LogDynamics
Research Report

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International Graduate School for Dynamics in Logistics

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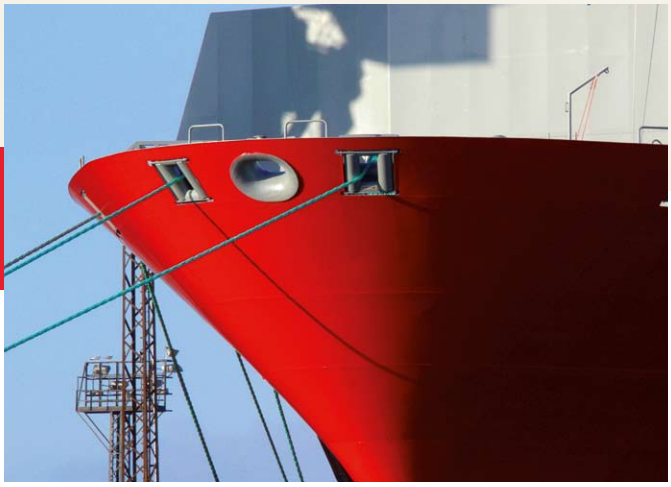
Research Report

Content

Dynamics in Logistics

Customer needs, markets, and technologies – particularly information and communication technologies – are subject to permanent and rapidly accelerating development in logistics. In addition, there is a tendency to offer individually clustered services in ever shorter product life cycles. This growing dynamism confronts the field of logistics with completely new challenges: It must be possible to rapidly and flexibly adapt logistic processes and networks to continuously changing conditions. Every advance in mastering these dynamic aspects carries enormous significance for the success of production and transport logistics throughout the whole world and will secure strategic competitive advantages.



Logistics in Bremen

Bremen is a traditional logistics location, important for the whole of Germany and beyond. Historically, the strength of the location is based upon its ports and freight terminals (Güterverkehrszentrum, GVZ). Established industries where logistics play a significant role for instance are aeronautics and space technology, automobile construction, food and allied industries. The importance of logistics for the state of Bremen is reflected in its innovation offensive.

Advances in science and technology are often developed at the intersection between various scientific disciplines. At the University of Bremen the “Bremen Research Cluster for Dynamics in Logistics” (in 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), with the goal to strengthen interdisciplinary research and development in the competence area of logistics.

The “International Graduate School for Dynamics in Logistics” is one of the three pillars of Log*Dynamics*. It offers outstanding researchers from all around the world – especially from the so called “emerging logistic markets” China, Southeast Asia, Latin America and from Germany – the opportunity to complete a structured graduate training at an excellent logistic location. The International Graduate School is closely linked to the demonstration and application centre “Log*Dynamics* Lab” for mobile technologies in dynamic logistic structures, as well as to the Collaborative Research Centre 637 “Autonomous Cooperating Logistic Processes – A Paradigm Shift And Its Limitations”, which is funded by the German Research Foundation (DFG).

Cooperation on different levels

Logistic problems are marked by the fact that they can rarely be solved satisfactorily within one single discipline. The fundamental idea of Log*Dynamics* is to make use of the synergy effects that result when coordinating the specific problem-solving competences of the concerned partners during work on logistic issues. Such an interdisciplinary exploration of topics that were formerly studied within a single discipline results in valuable progress when finding logistic solutions.

Focal point is the reference to industrial practice, which is why Log*Dynamics* wishes to increase the readiness and possibilities for cooperation between science and industry and promote small and middle-sized enterprises’ access to science. The consequential dialogue will broaden the mutual understanding of the different aspects of problems and solutions in logistics. Paramount goal is 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 applied scientific logistics and training young scientists.

Graduate Training at Highest Level

The aim of the International Graduate School is to identify, describe and model the required and feasible intrinsic dynamics inherent in logistic processes and networks and research and design new dynamic planning and control methods on the basis of these results by using new technologies. The research focuses on three topic areas:

- 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

This research gains its findings through interdisciplinary cooperation and the consideration of its intercultural aspects with industry in mind.

Research Beyond Boundaries

Faculty 1: Physics / Electrical and Information Engineering

Dynamics in Logistics is intrinsically coupled to 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 resulting data amount 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 mathematics theories and progresses in microelectronics and microsystemtechnologies, 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 to been investigated. **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. Otthein Herzog** include, for example, knowledge management for the planning and scheduling of autonomous logistic processes. He directs the Center for Computing Technologies (TZI) and the Mobile Research Center.

As in software engineering as well as in other areas of computer science, diagrams and graphs are also used in manifold ways for modelling logistic processes, easily describing and visualizing complex structures. Rule-based methods have proven 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 Center for Computing Technologies (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 is aimed 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 optimization 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 and of the Collaborative Research Centre "Autonomous Cooperating Logistic Processes – A Paradigm Shift and its Limitations" (SFB 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 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 todays major design options for the realization of sustainable economics. **Prof. Dr.-Ing. 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, 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.

A further research group in this context focuses on strategic management issues of complex adaptive logistic networks (CALS) in highly dynamic and volatile environments, which are driven by technological developments. Especially, this 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.

Prof. Dr. Michael Hülsmann is head of the unit "Management of Sustainable System Development" and co-founder and co-director of the SCOUT-Institute for strategic competence management.

International Graduate Training in Logistics

Since mid-2005 the International Graduate School for Dynamics in Logistics at the University of Bremen has been offering excellent researchers from all around the world the opportunity to complete an efficient, structured graduate training at a logistic location of long standing tradition.

The curriculum of the International Graduate School is designed for a three-year full time study. Besides the individual doctoral project, it covers collective thematic introductions, subject specific courses, interdisciplinary colloquia, dialoque forums, excursions, as well as individual coaching regarding soft skills. The common language is English. Graduates from abroad must be able to cope with everyday life in German and acquaint themselves with German culture. German graduates are given the opportunity to go abroad as a visiting researcher.

All these elements get the young researchers involved 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. Through the institutional combination of possibilities and obligation to actively exchange ideas and the accompanied self-management, a system of concerted individual measures ensures the well directed and effective personnel development which enables the graduate to receive a very good qualification and helps the university to gain some efficient new insight. Furthermore, it is the declared goal of the International Graduate School to transfer research findings into practice.

Structure of graduate training

The graduates at the International Graduate School for Dynamics in Logistics are supervised by eight Bremen professors who are available as immediate supervisors or as mentors. Furthermore, visiting researchers are invited. A structural supervision by the scientific Managing Director of the International Graduate School, as well as the involvement of postdoctoral research fellows from working groups of the respective supervisor round off the whole mentoring concept.

Doctoral project

Working at the doctoral project is the central research activity and takes up the biggest amount within the curriculum. It is integrated in the disciplinary research group of the supervisor and therefore makes use of the knowledge and the infrastructure of the respective subject area and institute. The graduates learn to use the exact tools of scientific work which are required for their particular project and receive individual support in their research activity.

Courses

The courses are divided into lectures with tutorials, seminars, workshops, practical training and integrated learning in small groups. Disciplinary courses are aimed at quickly catching up with the international standard of the respective research area.

Thematic introductions into the "other" disciplines serve as a support of the interdisciplinary cooperation at the International Graduate School. Furthermore, general qualifications from the course offerings at the University of Bremen are covered and an intercultural coaching is additionally available. The supervisor determines the subject specific courses, the other courses are chosen by the graduates together with their mentors.

Interdisciplinary research colloquium

The interdisciplinary research colloquium offers an institutional, (research) issue-related forum where graduates present and discuss concept and status of their docorate projects. Findings are exchanged and interdisciplinary questions are developed. There are discussion groups joined by all university lecturers of the International Graduate School and of the whole LogDynamics Research Cluster to ensure targeted impulses for the respective research project, and also regular discussion groups that leave the young researchers continuously with structural supervision among themselves.

Dialoque forum

Within the dialoque forum the graduates of the International Graduate School present the findings of their research at fairs or at events specially organized for the exchange

with industry. They discuss relevant questions with experts from industry to gain different perspectives on the issues. Through excursions or practical trainings they get new impulses for their research, allowing for practical relevance of their research project. A knowledge transfer takes place in both directions.

A Micromachining Pre-concentrator Focuser for Improving the Efficiency of Fruit Transportation Supply Chains

Ali Badar Alamin Dow
Prof. Dr. Walter Lang

A micromachining pre-concentrator focuser is a very important component used in gas detection systems for analysing the contamination of air. Logistics systems for the transportation of fruit must take care that the fruit attains good maturity and ripening levels. This is done by controlling the emission of ethylene. In this respect and so the fruit can reach the customers in very good condition it is vital to monitor levels of ethylene gas in fruit transportation containers. The intelligent container can provide full and updated information on the condition of the fruit.

Introduction >>> A high performance MEMS gas detection system for air analysis has been targeted by many researchers due to its manifold application in fields such as environmental monitoring and food transportation logistics systems. In fruit transportation logistic systems (Figure 1), it is very important to attain good maturity and ripening levels. This is controlled by monitoring the emission of ethylene gas (Table.1). Therefore, it is very necessary to measure the level of ethylene gas in intelligent containers used in the transportation of fruit in order to maintain optimum maturity and ripening so the fruit can reach the customers in very good condition [1, 2].

Traditionally, analyses of contaminated air were performed by a large bench gas measurement system in the laboratory. However, these systems suffered from their large size, high power consumption, and the slow analysis time.

Extensive research work has been carried out on developing a high performance mobile gas detection system. There is considerable interest in a fast, reliable and small-sized system for monitoring and analysing the air in containers. Hence, a micromachining pre-concentrator-focuser (PCF) is very necessary for enhancing the sensitivity of the ethylene sensor which is limited by the low parts per million (ppm) concentrations [2, 3]. The working principle of PCF is that the low-concentration compounds flow through the PCF for a prescribed time to allow the adsorption material to adsorb as much as possible; then these compounds are desorbed again as result of heating the adsorption material, allowing the high concentration released compounds from the PCF to be detected more easily by gas sensors. Monitoring the emission of ethylene gas in fruit containers will enhance the performance of fruit supply chain logistics systems by reducing the cost, required delivery time and quality of the fruit.

Table 1 Emission of ethylene from some types of fruits

Fruit Type	Ethylene Production Rate [µl/(Kg.h)]	Ethylene Concentration in the container [ppb/h]
Orange	0.01 ~ 0.1	15 ~ 150
Water melon	0.1 ~ 1.0	150 ~ 1500
Banana	1.0 ~ 10.0	1500 ~ 15000
Apricot	10.0 ~ 100.0	15000 ~ 150000
Apples	> 100.0	> 150000

Figure 1: The Intelligent Container of CRC 637

Conventional pre-concentrator devices are large in size [2] and exhibit high power consumption [3]. They also suffer from high complexity and limited heating efficiency due to their large thermal mass [4, 5].

Research Question:

In the design and fabrication of pre-concentrator focusers for ethylene gas sensing applications, many design factors have to be considered. These factors include checking, categorizing, and characterizing the available adsorption materials that could be used. Furthermore, the micro heater design should combine a large volume of adsorption material with fast and uniform heating of the adsorbents. <<<

Theory and Operation of the Pre-concentrator Focuser

In the design of a pre-concentrator focuser as a component in gas analysis microsystems, many factors such as size, driving power, pressure drop and fabrication technology need to be studied and highlighted in order to magnify small gas concentrations to a much higher level of concentration which can be detected easily by the sensors [5]. A pre-concentrator focuser consists of micro channels in which the adsorption material is filled, two ports for passing and collecting the sample, and heater beams used to heat up the adsorption material [6]. An air sample containing the ethylene is passed through the pre-concentrator focuser and the ethylene is adsorbed by the adsorption material. This is then heated, resulting in the desorption of ethylene – but now at a sufficiently high concentration to be easily detected by gas sensors.

Adsorption Process in the Pre-concentrator Focuser

The main goal is to capture as large an amount of gas as possible from the inlet stream within a specific time interval and then to flash the gas sample to the gas sensor by heating the adsorption material and releasing compounds with a higher concentration [4]. In order to achieve this, a number of design and operation factors have to be considered. These are namely:

- The adsorbent region needs to be maximized to allow an optimum amount of adsorption material
- The electrical power needed for desorption has to be minimized
- It is desirable to reduce the time needed to heat the adsorbent material during the desorption

Figure 2 Gas concentration in the pre-concentrator adsorbent

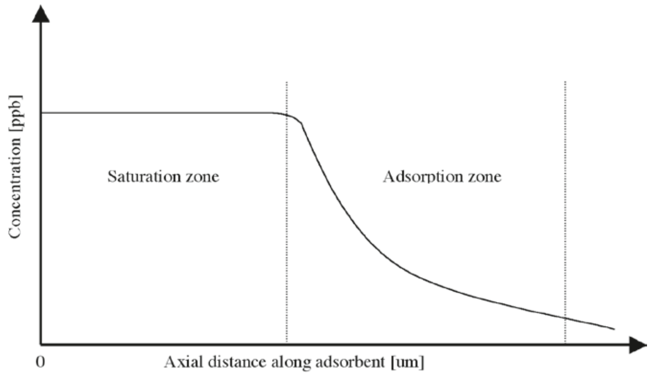


Figure 3: Behavior of adsorption isotherms at different temperatures

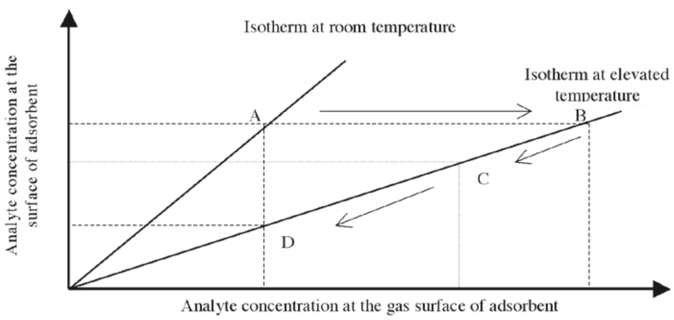
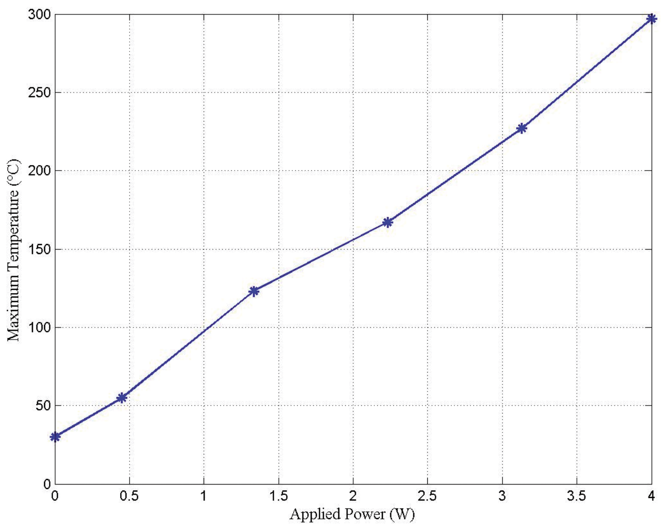


Figure 4: Thermal behavior of silicon heater



Due to the fact that the adsorption process is non-linear, some assumptions are applied to simplify the problem:

- Adsorption is irreversible;
- The adsorption is linear;
- The flow in the channel is laminar and considered just in 2D;
- The gas concentration on the adsorbent surface is relatively uniform;

Two zones will be developed during the adsorption process: a saturation zone and an adsorption zone as shown in figure (2). The saturation zone is the region in which the adsorbent material has adsorbed a maximum amount of gas, and the adsorption zone in which uptake is still occurring.

Desorption Process in the Pre-concentrator Focuser

In the adsorption process the adsorption material is heated up and the gas is released due to the temperature change. Figure (3) shows how the gas concentration changes after heating the adsorption material, leading to a higher concentration of released gas sample.

At the beginning the material is assumed to be in saturation state (A); then after heating the adsorption material to the elevated desired temperature, the desorption process begins to take place and the concentrated gas in the air mixture nearby to the adsorbent material surface is subsequently released and flashed out (from (A) to (B)). The concentrated gas will be continuously released and flashed to the gas stream until the concentration of gas returns to the initial level [4].

Adsorption Materials

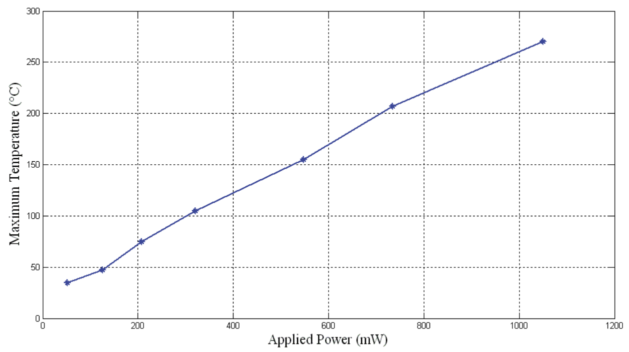
There are many types of adsorbent materials. The selection of the desired adsorption material is mainly based on its chemical reaction with the target gas, which in our case is ethylene. Carboxen 1000 was selected as an adsorption material in the pre-concentrator focuser due to its strong reaction with ethylene. The experimental investigations carried out in our lab have proven the very good reaction of this material with ethylene gas.

Results

Both internal and external heaters were considered in the design. For an internal heater, silicon was chosen and parallel silicon heaters [7] were designed. As shown in figure 4, 3.4-4 Watt is required to heat the adsorption material to the desired operating temperature.

For the external heater design, platinum thin films were considered due to their ease of deposition, high melting temperature (1,765°C) and resistance against oxidation. Moreover, they can be deposited either on glass or silicon wafers with titanium as an adhesion layer and they consume less power to reach the desired temperature (figure 5).

Figure 5: Thermal behavior of platinum heater



Future Work

The dry etching process for silicon etching has to be optimized. Furthermore, the influence of different operating conditions such as flow rate, pressure drop and channel length need to be investigated during the characterization and testing of the device to investigate their influence and to find the optimal operating conditions required for the device to achieve a good ethylene sensitivity.

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Design and Fabrication of a Micromachining Pre-concentrator Focuser for Ethylene Gas Detection System

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Energy Management in Wireless Sensor Networks

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This research focuses on the energy management of a wireless sensor network established in a closed space container; a way to decrease the energy consumption of the sensor nodes. To reduce both measuring and transmitting time of the sensor nodes, environmental parameters (EP) will be estimated instead of direct measurement. In this way, temperature, relative humidity and air flow in a few desired places inside the container will be estimated using a proposed model. As the first step, a new technique of model identification of EP will be introduced. After confirming validity of the proposed model using some results of experiments, conditions resulting in a near optimal estimation of EP in a few desired sensor nodes (DSN) will be investigated. DSN might be either sleeping because of reducing battery-consumption or inactive due to energy depletion. Proposed estimators use dynamic models between selected surrounding key sensor nodes and a DSN. In addition to use in the energy management methods, the proposed model could be extended for possible use in different applications such as EP controllers in air-conditioned systems as well as an estimator in fault recognition.

Introduction >>> One part of the attractive applications of sensor networks in field of control systems is identification, modeling and control of temperature (T), relative humidity (H), and air flow (F) as the environmental parameters (EP) in the air-conditioned closed space containers. We are looking for some model based methods to estimate EP. With respect to these platforms, simple, precise and applicable mathematical models can play a key role. According with our proposal, to achieve a model based energy management of a wireless sensor network it is indispensable to have this kind of model. Therefore finding a way to estimate EP in some desired positions can be the first step. There are three types of models:

1. White-box models which are made based on theoretical considerations.
2. Grey-box models which are extracted from the first principles and parameters of the models are obtained by measurement.
3. Black-box models are identified only by using measurement of the system input and output.

Some white, grey, and black-box models of temperature for air-handling units have been addressed in [1], [2], [4], [5], [6]. The effect of air flow pattern on the temperature is given by [7], [8]. Reference [3] is a brief review of numerical models of airflow in refrigerated food applications. Using (k-_) model and also a data-base mechanistic modeling technique, [5] outlines a methodology to achieve an accurate model of temperature in a closed space. All models are obtained between system input (inlet) and a point in the corresponding space. With the mentioned models, EP in DSNs can change due to variation in inlet. Most of the models introduced in the papers, either linear or nonlinear, do not consider interconnections between the important EP. Furthermore, particular conditions and the limit range of parameter variations are necessary for the implementation of such models. Despite the high precision; complexity makes some of them impractical and others inaccurate in some of applications. Nonlinear multivariable nature and interconnections between the variables of EP in addition to the presence of the load as an unpredictable, immeasurable disturbance, effects of flow dynamic, surfaces and walls inside the container, increase the complexity of the model which we are looking for. Some reasons for existing disturbances in the container are: opening the door, changing either direction or rate of air flow by some freight and the thermo dynamic influences of pallets. In addition to encountering some complicated conditions while solving the white-box model identification problem, disturbance may cause a big estimation error. Thus, our proposed technique considers the influence of disturbance on EP estimation by means of a grey-box model using a wireless sensor network. One of the advantages of this proposal is independency from air flow system in addition to achieving a minimum energy consumption of the batteries of DSNs. According to [11], a brief introduction of a new grey-box nonlinear model of EP between inlet and any desired sensor node (DSN) will be introduced. Then we will use benefits of a sensor network to achieve an independent multi input-single output (MISO) linear model. We use the simplified models in the estimation process and results will be supported with real experiments. Some practical rules to attain a near optimal EP estimation will be introduced. <<<

Problem Definition

Due to the coupling between different parameters of EP, carrying out independent experiments with such conditions are more difficult than it seems. The measurement result completely depends on the initial conditions. Any change in T or H of the inlet may change both T and H in all positions of the desired space. Changing F varies all measurement results. Measurements can be affected by disturbances at all and they might be different even in the same place. Accordant with fig. 1 we will use an optimal combination of several models obtained from surrounding key sensor nodes (KSN) and a DSN so that every non modeled disturbance is modeled as an implicit input change, not as a pure disturbance. KSNs will be the identifiers. When a disturbance is entered into the system, it might excite a number of sensor nodes. For the first time after initializing at least one of the identifiers with a disturbance, several models are obtained using received and existing data from KSNs. Those are identified only between some couples of a DSN and the selected KSNs. There will be a real network with several nodes and branches.

Figure 1: A container with inlet, KSNs (K1, K2), and one DSN (S1).

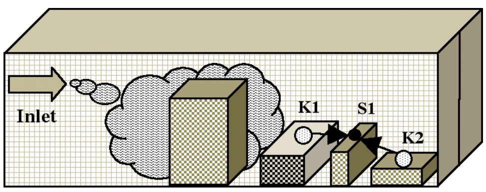
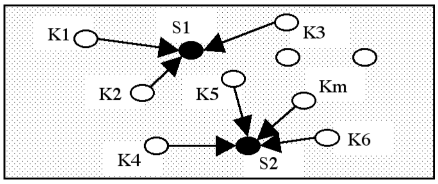


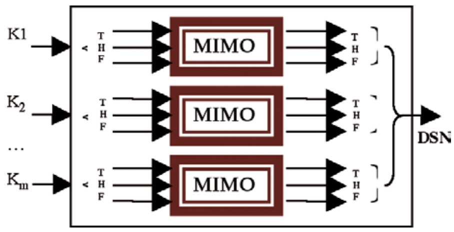
Fig. 2 shows a few KSNs (K1, …, Km) as input nodes and DSNs (S1 and S2) as output nodes. It is noted that in addition to characteristics like an ordinary sensor node (SN), KSNs have three major tasks: (i) they measure EP in a defined period; (ii) they might evaluate measured values and do estimation of EP in place of DSNs in some clusters and update previous models based on the new measurements (depending on using autonomous or non-autonomous strategies, main computations can be done by main processor or KSNs); (iii) they deactivate DSNs when all conditions are normal and there are no big changes in EP. DSNs can be in sleep mode or even they might have been failed. KSNs can be located anywhere in the container, near the door, near to inlet or surrounding the DSNs. If they are located in some key points, estimation mismatch error due to not considering unpredictable phenomenon would be avoidable. This is because during identification based on the presented method, most uncertainties and disturbances are considered indirectly as the input change in KSNs.

Figure 2: Proposed sensor network.



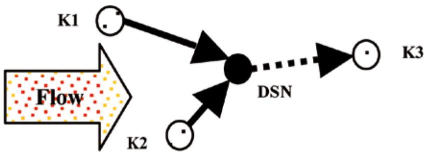
Several MIMO models will be established between KSNs and any DSN (fig. 3). Using a new technique, to achieve minimum battery-consumption we will estimate EP in a few DSNs instead of real measurement. When speaking about the container, with a variation in inlet or even any variation of the environment inside the container, signals measured by DSN and KSNs will be different from those during the identification stage. There are a few questions for reducing the estimation error: (i) How many KSNs are enough to do estimation? (ii) How long the achieved models are valid?

Figure 3: Block diagram of a MISO model of EP.



Whereas we would like to increase the accuracy of the estimations and decrease the total energy consumption by the sensor network, we are interested in turning more sensors to longer sleeping mode. Due to decreasing the calculation, we would like to reduce the number of KSNs contributed in the estimation. But, the accuracy will be increased with increasing the number of these estimators. Accordant with fig. 4, EP of some KSNs influence EP of DSN more than the other KSNs. Considering an air flow direction as a simple example in a three dimensional space, K1 and K2 are more effective than K3. We will obtain a relationship between different KSNs to choose the best estimators. It should be noted that although K3 is not among the impressive KSNs, it may have two properties. It has good correlation with related DSN then, it will improve the accuracy of the estimation.

Figure 4: Block diagram of a MISO model of EP.



Because of the chaotic nature of the air flow direction in the real applications and regard to the limitation in number of air flow sensors, predicting the direction and then verifying the effective KSNs is impossible. Therefore, there will be a mismatch error due to considering non-effective KSNs in the estimation process. It will be shown that using one KSN-DSN to create a single input-single output (SISO) model cannot present surrounding influences completely. It can only show EP variations in DSN from the side of the mentioned KSN. Estimation using multi input-single output model (MISO) will result in better accuracy than using SISO models. As a result, using more effective KSNs is better. Furthermore, whenever sensor failure is occurs in a KSN, other KSNs will be able to continue the estimation. There are also some KSNs which do not have any influences on the DSN. Far from the DSN, they could not help to increase the accuracy.

Motivation and Aims

- Making an applicable model for the environmental conditions inside the container.
- Investigation of performances of the models
- Decision about the optimal positioning of sensors.
- Investigation of the new energy management approach.
- Plausibility check with proposed model based method.
- Implementation of the proposed methods.

