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An alternative perspective on the role of applications of ICT systems for logistics

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Preface

This research has been performed at the Norwegian University of Science and Technology (NTNU), department for Production and Quality Engineering.

The Doctorate project has been sponsored by the Industry's Innovation Fund for NTNU[1]. This foundation was established by several Norwegian companies in order to create better linkage and cooperation between the industry and NTNU. This first round of this foundation has a planned life span of seven years, which ends in 2004.

There are four cross-disciplinary areas connected to the Innovation Fund:

- Energy and Environment.
- Transportation and Logistics.
- Medical Technology.
- Knowledge Network (Organisation and ICT[2]).

Sponsorships of doctorate projects are a major part of the Innovation Fund. This research is connected to a doctorate project placed under the cross-disciplinary area of Transportation and Logistics.

There are five doctorate projects connected to the area of Transportation and Logistics. All of these are founded within the area of logistics, but are approached from different professional angles. Such as: operation management, strategy and organisations, or environmental politics. This thesis is the result of a doctorate project that was established to study the relation between logistics and applications of ICT systems[3].

I want to thank Professor Asbjørn Rolstadås, my advisor in this doctorate project. He came in late in this project and through a relatively short time period he helped me turn this work from next to nothing into the results that are presented in this thesis. Without his support, this project would not have been the same.

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[1] The Industry's Innovation Fund for NTNU will be referred to as "the Innovation Fund".
[2] ICT = Information and Communication Technology.
[3] The information about the Industry's Innovation Found was gathered from its home page on Internet and its annual report from 1999.

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Special thanks go also to Professor Peter Falster, my first opponent, for his comments and hints during this work.

I want also thank my administrator Professor Bjørn Andersen and my second opponent Dr. Harinder Jagdev.

Great thanks goes to my colleagues at the Innovation Fund, NTNU and SINTEF teknologiledelse that have been contributing to this work through discussions and other kinds of inputs.

The same goes to all of the involved in the case studies presented in this thesis. They have given me insight that has become the very fundament of this research.

Last, but not least, I want to thank my Sissel for her patience, support, and understanding throughout this project.

Abstract

Ever since the 1950s, manufacturing enterprises have been using computers to support the flow of materials throughout their business units. Improving logistics performance through applications of ICT[4] systems has never been straightforward or easy. This has become especially evident during the last decades where several manufacturing companies has got their competitive abilities reduced for a shorter- or longer period after they have applied ICT systems to support their logistics processes. In extreme cases, such efforts have even driven companies into bankruptcy.

Simultaneously, there have been documented several cases were manufacturing companies have gained increased logistics performance through applications of ICT systems. While it is as good as impossible for a company to survive in most businesses today without an extensive use of ICT systems to support their logistics processes.

This means that applications of ICT systems for logistics within manufacturing companies may work as a two-edged sword. On one hand, applications of ICT systems for logistics are crucial, and often strictly necessary, for the survival of the manufacturing company. On the other hand, if the ICT systems are applied in the wrong manner they will have a negative impact on the company's logistics performance, and in worst case they may even lead the company into bankruptcy.

Therefore, the aim this research has been to propose an answer to *how logistics performance can be improved through applications of ICT systems.*

This problem has been approached by suggesting that the impact of applications of ICT systems for logistics has become too comprehensive to be seen in isolation. If logistics performance should be increased, the applications of ICT systems must be considered as an integrated part of the individual company's logistics mission, simultaneous as the impact the rest of the organisation has on these applications are taken into consideration. Therefore, this research project has tried to suggest an

[4] As mentioned earlier, ICT = Information and Communication Technology.

alternative perspective on the role of applications of ICT systems for logistics.

First in this thesis, three current perspectives on the role of applications of ICT systems for logistics are proposed and discussed:

- *The Manufacturing perspective* that illustrates the role of applications of ICT system for logistics through various manufacturing planning and control concepts.
- *The Supply Chain Management perspective* that illustrates the role of applications of ICT system for logistics through the concept of Supply Chain Management.
- *The Supply Chain Software Package perspective* that illustrates the role of applications of ICT system for logistics through the inherent properties of currently available logistics software packages.

Both the Manufacturing- and the Supply Chain Software Package perspective refer to specific ICT system designs and/or -software packages. It is not given that these software packages will fit the specific requirements needed to fulfil the logistics mission of each individual company. It is neither not certain that the organisation will use these ICT systems according to their original intentions. Therefore, this research suggests that these two perspectives do not look at the role of applications of ICT systems for logistics as an integrated part of the logistics mission of the individual company, simultaneously as they ignores the impact the organisation has on these applications of ICT systems.

The Supply Chain Management perspective presents applications of ICT systems for logistics only through the function they should fulfil within the supply chain and does not refer to any specific software design or – packages. Therefore, this research proposes that the Supply Chain Perspective presents applications of ICT systems as an integrated part of the individual company's logistics mission. However, the Supply Chain Management perspective presupposes (or do not discuss) that the ICT systems will be applied according to their original intentions, and therefore it does not consider the impact the organisation has on these.

Therefore, this research suggests that an alternative perspective on the role of applications of ICT system for logistics is needed. This perspective should both present the role applications of ICT systems for logistics as an integrated part of the individual company's logistics mission, and account for the impact the organisation has on the applications of ICT systems.

In this research, such an alternative perspective is formed by a logistics concept known as "Demand Chain Management" and a theory termed "Actor-Network Theory". Demand Chain Management is used to provide a base of logistics thinking into the perspective, while Actor-Network Theory is applied to explain the relations between the technology (the ICT systems) and the surrounding organisation. These two are combined to make up the Demand Transfer perspective that regards the logistics organisation as a set of interrelating demand transfers (and -transformations) that follows both predetermined and unplanned pathways throughout a logistics network. In this perspective, the role of applications of ICT systems for logistics is seen as one actor among others that lays these pathways for transferring the demand within the logistics network.

By using the Demand Transfer perspective, this research has suggested six conceptual guidelines for how logistics performance can be improved through applications of ICT systems:

1. Information is just a mean, not a purpose in itself.
2. Think total network, but do improvements within your own domain.
3. Applications of ICT systems for logistics should contribute in fulfilling the customers demand.
4. Separate real- and anticipated demand.
5. Seek simplification and reduction of the total demand transferring network.
6. When improving logistics performance through applications of ICT systems; stay close to the actual demand transfers.

This research concludes with that the Demand Transfer perspective is tailored towards studies of how applications of ICT can be used to improve logistics performance and therefore it must be seen an alternative to the other perspectives presented in this research, and not a substitute for these. In addition, the Demand Transfer does not describe anything that is new. It rather draws the attention to something that always have been there, and that – either directly or indirectly – have been used to improve logistics performance throughout all times. Nevertheless, this research points out that the Demand Transfer perspective separates itself from current thinking within this field in two basic ways:

1. Logistics thinking: The Demand Transfer perspective does not look at the material- and the information flows as two individual flows, but as elements integrated within the demand transferring network.

2. The place of the ICT systems for logistics within the organisation: The Demand Transfer perspective looks at applications of ICT systems for logistics as a part of a larger, patterned, network that are continuously being negotiated between it own constituent parts.

Content

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1 Introduction

The idea behind this research has it roots from when the author had first hand experience with consulting agency that made and implemented business applications of ICT systems to manufacturing companies.

This consultant agency based all their earnings on selling and implementing logistics related software packages, and they employed two kinds of consultants: business consultants and technical consultants.

The business consultants helped their clients with how the ICT[5] systems should be applied to support the organisation from business point-of-view. These people were highly educated professionals that had special knowledge on how the software packages could support the business functions within their area for expertise, like sales and marketing, production, accounting, purchasing, distribution, or maintenance.

The technical aspect of the ICT systems was handled by an own group of consultants. The technical consultant helped their clients with the technical issues of the ICT systems, like programming, software- and hardware installation, and corrections of various software errors.

The consultant agency employed almost three times as many business consultants than technical consultants. This indicates that the broad part of the challenges connected to applications of ICT systems in organisations is not of a technical character. The challenges concerning applications of ICT systems for logistics are more often of a strategic-, organisational-, and/or business logical manner.

Such impacts of applications of ICT systems in organisations have been documented earlier[6] and will be mentioned later in this thesis. However, these issues are not the main inspiration behind this thesis. This inspiration came rather from this author's observation of some experienced business consultants[7] that apparently had the ability to grasp the impact each individual ICT system or the different part of an ICT system had on the total logistics solution. It seemed like they had found

[5] As mentioned earlier: ICT = Information and Communication Technology.
[6] See e.g. Leavitt, 1964, Davenport, 1998, Akkermans et al., 1999, or Norris et al., 2000.
[7] …and some of the managers at their clients …

the key to how the various internal- and external pars of the organisation should use the ICT systems to fulfil their joint logistics objectives. And not only in a conceptual level, but also with in-depth description from market demands, via the single ICT tool on the factory floor, towards the overall strategic impact. In addition, many of these persons did go between completely different companies almost without doing any pre-studies and proposed business solutions on a practical and detailed level, at the same time as the total logistics solution was apparently ensured.

These observations made the author believe that there is some kind of basic logic or -principles that are similar in almost all kinds of companies. A basic logic that people has unconsciously been using within this area through all times and explains how the different applications of ICT systems for logistics work together with the rest of the logistics organisation, or –organisations. This research can therefore be understood as a quest for such a basic logic in the relations between logistics and applications of ICT systems.

2 Scientific assumptions

In order to clarify the research topics and to restrict the research domain into a manageable size, some scientific assumptions has been be defined for this research project. These assumptions will be presented in this chapter.

2.1 Research domain

This research has been approached from a logistics point-of-view and has in particular been focused on logistics within companies that performs discrete manufacturing[8]. The theoretical part of this research is presented from an engineer's perspective, and is based upon descriptions of applications of ICT (Information and Communication Technology) systems for logistics within literature concerning business logistics and - manufacturing management. This means that this research relates to both the field of business logistics as well as the field of manufacturing. The theoretical foundation will be presented in chapter 3 to 5.

Further, this research considers ICT systems for logistics as all kinds of systems of technical devices that can manage- and/or communicate logistics information, while applications of ICT systems refers to how these are applied within organisations. Such a view on applications of ICT systems for logistics may embrace whole range of devices that can supports logistics functions. Bowersox et al. (2002) separated the functionality of ICT systems for logistics into four categories: strategic planning-, decision analysis-, management control-, and transaction systems (See Figure 1).

[8] Discrete manufacture can be defined as production of distinct items, such as automobiles, computers and appliances (APICS dictionary, Ninth Edition, 1998).

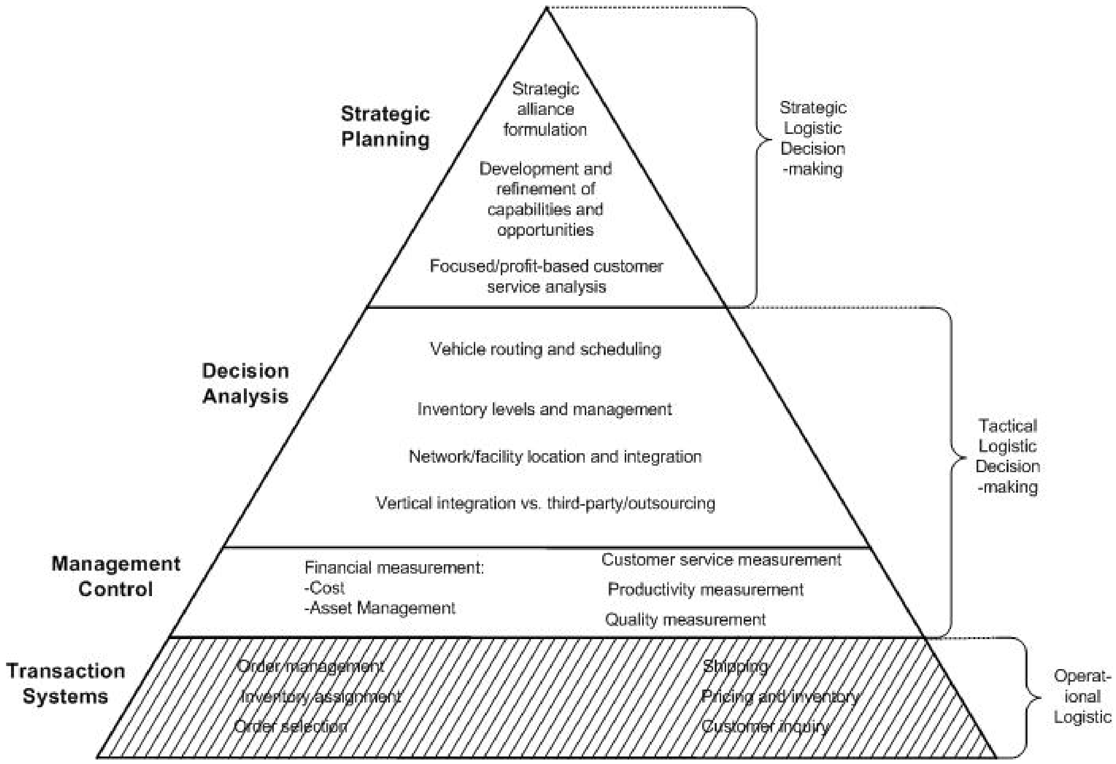

Figure 1. The functionality of ICT system for logistics (derived from Bowersox et al., 2002).

The notations on the left side of the pyramid in Figure 1 illustrate the functionality of the ICT systems for logistics. By following these it can be found that the top of the pyramid represents functionality for logistics strategy making. These functions support the work of the top management in doing strategic logistics decision making. Applications of ICT systems can support these processes by preparing business plans and decision-making models through organising and restructuring transaction information gathered in the lower parts of the pyramid. These planning- and decision models are usually not included as standard functionality in software packages. The models are rather made by internal- or external consultants in order to enlighten a specific problem. Examples of such strategic decisions are desirability of enhancing a strategic alliance or locating new production facilities (Bowersox et al., 2002).

Beneath the strategic planning we find the decision analysis functionality. These applications support decision-makers to do better decision through methods like mathematical modelling and linear programming. The application that operates within the decision analysis level has many similarities to the applications in the strategic planning level, but the decision analysis functions are often more structured and use predetermined models that are delivered as standard functionality within software packages. In addition, the decision analysis functionality is used to find solutions to problems within a shorter time span. Vehicle routing and -scheduling, or make-or-buy considerations are examples on applications that make use of decision analysis functionality.

The management control systems include applications for monitoring the logistics performance through things like financial reports and various kinds of statistics. These systems allow managers to monitor and receive feedback of the organisations' logistics performance. Common performance measures include inventory turnover, utilisation of production resources, and delivery precision.

The transaction systems are found at the bottom of the pyramid. These systems represent the backbone of the ICT systems for logistics. Through the support of core logistics functions like order management and inventory movements, the transaction systems provides the other layers of the pyramid with transaction data. Examples on applications of transaction systems include customer order management, inventory control, production planning, and the preparation of shipping documents.

The right side of the pyramid in Figure 1 indicate the range of application of the different functionality's. The strategic planning functionally supports strategic logistics decision-making. The decision analysis and management control functionality supports logistics decisions of a more tactical character. The transaction systems are used for operational logistics management.

This research has focused on application of ICT systems that supports the operational aspects of logistics management. These kinds of applications of ICT systems can be defined as *applications of ICT systems that support the practical execution of the basic functions of logistics*. This means this research is mainly concentrated towards the transaction system functionality of the ICT systems for logistics (see the shaded sector in Figure 1).

There are two reasons for this choice:

First, the upper layers in Figure 1 represent mainly functionality for analysing and measuring logistics transactions. This means they support the management processes that again support the execution of the logistics tasks. Such functionality does only indirectly contribute to the logistics performance. On the other hand, the operational applications support the core functions of logistics and have therefore a direct effect on how logistics are performed within the organisation.

Second, by pursuing upper layers of Figure 1, one may get an impression that application of ICT systems are strictly necessary in the process of managing logistics functions. Even if applications of ICT system may be of great help in these issues, there are alternative and more direct methods for managing and improving logistics performance that must not be ignored[9].

2.2 The problem statement

A problem statement can be defined through the following questions (Dahl, 2001):

- What is the problem?
- Why is the problem important?
- What have others been doing about this problem?
- What must be done?

These questions will be pursued in the following sections.

2.2.1 What is the problem?

The advent of electronically ICT systems has had a great impact of how logistics is performed within organisations. Especially, the usage of standard software packages has become increasingly important factor for how logistics have been handled during the last decades[10]. This trend of applying standard software packages has revealed that applying ICT systems in order to support logistics functions are not always advantageous for a firm. This research suggests two reasons for this:

1. *The embedded logic of the ICT systems.* The design or configuration of an ICT system may both enable and limit logistics performance. First, the ICT systems may represent an advantageous way for doing logistics tasks. On the other hand, the ICT system may enforce work

[9] See e.g. Schonberger (1986), for arguments for a more direct approach in logistics management.
[10] These software packages operate often under abbreviation like: MRP, ERP, OPT, EDI, SCM, CRM etc. These ICT systems will be discussed in chapter 4.

processes that not are the most effective for the firm's total logistics solution.

2. *The organisation's impact on the ICT systems*. Logistics performance can be increased if the organisation makes use of an ICT system to support their logistics tasks. However, even the "best" ICT system for logistics will not increase logistics performance if it is not (or cannot be) used, or -used as intended.

This illustrates a duality in applying ICT systems for logistics. At one hand, the ICT systems may enable new possibilities for improving logistics performance. While on the other hand, these devices may collide with a company's logistics strategy and/or -organisation, and therefore may therefore restrict-, or even act as a catalyst for reducing the logistics performance.

Therefore, the general problem this research has tried to find answer to can be summarised in the following question: *how can logistics performance be improved through applications of ICT systems?*

2.2.2 Why is the problem important?

Lately, companies have been spending large amounts of efforts and resources in applying ICT systems to support of their logistics processes. Applications of ICT systems for logistics has in an increasingly degree been used as a backbone for the integration of both internal and external business processes, which again have resulted in that independent software packages have emerged into enterprise wide solutions. This has made applications of ICT systems for logistics an increasingly important contributor to the overall logistics performance.

Despite of this new role of the ICT systems, only a few studies have provided insight of the effect these integrated ICT systems have on the logistics performance. Ranganathan[11] for instance, found the following studies concerning recent implementations of logistics related software packages[12]:

[11] See e.g. http://www.commerce.uq.edu.au/isworld/research/msg.26-11-2002-1.html (accessed; 19.12.03).

[12] These surveys focus on ERP-systems. These software packages will be discussed later in this thesis.

Meta Group Study, 1999: 63 companies that had implemented a logistics related software packages was studied. Average implementation time were 23 months, while the average costs were approximately 10,6 million USD for the implementation and 2.1 million USD for two years of maintenance. It took the companies 8 months to see any improvements of their efforts, while the median annual saving were estimated to be 1,6 millions USD[13]

Wharton Study, 2001: More than 1000 users of a specific software package were studied. This survey found that the users of these ICT systems had 1,7-4,2% higher productivity than the non-adopters.

Benchmarking Partners, 1999: 64 companies that had implemented a logistics related software solution was studied. 12% of these achieved ICT cost reduction, 34% personnel reduction, while 33% improved their order management cycles.

The Conference Board, 2001: Survey of 117 firms. 40% of the firms failed to achieve their business objectives after one year of implementation. 75% of the firms reported a moderate to severe productivity dip after the implementation. While 20% of the project was terminated before completion and one out of four were over budget.

The Standish Group (2002) performed a similar survey including 307 companies. They found that the average software-purchasing price was 1,3 million USD and the systems drove an average implementation cost on 6,4 million USD. Yearly average operation cost were approximately the same as the software purchasing price, while only 10% of the software installations were considered as successful.

These surveys concerns with applications of ICT systems that embrace more than what traditionally are understood as logistics issues. However, they do anyway indicate that recent efforts of applying ICT system in organisations have been costly, while their impact on logistics performance has been rather diffuse.

Notwithstanding, there exists several examples of companies that have had far from an all-positive outcome of their recent attempts of improving logistics performance through application of ICT systems.

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[13] The last statement sentence was fetched from Koch et al. (2003).

Hershey Food corp. for example, this company used more than 112 million USD in a project connected to the implementation of a new logistics related ICT solution. According to Computerworld (1999), the problems that spanned from the organisation's uptake of these software packages caused delays in their order processing routines that resulted in an instant drop of 19% of their profits earnings.

Snap-On Inc. used three years in designing and implementing a new logistics related ICT solution. After the start up, this solution caused things like delayed orders and miscounted inventories, which resulted in that the company lost sales for more than 50 million USD during the first half of 1998[14].

Applied Materials abandoned their logistics related improvement project because of the extensive of organisational changes that were required for adapting their work routines towards the new ICT systems (Davenport, 1998).

Another example is W.W. Grainger Inc. that within six months in 1998 got a loss of 19 million USD on sales and 23 millions USD in profits. All because of things like over-counted inventories and routine crashes that originated from their new ICT solution[15].

Geneva Steel declared bankruptcy the day after their 8 million USD, logistics related ICT project was finished (O'Leary, 2000).

In 1999, The Norwegian based company Glamox initiated a logistics related ICT-project that were budgeted to approximately 90 million NOK[16]. The problems that spanned from these efforts were one of the main reasons for sending the company into an economic crisis that they still[17] have not managed to overcome[18].

However, FoxMeyer Drugs represents maybe the most known unfortunate attempt for applying applications of ICT systems for logistics. This company was USA's third largest pharmacy firm before

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[14] See www.fortera.com/44nfailchart.pdt (accessed; 04.09.03).
[15] See www.fortera.com/44nfailchart.pdt (accessed; 04.09.03).
[16] 90 million NOK ≈ 13,5 million USD (21.12.03).
[17] Year 2003.
[18] Source: www.aftenposten.no.

they implemented a new ICT solution in 1996. After the start up, the company got problems with how the systems supported their business processes. The new solution functioned in only six of FoxMeyer's 23 warehouses, and the company's order processing abilities went gone down from 420.000 daily orders to only 10.000 daily orders. Shortly after, the firm went bankrupt, and FoxMeyer's trustees sued their accounting firm, the software vendor, and the consultant agency that implemented the systems, for 500 million USD each[19].

The examples above do not give a positive picture on recent attempts of applying of ICT systems to support logistics tasks. By comparing the cost of implementation and the indicated improvements on the logistics performance it may be tempting to suggest that companies should seek other ways for improving their logistics processes.

However, it does not have to be this way. Several companies have managed to drastically increase their logistics performance through application of ICT systems.

Dell for instance; this computer manufacturer had been focusing on logistics issues since they were established in the 1980's. When Dell was founded, most actors in the personal computer industry were making products from forecasts and sold their products through retail distribution channels. Dell used an alternative approach. This approach was based on a direct sales strategy and production from actual customer orders. In this way Dell managed to reduce the logistics costs through eliminating things like warehousing of finish goods and problems connected to overproduction and obsolete products.

Initially, this strategy did not drive high sales volumes and for several years Dell was only considered as a successful niche player.

However, Dell's fortune turned with the advent of the internet. When they introduced direct sales through the internet in the mid 1990s, they outperformed their competitor's logistics performance and boosted their sales numbers. Dell grew more than three times faster than the industry average, and by the third quarter of 1997 their revenue was up by 58%- and the profit had increased by 71% compared to the previous year (Christopher, 1998).

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[19] From Wired News (20.08.03), and Bukhout et al. (1999).

In the early 1990s, Håg, a Norwegian swivel chair manufacturer, rejected their old way of working and formed new ICT enabled logistics processes through an improvement project termed "HÅG Fast". These efforts improved their inventory turnover from 6 to 16, simultaneously as their delivery precision increased from 87% to more than 98%. In addition, the new routines reduced their delivery time from 15-20 days to 7 days, which outperformed the delivery time of their competitors, even if these were usually sited hundreds of kilometres closer to the customers than Håg[20] (Alfnes & Srandhagen, 2000).

However, the best example of achieving increased logistics performance through the application of ICT-systems is Toyota Motor Company. Since the oil crisis in the 1970's this company has been considered as the "world champion" in logistics performance. A broad share of this success can be credited to how they deal with application of ICT systems. Despite of their abilities for achieving logistics performance, the core of Toyota's logistics ICT systems is not based upon advanced electronic computing power, but on a manual system developed in the 1950's consisting of paper cards that are sent between the different units in the production system[21].

The examples above indicate that there may be a huge potential for improving logistics performance through application of ICT systems, but far from all manages to achieve this. Therefore, the problem of this research is important because *it is possible to drastically improve logistics performance through application of ICT systems. While there are indications on that a great share of companies today spends large amount time, efforts and resources on applications of ICT systems that gives moderate-, no-, or even negative effects on the logistics performance.*

2.2.3 What have others done with this problem?

Initially, the thinking of how applications of ICT system for logistics acted within manufacturing companies were dominated by thoughts derived from manufacturing management. Through manufacturing planning and control concepts like MRPII, JIT and OPT[22], the ideas from

[20] HÅG is sited in the middle of Norway, which is more that 1000km from the main European markets.
[21] Information handling at the Toyota plants will be discussed in section 4.1.2.
[22] These abbreviations will be explained in chapter 4.

manufacturing management provided guidelines for how ICT systems should support the flow of materials within a company.

During the last decades our perspectives concerning applications of ICT systems for logistics have grown beyond the boundaries of the manufacturing firm. Two forces have impelled this trend. First, new logistics concepts like Supply Chain Management have emphasised the importance of a more holistic view on logistics management. Second, new technological advances like the internet have cleared the path for software applications that supports business processes that spans beyond the domains of manufacturing management.

Therefore, in this research, the role of applications of ICT systems for logistics has been grouped into three basic perspectives. The first is the Manufacturing perspective that understands applications of ICT systems through various concepts for manufacturing planning and control. The second have been termed the Supply Chain Management perspective, and use the concept of Supply Chain Management and related concepts to illustrate the role of applications of ICT systems for logistics. Finally, the Supply Chain Software Package Perspective that presents the role of applications of ICT systems for logistics through the inherent properties of the logistics software packages that currently is available on the market.

