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Denmark

Creating IT architecture for supply chain automation in hospitals

Challenge

Zealand University hospital is going to be the main specialist hospital in the Region Zealand. The hospital will be completed in 2025. With hundreds of surgeries performed daily, including many specialist treatments, and thousands of outpatient visits each day, hospital supply chains will play an important role in its efficient operation. If medical devices and pharmaceutical products are not at the right place at the right time, treatment of patients will be at risk.

Solution

The aim is to have a hospital with an automated logistic infrastructure that is agile and can be adapted to future patient needs. A well-driven supply chain must get the right goods to the right destination at the right time. This requires the skills and involvement of many different departments, including procurement, production and logistical planning. To achieve this, the hospital is implementing a transport management system that is able to receive transport requests and send transport orders to the physical transport systems through the use of GS1 standards.

Electronic identification supports workflows and strengthens security

Hospital has a high degree of automation of workflows

35 autonomous mobile robots and more than 3,000 trollies form part of the automatic flow

More than 1,200 shipments handled for the hospital each day

Introduction

When complete, Zealand University Hospital will be the main specialist hospital in Denmark's Zealand region. The new hospital is three times the size of the existing one. The aim is to have a hospital with an automated logistical infrastructure that is agile and can be adapted to future patient needs. Using GS1 standards as part of the IT architecture is an important part of achieving this.

Regional business functions for supplying, linen, medicine, uniforms, and daily goods etc. are placed outside the hospital. Most of the goods are packed in trollies before they are transported to their final destinations – for example, wards and depots. Several IT-systems have been installed to enable automated transport without human intervention. Specifically, the hospital has installed an automated goods terminal and autonomous mobile robots (AMRs). The logistical trollies have a double function as both means of transportation as well as local storage.

Background

In 2026, Zealand University Hospital will be located in Køge. Køge is the first location to accommodate an automatic supply chain in the region. The hospital building in Køge is government funded. The current budget is 4.0 billion Danish Krone.

The University Hospital will have a special role, as it will:

- Be an emergency hospital for about a third of the region's population.
- House almost all specialised treatment in the region.
- Handle research and teaching tasks at a high level.

It is the region's vision to take advantage of technological opportunities including:

- A high degree of automation of workflows.
- A coherent patient pathway supported by logistics.
- Electronic identification to support workflows and strengthen security.

Facts about Region Zealand

837,225 inhabitants in **7,274 km²**, **17 municipalities** (April 1, 2020).

General areas: The health area, The social and special education area, Regional Development

The Danish healthcare system is universal and based on the principles of free and equal access to healthcare for all citizens. The healthcare system offers high-quality services, the majority of which are financed by general taxes. The state holds the overall regulatory and supervisory functions in health and elderly care. The five regions are primarily responsible for the hospitals, the general practitioners (GPs) and for psychiatric care. The 98 municipalities are responsible for a number of primary healthcare services as well as for elderly care.

In 2007, Denmark implemented a public sector structural reform that included an administrative and political reorganisation of the health sector. This provided an opportunity for a large-scale modernisation of the Danish hospital infrastructure to ensure access to state-of-the-art health services and improve quality across the entire health system. A cornerstone in this modernisation is the Super Hospital Programme.

IT-systems make the daily work at the hospital possible

With hundreds of surgeries performed each day, including many specialised treatments, and thousands of daily outpatient visits, hospital supply chains will play an important role in the efficiency of the hospital. If medical devices and pharmaceutical products are not in the right place at the right time, many treatment of patients will be at risk. To have an efficient, well-driven and transparent supply chain at the University Hospital in Køge, IT-systems supports automation and business functions.

The number of shipments throughout the regional supply chains has been estimated, and the likely activity in each area of the hospital. This information has then been used to plan for physical transport systems such as autonomous mobile robots. As the new University Hospital will be ready step-by-step – it will progress gradually up to 2025 – the patient activities will also scale-up stepwise. Likewise, the use of the new automation systems will scale-up as needed.