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Plausibility check and Energy management in a semi autonomous sensor network using a model based approach

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Electronic Seals for Efficient Container Logistics

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New security requirements for the international container trade are forcing changes in global supply chain processes. Simultaneously, shippers look to advanced technology to enhance the security and efficiency of their container logistics. Customs inspections at international borders, especially in maritime ports, are one of the biggest inefficiency factors, leading to delays and additional logistics costs. An electronic seal as an important part of a multi-layered security system has the ability to enhance the security as well as to improve the efficiency of container logistics. This paper is focused on the problem of reducing customs inspections variation at the ports, and evaluating investments in electronic seals. As a number of global security initiatives require implementing electronic seals on containers, the paper tries to measure the influence of different types of eSeals on the performance of container logistics with special regard to customs inspections in the ports.

Introduction >>> After the terrorist incident in 2001 the cost associated with the closing of U.S. ports for a few days surpassed $1 trillion [6]. Consequently the maritime industry needed to solve thousands of problems connected with new high security requirements that impact the efficiency of ever-increasing "just-in-time" container movements. Companies that use maritime transportation as a part of "just-in-time" logistics processes become more vulnerable to changes and disruptions in their supply chains. The key point affecting the efficiency of "end-to-end" shipping, especially in maritime business, is the customs inspection of containers in the ports. Processes of container transportation are vulnerable to security threats and associated uncertainties. The most critical points for shippers in international container supply chains are uncertainties and lead time in customs and in transit and visibility of their cargo en route from the point of origin to the destination point. Existing capabilities to reduce the customs lead time for container processes and increase visibility in supply chains are still quite limited.

As a result of increased security requirements on international supply chains, technology can be an important bridge between the efficiency and security of supply chain process. Electronic seal technology has such potential. ESeals serve both commercial as well as security interests by tracking commercial container shipments from their point of origin, while en route, through customs, and to their final destination. Companies, that voluntary take part in security programmes and are certified by U.S. Customs and Boarder Protection (CBP) can expect reduced container inspections and related importing costs. The set of requirements for participation includes an application with a written copy of the company's supply chain security plan approved by CBP, and then the intensive process of business validation. In addition, firms that implement additional security measures such as "smart" containers equipped with electronic seals may apply for "third-tier" status, the highest level of security validation. Third-tier companies will benefit from use of "green lane" advantage for containers, meaning that their containers will clear customs without undergoing inspection [2].

Besides fewer delays at border controls, the implementation of high-level security in container supply chain processes produces positive effects on the efficiency of the whole process, such as reducing logistics costs, decreasing inventory stocks and increasing customer service levels.

Thereby, the article addresses the following research questions:

1. How can shippers benefit from investments in electronic seals?
2. What monetary benefit results from avoiding customs inspections in the ports?
3. What type of electronic seal is the most profitable over a 5-year investment period? <<<

Container Electronic Seals

Electronic Seals (eSeals) present a very simple and at the same time very effective defence against various weaknesses concerning container safety in worldwide trade. By implementing various types of eSeals it is possible to enhance container security as well as improve the efficiency of container logistics processes throughout the whole supply chain.

According to current ISO 18185 [4] definition, an eSeal is a "Read-only, non-reusable freight container seal conforming to the high security seal defined in ISO/PAS 17712 [5] and conforming to ISO 18185 or revision thereof that electronically evidences tampering or intrusion through the container door". At the current time there are no global standards for frequencies and technical specification for electronic seals. The International Standards Organization's (ISO) Technical Committee 104 is trying to specify data protection technology, and as a result, ISO 18185-4 Gen 1 was released in August 31, 2005. However, the ISO 18185-4 Gen 1 did not satisfy requirements of data protection and device authentication for eSeals.

In this paper we introduce potential opportunities of eSeals to enhance the efficiency of lead times of containers going through customs inspection processes at a port. An eSeal provides not just physical security but also can contain a set of useful information such as seal number, container number, user data, security, battery and environment statuses and different data useful for supply chain management. An electronic seal has the great advantage of maintaining visibility en route and allows for real-time event reports using satellite or cellular communications. With high-end capability it becomes more attractive for security and business applications.

Finally, the adaptation of eSeals is connected with additional expenses for container business providers and for governments in particular. The problems of investments in such security devices on containers are evaluated in the paper.

Cost-Effective Investments and Returns on ESeals

Heightened container security requirements, especially for import operations, influence the container customs inspection process in ports. Extensive inspections become a bottleneck for container supply chains that slow it down and decrease operational performance. Tightened security control traditionally means increasing the inspection rate for container content rather than enhancing its effectiveness [3]. The effect of increased random sampling checks of containers leads to extended dwell time of containers in a port through the increasing number of containers waiting for inspection and additional logistics costs.

The greatest part of world container volume is repetitive: the same shippers make the same shipments for the same consignees with a large number of containers. These routine container flows are quite easy to "secure" and can be placed under less precise customs scrutiny [1]. Participation in the C-TPAT program and third-tier status will give companies an opportunity to avoid the additional expenses on containers waiting for inspection, to save costs of manual customs inspections itself and to accelerate the container turnover through the whole supply chain. Electronic seals, as a necessary part of "green lane" advantage, lead to additional investments in "secure" container logistics processes.

We present the evaluation of cost-benefit influence of three different eSeals on the efficiency of container supply chain by using the "green lane" opportunity. Cost-Benefit Analysis (CBA) allows us to weigh the total expected costs against the total expected benefits of one or more alternatives in order to choose the best or most profitable option. The process involves monetary calculations of expected expenses versus expected returns on investments.

The cost-benefit calculations of eSeals investments involve, at first, using time value formulas for Present Value (PV) and Net Present Value (NPV) calculations as well as Profitability Index (PI); and secondly, formulas based on record appraisals like Payback Period (PP) and Return on Investments (ROI).

To estimate additional logistics expenses caused by investments in electronic seals we compare in this paper three types of seals:

1. "Container Security Device" (CSD), containing seal ID number, container ID number, additional sensors to indicate environmental status of container content, alarm function to inform in real-time and satellite communication via GPS/INMARSAT systems. With the ability to provide real-time global visibility for container supply chain, CSD has the highest level of costs for its use. We assume that one CSD costs 4,000 € [7] and the possible rent is equal to 10% from the original price, i.e. 400 € per trip. We assume additional operating costs for container sealing (2.5 € per trip) and costs for information transaction (3 € per trip), when the minimum number of transactions is equal to 6.
2. Reusable or permanent active RFID eSeals also include a seal ID number, a container ID number; can initiate alarm calls and record time/date of container tampering. The current problem of RFID seals is that a worldwide RFID reading infrastructure is a prerequisite for their implementation. The question of who will invest to build a global RFID net is still under discussion among the many parties involved in container logistics. We assume that one permanent eSeal costs 500 € [7] and the possible rent is equal to 10% of the original price, i.e. 50 € per trip. We assume both additional operating costs for container sealing (1 € per trip) and costs for information transaction (3 € per trip). The minimum number of transactions is equal to 6.
3. Read-only, non-reusable eSeal defined in ISO 18185. This type of electronic seal contains only a seal ID number and is attractively priced in comparison to the two previously mentioned eSeals. The most common technology for this type of eSeal is passive RFID, which requires an appropriate reading device and software. We assume that one used eSeal costs 5 € per trip. We assume as well that operating costs for container sealing is 5 € per trip and costs for information transactions is 3 € per trip, the minimum number of transactions is equal to 6.

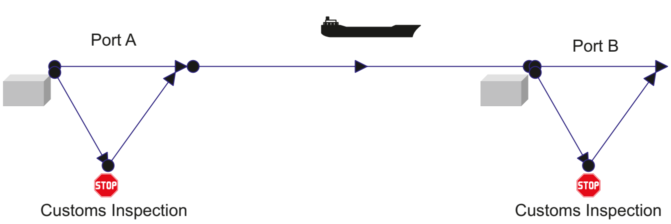
We assume that the necessary global reading infrastructure already exists for RFID transponders or will be a part of investment on the part of governments. The RFID reading infrastructure is the major part of all investments in eSeals and the issue of its responsibility is still open. The annual repair costs for eSeals are assumed as 1% of original price.

We assume that 1,000 containers move through the ports and each container makes 10 trips per year.

We consider two scenarios for containers shipping through the ports:

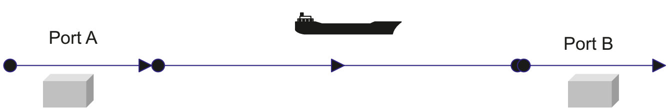
1. Scenario without eSeals. When containers enter the port of loading A, as shown in Fig. 4.1, two alternatives of physical container flows exist: the container goes directly to the waiting area to be loaded on the ship, or it is moved to the customs checking territory to be manually inspected by customs. The latter alternative brings additional costs for container logistics as well as extends container dwell time at the port, which in turn creates additional expense. We assume that the volume of such expenses is equal to 1% of lost sales. We assume inspection costs to be 100 € per container. The realistic rate of customs inspections is 2% of total number of containers. We assume as well that inspections cause additional storage costs for a container at a port. It is assumed that storage costs 1 € per day. The number of storage days due to inspection control is 7 days in the port of loading and 4 days in the port of discharge. Following inspection container a will be loaded on a ship and directed to a port of discharge B. We consider 3 possible variants of physical inspections: first, a container is checked once at the port of loading; second, a container is inspected once at the port of discharge, and; third, a container is checked once at the port of loading and once at the port of discharge. Customs inspections are random checks, so no shipper can be fully confident that their containers will not be opened to scrutiny.

Figure 4.1. 1st Scenario for container processing through the ports under customs inspections



2. Scenario with eSeals. The second scenario describes the perspective of using "green lane" advantage for "secure" containers equipped with eSeals. A container moves from port A to port B without any stops for physical inspection, (see Fig. 4.2). We assume that it brings one benefit for shippers, like the possibility to increase container turnover at least by 1%. We consider two acceptable situations: in the first case, customs checks randomly 0.5% of total number of shipped containers for the first 2 years following implementation of eSeals; in the second case, "green lane" advantage is fully available for use from the first year of eSeals implementation for "secure" containers.

Figure 4.2. 2nd Scenario for container processing through the ports without customs inspections



The 1st scenario presumes that no investment costs (IC) are realized in logistics processes. The authors look only at the change in logistics expenses from the point of view of customs inspections and investments in electronic seals. Thus the assumption is that all other logistics costs for container transportation through the ports do not change. Consequently, from this scenario we can first calculate the customs costs in the cases when the inspection takes place at one or at two ports for the same container, and secondly a possible loss of 1% in annual sales of container cargo (estimated value of 1 container is equal 5,000 €).

In the 2nd scenario, to calculate investments in eSeals we distinguish two variants of eSeal use: rental or outright purchase. The project time period is 5 years. We assume an increase in container turnover of 1% after the implementation of eSeals in container logistics process as one of other possible benefits. Its monetary effect is assumed as 1% annual growth in sales of carrying merchandise by container.

Our investigation distinguishes investment projects when CSD or reusable eSeals are rented by shipper for each container trip each year (I and II projects) and considers the situation where eSeals are purchased outright (III-V projects) for the whole project period:

I. "Rent CSD"
II. "Rent reusable eSeal"
III. "Buy CSD"
IV. "Buy disposable eSeal"
V. "Buy reusable eSeal"

Table 4.1. presents projected positive and negative cash flows for the investment projects and customs scenarios. From the above-mentioned table we can see the difference between projects with customs control (A, B and AB) and potential investment projects (I-V). The last column summarizes negative CFs for projects with 2% customs inspections and positive incomes in the cases of investments in project I, II, IV and V.

Thus, the analysis of annual incomes denotes possible efficiencies from eSeals versus customs inspections expenses.

Table 4.1. Potential Cash Flows

Scenarios/	CF [10^6 €]					Total CFs
Projects	1 year	2 year	3 year	4 year	5 year	[10^6 €]
A	-0.52	-0.52	-0.52	-0.52	-0.52	-2.6
B	-0.52	-0.52	-0.52	-0.52	-0.52	-2.6
AB	-0.542	-0.542	-0.542	-0.542	-0.542	-2.71
I	0.49465[1] 0.5[2]	0.49465[1] 0.5[2]	0.5[1] 0.5[2]	0.5[1] 0.5[2]	0.5[1] 0.5[2]	2.5[1] 2.49[2]
II	0.49465[1] 0.5[2]	0.49465[1] 0.5[2]	0.5[1] 0.5[2]	0.5[1] 0.5[2]	0.5[1] 0.5[2]	2.5251 2.49[2]
III	-0.11035[1] -0.105[2]	-0.11035[1] -0.105[2]	-0.105[1] -0.105[2]	-0.105[1] -0.105[2]	-0.105[1] -0.105[2]	-0.525[1] -0.5357[2]
IV	0.25965[1] 0.265[2]	0.25965[1] 0.265[2]	0.265[1] 0.265[2]	0.265[1] 0.265[2]	0.265[1] 0.265[2]	1.325[1] 1.3143[2]
V	0.25965[1] 0.262	0.25965[1] 0.262	0.265[1] 0.262	0.265[1] 0.262	0.265[1] 0.262	1.30[1] 1.31432

[1] Customs check randomly 0.5% of containers 2 years after implementation of eSeals
[2] "Green lane" advantages are from the first year

Nevertheless, it is still necessary to analyze each potential investment project, taking into consider the rental prices of eSeals, costs to buy each type of eSeal, and additional operational expenses that are incurred with their use, e.g. transaction costs, sealing and repair costs. We computed the values of NPV, PI, PP and ROI parameters for each project of potential investment by using Excel.

The analysis of the obtained results (Table 4.2.) reveals that variants II, IV and V are acceptable for realization over a reasonable 5-year project period. Project IV is the most profitable. It has the greatest NPV value and the highest ROI. The payback period is also the lowest for project IV. At the same time, reusable eSeals have a lower NPV and PP than project IV for the variant when a shipper buys the seals outright (Project V). It shows that this project is also acceptable for future investment. Furthermore, considering that the NPV of single-use seals is not much larger than that of reusable eSeals, these two variants of investment should be analyzed as alternative projects taking into account investments in reading infrastructure, development of device prices in the future and the benefits for potential eSeal users.

Project III has all negative parameters, as seen from the Table 4.2. So we can conclude that, with current prices of CSD, to buy and exploit them the shipper has to get more monetary benefits. These benefits should be included in the investment analysis to get more realistic results.

Table 4.2. Parameters of the investment values for different types of eSeals

Projects	IC [10^6 €]	NPV [10^6 €]	PP [years]	PI [%]	ROI [%]
I. "Rent CSD"	20.00	-18.11[1]	40.40[1]	0.09[1]	0.02[1]
		-18.10[2]	40.00[2]	0.09[2]	0.03[2]
II. "Rent reusable eSeal"	2.50	-0.61[1]	5.00[1]	0.75[1]	0.20[1]
		-0.60[2]	5.00[2]	0.76[2]	0.20[2]
III. "Buy CSD"	4.00	-4.41[1]	-4.39[2]	-38.1[1]	-38.1[1]
		-0.101	-0.102	-0.03[1]	-0.03[2]
IV. "Buy disposable eSeal"	0.25	0.751	0.75[2]	0.901	0.90[2]
		3.981	4.022	1.05[1]	1.06[2]
V. "Buy reusable eSeal"	0.50	0.501	0.48[2]	1.901	1.91[2]
		1.991	1.972	0.53[1]	0.52[2]

1 Customs check randomly 0.5% of containers 2 years after implementation of eSeals;
2 "Green lane" advantages are from the first year.

Conclusions

In the paper we have analyzed two scenarios for container shipping through the ports. The scenario without eSeals presents the current inspection costs for containers. For the scenario with eSeals we have analyzed how effective investments in container "security" by means of eSeals will be. The direct impact of "secure" container trade comes from avoiding customs inspections. This advantage alone can result in monetary benefits for shippers in less than one year. Considering the obtained results, the paper shows the positive tendency of investing in security devices on the efficiency of container business.

Our further research will entail a more detailed analysis of investment for reusable RFID eSeals. They provide more possibilities to be used for logistics purposes and new benefits for improving container shipping processes. We also plan to analyze the advantages of investing in CSD due to more visibility benefits for the container supply chains.

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Electronic Seals and Their Influence on the Dynamics of Container Logistics Processes

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The Supply Net Game

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The paper describes a simulation game called the Supply Net Game, built around the structure of a production network based on the "anchoring and adjustment heuristic", which is known as the one people use to infer about uncertain events. The game involves four participants managing manufacturing units which proceed to the joint production of items. While planning production and controlling inventories, the participant should minimize the costs caused by both backlogs and items in stock. The paper stresses the valuable impact of simulation games for engineering education. Particularly, the importance of learning implicit skills and gaining insight into inventory control of distributed production systems is fostered.

Introduction >>> Decision makers are younger than ever being thrown into key positions in global organisations, having had little previous accumulated experience to deal with the problems they face in the work environment – mainly because the management layers are shrinking. This case may also be extrapolated to students who learn in classrooms with conventional tools lacking interaction (case studies, exercises that promote linear thinking…). Decision makers should use gaming simulation tools to enable them to cope with the business systems in which they evolve and to acquire strategic management skills. Simulation games stimulate risk-free try outs of strategies, illustrate the relationship of system structure to behaviour, and portray learning according to the scientific method whose objective is understanding the problem genesis and dynamic behaviour of complex systems. This can provide sustainable policies. [1] emphasizes the need to introduce management games to practioners and engineering students so that they can learn the task of inventory management and aptitudes like communication and cooperation in complex distributed production systems such as production networks. <<<

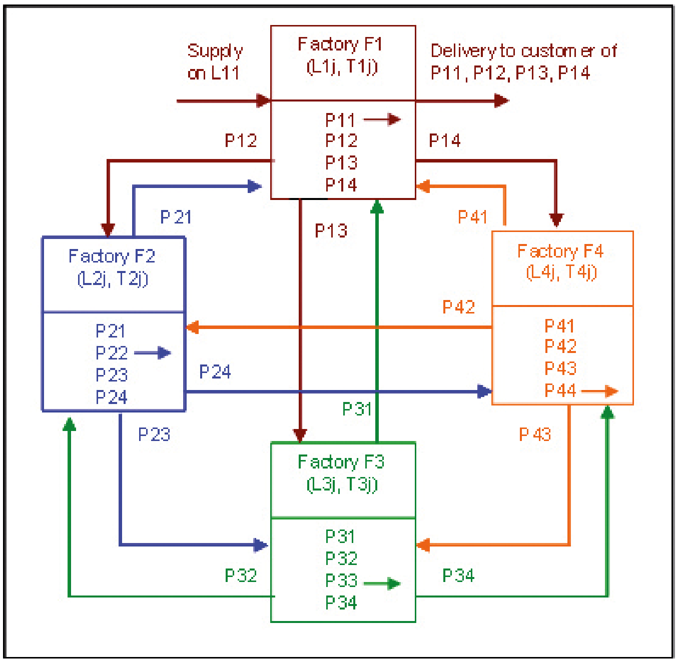
Simulation Games of Production Systems

The Beer Game and Dice Game are some typical inventory-control applications. The former portrays four participants in a linear supply chain structure with information and material flows, time and shipping delays. The latter leans on Goldratt's theory of constraints for capacity management problems. Some applications of distributed production systems exist such as Cosiga, Glotrain, and Share Game, to name a few. All of these simulation games were developed at the BIBA institute of the University of Bremen. Overall, they aim to train engineers on the principles of concurrent engineering, as well as product development, and are played in teams. The participants coordinate their efforts for the specification, design and manufacture of a product around the game's platform. These games are meant to reinforce trust, collaboration and teamwork in and across teams, whereby communication between the manufacturing units is primordial in a production network.

The Supply Net Game

The Supply Net Game is built upon a four-manufacturer production network (see figure 1) and has, as a replenishment procedure, the "anchoring and adjustment heuristic" [2]. It is a procedure that people utilize to make inferences about uncertain events. In the Supply Net Game, the participants manage the stock levels encompassed in their manufacturing units by placing orders of raw materials for the four production lines comprised in every unit.

Figure 1 Structure of the production network



Meanwhile, the participants try to minimize the costs incurred. The minimization of costs corresponds to bringing the bullwhip effect to its smallest expression since the effect, defined as demand variability over a supply chain, generates stacked backlogs when demand booms, and huge inventories when orders fall, the two situations producing considerable costs. Two types of costs are hypothesized: (a) 0.5 EUR per product in inventory per minute and (b) 1.0 EUR for a product in backlog. These costs are supposed to be the same for all manufacturers. This simulation game was modelled and simulated by means of the system dynamics methodology (see figure 2) because it possesses a long tradition of contribution to the refinement of individual and organizational learning [3].

Although the model based on the structure of Figure 1 is theoretical, some re-entrant production networks have their products start from a processing machine M1, then visit a machine M2 to return to M1 at the end. Obviously, this loop can be cycled more than once. In the semiconductor industry, chips are produced according to the re-entrant framework – like the production network presented in this study. Therefore, the semiconductor example describes a real-life setting for this model. Indeed, even though the production network is distributed, the different factories could be regarded as processing stations pertaining to one factory.

In this simulation game, every participant is assigned to the inventory control of one factory, integrating four production lines. Participants replenish their inventories by the placement of orders in each simulation period. For example, the scheduler of factory F1 subsequently fixes the order rates of the raw materials for items P11, P12, P13 and P14. Afterwards, the next user, who can readily see the levels of the stocks and WIP in the network too, decides on the requests for the manufacturing of the products in F2.

The scheduler in charge of replenishing the stocks pertaining to factory F2 uses the interface depicted in Figure 3. A multi-player simulation game was built with interactive graphs, scrolling tables, sliders and navigation views in Vensim's gaming mode. In deciding how much to order for a product, participants have exhaustive information about the magnitude of the (i) backlog for the product due to the network's internal demand (baPij) and that attributed to customer demand (badstPij), (ii) inventory (StPij); and (iii) work-in-process (WIPPij) as well as (iv) order rate (ORPij) already entered in the last period. Marginal costs for the entire network and per factory are plotted as a measure of the team's performance. The production rates of the factory can be graphically inspected as well. Furthermore, the participants are unaware of customer demand, but they can estimate it from the rest of the information in their possession. Communication between the team members is encouraged, since production networks are highly co-operative and collaborative environments.

Figure 2 Stock and flow submodel of the production lines L13 and L31

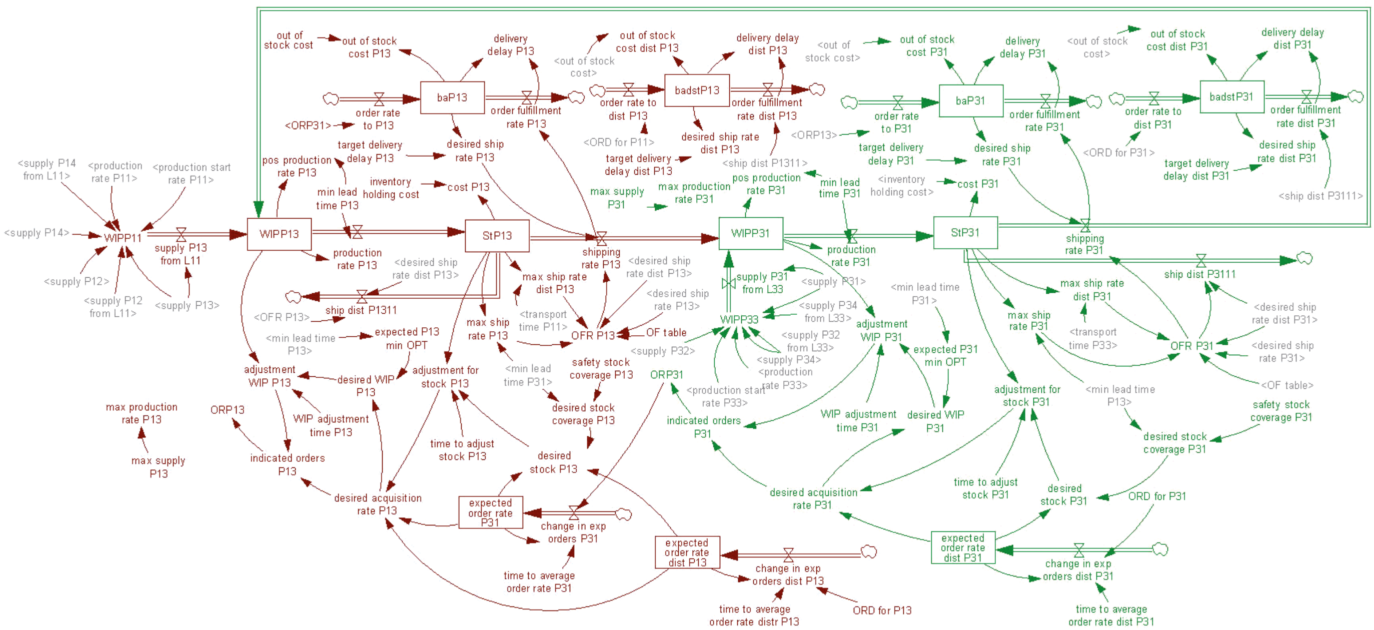
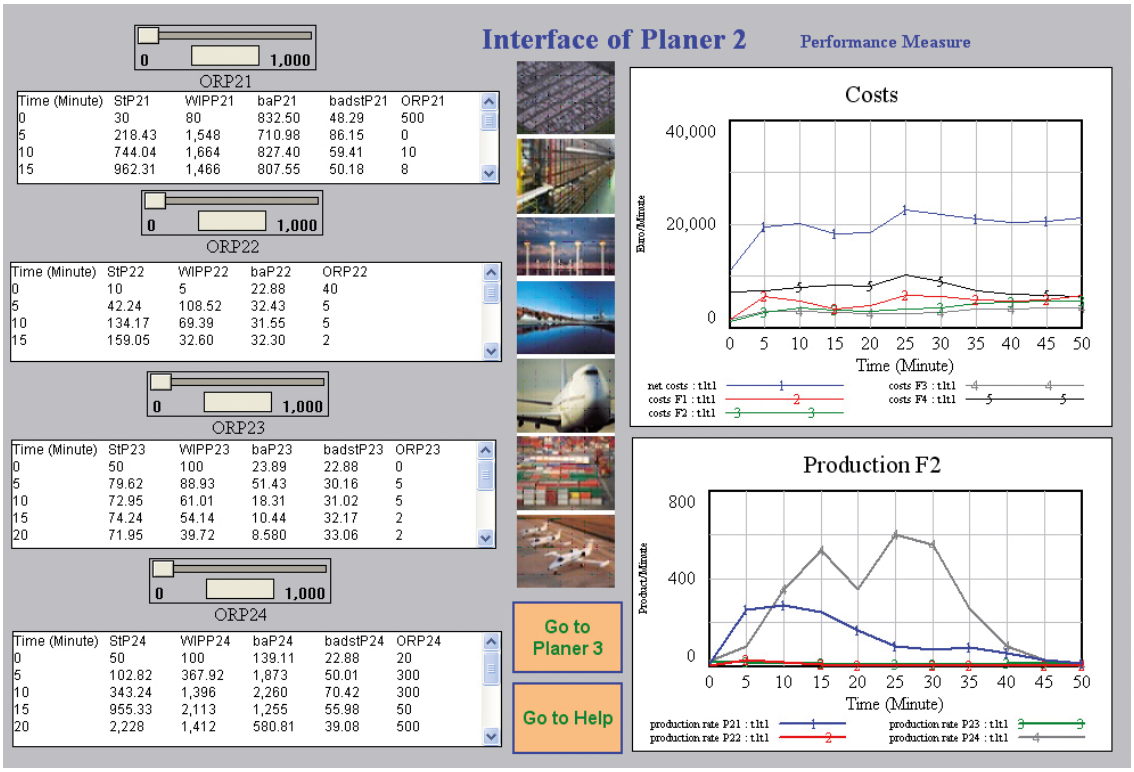


Figure 3 Interface of the scheduler responsible for factory F2



Practical Application

From a technical viewpoint, the Supply Net Game may be linked to the online ordering platform of the firm so that the results deriving from the policies chosen by the decision makers can be first tested on the game's platform. The idea is that the scheduler manages one position, while the computer takes the role of ghost participants for the rest of the positions. Afterwards, decision makers decide on the levels of orders to place. The online ordering system utilized by the firm will take care of this electronic transaction. Most important, the Supply Net Game is thought to promote an aggregate feeling in decision makers for the outcomes of their potential real-life strategies. If the online ordering system fails to exist in the organisation, the e-Logistics contractor's system can still host the simulation game. Because of the boom of logistics, the role of such contractors is steadily increasing.

