Intelligent Development Processes for a Real-time Transport Memory in a Logistics Context

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Abstract

This paper describes the development of a digital product memory that visualizes the influences on and history of a logistic transport process including different influences on the transported goods itself. Furthermore, resulting implications on the efficient usage of the development process for such an innovation in logistic R&D management are described.

Keywords
SemProM, DHL Realtime Solutions, Digital Product Memory, Smart Design, Intelligent Development Process.

1 Introduction

Main aim of this paper is to show the motivation and challenges for the development of a Digital Object Memory (DOM) considering requirements of a logistic specific solution to enable a Digital Transport Memory (DTM). Furthermore, it affiliates the general need for logistic specific innovation management processes, using the development of a realtime Tracking device as an example, where neither standard product development processes nor standard service engineering processes are applicable.

2 Motivation

What makes DHL, one of the biggest logistic companies of the world (Peter et al. 2009), become interested in what is called digital product memories (DPM)? The importance of DPMs that are emphasised by research and supported strongly by national research programs (BMBF, 2008 and 2009) is clearly comprehensible. From a logistic perspective, there are several reasons to focus on new ways to enable the internet of things in this sector.

- First, the distribution, commissioning and transport of objects have a strong stake in the life cycle of a product, and therefore a product memory would not be a complete one if it leaves out those life cycle phases.
- Second, the overall quality of a logistic process is strongly reliant on the knowledge of the current and past location and condition of the goods to be transported in combination with the knowledge about optimal handling procedures. A further quality improvement with DOMs is therefore motivation easy to be followed.
- Third, there is strong potential identified for a continuous availability of DOM information. This can be explained easily with the degree of innovativeness and number of products, services, process improvements as well as even new business models and solutions that could be developed and provided based on the information generated.

Furthermore, the semantic linkage between those objects enables even further innovative solutions (Böhms et al., 2008; Wahlster, 2009). In addition, the introduction of DOMs could create the foundation for self steering networks (Behrens et al. 2006, Jedermann et al. 2006) in the future with a tremendous improvement in the overall efficiency. Finally the highest motivation to deal with DOMs in logistics is the potential benefit for our customer and the possibility to increase transparency on all levels.

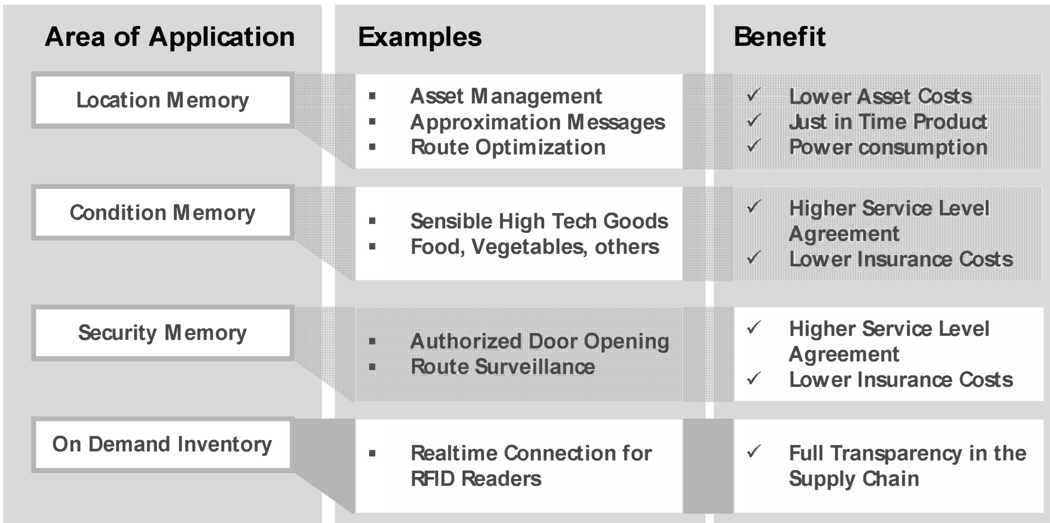

Figure 1: Increased values via realtime solutions.