The final output is estimated as visible in the table below – data box:

Data box description	
Estimations based on benchmark from other regional hospitals in Denmark	
Goods categories to be handled in the hospital – manually and automatic	20 +
Number of shipments per day to be handled in the hospital	1200 +
Number of trolley variations to be handled in the hospital – manually and automatic	20 +
Total number of trollies to be part of the automatic flow	3000 +
Number of autonomous mobile robots in 2026	35

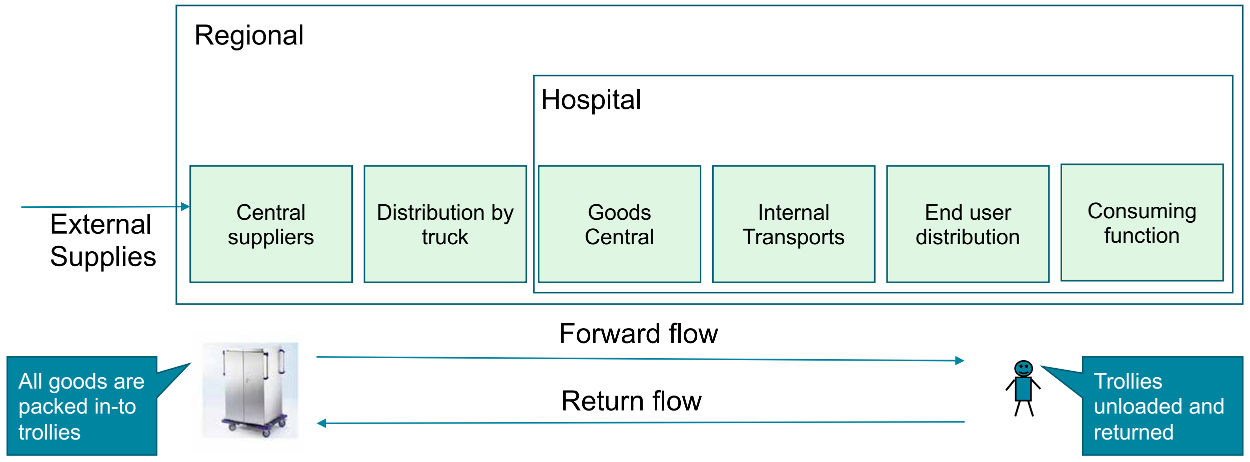

Figure 1: Future Regional supply chain, goods must be pack into trollies transported though all links and returned to the central supplier. Hospital refers to the physical location that hosts the business functions goods central, internal transport, end use distribution and consuming functions. Central suppliers are placed outside the hospitals. Trollies are transported from these central suppliers by truck to the goods terminal.

The future regional supply chain

Central regional suppliers such as warehouse and laundry acquire, produce and distribute goods to the hospital. These functions are responsible for the right goods being available in the right quantities and right places. Shortage of goods will be reported to these central suppliers.

The hospital is striving towards a push supply chain by using third party and fourth party logistics strategies – opposite to the existing pull-method. The major game changer is the movement of the decoupling point in the existing regional supply chain: the monitoring and ordering of goods is moved from the hospital ward staff to the logistics experts and the central suppliers. The other game changer is the major support for a higher level of controlled IT and information sharing infrastructure at a regional level.

However, there is no one best-fit supply chain strategy. A suitable supply chain strategy will be adopted based on needs and product type. Over time, the entire physical flow will find its best way of preventively building and re-building an overall regional supply chain based on capacity management – whether lean, agile or leagile.

Figure 1 above is a conceptual illustration of the automated supply chain.

The key points in the flow are:

1. Trollies are packed with goods and their destination registered.
2. The shipment's Serial Shipping Container Code (SSCC) is linked to the trollies' identification (Global Returnable Asset Identifier - GRAI), for both forward and return flow.
3. A goods category is assigned to the shipped trollies to manage the distinction between medicine, linen etc
4. Shipment, trollies, goods category, destination (consuming function) and sender (central supplier) is registered and printed on paper and attached to the trollies. This dispatch advice is used by the service personnel either when manually distributing the trollies after arrival or in case of errors where the information is not accessible through IT systems.
5. The actual content, the goods, is registered by the sender in the sender's system. This packing list can also be printed and added inside the trollies for the convenience of the receiver.

Business functions, automation and IT-systems

On one hand, each business function must be able to manage and perform their tasks; on the other hand, the supply chain must be efficient, well driven and transparent. To achieve this, each business function has an IT-system for local control that receives instructions from an overall IT-system that controls the shipments. The local IT-system manages the physical transport. The overall IT-system manages the logistics, a so-called transport management system. This deals with the planning, execution and optimisation of the movement of the trollies. It covers incoming, outgoing and internal flows. It is making sure the shipment is compliant and proper documentation is available.