Conclusion

In summary, since all decisions are left to the discretion of decision makers, the significance of and genuine need for gaming environments is underpinned in complex logistic and production networks. Current breakthrough examines the introduction of autonomy principles to production and transport systems with the characteristics of self-organisation and self-control. Only if these environments came to life could the development and encouragement of simulation games be challenged. Nevertheless, this will be a partial challenge as the autonomous logistic processes will be hybrid – which means under human control to some extent.

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Learning Evaluation of the Inventory Control Task with Simulation Games embedded in Learning Labs: - An Experimental Approach with the Supply Net Game

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Bridging Distant Contexts

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Any economic organisation faces two basic challenges: first, it must survive the challenges of today, and second, it must adapt to the challenges of tomorrow. This exploratory research will tackle the latter, focusing on logistics systems that connect/bridge distant contexts.

Organisations innovate and create wealth through the interplay of decision making and context feedbacks (i.e. market and non market). In this context; How to enhance business strategies/plans? We argue that globalisation supports / asks for complementarity of knowledge structures, resources, competences and interests. Therefore global logistics systems and their connective function play a central role in enhancing the effectiveness and sustainability business plans.

Introduction >>> Competition across borders impels the pursuit of new and attractive markets as well as high quality and low cost sources. The global economy in which the motto is: "to invest where you get maximum returns, source talent, raw materials, products and services from where it is best available, produce where it is most cost-effective, and sell where the markets are, without being constrained by national boundaries" [1] has imposed worldwide business and political challenges.

Globalisation is underpinned by communication and transportation evolution. These technologies have allowed business networks to expand out of their original national borders, exploit new markets, and locate production and sources in different countries [2]. Today, organisations have to deal with multiple interrelations between actors and stakeholders within distinctive environments [3]. Marketing, production and sourcing fronts have shaped material, information and value streams in more distant, dynamic and complex manners. Connective logistics systems' flows, assets and power dependencies have a remarkable influence on business strategies.

In this scenario the issues are: Is human nature already prepared for a global gathering? How should nations improve attractiveness for investments and thus enhance development? How could organisations improve fitness function aiming to cope with risks and profit from opportunities? Which individual behaviours and skills underpin tomorrow's key competences and should be inspired? <<<

Evolving Competitive Advantage through Logistics Systems

The process of searching and discovering business plans that fittingly coordinate physical and social technologies [7, 8, 9] for connecting markets, production and sources should target organisations' competitive advantage evolution. Changing competitors, dynamic behaviours and complex structures imply that competitive functions are not totally foreseeable. Therefore in order to achieve and sustain desired effects the process should be iterative and interactive.

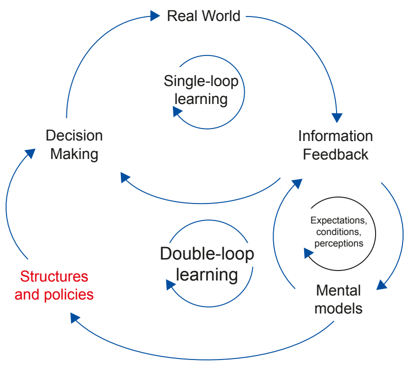
Competences within Open Systems

The competence-based view of the firm aspires to recognise and capture the dynamic, systemic, cognitive and holistic nature of organisations [10]. Competence can be defined as the "organisational, repeatable, learning-based ability to sustain the coordinated deployment of assets and resources enabling the firm to reach and defend the state of competitiveness and to achieve its goals" [11]. They may be derived from different kinds of knowledge: know-how – practical, hands-on forms of knowledge gained through incremental improvements to products and processes; know-why – theoretical forms of understanding that enable the creation of new kinds of products and processes; and know-what – strategic form of understanding about the value-creating purposes to which available know-how and know-why forms may be applied [10].

Decision-makers' bounded rationality [12] is dependent on available information, personal experience and background. A formal typology for the five competence modes was proposed by Sanchez [10]: mode I – cognitive flexibility to imagine alternative organisational strategic logics, perceiving feasible market opportunities for the organisation to create value; mode II – cognitive flexibility to imagine management processes for implementing those strategic logics; mode III – coordination flexibility to identify, acquire/access, configure and deploy chains of resources; mode IV – resources flexibility by the range of uses, time and cost associated; and, mode V – competence to use the resources efficiently and effectively.

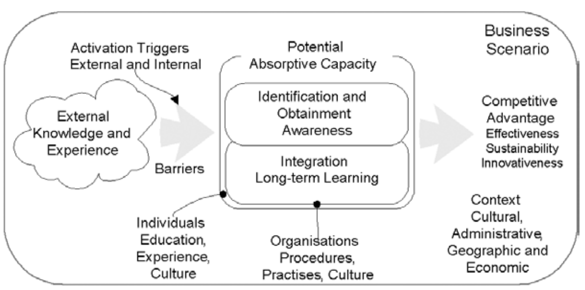
Open system view [13, 14] emphasises the interface between the organisation and its environment through open and semi-permeable boundaries. Therefore, the connective function of logistics systems fostered here will focus on modes I and II, both influenced directly by organisation-context interplay. When changes are dynamic, decision-makers must have cognitive flexibility to recognize and deal with/profit from emerging behavior. The organisational perspective should be oriented toward iterative double-loops (Figure 1) learning in which a reductionist, narrow, short-run, static view of the world is replaced with a holistic, broad, long-term, dynamic view [15, 16]. The acceleration of these loops could impel the emergence of more adaptive strategies, structures and policies and thus more effective decision making.

Figure 1 Learning process [adapted from 16]



Competitiveness depends on resource- and competence alignments to market's needs [11] and is related with embedded awareness – influenced by an organisation's scope and boundaries. Socially complex networks facilitate the identification (awareness) and absorption (integration) of externally generated experience and knowledge, embodying organisations' (potential) absorptive capacity [17, 18] (Figure 2).

Figure 2 Potential Absorptive Capacity [adapted from 17, 18]



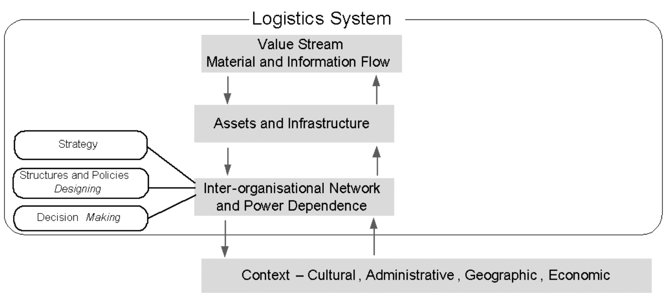
The question as to how knowledge sharing across individuals affects the development of organisational absorptive capacity leads to the conclusion that both overlap (to enable internal communication) and diversity (to potentialize the comprehension of outside information) of knowledge structures is required. Successful knowledge identification and acquisition require the receiver to possess suitable background and skills to assimilate new information [18]. Individuals have a central role in influencing search patterns and awareness, activation of triggers as well as knowledge integration. External information has on the one hand gained amplitude and scale; and, on the other hand, evolved in diverse and structurally complex manners. In fact, enhancing competitive advantage on this basis is an important capability within logistics systems. The integration of varied knowledge structures might be positive for awareness, yet new communication challenges may appear.

Logistics Systems: Interacting and Connecting

The effects of international venturing activities depend on firms' absorptive capacity [19]. As with international logistics systems, venturing activities enable gaining knowledge and capabilities that allow the exploitation of opportunities in foreign markets. In this case, greater benefits could be realized through the integration of new knowledge and capabilities [19]. These evidence the importance of relatedness/complementarity of new knowledge to existing wisdom. Globalisation has encouraged companies to expand internationally and to create new revenue streams. International venturing may give firms new knowledge and skills that fuel their innovation and business creation [20]. Strategic decisions impact on both path- and context-dependencies and should take advantage of co-operation with other organisations to best use available knowledge, resources and competences [11].

Sensing and learning through the connection with "real world" fronts – markets, production and sources – have widened the relevance of global logistics systems for enhancing competitive advantage. Logistics systems and their distinctive yet interlaced levels may be illustrated as interactive systems [21, 22], and viewed as a linked and interdependent universe of actions – i.e. decision making, structures and policies design as well as strategy. The descriptive model (Figure 3) aspires to draw, in a suitable fashion, the constructive elements, enhancing the understanding of this socio-technical system.

Figure 3 Logistics system [adapted from 22]



The discrete levels of analysis are inextricably attached elements of the logistics system [22]. Together they cover elements of system and context, though each level reflects quite different perspectives [22]. For example, level 3 distinguishes the system as an inter-organisational network, with nodes representing organisations – private and public sector – that interact with, possess or manage assets and infrastructure, and through which the physical goods and information flow. The design, plan and management of logistics systems – relevant to provide the exposition to our complex "real world" in the argued long-term learning – are particularly complex because of the diversity of contexts, organisations and individuals involved.

Complementarities across Diversities

The status of resources and competences might change all the time – in particular in vibrant markets. In order avoid risks and exploit opportunities, some guiding principle could be cited [11]: related diversification normally outperforms unrelated diversification; relatedness measured in terms of business units and resource endowment (knowledge structures); and modes of unrelated diversification without any substantial connection (horizontal/vertical) to actual business are problematic due to the threat of considerable resource and competence gaps.

How to develop reality understanding, yet avoid undesirable implications and risks? It would be important to foster individuals/agents' variety and also expose organisations – in some controlled manner – to diverse contexts. Knowledge accumulated in trial and error processes helps to increase the likelihood of success in case of refinement processes [11]. The role of logistics systems would be exposing organisations to new realities, contexts in strategic experiments. Long-term learning process would be the result of the interplay between the organisation and the context.

Moreover, innovation is defined as the application of knowledge in a novel way for economic benefit [11]. Innovation initiatives may be more effective and sustainable in the frame of interwoven, yet independent, organisation's networks that properly deal with complementarities. Therefore, logistics could support innovation impulse through experience and knowledge bridging – inherent to flows, assets and power dependencies – over borders between distant markets, production and sources' realities.

Bridging Distances

Innovative business plans' fitness function is dependent on market and non-market variables. Strategies for designing effective plans should foster awareness through suitable learning structures and policies. Furthermore, selective permeability of organisations' boundaries to valuable knowledge is strategic. High awareness to distant – cultural, administrative, geographic and economic dimensions [6] – contexts in early differentiation phase can improve survival rates and help avoiding over-optimisms due to bounded and unaware rationality.

Considering the ways in which culture express itself, assessing facts and evidences through resulting institutions, administrative practises, tangible products, beliefs and expressions might be of great worth. For instance, it is well known the relevance of cooperative behavior (trust sharing) for economic evolution.

Path- and context-dependencies inscribe causes and effects on both spatial and temporal levels (history and context matter). If suitable foundations are not available new business plans and investments might not endure. In a world where differences also matter [6], conducting comparative studies involving different contexts is relevant to (i) analyse implications regarding borders crossed and (ii) support the application of logistics systems as bridges and connectors.

The complexity perspective would say that government regulations form part of the fitness environment where organisations compete in. Nevertheless, markets must provide the mechanism for selecting and amplifying business plans. The state should create an institutional framework supporting markets' evolutionary work, foster effective balance between cooperation and competition, and shape the economic fitness function to best serve the needs of society [26].

Supportive context plays a relevant role in attracting external agents and activating development mechanisms and initiatives. Some drivers of this global motion could be cited [27]: political and macroeconomic stability, stable institutional and regulatory environment, openness to foreign investment, ease of hiring foreign nationals, openness of national culture to foreign influence, protection of intellectual property, and positive attitudes towards scientific advancements.

Administrative or institutional efficiency embody the necessary basis for the accumulation of physical and human capital accompanying technological innovation and, in the long run, to achieving long-term economic growth. It is important to keep in mind that cultural aspects influence but, in a longer term, are also affected by nations' economic, social and political evolution.

Differentiating Approaches by Industry and Perspective

Any economic organisation faces two basic challenges [9]: first, it must survive the challenges of today, and second, it must adapt to the challenges of tomorrow. To cope with evolving international threats and opportunities, organisations have to take into account distant (culturally, administratively, economically and geographically speaking) contexts, organisations and individuals. In analysing this subject different perspectives and also stratifications by industry and nations should be employed.

The global economy involves continual turnover of products, firms and industries and is characterised by novelty and variety, not similarity and homogeneity [28]. In the networked economy value is created through the establishment of new connections between elements [28]. To achieve effectiveness is necessary to produce the right outputs in line with present and future market needs. Furthermore, sustainability concept embraces both: (i) keeping effectiveness along time and (ii) preserving (or even enhancing) the economic, social and environmental resource base.

Business networks and logistics systems in an interwoven world characterised by cyclical opportunities and threats are distinctly challenging. The survivors will be the most adaptive and innovative, the ones capable of identifying and absorbing useful knowledge and transforming it into competitive advantage. Furthermore, to align networks, culture and processes in supporting a fast-moving organisation that can outperform its competitors, it is relevant to move beyond command-and-control paradigm towards a more organic approach – one that is holistic, omni-directional, iterative and interactive [24].

In regard to corporate strategic and forward looking, diversity supports the identification and exploitation of new opportunities. Abundance of information does not naturally lead to strategic and valuable knowledge gathering. Innovation can be interpreted as the iterative matching of technical possibilities to opportunities via market and non-market interactions, feedbacks and learning processes – throughout research and development, production and logistics networks. Profiting from this matching process requires organisations' boundaries to be conductive to valuable knowledge. In this perspective assets and power dependencies gain more relevance due to path-dependencies and their influence on strategic decision making. Business should evolve a portfolio of strategic experiments/plans [9] facing loss aversion and the stability preference mental models.

This corroborates the perception that proximity and awareness enhance effectiveness. It favours diversity and learning as forms of improving adaptability and speeding knowledge growth – the ultimate limit to organisations' growth [29].

Outlook

Bridging distances entails unidirectional (one nation among others) and bidirectional (between nations) assessment and connection. Therefore, to create a palatable problem – and also considering empirical data available – some aggregations on both organisational and national levels are mandatory. Forthcoming research will approach logistics systems that connect/bridge distant contexts, keeping the focus on the adaptations to tomorrow's challenges.

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Sustainability and Effectiveness in Global Supply Chains: An Approach Based on a Long-Term Learning Process

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Supply Chain Security: An Overview of Theoretical Applications

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The literature dealing with changes in security issues in supply chains applies principals from several areas of management theory, namely: risk management, total quality management, and crisis management. The terms security, vulnerability, and resilience are used frequently; however, there are no definitions of these terms, and there is a lack of common understanding and consistent usage of them. Definitions for these terms are proposed in this article. Secondly, the point is made that a real measurement of risks and uncertainties is lacking from the literature dealing with security in supply chains. Further, the reaction to the security requirements on the part of players in the logistics industry demonstrates that supply chain management theory is not being applied in the holistic way that is prescribed by the theory, and underlines the necessity of verifying the applicability of such. To this end, it is shown that supply chain security and efficiency are not necessarily opposing goals, but are both attainable with improvement to supply chain processes.

Introduction >>> After the terrorist attacks on the World Trade Center on September 11, 2001, the freight transport industry came under particular scrutiny, as there are concerns that container shipments and shipments of dangerous goods might be misused for malicious purposes. And these threats are not wholly unsubstantiated, as there are numerous examples of organized criminal activity around the transport industry: containers are used to smuggle illicit narcotics and immigrants, and theft continues to be a problem in the industry. Moreover, there seems to be evidence that funds gained from piracy and through smuggling activities are used to finance terrorist activity [5]. Although the actual risk of a terrorist attack via a shipping container is still an unknown, the security measures that are coming into effect are having a real impact on the costs in the shipping industry. In response to these threats and to the introduction of counter-terrorism measures imposed on the transport industry in the wake of 9/11, security of international logistics operations has seen an increase in supply chain management literature over the past five years. To date, a large area of research regarding supply chain security has addressed the immediate needs of players in the logistics industry to meet the requirements set out by new security regulations and government initiatives. Arguments justifying the necessity of heightened transport security precautions are made, mostly centring on the characteristics of the logistics industry that make it vulnerable to attack [9], [18], [22], [2]. Containerized transport is considered to pose a specifically high risk [6], and is the focus of the security initiatives proposed from the American side, as in the C-TPAT, 24-Hour Rule, CSI, and as of December 2006, the Secure Freight Initiative, as well as the ISPS-Code from the IMO. In response to these measures, research has been done firstly into the impacts of implementing such initiatives and the suitability of the proposed measures: the expected effectiveness from taking such actions, and difficulties that arise due to increased costs and the aversion to the necessary information sharing that these initiatives would entail. Secondly, the feasibility of meeting additional security requirements, while controlling for the added costs and maintaining efficiency is discussed. Many of the proposed solutions to the problem of efficiently hardening supply chains against attack draw on various areas of management theory, or look to existing and emerging technology. Principles are drawn from risk management, total quality management, and crisis management, and interfaces are sought between these and concepts from supply chain management. In the discussion surrounding security, however, a number of terms routinely recur, but are often left undefined: security, vulnerability, and resilience. It is even more uncommon to find quantified goals attributed to these concepts. It becomes clear that it is necessary to define here what is meant by security, and to place reasonable expectations on what can and cannot be achieved in terms of conditioning the supply chain. The introduction of international and regulatory security initiatives for supply chains is seen as a threat to undermine the efficiency of the supply chain, as they necessarily introduce new costs [7], while they do not create extra benefits, hence producing a net loss [23]. Efficiency in this context in the literature refers generally to the time and monetary cost of a transport process. The argument for efficiency loss is not only that extra costs dampen the supply chain, but rather that the principles of supply chain management used in the past to reduce costs and turnaround time – such as lean manufacturing and just-in-time supply chains – are threatened by the security requirements [8]. Costs relating to security can be broken down into direct and indirect costs. Direct costs for security are those related to investments in physical assets (fences, closed-circuit television CCT, access controls, e-seals, etc.), human resources (training and security awareness programs, background checks), and security fees, such as those taken by sea ports to cover their costs of regulation compliance. Indirect costs arise from delays due to security checks. In this case, unplanned delays of containers at ports or freight terminals reduce the efficiency of the supply chain processes; costs are raised, while the reliability and quality of the system diminishes. Improving this negative cost-quality relationship is then the goal of the research done in the area of logistics security [14]. **<<<**

Security, vulnerability and resilience of supply chains

Security is a term persistently used but, more often than not, left undefined and general. In the context of the threat of global terrorism, "security" refers to a general sense of well-being, and a confidence in the continuity of the present, especially business, conditions. On the other hand, security refers to any modifications made to supply chain processes, both organizational and technical, that are taken to prevent undesired events from taking place, such as theft, loss or sabotage by a malicious group. The goal of the government-led security regulations is to reduce the possibility of a terrorist attack taking place [9], [22], by reducing vulnerabilities in the supply chain.

Supply chain security: theoretical applications for improvement

Security initiatives, put in place since 2002, have already made an impact on business logistics, but it is questioned whether strictly adhering to the mandated security measures is enough to improve the vulnerability of supply chains. Investments and modifications for increasing security require a framework if they are to do more than increase costs. Supply chain management itself offers such a framework, as it provides principles for upstream and downstream information-sharing, process integration, and co-evolution of interacting firms for satisfying external demands, as well as for managing the inter-firm relationships necessary for inter-firm coordination to take place [16]. In an effort to frame the analysis of supply chain security, existing theoretical models from quality management, crisis management, and risk management lend insight into supply chain processes.

Quality Management

Quality management methods have been applied to logistics processes before supply chain management even became an established research field in management theory. The applicability of methods from quality management (QM) to supply chains is due to its cross-functional approach with a focus on satisfying customer demands [3]. Moreover, quality management provides methods for analysis and performance measures of processes to find areas where quality variations are created, rather than attempting to identify non-compliant finished products. Regarding a QM approach to logistics security, this translates into ensuring the integrity of a shipment from the point of origin through the supply chain. Lee and Whang [10] argue that the application of QM can improve both the cost efficiency and the security of supply chains by improving relationships with suppliers. Bichou et al. demonstrate how QM can be used by liner shipping companies to meet regulations, while allowing them to meet service and cost goals to reach a competitive advantage [4]. QM provides insight into how supply chain processes can be improved to make them less vulnerable to outsiders, but it lacks the ability to deal with real risks that persist due to non-controllable hazards.

Crisis Management

Crisis management recognizes the threat of catastrophic events, such as natural disasters or labour strikes, to business continuity. Catastrophic events are ones over which business managers have no control, but which create significant social losses. Managers must instead be able to recognize and respond to disasters in a way that minimizes losses in the long-term. The five-stage process to disaster contingency planning is: planning, detection, mitigation, response and recovery. Mitigation strategies must be: a) social, rather than physical; b)pro-active rather than reactive; c) focused on internal structures, rather than external forces; d) integrated with on-going processes; e) monitored, reviewed and modified for their effectiveness [21]. For supply chains, crisis management is useful in that it draws attention to the vulnerabilities created by the interdependencies of firms and impacts due to the network nature of supply chains [17]. Crisis management is the basis for the analysis by Barnes [2], and he demonstrates that crisis management should be used to help firms perceive and minimize losses resulting from a damaging event. Crisis management is most useful for understanding sources of vulnerability, identifying potential hazards and planning investments to reduce negative impacts on the supply chain, but does not provide the necessary framework for improving the network and relationships that are required.

Risk Management

Risk management (RM) approaches form the basis of the security measures proposed by the US-led C-TPAT, CSI and 24-Hour Rule, as well as the ISPS Code. RM seeks to match an identified risk, or hazard, with a likelihood of occurrence and a probabilistic impact. The goal of RM is to guide decisions for investment and process analysis to either reduce the likelihood of an undesirable incident occurring, or reduce its impact. RM and its relationship to SCM in the literature and areas for future research are discussed by Helen Peck [15], and an overview of supply chain risk-management literature is given by Ulf Paulsson [13]. Supply chain risk-management focuses on the risks related to flows in the supply chain [13], and especially those which are partly caused or amplified by processes in the supply chain; terrorism, theft and loss are then treated as flow-related risks (strategic/operational uncertainties). While the RM framework offers useful tools to identify, measure and mitigate risks, it is not wholly able to solve the problems of vulnerabilities in the supply chain to attacks from outside, as it tends to focus inwardly on the risks caused and amplified by the supply chain processes. An RM methodology is applied by Tzannatos [19] for the creation of a decision support system for shipping security. Lacking is still a quantitative assessment of the threat of terrorism via the shipping container; nonetheless, the impact would be unquestionably large enough to merit mitigation.

Conclusion

Securing supply chains requires thoughtful improvements to business processes. Simple adherence to legal requirements creates additional costs to the supply chain, and, while this may facilitate transport crossing at international boundaries, it does not go far enough to take advantage of the opportunity to refine inter-firm relationships and processes that can potentially produce efficiencies. Analysis of supply chain processes under the frameworks of quality, crisis, and risk management can highlight potential areas of improvements; transparency and improved collaboration along supply chains is a common theme, and promises reduced vulnerabilities, allowing the supply chain to deal with evolving threats, without sacrificing efficiency.

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Decision Support System for Intermodal Logistics under Considerations for Cost and Security

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Autonomous Fault Detection and Isolation in Transportation Systems

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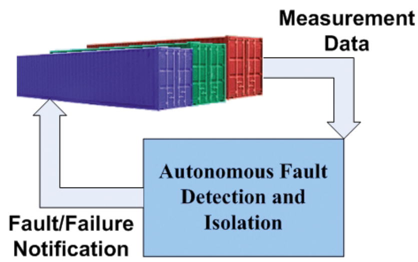
The new idea of this research is application of a new fault detection and isolation (FDI) technique for the monitoring of sensor networks in transportation systems. In measurement systems, it is necessary to detect all types of faults and failures, based on pre-defined algorithms. Recent improvements in artificial neural network studies (ANN) led to using them for some FDI purposes. In this paper, applications of new probabilistic neural network features for data approximation and data classification are considered for plausibility check in transportation systems. For this purpose, a two-phase FDI mechanism was considered for residual generation and evaluation.

Introduction >>> Nowadays, the application of autonomy is considered in industrial, logistics and production processes. These processes can be monitored and controlled using suitable autonomy approaches which are implemented with autonomous measurement systems based on the structure of sensors and communication method. Thus, autonomous methods play an important role in logistic applications such as tracking objects, reading data with or without line of sight, updating process databases instantaneously and providing high-speed remote access to system components. One important autonomy feature which could be applied on measurement systems is plausibility checking [1]. Combining some tasks like plausibility check and self-configuration will assure good performance, because the system will be able to distinguish which measurement signals are valid and valuable [2]-[5]. The most important target of this project is the selection and application of autonomy features to achieve a more efficient and reliable transportation system. In fact, the selection of suitable plausibility checking mechanisms for "fault detection and isolation" of sensor networks with regard to reliable measurement is the major goal of this project.

