes which a packet has to travel through to reach WiSeCoMaSys
Power consumption (mW)	Power consumes in a sensor node
Remaining battery (%)	Remaining capacity of two AA batterieswhich supply power for each node

Figure 2: WiSeCoMaSys and Management Service in Flat WSNs



node using [17]. The command can also be sent to a group of nodes or all nodes in the whole network based on the selection from the user. For reliable node configuration, a command can require a reply from a node.
The format of the request packet has the following fields:

- Address (2 bytes): the address of the destination sensor node. If the address is a broadcast address, all nodes can receive this packet and process it.
- Request (1 byte) is used to identify the command. This field supports 256 commands.
- Parameter (8 bytes) contains the parameter information needed for the command. Many parameters can be mixed to be fixed in this field, such as context-aware rule [6].

Table 2 shows the configuration which can be changed by commands at each layer. There are also commands to retrieve the configuration of each node from the sensor network.

Alert Mechanisms

WiSeCoMaSys also has an interface for users to configure the alarm settings using logical conditions. These alarms are set for each sensing value and will trigger a corresponding action when the conditions are matched. The actions can be set as followed if the condition is matched in a given period of time:

- Show a message on the screen
- Send an alert e-mail to a specific address list
- Send an alert SMS to a mobile number

Remote Access Over Internet

In some scenarios, users want to access the sensor network from a remote location. For example, if the sensor network is deployed inside a container to monitor the environmental conditions of packages, the user can access the network via infrastructure networks (e.g. WLAN, GPRS). WiSeCoMaSys supports remote communication by using multiple serial forwarders [8] which work as a client-server model.

Table 2: Configuration Supported by WiSeCoMaSys

Layer	– Configuration
PHY	– Power level settings – Radio channel
MAC	– Sleep/awake duty cycle [13] – Soft/hard-Acknowledgement [12] – Address recognition [9] is used for snooping data
Routing	– Beacon power [11] – Beacon period [5]
Application	– Data sampling period – Auto/Query / Context-aware mode [1] [6] – Context-aware rules [6] – Awake/sleep mode [1] – Localization parameters, localization techniques [7] – Number of transmission retries and retry delay – Time synchronization [5] – Reset network/nodes remotely – Logistics information (package, container) if sensor networks are deployed inside container for tracking logistic items [5] – Sensing services provide which sensors are available in nodes and can be used for measurements. – Configuration memory: the optimized configuration can be saved to the flash. Nodes will retrieve this configuration when it boots

Conclusion and Outlook

In summary, this paper presents an advanced tool, WiSeCoMaSys, to monitor, analyze, visualize and manage sensor networks. With the help of this tool, it can be believed that developers can save time in debugging and testing their deployments. Having a rich set of features, it also allows users to evaluate the performance of their applications easily.

The web-based feature is an open direction for future work to allow users to access their deployments through HTTP protocols. Adaptive control is also an interesting issue for improvement. Based on the network information collected, WiSeCoMaSys can automatically perform necessary computation and adjust the reconfiguration for nodes to enhance a better performance.

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Sustainable Development Issues and Strategies for Freight Village

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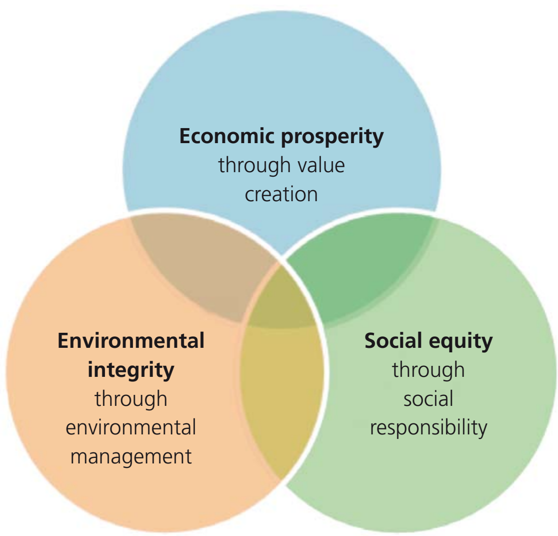
Since constructing a freight village requires large scale land usage, systematization of logistics activities, and reaction to environmental and economic problems, recent developments in freight villages show an increasing trend towards sustainability. While the freight village has emerged and boomed in its significant position in supply chains, the goal of attaining sustainable development has become a predominant issue in international environmental and development policy. Combining the sustainable development of three perspectives and functional activities within the freight village, this paper discusses the sustainable development issues for the freight village and suggests strategies for its long-term survival.

Introduction >>> With the background of global economic integration and rapid economic development, the logistics industry is increasingly becoming a pillar industry of the national economy and a new economic growth point. Dynamics in logistics industry such as trade barriers have been decreased, but the logistics services requirements as well as cost are constantly rising. They are searching for industrial and logistics areas where repacking, labeling, bar-coding, light assembly and other value-added services to merchandise in transit can be provided. The freight village does fulfill such needs. It initially emerged in Japan and nowadays the freight village concept is most commonly connected with distribution centres, central warehouses, transport nodes, logistics platforms, freight/transport terminals, logistics centres, districentres etc. The Euro-platform EEIG defined it as "a hub of a specific area where all the activities relating to transport, logistics and goods distribution – both for national and international transit – are carried out, on a commercial basis, by various operators" [1].

In recent years, climate change and environmental concerns about logistics issues have been increasingly discussed and such "environmental / sustainable development / green issues" are the main concerns of the present paper. As one of the most widely used expressions in the context of economy, environment, and society, sustainable development is a response to the mining of natural resources for the benefit of corporations and organizations that has advanced the need for long-term environmental management [2]. Figure 1 shows that the core idea of sustainability is the integrative consideration of the environmental, social and economic performance of society on the macro level as well as of the company on the micro level (Bansal, 2005) [3].