These perspectives will be further discussed in chapter 4.

2.2.4 What must be done?

The role of ICT systems for logistics has changed. New technology has transformed the impact of ICT systems of logistics from tools that supports the execution of individual logistics tasks or processes, into integrated units with a considerable effect on how logistics are performed within the manufacturing company. These impacts are now starting to expand beyond the borders of single enterprise, involving the whole logistics chain from the first supplier of raw materials to the end customer.

It is therefore not longer sufficient of see applications ICT systems for logistics as individual tools that supports individual logistics tasks or - processes. Applications of ICT systems for logistics must be considered from a more holistic perspective, where these are regarded as an integrated part of the involved organisations and their logistics mission. Therefore, the aim of this research has been to suggest *an alternative a perspective*[23] *on the role*[24] *of applications of ICT systems for logistics.*

2.3 Research questions

The following research questions have been formulated in order to make a suggestion for how logistics performance can be improved through applications of ICT systems:

1. What are our current perspectives on the role of applications of ICT systems for logistics?

2. Is it possible to present an alternative perspective on the role of applications of ICT systems for logistics?

3. Can this alternative perspective be used to develop some conceptual guidelines for how logistics performance can be improved through applications of ICT systems?

Two success criteria of the alternative perspective have been derived from the two rationales that were presented in section 2.2.1:

1. The alternative perspective must consider applications of ICT systems as an integrated part of the individual company's logistics mission.

2. The alternative perspective must account for the impact the organisation has on the applications of ICT systems.

2.4 Methodical approach

The research has been performed through the following activities:

1. The definition of a problem statement and a set of research questions.

2. A literature survey to reveal the current perspectives of the role of applications of ICT systems for logistics.

[23] A "perspective" can be defined as a "way of observing the world".
[24] "Role" can be defined as "an expected function or behaviour"

3. The preparation of a suggestion for an alternative perspective on the role of applications of ICT systems for logistics.

4. The execution of two case studies for validating the relevance this alternative perspective has to real life events.

5. The extraction a set of conceptual guidelines on how logistics performance can be improved through applications of ICT systems.

6. The preparations of the conclusions from this research and some suggestions of future research.

The first step has already been presented in this chapter, while the main purpose of the second step is to reveal the current perspectives on the role of application of ICT systems for logistics. These current perspectives are presented in chapter 4. The findings from step two are then used as a starting point for step three. Step three is the construction of an alternative perspective on the role of applications of ICT systems for logistics through selected concepts or theories. This alternative perspective is the main, original contribution of this doctorate project.

The alternative perspective is made from theory and must therefore be validated through real life events. In this research, this investigation between the alternative perspective and actual events has been performed through case studies. Such an exploration requires that the case studies must state a clear purpose as well as an own set of success criteria (Yin, 1994). The purpose of the case studies is to validate if the alternative perspective can be used to observe real life events, while their success criteria will be presented with the case studies in chapter 7[25].

Only one case study is needed in step four to do the exploration required for validating the alternative perspective (Yin, 1994). However, two case studies have anyway been performed during this research project. Both of these will be presented in chapter 7.

In step five the alternative perspective on the role of applications of ICT systems for logistics is used to form some conceptual guidelines for how

[25] The success criteria for the case studies must not be confused with the success criteria for the alternative perspective that were presented in section 2.3.

logistics performance can be improved through applications of ICT systems.

Finally, in step six, the conclusion of this research has been prepared among with some proposals of further research. These are presented in chapter 9.

This methodical approach is summarised in Figure 2.

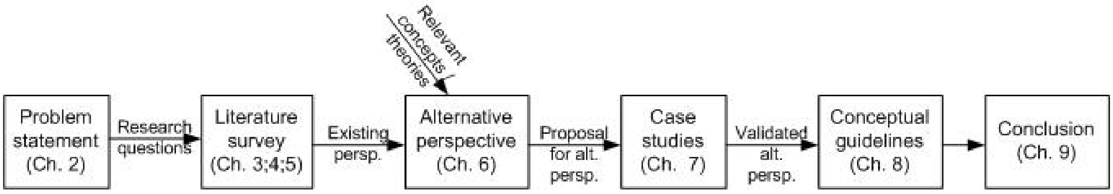

Figure 2. Methodical approach.

3 Logistics

3.1 The evolution of the logistics thought and its connection to applications of ICT systems

In this section, an overview of the historical evolution of the concept of logistics and the contemporary development of applications of ICT systems for logistics is presented. The purpose of this is to give an introduction of the historical relations between logistics thinking and applications of ICT systems, and to clarify the basics behind the prevailing understanding of this field. The current view of logistics and its relations to applications of ICT systems will be further discussed later in this thesis.

The basics of the logistics idea can be described as the relocation of objects in order to meet various kinds of demand or requirement. Today, most movements of goods are often presented as "logistics" in everyday language, but the term arose through managing large-scale material flows within military operations[26].

The need of ensuring sufficient supplies to the fighting forces has made logistics a key issue in military operation. This important role of logistics in warfare has been demonstrated repeatedly throughout history and up until today:

"We may take it then that an army without its baggage-train is lost; without provisions it is lost; without bases of supply it is lost." (Sun Tzu, 500 B.C.)[27].

"My logisticians are a humourless lot ... they know if my campaign fails, they are the first ones I will slay." (Alexander The Great, 356-323 B.C.)[28].

[26] The term "logistics" appeared in the French military around the 17th century (Solem, 1997). It were derived from the French word "logistique", art of calculating, but has linguistic roots back to the Greek word "logos", to reason.
[27] Sun Tzu was a Chinese general that wrote *The Art of war*. This work is known as the oldest treatise concerning warfare strategy (See http://textfiles.fisher.hu/etext/NONFICTION/suntzu10.txt, accessed; 05.08.03).
[28] See http://www.navsup.navy.mil/npi/lintest/mayjune03web/logqt.htm (accessed; 07.09.03).

"The war has been variously termed a war of production and a war of machines. Whatever else it is, so far as the United States is concerned, it is a war of logistics." (Fleet Admiral Ernest J. King, 9th Chief of U.S. Naval Operations, 1942-1945)[29].

"Every battle that was ever lost, every battle that was ever won, was because of logistics," (Lt. Gen. William Pagonis, in charge of logistics in the first Gulf War, 1990-1991)[30].

As indicated above, as good as all wars do reminds us on these strong relations between logistics and military operations. However, this research has studied logistics for business purposes that has arose as an own professional field during the last fifty years. The evolution of this branch of logistics thinking can be separated into four phases.

The first phase began in the late 19th century and lasted to the early 1960's. In this period, the concept of logistics was connected to the physical activities of *warehousing and transportation* (Ross, 1998). Logistics functions were treated like independent functional areas, and no formal concept or theory of logistics as an integrated unit existed (Bowersox et al., 1996)[31]. Logistics management was only seen as necessary for the daily operations, but not as important for improving a firm's competitive advantage. The search competitiveness was left to other functions, like production or marketing (Ross, 1998).

The development of applications of ICT systems have been one of the main forces behind the evolution of logistics thinking (Banken & Aarland, 1997; Bowersox et al., 1996; Persson & Virum, 1995). Prior to the first computerised ICT systems, logistics information was handled through manual- or paper based systems that supported individual logistics tasks. The first computerised applications ICT system for logistics increased the efficiency of each logistics functions through the automation of manual information systems. However, the entry of computer systems in logistics environments represented also a more profound impact on the logistics thinking:

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[29] See http://www.navsup.navy.mil/npi/lintest/mayjune03web/logqt.htm (accessed; 07.09.03).
[30] See http://www.washingtonpost.com/ac2/wp-dyn/A27501-2003Feb18?language=printer (accessed; 08.08.03).
[31] For the rest of this thesis, the word "logistics" referrers to logistics for business purposes.

"Early computer applications and quantitative techniques focused on improving performance on specific logistics functions such as order processing, forecasting, inventory control, transportation and so forth. The potential for achieving significant improvements sparked interest in cross –functional integration" (Bowersox et al., 1996)

This means that it was not the automation of logistics tasks that should represent the greatest benefits of applying computerised ICT systems for logistics, but their possibility to integrate traditionally separated functions.

The first logistics-related computerised ICT systems that had a significant impact on how logistics information were handled throughout the manufacturing organisation, was IBM's *Bill-of-Material-Processor (BOMP)*. This application did first appear in 1956, and was built on a simple logic for calculating gross requirements for components from the demand of end products (Ralston, 1996). The BOMP could increase the speed the customer requirements were communicated throughout the organisation, and represented therefore a significant potential for increasing overall logistics performance. However, the BOMP did only perform simple calculations and lacked functionality that was needed to make reliable production schedules. Therefore, the BOMP did soon develop into Material Requirements Planning (MRP) systems[32], which companies started to used during the 1960s (Christiansen, 1992).

In the end of the 1960s the focus of logistics thinking had changed. This formed the second phase in logistics thinking, which lasted throughout the first parts of the 1970s. Through ideas like *total cost management*[33] companies began to consider logistics as an important factor for improving a firm's overall performance. The total cost management philosophy states that reductions of logistics costs in one place might only increase the logistics costs in other areas. The total costs of logistics must therefore be taken into account if the improvements should have a significant effect. This paved the way for a trend where logistics mangers tried to calculate the total costs of logistics, for then to balance these towards a desired level of customer service (Ross, 1998). These events of drove a system approach for logistics management and caused an

[32] See section 4.1.1 for more detailed descriptions of the BOMP and the MRP systems.
[33] Total Cost Management was first introduced by Lewis et al. in 1956 (Kent & Flint, 1997).

increased degree centralisation of logistics management functions as well as a higher degree of integration of operative logistics tasks (Ross, 1998).

Simultaneously as the idea of total cost management was spreading, companies began to make more extended use of computerised tools within their logistics processes. The MRP systems were expanded into new packages that supported the concept of *Manufacturing Resource Planning (MRPII)*. These applications were still focused upon production planning, but had increased their range of application through functionality like cost calculations and economical analysis (Christiansen, 1992).

An alternative approach for logistics management were developed in the Scandinavian countries while the rest of the western world focused on total cost management. Through the idea of "Materialadministrasjon" (MA)[34] Scandinavian companies was also starting to develop a more complete view on logistics management. However, in contrast to the quantitative methods for balancing total logistics costs towards customer service of the total cost management philosophy, these companies had began to consider logistics as an active tool for improving the competitiveness of the firm (Banken & Aarland, 1997).

The third phase of logistics thinking includes the end of the 1970's and the 1980's. This phase was influenced by the concept of *Integrated Logistics Management*. Business functions that traditionally were considered connected to other fields[35] were starting to be referred to as logistics functions. One important factor to this trend was the holistic manufacturing thinking that came from Japan. The Japanese, and Toyota Motor Corp. in particular, outperformed their western competitors in logistics issues and was steadily winning market shares in the western countries (Banken & Aarland, 1997; Womack et al., 1990; Hopp & Spearman, 2000). Western logistics thinking were soon influenced by the Japanese ideas. And the view of logistics management as making trade-offs between logistics costs and service level, were abounded in favour for concepts that actively improved the competitiveness of a firm.

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[34] "Materialadministrasjon" must not be confused with the term "Material Management". "Materialadministrasjon" is a more holistic term, not unlike what we today now understand as "logistics" (Persson & Virum, 1995).
[35] E.g. functions like: production planning, purchasing, and customer order processing.

Therefore, Companies began to consider logistics as a powerful, integrated, unity that could be used as a strategic tool to win market shares within the competitive arena. These ideas paved the way for integrated logistics management, which is the base of the modern logistics thinking (Ross, 1998).

A good example for illustrating this way of thinking is Michael E. Porter's "Value Chain" from 1985. The value chain separates the functions of a company into two categories. Namely; primary activities (inbound logistics, operations, outbound logistics, marketing and sales, and service), and support activities (Firm infrastructure, human resource management, technology development, and procurement). According to Porter (1985), a company would achieve competitive advantage by organising and performing these activities in value chain better than its competitors.

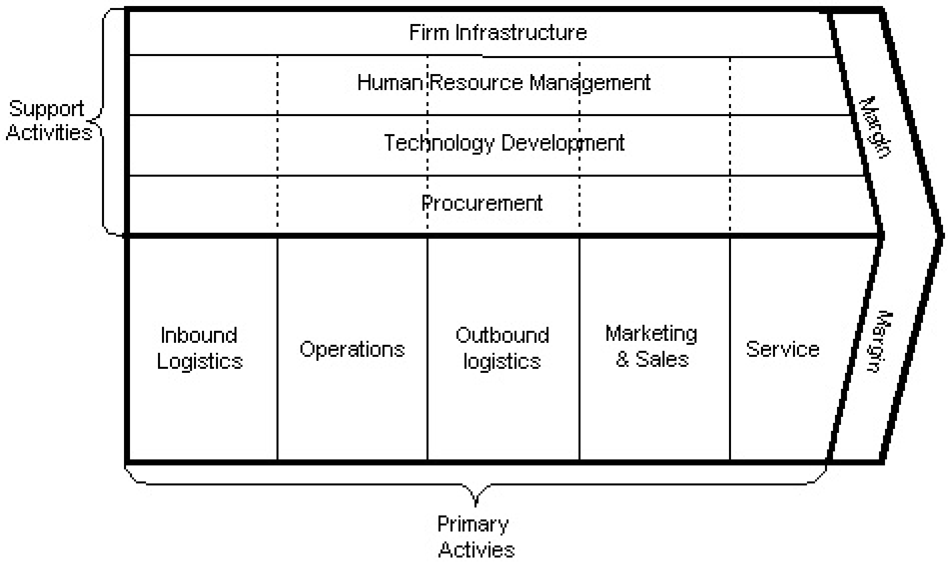

Figure 3. The Value Chain (Porter, 1985).

The Japanese had a great impact on how applications of ICT systems for logistics were handled in companies during the 1980s (Christiansen, 1992, Persson & Virum, 1995). The Japanese thoughts have been presented under many different appellations, but *Just-In-Time (JIT)* is probably the most known. The entry of these Japanese ideas divided the field of applications of ICT system for logistics into two schools: The JIT advocates that favoured the Japanese ideas, versus the MRPII camp that defended a more traditional approach for manufacturing management (Persson & Virum, 1995).

The last phase started in the 1990s and is still ongoing in many ways. Logistics thinking is still dominated by strategic issues. However, competitive advantage through logistics issues is no longer achieved by managing the company in isolation. The increasingly popular concept of *Supply Chain Management* have suggested that competitiveness both can- and should be achieved through integration of logistics processes beyond the borders of a single firm (Ross, 1998)[36].

This new way of thinking has changed the way applications ICT systems for logistics is treated in the literature. In the beginning of the 1990s the "old school" of discussing and comparing different manufacturing planning and control concepts were confronted with solutions that mixed elements from various concepts (Persson & Virum, 1995). Simultaneously, the discussions concerning applications of ICT systems for logistics within manufacturing companies were continued in a more logistics-specialised view that placed these in the light of *Supply Chain Management*[37].

Applications of ICT systems for logistics in the 1990's were also strongly influenced by the logic of the *Enterprise Resource Planning (ERP)* systems. These systems extends the functionally of the MPRII systems. Through its integrated database, the ERP-systems holds functionality that can support and integrate most logistics functions within an enterprise. The ERP-system has the possibility to integrate all warehouses and other units within the same enterprise, and can therefore enable integrated, enterprise-internal supply chains.

In the end of the 1990's the *internet* entered the business world. This entry has expanded the possibilities for both intern- and external exchange of logistics information. Companies have therefore begun to focus on applications of ICT systems that supported supply chains that go beyond the borders of a single enterprise.

The development of the logistics concept and the connected applications of ICT systems is summarised in the figure below.

[36] Supply Chain Management will be introduced in the next chapter.
[37] See e.g. Bowersox (2000), Bloomberg et al. (2002), Christopher (1998), Copacino (1997), Ross (1998), Knolmayer, et al. (2002), Ptak, & Schragenheim (1999), Hoover et al. (2001).

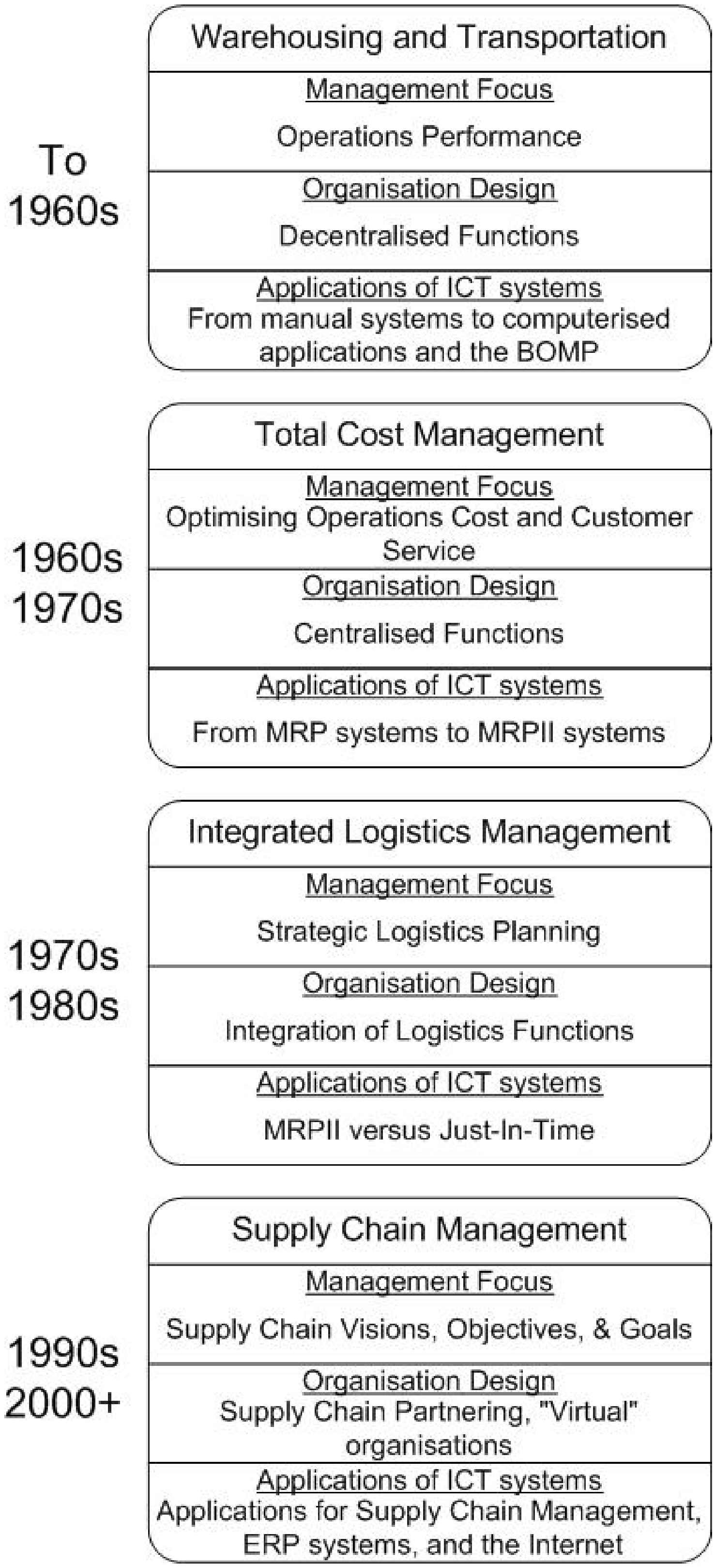

Figure 4. The historical development of the logistics concepts (based on Ross, 1998).

3.2 Logistics and Supply Chain Management

The essence of logistics can be illustrated through seven “R’s”. The ensuring of the availability of the *right* product, in the *right* quantity, at the *right* condition, at the *right* place, on the *right* time, for the *right* customer, and at the *right* cost (Coyle, et al., 1992). This indicates that the logistics mission can be described as achieving the fulfilment of customer demand, while logistics performance is related to how good this is done. However, there are other functions within a firm that also contributes to this. The concept of logistics must therefore be specified further in order to separate this from other business functions.

One of the most influential organisations within the field of business logistics – the Council of Logistics Management (Asbjørnslett, 2002) –, defined logistics in the following manner[38]:

“Logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements.”

This definition describes logistics as the management of the flows of goods, services, and information that are generated in the process of fulfilling customer demand. Chrisopher (1998) express a similar view on logistics. He argues that the mission of logistics management is to plan and coordinate all activates inside a firm in so that the desired level of customer service can be reach at the lowest possible cost. This calls for what he refers to as the company’s total systems concept, where the needs of the customers are fulfilled through managing and coordinating the flows of materials and information that extends the marketplace. This view is illustrated in Figure 5.

[38] See www.clm1.org (accessed; 08.08.03).

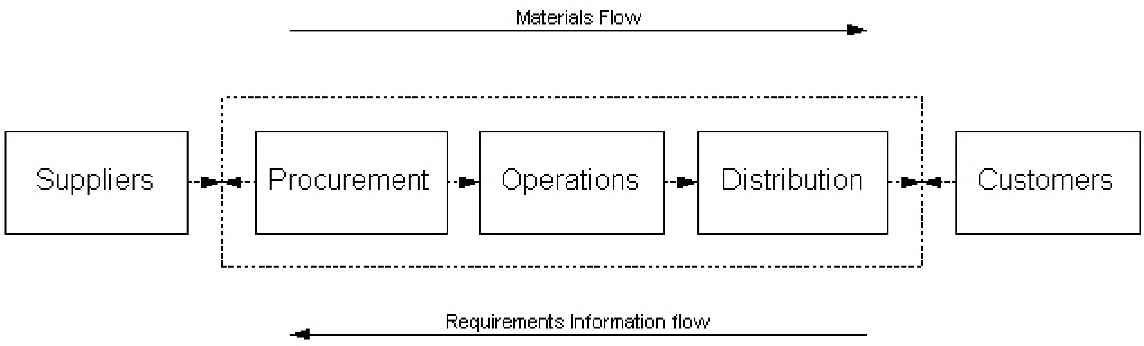

Figure 5. Logistics management process (Christopher, 1998).

Figure 5 illustrates that logistics management in involves the management of materials and the connected information that flows within three basic functions of an organisation: Procurement that deals with the acquisition of materials from suppliers, operations that transform the materials into products, and finally distribution that concerns with the shipments of goods towards the customers.

Today, logistics thinking is strongly influenced by the concept of Supply Chain Management. Christopher (1998) defined Supply Chain Management in the following manner:

"The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole"

This illustrates that Supply Chain Management broadens the original perspective of logistics management by including the suppliers and customers:

"Logistics is essentially a planning orientation and framework that seeks to create a single plan for the flow of products and information through a business. Supply chain management builds upon this framework and seeks to achieve linkages and co-ordination between processes of other entities in the pipeline, i.e. suppliers and customers, and the organisation itself" Christopher (1998).

Bowersox et al. (1996) supports such a view. He connects logistics management to internal integration and Supply Chain Management to external integration.

URN:NBN:no-3482

"…viewing internal operations in isolation is useful to elaborate the fundamental importance of integrating all functions and work involved in logistics. While such integration is prerequisite to success, it is not sufficient to guarantee that a firm will achieve its performance goals. To be fully effective in today's competitive environment, firms must expand their integrated behaviour to incorporate customers and suppliers. This extension, through external integration, is referred to as supply chain management…"

Cooper et al. (1997) confirms this understanding of Supply Chain Management by illustrating the goal of this concept as a quest for integration of business processes between the companies within the total supply chain. While the Consul of Logistics Management defined Supply Chain Management in the following manner (www.clm1.org, accessed: 08.08.03):

"Supply Chain Management is the systemic, strategic co-ordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."

This means that Supply Chain Management can be seen as a strategic term that suggests that logistics performance advantages can be achieved through the coordination and integration of both internal- and external business units within the total supply chain, while logistics management spans around internal improvements (see fig 6).

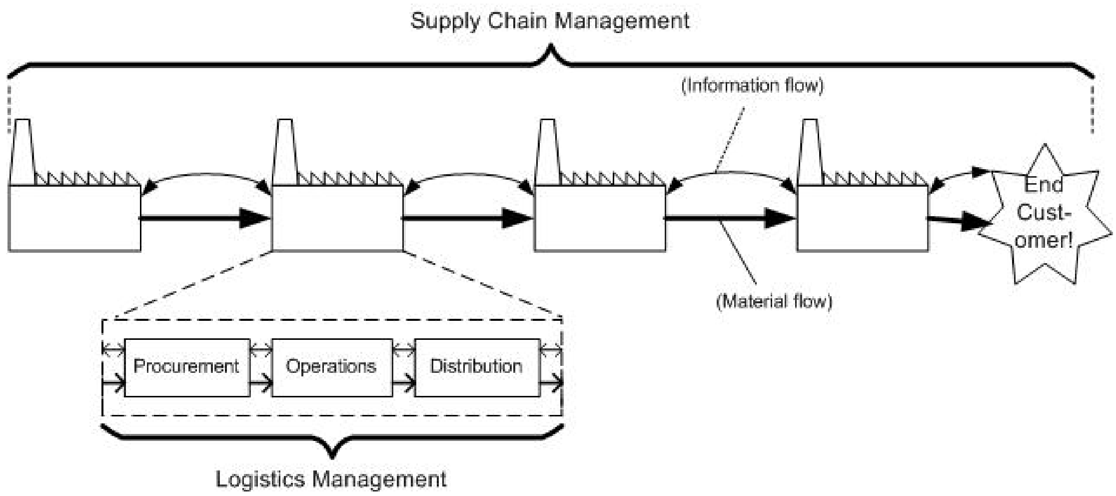

Figure 6. Supply Chain Management.

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Figure 6 illustrates that Supply Chain Management widens the perspective of logistics management by including the members of the whole chain, from the first supplier to the end customer.