It is important to have reliable readings in measurement systems and the application of data verification and validation techniques will increase the reliability of measuring systems. Also, subsequent to fault detection in a sensor network, the necessary measures could be provided to recover the system from failure or fault conditions in optimized time with lower risk; thus plausibility check algorithms will lead to cost efficiency, reliability and safety. <<<

Figure 1 Application of autonomous fault detection and isolation on measurement system



Using neural network mechanism for data approximation and classification

Innovation of new techniques for data classification in artificial neural networks (ANN) and fuzzy logic (like probabilistic features) led to them being applied in plausibility checking. In this category, training the plausibility check mechanism with previous measurements should be considered in place of modeling the whole process [6]-[8]. The application of artificial intelligence to measurement systems will cause a nonlinear mapping between measurement results and judgment about reliability of measurements [9], [10].

In this paper a neural network based FDI mechanism was applied for a set of data loggers; In fact, two separate ANN algorithms were considered for residual generation and residual verification phases, respectively. By comparison of recorded data with network prediction, fault residuals were generated and then all residuals were evaluated and analyzed. For training the network, previous valid signals were defined and fed to FDI mechanism with separate patterns. In each phase, the kernel-based learning method was applied with patterns which were obtained from previous valid records.

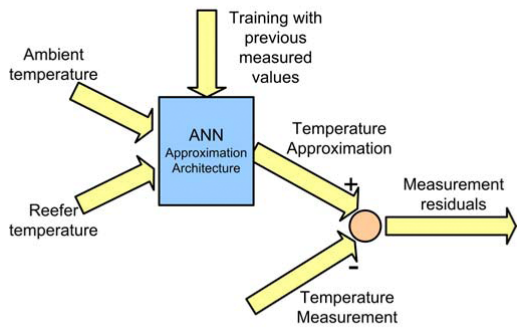
In the residual generation phase, obtained residuals were generated by comparing measured data with network prediction. In the second phase, depending on output of approximation architecture, probabilistic neural network (PNN) was applied to analyze probable fault/failure conditions in purpose of fault/failure classification. After evaluation of residuals, the situation of each signal was resulted.

Application of data analysis on trucks

In food transportation systems, it is necessary to supervise the quality of food by measuring environmental conditions, like temperature and humidity. Then, the measured data should be processed based on an appropriate technique for extracting useful information about quality of products. Thus, by tracking measurement results, all possible events in a transportation system should be detected and classified according to pre-defined faults/failure classes by analyzing measurement results [11]-[14]. In this paper, FDI mechanism was designed and applied on temperature records from "Rungis Express Company" which is a trading food company in Germany (Meckenheim) [15], [16]. The company has some trucks which are split into three compartments, containing fresh vegetables, fish and meat. Some auxiliary data loggers were attached at different positions of each compartment to record the temperature in the compartments, with an accuracy of ± 0.5 °C; there is also a reefer in the compartment and a fan for ventilation purposes. By means of using the On-Off cooling unit, some fluctuations could be observed. Using several data loggers provides the possibility of better assessment by FDI mechanism in compartments, despite differences between values based on position of loggers.

In a first step, ANN approximation architecture was applied to generate residuals by comparing current records with previously trained patterns. This architecture is a feed-forward neural network, which is generally used for function approximations in system modeling and prediction. The output is estimated using a weighted average of the outputs of training patterns, where the weights are related to the distance from the point being estimated inside network.

Figure 2 Residual generation in Transportation system

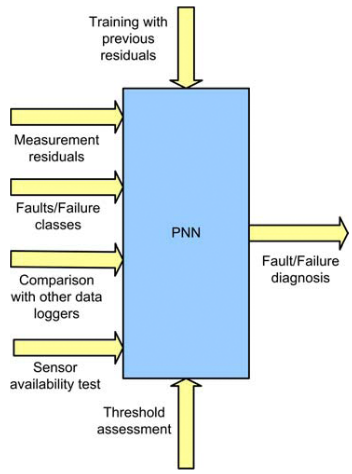


For approximation of temperature, the reefer and ambient temperatures were entered into the network as input patterns. Against input patterns, records of each data logger were considered as target patterns. In this way, each record for ambient temperature and reefer air were mapped to records of data logger; therefore, after spreading the data to network, the approximation mechanism was able to predict next temperature values of data logger based on new values of ambient and reefer temperature. Then, differences between temperature and approximation could be calculated and observed as residuals.

Residual evaluation with probabilistic neural network

Residual evaluation techniques can be established by threshold decisions, statistical methods, and classification mechanisms. In this paper, residual evaluation was established for classification of residuals, according to faults/failures classes and extra conditions for improving evaluation results. Fig. 3 shows the criteria which were considered for residual evaluation.

Figure 3 Residual evaluation in transportation system



By replacing the sigmoid activation function which is often used in neural networks with an exponential function, a probabilistic neural network (PNN) for defining nonlinear decision boundaries will be obtained. This architecture can map input patterns to all classification targets; so the task of this network is estimation of the probability for classification purposes. Also the architecture requires less training than the linear neural networks, but a higher number of hidden nodes. Training was limited to a reduced number of known residual patterns with mapping into assigned faults/failure classes for description of all possible problems. Before applying the neural network for evaluation of these residuals, the network has to be trained based on the mentioned classes.

Data analysis results

For residual generation and evaluation phases, records of first day were fed into the networks for training approximation and evaluation mechanism, for two trucks, respectively. As mentioned before, ambient, reefer and data logger temperature were recorded for the first 24 hours to train the networks. For the next 12 hours, data logger temperature could be approximated instantaneously based on records of ambient and reefer temperature. Then, by comparison between actual temperature records and approximation, residuals were obtained for feeding into second ANN architecture. Also threshold test and records of other data loggers near the "under test logger" are auxiliary tests for decision making by residual evaluation network.

For designing approximation architecture, radial basis network was used for function approximation including two layers. In the first layer, radial basis function was considered for calculating weighted inputs with distances. Two input patterns including ambient temperature ($T_{Ambient1}$) and reefer ($T_{reefer1}$) were applied for spreading into radial basis functions of network;

$$P_{in1} = \left[T_{reefer1}; T_{Ambient1}\right] \quad (1)$$

For training neural network, P_{in1} was applied for residual generation mechanism. The records could be obtained every 10 minutes, so for one day (24 hours) a total of 144 readings are available. Therefore, depending on ranges and number of records, P_{in1} contains 144 rows and 2 columns for mapping into 144 elements in Target (T_t). Therefore in the last layer, linear network was considered for calculation of weighted input against temperature readings as target (T_t).

Fig. 4 shows the training procedure of the network, based on ambient and reefer temperature for first truck. After training the network by means of records of first day, the mechanism started to predict the temperature for the next 12 hours. Based on the instantaneous values of ambient and reefer temperature, the mechanism started to predict the temperature of data logger.

Thus, after application of new input patterns (P_{in2}), approximation was made possible for comparison with data logger records (T_m). Input pattern (P_{in2}) contains new ambient temperature ($T_{Ambient2}$) and instantaneous reefer temperature ($T_{reefer2}$) for data approximation;

$$P_{in2} = \left[T_{reefer2}; T_{Ambient2}\right] \quad (2)$$

In Fig. 5, temperature approximation result is simulated, based on instantaneous records of ambient and reefer temperature, and in Fig. 6, temperature records and approximation could be compared with reefer in first truck. Also, the same procedure was applied for second truck for temperature approximation, by means of ambient and reefer temperature as input patterns.

According to Fig. 6, the accuracy of approximation results depends on the precision of training for the approximation network. In fact, another important feature which should be considered for residual evaluation is training error. For this purpose minimum, maximum and average values of training error were considered for improving residual evaluation performance.

Goal of designing residual evaluation architecture is to describe fault/failure classes for pattern classification. Therefore in the second neural network, by using probabilistic features, temperature records are classified in different fault/failure classes. Probabilistic features are used for decision making on residuals, especially those located in borders of class boundaries.

Fig. 7 shows one faultless residual after temperature approximation in truck for 12 hours. Also, some extra test routines, including threshold test and comparison of recorded data with other data loggers, improved the precision of pattern classification mechanism.

Figure 4 Training the network for temperature approximation

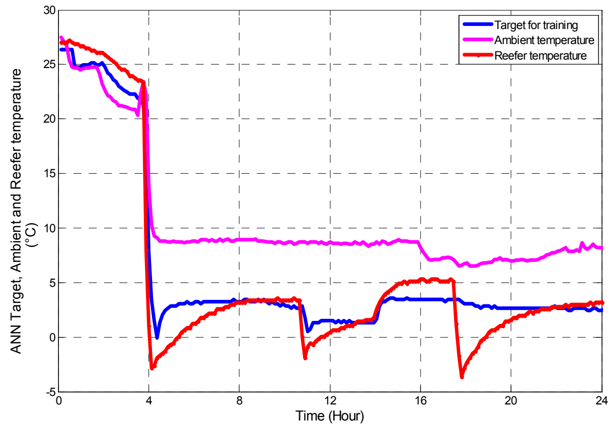


Figure 5 Temperature approximation results with ANN

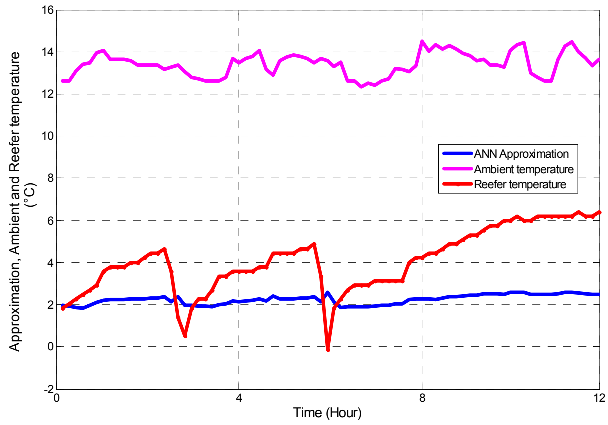


Figure 6 Temperature records and approximation results

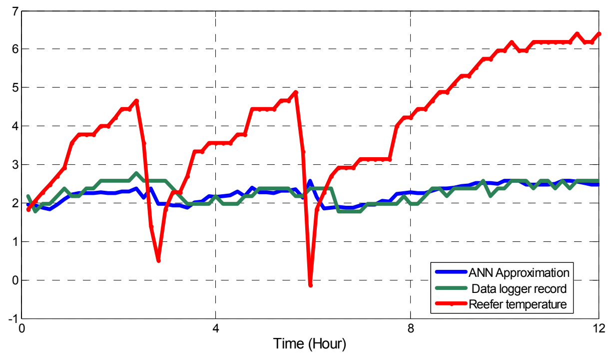
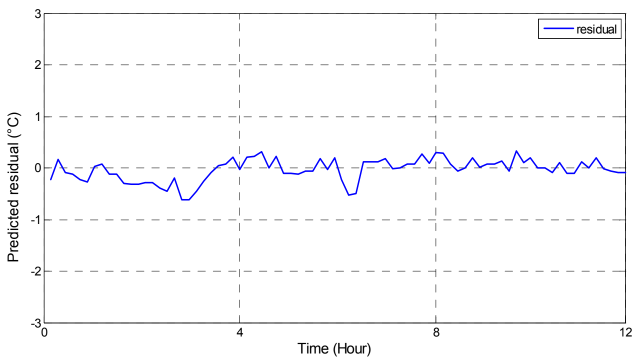


Figure 7 Calculated residual after Temperature approximation



For evaluation of residuals, the following classes were considered for faults and failures:

1. Data logger defection: for this purpose, recorded values from data loggers should be compared and rate of temperature oscillation should be unique between different data loggers. Big differences between values of one data logger with neighbors and also with approximated value will be detected as data logger defection (Class 1).

2. Positioning warm box: After positioning warm box in compartment (A box with at least 5 °C more than current data logger temperature is assumed as warm box), neighbor loggers will show different values. This means that temperature change won't be unique between data loggers, and rate of temperature changes will vary in some positions. Therefore, more than 5 °C temperature rise in curve is implemented as class 2.

3. Removal of warm box: After removing warm box, some loggers will show temperature changes by decreasing temperature in different positions. Temperature fall more than 5 °C temperature is categorized in class 3.

The fault/failures classes were used in designing the probabilistic neural network for decision making on residuals. Distribution of fault/failure classes is very important and could have significant influences on fault diagnosis performance. After application of the residual evaluation algorithm, the whole mechanism could diagnose all probable fault/failures. Therefore, the fault/failure mechanism is able to distinguish faulty and faultless records and related classes and lead to improved reliability in transportation systems.

Conclusion

In this paper, the application of neural network was implemented for autonomous fault detection and isolation in transportation systems. Two separate ANN architectures were considered for residual generation and residual evaluation. In the first phase, ANN approximation architecture was applied to generate residuals by comparing actual records with temperature approximation. In the second phase, based on output of first ANN architecture, probabilistic neural network (PNN) was applied for analyzing probable fault/failure conditions and fault/failure classification. After evaluation of residuals, the situation of each signal was resulted using ANN.

Acknowledgment

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Application of Autonomous Fault Detection and Isolation in Measurement Systems

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Optimized Sensor Network for Logistics Application

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This project is aimed to answer to this question whether autonomous sensor network operates more efficient or centric one? For comparison the performance, the network is simulated with the help of graph theory concepts and algorithm. Developing SCRA routing algorithm is next step after constructing the simulator base. Main specification of this algorithm is that it is target-oriented. In order to compute the energy consumption of messages transmissions, the wireless sensor nodes are modeled. The result of this project shows that autonomous network consume less energy than central network for the same number of message transmissions.

Introduction >>> With the increase in size of systems like the logistic system, the complexity of the control system will also increase. To avoid such complexity, dividing the systems into smaller segments is considered as a solution. [1] One of the issues related to this segmentation is how the segments interact with each other. Do they communicate directly, or via a central segment? Is there any authority to make decisions for them or, independent of any authority, can they make decisions in a collaborative way? The term "autonomous" refers to the ability of self-control and self-decision of the segments and "non-autonomous" is used for the existence of a central unit in the system which connects the segments and makes decisions for them. A question arises here: which of them is most suitable for the control system and why? Autonomous or non-autonomous? **<<<**

For comparing two systems structure, the performance of the structures could be considered as a factor. Performance is general term which must be interpreted as something practical based on the functionality of the system. In this project the term 'system' refers to a communication network. Basically the function of each communication network is connecting the nodes for exchanging the information between them. With regard to this functionality, the effort or energy consumption of the network for transmission of messages between two arbitrary nodes can be considered as one of the factors for performance measurement. Another factor which could be considered is what proportion of the messages would be delivered to the destination. Obviously, when the average energy consumption is decreased and the percentage of message delivery is increased, the network has functioned better. In other words the performance of the network has increased.

The energy consumption of the network for routing messages depends on the path via which the message travels to the destination. We know that the topology of the network is random. On another hand, source and destination are also random. Therefore the best way for the behaviour assessment of the network or performance measurement is simulation. [2] For simulation it is necessary to know that based on which rules the next destination will be chosen. Based on these rules the appropriate algorithm for programming could then be developed. Finding these rules leads to finding a routing algorithm for the network which fulfils the expectations for the autonomous and non-autonomous applications. One of the most important specifications is that the algorithm should be target-oriented [5] and not sink-oriented. Most studied algorithms [5] are sink-oriented, such as GRAdient [7] for instance.

Graph theory deals with vertices and edges and it can provide the tools for mathematical description of the network for the simulation. Vertices could represent the network nodes, and since density of electromagnetic energy is proportional with the distance square [6], then the edges can be representative of the energy consumption for message transmissions (figure 1). In practice there is the possibility to read the Received Signal Strength Indication (RSSI) [9] register and correspond the distance with the channel attenuation. For the energy consumption calculation, the total length of the passed edges is considered. In order to make the rules for routing the message, the minimum length tree can be chosen. [3] [5] Choosing the minimum length tree is based on the fact that in large numbers of sender and receiver pairs, the average passed length is expected to be minimal due to lowest energy consumption. If all the messages have to travel through the predefined tree, the average

Figure 1 Connected Graph

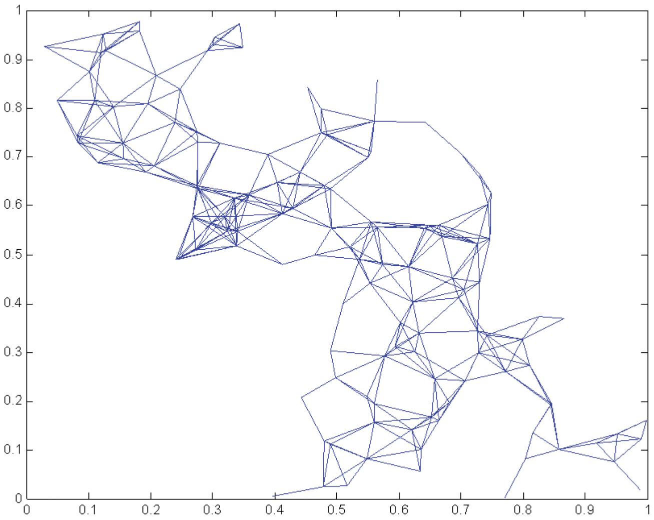


Figure 3 Energy consumption example

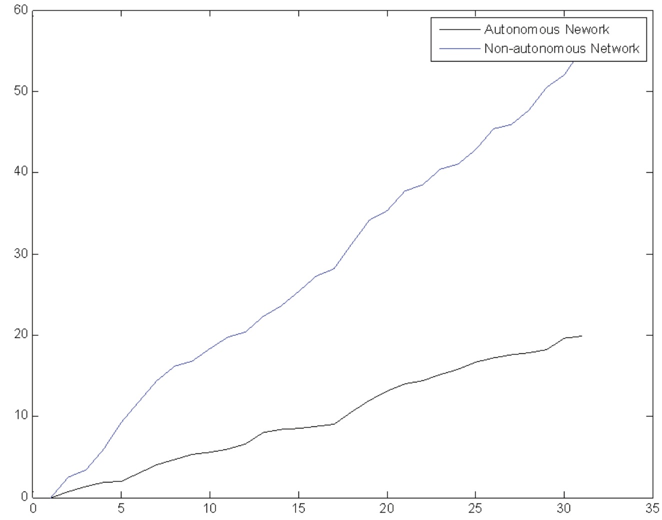


Figure 2 Minimum Length Tree

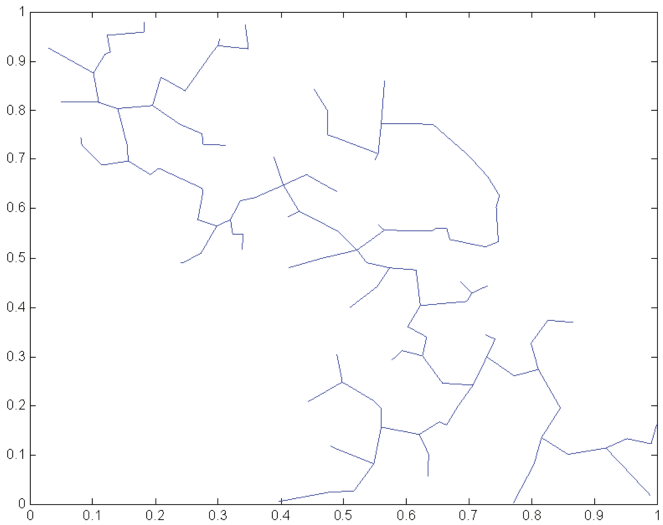
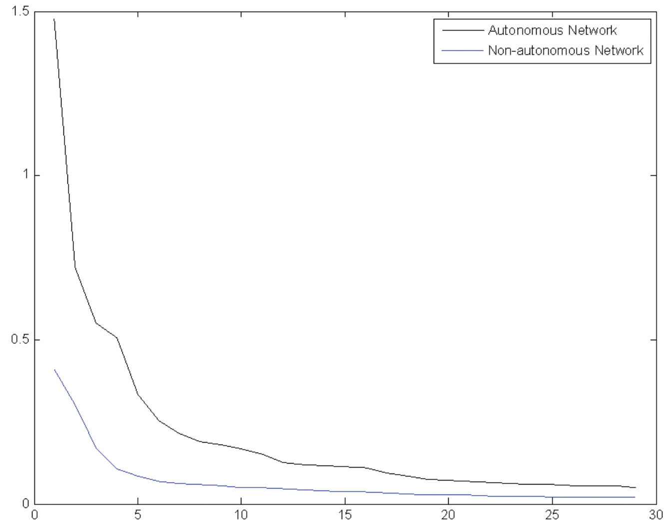


Figure 4 Performance comparison



of the passed length will be equal to summation of the edge of the predefined tree – which is not necessarily minimum, but with choosing the minimum length tree, after large numbers of random pairs, this average will get close to the length of the tree (figure 2). Each point in this simulation could be considered just as one single node or zone leader of a bunch of nodes [6]. From this point of view, both hybrid and hierarchical topologies [5] can be covered.

For moving on the tree, two solutions could be considered: making a routing table for each sender and receiver pair is one of the approaches which is categorized in proactive [4] routing algorithms. For autonomous systems, each node should have the table for other nodes, and in a large scale network this necessitates a big memory. Another approach can calculate the next node based on the local information which is stored inside the nodes. This information for example could be coordinates of the nodes; either geographical coordinates or virtual coordinates. In the sensor network since the nodes faces with limitation of power supply resource and for avoiding the complexity, the geographical coordinates are neglected and some kind of virtual coordinates could be used. In a minimum length tree, a sequential coordinate can be assigned to the nodes and the message can be routed based on the sequential coordinate [5]. This routing algorithm is called Sequential Coordinate Routing Algorithm (SCRA). The coordination dimension depends on the nodes degree in the minimum length tree and their arrangement.

In non-autonomous networks, the energy consumption for sending and receiving messages largely depends on the location of the sink (central node). With help of the graph theory it is possible to find the center of the network for location of the sink so that the total energy consumption of other nodes for sending and receiving the message becomes minimal. [3] After all these theories are realized, it would be possible to write a program for simulation. MATLAB is a powerful tool for programming such algorithms. For simulation, two nodes will be chosen randomly; one as sender and one as receiver. After routing a message in the autonomous and non-autonomous network, the energy consumption is computed and this action repeated for a large number of times. The expected result is that the values fluctuate around the average length of the edges on the paths. Since the nodes are stationary, the average values are constant and figure 3 as a result of the simulation depicts that the graph of the energy consumption is close to linear. Figure 4 shows that the performance of the non-autonomous network would drop faster than an autonomous network.

Energy consumption in a network is not only transmission energy but it also includes process energy. Process energy is divided into two parts. The first one is energy for routing algorithm computation, and the second one is for control task computation. In non-autonomous networks the control task is performed by a central unit, which are usually powerful devices and not considered as part of the network. In an autonomous network, control tasks are distributed over the nodes in the network, then their process energy consumption for performing the control task is considered as energy consumption of the network. It could be seen that an autonomous network consumes more energy from the node for processing than a non-autonomous network. Consequently, it is possible to claim that the autonomous network is better than the non-autonomous network with regard to energy consumption if the total transmission energy and process energy is less. This difference could be considered as an optimization factor. The control task should not consume more than the averaged difference, or the total process energy consumption should not exceed more than the difference between the transmission energy consumption of non-autonomous and autonomous systems.

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Optimized Sensor Network Structures for Logistic Applications

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Modelling Dynamic Production Systems with a Special Focus on Dynamic Bottlenecks

Huaxin Liu
Prof. Dr. Bernd Scholz-Reiter

Bottlenecks play the key role in determining overall performance of manufacturing systems. The proposed research attempts to develop a manufacturing model where all dynamic bottlenecks are categorized and taken into account within the decision making process in Holonic Manufacturing System architecture.

Introduction >>> Bottlenecks play the key role in determining overall performance of manufacturing systems. Improving the performance of bottlenecks may lead to low inventory, appropriate utilization, short lead time and low schedule deviation. Therefore, consideration of bottlenecks is of prime importance at all levels of decision-making in production management practice (e.g. Production Planning and Control) and even in decision-making for strategic investments (e.g. process improving projects, new facility purchases, etc). Although bottlenecks have been a subject of study for more than ten years, current work still produces promising results; especially new and enhanced features for bottleneck-oriented Production Planning and Control methods are still required. The bottlenecks of a system may vary from different perspectives. From the view of logistical objectives in manufacturing [Wiendahl 94], bottlenecks are categorised into inventory, utilization, lead time and schedule deviation bottlenecks [Nyhuis 03] [Windt 01]. In term of research subjects, bottlenecks can also be classified into resource, order and product bottlenecks [cp. Windt 01]. Based on the bottleneck appearance cycle, we can categorize bottlenecks into static and dynamic bottlenecks [cp. Windt 01, Zäpfel 98]. From the point of view of production logistics, several shortcomings of conventional bottleneck research have been pointed out. **<<<**

First of all, in previous research on bottlenecks, bottlenecks are usually evaluated using single or only few logistical objectives (e.g. utilisation). However, logistical objectives might be distinct due to the different manufacturing situation of manufacturers and various requirements of customers. To meet this demand from factory and market, the systematic and alterable logistical objectives should be considered during the process of analysing bottlenecks.

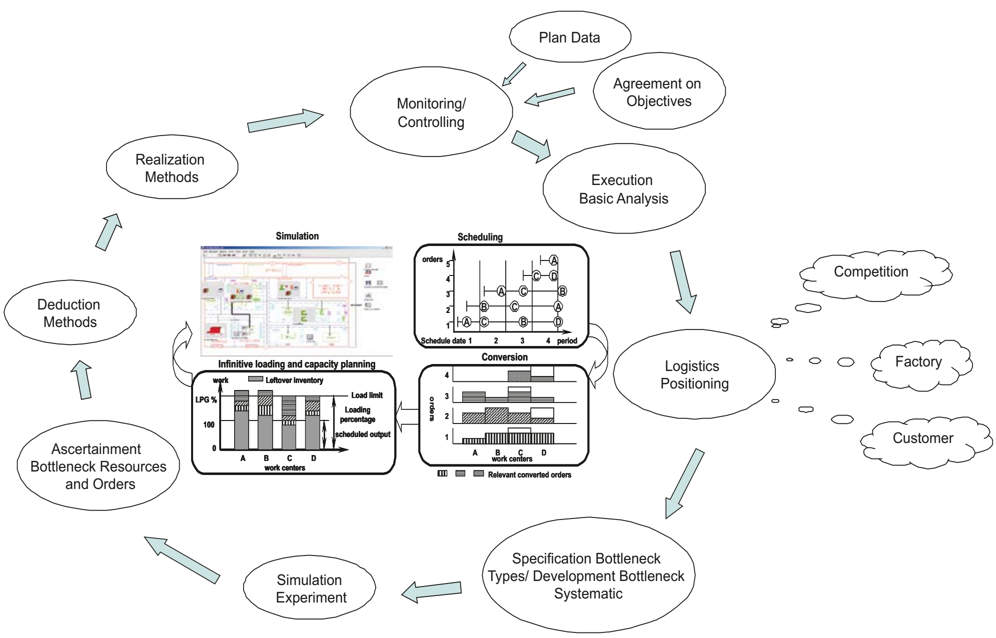
Secondly, most previous studies devoted themselves to the analysis and methods of reducing or avoiding bottleneck resource, bottleneck orders and products (logistic items in production systems) have not been researched separately. Therefore, the analysis results are not accurate enough to find suitable methods to reduce bottlenecks.