3 Research Objectives & Identified Challenges

3.1 Challenge of an holistic DTM approach

Initial internal research showed that addressing single objects as individual parcels or letters with a DPM is difficult to achieve. Next to the fact that different products are often packed in one parcel and therefore each of them would need to have an accessible memory of its own, the financial investments for an individual memory e.g. on each letter and parcel currently delivered are very unlikely to be made in the next years. Next to the intensive amount of memory storing devices (This becomes obvious, if we consider that the Deutsche Post DHL has a daily throughput of 70.000.000 letters only for Germany and that the DPM becomes even more interesting when thinking about parcels and packages) there is the infrastructural challenge to connect all existing supply chains including all networks (Express, Deutsche Post Brief, Freight, DGF, Supply Chain), transport assets (Plane, Train, Vans, Trucks, Cars, Bicycles, etc), and all depots, hubs and other centres with an adequate reader/writer infrastructure, which would be essential when using intelligent RFID tags as memory devices. Next to price and infrastructural feasibility there are technical limitations. Currently it is e.g. not technically reasonable to attach satellite communication to each parcel or letter as figure 2 illustrates, which is essential when we are considering shipments travelling overseas.

	Component	Item	Primary package	Case	Pallet	Container/Trailer	Vehicle (Water, Rail, Road, Air)
Labels	X	X	X	X	X	X	X
Chipless ID	X	X	X				
Passive RFID		(X)	X	X	X	X	
Active RFID					(X)	X	
Short Range LocSys					X	X	
Land Mobile Tele.					(X)	X	X
Satellite Navigation					(X)	X	X
Satellite Telephony						X	X

Figure 2: Technologies enabling a DTM in Logistics (Hydbom, 2007)

Currently first approaches had been rolled out as for example the metro cash & carry rollout in France (Plenge, 2009) on pallet level. There are also technologies applied for container identification using labels and partly active RFID systems. One of our main challenges next to the pricing of labels and RFID infrastructure is that there is no real time information available.Information about the condition, location or content can be just detected after the logistic process is finished and therefore neither the full benefit for the logistic company nor for its customers can be realized. Furthermore, benefits of combining actual memory with historical information as e.g. previous locations or time in the warehouse can generate additional benefits (Wahlster, et al. 2008).

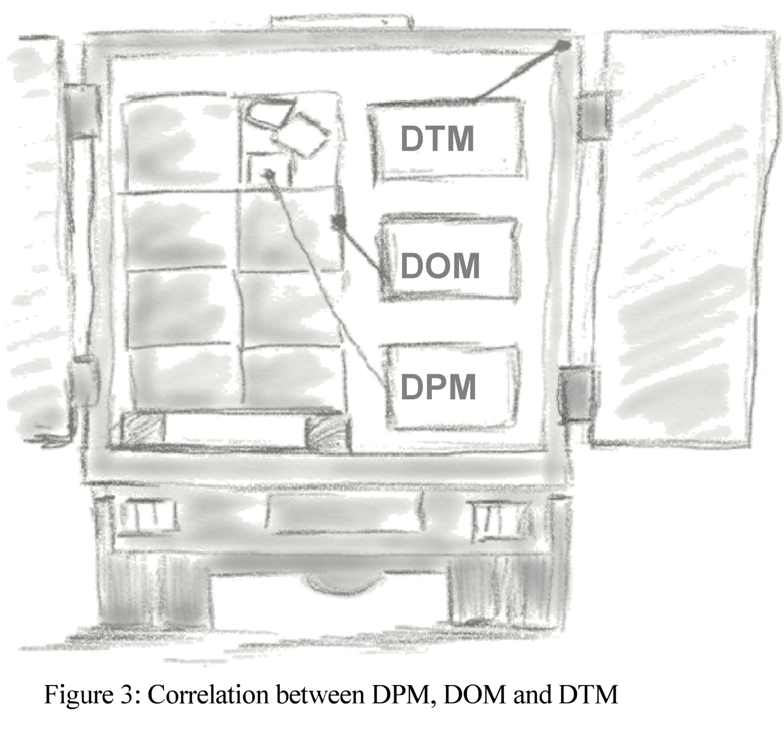

Figure 3: Correlation between DPM, DOM and DTM

3.2 The process of developing a DTM as logistic specific challenge

To enable this combination of historic knowledge and real time information a central platform is needed to consolidate the single DOM to one central DTM. In logistics the standard "product" is nevertheless not the same as from a customer perspective. Based on the 7R of Plowman (Plowman, 1964), logistic service providers (the name already suggests that we are not "just" focusing on products itself) are offering the service to transport the right product from A to B in the right time, for the right costs, within the right quality, to the right customer, etc. Therefore, the term "digital product memory" (DPM) is as misleading in logistics as "digital object memory"(DOM) and therefore should be rather changed to a "digital transport memory" (DTM). On the following pages we are therefore using the term digital transport memory (DTM), also to underline, that there are different requirements for both types of memory (See also figure 3). To conclude, the main challenges are very similar to the main research objectives and can be gathered in one question, that is: What technology should be selected or developed to gather information for a DTM:

- within one complete network,
- for acceptable TCOs and investments and
- with an adequate level of detail when "memorizing" a DTM

One further challenge identified is, that the logistics sector is neither known for the development of radical innovative solutions (for definitions see (Sturm, Josefiak and Schubert, 2008); for the logistic backlog see (Göpfert, 2008)) nor for the use of logistic specific R&D process models (except first research as shown e.g. in (Busse, et al. 2007) or (Spath, et al. (2000)).

Keeping this in mind, the development of a realtime software infrastructure, using a energy self-sufficient realtime transparency device, provided for different customer needs and services in a complete network is a huge development challenge. On the one hand, the requirements of the individual development objects (product, process, service, etc.) should be considered by following the optimal development process for each object. In our case, it requires to:

- develop the software e.g. via a defined and documented process model, e.g. (Bauer, 1995),
- the hardware following a specific process model, e.g. (VDI, 1993),
- the correlating services like communication, device management, Emergency response teams, etc using a service model, e.g. by (DIN, 1998),
- the development of the required processes and process improvements as maintenance, repair, reverse logistics etc. (e.g. via (Creveling, et al. 2003)),
- and the overall coordination with the help of a standard project management process, e.g. (Cooper, R.G. (1999).

In this case, at least 6 development process models should have been used to enable a systematic and therefore effective and efficient innovation management for logistics. Does theory recommend using all listed process models to guarantee the fulfilment of the individual requirements of the individual development objects? From a practical perspective the time needed for the selection, adaption and configuration of each process development model (not talking about the resources needed for actually living and following this processes) would not allow an efficient and effective use of resources in the overall efforts (see also Figure 4 for the increase in complexity).

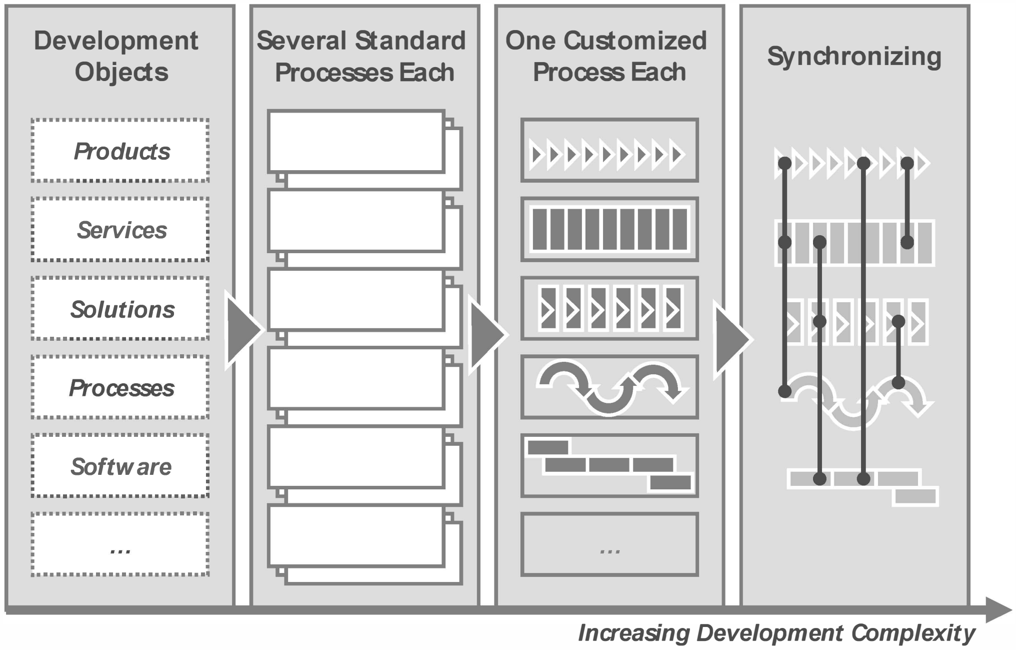

Figure 4: Challenges of systematic innovation management in logistics.