Supply Chain Management is continuum of the integration thinking that has dominated the field logistics for the last fifty years. Through the concept of Supply Chain Management companies are now starting to seek integration of their logistics processes beyond their borders, pursuing the idea that there are supply chains that compete, not companies

4 Current perspectives on the role of applications of ICT systems for logistics

Initially, the way applications of ICT systems for logistics acted within manufacturing companies were described through various manufacturing planning and control concepts. During the 1990s, the thoughts around applications of ICT systems for logistics began to disengage from the field of manufacturing management. Two forces drove this trend. First, the concept of Supply Chain Management broadened the focus of logistics processes towards suppliers and customers. Second, new and improved technology paved the way for software packages that supported the integration of logistics processes that acted beyond the borders of a single unit.

The way applications of ICT system for logistics are presented within current logistics literature are influenced by these trends. Therefore, in this chapter, the role of application of ICT system for logistics is presented through three basic perspectives:

- *The Manufacturing perspective* that illustrates the role of applications of ICT systems for logistics through various manufacturing planning and control concepts.
- *The Supply Chain Management perspective* that illustrates the role of applications of ICT systems for logistics through the concept of Supply Chain Management.
- *The Supply Chain Software Package perspective* that illustrates the role of applications of ICT systems for logistics through the inherent properties of currently available logistics software packages.

4.1 The Manufacturing perspective on the role of applications of ICT systems for logistics

The Manufacturing perspective has an exclusive view on a firm's internal processes. The manufacturing process can be described as:

"The series of operations performed upon material to convert it from raw material or a semi-finished state to a state of further completion. Manufacturing processes can be arranged in a process layout, product layout, and cellular layout or fixed-position layout. Manufacturing

processes can be planned to support make-to-stock, make-to-order, assemble-to-order, etc., based on the strategic use and placements of inventories." (APICS Dictionary, Ninth Edition).

Today's applications of ICT systems for logistics have been influenced by many different concepts for manufacturing management. These manufacturing concepts and their connected applications of ICT systems have been described under many different appellations. Such as: Production Planning and Control Systems (PPS)[39], Production Management Systems (PMS)[40], or Manufacturing Planning and Control systems (MPC)[41].

Several concepts or -methodologies have been connected to these collective terms[42]. However, the discussions within this field that have had the greatest impact on logistics, separates the different manufacturing planning and control concepts into two basic principles, namely: push or pull.

The push principle dictates that the production is driven by a requirement-plan that "pushes" the components through the manufacturing system, while the pull principle describes a system that "pulls" the components throughout the manufacturing processes by using real customer demand. Manufacturing Resource Planning (MRPII) is the most typical example of a manufacturing planning and control concept that are based upon the push principle. While Just-In-Time (JIT) and Optimised Production Technology (OPT) are concepts that often are connected the pull principle (Rolstadås, 1992)[43].

These three concepts will be discussed in this chapter.

4.1.1 Manufacturing Resource Planning (MRPII)

The production logic known as "Mass Production" ruled the western world, when the first electronically ICT systems for production planning emerged in the United States during the 1950's. Despite for a certain

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[39] See e.g. Olhager & Wikner (2000).
[40] See e.g. Browne et al. (1998).
[41] See e.g. Vollmann et al. (1997).
[42] For instance: Periodic Batch Control, PBC (See Burbidge, 1996), Load-oriented production control, BOP (See Wiendahl, 1995), or PIRSM (See, Vollmann et al., 1997).
[43] See also e.g. Browne et al, (1996), Hopp & Spearman (2000), Vollmann et al. (1997), or Zapfel & Missbauer (1992).

inconsistency of the exact contents of Mass Production, there is a wide understanding that the main contributors to these thoughts were Henry Ford (1863-1947), Frederic W. Taylor (1865-1915), and to some extent, Alfred Solan (1875-1966)[44].

In these early days of the industry, the market were considered stable and as goods as infinite for almost any kind of industrial products. The ideas behind Mass Production were clearly affected by this situation. Mass Production presupposes that unit costs should be reduced through producing standardised goods in large series. This created manufacturing environments where large, dedicated, machines were utilised to speed up the production rate, while unskilled labour was employed at the shop floor level to perform standardised, fragmented jobs, under a tight discipline.

The main characteristics of Mass Production are probably the separation between doing and thinking and a high degree of fragmentation of both administrative- and operational work tasks. At the lowest level, the working man was considered as a production resource that should perform repetitive work tasks without any influence on the total processes. The thinking were left to the higher levels of the hierarchy, which was made up of several layers of managers and specialists that prepared plans, routines, and other outcomes that had to be executed by the lower levels of the organisation (Hopp & Spearman, 2000).

The ideas of Mass Production did also influence how logistics information was handled. Prior to the computer, material replenishment information was triggered through independent tools like to-bin systems[45] or card index files. In addition, a great part of the logistics information handling in manufacturing companies were connected to production planning, where humans often were used as the main driver for spreading the information. Ralston (1996) explains:

"Manufacturing industry coped remarkable well before the advent of the computers. Of course, it was helped by a supply driven economy

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[44] See e.g. Hopp & Spearman (2000), Mokyr (2001), Womack, Jones & Roos (1990), or Skorstad, (1999).

[45] Two bin systems are systems where components are distributed equally in two containers. The components are first consumed from one container. A new load is ordered to fill this container as soon as it is empty, simultaneously as the consumption from the second container begins. When the second is empty, the first container is (hopefully) filled, so that consumption from this can start again, while a new load for the second container is ordered and so on.

following the Second World War – the customers were eager for any goods they could get. Most stock control was on an order point/order quantity basis, but the real driver was the progress chaser (or expediter) complete with shortage lists in his hand."

Ralston (1996) describes an aircraft manufacturer that before the computer used an extensive, "manual" production planning routine to drive logistics information throughout the manufacturing plant. These planning activities were based on customer orders that made up a material requirement plan. From this plan, component requirements were calculated to check the availability of components on stock. If there were parts in stock, the required quantities were allocated into kits. If the stock were empty or held too few components, the missing parts was noted on a shortage lists. This shortage lists were then handed to an expediter (or progress chaser) that had to obtain the parts before the production could start. This production start date was usually set to several months after the customer order had arrived.

As good as all orders were delayed, and robbing one delayed order to fill the shortage lists for a more urgent one, was rather the rule than an exception. The work of the expediter was therefore described as "*fair game*", done by people that needed "*a load voice, big feet and a good pair of eyes*" (Ralston, 1996).

Mass Production focused on productivity and capacity utilisation (Alfnes & Strandhagen, 2000). This, and the drive for specialisation, may be the reason that the some of the first efforts of using computers in the industry were connected to production planning. The first of these computerised production planning applications were IBM's Bill-Of-Material Processor (BOMP). The BOMP supports the production planning process by calculating the total quantity of each ingredient or component through multiplying the quantity of the product in each batch by the number of ingredients or components in the bill or recipe for the product. This means that the BOMP could help a planner to electronically calculate component requirements (Intentia, 1999).

The calculations provided by the BOMP had some rationalisation potential. However, these calculations gave only a simplified picture of the demand situation. They ignored things like existing components on stock, issued purchase orders, goods receipts already scheduled, planned work, lead-times, common components, or the fact that some components or ingredients were needed at once, while others could be supplied later in the production cycle. These imperfections impelled improvement in the BOMP's functionally, which made up MRP (Material Requirements Planning) –systems that companies started to use in the 1960's (Intentia, 1999).

The MRP system created schedules that accounted for many different factors, such as the total requirement on stocks, already planned production, scheduled goods receipts, and the total make or purchase need across a number of products (Intentia, 1999). Ralston (1996) claims that the MRP-system gained popularity because of its potential to predict future demands and providing a shop-floor prioritising functionality through the calculation of start- and due-dates of each operation. However, the reliance people had to these systems were somewhat exaggerated.

"The systems people genuinely believed that putting volumes of print-out onto the production controller's desk every month was all that was needed to run the factory - and it would be sufficient until the next monthly run." (Ralston, 1996).

The schedules made by the MRP calculations had one major shortcoming; they did not consider the capacity available in the factory. To help this problem, capacity consuming production steps were included in the MRP-systems bill-of-materials database. A capacity plan for the key resources could then be calculated from the master production schedule and compared with the anticipated available capacity. If the capacity calculated from the requirements exceeded the anticipated capacity available in the plant; the production schedule had to be re-planned. However, a change in the master production schedule required a recalculation of the capacity plan, and if it the capacity situation were still unsatisfying, new corrections in the master production schedule were required. The planning loop continued until the planner was satisfied with both plans. This method was named Rough-Cut-Capacity Planning (RCCP).

Rough-Cut-Capacity Planning and other extensions of the original MRP principles, like Production-Activity-Control (PAC), Capacity-Requirement-Planning (CRP), and Purchasing, emerged into a common platform that became known as Closed-Loop MRP (Browne 1993).

Around 1980, two additional steps transformed the Closed-Loop MRP methodology into MRPII. The systems functionality was expanded with costing information that could be combined to calculate total manufacturing costs. In addition, feedback principles were made to improve forecasts and to create a usable business plan that the whole enterprise would work with. The American Production and Inventory Control Society (APICS) began to standardise the components of a manufacturing planning and control concept that they termed MRPII (Manufacturing Resource Planning) and developed it into a recognisable shape (Intentia, 1999).

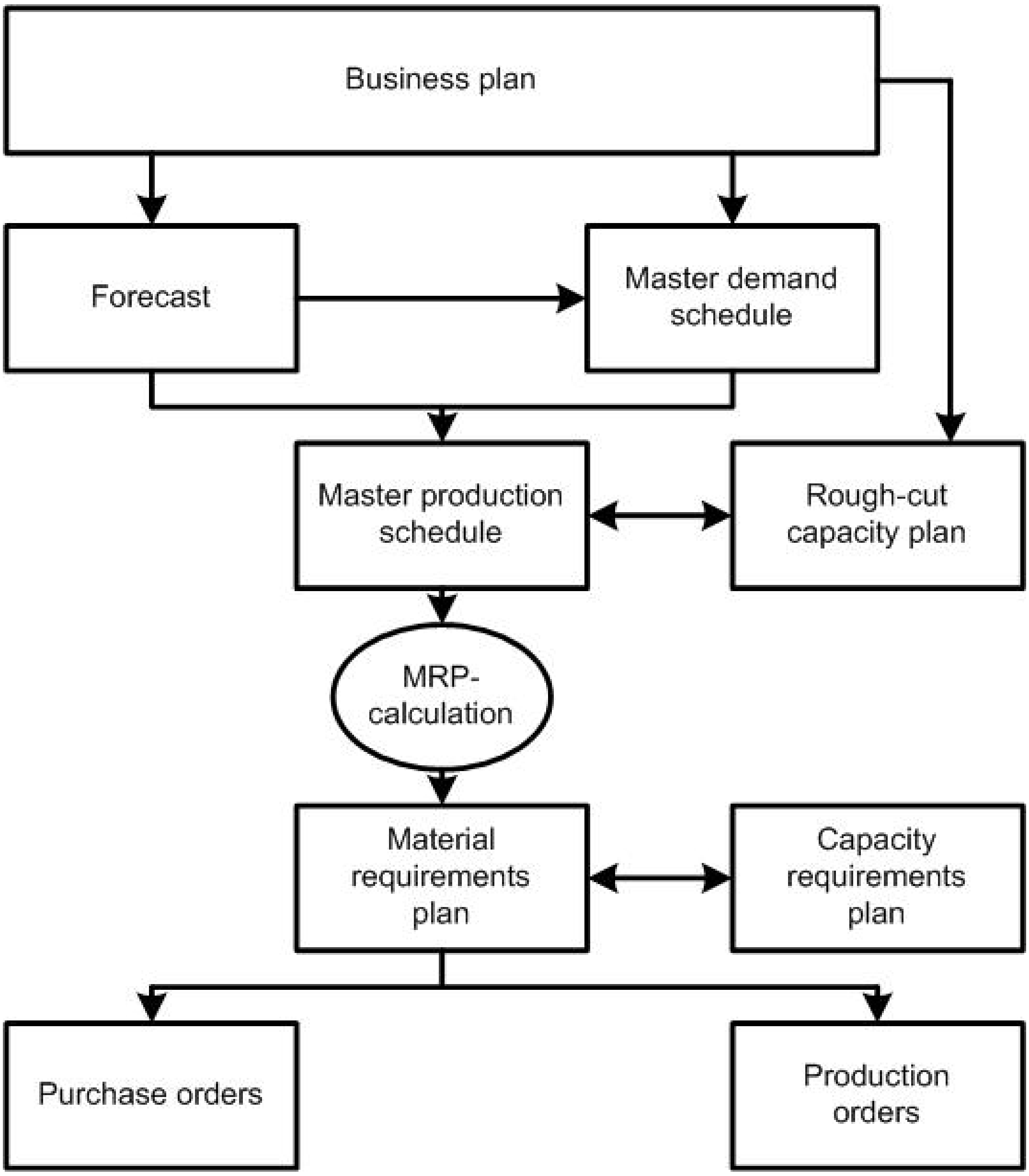

Figure 7. MRPII (revised from Intentia, 1999).

Figure 7 outlines the main components of MRPII. A business plan helps the firm to set its overall direction and provides the productions department's part in the firm's long term "game plan". It uses the total resources and the demand situation to produce forecasts and a master demand schedule, which again are combined into a master production schedule (Vollmann et al., 1997).

The master production schedule is blanched towards a rough-cut capacity plan, and transformed into a material requirement schedule[46] through a net-change- or a regenerative[47] MRP-run. A capacity requirement plan is then created and balanced towards the material requirement schedule. As indicated in Figure 7, the shop-floor systems in the MRPII approach (PAC-system) are influenced by the use of production (and purchase-) orders. The orders are issued in batches and coordinate the flow of materials from the suppliers and throughout the manufacturing company.

MRPII is a successful approach, and is still used as a base in most ICT systems for logistics and manufacturing management. However, it has its flaws. Some of these are connected to its origin from Mass Production (Alfnes & Strandhagen, 2001). For instance, like its embedded support for hierarchical organisations, centralised control, and focus on production planning. Others problems of the MRP-systems are related the planning logic they represents. For instance: the uncertainty of forecasts, insufficient functionality for shop floor scheduling, and the need for long planning horizons and "-schedule locking time".

Nevertheless, the main problem of MRPII is that the systems have unrealistic requirements to its surroundings. It relies on innumerable anticipations on how the organisation and other involved factors will behave. Aune et al. (1990) lists the following requirements for making a MRPII system work according to the MRPII concept:

- Customer requirements are known in sufficiently long future time scale, with a sufficient accuracy.
- Bill of materials and production processes is known in advantage.
- The status of stock levels, customer and vendors orders is always known.
- All databases are correct and updated.
- Lead times are fixed and known for every component, and they include enough slack to consume and smooth out peaks in the loading of the production system (This means that lead times often become

[46] The main difference between these two schedules is that the master production schedule is usually a quarterly or monthly plan focuses on key products and resources, while the material requirement plan is a shorter term, item-for-item plan.

[47] A net-change calculation does only consider the part of the master production schedule that have been changed since the last MRP-run, while a re-generative MRP-run re-calculates the whole schedule regardless of what is changed or not.

quite long, with raw process time and internal transportation counting for less than 10% of the total lead time for the component).

- The batch size for an order is fixed throughout the production process.

These problems connected with the concept of MRPII and the MRP/MRPII systems have been frequently described in the literature[48]. Such descriptions do often present the concept of MRPII as unfit for today's dynamic business environments.

4.1.2 Just-In-Time (JIT)

Simultaneously as the first attempts of using computers for production planning were performed in the western world, a new, more holistic, concept for manufacturing management started to emerge in Japan.

Ever since the 1950's and up until today, the Japanese industry has gained great efficiency and quality advantages compared to their competitors in the Western world (Womack et al., 1990; Hopp & Spearman, 2000). There have been many different explanations of this Japanese success, but the manufacturing approach that did grow out from Toyota has been considered as the main source for these prospers (Nilssen & Skorstad, 1994)[49].

The Toyota Production System (TPS) is mainly credited Taiichi Ohno, but the business consultant Shigeo Shingo has also been a significant contributor to this concept. Shingo claims even to be the founder of the basic thoughts behind this concept (Shingo, 1992).

From the 1970s, the ideas behind the Toyota Production System spread to other Japanese and Western companies, and gave root to many different manufacturing concepts, strategies, or approaches. Such as: Just-In-Time (JIT)[50], World class Manufacturing[51] or Lean Production[52]. Despite of their different names and angles, the basics thoughts behind these are

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[48] See e.g. Browne et al. (1996), Vollmann et al. (1997), or Hopp & Spearman (2000).

[49] Toyota has grown enormously since the advantages of their production system became apparent during the oil crisis in 1973. Today (2003), Toyota has for the first time become the most sold personal car brand in the United States (DagensNæringsliv, 04.09.03). In addition, from March to September this year Toyota has also been the second largest car manufacturer world, and are heading for the first place before 2010 (www.bilrevyen.no, accessed; 13.09.03).

[50] See e.g. Hirano (1989), Browne et al. (1996), or Vollmann et al. (1997).

[51] See Schonberger (1986).

[52] See Womack et al. (1990).

relatively similar (Skorstad, 1999). Therefore, "JIT" is adopted in this thesis to explain the ideas behind these concepts[53] and how they present applications of ICT system for logistics.

JIT can be described as a manufacturing philosophy that seeks the elimination of all sources of manufacturing waste through producing the right quantity of products, in the right place, and at the right time. Alternatively, it can be said that JIT tries to achieve the following goals (Browne, 1996):

- Zero defects
- Zero set-up time
- Zero inventories
- Zero handling
- Zero breakdowns
- Zero lead time
- Lot size of one

The basics of JIT have been described in many different ways. Cheng (1996) for instance, claims that JIT manufacturing is based on three elements: people involvement, plants, and systems. While Vollmann et al. (1997) presents JIT through several objectives and a set of building blocks. Browne (1996) divides the JIT approach in a philosophical part and set of techniques for designing, -planning, and -shop floor control. While Ohno (1989) claims that the Toyota Production System is supported two conceptual pillars, one connected to just-in-time deliveries and the other is made by combining automation with human intelligence.

Despite this inconsistency for the exact anatomy of JIT, most authors seem to agree on that JIT consist of a philosophical part and a set of given methods or techniques. The philosophical part is usually connected to waist reduction and the methods are presented as the solution for achieving this form for manufacturing.

JIT is often represented as an alternative to the Mass Production philosophy of the western world[54]. In contrast to Mass Production, JIT suggests that products should be tailored towards the needs of the single customer rather than standardised, while achieving a steady flow of

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[53] In addition, "Toyota Production System" will be used when referring to the original approach developed in the Toyota plants.
[54] See the previous section.

materials is more important than productivity and capacity utilisation. Further, JIT suggests that all kinds of "waist" should be eliminated, which includes things like administrative work that do not directly provide value to the customers or waiting time for workers at the shop floor. This have lead to that JIT is connected to less hierarchical organisations and employment of multi-skilled workers that performs more than a single task.

From a logistics point-of-view, the reduction of machine set-up times is maybe the most important step towards a JIT approach (Shingo, 1989). Reduction of machines set-up times makes it more economical to use shorter lot sizes. Shorter lot sizes will reduce the throughput time for each product, which means that a larger part of the manufacturing processes can be driven from actual customer orders. This again improves possibilities for making customer-configured products and reduces the need for stocks of finish goods and -work in progress. Short lot sizes does also smoothen the flow of components and materials that are needed from the suppliers, which again have a positive effect for the material level throughout the whole supply chain. In addition, small lot sizes are advantageous when it comes to wreckages in production; this because only a small quantity of items has to be wrecked if a defect lot is discovered. This idea of reducing lot sizes stands in large contrast to the original manufacturing thinking in the western world, where large lot sizes were considered as advantageous because they reduced the unproductive time for doing machine set-ups and thereby reduced unit costs and increased the firm's productivity measures.

JIT is a comprehensive approach, and it has several distinct features that are directly connected to applications of ICT systems. The most obvious of these is the shop floor control mechanisms. In contrast to MRPII that focuses on production planning and the use of production orders generated from forecasts, the JIT approach recommends the use of Kanban-cards issued from real demand for managing flow of materials.

The Kanban system is a manufacturing control methodology that utilises physical cards for transferring stock refilling information[55]. There are two basic variants of Kanban systems: single- and two-card systems (Vollmann et al., 1997). The two-card system makes use of both

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[55] There exist several variants of the Kanban system where various methods for transferring the re-ordering signal are used. E.g. like electronic signals, empty containers, or golf-balls.

conveyance- and production Kanbans, while the single-card system utilises only production Kanbans (Hirano, 1988). Nevertheless, the basic principle behind both approaches is similar: Buffers of stocks within the logistics chain are refilled according to the consumption of goods in the preceding operation. This principle is illustrated in Figure 8.

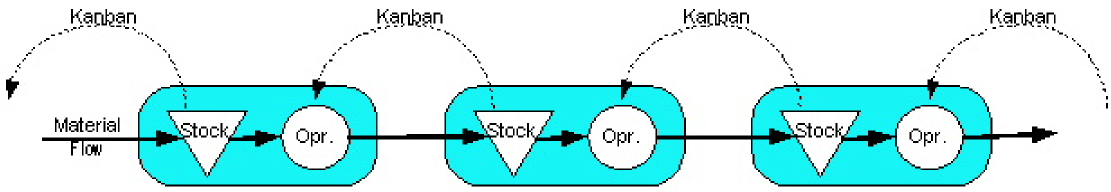

Figure 8. Kanban system (Single Card).

Figure 8 outlines that buffers of materials are placed in front of each operation. A Kanban card is transferred to the previous operation in order to trigger the production of a replenishment lot every time a certain quality of goods has been issued from the buffer in front of the operation.

The JIT approach dictates several other methods that may affect how logistics information is handled within the manufacturing company, such as "Andon" or "Poka-Yoke"[56]. Nevertheless, it is the attitude towards the ICT systems that gets most attention from the inventors of JIT. Ohno (1988) for instance, argues that information generates costs and therefore only necessary information should be processed and only when this is needed. He sees the potential of using computers in industry, but he warns of an exaggerated use of these and refers to the same waist reducing principles as he has for material handling:

"Is it really economical to provide more information than we need – more quickly than we need it? This is like buying a large, high – performance machine that produces too much" (Ohno, 1988).

According to Ohno (1988), these ideas differed from the concurrent logistics thinking in the western world:

"America's mass-production system has used computers extensively. At Toyota, we do not reject the computer, because it is essential in planning

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[56] "Andon" are line stop alarm lights used at the shop floor for dealing with problems like unexpected shortages components or machine breakdowns. "Poka-Yoke" concerns with building quality control tasks into the production processes for the prevention for producing defect parts. (Hirano, 1989).

production levelling procedures and calculating the number of parts needs daily. We use the computer freely, as a tool, and try not to be pushed around by it. But we reject the dehumanisation caused by computers and the way they can lead to higher costs" (Ohno, 1988).

Ohno (1988) calls attention to the necessity of flexibility between the planning functions and the shop floor control systems. Minor changes in the production schedule should be dealt with at the shop floor level without going through the management. He uses the human body as a metaphor by calling attention to that many of the body's functions is performed unconsciously without disturbing the brain[57].

Despite of these attitudes, Toyota managed large amounts of information within their manufacturing planning routines. These planning routines are dominated by an annual plan made from a market survey. The annual plan indicates the rough number of cars to be sold and is updated twice a year (Shingo, 1989). As time goes by, this plan is combined with other forecasts and turned into monthly plans. The monthly plans indicate the number of each car to be produced (but not their sequence) and are distributed to internal departments as well as to cooperating firms outside the Toyota plants (Shingo, 1989).

The monthly plans are frequently updated through actual orders. This differs from traditional methods for production planning where the monthly plan is locked for a specific time before production (Ohno, 1988). Daily, levelled, production schedules are created from this monthly plan a short time before the production starts. The daily schedules are just information of the daily quantity each line should produce of the different products. The production sequence schedule is only issued to on place: the final assembly (Ohno, 1988).

The final assembly schedule is generated from real customer orders and is balanced so that the flow of materials is evenly distributed throughout the logistics system. The use of Kanban cards ensures the transfer of the production sequence from the assembly throughout the other processes upstream the supply chain (Ohno, 1988). This provides the shop floor workers plain information about the requirement from the down streams

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[57] For instance, if a hand touches a hot item, it is removed automatically without the need of conscious thinking.

processes and allows them to do shop floor scheduling priorities at their own initiative[58].

The basic ideas of this manufacturing-planning routine are indicated in Figure 9.

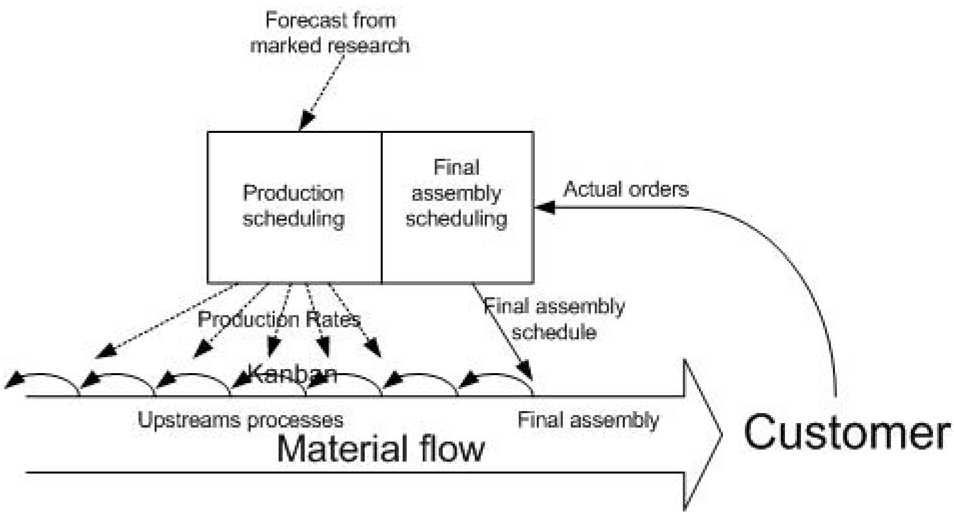

Figure 9. Manufacturing planning at Toyota.