Finally, previous studies are mainly focused on static bottleneck analysis and treatment methods. During the process, the dynamic characteristics of bottlenecks are ignored; therefore deduced methods can not efficiently handle bottleneck problems. In some cases, the derived methods are carried out on the wrong subjects (i.e. resources, orders or products) or at the wrong time and even worse performance of production logistics systems.

The above mentioned shortcomings of conventional development create the need for novel manufacturing control systems that are able to efficiently reduce dynamic bottlenecks which are caused by environmental change (e.g. external customer demand change, raw materials failure etc.) and production disturbances (e.g. machine breakdown, non-scheduled maintenance etc.). In order to cope with dynamic bottleneck problems, the ongoing paradigm shift from a centralised control of "non-intelligent" items in hierarchical structures towards a decentralised control of "intelligent" items in heterarchical structures in shop floor control. However, neither fully hierarchical, nor fully heterarchical control structures can deal with dynamic bottlenecks to achieve satisfactory system performance. To meet these new requirements, a number of novel concepts for the control system have been proposed and partly realized in the last two decades. The most popular ones are the Holonic Manufacturing System (HMS), the Genetic Manufacturing System and the Biological Manufacturing System [cf. Freitag 07].

The proposed research attempts to develop a manufacturing model where all dynamic bottlenecks are categorized and taken into account within the decision making process in HMS architecture. The architecture consists of three types of basic holons: resource holons, product holons and order holons. Every basic holon type focuses on different responsibilities of the manufacturing system. The holons exchange process knowledge, production knowledge, and process execution knowledge respectively. Aggregation is used to focus on different levels of holons. Specialisation is used to focus on different functionalities of holons. The concept of staff holons allows for the presence of centralised elements and functionality in the

Figure 1 Dynamic Bottlenecks Analysis and Control Loop



architecture. However, staff holons do not introduce a hierarchical rigidity into the system, since the final decision is still to be taken by the basic holons. In fact, the concept of basic holons, enhanced with staff holons giving advice, decouples robustness and agility from system optimisation [Brussel 98]. Due to its distributed basic architecture, the HMS delivers robustness and agility and is simple to extend and reconfigure. When staff holons are added, the basic holons will follow this advice as well as possible. Due to environmental change and production disturbances, the hierarchical staff holons perform badly; the advice may be ignored by the basic holons, which again take autonomous actions to do their work. In our case, the basic holons will deviate from the plan if any dynamic bottlenecks appear; the centralised production planning will be conducted later, again with regard to deviation from reality. On the other hand, when disturbances are absent, an HMS can be configured so that the basic holons follow the advice of the staff holons.

Simulation experiments will be constructed using eMplant 7.6 (a discrete, event-oriented simulation program) to visualize dynamic bottlenecks and assess the influence of proposed methods on logistical objectives. The configuration of the manufacturing system model is based on a real hanger manufacturer in Germany. The model comprises 196 workstations grouped into 32 station families, and 4,000 products composed of 360,000 orders. By applying the empirical simulation data which exported from FAST/Pro (an infinitive daily Production Planning and Control program) in simulation process, dynamic bottlenecks information will be derived from comparison of planning and actual data. The proposed research will reduce dynamic bottlenecks in manufacturing systems and thereby improve performance of manufacturing systems through reducing deviation of logistical objectives and mean values. The results of research may be integrated within traditional central Production Planning systems to realize effective shop floor control in the future.

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Modelling Dynamic Production System with Special Focus on Dynamic Bottlenecks

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Modelling Logistic Processes – The Termination Problem

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In this note the termination problem for logistic processes is sketched and discussed. Termination is a key property of logistic processes, but it is undecidable in general. Hence, one must look for special cases and sufficient conditions that guarantee termination.

Introduction >>> Most problems in logistics are related to dynamics: transportation, distribution, material flow, etc. (see, e.g., [HKS08]). Hence the modelling of logistic processes is a central issue. A model like an event-driven process chain, a Petri net or a UML diagram (see, e.g., [KNS92, STA05, GV03, JBR99, BRJ05]) describes a logistic process in such a way that the process steps are defined as well as how these steps must be composed to run the process. Moreover, the initial configurations where the process starts from are given and the terminal configurations which are to be reached. This means that the process of interest is only known through its description. Whether a process behaves in the desired way or not can only be found out through the use and analysis of the describing model – or not at all. For example if one wants a process to produce correctly a certain effect for each input after a finite number of steps, the process must at least terminate. Therefore, termination is a key property of logistic processes. **<<<**

Example: Travelling salesman problem

Consider, for instance, the travelling salesmen problem (TSP). Given a set *S* of sites and a set of pairs of sites $P \subseteq S \times S$ (connecting these sites directly), one wants to know whether a salesman can travel through all the sites coming back to the starting point without visiting any site twice. Usually, there are also distances given between the sites and one asks for a minimum tour. In the formulation above, one can assume that all distances between the sites are equal. A proper tour is a sequence $s_1 \ldots s_n$ of sites, whereby each of the sites is visited, none of the sites is visited twice, and each pair of successive sites (s_i, s_{i+1}) is in *P* (where s_1 is considered as successor of s_n, i.e. $n + 1 = 1$). A proper tour can be found by an exhaustive search of all sequences with n sites, checking the required properties for each of them. This process always yields the correct answer, but it takes a lot of time as the numbers of sequences of sites grows exponentially with the number of sites. Indeed, this takes much more time than is available in logistics. Another logistic process solving the travelling salesman problem starts from one site and adds another one in each step, provided that the last but one site and the last site form a pair in *P*. If this step can be continued $(n - 1)$ times and the last site and the first one are also a pair in *P*, then the process has found a solution. Because the number of sites that can be added gets smaller with each step, the process always terminates. If a proper tour exists, then one of the process runs finds it. But the process is nondeterministic because there may be several choices of sites to be added to the tour and some of them can be wrong. This shows that the TSP belongs to the class NP of nondeterministic polynomial problems to which many logistic problems belong. The trouble with these NP problems is that all known deterministic processes used to solve them are exponential. In the case of TSP, correctness and termination are easy to prove, it is the running time which creates the trouble. Concerning more practical and realistic logistic processes, correctness and termination are also hard to prove.

Termination

On an abstract level, a logistic process may be modelled as a construct proc = $(K, \rightarrow, I, T, C)$, where *K* is a set of configurations on which the process runs, $\rightarrow \subseteq K \times K$ is a set of pairs of configurations defining the process steps, *I* is a set of initial configurations and *T* a set of terminal configurations, and *C* is a control condition, which regulates the use of the steps. A process run consists of a sequence of steps $k_1 \rightarrow k_2 \rightarrow \cdots \rightarrow k_n$ with $k_1 \in I$ which is permitted by the control condition. A run is successful, if $k_n \in T$. In most modelling frameworks, termination is undecidable (see, e.g., [Plu98]), meaning that there is no general procedure to guarantee termination. But in special cases one can do better. The most common approach to guarantee termination is to find an evaluation function eval : $K \rightarrow \mathbb{N}$ that associates a natural number to each configuration with the additional property that the value decreases whenever a process step is done, i.e. $eval(k) > eval(k')$ for $k \rightarrow k'$. Alternatively, one may replace the natural numbers by some ordered domain which does not have any decreasing infinite sequence (see, e.g., [DM79]). Note that this is just the proof principle that can be applied to show termination in the process that solves the TSP above because the number of unvisited sites decreases in each step.

An improved criterion

Unfortunately, this criterion applies only to very special processes and does not work for many others, although they terminate, too. The reason is that one may not find any evaluation function that decreases in each step. Consider, for example, a plate of cookies as configuration and the following steps: *plus1* = add one cookie, *plus2* = add two cookies and *minus4* = take four cookies. Moreover let us assume that we know from the description of the process that the three steps, *plus1, plus2* and *minus4*, are always applied in this order and this for as long as possible. This process terminates, because there is one cookie more taken than added after each three steps. The crucial point is that something is decreased from time to time, rather than in each step, and eventually totally deleted. To check this, one has to consider sequences of steps rather than single steps. The key concept is the control condition that specifies how the process steps can be composed. There is no problem concerning termination if the lengths of process runs are bounded. This is the case, if the control condition fixes a certain number of steps explicitly. But most problems require control conditions of the form "apply certain steps as long as one likes", or "apply certain steps as long as possible", which may lead to infinite runs potentially. When there are repetitions one has to consider all possible explicit sequences and identify what is decreased by them (for the repetitions this has to be summarized under worst case assumptions). Then one has to analyse the possibilities of interaction between all sequences, respectively the summarizations to check, if something is eventually decreased.

Graph transformation as modelling framework

To make this idea workable, one needs an explicit framework for the modelling of logistic processes. A possible choice is graph transformation (see, e.g., [Roz97, EEKR99, EKMR99]) and, in particular, graph transformation units and autonomous units (see, e.g., [KKS97, KK99, HKKKK07]), which cover event-driven process chains, Petri nets, and many types of UML diagrams as special cases. In this framework, configurations are represented by graphs, process steps are specified by rules and rule applications, initial and terminal configurations are defined by graph class expressions of various kinds. Moreover, there are many potential choices for the definition of control conditions. The most frequently used control conditions are regular expressions which allow one to describe the sequential order, the alternatives, and the iteration of rule applications. They become even more useful if they are supplemented by an "as-long-as-possible" operator. The investigation of the termination of logistic processes in this framework according to the ideas sketched above is work in progress. Its details are beyond the scope of this summary.

Conclusion

In this summary, we have discussed the termination problem of logistic processes, sketching sufficient criteria to guarantee termination. The termination problem of graph transformation units, which provide a framework for the modelling of logistic processes, is currently being investigated by the first author as a central issue within her PhD thesis.

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Graph Transformation as a Modelling Method in Logistics-Modelling Concepts and Their Properties

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Framing Innovations to Grasp Stakeholders' Attention: A Dynamic Capability-based Conception of Innovation Communication

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Innovation needs communication. But does communication need innovation? Linking strategic management to the necessity to generate and successfully launch new products, communicating innovations – viewed on the macro-level of a company – entail obtaining stakeholders' attention for certain aspects of newness with the aim of positively influencing their adoption and gaining competitive advantage. Thus, the purpose of this article is to introduce innovation communication as a dynamic capability-based conception in order to provide a means for grasping stakeholders' attention by framing innovations. Based on diffusion theory and framing theory, innovation communication might influences positively the adoption of an innovation in terms of informing stakeholders' understanding of companies' innovations. After a brief literature review, the article provides a description of the communicative phenomenon for a mutual understanding and gives further managerial implications for the management of innovation, communication, information, and reputation.

Perception of Newness and How to Attract Stakeholders' Attention

In management and research it is widely accepted that innovations represent an important factor leading to profitability and competitive advantage of an organisation (e.g. Henard & Szymanski, 2001; Ulijn et al., 2000; Johne, 1999; Johnson, 1990). Hereby, the term 'innovation' is understood as an idea, concept, prototype, practice, or object that is perceived as new by companies' stakeholders (e.g. Rogers, 2003; Westphal et al., 1997) used to as a mean of worthwhile benefits (McDermott & O'Connor, 2002). According to Johne (1999), technology competences tend to facilitate market innovations and their applications, for instance in terms of new products (Prahalad & Hamel, 1990) encompass competitive advantage by offering new values for customers. However, the impact of innovations on a company's success is not guaranteed. Apart from differences in companies' capacities for being innovative and their innovation/technology portfolio (Drejer, 2002), several empirical studies mention the ambiguity attached to the profitability of innovation's (Andrew & Sirkin, 2003).

Thus, scholars are highly interested in identifying the drivers for a successful commercialisation of innovation/s and the determinants for stakeholders' decisions to adopt or reject an innovation. Regarding the diffusion theory (Rogers, 2003), among other factors like time, social system, characteristics of an innovation and communication, stakeholders' perception within decision-making is also illuminated. Rogers (2003) outlines stakeholders' perception as an important influencer for information seeking and processing, ending up in a decision to adopt or reject an innovation. In this context, especially the question remains unanswered as to how companies can design their communication of innovations in a way that attracts stakeholders' attention, and therewith their perception, thus influencing the adoption of an innovation. Therefore, the purpose of this article is to introduce innovation communication as a dynamic capability-based conception in order to provide a means for grasping stakeholders' attention for certain aspects of newness by framing innovation/s.

While researchers have been primarily concentrated on marketed-centred activities (e.g. Chakravarti & Xie, 2006; Ziamou & Ratneshwar, 2003; Bailey, 2005; Ruiz & Sicilia, 2004) or interpersonal communication (e.g. Berger, 2005; Burgoon & White, 1997), innovation communication has been substantially under-researched (Mast et al., 2005: 11-12; Zerfass & Huck, 2007). No more than a few years only some researchers (Zerfass & Huck, 2007: 108 and Mast et al., 2005; Johnson & Chang, 2000; Rothwell & Robertson, 1973) investigated innovation communication; but one main shortcoming is the mutual understanding of innovation communication as a company's capability not only located in marketing or corporate communication. Thus, this paper would like to provide a communicative perspective on innovation management by describing the effects of a capability-based conception of innovation communication regarding the perception of newness and its implications for managing the interrelations of innovation, communication, information and reputation.

With this objective in mind, the second section will deduce – based on framing theory – the necessity to guide innovations and to provide a conception of innovation communication as a comprehensive perspective for managing the communication activities of a company. The third section presents a definition of innovation communication in a broader sense of strategic management and describes eight dimensions referred to as constitutive criteria in order to contribute to the mutual understanding on the macro-level of a company. Managerial implications for the realisation of the instrument on strategic and operational level will be given in the fourth section. Finally, concluding remarks and an outlook for further research in this field is provided.

The Necessity to Foster Stakeholders' Understanding for Innovations

In recent years communication attracted considerable interest in research, for instance due to environmental changes, the increase in media consumption within society, and the access to and availability of information which are associated to economic success (Donsbach, 2006). Further, internal and external communication between a company and its stakeholders foster competitive advantage (Cornellissen & Thorpe, 2001), have a significant effect on the assimilation of ideas (Johnson, 1990) and also might overcome the resistance to adopting an innovation (Fidler & Johnson, 1984).

However, nowadays it is difficult to attract stakeholders' attention for newness due to the 'jungle of information' as well as to the dynamics of new product development processes (Töhlke et al., 2001: 4; Moreau et al., 2001: 27). Thus, for communication it is given that prior knowledge of individuals might lead to resistance to adopting discontinuous innovations (Moreau et al., 2001) or the meaning of a communication situation is ambiguous, which leads to misperception due to individuals' 'misframing' (Johansson, 2007: 277). Moreover, a company's communication about its innovation activities is kept to a minimum and therefore tends to result in stakeholders' predictions based on a small amount of information (Mast et al. 2005: 6), which is especially vulnerable to misguided framing (Johansson, 2007: 277). According to Bryant and Miron, framing theory assumes that contexts influence individual's action, behaviour, and understanding (Bryant & Miron, 2004: 693) Further, Pecher and Zwaan mention that 'the way people represent and understand the world around them is directly linked to perception and action' (Pecher & Zwaan, 2005: 3). This leads to the importance of framing innovation/s due to the fact that frames, understood as context-issues, represent cognitive structures used to inform our understanding (Goffman, 1974), tend to avoid misperception, and positively effect individuals' adoption.

Therefore, company's internal and external communication of innovations is crucial, but similarly there is a necessity for a conception of innovation communication, including framing of innovations, in order to facilitate the adoption process.

A Dynamic Capability-based Concept of Innovation Communication Directed to Framing of Innovations

In the field of strategic management, research scholars pay attention to the internal sources within a company, i.e. on the capabilities as well as resources, to gain competitive advantage and to evolve strategy (e.g. Grant, 2008: 15-16). The resource-based approach (e.g. Peterraf, 1993; Wernerfelt, 1984) has nowadays advanced to the dynamic capability approach (e.g. Dosi et al., 2000; Teece et al., 1997; Prahalad & Hamel, 1990), which comprehends strategic management as a managerial function that has to deal with the renewnal of competences to obtain accordance to changing environments as well as with the capacity to manage organisational resources and competences to fulfil the requirements of the changing environment. In this context, corporate communication can be understood as a human resource (Grant, 2008) account for organisational change (Lewis et al., 2006) and affect the assimilation of ideas by reducing uncertainty (Johnson, 1990) as well as improving corporate reputation (e.g. van Riel & Fombrun, 2007). Further, Cornelissen et al. note that examination in the field of corporate communication, focused on the firm-stakeholder interrelation, primarily establishes theories regarding the stakeholder output such as image and reputation. Only in recent years have some findings paid attention to corporate communication as a managerial function (Cornelissen et al., 2006: 117). Taking these aspects into closer consideration and linking them with the necessity for framing innovation/s for successful commercialisation, innovation communication might be an important managerial function; understood as a firm's capital that tends to enhance competitive advantage, see figure 1.

Figure 1 Innovation communication as a firm's linking capability

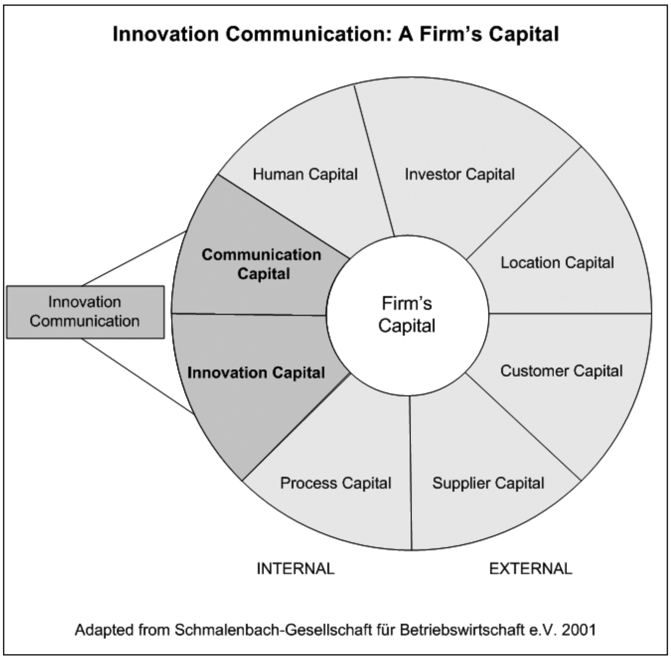
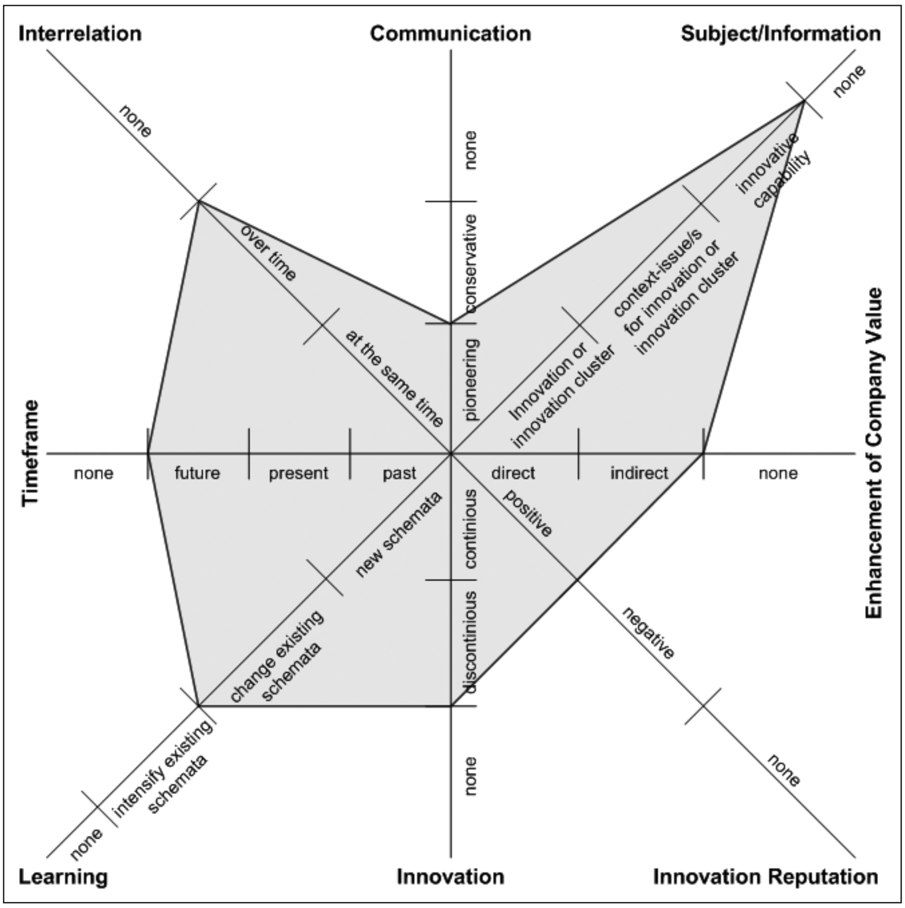


Figure 2 Dimensions of innovation communication



According to Mast et al. the term innovation communication is understood as symbolic interactions between organizations and their stakeholders, dealing with new products, services, and technologies (Mast et al., 2005: 4). With respect to the understanding of innovation communication as a dynamic capability of a company, the need for a definition in a broader sense of strategic management has emerged.

Innovation communication is hereby defined as the pioneering past, present and future-orientated transactional procedure of information transmission between an organisation and its stakeholders, linked over time in terms of the capability of an organisation (1) to introduce ideas, concepts, prototypes, practices, objects or different combinations of these types of innovations, referred to as innovation cluster, (2) to generate and highlight context-issue/s for the innovation or the innovation cluster and (3) to present the innovative capability with different types of competences used to increase directly and indirectly company value by building up new schemata (knowledge domains), modifying existing schemata or providing market-level information to influence the adoption process as well as by intensifying stakeholders' collective positive judgements of an organisation's innovativeness over time (= innovation reputation).

Regarding this definition, eight dimensions, see figure 2, can be presented as constitutive criteria referred to as competences identifying innovation communication as a company's capability: (1) Communication: Pioneering refers to the dynamic aspect of communication with the aim to create concepts and activities achieving stakeholders' attention/perception for the innovation and innovative capability. (2) Innovation: Both continuous and discontinuous innovations are fundamental for innovation communication. (3) Timeframe: This addresses the timeliness of information and emphasises the importance of considering past, present and future-orientated information to communicate about the innovation/innovation cluster, context-issue/s and innovative capability of a company. (4) Interrelation: Companies basically could have different kinds of innovations, more precisely 'technology competences', at the same time and over time (Drejer, 2002). Both the transmission of information about technology competences over time as well as the communication of innovations at the same time should be interrelated. (5) Subject/Information: This dimension addresses three aspects: innovation and innovation cluster, the context-issue/s regarding communication, and the innovative capability per se. Beside communicating about an innovation or different kinds of innovations, one further aspect is the information about an innovation or innovation cluster given by context-issue/s. Based on the framing theory (e.g. Byrant & Miron, 2004), which understands context-issues as cognitive structures used to inform our understanding, communication takes place in terms of frames for a better understanding of certain aspects of newness. (6) Learning: Based on schemata theory (Miller, 2005: 85-89), this refers to creating knowledge by changing existing knowledge as well as building up knowledge in terms of schemata. (7) Enhancement of Company Value: By this is meant the effect of innovation communication tends to increase directly and indirectly a company's value. (8) Innovation Reputation: Innovation reputation, understood as the stakeholders' collective positive judgements of an organisation's innovativeness over time (based on Barnett et al., 2006), is positively influenced by innovation communication and therefore may represent a crucial indicator for innovation communication.

Concerning management on strategic and operational level, the management of innovation communication is defined as a set of activities which are systematically planned, performed, and evaluated in order to support the enabling function within the commercialisation process and the management of innovation reputation, the initiating function for business development, and the networking function within the organisation used to improve competitive advantage using the worthwhile benefit of innovations (based on Drejer, 2002; McDermott & O'Connor, 2002).

Managerial Implications

Firstly, in order to realize the conception of innovation communication to foster the enabling process it is necessary to set up institutionalised means for R&D, marketing and corporate communication. The internal communication flows (Moreau et al., 2001) for the management of the transmission of information from the idea up to the product launch has to be managed more efficiently and effectively. Moreover, past, present and future-orientated information for different technology competences, for innovations as well as for their context-issues, has to be administered capably and actively at the same time and over time in order to improve innovation reputation. Thus, the conception constitutes the foundations for an integrated view on the management of innovation, innovation communication as well as of information and reputation.

Secondly, timing tends to represent an important factor within strategic management. With respect to the implementation of the conception of innovation communication, decision-making for a first or follower strategy for issues concerning different communication markets has to link to a first or follower strategy for product markets. Thus, it can be deduced that both strategic decisions may affect each other and should be taken into closer consideration for embarking strategies.

Conclusion and Outlook

This paper presents a capability-based conception of innovation communication. Innovation communication can be understood as a company's capability consisting of different competences in order to grasp stakeholders' attention, which affect positively the adoption of an innovation. Linking diffusion theory with framing theory, we propose that the conception of innovation communication influences positively the adoption of an innovation in terms of informing the understanding of different aspects of newness. For the management of its realisation two main issues can be mentioned: (1) establishment of institutionalised means for information flows primarily among R&D, marketing and corporate communication, as well as (2) association of strategic decision-making for communication and product markets.

Regarding future research, two important subjects could be addressed. First, the impact of strategic innovation communication on the information flows of a company due to the framing process of innovations; more precisely, the communication of different context-issues and the managing of information in order to generate competences for managing the dimension of innovation communication. Second, a causal explanation for framing of one or more parallel innovations in terms of context-issues refers to time and interrelation. Alternative research methods such as longitudinal study or multiple case studies could be a means of analysing the causal interrelation of innovation communication and the impact on stakeholders' attention and thus on the perception of newness in more detail and over time.