Even if coping with all the different requirements, challenges and resulting processes would be done in "real life", how could it be ensured, that the selected development process is the best suited one? E.g. for a technical oriented hardware development at least 30 different, more or less highly sophisticated, development process models are available. Therefore, in "real life" an innovation project like the one described often lacks the individual and optimal configured development process models. Typically you will rather find "one fits all", company or at least branch specific development process models in use.

4 Research Approach and First Research Results

4.1 Digital transport memories enabling realtime transparency

Breaking down the DPM to a generalized DOM and this one again to a DTM finally enables a positive business case for usage in Logistics. Instead of applying a DPM to each product that is been transported, we decided to generate the realtime transparencies requested on a higher level and brake the information generated regarding location, time and condition down towards the object being transported based on the barcode scan events, collected throughout the supply chain. The highest, still reasonable level, we identified was the general transport asset level. In our special case, this does not include the level of pallets or roller cages due to the missing up-scalability within our different business units. It was decided to focus on transport assets as Swap Bodies and Trailers in a first step. During the hardware development phase of the device that will generate the needed information one of the first steps to enable a DTM for logistics was the systematic evaluation of different technologies and technology providers for their use in the logistic sector. The upper table gives an impression on different communication technologies over logistic requirements. It became obvious, that next to the availability of the communication ability, especially the costs for the single devices are central challenges. After finalising the RFI and RFP Phases, after clarification and definition of the requirement- and specification lists, the first hardware tests in a small (25 Devices each) pilot of the few potential suppliers revealed that the proposed technologies are not yet able to cope with the rough logistic environment from a technical perspective and that the proposed TCO approaches are not adequate for equipping a complete logistical network. This is one reason, the decision was taken to start a DHL internal development.

technical feature	availability	data transmission	accuracy of locating	in-house applicability	energy consumption	dimension (unit)	overheads	asset cost (unit)	asset cost (infrasctructure)
Bluetooth	section (infrastructure)	3Mbit/s	N/A	high	low	small	none	low	none
GPS	worldwide	N/A	exact	low	high	medium	none	high	N/A (satellites)
GSM / GPRS	entire mainland	9,6kbits/s 115 kbits/s	section	mid	high	small	mobile communication	high	N/A (radio mast)
Iridium	worldwide	N/A	exact	mid	very high	medium	mobile communication	high	N/A (satellites)
Loran-C	entire mainland	N/A	exact	high	high	large	N/A	very high	N/A (satellites)
RFID activ	section (infrastructure)	HF / UHF	exact (during visual contact)	high	low	small	none	mid	high
RFID passive	section (infrastructure)	HF / UHF	section	high	low	small	none	low (depending on functionality)	high
UMTS	section (infrastructure)	384 kbit/s	section	mid	high	medium	mobile communication	high	N/A (radio mast)
Wlan	section (infrastructure)	>1Mbit/s	exact (depending on XXX)	high	high	medium	none	high	low
WiMax	section (infrastructure)	>40Mbit/s	exact (but expensive)	high	high	medium	low	high	N/A (radio mast)
Zigbee	section (infrastructure)	250 kbit/s	exact (but expensive)	high	low	small	none	low	low (home automation)

Legend	good	medium	bad

Figure 5: Excerpt of technical screening for potential real-time technologies.

4.2 Effective and efficient development processes enabling logistic innovations

For the development of the so called DHL Real-time Solution, several sub development streams were identified. Next to the development of the specific SWAP Body Tracking Hardware Device, several Services needed to be developed. E.g. mounting processes for equipping a network spread throughout the whole country of Germany needed to be designed as well as the approach, how the information from the DTM should be visualised and presented to the internal customers in a first step. Next to this Service Engineering, additional Process Development questions needed to be answered as for example how DHL can guarantee, that a failure on a device is detected and how maintenance and repair on those devices on a Germany wide level can be ensured. Furthermore, we needed to develop software architecture, being able to process realtime information guaranteeing the required DHL safety and security standards are met. It became obvious, that the needed “components” were not just “subprojects” or simple “program parts”. We needed to deal with almost each of them like an individual development project – including all the development object specific requirements and specialities and considering the impact on other development objects. While developing the hardware for the tracking device for example, we followed several technical rapid prototyping approaches that were not required in the used service engineering procedures for the depending services. At a further advanced step of the hardware development, issues of not having adequately tested mounting services on current hardware prototypes were revealed that resulted in changes of the current design. One reason for this general lack of efficiency might be the lack of adequately designed and synchronized process model. Also, the customization of processes can be a challenging task.