Figure 9 illustrate that this production scheduling methodology consists of two parts: The first scheduling function is based on anticipated demand from a market research and ends as production rates that are communicated to the shop floor. The purpose of this first scheduling activity is to anticipate any disturbance in the demand, so that the various production units can prepare for these. The second scheduling function is the final assembly scheduling that is based on actual customer orders. This scheduling drives the final assembly, which initiates the Kanban systems that transfers the actual production requirements throughout the logistics chain.

Figure 9 indicates that the JIT system seeks to create an even flow of materials throughout the whole logistics system. As the flow of materials moves towards the end customer the production processes becomes less influenced by the production rates and the real customer demand is gradually turning into the main driving force for the material flow. This idea is different from most other methods for order driven production

[58] The planning activities at Toyota in Japan are described in Monden (1998), Ohno, (1988) and Shingo (1989).

where the assembly is separated clearly from the rest of the production processes through a buffer- or a stock of components (Shingo, 1989).

4.1.3 Optimised Production Technology (OPT)

OPT is a well-known and frequently referred to concept when it comes to ICT systems for manufacturing management. OPT is often presented as an alternative to both MRPII and JIT[59]. OPT consists of a manufacturing philosophy and a related software package (Browne et al., 1996).

The OPT[60] philosophy proposes that making money is the ultimate goal for the manufacturing company and that this can be achieved through observing three indicators: throughput[61], inventories[62] and operating expenses[63] (Goldratt, 1989). The basic idea behind OPT is to increase throughput simultaneously as inventories and operating expenses are being reduced. According to the OPT philosophy, these objectives can be pursued by focusing on the activities at the shop floor (Browne, et al., 1996).

“Bottlenecks” receive special attention in OPT-thinking. Bottlenecks are restrains in the manufacturing process that dictates the output of the whole process (Rolstadås, 1992). OPT suggests that the output of the whole manufacturing system can be determined through the management of these bottlenecks. One way of doing this is to follow the “buffer-drum-rope” principle (see Figure 10).

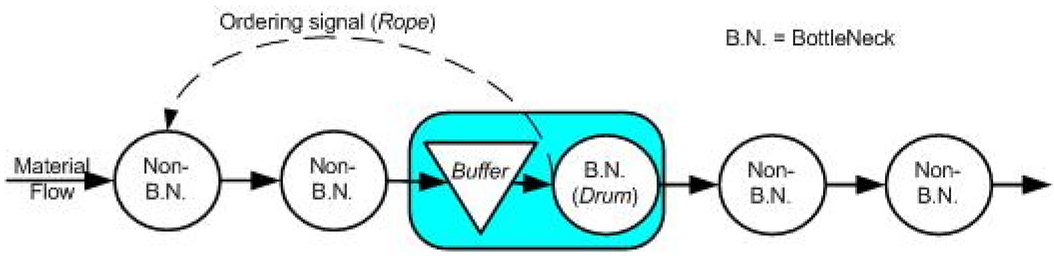

Figure 10. The Buffer-Drum-Rope principle.

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59 See e.g. Browne et al. (1998), Vollmann et al. (1997), or Olhager & Wikner (2000).
60 The philosophical part of OPT is often connected to the Theory of Constrains (TOC).
61 Throughput in OPT: The rate at which the firm generates money through sales (APICS Dictionary, ninth Ed.).
62 Inventory in OPT: Those items purchased for resale and include finished goods, work in progress, and raw materials. Inventory is always valued as purchase price (APICS Dictionary, ninth Ed.).
63 Operating expense in OPT: The quantity of money spent by the firm to convert inventory into sales in a specific time period (APICS Dictionary, ninth Ed.).

The circles in Figure 10 illustrate operations in production. The bottleneck is sited in the middle of the five operations. Since the other operations are non-bottlenecks, the output the total system relies on the bottleneck's output. Therefore, the bottleneck will act as a *drum* that beats the throughput rate of the whole system. A *buffer* is established in front of the bottleneck operation for always to keeping it busy, while size of this buffer is held at a low level through a signal (*rope*) that initiates production at the first operation every time an item (or a certain quantity of items) is withdrawn from the bottleneck's buffer.

The OPT philosophy is based on nine main rules or principles (Vollmann, et al., 1997):

1. Balance flow, not capacity.
2. The level of utilisation of a non-bottleneck is not determined by its own potential but by some other bottleneck in the system.
3. Utilisation and activation of a resource are not synonymous.
4. An hour lost at a bottleneck is an hour lost for the total system.
5. An hour saved at a non- bottleneck is just a mirage.
6. Bottlenecks govern both throughput and inventories.
7. The transfer batch may not, and many times should not, be equal to the process batch.
8. The process batch should be variable, not fixed.
9. Schedules should be established by looking at all of the bottlenecks simultaneously. Lead times are the result of a schedule and cannot be predetermined.

The other part of the OPT concept is the software package. The OPT-software is based on a secret algorithm, but its underlying logic is somewhat understood. First, the software utilities of data from a bill of material file, a routing file, and the master production schedule to form a "product network" (Vollmann et al., 1997). Using this network, the OPT software calculates the load on each resource, which reveals the bottlenecks. Thereafter, the network is divided into a critical- (OPT) and a non-critical (SERVE) sub-network. The critical sub-network includes the bottlenecks and all succeeding operations, while the non-critical network consists of the operations upstream for the bottlenecks. A special algorithm is then used on the critical sub-network to prepare a forwardfinite loaded production schedule, while a backwards-scheduled schedule is formed from the non-critical network by using MRP-logic[64].

OPT relates to both MRPII and JIT. The OPT-software is often seen as an extension to MRP-based applications[65], simultaneously as many do refer to the strong relations between the philosophical parts of OPT and JIT thinking (Rolstadås, 1992; Vollmann et al., 1997).

4.2 The Supply Chain Management perspective on the role of applications of ICT systems for logistics

In 1982, Oliver and Webber introduced the concept of Supply Chain Management. Supply Chain Management was motivated by the superior logistics performance the Japanese firms were demonstrating compared to their competitors in the western world. In contrast to the authors of the JIT approach, Oliver and Webber (1982) did not recommend to copy the methods and the management principles that were developed within Toyota. They rather adopted the holistic view of material handling from the Japanese, and stressed the importance of strategic management. They introduced the term "Supply Chain Management" and presented four aspects in which this concept differed from traditional ideas of material management (Oliver & Webber, 1982):

"Supply-chain Management differs significantly from classic material and manufacturing control in four aspects. First, it views the supply chain as a single entity, rather than relegating fragmented responsibility for various segments in the supply chain to functional areas such as purchasing, manufacturing, distribution, and sales. The second distinctive feature of supply-chain management flows directly from the first: It calls for - and in the end, depends upon - strategic decision making. "Supply" is a shared objective of practically every function on the chain and is of particular strategic significance because of its impacts on overall costs and market share. Third, supply-chain management provides a different perspective on inventories, which are used as balancing mechanism of last, not first, resort. Finally, supply-chain management requires a new approach to systems (note: ICT systems)*; Integration, not simply interface, is the key."*

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[64] See e.g. Vollmann et al., (1997) or Browne, et al., (1996) for a more intimate discussion of this algorithm.
[65] OPT logic is often used within the SCP (or APS-) systems. These software packages will be discussed later in this thesis.

Applications of ICT systems were an important topic already in the earliest writings about Supply Chain Management. Oliver and Webber (1982) considered software applications as effective mechanisms for enabling control over the logistics processes, but they claimed that the current ICT systems did not support processes that acted across departments. In the 1980s, most applications of ICT systems were tailored to support only on particular function or -functional area[66]. This meant that each application acted as independent units that only interacted through various interfaces. According to Oliver and Webber (1982), these interfaces resulted in a number of unfortunate outcomes:

"The system interface approach has several shortcomings, not the least of which is its hidden cost in terms of indirect manpower, and the related delay and distortion in the transfer of information. In addition, this approach frequently results in strategic and directional decision-making at too low level. Further, systems groups either directly or indirectly "sell" their services separately to functional vice-presidents or directors"

Oliver and Webber (1982) referred to the MRP systems[67] as the "*probably best example of this problem*", while they presented real integration between the different applications and the managers control over these as the solution to these problems.

As presented in section 3.2, current Supply Chain Management thinking is mainly connected to external integration. Nevertheless, the basic principles made by Oliver and Webber (1982) are still valid.

Integration is still held as a key factor in recent descriptions of information handling in supply chains, which often is illustrated as various flows of information between the different parties in the supply chain. What kind of information that flows between the units, may vary from author to author. Lee and Whang (2000) for instance, identifies several different information flows between companies in a supply chain, like inventory levels, sales data, order statuses, sales forecasts and production/delivery schedules. Knolmayer et al. (2002) suggests that information sharing in a supply chains consist of information of things

[66] Like sales, production, warehousing or purchasing.
[67] See section 4.1.1.

like orders, forecasts, inventories, and resources. While Bowersox et al. (2002) argue that the main purpose of such information flows is to integrate operating areas through communicating requirements information for initiating the movement of materials.

In this research the basic concept of Supply Chain Management is used to explain the Supply Chain Management perspective's view on applications of ICT for logistics. However, during the last decade many other approaches, methods, or concepts have been connected to both logistics and application of ICT systems. Some of these thoughts are directly connected to Supply Chain Management or may even be attempts to develop this concept further, while others are only indirectly coupled to this kind of thinking. Therefore, in order to clarify their connection to current logistics thinking, the most important and relevant of these are mentioned in the following sections.

4.2.1 Business Process Re-engineering

The concept that maybe has had the greatest impact on how ICT systems have been applied in organisations during the 1990s is "Business Process Re-engineering" (BPR). Business Process Reengineering has it roots in the research program "Management for the 1990s" at MIT Solan Management School (Glasson, 1994), and through an article by Michael Hammer in 1990 the basics behind this concept were introduced to the public for the first time[68].

Business Process Reengineering relies upon the existence of business processes. Johanson et al. (1993) defined a process in the following manner:

"*A process is a set of linked activities that take an input and transform it to an output.*"

Davenport (1993) used as similar description on this phenomenon:

"A process is a structured, measured set of activities designed to produce a specified output for a particular customer or market... A process is thus a specific ordering of work activities across time and space, with a

[68] See Hammer (1990).

beginning, an end, and clearly identified inputs and outputs: a structure for action."

While Hammer and Champy (1995) defined a business process as:

"A collection of activities that takes one or more kinds of inputs and creates an output that is of value to the customer."

These definitions reveal that a business process is as a rather abstract phenomenon that consists of activities that collaborate to transform some kind input into outputs that should represents value to a customer.

Business Process Reengineering challenges the very foundation of the way we are doing business. The first notations of this foundation were laid in 1776 when Adam Smith proclaimed the benefit of the division of labour in his book "wealth of nations". Smith discovered that productivity could be drastically increased by separating the fabrication of a product into smaller and simpler work tasks, and allocating individuals to execute each of one these.

Throughout the years this logic of the division of labour has been further developed, not only throughout the fabrication processes but also in management- and administrative functions, and is the base for how work is performed within most organisations of today[69]. (Hammer & Champy, 1995; Hopp & Spearman, 2001; Skorstad, 1999; Willock, 1994; Womack et al., 1990).

Decades of separation of work have created bureaucratic and pyramidal organisations consisting of fragmented business processes. According to Hammer and Champy (1995), these traditional organisations functions well as long as the market demand is steady or steadily increasing. However, fragmented business processes makes it difficult to see the value each work task has for the end customer, and therefore it may also drive an absence of responsibility for the completion of the total service or -product.

In the competitive arena of today, demand is uncertain and far from steady, which requires that companies must behave dynamically. The

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[69] This logic may also be described as the main fundament behind logic of "mass production" (see the previous chapters).

absence of overview caused by fragmented business processes in a dynamic environment may lead to that unnecessary work tasks are created and therefore reduce the organisations ability to fulfil the needs of the customers. Hammer and Champy (1995) claimed that this has made the workflows inherited from the heydays of the industry unfit for modern companies, and new ways for organising the work is needed:

"It is no longer necessary or desirable for companies to organise their work around Adam Smith's division of labour. Task-oriented jobs in today's world of customers, competition, and change are obsolete. Instead, companies must organise work around process" (Hammer & Champy, 1995).

Business Process Reengineering suggests that instead of allocating single people to do single work tasks, should work rather be organised around business processes that are managed by work groups that has the responsibility of the completion of the total process, from start to finish.

Business Process Reengineering predicts that applications of ICT systems can fundamentally reshape the way business is done (Davenport & Short, 1990). However, Hammer (1990) claims that within many companies, applications of ICT systems are only used for automating old work tasks, which again will result in mechanising the old ways for doing business. If applications of ICT system should represent a significant improvement, they must be used as an enabler to create new business processes:

"Instead of embedding outdated processes in silicone and software, we should obliterate them and start over. We should "reengineer" our business: use the power of modern information technology to radically redesign our business processes in order to achieve dramatic improvements in their performance." (Hammer, 1990).

The Business Process Reengineering literature gives special attention to the effects this new way of applying ICT systems will have on the middle management. Business Process Reengineering claims that a large part of the middle managements' work-task is connected to transferring information from the work floor to the levels above. This has resulted in that most applications of ICT systems have become focused on supporting the management and not the processes that creates value to the customers. Consequentially, all manual information handling done by the middle management should therefore be exchanged with electronic ICT systems that transfer the information directly to the higher levels of the organisation (Willock, 1994).

Hammer (1990) suggested seven principles for reengineering business processes:

- Organise around outcomes, not tasks.
- Identify all the processes in an organisation and prioritise them in order of redesign urgency.
- Integrate information-processing work into the real work that produces the information.
- Treat geographically dispersed resources as they were centralised.
- Link parallel activities in the workflow instead of just integrating their results.
- Put the decision point where the work is performed, and build control into the process.
- Capture information once and at the source.

The Business Process Reengineering literature is clear on that the required changes to the business processes are so radical and profound that they must be implemented through an "clean sheet" approach, where new business processes are designed from a customer's point-of-view and all works tasks that do not create value in the face of the customer are either eliminated or minimised (Willoch, 1994).

Hammer and Champy (1995) defined Business Process Reengineering in the following manner:

"The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed"

Business Process Reengineering has undoubtedly an effect on applications of ICT systems for logistics. Copacino (1997) for instance, claim that Business Process Reengineering efforts have an effect on logistics performance, but it embraces other fields as well. While Ross (1998) emphasises that the Business Process Reengineering improvement initiative can get confused with Supply Chain Management even if these are far from identical. He argues that Supply Chain Management is more than engineering business processes. According to him Supply Chain Management is rather about creating synergy beyond the company borders to create a single channel system that can respond to any market demand with superior competitive advantage, while Business Process Reengineering is one tool for achieving supply chain improvements.

This sums up the relations between Supply Chain Management and Business Process Reengineering. Supply Chain Management the superior logistics concept that touts the vision of the integrated supply chain, while Business Process Reengineering is a methodology for doing business improvements in general, that may (and often will) have an effect on logistics performance.

4.2.2 Efficient Consumer Response

According to Christopher (1998), ideas derived from JIT[70] combined with applications of ICT systems within the supply chain, created the concept of "Quick Response Logistics". The core idea of Quick Response Logistics is to increase the speed of replenishment by applying ICT systems to capture demand information in real-time and as close to the customer as possible. This way of thinking has been adopted by the grocery industry that has developed it into the approach known as "Efficient Consumer Response" (ECR).

The key idea behind Efficient Consumer Response is that distributors and suppliers in the grocery industry should work tight together to create better value for the customer. Christopher (1998) summarised the idea behind Efficient Consumer Response in the following manner:

"The fundamental principle of ECR is that through partnership within the supply chain, significant cost reduction can be achieved through a better allocation of shelf space in the retail store, fewer wasteful promotions and new products introductions and more efficient physical replenishment. The key to the achievement of these goals is shared information, in particular information on sales gathered at the checkout counter and transferred directly to suppliers."

Brown and Bukovinsky (2001) presented four strategies that can be used to achieve Efficient Consumer Response:

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[70] See section 4.1.2.

- *Efficient store assortment* involves the use of modern product category management techniques that focuses on product categories instead of individual products. These can be applied to increase retailer efficiency and improve the fulfilment of end customer demand.
- *Efficient replacement* includes automated inventory control and computerised order processing routines. The issue of products in stores should be constantly monitored, while replacement orders should be automatically sent from the retailer to the food manufacturer by the use of tools like Electronic Data Interchange (EDI)[71].
- *Efficient Promotion* dictates that promotions should be performed so that manufacturers can promise low product prices in return of a steady stream of orders from the retailers.
- *Efficient product introduction* means that products that fail on the market should be withdrawn as fast and efficient as possible.

Efficient Consumer Response does not have an exclusive focus on logistics issues. Copacino (1997) mentions that this approach is build through developing capabilities within three different areas: marketing, technology, and logistics. However, he emphasises that a strong logistics strategy is necessary to complete an Efficient Consumer Response program.

From a logistics point-of-view, Efficient Consumer Response is a framework for achieving supply chain advantages within a certain business sector. This means that Efficient Consumer Response is not an alternative to Supply Chain Management, but rather an application of this kind of thinking.

4.2.3 The Extended- and Virtual Enterprise

New possibilities for inter-enterprise coordination have emerged through the advent of the internet. Collaboration between external parties in a supply chain has therefore become an increasingly important topic in the logistics debate.

Logistics performance can undoubtedly be increased by combining supply chain thinking and internet based applications for inter-enterprise collaboration. For example, Lee and Wang (2001) addressed the

[71] See section 4.3.4.

possibilities to reducing the “bull whip”[72] effect in supply chains through internet based collaboration, while a simulation experiment performed by Ovalle and Marques (2003) found that supply chain performance would be significantly increased if the members of the supply chain collaborated through internet tools[73].

However, the entry of the internet may also have a more profound impact on supply chains. Jagdev & Thoben (2001) claims that collaboration through the internet may change the face of the supply chains and form Extended- and Virtual Enterprises:

“…The emerge of affordable Internet based ICT technologies is pushing the frontiers of enterprise collaboration to new levels and as a result the emerge of new paradigms from the supply chain type of collaboration – the Extended and Virtual Enterprises”

These ideas of the Extended- and Virtual Enterprise did not arise from arrival of the internet alone. Browne et al. (1995) emphasises that the vision of the Extended Enterprise appeared because in order to meet future challenges, manufacturing companies can not longer be seen in isolation. They must rather be seen as a part of an inter-enterprise network.

Browne et al. (1995) identified five trends that have contributed to this trend:
1. The drive for reduced product life cycles.
2. The issue of time-based competition and the need to reduce time-to-market for new products.
3. The need for heightening the awareness of environmental problems through a product lifecycle view.
4. The need to creating organisation and systems that attract high quality people.
5. The need of making manufacturing strategies that fits the individual manufacturing facilities within the supply chain.

The Extended Enterprise can be described as a collection of organisations or parts of organisations, customers, suppliers, and subcontractors that are

[72] The “bull whip” effect addresses the problem with amplification of demand variability as we move upstream the supply chain.
[73] See section 4.3.4.

engaged in the design, development, production, and delivery of a product to an end user (Browne et al. 1996). This means that an extended enterprise represents a view that goes beyond the traditional boarders of a firm so that it no longer can treat its nearest suppliers and customers as "*them*", but include these as a part of "*us*" (Browne et al. 1995).

The Extended Enterprise separates itself from other kinds of inter-enterprise collaboration by exchanging information seamlessly on top of an already existing and successful relationship (Jagdev &Thoben, 2001). This indicates that application of ICT system is an important, but not sufficient enabler for an Extended Enterprise.

The Virtual Enterprise is a concept that is closely related to the Extended Enterprise. The Virtual Enterprise can be described as a network of independent organisations that virtually are acting as a single entity to provide a product or service.

Matrtinez et al. (2001) presented the main objectives of a Virtual Enterprise as the establishment of a common working environment where the attaining companies participates contribute with their strengths and core competes to the achievements of a common goal. Jagdev &Thoben (2001) found the following characteristics of this kind of inter-enterprise collaboration:

- *The partners (or more) in the Virtual Enterprises are individuals and independent companies who come together and form a temporary consortium to exploit a particular market opportunity.*
- *Within the scope of collaboration, partners share vision and work towards shared goal.*
- *Partners in Virtual Enterprises make extensive use of ICT technologies for communications and sharing information. Most of the day-to-day information exchange among the partners will almost always be automatic and without human interference.*
- *Virtual Enterprises assemble themselves based on cost effectiveness and product uniqueness without regard to organisation size or geographic location.*
- *Unlike SC[74] or EE[75], Virtual Enterprises once formed will have a unique dynamics, new identity and quite possibly a new name.*

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[74] SC = Supply Chains.

- *The efficiency of the Virtual Enterprise is greatly determined by the speed and efficiency with which information can be exchanged and managed among business partners. Efficient collaborative engineering, production and logistics require effective electronic management of engineering and production information. Thus it is a prerequisite that participating enterprises have sufficiently sophisticated IT and decision support tools and mechanisms to make the integration possible.*
- *Virtual Enterprises pool costs, skills, and core competencies to provide world-class solutions that could not be provided by anyone of them individually. Therefore, Virtual Enterprises often focus on complete products or solutions as opposed to providing partial solutions in a value chain.*
- *The decisions are jointly arrived at by making the best use of the competencies among the partners.*
- *Virtual Enterprises will often be complex networks where each enterprise can be seen as a node.*
- *The relationship between a set of Virtual Enterprises will mostly be non-hierarchical in nature.*

Jagdev & Thoben (2001) considers Extended- and Virtual Enterprises as sophisticated versions of supply chains. According to them, the essential features and underlying principles of supply chains are still valid within Extended- and Virtual Enterprises:

"*The Extended- and Virtual Enterprises are merely new paradigms reflecting the extent to which the information systems of the collaborating enterprises are integrated with one another and they actually communicate and collaborate with one another. In other words, Extended- and Virtual Enterprises are different (more sophisticated!) manifestos of the supply chain. Hence most of the underlying principles and operational issues prevalent in a supply chain will be present in Extended- and Virtual Enterprises. Indeed, the supply chain between the collaboration enterprises has to be set up before they switch to Extended- or Virtual Enterprise mode"*

Christopher (1998) confirms this view of regarding the Extended- and Virtual Enterprise as extensions of supply chain thinking. He presents the

[75] EE = Extended Enterprises.

Extended Enterprise an organisation without borders to its suppliers and customers, and that have formed tightly integrated supply chains through applications of ICT systems:

"*Underpinning the concept of the Extended Enterprise is a common informational "highway". It is the use of shared information that enables cross-functional, horizontal management to become a reality. Even more important it is the information shared in the supply chain that makes possible the responsive flow of products from one end of the pipeline to another. What has now come to be termed the Virtual Enterprise or - supply chain is in effect a series of relationships between partners that is based upon the value-added exchange of information*"

Christopher (1998) illustrates this view through a figure (See Figure 11):

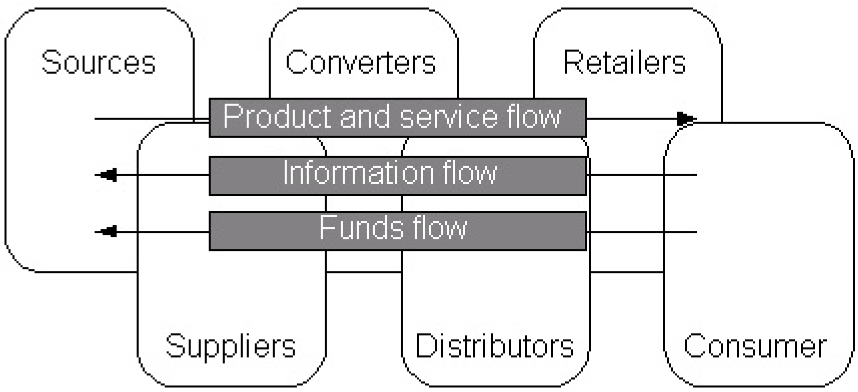

Figure 11. The Extended- and Virtual Enterprise (Christopher, 1998) [76].

Figure 11 outlines the relations between Supply Chain Management and the Extended- and Virtual Enterprise. Most of the underlying logistics principles from Supply Chain Management are still valid within the Extended and Virtual Enterprise. However, the Extended- and Virtual Enterprise include their nearest partners in a collaborative process throughout the whole product life cycle. This means that the Extended- and Virtual Enterprises are strategies that are based on the assumptions of the integrated supply chain, but represents a scope that goes beyond what traditionally is known as logistics issues[77].

[76] Christopher refers to "A.T. Kearney" as the source of this illustration.
[77] This may be the reason for that the management of the Extended- and Virtual Enterprise often is described from a project management point-of-view. See e.g. Kovács & Paganelli (2003), or Martinez et al. (2001).

4.3 The Supply Chain Software Package perspective on the role of applications of ICT systems for logistics

During the last decade, many different software packages have been developed to support logistics tasks within and between partners in a supply chain. These tools have had a great impact on how logistics is performed within supply chains. This is reflected in recent logistics- and Supply Chain Management literature that often have a considerable coverage of such software packages[78]. The most important of these software packages are presented in this chapter.

4.3.1 Enterprise Resource Planning systems

The term "Enterprise Resource Planning" (ERP) was introduced by Gartner Group in 1990[79], and can be defined as:

"*A method for the effective planning and control of all resources needed to take, make, ship, and account for customer orders in a manufacturing, distribution, or service company*" (APICS Dictionary ninth Edition).

