An Integrated model for Pharmaceutical Supply Chain Security through IT

by

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ABSTRACT

How to ensure non-manipulated, original pharmaceutical products to be sold to the final consumer is a matter of national interest. In this contribution we are going to present an approach which combines both information technology as well as process reengineering to ensure pharmaceutical correctness and safety of the drugs sold. Firstly, requirements for a model will be determined. Secondly, existing approaches and their pitfalls are presented. Finally, we will introduce a new model for controlling the security of pharmaceutical supply chains.

Keywords:

Pharmaceutical Supply Chain, RFID, Counterfeit Drugs.

INTRODUCTION

A pharmaceutical company which is already approved by national health services would also be able to manufacture adulterated drugs for economic interest. This could be one source of adulterated drugs, the other source is related to the supply chain from the pharmaceutical company to the pharmacy or medical institution where drugs are issued or sold to the patients [5].

Counterfeit drugs that contain erroneous ingredients, an improper amount of active ingredients, no active ingredient, and/or those drugs that are labeled and packed unsupervised [27] also present a major challenge for the health system.

Various single approaches (see for example [18, 17, 6]) have been produced to address single issues within the supply chain such as evaluating RFID chips on drugs. Through the

publication, an integrated approach based on RFID-technology is elaborated and compared against the current dominant barcode based approach.

THEORETICAL BACKGROUND

The following chapter contains theoretical concepts to be used within the contribution; the first section deals with the business process modeling approach and the latter with the basics of the corporate infrastructure.

Knowledge Modeling and Description Language

Compared to other languages for business process modeling and knowledge related activities, the knowledge modeling and description language (KMDL) [10, 9, 2] facilitate the visualization of tacit knowledge through integrating individuals and allows to describe variants and instances of knowledge related activities through its conversion-based view. Therefore, in this contribution the modeling approach KMDL is used. It is only briefly introduced here due to a space limit (please refer to [10, 9, 2] or http://www.kmdl.de for a full introduction). Figure 1 contains selected objects included in KMDL.

The recent version 2.2 of KMDL uses three layers which are also called modeling views: The process-based view, the activity-based view and the communication-based view.

The process-based view describes the operational course of the business process from the perspective of process steps. This layer shows which task should be completed before the next task begins and which alternatives exist. The task assignment of each resource also takes place in this layer. These tasks describe the logical sequences of the business process and are executed by roles.

The activity-based view provides a more detailed description of the knowledge conversions performed of complete tasks in the process. It is commonly used only for the knowledge-intensive tasks identified in the process-based view. These tasks are analyzed closer and decomposed into knowledge conversions. These conversions are derived from the concept of knowledge generation introduced by [15]. Four conversion types can be differentiated:

- From tacit to tacit knowledge: Socialization means the exchange of experiences, where shared mental models and technical skills can be created. This can happen, for example, during a personal dialogue or through imitation. Tacit knowledge is gained through experiences.

- From tacit to explicit knowledge: Externalization means the articulation of tacit knowledge into explicit concepts. Tacit knowledge can be expressed in a way that it will be understood by third parties using, for example, metaphors, analogies or models.
- From explicit to explicit knowledge: Combination: Existing explicit knowledge is put together by combination, resulting in new explicit knowledge. Different forms of explicit knowledge can be added to the existing knowledge through the use of media such as telephone calls and e-mails or reconfiguration and categorization.
- From explicit to tacit knowledge: Internalization: Internalization means the conversion of explicit to tacit knowledge. It is very closely related to learning-by-doing. Experiences gained through socialization, externalization or combination can be integrated into the existing individual knowledge basis. This way, it becomes part of the individual know-how or a mental model.