Some development objects might just need a simple guideline to ensure the standard development procedures being met with few risks of development failure, few stakeholders, just two relevant decision gates etc. while other development objects might need a very detailed and restrictive approach using many stage gates and involving many differently motivated stakeholders. Considering the overall efficiency of a development project that needs to enable synchronisation of 6 different, individually customized, development models, the needed efforts for the setup of the development process model are tremendous. The synchronized processes discussed above should clearly define the moment and partners of interaction needed and would surely help to reduce the described issues but they would also result in a giant increase of the overall complexity if they need to be identified in each process model after it was customized for the individual development object. After first evaluations, this manual procedure can hardly result in an increase of overall efficiency.

5 Future Research and Development Topics identified

5.1 Increase in information density for digital transport memories

The development of a realtime transparency solution for the generation of a digital transport memory with breaking down the generated information from SWAP body level to the individual shipment- and therefore product level was finished successfully. Next to the information concerning the individual time connected to current- and past locations, future extensions need to address further storable information for a DPM that is relevant for the final customer. Temperature, humidity and other environmental information as shock or permanent vibrations will be interesting for the customer, especially on temperature or humidity sensitive goods. First developments as the "DHL Smart Sensor Temperature" are ways to deal with these customer needs from a DPM side – on DTM Level, further developments were initiated. Due to the fact, that there are heterogeneous temperature-profiles inside a container or SWAP Body (Jedermann, 2007), one technical challenge is the detection of several temperatures inside each SWAP Body to generate a DTM that enables a temperature memory calculation on shipment- or product level. Another one is the challenge that the current position of a shipment inside a SWAP body need to be known for the accurate calculation of temperature exposure. An approach to enable this and to ensure that the quality of the DTM is increased from a logistic point of view is measurement of the current load volume inside a SWAP body. Furthermore, there are several business challenges for a universal DPM. The biggest one here, as often in logistics, is an infrastructural one. As long as the equipment of transport assets is not established in every network and supply chain provided by DHL, a continuous DTM cannot be guaranteed and a continuous DPM cannot be ensured. Due to not having a standard solution for this challenge, one approach will be the presentation and demonstration of our solution to further business units of Deutsche Post DHL as well as a innovative full-solution (not "just" full service) business model for internal as well as external distribution.

5.2 The need for more adaptive development processes

The identified challenges in the procedural innovation management for logistics revealed the need for much more adaptive and flexible but still development object specific process models. The automotive manufacturers for example have the advantage, to clearly know what they are developing (cars) and they had enough time to adapt this development process to the specific challenges and requirements. In logistics, the innovation experience is still being build up and there are no standard development objects. As experienced not just in this project, logistic innovation projects often have varying development objects, from smaller process improvements to new physical products, intangible services or software and new business models. In addition, in the beginning of a development project, it often cannot be clearly defined, if the development outcome will be a new product or maybe just a process improvement. How should this challenge be addressed in a universal development process as they use it for the development of a new car? A development process model serving all the different logistic specific requirements could not be found yet.

6 Conclusions

Due to the current cost structures and margin rates of logistics in combination with the missing overall RFID infrastructure and the still too high costs for a single RFID tag, the chosen approach of storing the DPM centrally and making it available in real-time via the proposed approach seems to be working fine. Furthermore, the developed hardware, software, services and processes started to get a very high attention inside Deutsche Post DHL and the identified needs for a working DPM could be served quite well with the proposed approach. The additionally revealed potentials while using a real-time approach for the generation of a DTG (like the improved network steering capabilities, the reduced efforts for the asset management etc.) made the implementation in operations easier than expected. Concerning the development or innovation process, improvement potential could be identified. Currently, an optimal process needs to be configured / developed individually for each new innovation project. One first conclusion is that the process should follow the development object, not vice versa. It is one of the additional identified logistic specific research topics how this can be established.

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