This paper introduces the concept of a freight village as an integral part of a logistics system reacting to environmental problems and economic limitations related to long-distance and regional freight traffic which has created a need for a sustainable way to manage the logistics activities. <<<

Figure 1: The Integrative Concept of Corporate Sustainability (According to Bansal, 2005)



Sustainable Development Issues in the Freight Village

Traditionally, logistics operation mainly concerns a single objective function such as cost minimization or profit maximization. Nowadays, sustainable development as well as environmentalism appear as key issues facing logistics operation. For example, the literature has made more frequent references to "reverse logistics", "sustainable supply chains", "green logistics", "ecological freight village"…all issues relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials, and disposal" [4]. Consideration of the wider objectives and issues connected with green logistics leads to new methods of working and new models, some of which pose interesting new applications for operational research models of various types [5].

Sustainable development of the freight village refers to a balance between the capacity of logistics services for the economic society's development and the safeguard of the natural environment. It is one of the ideal objects for regional logistics industry which can not only save social circulation capital and resource, but also improve the efficiency of resource deployment. It would bring all-round benifits from the following issues in the context of sustainable development: (1) Producing and distributing goods in a sustainable way, e.g., inter-modal shipping; (2) Reducing the energy usage and waste in logistics activities, such approaches as "researve logistics, circular economy" correspond to this aspect. (3) Implementing technological reform and innovation, especially the adoption of technological solutions considering eco-balance for designing and planning of freight villages, using green energy and improving operational process; (4) Enhancing efficiency of information processing to break down communication barriers inside inter-work organizations, thereby bringing quick response and goal congruence of sustainable development in freight villages; (5) Spreading and excavating ecological consciousness among individuals of organizations in freight villages, as well as forming sustainability ideas and formulating corresponding development policy.

Strategies for Sustainable Development of the Freight Village

Sustainability strategies have now gained momentum among different scholars of strategic management and in the field of strategic political management. Freight villages that undertake sustainable development strategies could stress such aspects:

- Learning Skills and Knowledge
  Organizational learning is defined as a quantifiable improvement in activities, increased available knowledge for decision-making or sustainable competitive advantage. Learning skills and knowledge approach as the basic strategy come from the strategic tool Balanced Scorecard which regards itself as a training program designed to educate and ultimately empower employees to achieve the objective. Additionally, the Balanced Scorecard is a strategic planning and management system that is used extensively in business, industry, government, and non-profit organizations worldwide to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organization performance against strategic goals [6].
  According to the population policy and education concept based on sustainable development, to improve people's quality includes both scientific education level and renovation ability and enhancing propaganda and education on sustainable development ethics and moral concepts, raising the public's environment awareness and resource consciousness [7]. The development of ecosystem-based projects requires the understanding that well-defined functions and responsibilities must be assigned within an organized management structure to qualified personnel awareness. Thus, the sustainability awareness-raising and education campaigns play an important role in influencing implementation of sustainable development strategy and facilitating sustainable freight village choices.

- Information Processing
  Our industrial society is transforming into an information society which has the potential to substitute information and knowledge for material products to some extent.
  Information systems and the internet are improving the logistics of distribution centres, enabling companies to exchange information for products and services. The result is that people can take advantage of more and more computing power and data transfer without requiring more space, energy or cost. The five major areas of logistics are production, inventory, location, transportation, information. Information is the basis upon which to make decisions regarding the above-mentioned four areas, as well as the connection between all of the activities and operations in a logistical system. The information-processing paradigm has been prevalent over all the operations in term of the freight village's sustainable development that has been characterized by technology intensive, optimization-driven, efficiency-seeking organizational change. Operators within freight villages aquire much more information on the reasoning behind policy decisions and on the available alternatives and a better understanding of concepts or technical factual matters optimizing resource utilization and reducing burdens for enviroments. In this process a broad range of applications is covered by the information systems, including monitoring and control, information management, data analysis, as well as planning and decision support.

- Stakeholders Collaboration
  From stakeholders' influence, stakeholders' participation to co-governance, the revelation on stakeholder theory development has revealed the trend of collaboration design among them. The success of proactive sustainability strategies for freight villages and their concretisation in the form of strategic initiatives is determined by many different stakeholders who confer legitimacy to the design of these new practices (Hamprecht & Sharma,2006)[8], each being concerned with respectives sustainability issues (Roloff, 2008a; 2008b)[9][10] and possessing sufficient influence, resources or legitimacy to either support or oppose the implementation of the strategy (Mitchell et al,.1997)[11].
  There are many different suggested approaches for stakeholders classification, e.g., internal (functional departments, employees, managers) and external (customers, suppliers, governors), core (critical shareholders) and fringe (peripheral stakeholders), depending on the research objective and the characteristics of the stakeholder groups. In this paper, with respect to identifying types of stakeholders necessary for the

sustainability strategies, a classification of societal stakeholders and economic stakeholders has been made. The societal stakeholders include the regulatory stakeholders (environmental social legislation or administration control) and external stakeholders (environmental group, media and community) who place more stress on the societal performance of actitives in freight villages. On the contrary, economic stakeholders put more emphasis on the financial performance; mainly refer to the operators (shipping service companies, processing companies) and business partners around the trading tasks.
Seeing the conflict of the two groups' benifits emphasis, the strategy of collaboration seems to be a necesstiy for achieving the sustainable development. Both stakeholder analysis and stakeholder management – collaboration designs are vital tools and should be used iteratively throughout a project to keep everyone on the same page.

Conclusion and Outlook

In this paper the discussion of sustainable development extends to the logistics field which could adjust the traditional outlook on development of freight villages, thus incorporating sustainable development into their planning and policy. In the first phase it should identify the issues relating to sustainability within freight villages. Then, in the next phase it should create adaptive strategies including learning skills and knowledge, information-processing, as well as stakeholders' collaboration.