Conversions are used to describe intermediate steps that eventually lead to the desired knowledge which then is used to perform a task. By studying the knowledge origin and information objects, their use as well as knowledge flows, statements about the creation of knowledge and information and their use within the process can be made. Each conversion uses information and knowledge objects as input and generates output as information and knowledge objects. Knowledge objects reflect tacit knowledge and are always attached to persons. Attributes are used to describe the qualification of each knowledge object. It is possible to define requirements for every conversion. A differentiation between functional, methodical, social and technical requirements is made. The technical requirements can be covered by functions of information systems. The coverage of the remaining requirements is ensured by - also differentiated - knowledge objects of persons / teams. Start- and end-objects of conversions can be both information objects and knowledge objects. Knowledge objects can be related to persons, teams or undefined persons. A task in the process-based view can consist of multiple conversions, and means an abstraction of the application area.

The communication-based view provides the basis to model the communication within an organization.

KMDL includes a procedural model in order to identify, visualize and improve knowledge-intensive business processes. It facilitates an integral visibility of knowledge flows within the modeling of business processes.

In this contribution only the modeling language is used. A focus is set for a process description of the pharmaceutical model.

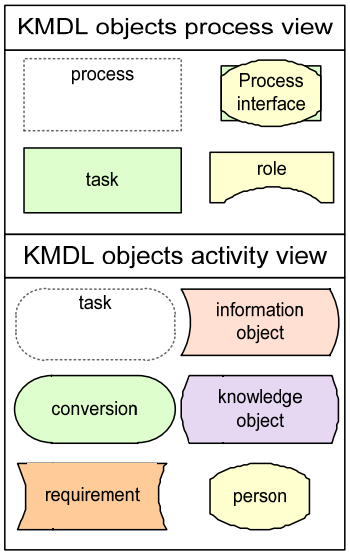

Figure 1: Selected KMDL Objects

Corporate Architecture

According to [1], the corporate architecture consists of the organizational architecture, the comprehending of business processes as well as the organizational entities.

Business processes are defined as a collection of activities that take one or more kinds of input to create an output, namely value to the customer [11]. A similar definition was presented by [7], but there is no emphasis on the creation of value.

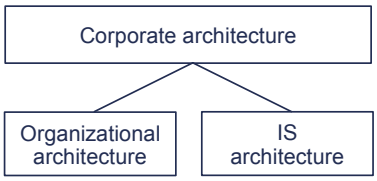

Figure 2: Corporate architecture [1]

DERIVATION OF A MODEL

Various concepts exist for solving the counterfeit problem. These differ in strategically concept, organizations and participants involved as well as in the technologies used. These criteria form the basis of a model which will subsequently be constructed.

A common idea of enabling transparency in pharmaceutical distribution is the so called Supply Chain Visibility [26]. It is the basis of the fight against drug counterfeiting. For this

purpose, it must be made clear how the distribution in the pharmaceutical environment looks. Figure 3 shows the distribution concept of pharmaceutical industry.

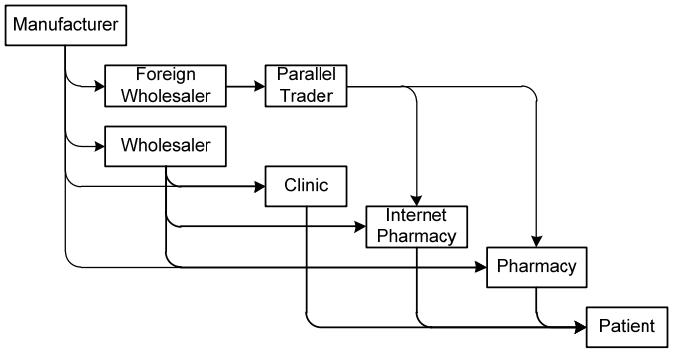

Figure 3: Distribution concept of pharmaceutical industry [26]

Since the model consists of layers, here refer to Information Management (IM)-layer model of Wollnik [22], which provides a systematic structuring of problem and task fields along the dimension of Technology Nearby. In this model, as shown in Figure 4, each layer sets requirements to next layer down and provides support services for next layer above. The upper/strategic level addresses the required information for decision-making and problem-solving. This includes all areas of responsibility that are directly associated with information. This includes, in particular, the questions of who needs what information and how to make them available to users. The users and creators of this information are in the participant layer. The process layer results lead to requirements for the underlying technology layer. This will include the design of information systems regarding the procurement, processing and provision of decision-relevant information as well as the technical infrastructure (computers, networks, system software, and others) on the lowest layer.