Figure 2 outlines business functions in the regional supply chain, the level of automation and IT-systems necessary to achieve automation. As mentioned above, the figure distinguishes between the logistic IT-system , also known as the transport management system, responsible for the supply chain as a whole and the physical transport IT-systems, each responsible for a part of the supply chain.

The region purchased physical transport systems for each business function and the transport management system for the overall control of the automated supply chain. This decouples the logistics concerns and the automation concerns. This has two advantages, firstly, the transport management system can support the business steps as defined in the Core Business Vocabulary (CBV). This specifies the structure of vocabularies and specific values for the vocabulary elements to be utilised in conjunction with GS1 Electronic Product Code Information Services (EPCIS) for data sharing. Secondly, well defined interfaces between the transport management system and the physical transport IT-systems eases the replacement of existing systems and the introduction of new ones.

Business functions	Central supplier	Distribution by truck	Goods Central	Internal transports	End user distribution
Automation	Automatic packing and distribution	Distribution by truck (GPS-Monitored)	Automated Goods supply (AVM)	Automated Autonomous Robots (AMR)	Robots
Physical transport IT-systems	Warehouse Management System	Fleet Management System - truck	Automation Control System	Fleet Management System - AMR	Fleet Management *System*
Logistic IT-system	Transport Management System				

Figure 2: The figure outlines business functions, type of automation and IT-systems necessarily to achieve automation.

IT-systems and their interaction

The transport management system must be able to receive transport requests and send transport orders to the physical transport systems. To do this, it must receive adequate information when relevant events happen – the physical transport systems must send alerts when trollies arrive at the hospital, arrive at the destination, and when trollies are picked up from the stations. The GS1 EPCIS standard already supports most of these events through the CBV. This standard enables the physical transport systems to share information about the physical movement and status of the trollies as they progress thoughout the supply chain. So far, only transport request and transport order are added in the vocabulary customised to the automated supply chain.

Figure 3 show the initial implementation (first transition) of the IT architecture. The user registers the transport in the transport management system via a web interface, which then creates a commissioning and returns an identification of the transport for the user to enter in their warehouse management system (or equivalent). Alternatively, the two systems can be directly integrated, sending transport requests without the web interface. Currently, the fleet management system for trucks is not included, but can be included if beneficial at a later stage. In addition, the distribution from the trollies arrival station to the consumer is currently provided by service personnel but could potentially be replaced by dedicated robots at a later stage, freeing up staff for other tasks.

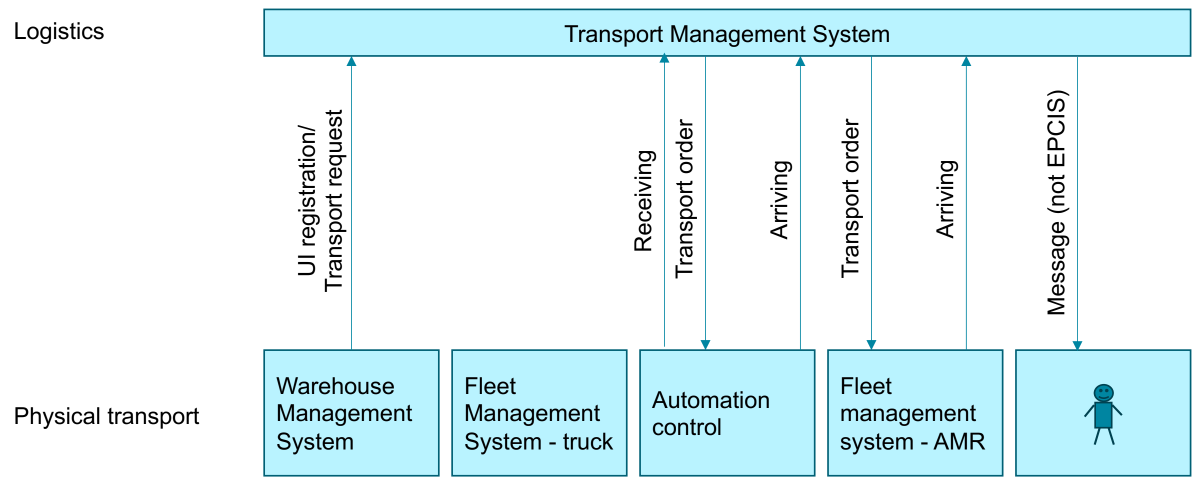

Figure 3: Use of GS1 EPCIS events in the IT architecture currently implemented. The figure is a simplified for illustration, it does not show all events and flows.