Even if "ERP" initially were presented as a method for managing a enterprise, the term has undoubtedly become most known as a standardised type of software package. These software packages have been commonly used during the 1990s and today[80] they are the backbone of most enterprise's business related ICT systems.

The ERP systems are based on the MRP systems, but its original functionality has been expanded to embrace more business functions (Ptak & Schragenheim, 1999; Wortmann, 1998). There have been made ERP systems for enterprises of all sizes[81], and several software vendors have focused their systems towards one or more business sectors.

Nonetheless, all ERP-packages consist of various parts or modules that can support different functional areas within an enterprise. The number and type of modules included may vary from software package to

[78] See e.g. Bowersox (2001), Bloomberg et al (2002), Christopher (1998), Copacino (1997), Ross (1998), Knolmayer, et al. (2002), Ptak, & Schragenheim (1999), Hoover et al. (2001).
[79] See www4.gartner.com (accessed; 10.09.03).
[80] 2003.
[81] The most known of the ERP-packages are the ones that made for larger enterprises, like SAP R3, Oracle application, Peoplesoft, JDEdwards and Baan.

software package and installation to installation[82], but the most important of these can be summarised in the figure below (See Figure 12).

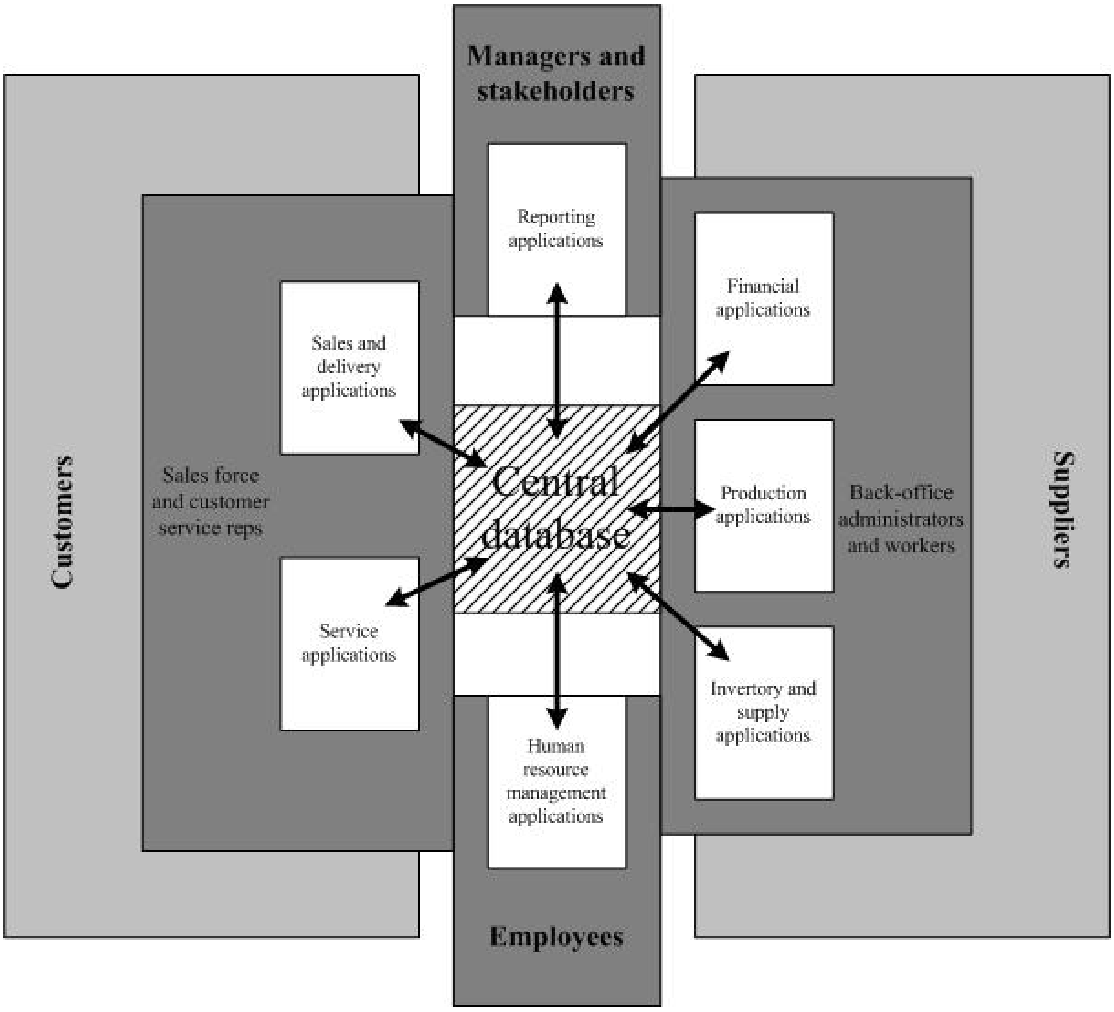

Figure 12. The ERP-system (derived from Davenport, 1998).

Figure 12 indicates that the ERP system has the functionality to support the main functions within a manufacturing enterprise such as production, financials, inventory and supply, services, and sales and deliveries. It can therefore handle information derived from various sources, like suppliers, customers, employees, managers and stakeholders.

Despite of its name and it's origin from the MRP systems, the true ambition of the ERP system is not planning, but integration of traditional separated business functions through a common database (Koch et al., 2003). This common database may reduce the efforts and costs for storing

[82] See e.g. apics's ERP survey at www.apics.org (accessed: 02.10.02).

and rationalising redundant data, re-keying and reformatting data from one system to another, updating and debugging obsolete software code, as well as for programming communication links between systems to automate the transfer of data (Davenport, 1998).

Nonetheless, the greatest benefit of the ERP-system's integrated nature is its potential to create processes that goes beyond the traditional functional borders of a company (Bowersox et al., 2002; Ptak and Schragenheim, 1999; Christopher, 1998). The ERP-system integrates a company's internal departments and through functionality like Distribution Requirements Planning (DRP)[83], their enterprise-internal warehouses and factories.

Davenport (1988) describes this integrated nature as the allure of these systems. He uses an imaginary example to illustrate this attraction:

"Let's say for example, that a Paris-based sales representative for a U.S. computer manufacturer prepares a quote for a customer using an ES (note: ES = Enterprise System = ERP system). *The salesperson enters some basic information about the customer's requirements into his laptop computer, and the ES automatically produces a formal contract, in French, specifying the product's configuration, price, and delivery date. When the customer accepts the quote, the sales rep hits a key; the system, after verifying the customer's credit limit, records the order. The system schedules the shipment; identifies the best routing; and then, working backward from the delivery date, reserves the necessary materials from inventory; orders needed parts from suppliers; and schedules assembly in the company's factory in Taiwan.*

The sales and production forecasts are immediately updated, and a materials-requirements-planning lists and bill of materials are created. The sales rep's payroll accounts are credited with the correct commission, in French francs, and his travel account is credited with the expense of the sales call. The actual product cost and profitability are calculated, in U.S. dollars, and the divisional and corporate balance sheet, the accounts-payable and accounts-receivable leaguers, the cost centres account, and the corporate cash levels are all automatically

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[83] DRP is connected to the management of distribution orders within an enterprise and can be described as "*a function for determining the need for replenishing inventories at branch warehouses*" (APICS Dictionary, ninth Ed.).

updated. The system performs nearly every information transaction resulting from the sale."

The ERP-system has undoubtedly a potential for integrating and rationalising processes. However, the ERP systems have other impacts on the organisation as well. Norris et al (2000) summarises these in the following manner:

"What ERP really does is organise, codify, and standardise an enterprise's business processes and data"

This view is supported by Davenport (1998), who describes the configuration of such systems as a series of compromises between how the firm wants to work and how the system allows them to work. He calls attention to the danger of choosing a system that may collide with the organisation and/or its strategy.

The ERP systems have developed enormous amounts of tables and parameters in order to be configurable enough to meet the various requirements from the different companies[84]. This pursuit for flexibility has led to complexity, which again have increased the difficulty of installing an ERP-system (Wortmann, 1998)[85]. Further, the flexibility seems only to be valid when it comes to configuring the systems. There is usually difficult to change something in the configuration after the ERP system is implemented and running in the organisation. In addition, the implemented solutions are often similar to corresponding installations in other companies, which may lead to a loss in the unique competitive advances a company has on its competitors (Davenport, 1998; Upton & McAfee, 2000). The ERP-system may therefore be understood as too flexible in the process of implementation and too inflexible and standardised when it is implemented.

Despite of these unfortunate characteristic, there are indications that most implementations of ERP systems have been for the best for the company. Olhager & Selldin (2003) for instance, found that the main share of Swedish enterprises that have adopted an ERP system, improved their performance measures in several areas. Like quickened information

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[84] Bancroft (1996) reports that SAP R3 has approximately 8000 configuration tables.

[85] Even if the ERP systems can be configured to follow almost an infinite number of business models, most companies do perform modifications- or make additions to these in order to meet their specific business requirements.

response time, increased outcomes across the whole enterprise, and improved order management cycles. While Hunton et al. (2002) claimed that the ERP adopters in his study performed significant better on return on assets, return on investments, and asset turnover than non-adopters.

4.3.2 ERP systems for logistics

The ERP system embraces more than all logistics issues. Therefore, in this section the main logistics functions of the ERP systems are identified and presented.

As mentioned, the ERP system arose from MRP systems, but other software packages have influenced the functionality of the ERP systems as well. While new functionality is constantly being added into these systems. According Forger (1999) the logic now known as the logistics functionality of the ERP systems, came from five different software packages that were integrated with the original idea of Enterprise Resources Planning. These software packages are:

- Supply Chain Planning (SCP) systems. These systems represent analytical tools for planning across the supply chain[86].
- Order Management Systems (OMS). The Order Management Systems is used to manage, validate, and prioritising customer orders.
- Manufacturing Execution Systems (MES). The manufacturing execution functionality manages resources at the shop floor so that production orders can be fulfilled in best possible manner. For instance by allocating sufficient equipment, capacity, and raw materials.
- Warehouse Management Systems (WMS). This functionality controls all activities within the four walls of the warehouse.
- Transportation Management Systems (TMS). The Transportation Management Systems manages the inbound, outbound, and intra-enterprise movement of goods.

Even if the different ERP-systems holds much- and advanced logistics functionality; the basic principle of how these systems drive the logistics processes throughout the manufacturing companies are somewhat simple.

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[86] Another word for the Supply Chain Planning module is the "*Supply Chain Management-*" or the "*Advanced Planning and Schedule*" module. The functionality of this ICT system will be discussed in the next section.

This principle can be described through five basic parts, functions, or modules[87].

- Customer order management. This part of the ERP-system deals with customer order receipts and deliveries.
- Production order management. This module supports most aspects concerning production planning and execution.
- Purchase order management. This module is connected with managing purchase orders and goods receipt.
- Distribution order management. This part of the ERP system administrates the transfer of goods between an enterprise's internal warehouses and/or producing units.
- Inventory management. This module supports most aspects connected to information handling for inventory management and the transfers of materials between stock locations within a factory or a warehouse. The inventory management functionality is the core of the ERP system's logistics functionality, and acts as a base for the other functions and allows these to interact.

In addition, ERP installations for logistics within manufacturing environments do usually involve applications for financial management[88]. The financial capabilities of the ERP-systems will not be discussed in this thesis.

The mentioned functions or -modules interact to support the flow of materials throughout a company. This is illustrated in Figure 13.

[87] These functions have been found through literature studies and studies of several ERP software packages. Including: Baan, Intentia/Movex, Oracle Applications, and SAP.
[88] Olhager & Selldin (2003) found that ERP-systems in Swedish manufacturing companies are mainly used to support the material and information flows, and secondary the financial flows.

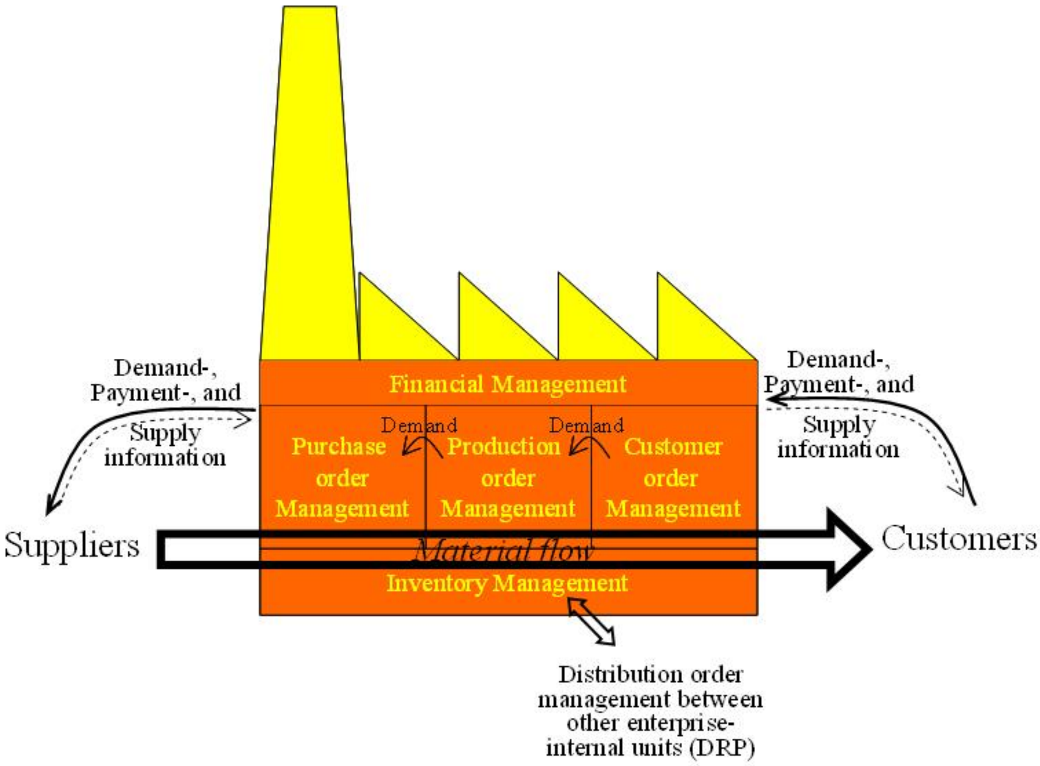

Figure 13. ERP-systems for logistics (revised from Floer, 1999).

Figure 13 outlines that customer requirements are entered into the ERP-system as customer orders. These requirements are then transmitted throughout the company and towards other units with the help of production orders, as well as purchase- and distribution orders.

The customer orders are used as a backbone for the information handling throughout the whole order-to-delivery cycle; from order entry, via things like picking, packing and delivery, to the final invoicing.

The customer orders play also an important role in driving the production processes. This because the customer orders can – both directly and indirectly – be used to initiate planned production orders. The way this is done depends on the company's manufacturing strategy and the corresponding configuration of the ERP-system[89].

Rolstadås (1992) separated between three main principles for initiating production requirements:

[89] ERP-system can be configured to meet several different manufacturing strategies, like Make-to-Stock, Assemble-to-Order, Make-to-Order, and Engineer-to-order.

1. Order initiated systems. In this case each customer order line acts as signal for initiating the production requirements.
2. Stock initiated systems. This principle consists of two replenishment methods. First, the reorder point methodology that initiates a replenishment signal of a fixed reorder quantity every time a stock level (and its scheduled receipts) reaches a predetermined level. Second, the time phased reorder point methodology that initiates a replenishment signals through fixed time phases, and in such a quantity that a stock level (and its scheduled receipts) should reach a predetermined level.
3. Program initiated systems. This principle dictates that the production is initiated by requirements calculated from a material requirements plan which may include things like forecasts, inventory levels, scheduled receipts, and scheduled withdraws.

All three principles can be used by the ERP systems to generate planned production orders[90]. This means that sales requirements can be transferred into planned production orders in three basic ways; first through requirements that directly are generated from each customer order line. Second, by that a product's on-hand quantity reported in the ERP systems database is hitting a reorder level (or a reorder time is due). Finally, the planned production orders can be initiated through requirements that are calculated from a material plan. In other words; The ERP-system can be configured to follow customer order initiated production, re-order point initiated production, or production based on a net/gross calculation[91].

After they are initiated, the planned production orders are included in a material requirement plan. Then as their scheduled start date arrives, these planned production orders are sequential turned into firm planned orders-, and later actual production orders[92]. The production orders are thereby used as an information backbone throughout the whole production process, through the support of things like withdraws of raw materials, determination of routings, production data acquisition, job-shop scheduling, and put away of finish goods.

[90] Of course, production orders can also be created manually by a user.
[91] For information: the MRP logic dictates that the production shall be initiated from net/gross calculations that are based on forecasts.
[92] Normally, the planned order proposals are immediately turned into real production orders when an order initiated principle is used.

Not all ERP installations follow the production logic described above. Some may utilise an alternative production logic included in the ERP-packages (or an add-on software package), such as flow production or electronic Kanban[93]. In addition, companies like distribution companies, or companies that make use of manual- or a third party production planning systems may override the production module of the ERP-system.

Regardless production method, the requirements from production (and/or sales) impels a demand for purchased products. In the ERP-system, these requirements are initially shaped as planned purchase orders that either is created manually by a user or automatically generated by the ERP-system[94].

The planned orders are then turned into actual purchase orders, which open for that that ordering documents can be sent to the suppliers. The ordering documents can either be printed and send "manually" to the customers, or they can be transferred directly through the use of electronic communication devices[95]. Finally, through events like put away, quality inspection, and invoice processing, the purchase orders records plays an important role when the goods arrives from the suppliers.

The last order type is the distribution orders that function more or less through the same principles as for the other orders types. The distribution orders are used to transfer materials between various warehouses and production units the enterprise and therefore they supports both inbound and outbound transactions within these units.

By keeping track of products, on-hand levels and other inventory information, the inventory management module of the ERP-system supports and connects the management of the customer-, production-, purchase, and distribution orders. In addition, the inventory module includes functionality that supports thing like product costing, physical inventory, inventory statistics, lot numbering, and the movement of goods within a warehouse or manufacturing plant.

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[93] See APICS's ERP-survey at www.apics.org (accessed 02.06.03) for an overview of the production functionality of the ERP-systems.

[94] The ERP-system can generate planned purchase orders through the same principles as for the planned production orders. However, some kind stock initiated logic is normally used for this task.

[95] E.g. like EDI or XML, see section 4.3.4.

An indicated above, the essence of ERP systems for logistics can be described as integrated order management (Knolmayer et al. 2002). As good as all logistics transaction data within the ERP-system are related to some kind of orders. Such an order handling logic is so thoroughly founded in most manufacturing- and logistics companies[96] of today's, so that only a very few alternatives to the ERP systems exists. Indeed, for most companies, the only alternative to the ERP system is to use separate applications for order management or to integrate the individual software packages with help of Enterprises Application Integration (EAI) technology[97] (see e.g. Jacobs, 2003). But even these installations do usually result in a business logic that follows the same order management principles that is embedded within the ERP systems.

As good as all current companies utilities an ERP system. For example, Olhager and Sledin (2003) found that 89,1% of the Swedish firms in their study had implemented-, or were in process of implementing an ERP system. Rutner et al. (2003) found that the corresponding numbers was 93% for their study concerning companies in the United States. While in a survey of Norwegian companies by Bolseth et al. (2002), all of the respondents confirmed that they used an ERP-system.

Therefore, the ERP system is the backbone of the logistics related ICT systems in most companies today, and will continue to hold this position for several years to come (Wortmann, 1998; Bowersox et al., 2002).

New modules and functionality are constantly being added into ERP packages. Most of these extensions have only an indirect effect on how the ERP system supports logistics issues. For example Choy et al (2003) presented the Customer Relationship Management (CRM) system and it's less known counterpart, the Supplier Relationship Management (SRM) system. The Customer Relationship Management systems can help a company to understand its "*customers from the perspective of who they are, what they do, and what they're like*" (Couldwell, 1998), while the SRM system supports a company with finding and managing preferred suppliers in order to maximise the value of the manufacturer's supplier base (Hermann and Hodgson, 2001).

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[96] Almost all logistics related companies utilise some kind of customer- or purchase orders, even if some companies use Kanban systems or other alternatives to production orders.
[97] EAI = "*a set of technologies that allow the movement and exchange of information among different applications and business processes within and between organisations*" (Stallings, 2001).

However, an extension that in this thesis is termed as the "Supply Chain Planning" systems has lately received considerable attention in the logistics literature. This module will be presented in the next section.

4.3.3 Supply Chain Planning systems

The Supply Chain Planning system, which sometimes also has been referred to as an Advanced Planning and Scheduling (APS)[98] system, extends the logistics functionality of the ERP system. These applications are either an integrated part of the ERP system, or they may be an add-on application made by a third party software vendor (Bowersox et al., 2002).

According to Bowersox et al. (2002), the Supply Chain Planning systems arose because of four new logistics requirements. First, the reduction of planning-horizons through JIT[99] initiatives had shortened planning cycles, and simultaneously generated a need for more comprehensive- and effective planning tools. Second, the need for visibility of supply chain inventories and -resources. Third, the need for simultaneous consideration of supply chain resources. Finally, the increasing need for better supply chain resource utilisation.

The exact functionality of the Supply Chain Planning systems may vary from software package to software package. However, the Supply Chain Planning systems use mathematical models to find solutions to problems that range from strategic-, via tactical-, to operational analysis (Norris et al., 2000). Examples on applications of such tools are demand planning, network optimisation, production planning, inventory planning, requirements planning, and transportation planning (Bowersox et al. 2002).

The Supply Chain Planning systems may also have the ability to act upon several ERP systems. This opens a potential for using these systems to follow the ideals of Supply Chain Management through the integration- and coordination of logistics planning data from number of non-integrated databases.

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[98] The Advanced Planning and Scheduling system is also (and more usually) connected to the OPT concept, see section 4.1.3. (Ptak and Schragenheim, 1999; Blanchard, 1998).
[99] See section 4.1.2.

There are companies that claim that their logistics performance has been improved through the use a Supply Chain Planning system (Norris et al., 2000). Nevertheless, the Supply Chain Planning systems represent advanced planning functionality that is performed through complex mathematical algorithms, which again requires a high degree of data integrity. This means that a small inaccuracy in the planning data may have dramatically impact on decision reliability and stability (Bowersox et al., 2002). Further, the Supply Chain Planning is usually placed "on top of" one or more ERP systems (Knolmayer et al. 2002). This means that the MRP-based ERP system provides the Supply Chain Planning system with most of its planning data, which again – as indicated in chapter 4.1.1 – has been considered as good as unfit for planning tasks because of its lack of integrity between its planning data and real life events.

4.3.4 Internet applications

At all times logistics information has been communicated between internal- and external business units through the use methods like letters, personal contacts, messengers, and fax messages, but the arrival of the internet has introduced a new whole range tools in this field.

Debates concerning internet and logistics do often involve the impacts of EDI and XML. Electronic Data Interchange (EDI) is a method for structured information transfers to provide a direct communication link between the information systems within separated business units. EDI have been around for more than 25 years and use standardised document formats to transfer trading documents such as purchase orders, invoices, and bills of lading (Stalling, 2001). The usage of EDI system has the potential to increase productivity, improve channel relationships, and decrease operation costs. However, this type of connections is static and structured, and special expertise is required for both establishing and maintaining the communication links. EDI solutions are therefore best suited for high volume, longer-term relationships (Bowersox et al., 2002).

For smaller of volumes of transactions are standards based on eXtensible Mark-up Language (XML) emerging as an alternative. XML is a mark-up language based on internet standards for structuring document information. This programming language can be used in the transfer of data between ICT systems, databases, and Web-browsers (Bowersox et al., 2002). By first glance, XML can be understood as inexpensive, flexible, and easy to maintain and therefore superior to EDI. However, EDI and XML are not variants of the same thing. XML is simply a programming language for structuring data through the internet, while EDI is a collective term of certain communication standards for electronic data interchange. This means that it is the communications standards that are based on XML that "competes" with EDI, and not XML itself.

Several communication standards have been made for XML[100] but none of them have yet overtaken the role of EDI (Norris, et al., 2000). Lately, there have also been raised question if these XML standards will ever conquer the EDI transactions, or if they only will complete these[101].

There are myriads of other internet based applications of ICT systems that are connected to Supply Chain Management. Ovalle and Marquez (2003) claim that replenishment information between two partners in a supply chain is often exchanged through a Continuous Replenishment Program (CRP) or a Vendor Managed Inventory (VMI). A Continuous Replenishment Programs implies that the buyer shares his inventory data with the supplier, so that the supplier can initiate the replenishments. Vendor Manage Inventory is a related approach that enables manufacturer-driven replenishments through updated information about the retailer's stock level situation. However, the Vendor Managed Inventory differs from similar methods of collaboration in the supply chain by suggesting that the manufacturer, and not the retailer, should create the purchase order. Another related approach is the Co-Managed Inventory (CMI)[102], which suggests that the supplier and buyer should both share inventory information and the responsibility for managing the supplies (Tyan & Wee, 2003).

A hot topic when is comes to applications of ICT systems over the internet is Collaborative Planning and Forecasting (CPFR). Collaborative Planning and Forecasting can be described as an inter-enterprise process that enables retailers and manufacturers to jointly schedule production and forecast demand (Ovalle, et al. 2003). According to Bowersox et al. (2002) the Collaborative Planning and Forecasting process supplements automatically replenishment strategies with a cooperative process where the supplier and buyer work together to develop plans. Collaborative

[100] E.g. OASIS, EDIXML, OBI, and Rosettanet.
[101] See "The truth about XML" The McKinsey Quarterly, 2003 Number 3.
[102] Another word for CMI is Jointly-Managed Inventory (JMI).

Planning and Forecasting process can be separated into three steps that each includes several activities (Hugos, 2003):

Collaborative Planning:
1. A front-end agreement is negotiated for defining the responsibilities of each of the collaborating companies.
2. A joint business plan is made that illustrates how these companies will work together to meet customer demand.