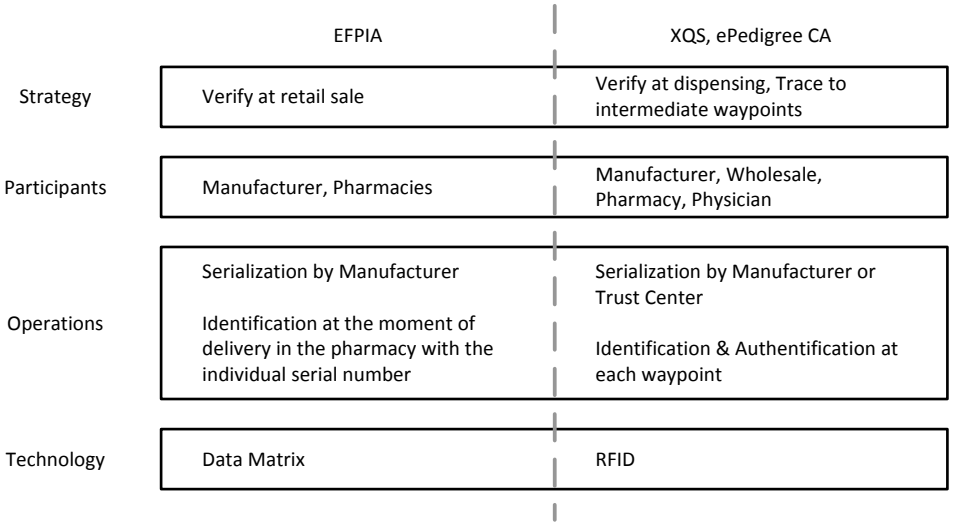

Figure 4: Layered Concept Comparison

Serialization is the key in both concepts, either through data matrix or RFID. However, the main difference is still on strategic level. The EFPIA-model depicted in Figure 5 provides an exclusive verification before the retail sale and no traceability of intermediate waypoint of trade before.

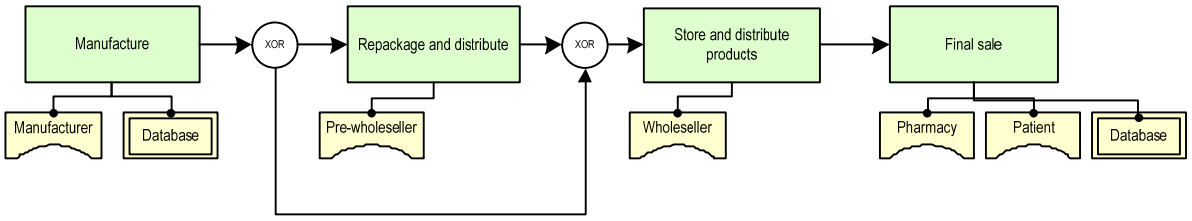

Figure 5: EFPIA-Model

The RFID-based model [23, 24, 25, 19] depicted in Figure 6 introduces feedback authentication at every waypoint. On the one hand, it increases the transparency in the pharmaceutical supply chain significantly; on the other hand, it allows other process improvements for all parties involved.

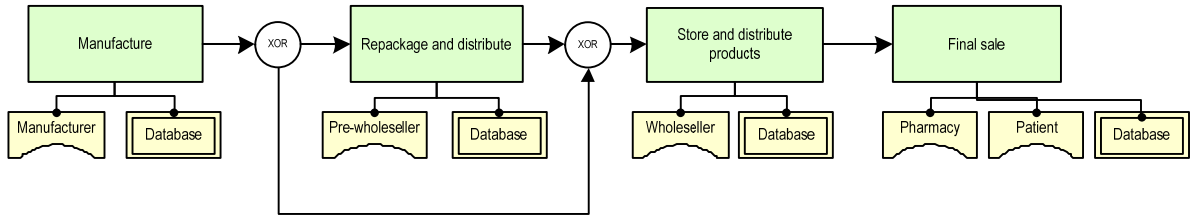

Figure 6: XQS Model

Comparison on Strategy layer

The EFPIA model (which is favored by associations, for example PHAGRO, ABDA, vfa) follows a strategy of avoiding efforts among the supply chain by verifying the pharmaceutical product at the retail site, intentionally leaving out the wholesaler. The lack of consistent tracking before the pharmaceutical products are sold is aimed at creating transparency among the supply chain.