However, this research may not remain on the exterior objective facts; also the analysis of embedded linkages is necessary. In the following research, the knowledge management ideology could be adopted to support the making of strategies, and some actual case analyses are helpful to better understand actual practice based on the theoretic research.

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Research on Sustainable Development of Logistic Park Based on Knowledge Management

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Strategy to Improve Wireless Sensor Network Performance in Logistic Applications

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Wireless Sensor Network (WSN) offers the possibility for its users to observe the physical environment in a scientific way. In logistics, this offers the opportunity to obtain the important environmental parameters without interrupting or delaying the supply chain. As the implementation of WSN in logistics develops, the concept of "Transparent Transportation" has been suggested, as well as the "First-Expire-First-Out" policy in the food transportation in logistics.

Introduction >>> With the WSN technology, it is possible to obtain all kinds of environmental data, from temperature, humidity, pressure to gas concentration. All this data can be obtained with sensor motes and forwarded wirelessly for users. How can we make use of this technology to improve the performance of supply chains? As cargo containers are used world-wide, is it possible to penetrate those metal walls and make the containers and the whole supply chain "transparent"? Is it possible to monitor the life of transported food from South America to Europe on time? If a whole container of bananas is going bad, is it possible to obtain up-to-data shelf-life so that it can be delivered to a nearest branch instead of being thrown away? **<<<**

Food transportation, due to its high requirement of the efficient time and accurate environmental control, has been a challenging field to explore the implementation of WSN in logistics. The concept of "Transparent Transportation" proposed in this research benefits from the idea of "Telematics for Totally Transparent Transportation" (T4) [1].

To be more specific, using a food transportation as an example, a transportation process can be considered to be transparent from the following point of view, corresponding technical solutions are suggested to realize the goals.

- Transparent Environment. All the parameters which effect the quality variation of the transported goods can be obtained through WSNs, from temperature, humidity to acceleration parameter and ethylen density in the air. To fetch the complete physical information inside the containers, sensors need to be able to "know" the temperature in every corner of the container. More important, to cover every core of concerned goods, since the goods are often compiled to very big size pallets, as shown in Fig. 1.

  However, the radio transmission in such WSNs suffers inevitably signal attenuation due to the goods in the containers; this is observed while using TelosB [2] and Tmotes [3] for the WSNs.

To solve this problem, the radio propagation characteristics inside containers need to be studied. Therefore, empirical radio models need to be built to predict the reasonable sensor distribution in the containers, in order to guarantee the connectivity in the WSN as well as reducing the cost by calculating the actually needed sensors instead of placing extra sensors. Compared to normal wireless networks, multi-hop network protocols need to have mechanisms to fulfill the extremely limited energy and computation capacity of sensor networks. Duty-cycling is one of the options to prolong the lifetime of sensor networks, while compromise needs to be found between guaranteed data delivery and low power consumption.

Figure 1: Cargo Container Loaded With Bananas and Implemented WSN

- Transparent Handover. The loading and unloading processes of the transportation are very critical for logistics considering the security as well as the possible quality change, specially for food transportation due to the environment changes and human factors. For example, in fruit transportation, if one packet reaches a temperature threshold where ripening might start during unloading or reloading process, it is highly possible that the whole container will be affected and will enter a disaster too-early-ripe process. Since the ripening process is irreversible, this could lead to high loss.

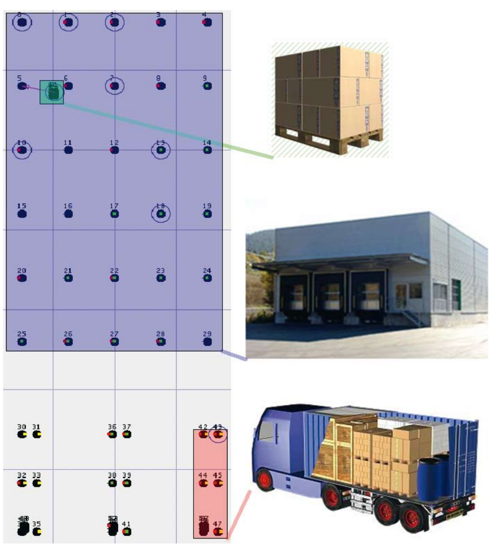
  The loading process in logistics challenges the traditional WSN network protocol with the problem of mobility. Fig. 2 shows a simulation of loading process from the warehouse to vehicles. Self-configuration functionality is important here to solve the problem of mobility. Mechanisms, such as beacons, need to be adopted from normal wireless network protocols with the condition of guaranteeing the low power consumption. Cases like sensors running out of battery, flooding by water or damage can also be solved because it can also be considered as a problem of topology changes.

- Transparent Tracing. Besides the specific physical environment in each truck, the location of all trucks in the whole transportation should also be traced [4] and be updated within certain time intervals. This is needed for moments when accidents happen, traffic jams or defects of cooling systems, leading to unexpected quality variation in a container. The goods can be delivered to the nearest branch to reduce the loss.

  To trace all the products in the whole transportation process, "cooperation" between WSNs and usual Internet Protocol (IP) networks is required. Intelligent "decision-making" models can be implemented in softwares for WSNs with the help of "shelf-life" models [5] to report important environment change in one transportation truck, while this signal should be successfully understood by the IP network to trigger a route change of the truck. Also specific understandable commands for WSNs from IP networks can help to realize the on time supervision of transportation.

To solve the above described challenges, fields tests are done to obtain data in a finished project, T4 project in SFB 637 [6]. Multi-Hop network protocols are implemented and evaluated with TelosB motes and Tmotes. A sensor network with a size of more than 20 motes is installed in the containers in a transport truck. Data such as temperature, humidity, RSSI (Radio Signal Strength Identifier) and battery status have been obtained from this scenario. Transparent handover, namely self-configuration as well as power consumption are implemented as well and are evaluated. The network behaviour and radio performance characteristics can also be observed from this data file after post processing and analysing, which offers the opportunity to set up the radio model in containers and improve the current protocols. Transparent tracing is also realized in this project with the help of access points and needs to be improved.