Collaborative Forecasting
1. Each of the collaborating companies prepares a sales forecast.
2. Any exceptions or difference between the sales forecasts is identified.
3. The exceptions are resolved to provide a common sales forecast.

Collaborative Replenishment
1. Each or the collaborating companies prepare a replenishment forecast.
2. Any exceptions or difference between the replenishment forecasts is identified.
3. The exceptions are resolved to provide an efficient production- and delivery schedule.
4. Actual orders are generated to meet customer demand.

According to Johnson (1999) a Collaborative Planning and Forecasting solution requires information from three ICT systems; The Customer Relationship Management system that contributes with anticipated demand for promotions and forecasts; the Supply Chain Planning system that is used to determine requirements that affects the forecasts; and the ERP system that provides item catalogues and actual orders (See Figure 14).

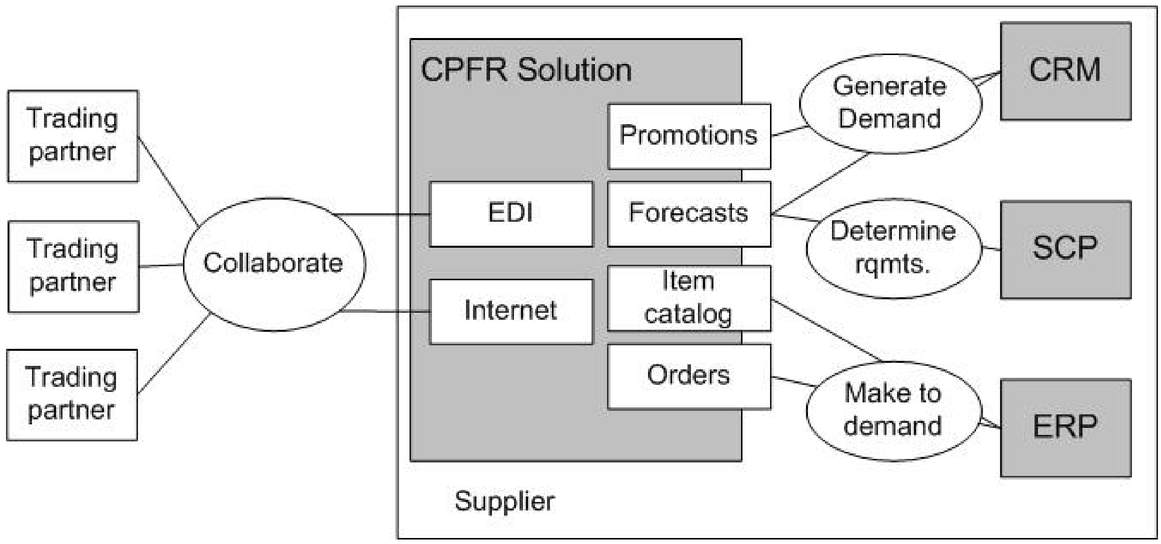

Figure 14. Collaborative Planning and Forecasting (Johnson, 1999).

Figure 14 illustrates that a Collaborative Planning and Forecasting solution use information from the three mentioned ICT systems to prepare promotions, forecasts, item catalogues and actual orders. Then, this information is transmitted between the collaborating parties through the use of EDI- or internet applications so that common plans can be prepared.

Applications based on internet technology will play an essential role in increasing Supply Chain performance. New concepts- and software for supporting logistics issues through the internet are continuously being developed, while some do even claim that applications of ICT systems based on internet technology will dominate how information handling is performed within future supply chains (Norris et al. 2000).

Internet applications have opened new possibilities for effective Supply Chain Management. However, none of these can replace the order processing logic of the ERP system. This means that the traditional ERP systems are still the backbone in most supply chain's logistics information systems. Therefore, applications of ICT systems in supply chains can be seen as a network of connected ERP systems and their support applications. Such a view is sketched in the figure below.

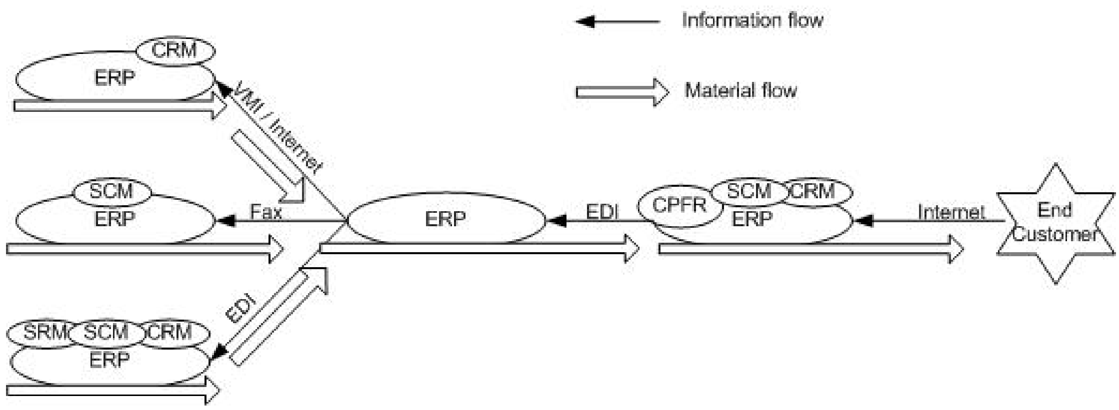

Figure 15. An example on applications of ICT systems in a supply chain.

Figure 15 illustrates an example of information handing in an internet enabled supply chain. All involved parties utilises ERP systems for order management and transactions processing, while some units make use of a Supplier Relationship Management-, a Customer relationship Management-, and/or a Supply Chain Planning system to enhance the functionality of the ERP-system. Between the ERP systems, the different members in the supply chain utilise various internet applications, or other methods, to coordinate and transfer replenishment information (like EDI, Vendor Managed Inventory, or fax messages).

4.3.5 The future of applications of ICT systems for logistics?

There are several indications that information handling in supply chains will continue to build upon the framework the of the ERP system. Most of the other applications mentioned in this (and the previous-) chapters has already been integrated within ERP packages. This has formed Extended ERP systems that combine the standard ERP-functionality with advanced supply chain functionality[103]. This indicates that these kind systems will continue to grow and explore its functionality in the same manner as it have done since they first appeared as the BOMP for almost 50 years ago.

Gartner Group[104] predicts that the ERP systems will eventually evolve in into ERPII systems[105]. ERPII dictates that the future of applications of

[103] See e.g. www.baan.com, www.ifs.com, www.intentia.com, www.oracle.com, or www.sap.com (accessed; 10.09.03).
[104] Gartner Group did also introduce the term “ERP”.

ICT systems for logistics will be based on the current ERP-systems, but they will extend their functionality throughout the internet (Ward, 2001). Gartner Group defines this transaction from ERP to ERPII through six dimensions (Bond et al, 2000):

- Role. ERP focuses on enterprise optimisation, while ERPII turns towards value chain participation and enabling collaborative commerce.
- Domain. ERP is mainly focused towards manufacturing- and distribution businesses, while ERPII will support all sectors and segments.
- Function. The ERP-systems supports functions like manufacturing, sales, distribution, and finance. ERPII will support cross industry sectors and specific industry processes.
- Process. The processes of ERP-systems are internal and hidden. Externally connected processes are a main characteristic for ERPII.
- Architecture. The closed, monolithic architecture of ERP is turned into a web-based-, open-, and componential architecture in ERPII.
- Data. ERPII systems will publish and subscribe data both internally and externally, while the ERP systems of today is internally generated and consumed.

Even if Gartner Group predicts a complete transformation of the traditional ERP systems it is clear that the vision of ERPII is the results of a direct evolution from the earliest BOMP/MRP systems. This development is illustrated in Figure 16.

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[105] For information: ECM (enterprise commerce management) is a similar-, but alternative, concept to ERPII. The vision of ECM is promoted by AMR research (www.amrresearch.com), and focuses less on the technological development the ICT systems.

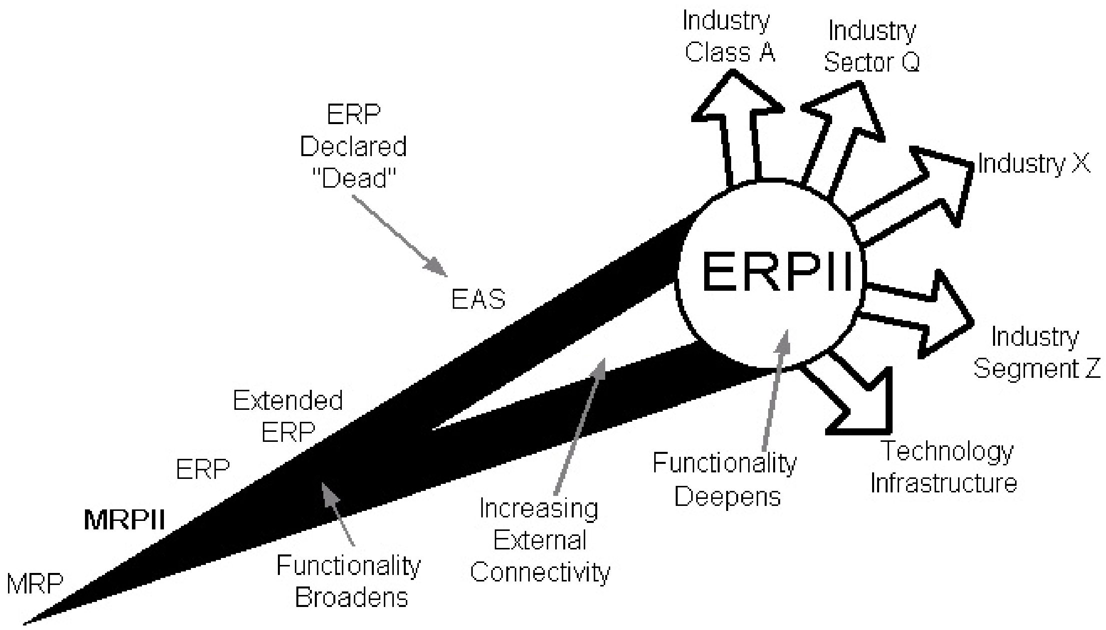

Figure 16. Gartner Group's ERPII (Bond et al. 2000).

Figure 16 indicate that the ERP system will broaden its functionality and form extended ERP systems, which sequentially is turned into Enterprise Application Suites (EAS). The EAS can be described as a vision where the ERP-system has expanded it functionality to such an extent that it can support all business units within an enterprise. According to Gartner Group this state of EAS will be succeeded by a focus on external integration and a specialisation of the software functionality towards specific industry domains, which finally will make up ERPII.

"…the EAS's unwritten mantra of providing "all things to all people" within the enterprise renders it ill-suited to a future that demands focus and external connectivity. The ERP II vision addresses the future by focusing on deep industry domain expertise and inter-enterprise, rather than just enterprise business processes." (Bond et al., 2000).

5 A critical discussion of the current perspectives on the role of applications of ICT systems for logistics.

The previous chapter presented three current perspectives on the role of applications of ICT systems for logistics.

- *The Manufacturing perspective* that illustrated the role of applications of ICT systems for logistics through various manufacturing planning and control concepts.
- *The Supply Chain Management perspective* that illustrated the role of applications of ICT systems for logistics through the concept of Supply Chain Management.
- *The Supply Chain Software Package perspective* that illustrated the role of applications of ICT systems for logistics through the inherent properties of currently available logistics software packages.

In this chapter, the way these three perspectives look at the role of applications of ICT systems will be further discussed. However, in order to provide a base for such a discussion; the basic ways for describing an ICT system must first be revealed.

Bjørke (1995) defined the essentials of a system in the following manner:

"A set of connected elements"

While APICS presented this definition (APICS Dictionary, ninth Ed.):

"A regularly interactive or interdependent group of items forming a unified whole toward the achievement of a goal."

Oliver et al. (1997) suggested a similar definition:

"A system is a complex unity formed of many often diverse parts subject to a common plan or serving a common purpose."

These definitions indicate that systems are built from some kind of items, parts, or elements that through interconnections forms a set, whole or unity, in order to fulfil a purpose or achieving a particular behaviour.

Further, a system is a restricted phenomenon that interacts with is surroundings. This means that a system must be seen in relation to the context in which it operates. These observations correspond with the findings of Oliver et al. (1997), which suggests that a description of a system can consist of three fundamental parts: its structure, its behaviour, and its context.

The structure describes the system elements and how they are connected, or more promptly; *how the system is built*. The behaviour of the system describes the dynamics of this. Alternatively; *what the system does*. While the context illustrates *how the system relates or contributes to its surroundings*.

Oliver et al. (1997) makes it clear that there is no one-to-one connection between a system's structure and behaviour. Certain behaviours may be performed by different structures, and vice versa, a single structure can be used in different manners and for different purposes. Therefore, these two properties must be considered independently. For example, when systems are designed, the behaviour of the system is first outlined. This behaviour is usually based upon requirements from the context in which the system will operate. Then, the behaviour is mapped into different structures, and a trade-off between the best match of these two components are found and chosen[106].

This research seeks to find an alternative perspective on the role[107] of applications of ICT systems for logistics. This means that this research focus on how these perspectives dictates the function or *behaviour* of the applications of ICT systems within a logistics *context*. However, descriptions of the role of applications of ICT systems can also include the structure of the ICT systems. As in this simple example: EDI systems (the structure) are used to transfer ordering information between two companies (the behaviour), in order to integrate the processes of two companies within a supply chain (the contexts).

Using this logic on the tree perspective presented in the previous chapter, the following statements can be found;

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[106] For instance, when designing database systems, this is usually done through activity- versus object modelling.
[107] As mentioned, this research have defines "role" as "an expected function or behaviour".

The Manufacturing perspective tells us that given ICT systems (like MRPII systems, Kanban or OPT/serve systems) are used to support specific functions within the manufacturing plant (like production planning or material replenishments) in order to achieve a specific Manufacturing Planning and Control concept (like MRPII, JIT or OPT). This means that the Manufacturing perspective covers both the *structure* and the *behaviour* of the applications of the ICT systems, as well as the *context* they operates within.

The Supply Chain Management perspective tells us that applications of ICT systems for logistics are used to integrate the information flows between units in a supply chain in order to support the management- and integration of the total supply chain. This means that this perspective does not focus of the specific structure of the ICT systems. But it describes how the ICT systems should *behave* (support the integration of formation flows between companies) and in which *context* this behaviour operates (to support the management and integration of the total supply chain).

The Supply Chain Software Package perspective tells us that given ICT systems (like ERP systems, SCP systems, or EDI systems) are used to support specific tasks within a supply chain. This perspective covers the *structure* of the systems as well as their individual *behaviour*. However, these individual efforts do not share a clear, common logistics vision within a logistics context.

These three perspectives is summarised in Table 1.

Perspective	Structure (How the system is build)	Behaviour (What the system does)	Context (How the system contributes to logistics)
Manufacturing Perspective	The structure of the systems is illustrated through description of things like MRP-, Kanaban-, or OPT/Serve systems	The ICT systems support various functions within the manufacturing plant. Like production planning or materials replenishments	The ICT systems contribute in achieving a specific manufacturing planning and control concept. For instance, MRP systems supports MRPII, and Kanban supports JIT
Supply Chain Management Perspective	The specific structure of the ICT systems are not in focus	The ICT systems support the integration of the formation flows between units in a supply chain	The ICT systems contributes in achieving and managing an integrated supply chain
Supply Chain Software Package Perspective	The structure of the systems is illustrated through description of things like ERP-, SCP-, or EDI systems	The ICT systems support various functions within the supply chain. Like order management or collaborative supply planning	The individual systems does not share a clear, common, logistics vision

Table 1. Three perspectives on the role of applications of ICT systems for logistics.

In Table 1, it can be found that the current three perspectives identified by this research present the role of applications of ICT system for logistics in different manners. Manufacturing perspective, describes the role of the applications of ICT systems is through the behaviour- and the structure of the ICT system, as well as through the logistics contexts in which they operates. The Supply Chain Management perspective ignores the

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structure of the applications of ICT systems, which means that their role are only described through their behaviour and the context in which they operates. Finally, the Supply Chain Software Package perspective connects the behaviour of the applications of ICT systems to specific structures, but usually does not put these into a larger logistics context. This means that this perspective presents the role of applications of ICT system for logistics mainly through the structures of the ICT systems. These three views for looking at the role of applications of ICT systems for logistics are summarised in the figure below.

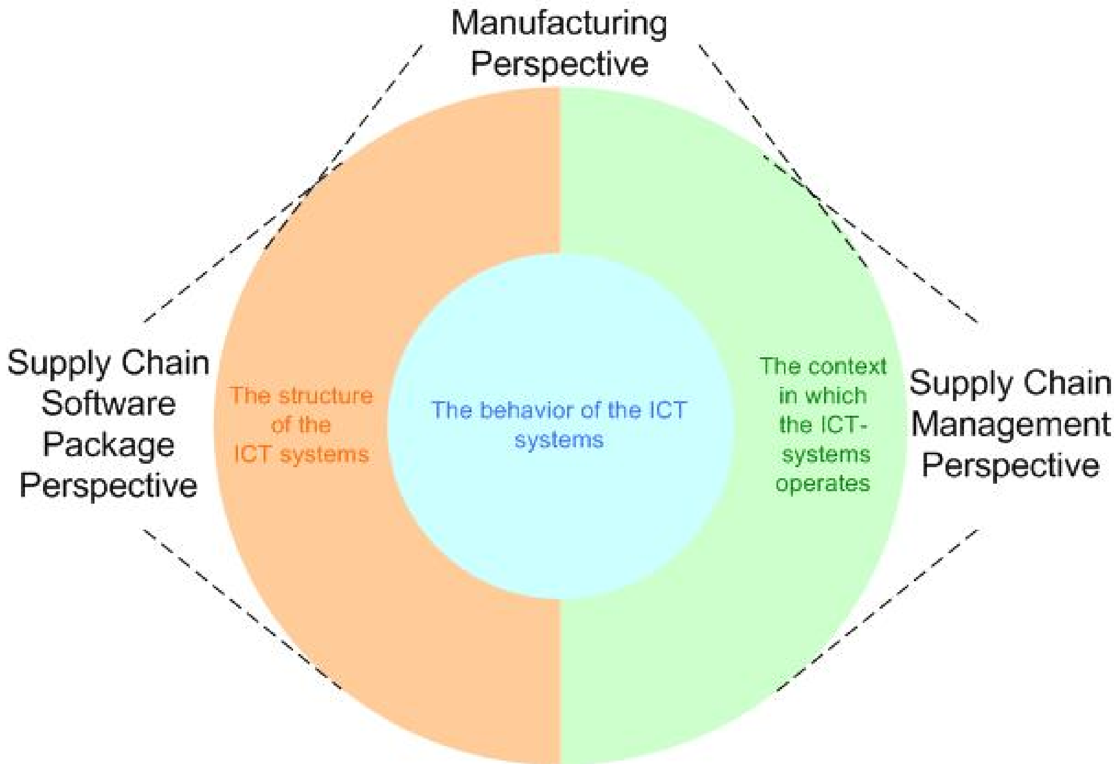

Figure 17. Tree current perspectives on the role of application of ICT systems for logistics.

The figure illustrates that the different perspectives presents the role of applications of ICT systems through different channels. The Manufacturing perspective presents this role by connecting the behaviour of the ICT systems to certain structures and puts these within a specific logistics context. The Supply Chain Management perspective presents the role of applications of ICT system for logistics through describing the behaviour of the ICT systems according to their place within the context of the supply chain. While the Supply Chain Software Package

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perspective presents the role of applications of ICT system for logistics by connecting the behaviour of the ICT systems to certain structures.

5.1 A discussion of the Manufacturing perspective on the role of applications of ICT systems for logistics

Through illustrations of the design and operation of things like Kanban systems or MRP-calculations, the Manufacturing perspective provides descriptions of both the structure and behaviour of ICT systems. Each of these applications of ICT system are again connected to a specific manufacturing planning and control concept (like MRPII, JIT or OPT).

This means that the Manufacturing perspective gives an integrated view on the structure, behaviour and context of the applications of ICT systems, and therefore it may seem that this perspective represents a complete view on the role of applications of ICT systems for logistics. This may not be the case, since by connecting the structure of an ICT system to certain contexts and behaviour is the same as locking a mean to an end.

This may result in problems of knowing when and where the different applications of ICT systems should be used and where they should not be used. For instance, according to the Manufacturing perspective the JIT concept is as an alternative to MRPII, but several Japanese authors[108] have illustrated that the Toyota Production System (and thereby JIT) is not necessarily incompatible with MRP based systems[109].

This problem has also been observed in the western literature. Vollmann et al. (1997) for instance, warns about using the “right” solution the “wrong” place:

“There’s a temptation to view some MPC (note: Manufacturing Planning and Control*) design options as a continuum where movement toward JIT is “good”. This isn’t the correct conclusion. We must match MPC system design with the ongoing need of a company’s market, the task in manufacturing, and the manufacturing process”*

[108] E.g. Ohno (1988), Shingo (1989) or Monden (1998)
[109] MRP system used in JIT environments is usually described and “Syncro MRP” systems.

Such observations resulted in that many started to talk about mixes of different manufacturing planning and control concepts during the 1990s[110]. Persson and Virum (1995) for instance, observed the following:

"*An increasing number of people is beginning to see that the choice of the manufacturing planning and control design depends on the prevailing circumstances, not "either-or" but a "both-and". For example JIT principles is not always superior the MRP principles, and vice versa… …A "good" principle used in the "wrong" situation is not a good solution*."[111]

However, having a mixed view on manufacturing planning and control systems will only dampen, and not solve these problems of the manufacturing perspective.

The Manufacturing perspective may therefore lead to technological determinism[112]. This can be illustrated through Shingo's[113] frustration of westerns managers' tendency of connecting the Toyota Production System and the Kanban control mechanism (Shingo, 1992):

"When I mention the Toyota Production System in the United States and Europe, people's first reaction is often, 'Oh, you mean the Kanban system, right?'

As far as they concern, the Toyota Production System and the Kanban system are the same thing! Their perception, in other words, is that the Toyota Production System does not exist apart from a Kanban system"

According to Shingo, such assumptions could lead to that the wrong ICT system was selected:

"Certain scholars and managers have proposed the use of various types of Kanban as an ideal. Such claims, however, only illustrate their ignorance about the basic function of production." (Shingo, 1992)

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[110] See e.g. Alfsnes & Strandhagen (2000)
[111] This paragraph was translated from Norwegian.
[112] Technological determinism holds that the technology determines the presiding events within its surroundings.
[113] As mentioned, Dr. Shigeo Shingo was one of the main architects behind the JIT concept.

This illustrates that this way of looking at applications of ICT systems was heavily criticised by Shingo (1989, 1992). Shingo claims that many western authors are so focused on the methods and tools at the Toyota plant that they are forgetting the purpose of these, while he emphasises that these only are means for achieving the goal of JIT and are not goals in themselves. He points out that the methods and tools described in the JIT literature is formed by the specific circumstances at Toyota plant, and may therefore not be the best approach for achieving JIT in other settings. To prove his point he refers to a washing machine manufacturer that followed the basic ideas of JIT and integrated their production processes so tight together that no traditional information systems were needed (Shingo, 1992).

Therefore, the main problem with the manufacturing perspective's view on the role of applications of ICT systems for logistics is that it assumes that a specific ICT system that has functioned well in one place will perform just as well in other places. Further, this perspective substantiate a thought of that implementing a specific application of ICT system is the same as achieving the basic ideas or principles of a manufacturing planning and control concept. And vice versa, achieving the basics of a manufacturing planning and control concept can only be reached through applying certain ICT tools.

Another, and more explicit problem with the Manufacturing perspective, is that it focuses on the manufacturing processes within a company. Applications of ICT systems for logistics should be regarded without limiting the perspective to the internal functions of an organisation.

5.2 A discussion of the Supply Chain Management perspective on the role of applications of ICT systems for logistics

As mentioned, the Supply Chain Management perspective presents the role of application of ICT systems for logistics as tools that integrates the information flows between units in a supply chain in order to support the management- and integration of the total supply chain

This perspective describes the behaviour of the ICT systems according to the conceptual ideas of Supply Chain Management (context) without locking this view to specific structures. For the purpose of this research, this way of looking at the role of applications of ICT systems for logistics is advantageous, because descriptions of specific software packages or ICT system designs will not interfere with how the application of ICT systems can contribute to the logistics mission of a company.

However, there are some other features of Supply Chain Management that may undermine its role as a base for understanding the role of applications of ICT systems for logistics.

One of these is connected to the management and their relations to the rest of the organisation. Even if the basic thoughts of Supply Chain Management have its roots from more holistic Japanese manufacturing approaches; the inventors of this concept did make it clear that the Japanese management styles should not be imitated:

"It is not feasible, of course, to suggest that Western firms slavishly emulate the Japanese, either in terms of the particular features of their production operation (de-integration, smaller plants, narrowly focused facilities, etc.) or in terms of their particular managerial style (consensus and "bottom-up" decision making)" (Oliver & Webber, 1992).

Supply Chain Management dictates a clear top-down focus that stresses the role of the management. This means that the concept of Supply Chain Management substantiates an idea that a few managers can manage and control the whole supply chain through the help tools like ICT systems. This is repeatedly confirmed through the emerging visions of new, often internet enabled, software packages where the management apparently can view, control and manage their supply chains from the PC at their office desk. One example of this is the Supply Chain Planning software (See section 4.3.3), that suggests that the management can calculate the supply chain towards increased logistics performance.

This illustrates that Supply Chain Management suggests that *you* should control the supply chain, but there are often many "*you*" involved in a supply chain, so who can (or should) control it? Therefore, it may not be feasible-, nor the most effective, that one or a few persons should seek control over all activities within the total supply chain.

This indicates also that the Supply Chain Management perspective assumes that the organisation should apply the ICT system according to the intentions of the management, which again illustrates that this perspective suggests that technology can dictate the behaviour of the organisation. This means that the Supply Chain Management perspective does not discuss the impact the organisation has on the applications of the ICT systems.