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Cooperation in Autonomous Logistics: Team Formation Based on Concept, Location, and Time

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Recent developments in logistics show an increasing trend towards autonomous control. Intelligent software agents are an established means to represent logistics objects like shipping containers and to act on their behalf. The task of such agents is to autonomously plan and schedule their way through a logistic network. In order to meet this objective it is sometimes useful or even necessary to cooperate with other agents. This paper presents a clustering protocol for team formation of intelligent agents. Since agents should be autonomous in their decision whether and with whom to cooperate, all decisions are made locally. The approach is not limited to quantitative distance measures, but is also suited for qualitative representations of concept, location, and time.

Introduction >>> Team formation is a frequent task for intelligent agents. Being incapable or unwilling to solve a certain task on their own, agents may form teams in order to jointly reach their goal [8]. This is particularly challenging if a high number of potential cooperation partners exists. In such cases it is necessary to establish distinct groups of agents based on their properties. For instance, consider shipping containers at a container terminal waiting to be forwarded to a warehouse. One option for agents representing containers is to request a truck for transport. However, in terms of costs it is often much more desirable to be transported together with other containers, e. g., by train. Sharing a common location and destination at the same time are criteria for successful cooperation in this scenario.

Clustering algorithms separate a given set of objects into distinct groups. The objective is to achieve a maximal distance between different clusters and a minimal distance between the members of each cluster. Previous algorithms, such as k-means [5], take a centralised perspective on the objects to be clustered. Hence, no autonomy regarding clustering is left to the affected entities. By contrast, intelligent agents should be autonomous in their decision whether or not to join forces with other agents. Furthermore, they should be able to deliberately choose with whom to cooperate, which demands local decision-making.

Such distributed clustering is for example applied in wireless sensor networks. A common approach [3] is to cluster spatially proximal sensors in order to reduce communication costs. Cluster members provide their local cluster-head with the data acquired. The cluster-heads then transmit the aggregated data to the base station. However, quantitative distance measures (like spatial proximity) are not always adequate for the decision whether agents should cooperate. By contrast, Sect. 2 discusses why knowledge about qualitative relations (especially regarding concept, location, and time) is often much more suitable. Subsequently, Sect. 3 presents a clustering protocol that is capable of handling such representations and that additionally leaves all decision-making to the participating agents. <<<

2 Conceptual, Spatial, and Temporal Clustering Criteria

Quantitative measures are not always sufficient and adequate in order to represent the location of agents. Imagine that the spatial distance between two shipping containers in a port is 500 metres. Although this is rather short, it does, however, reveal almost nothing about the question whether cooperation is eligible for these containers: They might be located in neighbouring container terminals of different operators which prevents them from being loaded onto a common train. By contrast, a meaningful qualitative abstraction that tessellates the port into distinct areas enables, for instance, the application of topological relations [6] for reasoning about team formation. The temporal logic of [1] enables corresponding reasoning tasks to be performed on temporal intervals in order to coordinate agents by time constraints.

In addition to location and time, for some tasks it is necessary to regard conceptual properties in order to identify potential partners. For instance, consider shipping containers which are supposed to be received in a common warehouse if they carry similar goods. Applying description logics enables characterisation of their content by ontological concepts. Based on this foundation it is then possible to determine their similarity by applying the five degrees of match (e. g., subsumption) proposed by [4]. A more extensive discussion of conceptual, spatial, and temporal clustering criteria is given in [7].

3 Clustering Protocol

The distributed clustering protocol (Fig. 1) presented in this section is capable of handling both quantitative data and qualitative relations. Furthermore, it leaves all decision-making regarding clustering to the agents concerned. If an agent chooses to be clustered, it queries a catalogue service for existing clusters. Subsequently, it communicates its properties to all cluster-heads. Clusters matching the properties of the agent send positive answers. Having received a positive answer, the requesting agent joins the respective cluster. Otherwise, it registers as a cluster-head itself.

So far, the protocol suffers from a potential problem: concurrency. Querying the catalogue and registering oneself as a cluster-head is not an atomic operation. Hence, other agents with the same properties can register in between. In order to address this issue, the agent has to send its properties to all cluster-heads that have been registered in between as soon as its registration is finished. If the agent finds another cluster-head exhibiting the same properties and an earlier registration time-stamp, it deregisters and joins the earliest cluster found.

The clustering protocol is implemented within the JADE [2] agent framework. In order to show that it overcomes limitations of recent approaches regarding distribution and qualitative relations, a case study with data from more than 2,400 shipping containers is conducted. They have to be clustered in accordance with their content (described by concepts of an ontology). A manual inspection reveals that there are 215 clusters; so this is the expected outcome of the experiment.

Figure 1 Distributed clustering approach for autonomous agents described by an AUML sequence diagram (without exceptional messages for the sake of readability)

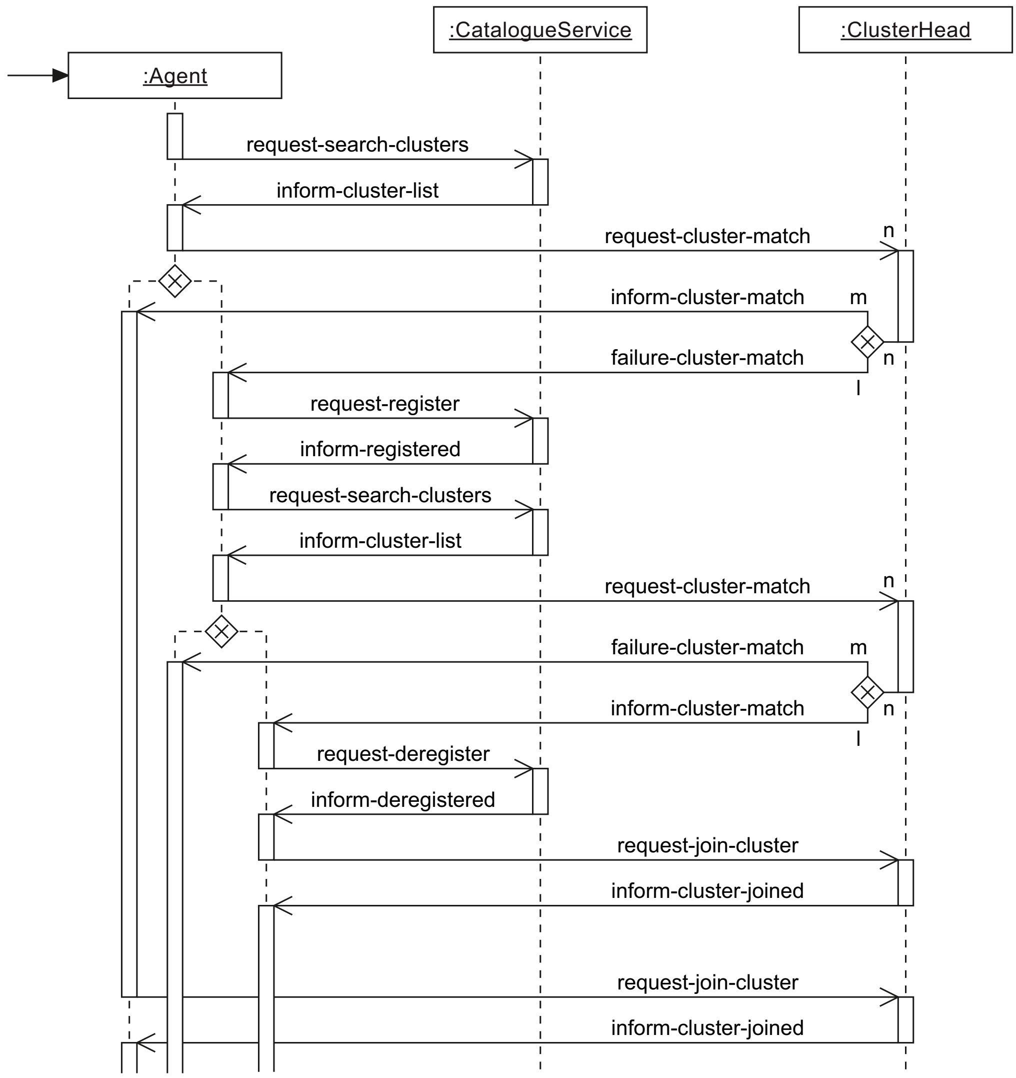
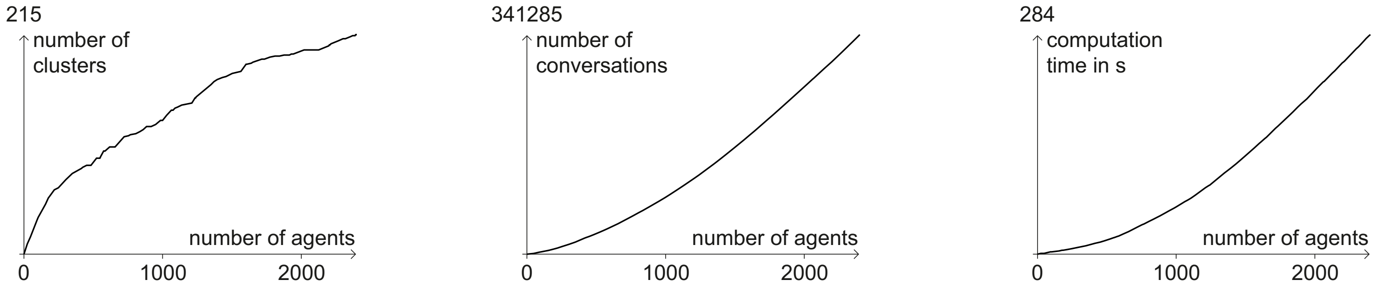


Figure 2 The number of clusters (left) and conversations (centre) and the time needed for computing the simulation (right) in relation to the number of agents



The average results of 50 test runs are given in Fig. 2. The number of clusters in relation to the total number of agents is depicted on the left hand side. Since the final number of clusters is 215 for all test runs, the algorithm is capable of solving the addressed problem.

The asymptotic communication complexity of the protocol is O(mn) since all n agents contact at most all m clusters, whereby m <= n. For most applications, m is considered to be even much smaller than n, which means m << n. In the case study, the total number of conversations (Fig. 2 centre) is 341,285. This is below the expected asymptotic complexity. This result can be explained by the fact that not all clusters exist right from the start. On a computer with Windows XP and an Intel Centrino Duo processor with 2.16 Gigahertz, the total time for clustering is 284 seconds (Fig. 2 right). The main benefit of this protocol, however, is the degree of autonomy left to the individual agent, since the catalogue service does not make any decisions for the agents.

Conclusion

The clustering approach introduced allows agents to form teams by semantically defined properties instead of being limited to quantitative data. Being highly distributed, the clustering protocol leaves all decision-making to the participating agents instead of a central entity. Its general applicability is demonstrated in a logistics scenario. However, the application is not limited to logistics as no special assumptions on the represented objects are made.

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Clustering in Autonomous Cooperating Logistic Processes

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Due to the growing complexity of logistics processes, "Autonomous Cooperating Logistic Processes" are considered as a way to handle this complexity growth (Scholz-Reiter et al. 2004). In this concept, knowledge and decisions are distributed among the participants of the logistics process. Logistic components may have common aims, e.g., several goods that are at the same location and have the same destination. In such a case, it can be sensible to form communities of those components and determine a community leader that acts on behalf of all members. It is expected that thereby the required communication among the logistic components be optimized. This paper identifies challenges in the area of communication that arise from the distributed decision process and the interacting components. An approach of clustering the packages first and then routing to their final destination is introduced in this paper and a result on the amount of communication traffic is presented with analytical formulation.

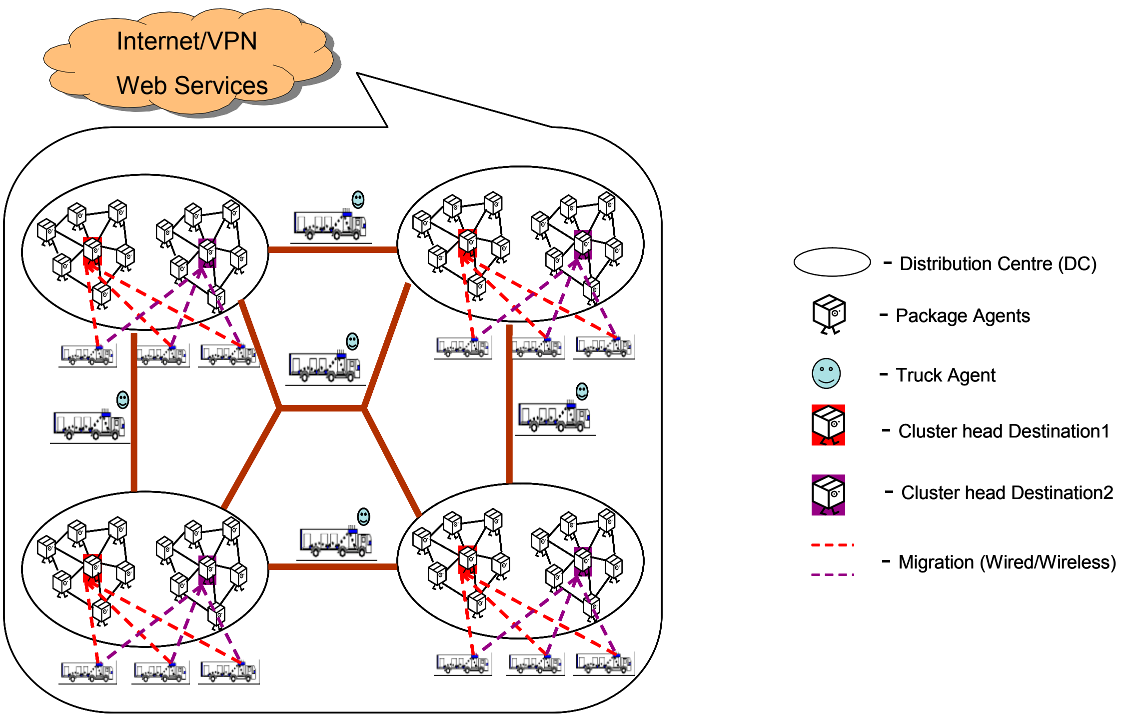
Introduction >>> The increasing complexity in logistics processes together with rising dynamics has resulted in embedding new technologies or paradigms in the logistics domain. Autonomous Cooperation (AC) is one of the growing paradigms for handling this dynamism and complexity that has witnessed a tremendous upsurge in recent years. This paradigm shift is facilitated by the availability of a wide range of information and communication technologies that can be utilised to devolve decision making down to the level of a vehicle, and indeed down to the individual item in the logistics chain [1] [2]. The implementation of AC aims at a flexible self-organizing system structure that is able to cope with the dynamics and complexity while maintaining a stable status [3]. Thus, logistics entities can be defined as items that have the ability to interact and communicate with other entities in the logistics network. Software agent technology is said to provide the means of creating autonomous, intelligent and social software entities capable of supporting autonomous decision making by sharing and interacting with each other. The distribution of planning and decision-making to autonomous components is a widely accepted promising solution to handle complex problems [4]. The motivation comes from the fact that the agent-based systems reflect the distributed nature and are able to deal with the dynamics of execution and planning on the real-time settings [5]. In case of large networks with large numbers of logistics entities it may result in substantially large communication. So the key challenge is the reduction in the amount of communication to bring about autonomous cooperation in a logistics network. <<<

Routing and Clustering Approach

In case of transport logistics, AC means that the vehicles and goods are able to act independently according to their objective, e.g. vehicles try to achieve aims such as cost efficiency while the goods aim to find a fast path to their destination. As the goods need to be transported by vehicles, there is an interdependence between the goods' and the vehicles' decisions. In order to deal with this interdependence, the "Distributed Logistic Routing Protocol" (DLRP) was proposed [6]. In this protocol, information retrieval is done using route request and route reply messages. In large networks, the route request and route reply messages cause a significant amount of communication traffic. If goods with similar aims can be combined into a community with one "speaker", a reduction of this traffic is expected.

Logistics entities are represented by software agents, and the solution proposed to reduce the communication traffic is the approach of clustering these logistics entities (software agents). The objective is to cluster the logistics entities which have common goals, like packages having the same destination, type of packages etc., shown

Figure 1 Transportation Logistics: Clustering of Logistic Entities



in Fig. 1. Organizing logistical entities into clusters can reduce the communication overhead associated with each of the individual entities and provide scalable solutions. The data associated with the package agent (like the destination ID) can be used as a reference to form clusters by performing intra-communication (communication within packages of same destination) and inter-communication (communication between various cluster-heads). Once the cluster is formed, a cluster-head can be selected to act on behalf of the cluster members instead of the individual entities communicating with each other. Thus, the cluster-head will be the information pool which can negotiate with other entities, for example vehicles, other cluster-heads etc.

This paper addresses the measure of communication traffic analytically with the approach of clustering and routing of logistics entities. Clustering has been a research topic in various fields of communication networks like sensor networks and ad-hoc networks, where all deal with the problem of energy saving (battery life) by reducing communication [7]. The underlying problem in all domains is the same; given a number of objects, a cluster should be created, such that items in the same cluster are more similar to each other than they are to items in other clusters. The algorithms applied in the previously mentioned fields can be mapped to logistic networks. For the mapping of these algorithms from communication networks, it is necessary to identify where these networks are similar and where they are different.

Clustering can be applied at various levels in a logistical network. Clustering of the packages can be done based on common destinations or type of objects like food, clothing etc. Clustering can also be done by the cities, depending on the route taken by the vehicle or the vehicle itself, based on the material they are carrying or destination to which they are travelling via a certain route.

In this paper, a semi-autonomous scenario is assumed, first concentrating on the cluster formation and then routing of the logistics entities. The amount of communication traffic for the routing procedure with and without-clustering of the packages is measured and compared analytically based on the number of messages exchanged.

Messages sent during clustering processes

In the clustering procedure, the logistical entities involved are the package agents, the associated vertex (Distribution Centre), and the cluster-heads (after the selection procedure). The messages exchanged between the packages, vertices and the cluster-heads are discussed. In the initial stage, it is assumed that, once the package (agent) arrives at its associated vertex, it sends a registration request (RegReq) and gets back a registration acknowledgement (RegAck). The associated vertex on sending acknowledgement looks out for the cluster which has the same destination as for the presently arrived package. Once it finds that the newly arrived package has no clusters based on this destination, it forms a new cluster based on that destination and selects the present package as the cluster-head sending it a message (CHAnn). In case, it has a cluster with the same destination, its sends the cluster-head information (CHInfo) of that cluster to the package so that it can register itself with that cluster (CRegReq). In addition, the cluster-head will send back the acknowledgement (CRegAck). The message cluster completion (CComplete) is considered in this scenario based on the cluster size assumed.

Communication traffic for clustering processes

The total amount of communication traffic for clustering taking into account some assumptions of the message exchange, the number of packages, the number of destinations, the number of clusters and cluster size are presented below.

Representation and Assumption:
Number of packages stored in a DC = N_packs
Number of destinations = N_dests
Number of Clusters = N_Clusters
Cluster size = Cl_size

Cluster-head Announcement / Information:
Total number of Cluster-head Announcements
(CH_Ann) = N_dests
Total number of Cluster-head Information
(CH_Info) = N_packs – N_dests

Clustering Process:
Total number of Cluster Register Request
(CRegReq) = N_packs – N_dests
Total number of Cluster Register Acknowledge
(CRegAck) = N_packs – N_dests

*Total Clustering Volume = (5 * N_packs - 2 * N_clusters)*

*where N_clusters = N_dests * ⌈N_packs / (N_dests * Cl_size)⌉*

Messages sent during routing processes

During the routing process in DLRP, the entity (package or vehicle) that performs the routing generates a high amount of data traffic. As there are usually more packages than vehicles and clustering should be applied to the packages, only the package routing is covered in the following.

The routing starts with two queries to the associated vertex and the corresponding responses. These queries inform the package about some initial parameters such as destination, associated vertex etc. that it needs for the routing. Then the package sends a route request (RREQ, exactly one) to its associated vertex, which in turn adds some data to the request and forwards it to all neighbour vertices, thus it is multiplied by the vertex's branching factor, which states how many neighbours are available as recipients of the forwarded route request. This is continued until the request reaches the destination or its hop limit. A route reply (RREP) is then sent back for each request that reaches the destination.

Assuming an average branching factor b and an average route length of l hops, the amount of route replies is b^{l-1} , while the total number of route requests sent in the network is

$$\sum_{i=0}^{l-1} b^i .$$

After having received the route replies, the package decides the route and announces it to the affected vertices, which leads to other route announcements (RANN) per route, so if the package announces alternative routes, the total number of route announcements is nl.

For a small logistics network with a branching factor of 3 and packages choosing 3 alternative routes, an average route length of 4 would correspond to 40 route requests and 27 route replies for a single routing process. If for a network, the average route length is just one more, i.e. 5, and then this would lead to a huge increase in routing traffic (121 route requests and 81 route replies).

In the case where each package routes individually, each package generates this amount of messages. In contrast, if the routing is only done by one cluster head instead, only the cluster head generates the messages. Therefore, clustering brings a reduction of routing messages by a factor of Cl_size when compared to the non-clustered case.

The assumptions with respect to number of packages, number of vehicles is presented in the Table. 1.

Table 1. Parameters for Clustering and Routing

Parameters	Representation	Value
Number of Packages	N_packs	Min 50 Max 500
Number of Destinations	N_dests	5
Route Length		Min 3 Max 7
Branching Factor		Min 1 Max 8
Number of alternate routes		3
Cluster size	Cl_size	Min 2 Max 20

Results

The results depicted in Fig. 2 and 3 give the total amount of communication traffic taking into account clustering and routing messages for varying number of packages, route length, and branching factor, respectively. The set of curves are presented for the parameters such as Without clustering, varying Cluster size, and No cluster size limit. As seen in Fig. 2 the communication traffic goes on increasing linearly with increasing number of packages and is of maximum value in the case Without Clustering, while the communication volume decreases gradually with the increase in the cluster size. Fig. 3 depicts the results for varying route length, and it is observed that the communication traffic has its maximum value in case of Without Clustering. This implies that as the route length increases the amount of communication traffic increases substantially, but not as high as compared to the increase in the number of packages.

Hence, it can be concluded that clustering of the entities helps in reducing the communication volume, which eventually depends on the size of the clusters. The larger the cluster size, the less the communication between the logistical entities will be, as only one of the members needs to communicate on behalf of all others, whereas there will be a slight increase in the communication within the cluster members to form the clusters.

Figure 2 Communication traffic vs. Number of packages

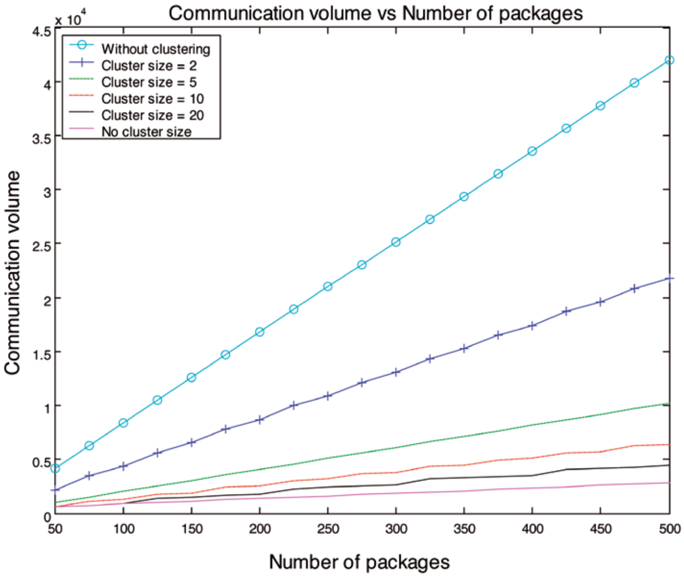
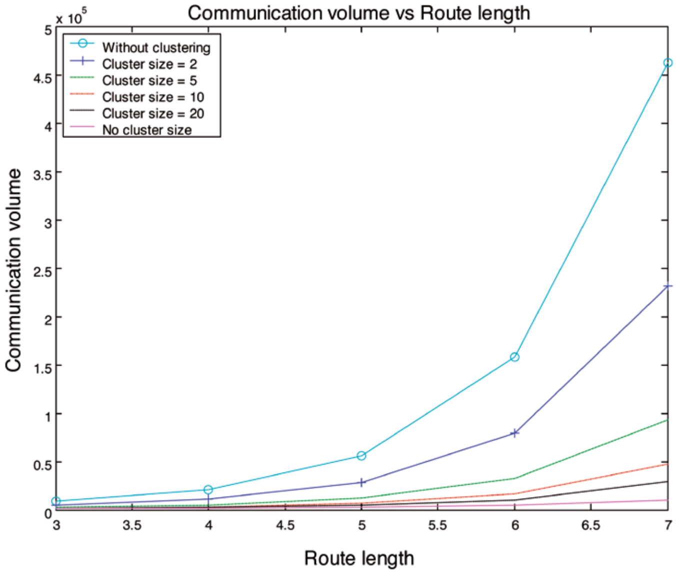


Figure 3 Communication traffic vs. Route length



Summary and Outlook

In this paper, the communication-related challenges of autonomous cooperating logistic processes were briefly introduced, and a cluster-based approach to reduce the communication volume was proposed. Some results are presented with respect to the communication volume with varying number of packages and route length. This approach will be investigated by simulation in the near future, opening up a significant improvement in communication efficiency.

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Knowledge Management in Food Supply Chains

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In a food supply chain, companies exchange information and products to create value. The competitive advantage of the company relies on that of the entire chain. This paper addresses knowledge management in a food supply chain, with special regard to the promotion of knowledge sharing and transfer. This is a substantial issue when, for example, a company comes to leave the supply chain voluntarily or disappears because of natural or man-made catastrophes. In this case, the question remains whether the substituting organization can acquire the tacit knowledge needed to fulfill its mission. Consequently, the operation of the supply chain becomes an acute issue too. The paper proposes a methodology based on organizational and interorganizational learning and develops a learning laboratory that facilitates knowledge sharing and transfer. This lab supports (a) knowledge sharing through the mental map's knowledge elicitation of every company's leader, and (b) knowledge transfer via dedicated learning-based environments.