Figure 2: Simulation of Loading Process Equipped With WSN



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Process-oriented Knowledge Management in Business Logistics: Review of Theoretical Basis

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The application of knowledge management (KM) in logistics has been put forward in literature in recent years and attention has been paid to the dynamic logistics process. Furthermore, the integration of KM and business process management (BPM) is increasingly necessary and some initiatives of process-oriented knowledge management (PKM) have been proposed. This paper first introduces the importance of implementing PKM in logistics within such dynamic environments and business processes. Then it offers an overview of the theoretical basis, i.e. KM, BPM, and PKM. The main points are the definitions, process and application of KM, concepts and characteristics of BPM, the advantages and approaches of PKM. This review tries to integrate the related theories into logistics and to provide rationale for further empirical research.

Introduction >>> Since the 1990s supply chain management and logistics have become powerful sources for enterprises to sustain competitive advantages (Olavarrieta & Ellinger, 1997). The dynamic of the global marketplace changed dramatically (Coyle, 2003). The growing importance of logistics as well as the increasing dynamic complexity of markets, technologies, and customer needs has brought great challenges to logistics. It must be possible to rapidly and flexibly adapt logistics processes and networks to continuously changing conditions (Scholz-Reiter, 2008). Knowledge- based resources are seen to contribute most to the performance in a dynamic, changing environment (Lee & Hong, 2002).

Logistics itself is a very dynamic field of knowledge and science. Logistics provide service rather than goods which determines the close relationship with the customers and the active response to their changing demands. This requires knowledge management (KM) which means providing the right knowledge for the right people in the right place at the right time. Industry watchdog Gartner Group reports 80% of Fortune 500 companies have begun some level of knowledge management initiatives. Logistics companies have different technological and organizational knowledge in terms of management skill, corporate culture, rules, procedures, standard operations procedure, logistics expertise and customer loyalty (Chow et al, 2005). All of them develop a collective memory of past problems and solutions and use behavioral rules and standard operations procedures to deal with environmental changes (Cyert & March, 1992).The implementation and the use of knowledge management hold the potential for the development of sustainable competitive advantages (Haasis, 2008). The main purpose of implementing knowledge management solutions in logistics is to reduce costs and improve customer care and service (Wilk, 2007).

Logistics is also a process-oriented business. It is the part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption in order to meet customer requirements (U.S. Council of Logistics Management). Within the logistics processes input attributes such as raw materials, people, resource, information, knowledge commitments are transformed into outputs representing desirable results through a set of processes or procedures (Chow et al., 2005). The logistics process is human centered (Myers et al., 2004), most decisions are made and acted upon by people with different kinds of experience, knowledge, values and cognitive abilities. Within dynamic logistics processes, logisticians are guided by not only operational manuals (explicit knowledge), but also rely on practical experience (tacit knowledge), their experience and knowledge in operating these processes becomes important (Harry et al., 2007).

Therefore it is very necessary to integrate KM and Business Process Management (BPM) as Process-oriented Knowledge Management (PKM) in order to improve the corporations' performance greatly. There have been various initiatives to introduce the process concept to KM and respectively the knowledge concept to BPM in order to combine the advantages of the two paradigms (Berztiss, 2000; Choi et. al., 2004; Han & Park, 2009; Maurer & Holz, 1999; Woitsch & Karagiannis, 2005). Usually the typical action of the static KM is to store all kinds of knowledge, documents and information etc. in the Office Automation (OA) database for the reference of the employees. While the dynamic PKM is to actively guide the employees in different business processes to share and transfer their individual knowledge into organizational knowledge, and meanwhile apply the organizational knowledge to the business

Table 1: Hedlund and Nonaka's Knowledge Management Model (1993)

	Individual	Group	Organization	Inter-organizational Domain
Articulated knowledge	Knowing calculus	Quality circle's documented analysis of its performance	Organization Chart	Supplier's patents and documented practices
Tacit knowledge	Cross-cultural negotiation skills	Team coordination in complex work	Corporate culture	Customer's attitudes to products and expectations

process (Du, 2008). Moreover, it also considers the participants both inside and outside of the organization. PKM will enable users to filter valuable knowledge and thus avoid information overload (Jung et al., 2007). Also it will enhance the value chain and improve the efficiency of logistics processes. <<<

Knowledge Management

Knowledge Management describes everything from the application of new technologies to the harnessing of intellectual capital within an organization (Sallis & Jones, 2002).

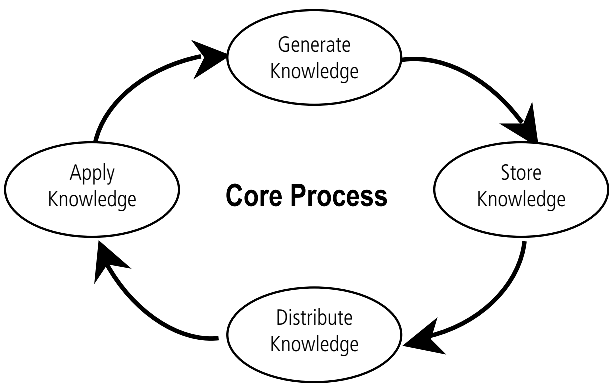
Early perspectives of KM focused on standardization or utilization of a particular process. Wiig (1993) described KM as the ability to acquire, create, organize, share, and transfer knowledge. Hedlund (1994) suggested that KM addresses the generation, representation, storage, transfer, transformation and application of organizational knowledge.

A later perspective is viewing organizations as bodies of knowledge. Bhatt (2001) defined KM as the processes and procedures that govern the creation, dissemination and utilization of knowledge by merging organizational structures and people with technology. Malhotra (2001) described that knowledge management embodies organizational processes that seek a synergistic combination of data and information processing capacity within information technologies, and the creative and innovative capacity of human beings.