An additional problem with Supply Chain Management perspective is that it illuminates logistics issues as a chain, which means that this perspective usually focuses on information handling between companies and ignores the information handling within these. This creates an understanding of that logistics processes are disconnected, which consequently may have a negative impact on the total logistics performance.

5.3 A discussion of the Supply Chain Software Package perspective on the role of applications of ICT systems for logistics

The Supply Chain Software Package perspective illustrates the role of applications of ICT system for logistics through conceptual descriptions of the functionality of various kinds of software packages (like; ERP systems, SCP systems, APS systems, EDI systems, SRM systems, and so on). Therefore, this perspective illustrates the behaviour of the ICT system mainly through the individual structure of these systems, and not their contextual place within the Supply Chain.

The Supply Chain Software Package perspective is a good perspective for describing the characteristic of a certain ICT tool or to illustrate the configuration of a specific ICT installation. However, this perspective may create a rather static view on the role of applications of ICT systems for logistics that is restricted to the existing software packages available on the market. This means that other technologies or methods for communicating information may be ignored.

Further, observations such as Ralston's descriptions of the so-called "progress chasers"[114] indicate that information handling is not always connected to technology at all, but humans may also play an important part in these processes. Ohno (1988) verifies the importance of this by claiming that ICT systems should only be used when it is necessary, and that information should be handled in the simplest possible manner. For example by utilising the product itself as an information carrier:

[114] See chapter 4.1.1

"Workers in the sub-process can also tell what to do as soon as they can see the car. If the car is not visible because it is blocked by equipment or pillars, information is passed by Kanban in the following way…" (Ohno, 1988).

Further, by describing the role of application of ICT systems for logistics through the existing software- and/or technology available on the market, the focus may turn towards the technological attributes of the ICT systems instead of how they can contribute to the logistics performance. The software perspective may therefore substantiate an understanding that applications of ICT systems have an unquestionable positively effect on logistics performance, which again may lead to that improvements of logistics performance are only connected with the exploitation of new technology.

Therefore, this perspective may substantiate a tendency of using solutions that enables ICT systems that are technical superior, and hamper solutions that may be better from a logistics point-of-view. If logistics performance should be increased, the role of the ICT system must be understood from how these can contribute to the logistics mission of the company, and not the static structure of the individual software package.

5.4 The need for an alternative perspective on the role of applications of ICT systems for logistics.

Two success criteria for the alternative perspective that this research seeks, were identified in section 2.3. The first of these was that alternative perspective must consider applications of ICT systems as an integrated part of the individual company's logistics mission. The second was that the perspective must account for the impact the organisation has on the applications of ICT systems.

If the first successes criteria should be fulfilled, the behaviour (or role) of the applications of ICT systems must only be understood through the logistics context they should fulfil within the company and not be restricted by the specific structure- or the technical design of the ICT systems. This because all companies are unique, and therefore it is not certain that the logic represented by certain software package- or ICT system design will fit the specific requirements that are needed to fulfil the logistics mission for the individual company.

The Supply Chain Management perspective is the only one of the three perspectives that illustrated the role of applications of ICT systems for logistics without involving the structure of the ICT systems. This means that this perspective is the only perspective that fulfils the first success criterion of this research.

However, the concept of Supply Chain Management dictates a top-down approach that presupposes that it is possible for a few persons to use applications of ICT systems to integrate, control, and manage the whole supply chain without considering the impact of other actors within the involved organisations. Consequently, the Supply Chain Management perspective ignores the impact the organisation has on the applications of ICT systems, and therefore it fails to meet the second success criterion of the perspective that is sought by this research.

This means that an alternative perspective the role of applications of ICT systems for logistics is needed. This perspective must present on the role of the applications of ICT systems only through the logistics mission of the involved companies, simultaneously as it accounts for the effect the organisation has on these applications of ICT systems. Such a perspective is presented in the next chapter.

6 Towards an alternative perspective on the role of applications of ICT-systems for logistics

6.1 Theoretical framework

In this chapter an alternative perspective on the role of applications of ICT system for logistics is presented. This perspective is made up by a logistics concept termed “Demand Chain Management” and a theory that describes the relationship between technology and society that is named “Actor-Network Theory” (see Figure 18).

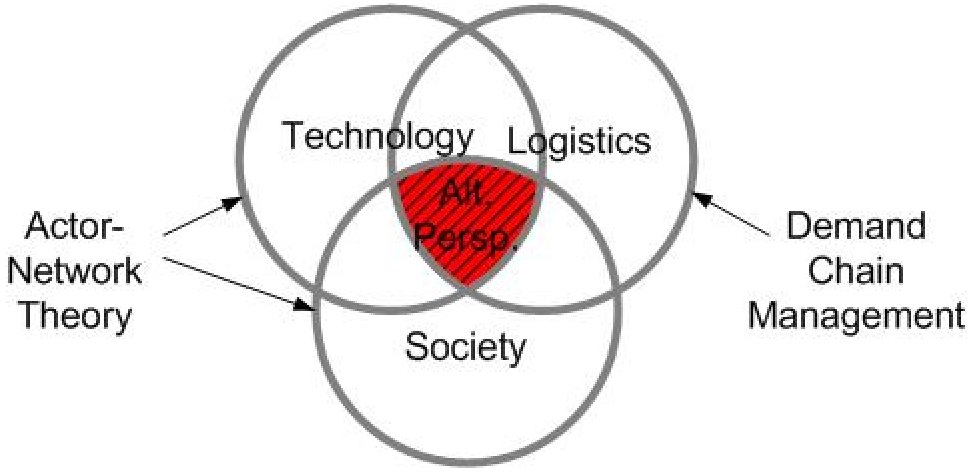

Figure 18. The components of the alternative perspective on the role of applications of ICT systems for logistics.

Figure 18 illustrates the components of the alternative perspective. Demand Chain Management is a logistics concept that is related to Supply Chain Management, and is used to provide logistics thinking into the alternative perspective. While Actor-Network theory is used to understand how technology (the ICT systems) and humans relates to each other. Demand Chain Management and Actor-Network Theory will be presented first in this chapter, and then will these be combined to form the alternative perspective on the role of ICT systems for logistics.

6.1.1 Demand Chain Management / Demand Network Management

Lately, the concept of Demand Chain Management has gained considerable attention in the logistics literature[115]. Demand Chain Management is related to Supply Chain Management. Actually, so related that these two concepts can be understood as different terms of what basically is the same approach. Vollmann et al. (1997) confirms this view, by claiming that the turn from Supply Chain Management to Demand Chain Management is just a question of semantics.

This idea of giving "old" concepts a new "wrapping" will in most cases only generate rhetorically values and less insight into the basics of the field of study. However in this case, the exchange of "supply" with "demand" may have a significant impact on how we understand logistics because this may alter the focus of logistics management. The "traditional" view of Supply Chain Management is concentrated towards supplies, while Demand Chain Management draws the attention towards the customer, implying that it is the fulfilment of his or her demand that is the key issue for a firm's logistics functions. Therefore, by going from supply chain- to demand chain thinking, the focus of logistics management should change from starting with the supplier/manufacturer and working forwards, to starting with the customer and working backwards.

Even if this difference between Supply Chain Management and Demand Chain Management seem to be trivial may its long-terms effects be profound. Vollmann et al. (1995) suggests that Demand Chain Management will create a drive for establishing a synergy from the end customers throughout the whole chain and towards the very last of the suppliers. Such a synergy should reduce costs throughout the chain, and increase the value of the goods and services provided to the customers.

According Vollmann (2001) this turnover from the old thoughts of supply will drive new ideas into the organisations, like "mass-customisation" and inter-enterprise collaboration. ICT-systems should become externally focused and applied to achieve simplified work routines. This simplification can be performed through eliminating things like the need for ordering and complicated production planning routines, while

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[115] See e.g Childerhouse, Aitken & Towill (2002), Christopher (1998), Heikkilä (2002), Markham &. Westbrook (2002), Raabe (1999), or Vollmann (1995; 1997; 2001).

communication of true customer demand should be enabled by letting manufacturing departments talk to manufacturing departments. Vollmann (2001) is clear on that these new processes should not be driven by the technical development of ICT systems. The changes should rather be part of a strategic process, where the ICT systems are used as a fast follower. These thoughts are now starting to grow in certain companies and are used to form new approaches or paradigms that are based on, but go beyond the Japanese ideas (Vollmann, 1997).

The turn towards Demand Chain Management has two clear impacts on applications of ICT systems for logistics.

- First, it strengthens the position of the applications of ICT systems within the logistics company. Supply Chain Management draws the attention towards supply and the material flows, leaving applications of ICT systems as a support activity. While Demand Chain Management focuses on the demand and the demand information, which means that applications of ICT systems are upgraded towards a main activity within the logistics company.

- Second, Supply Chain Management draws the attention towards the management of the physical materials flows, which creates a need for tools that can support these management processes. Consequentially, Supply Chain Management substantiates a view that applications of ICT systems should fulfil the need of the managers for managing and controlling the material flow. While Demand Chain Management draws attention towards the customers and their demands, which implies that applications of ICT systems for logistics should mainly be used to fulfil the needs of the customers.

Christopher (1998) drives this idea of Demand Chain Management further. He argues that Demand Chains do consist of multiple customers and multiple suppliers that form networks instead of chains. Therefore, by replacing “chain” with “network”, the concept of “Demand Network Management” is born. This idea is illustrated in Figure 19, where a focal company is sited at middle of such a demand network.

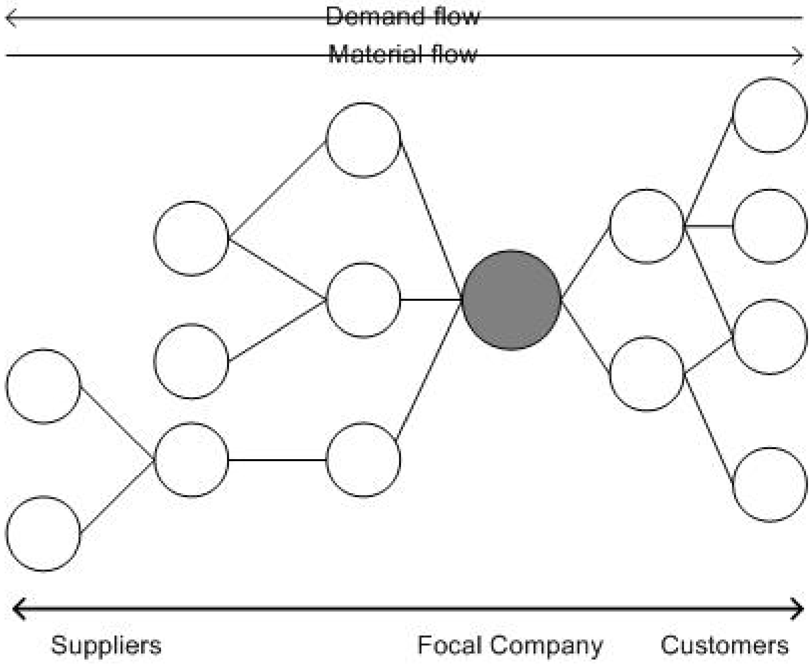

Figure 19. Demand Network Management (derived from Christopher, 1998).

6.1.2 Actor-Network Theory

Actor-Network Theory (ANT) is a framework for analysing interactions between society and technology. Actor-Network Theory dictates that technological (and social) development is determined through interactions between humans and non-humans. This means that social and technological development is not done independently, but through an integrated process.

Actor-Network Theory builds upon a metaphor of heterogeneous networks, and is a way of suggesting that, society, organisations, humans, and machines are all effects generated in patterned networks of diverse material (Law, 1992). Monteiro (2000) presents the core idea of Actor-Networks by emphasising that we are not living in a vacuum:

"*When going about your business – driving your car or writing a document using a word processor – there are lot of things that influences how you do it. For instance, when driving your car, you are influenced by traffic regulations, previous driving experience, and the car's manoeuvrability; the use of a word processor is influenced by earlier experience, the capabilities of the word processor, and so forth. All of these factors are related or connected to how you act.*"

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This means that there are many different factors that influence our behaviour, and therefore, our actions must not be seen as isolated events.

An actor-network can be described as a network of interrelating technical and non-technical elements that make up context. Lator (1991) illustrates the essence of such actor-networks through an example of a hotel manager that wants that his guests to deliver their room keys in the reception if they are leaving the premises of the hotel during their stay. First, he tries to verbally express this wish. This has some effect, but the majority of the guests do still bring the keys with them when they are taking a trip around town. Then, he uses a sign behind the counter for kindly reminding the guests to leave their keys. Again, an increasing number of keys are being delivered, but the hotel manager is still not satisfied with the delivered number. Then, he attaches a metal knob to the keys, and by adjusting the weight of this knob, he manages to get a satisfying number keys delivered in the reception.

In this example the so-called *actors*: the manager, the keys, the manager's verbal request, the sign, the metal knobs, and the customers, forms an actor-network[116]. In this network, one actor (the hotel manager) use other actors (the verbal statement, the sign behind the counter, and the weight on the keys) to affect a third group of actors (the customers and the keys). This illustrates that certain actors can be used to influence the relations between other actors, alternatively it can be said that actors can *inscribe* the behaviour performed by other actors.

Inscriptions indicate how actors embody patterns of use. These inscriptions should not be understood as absolute and defining the relations. It must be a balance between an objective stance where artefacts determents their use and a subjective stance holding that an artefact is always interpreted and appropriated flexibly (Monteiro, 2000). This means that one actor can either follow the inscribed patters of another actor, or it can be said that the actor follows *a program of action*. Alternatively, the actor may not follow the original intentions of the inscriptions, which means that the actor follows an *anti-program* (Lator, 1991).

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[116] In order to overcome the strong human bias to the word "actor" do some prefer to use the word "actant" when referring to actors within an Actor-Network.

Actors can vary in the degree they inscribe behaviour; some may inscribe weak/flexible programs while others inscribe strong/inflexible programs (Monteiro, 2000). Therefore, a designer can attempt to force the other actors to follow his program of action by changing the degree of inscription. Like in the hotel key example, the weight of metal knob on the hotel keys can be increased to inscribe a stronger program for action. However, if the metal knob gets too heavy, it may lead to unexpected behaviour that is unfolded through anti-programs. For instance, the customers may begin to detach the metal knob from the key or they may get annoyed of the whole solution (and thereby the hotel) resulting in that the manager starts to loose customers instead of keys.

Inscriptions lead to another important feature of Actor-Network Theory, namely *translations*. Translations can be seen as alterations of the total network through the process of inscribing actors. In the hotel key example, the hotel manager translated the face of the network three times; first by using the verbal statement, then through the sign behind the counter, and finally by using the metal knobs. This is illustrated in Figure 20.

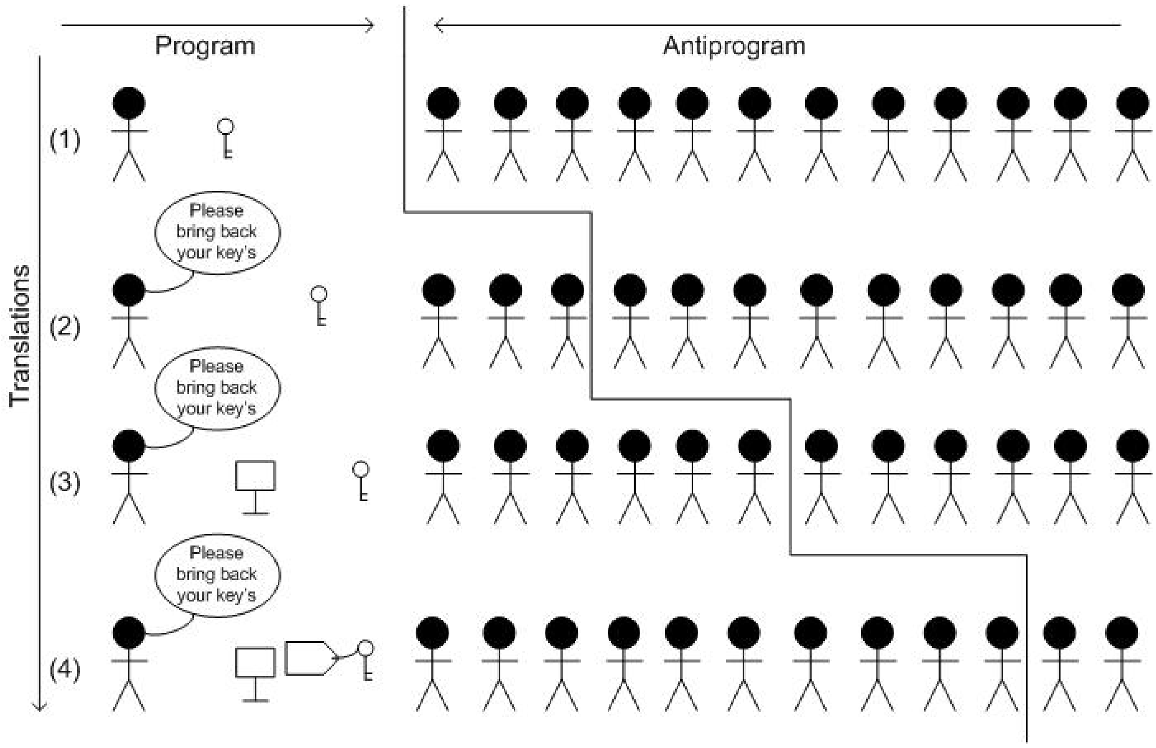


Figure 20. The hotel key example (derived from Lator, 1991).

The figure above outlines that the actor-network in the hotel example is translated through fours steps. In the first step, the hotel manager is the only actor that wishes for the delivery of the hotel keys. This means that all of the guests follow anti-programs. In the next step, hotel manager verbally requests the guests to do follow his wish, which results in that a small number of keys are delivered at the counter. Then, he allies himself with a sign, which results in that a larger number of customer acts according to his program of action. Finally, metal knobs are attached to the keys and thereby the hotel manager manages to get a satisfyingly number of customers to follow his program of action.

This illustrates that the hotel manager allied himself with other, non-human actors to create patterned networks for aligning the interest of the customers with his own. However, not all of the customers acted according to patterned networks. This illustrates that Actor-Network Theory suggests that the different actors do always seek to follow their own interests, which again results in that the networks are constantly negotiated (or translated) by its own members until their expectations are *aligned* around realisable objectives (Lator, 1991). It is important to notice that alignments of actor-networks are not straightforward or precise, but is dynamically interpreted and continually negotiated between interests.

Actor-Network Theory does not divide between macro- and micro levels. This can be a problem in a macro-level analysis because the observer may have to deal with extensive and complex networks. The concept of *black-boxing* may be used to help this problem. Black-boxing suggests that one (or several) actor-network can be treated as a single actor in macro level studies, in order to form actor-networks consisting of macro-actors that act as micro-actors (Monteiro, 2000). This do also outline that Actor-Network Theory demands a deliberate selection of the context of the study in order to restrict the extension and complexity of the total network (Monteiro, 2000).

It is important to notice that Actor-Network Theory does not represent a clear conceptual framework, and that the theory is usually approached in an eclectic manner (Aanestad, 2001). In this research Actor-Network Theory is used as a tool for understanding the basic of how applications of ICT systems for logistics relates to the surrounding organisation. Actor-Network Theory is well suited for such studies, because applications of ICT systems may be seen as a powerful actor that forms patterned network for how work is performed within an organisation. For instance, when designing computer systems a designer composes a scenario of the work process or -processes, and tries to inscribe this pattern in the software. When the solution (system) is running, this pattern will be adopted by the users who interpret the system into their own context (Monteiro, 2000).

The usage of Actor-Network Theory in this research can therefore be summarised through the scenario presented in Figure 21. This figure consist three columns. In the leftmost column, a simple, imaginary example is described. This example illustrates an organisation that wants to improve their warehouse routines through the use an ICT system. In the middle column, some basic illustrations are sketched to supplement the example. In the far right column, the example is explained by using expression derived from Actor-Network Theory[117].

[117] The use of Actor-Network in this research has been based upon the vocabulary made by Monteiro (2000).

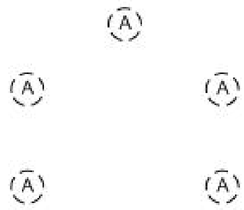
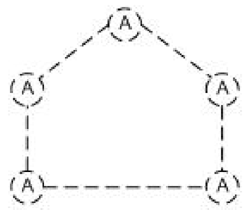
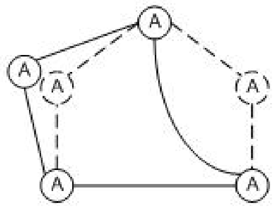
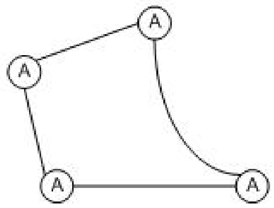
Example	Illustrations	Actor-Network terminology
A company wants to improve their warehouse routines. A new ICT systems is selected and the involved users (and other factors) are identified.		The actors (human and non-humans) are identified and/or selected.
New work routines is sketched. The system is programmed and/or configured to support these and the users are trained in performing these routines.		The actors are inscribed to follow a program of action.
The new solution is put into use. The new routines functions well in some parts, but in other parts the solution does not behave as expected.		The actors follows programs- or anti-programs of actions. => The network is negotiated between interests.
After a while, the initial problems is solved and the new warehouse routines have been established.		The Actor-Network is aligned.

Figure 21. An example of usage of Actor-Network Theory.

Following the example in Figure 21, the topmost tier in the figure illustrates a company that want to improve their warehouse routines. In order to do this, they must first identify the users and all other involved factors[118] and decide of what system to use. Then, in the second tier, new work routines are sketched, while the ICT system is configured to support these and the workers are trained in performing these work patterns. Using Actor-Network terminology: The actors are inscribed.

[118] Like; the layout of the warehouse, the number of daily transactions, the product labelling, the numbers of users, the state of the wiring of the communication network, and so forth.

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The third tier from the top illustrates the implementation of the new routines. Unfortunately, the involved actors do not always follow the inscribed patterns. Some of these problems may merely be caused by non-human actors. Such problems can be unfolded through things like network breakdowns, errors in the software code, or documents that are printed in a different printer than it were supposed to. However, the human actors may also contribute to this unstable state. Some of these may not have got sufficient training in how the ICT system- and the connected routines works, some may feel threaten by the new technology and therefore tries to boycott the whole project, some may not see the point of reporting things into a computer system when they just can pick the items directly from the shelves, while some may not have the slightest abilities for understanding how a computer works, so they continue to use it in the wrong way no matter how hard they try. The reasons for not following the inscribed work routines are endless, and the creativity to – both consciously and unconsciously – create new ways for doing things is correspondently. Using Actor-Network Theory, this can be understood as that the patterned network is negotiated between interests.

After a while the initial problems have been solved and new routines are that (almost) everyone "agrees" upon are formed (see the bottommost tier in Figure 21). Alternatively, it can be said that the actor network has been aligned.

6.2 An alternative perspective on the role of applications of ICT systems for logistics

In this section, an alternative perspective on the role of applications of ICT systems for logistics is presented. Demand Chain Management is used to provide a core of logistics thinking into this perspective, while Actor-Network Theory is applied to describe impact the surrounding organisation has on the ICT systems (See Figure 22).

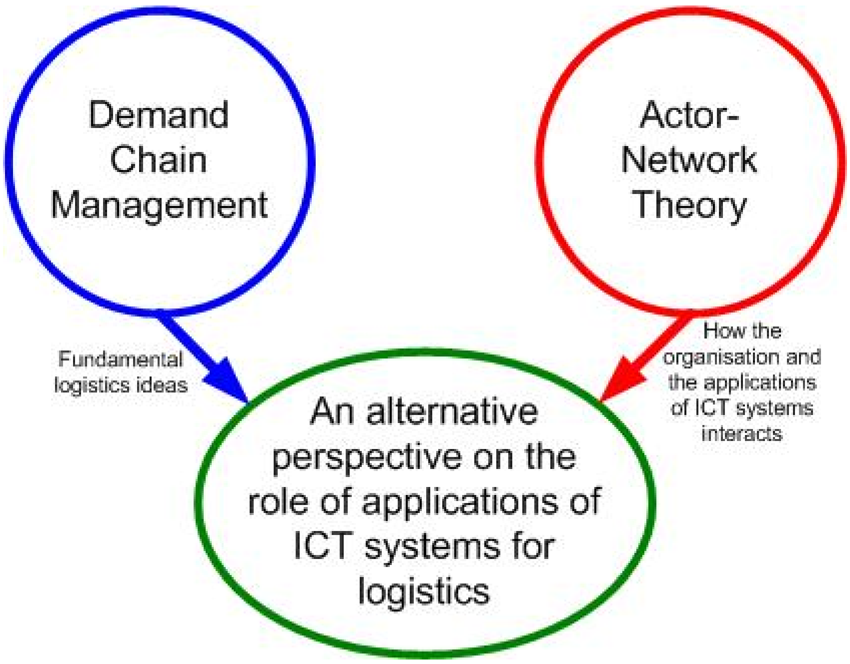

Figure 22. The contributions of Demand Chain Management and Actor-network Theory into the alternative perspective.

Recent description on the role of application of ICT systems for logistics is usually influenced by Supply Chain Management thinking. In this research Supply Chain Management is abandoned in favour of the concept of Demand Chain Management. This choice may have a significant impact on how the role of applications of ICT system understood, because it dictates an alternative view of why these systems should be used in the first place. By going from Supply Chain Management to Demand Chain Management the main purpose of applying ICT systems for logistics ought to turn from supporting the management of the supply chain towards a unilateral focus in fulfilling customers demand.