The RFID-based model strategy is to follow the pharmaceutical product along the supply chain to each waypoint.

Comparison on Participants Layer

Only the manufacturer and the pharmacy participate within the EFPIA model. The XQS Model based on RFID comprehends an interaction between the manufacturer, the wholesaler, the pharmacy and the physician.

Comparison on Process Layer

In the pharmaceutical and health care industry the RFID technology are not only increase efficiency for all partners in the logistics chain, but also enables the traceability in the supply chain and protect patients from counterfeit drugs. In the United States the ePedigree model has been implemented: related to gray and parallel imports and subsidy fraud laws have been adopted to create a guarantee that the origin for drugs follows a complete documentation from the owner of the drug in the supply chain. Traceability in Pharma encompasses by this model:

- Flow of goods along the supply chain
- Manufacturing steps
- Route to all distribution channels
- Formulation and consignment, which is patient-related

- Hand over
- Medication (Bedside verification)
- Medicines Control (Drug Utilization Review)

Traceability is a core process improvement. The origin, interim stages and ambient conditions arising along the entire value chain for drugs and medicinal products can be traced independently of time and place. Traceability – in other words, the gap-free tracing of every stage in the entire value chain – requires persistent storage of data relating to drugs immediately after production, including the information on packages, their content and ambient conditions, delivery information and time of receipt. Traceability includes temperature and order histories, drug flows and statistical evaluations. Those data is used to detect irregularities, such as the purchase of large quantities which never reappear in the market. In this sector, these "black holes" may be linked to illegal exports, counterfeiting and product manipulation.

If a cooling chain is interrupted, damaged or sensitive medication bottles are shaken, their use has serious consequences [14]. A study from Ireland found that 37.8% of family physicians allowed their vaccines to be stored outside the specified temperature range [8]. According to the researchers Weir and Hatch3 humans pose a dangerous security risk for the cool chain [21]. In Germany there are currently about 250 sorts of drugs which require such cooling chains [14]. In most cases, the active ingredients are rich in protein. These include vaccines, antibiotics, insulin, blood products, different eye drops and botulinum toxin preparations [16]. The volume of drugs which must go through a cooling chain is steadily increasing. Since the enlightenment of the human genome, the number of known targets of endogenous proteins, such as antibodies, cytokines and hormones, are growing rapidly.

A special feature of the recombinant proteins with Natural models is common: a high sensitivity to environmental factors [3].

Possible enhancements among the supply chain are depicted in Figure 7 and explained further at a later point.

Temperature fluctuations which exceed the allowed range of storage and transport temperature often lead to irreversible changes to the active ingredients. Patient safety is at risk without explicitly knowing it: for example, if diabetics inject too little effective insulin than they are advised, it can lead to the hyperglycemic shock [4]. Children, especially

premature babies and those with birth defects are often unable to receive proper vaccinations. Cytotoxic drugs, which have lost chemical effectiveness due to the violation of the prescribed temperature range in effectiveness, can ultimately lead to treatment failure for oncology patients. Large variety of temperature, low temperature and harsh impacts are important factors which can lead to hairline cracks in ampules or syringes, through which impurities (toxins or infectious agents) can get into the medicine. These unexpected adverse side effects carry potentially fatal consequences.

Another process improvement is to avoid false designations. False designations cost pharmaceutical companies millions of dollars in financial damages that can be avoided by using of RFID-based serialization.

The legally enforced mandatory discount of 16% since the 15th amendment of AMG from 1 August 2010 caused false, incorrect and superfluous identifications for pharmaceutical companies. Due to the data complexity and diversity, pharmacies cannot understand the route of their goods and the subsequent misused data leads to liability of these companies.