Nonaka and Hedlund categorized knowledge into the individual, the group, the organization and the inter-organizational domains. The inter-organizational domain includes suppliers, competitors, customers, etc.

Knowledge management process has been described in different ways. In order to analyze the business process and assure the involvement of process owners from all organizational levels, Mertins, et al, (2001) used four core activities shown in Figure 1.

Figure 1: Core Process of Knowledge Management



Source: Mertins, Heisig, Vorbeck (2001)

Knowledge management systems (KMS) and associated technologies are one aspect of KM. There have been various projects and approaches that emphasized the process, as can be seen in Table 2.

Table 2: Knowledge Management Systems

KM Process	Knowledge Creation	Knowledge Codification	Knowledge Transfer	Knowledge Application
Knowledge Management Systems	Groupware Intranets E-mail Expertise location Discussion groups	Knowledge repositories Database systems Search engines Knowledge Maps Portals	Groupware Intranets Electronic Bulletin Boards Expertise location Videoconferencing Discussion groups Knowledge Maps	Intranets Work flow system Expert system

However, Davenport et al. (1996) stated that the most dramatic improvements in KM capability in the next ten years will be human and managerial. Mertins et al (2001) also presented that KM approaches include both technology and non-technology design.

Business Process Management

Business process management is a management approach focused on aligning all aspects of an organization with the wants and needs of clients. It promotes business effectiveness and efficiency while striving for innovation, flexibility, and integration with technology (Smart et al., 2008).

Logistics is a process-oriented business constituting numerous processes linked together to perform different logistics operations (Harry et al., 2007). Logistics is the process of planning, making and controlling efficient and fluent turnover and storing of not only raw materials, work in process things and products but also services and adequate information from the source of raw materials extraction to clients according to their expectations (Gołembska, 2001).

Knowledge management and learning are increasingly important to improve business efficiency within the organization and also enhance value delivery to the customers. The logistics process is human centered (Myers et al., 2004). Starting from inbound logistics activity, e.g. the stock receiving process, to the stock delivery in outbound logistics, most decisions are made and acted upon by people with different kinds of experience, knowledge, values and cognitive abilities.

Process-oriented Knowledge Management

Process-oriented Knowledge Management is based on models of dynamic changes within organizations and adminstrations (Abecker et al. 2002). In order to provide knowledge for value adding activities within the business processes, KM instruments and KM systems have to be adapted to business and knowledge processes (Remus & Schub, 2003).

The advantage of process-oriented knowledge management is that it can help users avoid information overload and concentrate on important information which is essential for company value chains (Kwan & Balasubramanian, 2003). It can also improve the usability of knowledge in companies and the efficiency of implementing knowledge management system. Remus & Lehner (2000) listed the potentials and benefits of the process-oriented approach as following: value chain orientation, context relevance, improvement in knowledge processing, support for process-oriented knowledge management, and navigation and design components of KMS.

Jung et al. (2007) proposed integrated system architecture for PKM based on a comprehensive framework that reflects lifecycle requirements of both KM and BPM. They defined three types of knowledge as process template knowledge, process instance knowledge, and process-related knowledge. Mertins et. al (2001) presented some approaches that tried to integrate KM activities into the business processes: the CommonKADS methodology, the business knowledge management approach, the knowledge value chain approach, the building block approach, the model-based knowledge management approach, and the reference-model for knowledge management. They stated that these approaches focused on explicit knowledge, and particular areas.

Conclusion

The dynamics of environment, market, technologies and customer needs drive logistics to better leverage the valuable knowledge with business processes to keep a competitive advantage and sustainable development. Logistics is process-oriented business, and knowledge intensive service. It is very necessary to integrate the knowledge management approaches into the business process, in order to enhance the value chain and improve the efficiency of logistics processes.

The PKM concepts, necessity and initiatives of implementation in literature provide basic theory framework for the research. It combines the advantages of the two most important organizational assets, and makes them adapt themselves to each other. However, the current PKM focuses more on Information Systems, e.g. Wiki, Groupware, Intranets, etc. Hence, further empirical research of PKM perception and application in business logistics is required.

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Process-oriented Knowledge Management in Business Logistics: A Dynamic Perspective

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Strategy for the Development of Collaboration Environments to Ensure Collaboration Preparedness

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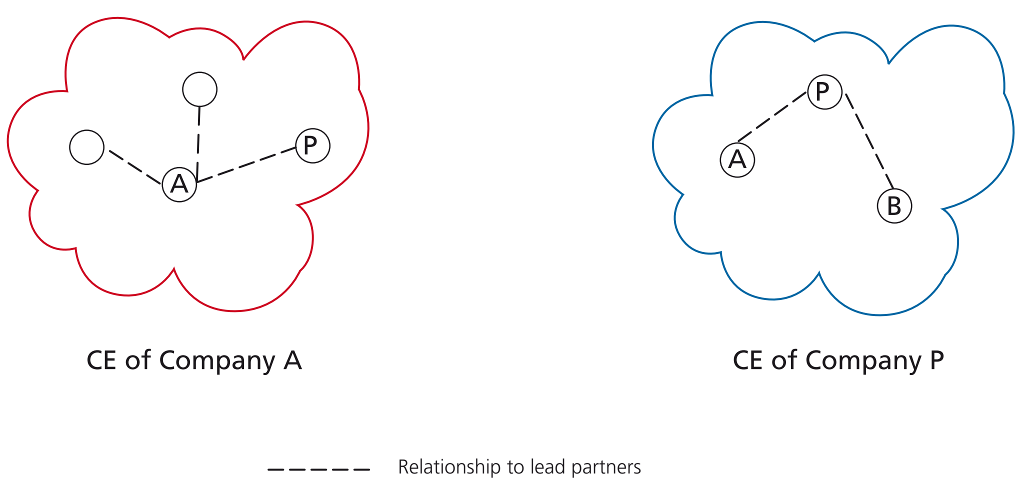
The focus of this work is to propose developing collaboration environments (CE) from the points of view of individual enterprises to ensure collaboration preparedness that enhance enterprises' collaboration abilities. The definition of the CEs is given and their dynamic characteristics are discussed. Therefore, for the purpose of doing collaboration business successfully a strategy is necessary for enterprises to develop CEs by dealing with the dynamic. The initial insight is to establish a new concept of CE that helps enterprises to run their collaboration business.