Introduction >>> A food supply chain comprizes a number of organizations responsible for the production and distribution of vegetable and / or animal-based products. Bourlakis and Weightman (2004) defined the food supply chain as controlled processes combining knowledge, skills and technology in addition to a wide range of other disciplines. Products are supplied by farmers and delivered to potential customers. The orientation to customers and the underlying social responsibility lead to a change in the supply chain caused by the development of strategic management. Partly, this is achieved by globalization which offers the opportunity to develop new businesses and improve the satisfaction of customer demand. Moreover, globalization promotes the applications of information technology, and hence; it supports the movement of products, and the dissemination of product information through the food supply chain (Bourlakis and Weightman 2004). However, globalization can also complicate the performance of a food supply chain when competitiveness is increased and international reallocation of suppliers and consumers is altered. An informational channel between the different sectors of the food supply chain (suppliers, farmers, manufacturers, clients) is needed in order to share and create knowledge. This facilitates collaboration within the food supply chain. Indeed, success depends on a program of mutual benefits based on trust, communication, production continuity; and time and visibility to make changes (Seyed-Mahmoud 2004). High levels of information exchange and knowledge transfer represent a common characteristic of leading companies such as Wal-Mart and Rewe. In the food retail industry, the Wal-Mart model is usually applied. This model is dependent on the continuous replenishment of inventories. Accordingly, Wal-Mart shares information with customers and manufacturers electronically, and therefore it can replenish the inventories in its stores (Seyed-Mahmoud 2004). This electronic data interchange (EDI) system not only performs an easy, quick as well as responsible supply of shelves in supermarkets but also improves the traceability of food with the resulting cost reduction in the food safety program (Wijnands and Ondersteijn 2006). Rewe and other independent retail dealers began a project involving the application of radio-frequency identification (RFID) along the meat supply chain. The project aims to examine and optimize information transparency concerning the handling, transport and storage conditions. This will enhance traceability and reliability throughout the food supply chain.

Following a review of knowledge management processes, the paper describes how a food company can share and transfer knowledge about its operations in the supply chain (with suppliers, farmers, etc.) based on the foundations of organizational behavior. As an approach, both organizational and interorganizational learning are used in order to create and facilitate knowledge in a food supply chain. Organizational and interorganizational learning suffer from defensive routines and "people barriers" featured by diverse fears and aversion to knowledge sharing (Argyris 1985; Barson et al. 2000). Therefore, it is valuable to have an effective strategy to learning and use dedicated tools such as the learning laboratory discussed in this paper. <<<

Knowledge Management Processes

Knowledge management can be described as practices used by companies to identify, create, share, transfer and turn knowledge into a competitive advantage. Davenport et al. (1998) deemed knowledge to be information combined with experience, context, interpretation and reflection. Thus, knowledge exploitation plays an important role within each organization and between organizations integrating the supply chain, especially in the business relations between suppliers and customers. However, extending internal knowledge management programs to external sources is a demanding task because of some typical barriers. Barson et al. (2000) classified these barriers in four categories: technology barriers, e.g., available technology and legacy systems; organization barriers, e.g., distance, poor targeting of knowledge, costs of managing knowledge transfers, protection of proprietary knowledge; people barriers, e.g., internal resistance, self interest and lack of trust; and finally cross-category barriers which are featured by technology, organization and / or people, e.g., existing resources, the need for rewards and culture.

A short description of the processes forming knowledge management is presented to clarify the most important components within this concept. Some of them are consequential in the development of the learning laboratory. Alavi and Leidner (2001) identified knowledge management as a salient factor in the accrual of a company's competitiveness and proposed the following processes:

- Knowledge creation: explicit through systematic language, scientific formula; and tacit, i.e. ideals, values, emotions, etc. (Nonaka 1991). Both are strongly interconnected and cannot be easily differentiated.
- Knowledge storing: the capacity to retrieve knowledge
- Knowledge transfer: identification, assimilation and exploitation of knowledge
- Knowledge application: use of knowledge in order to increase or maintain the competitive advantage

These processes take place in today's globalized world which is replete with information. Companies exchange information, resulting in a potential for knowledge sharing. It is essential that companies recognize and promote it because knowledge sharing prevents reinventing the wheel (Bender and Fish 2000), creates shared understanding (Nickerson and Zenger 2004); reduces uncertainty (Thusma 1978), and turns individual learning into organizational learning (Nonaka 1994). Berends (2005) distinguished between direct and indirect contributions of knowledge sharing. The former has an immediate effect on problem solving with either (a) a contribution to the solution of a problem, (b) a change in the problem statement; or (c) activation of new actions. The latter possesses a long-term plus-value, in that it helps the development of background knowledge.

Organizational Approach to Knowledge Management

Lasting learning involves double-loop learning (Argyris 1985) which questions the underlying goals, assumptions and programs of the organization's shared mental model instead of just adjusting its behavior to achieve a desired outcome, as is the case in single-loop learning. Double-loop learning provides the organization with a shared, tacitly learned behavior that survives the people who leave it in a voluntary or forced manner. Organizational learning offers knowledge elicitation methods that facilitate double-loop learning. Examples of these methods are the left-hand column method (LHC), originally introduced by Argyris & Schön (1974) and the ladder of inference portrayed in Senge et al. (1994). Both methods allow knowledge sharing since they unearth that tacit knowledge held in mental models and render it visible and explicit. Learning-based environments (management flight simulators, microworlds, etc.) are learning processes, tools or environments that help activate double-loop learning. These tools can transfer individual learning to organizational learning since the knowledge source is the individual who interacts with the computer model to find out sustainable strategies which will be later applied to the organization (knowledge recipient). The combination of (a) knowledge elicitation and (b) learning-based environment yields a dedicated framework for learning, often called a learning laboratory. It is an effective environment to share knowledge through mental model elicitation and to transfer knowledge using learning-based environments.

Learning Lab

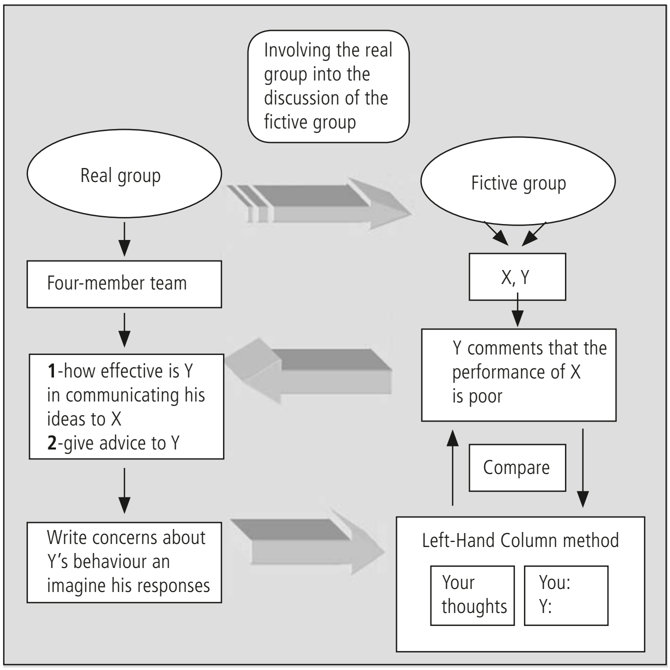
First of all, it is important that technology evolves rapidly in the supply chain in order to ensure that every company has little domination over the others. From one side, the concentration of power is held by supermarkets in the food supply chain. The retailers sometimes apply pressure on farmers with respect to the buying price, thus, farmers find themselves obliged to sell their products at a price close to the cost of production. From the other side, technology is of standard use to preserve fresh and quality products. Second, the member companies should be willing to learn and perhaps already have a history in organizational learning. The initiation of a learning effort is pertinent only when the participating food companies have a true interest in learning. The learning lab sustains knowledge sharing and transfer by the use of the left-hand column method and learning-based environment respectively. The learning laboratory is offered within a workshop and it is led by a facilitator. Its duration depends on the material studied by the participants and the pace of the steps. Overall, the workshop is feasible in three hours.

Knowledge Sharing

One representative member of each company in the supply chain experienced knowledge sharing through the left-hand column (LHC) method. Naturally, a skilled facilitator is required to achieve a rewarding interactional environment. Furthermore, for the prevention of conflict outbursts during the elicitation of decision makers' mental maps, a systematic record of discords is thought to help avoid the cause of the conflict in the subsequent sessions of the learning lab. For learning in groups suffers from defensive routines. Hence, the LHC method detailed in the next section takes a fictive story between two decision makers X and Y as prevention against interpersonal conflicts. The elicitation method adopted follows the methodology described by Argyris and Schön (1974) summarized in Fig. 1. Y commented on the poor performance of X with regard to the inventory control of food products:

"Your orders were fluctuating too much.
Your ordering policy was immoderate.
The forecast of customer demand you gave me was exaggerated.
As a result, the whole inventories oscillate.
You provoked dramatic inventory costs."

Figure 1 Procedure for LHC (adapted from Argyris and Schön 1974)



The team read these comments (of Y towards X) and based on that, it decided whether (1) Y had been effective in communicating with X about those issues and (2) gave Y recommendations in respect to the comments on or reproaches to X. In order to test whether the participants observed the advice provided to Y, they were asked to write down according to the format of the left-hand column method their concerns about Y's behavior and imagine the respective responses of Y in a conversation with this decision maker (Fig. 2).

The method shows whether the team members generate the same problems, issues and comments as Y. Moreover, it enables them to discover whether their theory-in-use (what they actually do as demonstrated by the left-hand column) converges with or diverges from their espoused theories (what they say they would do such as the advice given to Y). The facilitator should look at the responses of the participants and point out if they are making use of Model I and help them develop Model II for the next step of knowledge transfer (see Argyris 1985 for more details on Model I and II). Negative or control attitudes, determining the inconsistencies of the participants as depicted by the left-hand column method, should be stressed.

Figure 2 Left-hand column in a fictive conversation with Y (Argyris 1985)

Your thoughts and feelings	What you and Y said
(Tell here what you thought, but what you did not disclose to Y)	I: Y: I: Y:

Knowledge Transfer

The individuals underwent knowledge transfer by running the supply net game (Scholz-Reiter et al. 2006). This simulation game is designed to be played in a team of four persons. Players control the four inventories included in their respective factories, and place orders for the replenishment of the stocks. While regulating their inventories, players should pay attention not to let them drop too much because of the out-of-stock penalty of 1.0 EUR per item per minute. Meanwhile, they should impede the build up of stocks because of the 0.5 EUR cost for each product on hold. The game's objective is the minimization of the total inventory costs. Debriefing sessions are planned to evaluate the thoughts of the subjects and discuss the dynamics of the system, feedback loops, and behavioral patterns of variables such as customers' orders.

This structural setting not only favors organizational learning but also advances interorganizational learning. In other words, learning takes place between the team members of the food supply chain. When players quit the session for whatever reason, it is still possible to retrieve what they experienced since they transferred and shared their knowledge with the rest of the team. Hence, the player who replaces the one who left will immediately benefit from the knowledge of the latter through the team. In this way, people relate to one another's experiences in the food supply chain.

Conclusion

Sharing and transferring knowledge in the food supply chain increases the competitive advantage of the whole chain and guarantees the continuity of its operations. The globalized world with the associated technological innovations affords a prospective environment for the development of knowledge management. In spite of some commonplace barriers such as the lack of trust capable of generating delays in practice, the moral and social responsibility of retailers in the food supply chain empowers them to play a significant role for gradually accelerating the change processes, and hence, eliminating the aforementioned barriers. Therefore, it is important that retailers recognize their major role and learn to share knowledge efficiently.

The methodology elaborated around the learning laboratory showed how to share and transfer knowledge in a food supply chain. This approach can be utilized in the case of the networked or extended supply chain. First, knowledge is shared through the knowledge elicitation of the team's mental models. Second, knowledge is transferred via a learning-based environment such as a gaming simulation tool. Few knowledge management initiatives have addressed extended supply chains. This is why the paper certainly bridges a gap by its contribution to this research arena. Even though this methodology focuses on the food industry, it can be applied to other industries, with a few adjustments, to deal with the real problem at issue. Knowledge elicitation via the left-hand column method should always be part of the learning laboratory. This lab represents an effective strategy to knowledge sharing and transfer in food supply chains considered as vulnerable to team rotation or change in today's highly dynamic environments. All in all, the methodology proposed is highly flexible and can be practically applied. Finally, the novel adaptation of the left-hand column method as introduced, with the reliance on a fictive group, is thought to lessen the barriers to knowledge sharing in food supply chains.

The learning lab was successfully employed for the instance of a production network manufacturing items whose demand is quite variable and oscillating within the network. This phenomenon is referred to as the bullwhip effect in a linear supply chain. The participants of the workshops were asked to remedy for this situation when replenishing the inventories of their manufacturing units by minimizing the inventory costs of either the products available in stocks or those backlogged. Preliminary experimental results show that the best performing team is one that experienced a mental model elicitation (Scholz-Reiter and Delhoum 2007). Consequently, the learning lab is assumed to have influenced this team to achieve this quite positive outcome.

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Autonomous Logistic Processes Within the Fresh Food Supply Chain

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Opportunistic Routing in Wireless Sensor Networks for Harbor Logistics

Que Son Vo
Prof. Dr. Carmelita Görg

The collection of information for management in logistics is of great concern today. Having the advantage of self-configuration, relatively low price and long network lifetimes, Wireless Sensor Networks (WSNs) are progressively being applied in many logistics scenarios. This paper presents ODEUR (Opportunistic relative Distance-Enabled Uni-cast Routing) [1] and its application for harbor scenarios. In this type of scenario, there are data collectors in the different locations through which large numbers of containers need to be moved. Detected by the ODEUR protocol, the movement of containers between the locations provides information to choose the most suitable data collector to send data. By this, the progress of collecting information from intelligent containers is automatically performed in any one location.

Introduction >>> Having a long history of development and in spite of available mature technology, there is currently no completely automatic management in logistics. A logistics network consists of many entities such as: suppliers, factories, warehouses and distribution centers through which raw materials are acquired, transformed, produced and delivered to the customer [2]. Each of them has a different information management system and thus they do not easily share information with each other. Moreover, the current logistics networks do not automatically provide enough information for full management.

Some modern technologies have been progressively applied to logistics applications in some processes. For example, RFID tags are embedded into goods to facilitate management. The idea of an intelligent transport system is still under development by many researchers worldwide. Wireless Sensor Networks (WSN) is a key enabling technology for monitoring and autonomous control in logistics.

A WSN is a set of nodes (shown in figure 1) each equipped with embedded sensors (e.g. temperature, humidity, acceleration), processors and radio interfaces which collaborate to perform the task of collecting data in an area and sending them to the target destination. There are a number of well-known sensor projects with small size nodes such as WINS of UCLA, Smart Dust of UC Berkeley, and eGrain from Fraunhofer, [3] [4] [5]. Different from Wireless Data Network and Wireless Telecom Networks, nodes in WSNs have features such as mobility, low power, multi-hop routing, low latency, self-administration. They can also collaborate to perform a given task [6]. With these features, WSNs are a suitable candidate for applications like collection and control.

One of the main issues in WSNs are effective routing protocols to transmit data from source to destination, possibly using other nodes as relays. Opportunistic routing is a routing protocol which searches the best opportunistic condition to relay the messages further to the destination/sink. This does not necessarily require an end-to-end connectivity. Most of the approaches in this area [7], [8], [9] are limited to static single-sink scenarios which do not fit well in the harbor scenario (shown in figure 2).

This is because in harbor scenarios, the containers in storage house will be moved to a crane area by a truck, and after that they

Figure 1 TelosB sensor mote

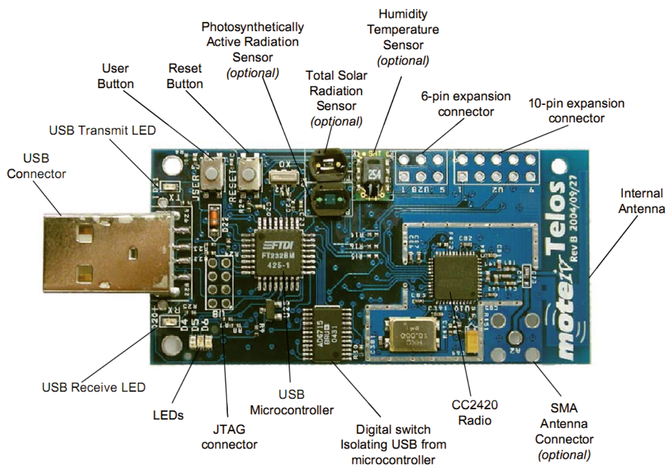
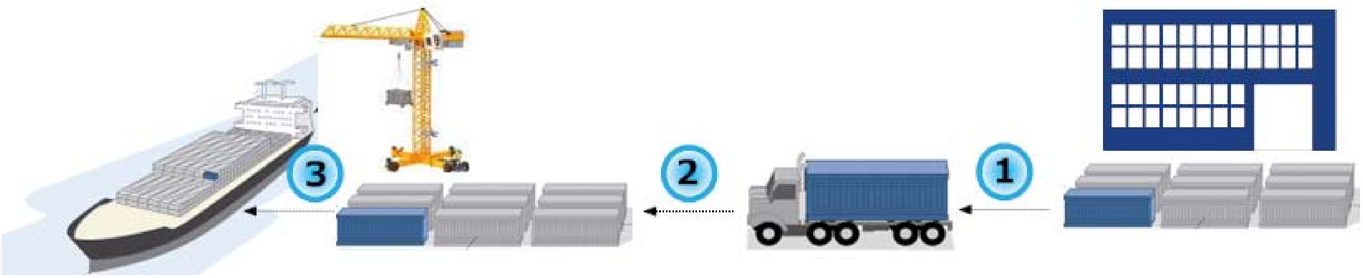


Figure 2 Flow of container transportation from storage house to ships



will be loaded to the ship by a crane. The data sinks in a harbor are ships, cranes or trucks, and can be static or movable (they can move out of their locations). Therefore there are many sinks for corresponding WSN domains. Each container with a sensor periodically collects the status of goods (e.g. temperature, humidity) to be sent to sinks that act as data collecting nodes. Of course, all of the sinks act as (mobile) gateways connecting WSN domains and Internet.

ODEUR is designed to overcome these difficulties and can be applied to harbor scenarios with many sinks at the network layer. By considering the address of sinks as an identifier of the type of sink, an application of a sensor node can choose the appropriate sink to communicate to. Therefore, ODEUR has many advantages in the harbor scenario where there are mobility and multi-sink features.

This paper is structured in 4 main sections: section 1 describes the introduction, section 2 describes how the ODEUR protocol works, section 3 describes the operation of WSNs in the harbor, and section 4 concludes the paper. <<<

Odeur

ODEUR (Opportunistic relative Distance-Enabled Unicast Routing) is a routing scheme, looking for opportunities to transfer the data to a node which is closer or coming closer to one of the sinks. It is designed for scenarios with mobility, multiple sinks and applications not requiring an end-to-end connectivity. It is therefore generally suitable for transferring data from containers to different sinks. In the following the ODEUR routing protocol is described in more detail.

Sink nodes periodically transmit beacons with higher power. This allows all the sensor nodes in the beacon range to receive beacon information from it although the sensor nodes cannot necessarily communicate with the sink nodes.

As shown in figure 3, the beacon range is usually larger than the sink communication range. In order to detect the movement of a sensor node towards or away from a sink, a sensor node uses the Received Signal Strength Indication (RSSI) in each beacon frame. By computing the (averaged) difference between continuous RSSI values, a sensor node can calculate the Mobility Gradient (MG), a value that indicates the relative movement between the sensor node and the sink node. The MG is in the range [-1, 0, 1] and indicates either, that moves further away from the sink, the distance to the sink is constant or the node the node moves closer to the sink, respectively.

Each sensor node in ODEUR can act as a relay node. After receiving information in a beacon from a sink, it creates its own beacon which includes: the address of the sink and the value of RSSI it received from the respective beacon, and its MG to this beacon. This new beacon will be forwarded with normal power.

All the receiving nodes will use the received direct or indirect beacons to build the neighborhood information database. This database contains all the neighbor nodes with their mobility gradient and RSSI. From this, each node can elect the best neighbor to forward the messages to. It can also decide to keep the message, e.g., if it is itself approaching a suitable sink.

Another feature of ODEUR is that it does not need a non-interrupted end-to-end connection; instead it always tries to transmit data to the node with the best opportunity to reach the sink. This can support the establishment of a hop-wise connection to transmit data between sensor nodes and sink nodes at any locations. The relay feature in ODEUR is a good way to communicate with a sink node when sensor nodes are not directly in the sink range. In the case that there is no available sink to communicate with directly, a sensor node can forward all messages to the best neighbor node in its database. This can improve the reliability of the communication between nodes.

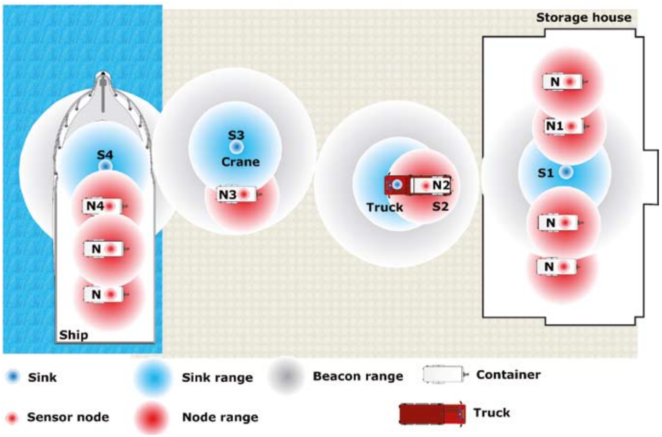
Sensor Networks in Harbor Scenarios

In the harbor scenario investigated, information is sent from the container to different logistic entities. The container collects data, like status information, measurements, that it needs to communicate to a control center. So they need to be sent via the most suitable Internet Gateway. Furthermore, the container needs to communicate directly to logistic entities in the harbor, like the truck to inform about hazardous or sensitive goods before being transported, to the truck about constraints imposed by the content of the container, or to the port authorities for toll declaration or information about dangerous goods.

On the way from the ship to the truck or train the container can either directly communicate with theses entities or communicate via changing gateways. The selection of the gateway mainly depends on the actual location of the container and its neighbors. But it also might depend on traffic on the sensor network and other factors.

In the harbor scenario investigated, an example is given with four locations: storage house, truck, crane and ship with sink nodes. The application in each sensor node must know which sink it should connect to. This is because at some locations, a sensor node can communicate with more than one sink node (e.g., containers in a storage house can transmit messages to the sink in storage house (S1) or the sink on the truck (S2)). In this scenario, only WSN domains are considered. That means the data transmission is only from sensor nodes (containers) to the sinks (gateways).

Figure 3 Using WSNs in harbor scenarios



The movement of the container is from the storage house to the ship and vice versa. Only the flow from the storage house to the ship (including 3 steps shown in figure 2) is examined in this scenario. Normally, a sensor node in its area communicates with its sink node using ODEUR protocol as described earlier (e.g. N1 communicates with S1, N4 with S4). Once a truck takes a container N2 from the storage house, N2 can connect with both S1 and S2. When moving, based on information from ODEUR, N2 can know that it is in 2 areas (storage and truck). Thus, it will disconnect with S1 and set up connection with S2 to send data. During the way to the crane location, N2 only connects to S2. At crane area, N2 can connect to S2, S3 (and maybe S4). It will setup connection with S3 (assuming having higher priority than S2). By detecting the movement of N2 with S3 (when it is loaded to ship by the crane), N2 can connect to S4. Priorities can be used to distinguish sinks. The connection of a sensor node above can be directly to the sink node (if it is in the sink range) or via the best neighbor node elected by ODEUR (if it is out of sink range). In case the ship is departing from the harbor, a passing ship (or containers on the ship) approaching the harbor can collect the information and deliver it.

The setup phase to a new sink is easy because each sensor node always keeps a list of available sinks with which it can connect. Although only one sink in each geographical location is considered, many sinks of each area can be extended without any difficulties. This is because all the sinks in each area have the same functions, so the connection from one sensor node to each sink in an area is the same.

Conclusion

The application of the ODEUR routing scheme, developed at ComNets Bremen to a harbor scenario with mobility is presented. The feasibility to apply WNSs in logistic applications with several data sinks (collectors) is presented. Future work will focus on the implementation of this model in the real system and simulations to evaluate the efficiency.

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Modeling and Implementation of Sensor Networks for Logistic Applications

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Agent-Based Container Security Systems: An Interdisciplinary Perspective

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Container security systems including electronic seals play an important role in securing container logistics. Nevertheless, a lack of standards prevents devices by different vendors from effective interoperability. Hence, this paper proposes an interdisciplinary perspective incorporating the agent paradigm of computer science. In this approach interaction between different autonomous entities is based on standardised communication protocols. In addition, for container security systems a cryptographic concept must be applied in order to secure communication.

Introduction >>> The terrorist attacks of September 11, 2001 led to an increased demand for security in logistics processes. A special focus lies on shipping containers due to their high throughput in the intercontinental transport of packaged goods. An important step towards more secure logistics is to seal containers in order to protect them from thieves but also from terrorists trying to smuggle dangerous goods. Conventionally, this is accomplished by mechanical seals, e. g., numbered bolts. A more sophisticated approach makes use of electronic seals which notice tamper immediately and alert the cargo owner [Hic04]. Additionally, container security systems can also comprise sensors that continuously monitor the interior of the respective container [Sch04].

Containers, and therewith their security systems, are applied all over the world. The environment of each container changes dynamically on the way from its origin to its destination. The demand for flexible interaction with other entities often arises during transport. For instance, consider customs personnel wirelessly requesting security information with hand-held devices. As another example, multiple containers from one company might cooperate in their security efforts in order to save their bounded resources. Although a great many vendors of container security solutions exist, due to a lack of standards their interoperability currently remains an open issue [Hic04].

This paper argues in favour of an interdisciplinary perspective, integrating experiences from the agent paradigm of computer science [Wei99]. The main advantage is that software agents located on different systems and based on completely different standards can communicate by applying interaction protocols as a standardised interface. The three main criteria for successfully applying multiagent systems in problem solving (natural distributivity, flexible interaction, and dynamic environment) proposed by [Mül97] are obviously satisfied by the container logistics domain.

The remainder of this paper is structured as follows: Section 2 discusses requirements of container security systems. Subsequently, Sect. 3 presents an agent-based approach incorporating encryption and trust concerns. Finally, a conclusion follows in Sect. 4. <<<

2 Container Security Systems

The general purpose of seals is to secure the content of containers. Conventional seals generally comprise a bolt that mechanically prevents the container from being opened [Fie05]. At the destination it has to be validated that the seal is still intact and that it is still the same [Tir05]. Conventional seals are comparatively cheap and not reusable: if a container is legitimately opened, a new seal has to be affixed [Had05] and its unique number [Fie05] has to be recorded. Compared to their low purchase price the handling costs are quite high since the inspection has to be conducted manually and is therefore time consuming [Tir05]. Although mechanical seals increase the effort for tampering with a container their benefit is still limited. As an example, [Had05] argues that criminals can remove the doors of the container completely without damaging the seal, cut a hole into another wall, or create a new seal after having finished. Furthermore, containers are not monitored in real-time.