Challenges

It is helpful to specify sequence diagrams for all types of flows – in-bound, out-bound and internal – to ensure a strong and well understood interaction between the software systems. These diagrams show both of the IT systems, robots, stations and certain user interfaces. The diagrams are currently finalised in cooperation with the IT-system suppliers, who have acknowledged them as a good tool for precise specification.

For optimal planning across all types of flow, capacity management has to be implemented in the transport management system. This will require balancing planned transports with non-planned. The planned transports are registered before trollies are inserted into stations, whereas the non-planned are not. This is not a trivial problem. It requires planning, forecasting and prioritisation to be built into the transport management system.

	Data category	Description	Standards	
Categories of Data in the "Share" Layer of GS1 standards. Table 2-2 in EPCIS implementation guide v 1.2	Master Data	Data, **shared by one trading partner to many trading partners**, that provides descriptive attributes of real-world entities identified by GS1 Identification Keys, including trade items, parties, and physical locations	GDSN	
	Transaction Data	Trade transactions triggering or **confirming the execution of a function within a business process** as defined by an explicit business agreement (e.g., a supply contract) or an implicit one (e.g., customs processing), from the start of the business process (e.g., ordering the product) to the end of it (e.g., final settlement), also making use of GS1 Identification Keys	GS1 eCOM XML	
	Visibility Data	Details about physical or digital **activity in the supply chain** of products and other assets, identified by keys, detailing where these objects are in time, and why; not just within one organisation's four walls, but across organisations.	EPCIS	Logistics control
Added by author	Automation	**Automation** and control of physical handling off goods and their transport.	PACKML, MQTT, OPC-UA	Physical transport

Figure 4: Automation is usually realised using standards that are real-time such that the state of moving parts is known near-immediately. In logistics, however, the events of interest are from minutes or even days apart.

Standardisation

Supply chain automation requires both standards from the logistics domain and the automation domain.

The use of GS1 standards plays a central role in the IT architecture. Modifications to the GS1 CBV standard are implemented to achieve this.

The GS1 standards are able to create the merge between the business processes and the execution systems (eg. AMRs) – thereby GS1 standards can cover and support the whole stack for supply chain concerns but for the automation part a different set of standards are used. In figure 4 some examples of such standards are shown in the bottom row.

Conclusion

Controlled management of the supply chain supported by automation gives better opportunities to streamline, increasing productivity and efficiency. At University Hospital Zealand, an IT infrastructure has been built through which the logistics IT-system and the physical transport IT-system are separate but closely communicate. GS1 standards have supported this since they provide a business terminology (CBV) and predefined syntax (EPCIS) for IT system vendors to follow.

About the author

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Lars has 17 years' experience in enterprise architecture. He works within interoperability, change management and standardisation. Lars is engaged in strategic initiatives for the region, creating a modern health sector and developing agile solutions for its hospitals. He holds an MSc in physics and computer science and is TOGAF (The Open Group Architecture Framework) certified. Lars would like to express thanks of gratitude for the inspiring corporation with colleges that made this article possible. Especially thanks to Gulshan Akhtar Din, Troels Werner Christensen, Martin Andersen, Frank Thomas Hansen and Lisa Dalum for knowledge sharing and feedback.

About the organisation

REGION SJÆLLAND

Region Zealand safeguards tasks, services and interests for a total of 821,000 citizens. The wide range of services is spread out across 22 cities in the region. Region Zealand is a politically governed institution, and it performs two main tasks: regional development and an operational enterprise in the area of healthcare and social affairs. Every year around one million outpatient treatments are completed and 190,000 patients are treated in the region's hospitals. The Regional Council consists of 41 directly elected members, who are elected for a four-year period. Region Zealand's vision is to create the best framework for sustainable growth and quality of life for its citizens.