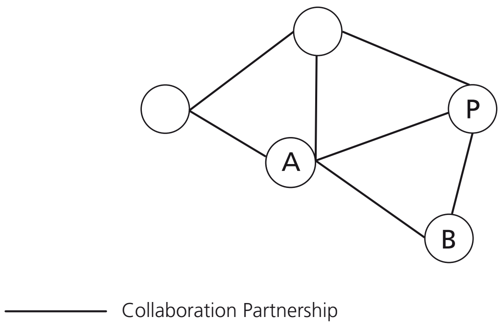
Introduction >>> In manufacturing, since the later 1980s, the ability to improve supply chain performance was important for companies. In the 21th century, faced with increasing global competition and short product life cycles, the ability to configure order specific collaborative networks (CN) is the main competitive advantage of companies. CNs are configured based on the required competencies for specific business opportunities. The configuration of a CN is generally completed by the company in contact with the customer which is named as lead partner. The basis for searching partners are existing relationships to current and former business partners of the lead partner. The sum of current and former business partners and their relationship to this lead partner forms an environment which is termed here as collaboration environment (CE). In consequence each company has its own CE.
Two examples of CEs are shown in Figure 1. Here, "Company A" and "Company P" with their roles as lead partner are shown with their respective CEs. <<<

Figure 1: CEs of „Company A" and „Company P"



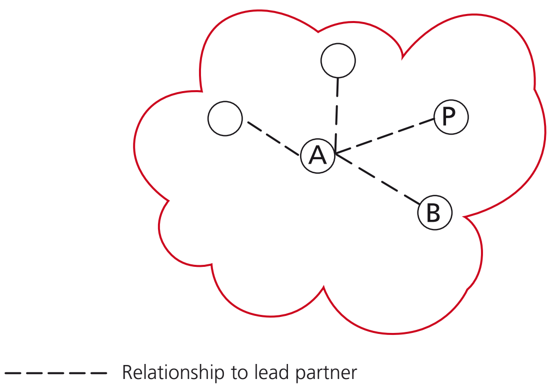
In some cases, there might be a need to search partners outside the current CE which leads to a change of the CE, e.g. if one required competence is not available in this CE. This example is illustrated by Company A which is responsible to initiate a CN. In case that the current order requires a competence which is not covered by the CE of Company A, the lead partner has to identify a suitable partner outside its CE. Company P which is a partner of Company A knows that Company B outside the CE of Company A has this competence. Thus, Company B is involved in this CN. The configuration of CN is shown in Figure 2.

Figure 2: Company A initiates CN



In the course of collaboration, Company B becomes known to Company A. After this collaboration, Company B could become part of the CE of Company that leads to an evolution of the CE, which is shown in Figure 3.

Figure 3: Evolution of CE of Company A



In addition to the evolution of a CE in terms of constant-changing partners, existing relationships within the CE are changing over time. Generally, relationships to frequent partners become stronger; other relationships with rare contacts become weaker. Due to evolution in terms of over-changing partners and the existing relationships, a CE is mostly dynamic which implies that involved companies do not have formal memberships.

In a word, before the ability to improve supply chain performance was important for companies; today the ability to quickly establish an order specific CN is the main competitive advantage. In consequence, the asset of a company to run collaborative networks is its CE. Nevertheless, the CEs are not necessarily planned and conducted. Therefore, it is necessary to develop and conduct the CEs to ensure individual enterprises and their business partners are ready and prepared to configure collaborative networks.

Motivation

From a long-term perspective, the enterprises are obligated to maintain their own CEs to ensure the availability of quickly involving the most suitable partners for collaboration which is defined as collaboration preparedness.

One concept of formalizing CE is virtual organization breeding environment (VBE). A VBE is a well-defined CE in an inter-organizational context in terms of clear memberships and agreements among members for increasing collaboration preparedness. A VBE has a formal structure. This means that a VBE is stable, static and long-term oriented. In this sense, a VBE has a fixed and relatively narrow business interests which implies that a VBE does not consider the changing needs of competencies required from specific business opportunities.

However, from a single organizational viewpoint as described before, CEs evolute towards involving required competencies to meet the requirements of different business opportunities. For this reason, CEs of single companies need to attract more attention and thus improve single company's collaboration abilities. In this single organizational context, the CEs often do not have formal structure and are dynamic in terms of over-changing partners and the existing relationships. Thus, a high level of preparedness in CEs is the success factor for enterprises to set up CNs and do business. Therefore, the CEs need to be developed and conducted towards a high level of collaboration preparedness.

Problem Definition

The CEs in a single organizational context do not have a formal structure and thus possess a nature of high dynamic in terms of business partners and the existing relationships. Furthermore, due to the fact that business partners for collaboration are largely autonomous and geographically spread the interests for collaboration are highly divergent and heterogeneous. Without prior coordination of these interests it could result in conflicts inducing the collapse of a collaboration.

Taking into consideration the dynamic nature of CEs and the heterogeneity of business partners in CEs, to achieve a high preparedness level to set up networks, a strategy is necessary to develop and conduct the CEs. The concern of this research is how a strategy is to be designed for CEs to deal with its dynamic behavior to ensure collaboration preparedness and how the strategy could be implemented and evaluated to improve the collaboration preparedness of the CEs.

One of the existing methods to implement strategies is the well-known balanced scorecard (BSC). The BSC was designed to deal with the issues in an intra-organizational context. The BSC was introduced as a flexible tool, how to adapt BSC in an inter-organizational environment is the challenging question of this research.