Electronic seals are intended to overcome some of the limitations of conventional seals. Apart from mechanically locking the container they also exhibit computation and communication abilities. Therefore, it is possible to verify them by a radio-frequency identification (RFID) scan [Tir05]. This feature does not only massively decrease the handling effort, but also enables an almost continuous monitoring as the scanning can be performed easily and often. Thus, the seal can also act as a surrogate for the container number since RFID technology enables a recognition rate of over 99% while optical character recognition systems achieve only about 80% under real-world conditions [Had05]. Despite their higher purchase price, electronic seals might therefore be the better choice regarding their total cost of ownership [Tir05].

Apart from the seal, container security systems can be enhanced by embedded sensors which monitor tampering, theft, and placement of unintentional freight. Examples are door light sensors, gamma ray detectors, as well as chemical sensors [Sch04]. As the applied sensors depend on the concrete purpose, the participating entities must be equipped with the ability to establish ad hoc networks. In this context it has to be ensured that access to the network is restricted to trustworthy entities, e. g., by certification. Otherwise, thieves or terrorists could corrupt the system by injecting manipulated data.

The security system's interface to the outside world is another vulnerable point. As an example, stevedores and truckers are legitimate recipients of some security-related data. Due to restricted resources it might also be an option to join forces with security systems of neighbouring containers. These forms of communication have also to be restricted to trustworthy partners. As an example, from the perspective of safety it might be desirable for a container to inform the environment about hazardous content. By contrast, this is not the case from a security point of view. It is not advisable to broadcast a container's attractiveness for terrorist attacks to everyone including the terrorists themselves [Had05].

To recapitulate, electronic security systems can significantly improve container security. Since they demand flexible cooperation, their interaction with the outside world has to be secured in its own right. This can be achieved by limiting communication to trustworthy partners.

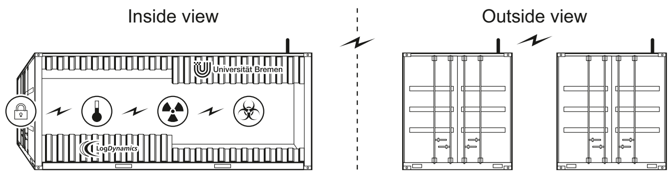
3 An Agent-Based Approach

In the agent paradigm, software agents act on behalf of the (logistics) entities they represent [KT99]: they are assumed to be embodied in an environment, to act autonomously, and to be able to sense changes and react appropriately. Multiple agents are organised within a multiagent system (MAS) which offers essential services to the respective agents [Wei99]. Regarding container security systems a double-layered approach applies (Fig. 1). The first level consists of all entities belonging to a container, e. g., electronic seals and sensors, which jointly form a MAS (the inside view). Here, the main task is to collect data and to monitor whether all values are within admissible ranges. The second level encapsulates all internal components by an additional software agent. This agent is situated within a MAS of all containers and other entities related to container logistics (the outside view). On both levels, standardisation (Sect. 3.1) helps in enabling communication and cooperation of different devices (Sect. 3.2). Section 3.3 addresses trust and encryption, which play an important role in this context.

3.1 Foundations

The basis for applying intelligent agents is formed by specifications of the IEEE Foundation for Intelligent Physical Agents (FIPA). The standards proposed by this group specify essential parts of MAS which, for instance, manage the life cycle of agents. Another part of the system provides a yellow pages service where agents can register the services they provide to other agents. This paper focuses on cooperative agents that support each other in solving the problem of ensuring the security of containers during transport. This, however, requires that competitive agents are reliably excluded from the system (see Sect. 3.3).

Figure 1 Agents within the container communicate with each other, e. g., the electronic seal as well as different sensors observing the interior (left). Additionally, the agent representing the container as a whole can also exchange messages with other containers (right)



JADE, the Java Agent Development Framework, is an implementation in compliance with FIPA standards [BCG07]. It comes along with LEAP, the Light Extensible Agent Platform, which is a derivative for mobile devices. It focuses on providing a technical infrastructure for enabling the transition of agents to platforms with limited resources. Hence, it is well-suited for an application in container security systems.

3.2 Communication and Cooperation

According to FIPA, communication is conducted with specific interaction protocols. The conversation flow of interaction protocols comprises unique speech acts, which are defined in the Agent Communication Language (ACL). The purpose of such protocols is, for instance, to request actions from other agents, or to coordinate purchasing by auctions. Due to the standardised communication even completely different agents can exchange messages. Hence, this paradigm also forms a promising approach for container security provided that additional security functions are implemented (see Sect. 3.3).

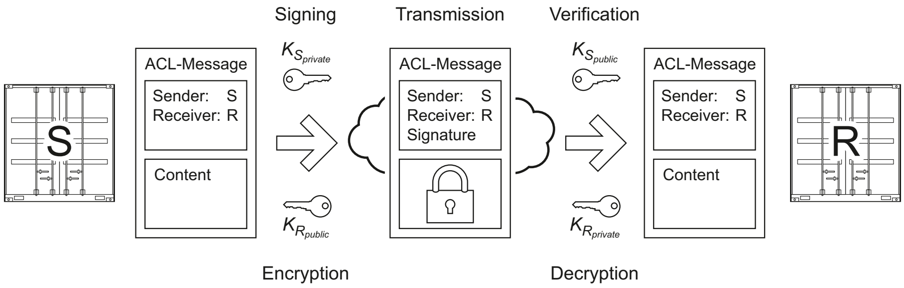
Acting autonomously in container security systems, agents are situated in a resource-bounded environment. This constraint holds for both the inside and outside view of the container. Examples of such restrictions are bounded computational power as well as memory restrictions. The mobility of container security systems also influences the amount of energy available. As a result, these restrictions lead to a need for cooperation of container agents in order to bundle and delegate common tasks. A general approach formalising the cooperation between agents is the model for cooperation [WJ99].

The techniques discussed in this section enable realisation of a dynamic and adaptive management of container functions. Applying an ontology ensures that the semantics of conversation contents can unambiguously be deduced by all communication partners.

3.3 Trust and Encryption

As described in Sect. 2 it is crucial to ensure that only legitimate recipients obtain data from the container security system (encryption). Hence, it is also important to clearly identify authorised cooperation partners (signature). Both demands for trustworthiness can be addressed by applying public key cryptography [Tan03], which is based on pairs of asymmetric encryption keys. In this approach, the public key of an agent is known to everyone and is applied in order to encrypt the content of messages for the respective agent (Fig. 2).

Figure 2 The software agent managing container S sends a message to the agent of container R. Therefore, S signs and encrypts the content of the message before transmission. The received message is then validated and decrypted by R



Decrypting such contents can only be accomplished by applying the private key which is kept secret and only known to the agent itself. A sender additionally signing the message with its own private key enables the receiver to validate its authenticity with the respective public key.

In order to identify trustworthy communication partners, each container security system agent has to be provided with the public key of the company. The respective private key can, however, not simply be provided to all participants. Otherwise, the whole system runs the danger of being compromised if, e. g., a hand-held device with the key is lost. A finder or thief would then be able to decrypt all messages intended for the company. Instead, a public key infrastructure [Tan03] has to be established. In this concept each entity gets its own private key that is signed by the private root certificate of the company. Validating the respective public keys with the company's public key then reveals whether a communication partner is trustworthy. The problem of loss can be approached by demanding keys to regularly expire and be renewed.

4 Conclusion and Outlook

Container security systems play an important role in securing container logistics. Nevertheless, a lack of standards currently prevents interoperability of components from different vendors. This paper argues in favour of an agent-based approach in order to overcome this limitation. By implementing electronic seals and sensors as agents, standardised communication protocols can be applied for the interaction. In addition, aspects of trust and encryption must be considered as not every communication partner is trustworthy. In order to save resources, multiple components of one container security system as well as multiple systems may join forces by cooperating. However, cooperation may not always suffice to overcome limitations caused by bounded resources. Some applications in dynamic environments additionally have high requirements on the internal management for the respective agents. Hence, an efficient handling of acquired knowledge and strategies to keep knowledge bases manageable are necessary. This aspect gains more importance when complex reasoning techniques are considered.

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Dynamics in Knowledge Bases of Resource-Bounded Agents – Learning, Recalling, Forgetting

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Adaptive Production and Inventory Control in Supply Chains for Transient Demand

Markus Zschintzsch
Prof. Dr. Bernd Scholz-Reiter

In the paper we applied a gain scheduling controller to the general replenishment rule for the supply chain scheduling decision support system. The starting point is the 'automatic pipeline, variable inventory and order based production control system' replenishment rule. In the current literature the rule provides the balance of bullwhip and inventory fluctuations reduction for independently and identically distributed stationary stochastic demand. In the real world the demand signal consists of the trend and changing noise (e.g. along the product life cycle). Based on this account we developed an adaptive mechanism, which is able to adjust the system based on the states of the system and the demand input. The new adaptive mechanism balances between the production and the inventory fluctuation level and sets the appropriate inventory coverage level by adjusting the right production and inventory adjustment parameter, the right target inventory level and the right forecast time.

Introduction >>> Decision-making in supply chains is based on production and inventory control (PIC) policy. The aim of the rule is the reduction of uncertainty for the customer and the supplier as well as the reduction of costs for production fluctuations and inventory holding. In order to ensure a certain service level for customer, the system should be following the demand requirements. In the case that demand tracking is not successful a safety stock must be held. At the same time the policy should detect and reject unnecessary demand fluctuations, in order to avoid needless production and order fluctuations. Production fluctuations increase the production costs by ramp-up and run-out of production and capacity holding. Order fluctuations increase the supplier uncertainties and lead to increasing fluctuations in the supply chain from the point of origin to the point of consumption. This effect is called 'Bullwhip Effect" [1] and was shown in many real-world supply chains e.g. [2].

The bullwhip effect is mainly caused by 'non-zero lead times', 'demand signal forecasting', 'order batching', 'gaming' and 'promotions' [1]. The focus in the paper is on 'non-zero lead times' and 'demand signal forecasting'. The similar bounds are used by [3] and [4]. The bullwhip effect is measured by the "variance ratio" based on [3]. The variance ratio is the long term ratio between the variance of orders and production respectively over the variance of demand. The ratio can be applied for single order decision (e.g. [5]) or order decision in each echelon over the whole supply chain (e.g. [6]). In order to measure the effectiveness of the policy in terms of inventory holding, the variance ratio of the inventory is used. The variance inventory ratio is defined as the variance of inventory over the variance of demand.

The aim is the development of a production and inventory control policy under the trade-off of production and order fluctuations on the one hand and inventory fluctuations on the other hand. As a starting point we focus on the order-up-to policy. Dejonckheere et al. [7] showed that the order-up-to policy is a special case of the general "automatic pipeline, variable inventory and order based production control" (APVIOBPC) policy. Furthermore, he pointed out that by setting the right parameters the APVIPBPC policy is able to eliminate the bullwhip effect and even to reduce the demand fluctuations. On the same path, Disney et al. [8] calculated the "golden ratio" between production and inventory fluctuations depending on the weight on inventory and capacity costs. In their research they set restrictive assumptions on the parameters regarding the reduction of the smoothing parameters and leave out the safety stock coverage. Also they ignore changes in the demand trend and in demand fluctuations.

In this paper, we present a production and inventory control policy with adaptive parameters considering the changes of demand trend and demand fluctuations. Our approach refers using the gain scheduling control mechanism, which gives new possibilities to adjust parameters despite uncertainties like changing demand uncertainties.

The paper is organised as follows: In section two the production and inventory control system with the policies is described by means of a block diagram. In section three the measurement of the bullwhip effect and the inventory holding is characterised. Furthermore, we discuss the overall objective function. In section four the adaptive control method 'gain scheduling control' is described. In section five the production and inventory control policy is expanded by adaptive control variables considering changing trend and changing uncertainty in demand. <<<

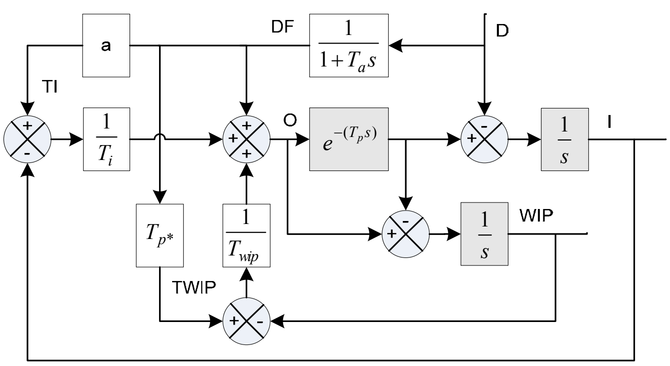
Production and inventory control policy

In this paper we studied the APVIOBPC system [9] which is the most parameterised form of inventory and order based production control (IOBPC) system [10]. The IOBPC family is the basic for control theoretical approaches and has been used in many studies [4].

The block diagram shown in Fig. 1 is a continuous time representation of the APVIOBPC system. The system consists of the production and inventory system (grey) and the APVIOBPC policy (white). The input for the production and inventory system are orders (O) and the output of the system are work-in-progress (WIP) and inventory (I). The throughput consists of the production with the lead time (Tp) and a stock for work-in-progress and inventory. The work-in-progress is the integral of the difference between orders and production rate. In a similar way the inventory is calculated as the integral of the difference between production rate and demand.

The APVIOBPC policy output is the order rate (O) or the production respectively. The policy output is a sum of "demand forecast" (DF), "work-in-progress adjustment" and the "inventory adjustment" with "variable inventory target". For the demand forecast (DF) different forecasts can be used. In our case we used exponential first order smoothed forecasting with (Ta) as adjustment parameter. The work-in-progress adjustment is defined as the ratio of the current work-in-progress (WIP) minus the target work-in-progress (TWIP) over the adjustment time (Twip). The inventory adjustment is calculated in a similar way by the ratio of the current inventory (I) minus the target inventory (TI) over the adjustment time (Ti).

Figure 2 Block diagram of APVIOBPC policy



Furthermore, the target inventory is the product of the inventory coverage (a) and the forecasted demand.

In APVIOBPC policy has four adjustment parameters to control the system. The first one is the parameter Tp*, which is an estimation of the production lead time (Tp). The production lead-time is modelled as a pure time delay and is greater than one. The second parameter (Ta) is the average age of the exponential forecast and also greater than one. The last two parameters are smoothing parameters Twip and Ti for the work-in-progress gap and the inventory gap. Both parameters should be greater than one in order to keep the system stable.

Variance ratios and objective function

The bullwhip variance ratio (order variance over the demand variance) and the inventory variance ratio (inventory variance over demand variance) are important measurements of the system and the policy respectively. These ratios set the output variances in relationship to the input variance.

The bullwhip ratio decreases with shorter production lead time (Tp), with greater forecast smoothing (Ta) and with greater smoothing parameters for the work-in-progress (Twip) and the inventory feedback loop (Ti) [8]. The inventory ratio decreases with the shorter production lead time (Tp). The minimum inventory variance occurs when the smoothing parameters for work-in-progress (Twip) and inventory (Ti) feedback loop equals one. In contrast to the bullwhip ratio, the inventory ratio increases with smaller smoothing parameter (Twip and Ti) Therefore, the identification of the appropriate smoothing parameter (Twip, Ti) is a trade-off between production (bullwhip) and inventory fluctuations. In order to solve this trade-off an objective function is introduced. The basic objective function is the minimum of the sum of the production and inventory amplifications [8]. The 'golden ratio' [8] between production and inventory fluctuations is based on the assumption of independent and identical distributed stationary stochastic demand. We investigate transient demand for the policy development for the production and inventory system. Transient demand can be divided in the trend and the noise value.

Methodology

Adaptive control is considered for plant control under changing conditions, when the usage of linear and fixed controller is unable at the same time to achieve both stability and desired performance of the process. Adaptive control is highly recommended especially for nonlinear systems, because of the benefits from the stability concept. The adaptive control concept is used in many control studies and deals with the adjustment of control parameters for reaching the desired performance and global stability.

In this paper gain scheduling controller was applied on the process to achieve better performance and stability. The idea of gain scheduling adaptive control is finding sensitive process parameters which are correlated with changes in dynamics of the process. In this way, it will be possible to compensate for variation of plant variables by proper commands of controller based on the events. In fact, after any changes in sensitive parameters of the system, the controller will adapt the whole process to new circumstances. In operation, the parameters are measured and the controller is scheduled according to the parameter variations. When the process changes despite operating conditions in known and predictable manner, gain scheduling can provide the required performance of the system.

It is necessary to assure stability of the whole system after application of the controller. The system should be stable against uncertainties, disturbances and new unknown events. Thus, for designing the controller stability studies should also be considered for obtaining desired performance. In this paper bounded-input bounded-output (BIBO) is used.

Adaptive policy

Adaptive PIC policy development requires knowledge of the environment, the structure and the behaviour of the system (e.g. sensitive parts of the system). For the system environment we focus on changing demand. The changing demand has many reasons (e.g. changing customer behaviour and changing competition). The demand input consists of linear trends and overlapping pink noise.

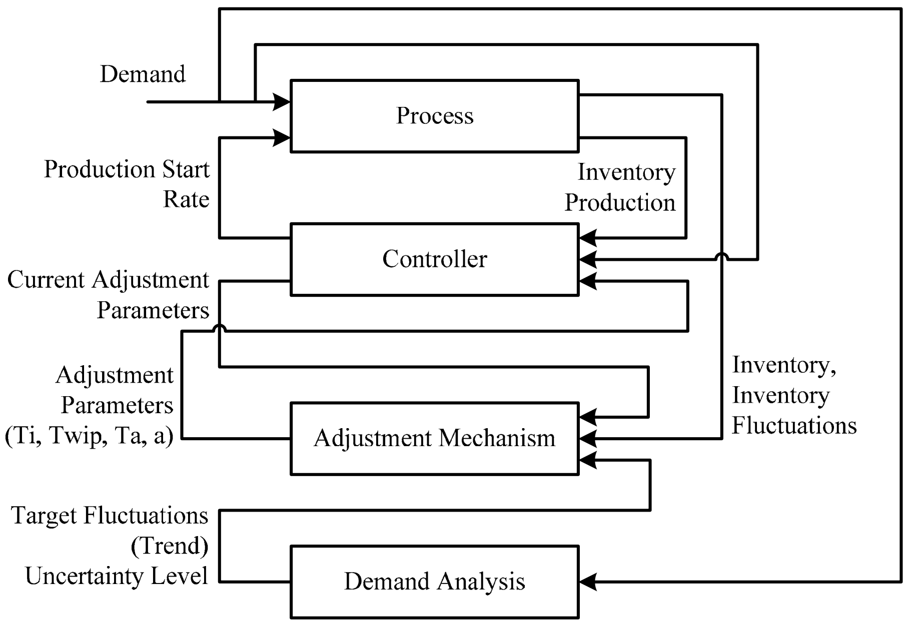
The desired input of the process should be predicted by the demand analysis unit, in order to estimate the noise-free input. For the demand analysis we split the demand signal in a trend function and noise. The trend is extracted from the demand input based on the second order exponential smoothing according to Hold [14]. Following trend identification the gap between the trend and the demand input is calculated. This gap is assumed as the error in the trend detection and as uncertainty of the trend function respectively. The trend error is a random variable which is approximately normally distributed. Based on this we can use the 'estimation of the root mean square deviation' to find the 'norm standard deviation' of the gap between the trend and the current demand value within a specified time range. This 'norm standard deviation' can be seen as current uncertainty measurement concerning the demand trend. The target of the PIC policy is to follow the trend value of the demand and recover the PIC system from unnecessary uncertainty.

In order to develop an adaptive policy based on the changing trend and changing demand uncertainties we have to define important operating points. The operating points are defined based on the objective function described in chap. 3. This function is defined as minimum between production variance and inventory variance. The function depends on the driving feedback loops and related adjustment parameters (see chap. 2). With the help of sensitivity analysis the operating points were defined as illustrated in figure 3.

The demand input of the production and inventory system is split in the trend and the uncertainty based on the second order exponential smoothing for the trend and the estimation of the root mean square deviation for demand uncertainty. The demand trend should be applicable to the system without generating unnecessary fluctuations in the system. In order to fulfil these requirements, the smoothing parameters of the trend function are adjusted to the longest 'time delay' in the system, the production lead time (Tp). From the appropriate trend function, the trend fluctuation is calculated based on the smoothed root mean square of previous values. Later the signal to noise ratio between the root mean square of the trend and the root mean square of the noise are calculated. The signal to noise ratio and the current adjustment parameters Twip, Ti, Ta and are the input parameters for the adjustment mechanism.

In the gain scheduling mechanism two basic steps will be applied. First the signal to noise ratio defines the parameters Twip, Ti and Ta in the system. In detail, the lower the noise influence and the higher the signal to noise ratio, the smaller should be the adjustment parameters Twip, Ti and Ta. The minimum value for the Twip, Ti and Ta are defined by the sensitivity analysis. The minimum values of Twip, Ti and Ta are 1.5, 2 and a related value of the lead time (Tp). High noise and small 'signal to noise ratios' respectively require

Figure 3 Application of gain scheduling approach for adaptive inventory control

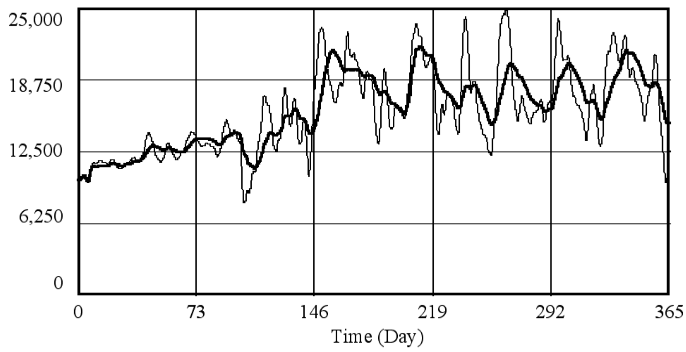


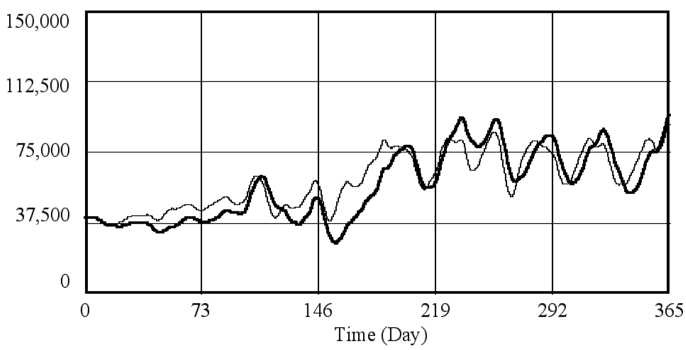
high values of the adjustment parameters (Twip, Ti and Ta). For relatively small 'signal to noise ratios' the adjustment parameters should be high because signal tracking does not make any sense. The adjusted parameters Ti, Twip and Ta hold the production fluctuation stable and partly increase the inventory fluctuation.

The second step is the adjustment of the inventory in the presence of high inventory fluctuations. If the root mean square value of inventory is higher than a certain percentage of the inventory, then the inventory target will be set to a higher value. This adjustment generates instability in the system, because the inventory target loop changes the target of the whole system. The target adjustment generates changes in the work-in-progress loop and in the inventory target loop, but due to the fact that the adjustment parameters Twip, Ti have a high value the system will be stable again. Therefore by application of gain scheduling controller, the process obtains adaptation features to behaviour of the system, external trend and uncertainties as well as to parametric changes. The applied gain scheduling controller against changing trend and changing demand uncertainties is shown in Fig. 3, including demand, process, and adaptive control diagram and parameter adjustment mechanism.

After development of the adaptive control policy we simulated the new adaptive policy and compared with the APVIPBPC one (see Fig. 4). The system is modelled based on the production and inventory control policy and the adaptive mechanism. The production lead time (Tp) and the estimation of the production lead time (Tp*) are equal to eight days.

Figure 4 Comparison between APVIOBPC (Fine) and the adaptive policy (Thick)





The demand input for the system is made up of trend and noise (see Fig. 4 right top). The linear trend starts with the initial value of 10,000 [parts/day] and ends with the demand of 18,000 [parts/day] on 200th day. Afterwards the linear trend stops on the level of 18,000 and this constant value continues until the end of the simulation period on the 365th day. For the noise value we use pink noise, because pink noise represents the behaviour of the customer beyond the trend and seasonality. Changes with a higher frequency (like daily changes) have lower amplitude than changes with lower frequencies (like weekly changes). This means that unsystematical changes with lower frequency have a higher impact. The maximum amplitude for the pink noise is 1,000 [parts/day] until the 100th day and 4,000 [parts/day] from the 101st day.

Three different cases are created by the demand input. In the first case from day 1 until day 100 the customer order rate has a linear trend and a low uncertainty level. In the period from day 101 until day 200 (second case) the customer orders are characterised by a linear trend and high uncertainty. In the last case (from day 201 until day 365) the demand has high uncertainty and no trend. In Fig. 4 the production start rate (top left) and the inventory level (bottom) are shown for the APVIPBPC policy (Fine) and the adaptive policy (Thick). For the comparison between these two policies we distinguish between three cases.

In the first case both policies track the linear trend very well. The adaptive policy generates fewer fluctuations in the production start rate than the APVIPBPC policy. The reason for that is the adjustment of the smoothing parameter in presence of uncertainty. The adjustment of the smoothing parameter is not critical for the inventory fluctuations. Here the inventory target is stable. This behaviour of the adaptive policy optimises the fluctuation of the production start rate and holds the inventory stable, thus guaranteeing a certain service level.

The second case has to handle higher uncertainties and also a linear trend. This demand input generates even higher fluctuations in the production start rate by application of the APVIPBPC policy. The adaptive policy holds the production start rate adequately stable, so that the system is able to follow the production start rate fluctuations by application of even higher smoothing parameters. The setting of high smoothing parameters increases the inventory fluctuations so much that the inventory target level is increased in order to guarantee a certain service level. In the second case the overall objective function is also optimised by the adaptive policy.

In the third case the system has to handle only a high uncertainty level. Again the adaptive policy generates lower fluctuations in the production start rate and an appropriate inventory level comparing with the APVIPBPC policy.

Summary

In this paper, the adaptive controller is developed and applied for the production inventory control system. The aim of the controller is to solve the trade-off between production and inventory fluctuations for changing trends and changing uncertainty in demand. For this purpose a gain scheduling algorithm was developed by setting sensitive parameters including inventory adjustment, forecast parameters and target inventory for adapting behaviour of the system to new circumstances. In addition the bounded-input, bounded-output method was applied for stability analysis despite demand trend and uncertainties. Finally, performance of the process was compared before and after application of the adaptive controller.

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Coordination of Global Supply Chains over the Product Life Cycle – Policy Development by Use of the Method System Dynamics

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