An aggravating factor is that on 08/01/2010 retroactive to 08/01/2009 there was a forced price reduction, which in addition to the 16% discount, must be paid by companies and can reach a percentage of almost 20%. With pharmaceutical sales of one billion Euros a potential risk of approximately 50 million Euros can plausibly arise now.

This amount is imposed on pharmaceutical companies, although there is no turnover. These illegal charges can be detected, and prevented solely by a serialization of the drugs. Though RFID technology is optimal for serialization purposes, and it also offers additional options like sensory (temperature, shock, etc.) which make an RFID-based system an ideal support structure for the supply reliability and cost efficiency in health care.

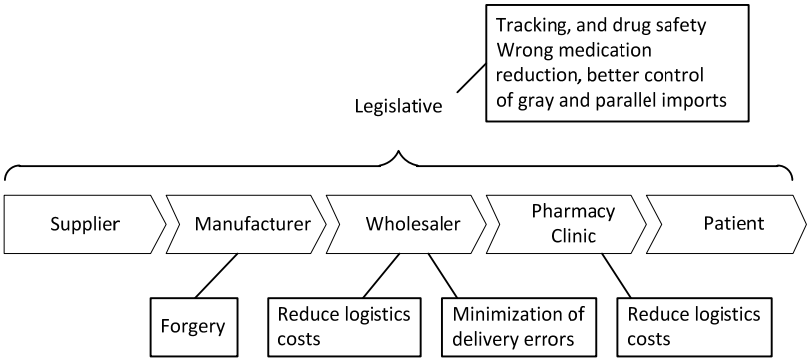

Figure 7: Process enhancements through RFID [26]

Comparison on Technology Layer

A comparison on this layer means to contrastingly juxtapose the both key technologies Data Matrix and RFID. Optical Methods such as Data Matrix have a significant advantage: it is inexpensive to print the package (0.1 to 1 cent). But it is chemically, mechanically unstable, provides no bulk reading ability. Each package must be shown to the camera and there is no support for additional sensors, either.

The RFID technology is more expensive and it is less trivial to affix a transponder to a package than to print it with a data matrix on the one hand. On the other hand RFID-transponders are tamper-proof, fault-tolerant, chemically and mechanically stable. They provide bulk reading ability, and additional sensors (for temperature and shock monitoring, etc.) are available. A detailed comparison of both key technologies can be found in [13].

CONCLUSION AND FUTURE RESEARCH

The EFPIA model is based on optical recognition of pharmaceuticals. Optical recognition requires each unit to be placed in front of a scanner requires a time-consuming scan of each bulk container. Furthermore, any damage of the image drastically reduces the reading ability drastically. Additionally, legislation might impose certain transportation means and environments during the transport (e.g. a determined temperature and pressure). Optical methods do not provide additional sensors for monitoring the environment. Though the pitfalls exist, the cost of printing the optical character on the pharmaceutical product is very low for the manufacturer. The cost of scanning the pharmaceutical products is ultimately paid by the final consumer.

The RFID-solution provides a comprehensive approach that avoids previously mentioned shortages: Pharmaceutical products can be scanned from a bulk container without to remove

each unit. Furthermore, a change in the environment (e.g. temperature or pressure change) can be detected and saved within the chip. Once the pharmaceutical product is sold to the patient, information recorded on the product can be accessed. The distribution of the costs in case of the RFID model disfavors the manufacturer since the RFID tag is more expensive than the printed barcode.

Overall, the EFPIA model can be implemented when low-cost medicine is manufactured and distributed. Once the price for the medication and requirements increases, the RFID based model will be more favorable from perspective of health care.

Various research issues are still remaining. One issue to be addressed is the increase of security by use of sensors detecting unexpected physical agitation and temperature changes. The second issue relates to regulatory bodies that should establish an equal level playing field for all participants within the supply-chain regarding by setting minimum standards. Another related research topic is the statistical analysis of the material flow to detect irregularities among the supply chain and alert respective entities if action is required.

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