Approach

The analysis of the research problems would start with the definitions of the CE. In CEs, the dimensions of preparedness will be discussed. The strategy will be defined on the basis of these dimensions and interpreted by a BSC based approach. This way the necessary conditions for the BSC to be extended/adapted to the overall needs of CE strategy would be studied. This is followed by the development and evaluation of the BSC method for CEs to ensure collaboration preparedness.

Initial Insights

The study will establish a new concept of CE that helps enterprises to run their collaboration business. The contribution of the strategy is to provide insights into actions necessary among enterprises to gain a well conceived collaboration preparedness which could enable rapid formation of CNs according to the needs of business opportunities to win competitive advantage. The BSC based approach will introduce clear indicators to measure the level of preparedness among inter-organizations and harmonize progresses towards collaboration preparedness

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Strategy for Development of Collaboration Environment to Ensure Collaboration Preparedness

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Modeling and Improving the Supply Chain of Mineral Natural Resources Extraction Industry

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The research focus of this work is on identifying how the SCOR model can be extended for modelling and evaluating the processes in the mineral natural resources extraction industry. In this industry the processes, KPIs and the best practices will be collected and identified. After this, it will be possible to describe the raw material supply chain by the example of copper, and then to identify the challenges in this market which need to be considered.

Introduction >>> After many years of exploiting an abundant and inexpensive supply of natural resource based materials, the manufacturing industry is now facing a more complex scenario for its supply chain (Vial, 2004). This complexity arises from the larger number of players in the chain, as well as from their interaction and the growing dynamics resulting from consumer-oriented strategies. Further complexities are added by the fact that mineral raw materials are a finite resource, and extraction is spatially constrained to the areas in which the materials naturally occur. Those are some reasons why the supply of diverse raw materials will be more restricted in terms of availability and price.

In the near future the manufacturer of semi-processed products must deal with the compliance of the producers of raw materials regarding their demand. These requirements depend on the commitments to be fulfilled to their clients in the manufacturing industry.

In a recent paper Seifert (2009) highlights that every added value process begins with the purchase of raw materials. Also, he emphasizes that without reliable access to the required raw materials, the customer's needs will not be completely satisfied, hence, the whole supply chain's competitiveness is at risk. In consequence, a reliable supply of raw materials is fundamental for the success of the whole supply chain .

As the supply chain depends on a sure, reliable and steady supply flow of specific raw materials, the question is: how can the manufacturing industry satisfy its expectations under the present conditions of restricted availability of raw materials?

In this case, under the new conditions of reduced availability of raw materials, there is a need to study the early part of the supply chain. This part involves the raw materials industry and the manufacturer of semi-processed products. It must take into account the modelling and improvement of the processes of the natural resources extraction industry, including the adequate Key Performance Indicators (KPIs) and the best practices for this industry. <<<

Research Problem

The current modelling and evaluation approaches to supply chains consider the raw materials market for minerals as an infinite source. Therefore, the supply of mineral natural resources has been more or less excluded from existing models so far (Vial, 2004). An example is the well known Supply Chain Operations Reference (SCOR) model which can be considered as a quasi standard (SCC, Inc., 2008).

The limited access to mineral natural resources and scarce resources will be an essential aspect when speaking about the reliability of supply chains (Seifert, 2009). The task to guarantee reliable access to mineral natural resources will be a major success factor for every supply chain. This means that the early supply chain processes need to be considered in supply chain modelling and evaluation approaches.

Available supply chain models do not cover the specific characteristics of the mineral raw materials market (e.g. SCOR: make to stock, make to order, engineer to order). Although Key Performance Indicators (KPIs) and best practices focus on the manufacturing industry, they do not consider the early part of the supply chain.

Figure 1: The Mineral Industry Supply Chain

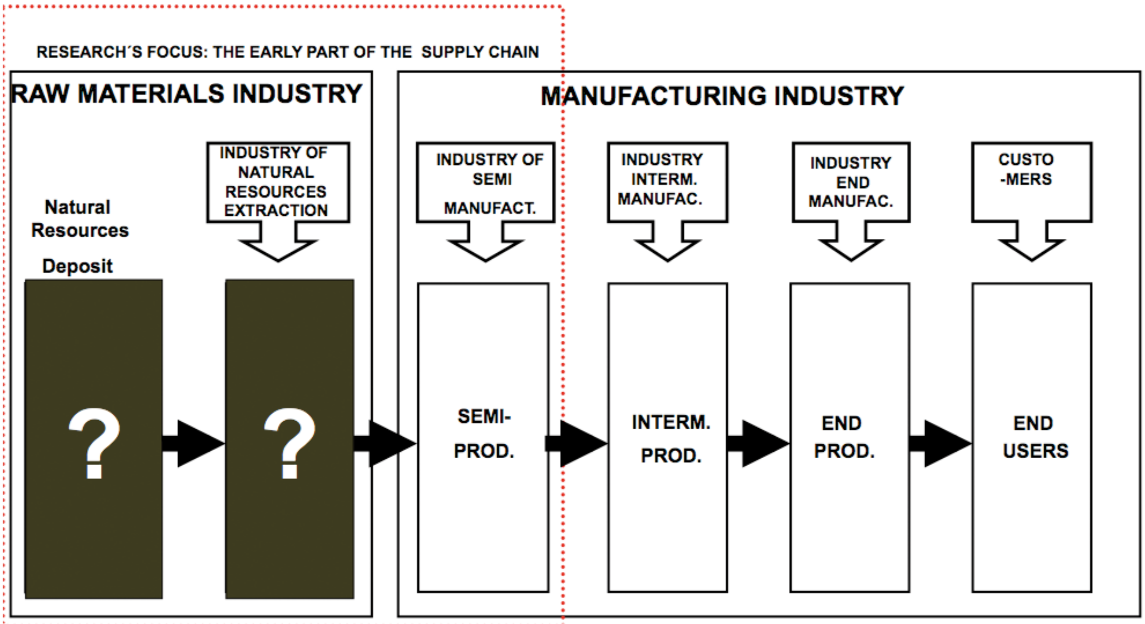
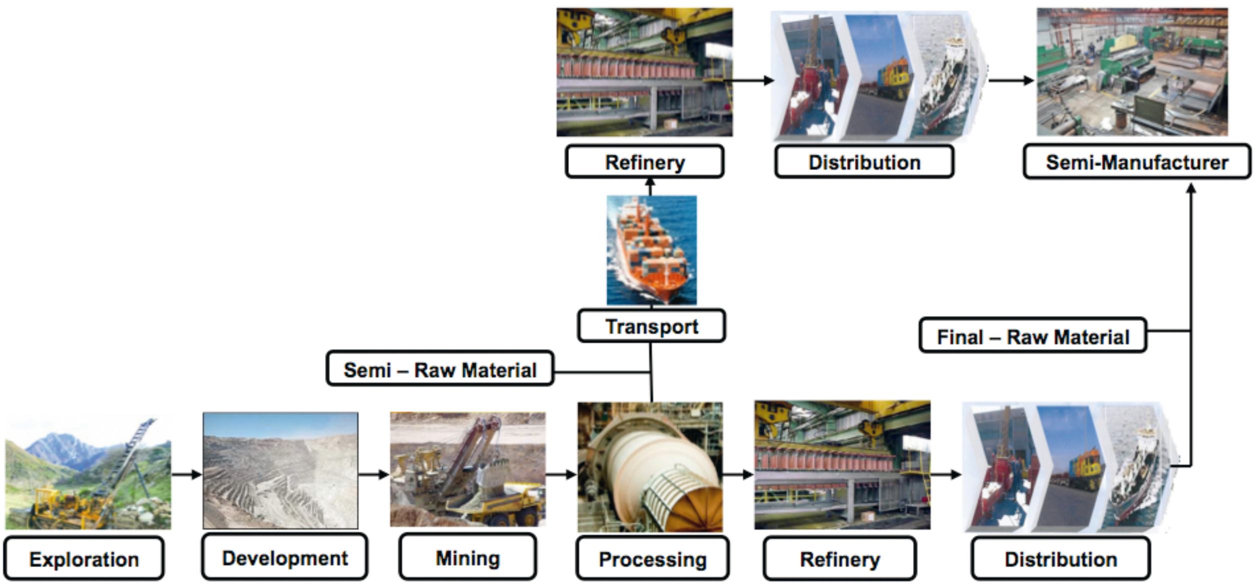


Figure 1 depicts the whole mineral industry supply chain and shows the early part of the supply chain that will be studied in this research. The symbol "?" represents the focus on which processes, KPIs and best practices need to be taken into account in the minerals natural resources extraction industry.

Figure 2 illustrates the processes of the mineral natural resources extraction industry in the early part of the supply chain. These processes must be modelled and evaluated; the problem is to understand how the existing SCOR model can be extended for modelling and evaluating these processes.

Figure 2: Processes of the Mineral Natural Resources Extraction Industry



Even if the existing SCOR model does not meet all the characteristics of the processes in this industry, it has a promising potential for extending it to this industry. This is because the SCOR model covers the supply chain from the supplier's supplier to the customer's customer.

Therefore, the research focuses on identifying how the SCOR model can be extended for modelling and evaluating the processes in the mineral natural resources extraction industry.

Research Objective and Approach

An extension of the SCOR model will be developed as a process model to describe the early supply chain processes on the mineral raw materials supplier market. The extended model will cover: the process model, the KPIs to evaluate the processes, and the best practices for the supply chain processes on the mineral natural resources extraction industry.

The analysis of the research problems would start with an analyses of different frameworks based on the SCOR model for modelling and improving processes in the supply chain. In this part, it is important to develop requirements for an extension of the model to the early part of the supply chain. In the early part of the supply chain the processes, KPIs and the best practices will be collected and identified. After this, it will be possible to describe the raw material supply chain by the example of copper, and then to identify the challenges which need to be considered in this market.

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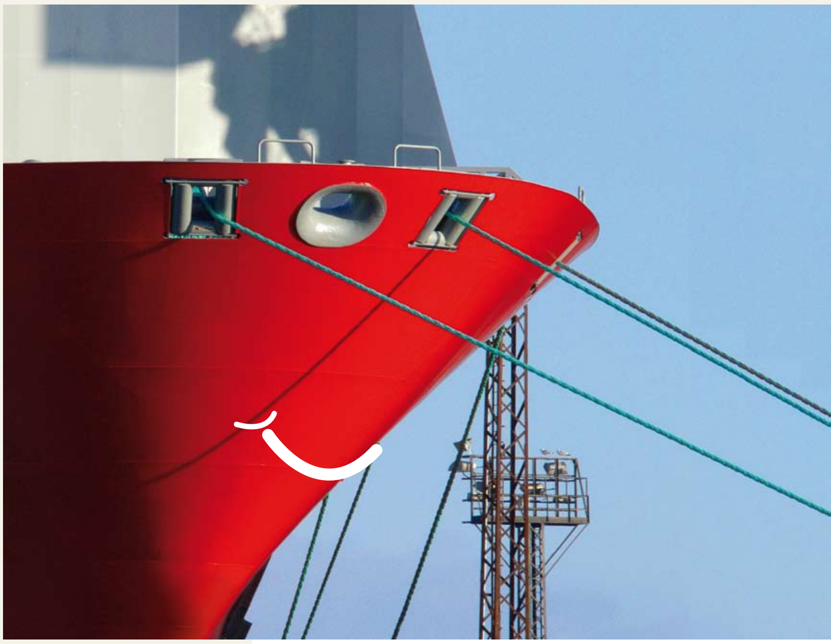

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