By starting with the customer and the customer's demand, it can be found that the customer and the Demand Chain interact through two main channels. The first of these appears when the customer's demand is communicated to the Demand Chain. The second interaction is represented by physical transfer of goods from the Demand Chain to the customer (see Figure 23)

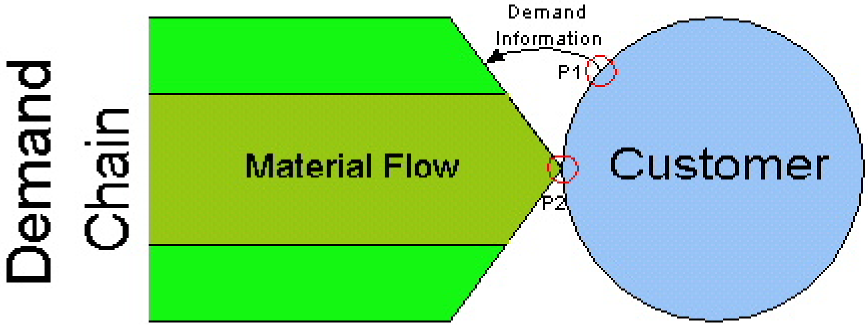

Figure 23. The customer and the Demand Chain.

Figure 23 illustrates the two channels in which the Demand Chain and the customer interact. The intersections between the Demand Chain and the customers are marked “P1” and “P2”. P1 marks the point of demand creation. This point indicates the when the customer’s demand appears for the first time. P2 marks the point of demand fulfilment. This point describes the moment when the customer’s demand is met.

A “perfect” Demand Chain should fully and immediately fulfil the demand that appears at P1. This means that the following equation can be used to describe such an “ideal” logistics network.

Demand P1 = Demand P2

This is difficult, and often impossible to achieve this in practical life, and a one-sided pursuit for always and immediately fulfilling the smallest of the customer’s demand would often be enormously costly. Nonetheless, this idea opens the possibility of seeing the start and the end of a Demand Chain as two points of what ought to be the same demand. It may therefore be relevant to study why the demand in these two points is not identical. One way of doing this is to track what is happen between these two points. Figure 24 presents this idea.

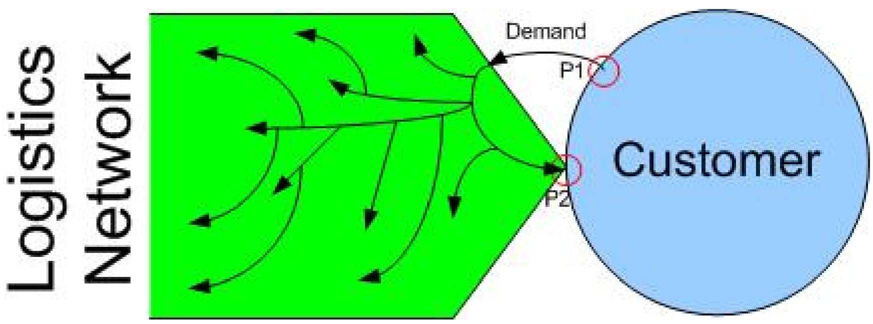

Figure 24. The customer and the logistics network.

The figure above illustrates that demand is transferred from the customer to a logistics network[119]. The demand is then handled and transformed in various ways so that the customer's requirements may be fulfilled. However, a logistics network (e.g. a company, a demand chain, a distribution channel, etc.) is usually not made to serve only a single customer. Logistics networks do rather fulfil the demand of several customers forming a market.

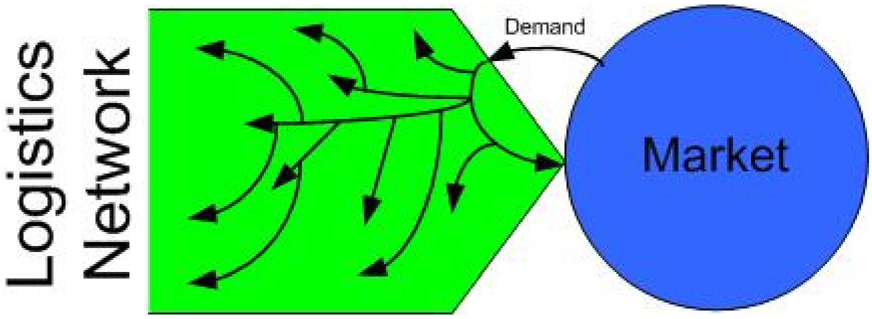

Figure 25. The market and the logistics network.

Figure 25 illustrates that a logistics network is in fact a reflection of a market (Shingo, 1989)[120]. Therefore, this perspective illustrates that the logistics network is formed to transfer the individual demand from the customers within the marketplace, so that their demand is fulfilled in the best possible manner. These individual demand transfers forms streams of demand that are transferred throughout the whole logistics network. It is important to notice that these demand transfers are not limited to the events that directly affect the customer[121]. The streams of demand are sent further down the logistics network and often in a new a form. For instance, a company make use their customer orders to initiate the production process. This production process requires a specific kind of raw material that they get from a supplier. Every time the company's raw material stock is reduced to a certain level, a new shipment is ordered from this supplier. This means that the flows of demand between the company and the customers are transformed into another flow of demand that operates between the company and the supplier.

[119] In order to separate the alternative perspective from the concept of Demand Chain Management; "Logistics Network" will be used instead of "Demand Chain" for the rest of this thesis.
[120] Actually, Shingo (1989) said that a *production system* is a reflection of a market. This statement is rephrased to fit the topic of this research.
[121] These events are usually refereed to as the order-to-deliver cycle.

Other sources of demand that may affect the transfer of customer demand should also be taken into account. Such as: wreckages in production or anticipated demand from forecasts.

The role of applications of ICT in this web of demand transfers can be found through Actor-Network Theory. The total logistics network may be seen as a large actor-network where the different actors are used to transfer (and transform)[122] the demand and/or influence how this happens. This means that various actors' forms networks that make up pathways for transferring the flows of demand from customers in the marketplace and throughout the logistics network. The whole network should be aligned to do one thing: to transfer the flows of demand from the marketplace in the best possible manner.

This perspective has a unilateral focus on the demand, while the other actors in the logistics network like humans, products, storerooms, building, machine tools, and ICT systems are only seen as mediums for the transfer of this. It is important to notice that this perspective does neither separate between the information- and the material flows, because they both are seen as means for transferring the demand.

Applications of ICT systems for logistics may be an important actor in such a network, because they can lay patterns or "pathways" within the network that inscribes how the demand is transferred. For example, an ERP system may act as an actor between a sales- and a production department through turning demand from customers order into demand in form of planned production orders, or applications of ICT systems may be an actor for transferring demand between two companies through communicating ordering- and shipping information through EDI messages.

This means that ICT systems can be used as a powerful actor for inscribing the pathways for transferring demand throughout the whole logistics network. These inscriptions must not be seen as a tool for limiting people's autonomy through manipulation of their behaviour. It must rather be seen as a process for arranging the work where ICT systems can inscribe different programs of actions. For instance, the customer demand may be transferred to a production department by

[122] For simplification: In the rest of this thesis "demand transfers" will be used when it is referred to both demand transfers *and -transformations*.

handing over the customer orders to the workers and let themselves work out how the production should be scheduled. Alternatively, customer demand can be transferred to the production department through an advanced planning routine and presented through a dispatch lists that each worker has to follow strictly. The challenge lies in inscribing a total network that fulfils the demand from the marketplace as good as possible under the prevailing circumstances, which means that the interest of all actors within the logistics network be aligned in fulfilling this.

However, not all of the actors will follow the inscribed patterns. Some of the actors may have other interest and therefore begin to transfer the demand in their own way (or not transferring it at all). Alternatively: they follow anti programs. In the integrated world we have today, such anti programs may have significant consequences of how the other actors within the network behave. For example, an ERP system will present incorrect stock level readings if employees in a production department do not report the exact amount of raw materials they consumes. This again, makes the ICT system unable to calculate the need for new purchases, and the purchase department must solve this problem by manually checking the stock locations. Further, these errors will also transmitted to other parts of the organisation, resulting in things like accounting errors, false messages on material shortages, delayed customer deliveries, and so on.

This means that anti programs may result in that the demand is transferred through unforeseen pathways. However, some anti-programs may be for the better. For instance, if the central computer system breaks down, alternative methods for handling demand information may be crucial to maintain essential deliveries.

Therefore, the alternative perspective presented in this chapter draw a picture of a logistics network where pieces of individual demand from the marketplace (and other sources) forms intangible streams of demand that flows through both predetermined and unforeseen pathways throughout the logistics network. Networks of human- and non-human actors form these pathways that transfer these streams of demand. This must not be understood as a steady, even flow. The demand is rather pouring through a network of courses, while new sources are added and the demand is constantly finding new, maybe unforeseen pathways.

Several types of demand are added from different sources into this web, such as real demand from customers, anticipated demand from forecasts, or demand made by wreckage in production. ICT systems for logistics are applied to inscribe pathways into the networks to transfer, transform, manage, and control these flows of demand throughout the whole logistics network.

6.3 Summary

This chapter introduced an alternative perspective on the role of applications of ICT systems for logistics. Using the rationales from chapter 5, this perspective can be described in the following manner.

The Demand Transfer perspective tells us that applications of ICT systems for logistics are used as one of many actors that supports the transfers and transformations of demand that flows through both predetermined and unforeseen pathways throughout the logistics network in order to fulfil the individual demand of customers within the marketplace.

By using this description, the Demand Transfer perspective is summarised and compared with the other perspectives on the role of applications of ICT systems for logistics in the table below.

Perspective	Structure (How the system is build)	Behaviour (What the system does)	Context (How the system contributes to logistics)
Manufacturing Perspective	The structure of the systems is illustrated through description of things like MRP-, Kanaban-, or OPT/Serve systems	The ICT systems support various functions within the manufacturing plant. Like production planning or materials replenishments	The ICT systems contribute in achieving a specific manufacturing planning and control concept. (e.g. MRPII, JIT and OPT)
Supply Chain Management Perspective	The specific structure of the ICT systems are not in focus	The ICT systems support the integration of the formation flows between units in a supply chain	The ICT systems contributes in achieving and managing an integrated supply chain
Supply Chain Software Package Perspective	The structure of the systems is illustrated through description of things like ERP-, SCP-, or EDI systems	The ICT systems support various functions within the supply chain. Like order management or collaborative supply planning	The individual systems does not share a clear, common, logistics vision
Demand Transfer Perspective	The specific structure of the ICT systems are not in focus	The ICT systems is used a one of many actors that supports the transfers- and transformations of the streams of demand that flows throughout the logistics network	The ICT systems contribute to the fulfilment of each individual demand from the customer in the marketplace

Table 2. Three current- and one alternative perspective on the role of applications of ICT systems for logistics.

Two criteria for the alternative perspective were presented in section 2.3:

1. The alternative perspective must consider applications of ICT systems as an integrated part of the individual company's logistics mission.
2. The alternative perspective must account for the impact the organisation has on the applications of ICT systems.

The Demand Transfer perspective follows the ideals of Demand Chain Management, which suggests that applications of ICT systems should support the fulfilment of the customers demand. This means that this perspective considers the fulfilment of customer demand as the logistics mission of a company, and through the transfers of demand, the ICT system of logistics plays an integrated and important part in these events. Therefore, the Demand Transfer perspective fulfils the first of the two criteria.

Further, through Actor-Network theory the applications of ICT systems is seen as one actor among other actors in a large demand transferring network that continuously is negotiated between interest. This means that this perspective accounts for the impact the other actors within the organisation has on the ICT systems. Consequentially, the Demand Transfer perspective fulfils the second success criteria.

The Demand Transfer perspective on the role of ICT system in logistics environment can be summarised through the following three sentences:

- In logistics environments, patterned networks of diverse materials are formed to transfer (and transform) the demand from the customers in the marketplace.
- These transfers form intangible streams of demand, which alter as they flow through both predetermined- and unforeseen pathways throughout the logistics network.
- Applications of ICT systems are utilised as an actor in interaction with other actors to manage and control these streams of demand.

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7 Case Studies

A perceptive on the role of applications of ICT systems for logistics must be applicable into practical settings. Therefore, empirical studies are needed to validate if the Demand Transfer perspective can be used to study real life events. In this research, this empiricism is provided by two case studies that illustrates how ICT system for logistics has been applied within two different companies.

A perspective is way of observing the world. The case studies should therefore only validate or invalidate if it is possible to use the perspective to observe how applications of ICT systems acts within logistics organisations. This means that the aim for the case studies is not to present a specific method- or solution for how ICT systems for logistics should be applied to support logistics tasks. The cases studies do rather present typical challenges that companies have been struggling within in this area. Therefore, in order to obtain as much freedom as possible for describing these challenges with applying ICT systems to support logistics issues; all parties in the case studies are held anonymous.

Both of the case studies are focused on internal processes within a production facility and the use of an ERP system. This means that there are many similarities between these case studies despite that they are performed within different businesses. The choice of case objects has been influenced by several factors. One important factor has been the accessibility of case objects and -documentation. Another reason for choosing exact these cases are that they provide good illustrations of how demand is transferred within logistics networks.

The case studies have been performed through participating observations, presentations from the project management, interviews of involved project members, and studies of project documents and process descriptions[123].

As described in section 2.4, a purpose and an own set of success criteria must be defined for the case studies[124] (Yin, 1994). The purpose has

[123] See appendix A and B
[124] Again, these criteria must not be confused with the success criteria for the alternative perspective that were presented in section 2.3.

already been presented: the case studies shall confirm if the alternative perspective can be used in real life settings.

While a set of success criteria can be prepared by rephrasing the three statements presented at the end of the previous chapter:

- In the case studies, is it possible to find patterned networks of diverse materials that transfers and transforms customers demand?
- Do these demand transfers create intangible streams of demand, which alter as they flow through both predetermined- and unforeseen pathways throughout the logistics network?
- Are applications of ICT systems utilised as an actor in interaction with other actors to manage and control these streams of demand?

7.1 Case study one; Bakery

Case study one is concentrated on the logistics processes within a bakery. This bakery is a part of an international enterprise, where the Norwegian branch consists of several industrial bakeries- and bakery shops that are scattered around the southern parts of the country. The bakeries make all kinds of bakery products like bread, confectionery, cookies, sandwiches, and bakery products for fast food. They have daily deliveries to their customers, which includes local groceries, kiosks, service stations, and large-scale catering businesses. The Norwegian branch of the enterprise has totally 500 employees and a yearly turnover of approximately 600 million NOK[125].

The case study was performed in connection with an improvement project that involved the whole Norwegian branch of the enterprise. However, the case study is focused towards one specific bakery and the logistics handling of the production- and the purchasing functions within this bakery in particular.

In 1998, the enterprise discovered that many of their ICT systems were not year 2000 compatible. This meant that they had to choose and implement several new ICT systems before the millennium shift. Instead of upgrading each individual software package, they selected an integrated ICT system (an ERP system) that could support most of the enterprise's logistics processes within the same package. Each production

[125] Numbers from 2002.

unit (bakery) had to implement several modules of the ERP system. Four of these were directly connected to logistics handling:

- A sales module that took care of customer orders and deliveries – this module were mainly to be used at the central sales office.
- A production module for production planning and shop floor control.
- A purchasing module for purchase order management and goods receipts.
- An inventory management module for stock control and distribution order management.

These modules were integrated through the ERP systems common database. This meant that the main logistics processes within the enterprise were supported by a software package that acted as a single system.

The implementation of the system was executed through a business improvement project that was based upon ideas from business process re-engineering[126]. This project was performed by consultants from an external consultancy in interaction with the enterprise's own people. In addition, some consultants from the software supplier were invited into the project group to support the establishment of the technological environment and to provide special knowledge about the functionality of ERP system.

7.1.1 The initial solution

The initial improvement project was completed in time before the new millennium. However, it became soon evident that something had gone wrong. Several aspects of solution that the project group had made were not put into use, and the enterprise was far from satisfied with how the ICT systems supported their logistics processes. They were especially discontent with how the solution acted within the production- and purchase departments within the different bakeries. Almost nothing of the systems functionality was put into use and the expected improvements in the work routines were far from achieved.

Back then, the bakery this case study will focus on performed their logistics processes in the following manner:

[126] See section 4.2.1.

The people in the central sales office received requirements from the bakery shops and external customers in the local area. These requirements were added into the ERP system as customer orders, which then were used to create things like picking lists and preparation of shipment documents when the goods were shipped from the different bakeries. The sales module and its connected routines functioned rather well, but the system support in other logistics areas was less successful.

During the initial implementation project, the standard production planning functionality of the ERP system was considered as insufficient for this specific enterprise. Therefore, a new, tailor-made, planning module was made and integrated with the ERP system's production functionality.

This extension of the production planning functionality was meant to make the system better fit for the needs of the different bakeries. However, the users found the planning routines supported by this special module cumbersome and too comprehensive for everyday use. The new functionality was also sensible when it came to the integrity of the planning data. And there were plenty of errors in the database. These inaccuracies was caused by things like fixed-, and wrong basic data as well as insufficient-, delayed-, and/or faulty feedbacks from the users at the shop floor. In addition, the logic of this planning module was based forecasts, which often generated overproduction of some products and shortages of others. These problems resulted in that the production planning were performed as good as manually, and the system was mainly used as a "typewriter" for manually issuing production orders and reporting these back into the database to capture the transaction data.

The situation was not better in the purchasing department. One person had the job of managing the daily purchasing activities within the bakery. He was responsible for the raw materials on stock and performed all functions connected with the purchase orders and goods receipt.

Withdraws of raw materials to production happened by that the bakers went down to the raw material stock locations and picked whatever they needed directly from the shelves. The withdrawals from the ERP system stock level readings were calculated automatically when a production order was reported as completed in the production module. However, this solution did not work so well in practice, because of things like unreported wreckage, pilferage, and incorrect bill of materials. This resulted in that as well as all of the on-hand quantities of raw materials in the ERP system were incorrect.

Purchase requirement was therefore transmitted through hand-written lists that were sent between the bakers and the purchasing responsible. In addition, the purchasing responsible had made some “manual” re-order point systems. One example of such a system was a chalk line on the wall at the stock location where the flour was stored. When this line became visible, the purchasing responsible knew it was time to order a new shipment of flour.

The purchasing responsible took the lists of requirements from the bakers and the requirement he found through his “manual” routines, and entered purchase orders in the ERP system. Then, he printed the orders and copied the contents of these printouts into another set of hand-written forms that he faxed to the different suppliers.

A shipment of raw materials would usually lie in the receiving area for some time after it had arrived. Then, when the purchasing responsible found time, he controlled shipment and placed the items into the shelves. Finally, he reported the received quantities against the purchasing order records in the ERP system.

7.1.2 The need for change

The bakeries had several reasons for making better use of the ERP system. Some of these were:

- The production planning routines were ineffective, and resulted often in unrealistic plans.
- The purchase ordering routines were cumbersome and allocated much of the purchasing responsibles’ time. Unnecessary inventory and stock-outs were common.
- The on-hand quantities of raw materials displayed by the ERP system were always wrong. This meant that the only way of knowing if there were raw materials on stock was to physically go down to the stock location and see if there were any items in the shelves.

- Historical transaction data were unreliable. This meant that the database was not suited for things like management accounting, performance reports, statistics, or historical analysis.

In addition, the general manager that was responsible for all purchasing activities within the Norwegian branch of the enterprise had another reason to make better use of the ERP system. He had started to negotiate new agreements on the behalf of the whole Norwegian part of the enterprise. But despite of his instructions, the people at the different bakeries continued to do many of their purchases as they always had done, using their "own" suppliers and agreements. Therefore, he wanted to use the purchase agreement functionality of ERP system to support the centralisation of the management of these agreements.

These issues led into a series of meetings between the representatives from the enterprise, the consultancy that been responsible for the implementation project and people that had delivered the system. New activities were initiated, and new consultants were hired to sort out the problems, but nothing seemed to help.

7.1.3 Towards a new solution

Approximately one year after the first implementation project, the enterprise hired a business consultant from the software supplier to do a short course on the ERP system's purchasing functionality. During this course, this consultant was invited to look at the problems with the production planning routines within the bakery that this case study is focusing on. Half year lather, he and the production managers at this bakery had created a completely new solution for production planning and -execution. This solution represented a great improvement in how these functions were performed, and the solution was already functioning satisfyingly in the daily operation of the bakery.

The new routines simplified the old production-planning routines and used less of the ERP system's production planning functionality. Through a couple of months of joint discussions and testing of different solutions, the tailor-made production-planning functionality made in the first implementation project was rejected. Instead, they created a solution that used the standard functionality of the ERP system.

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Traditional production planning by the ERP systems is realised through a material requirement plan that includes production order proposals generated from forecasts (traditional MRP logic). The new solution did not use such a planning logic, but dictated that the production should rather be triggered from real demand generated from the customer orders. In practice, this meant that the system should automatically create production order proposals that reflected the next day's deliveries. One way for doing this is to configure the system to make one production order for each customer order line (make-to-order logic). However, many of the customers ordered the same things and therefore such logic would create tremendous amounts of production orders for the same product at the same day[127]. The bakers in production wanted only to know how many of each product they should bake for the next day, and did normally not need information about which customer that should have the individual goods.

This problem was solved through combining traditional MRP logic[128] and production from real customer demand[129]. The customer orders can be used by the ERP system as one source to calculate gross requirements for the individual products. If the on-hand quantity in the ERP system record is zero, and no forecasts or "false" orders does influence the demand situation for the specific product at the following day: The daily gross requirement will reflect the total amount of each product that are needed to be produced the next day (net requirement).

Using this logic, a new planning routine was formed. When the customer called in his requirements, the people at the sales office created customer orders that contributed to the daily gross requirements of each finished product. Then, the ERP system used net/gross calculations to generate production order proposals from these requirements. These proposals contained the exact amount of each product needed to fulfil the next morning's deliveries. The planner's job was then to check and release these proposals into "real" production orders before the first bakers came to work the next morning. The bakers were then responsible to bake products according to the production orders and report these back into the ERP system. Thereby, the goods were sent to the customer according to the customer orders and the deliveries were reported into the ERP-

[127] The bakeries received hundreds of customer orders each day that each included several order lines.
[128] More accurate: net/gross calculations.
[129] More accurate: make-to-order.

system's sales module. After the production was finished and all deliveries were made, the production planner controlled that all transactions were finished-marked and prepared the system for the next day. This logic created a daily circle of transforming customers requirements into production orders (see Figure 26).

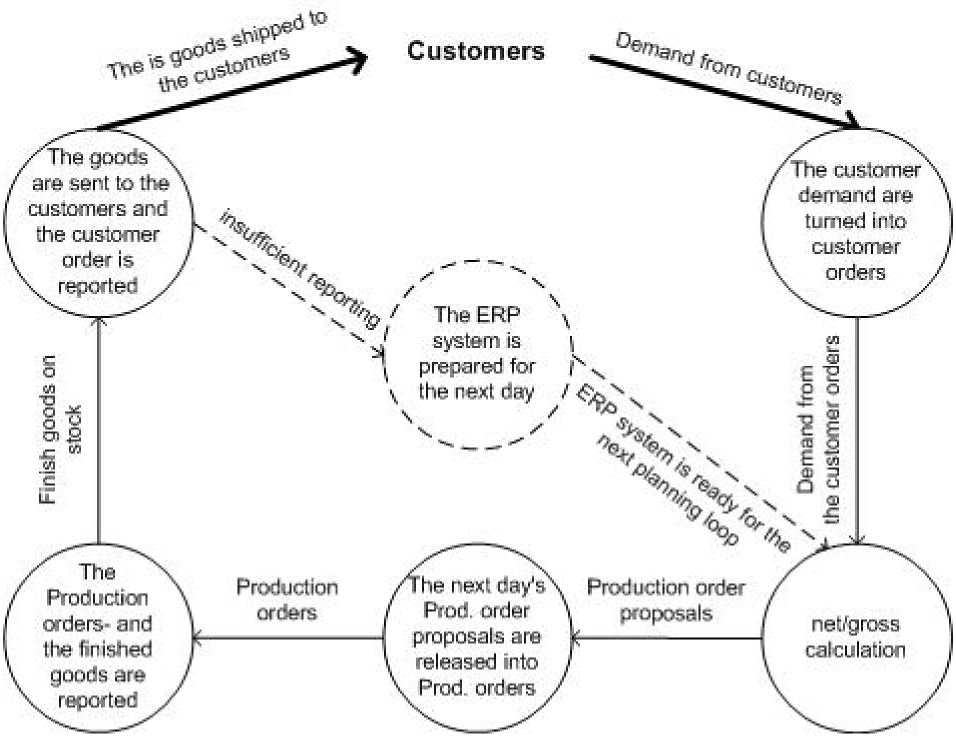

Figure 26. The bakery planning loop.

Figure 26 illustrates how the production module of the ERP system handled the planning information within this bakery. The ERP system received demand information from the customers via customer orders. Then, were these transformed into production orders proposals through a net/gross calculation, which sequentially was turned into real production orders. When the production was performed, the production was reported towards the production orders in the ERP system, and the goods were sent to the customers. Finally, the planner prepared the system for the next day's planning loop.

After the problems in the production department had been improved, the time had come to do something with the purchasing solution.

The general manager of the Norwegian purchasing activates, initiated a project for improving the ERP system's support of the purchasing processes. The project group had two fixed members: the general manager himself and a business consultant from the software supplier.

The most important topic for this project was to improve the quality of the data within the ERP system's database. This would help the reliance the people had to the system and release the true benefits of using an integrated system. In addition, the general manager's intentions for using the system for centralising the management of purchase agreements could not be done before the data in the database were bettered.

The main problem connected to the inaccurate purchasing data was that as good as all items at the raw material stock had incorrect on-hand readings. By analysing the system and conferring with the users, it became evident that the main reason for this was that many items had multiple identifications registered in the database. This was caused by that the different purchasing responsible had made a new raw material identity every time they could not immediately find the correct item code in the ERP system database when preparing a new purchase order. In this way each purchasing responsible had made multiple sets of item identities, which meant that there were several identities for the same product operating within the ERP system.

This resulted in that the same product could be received as one identity and withdrawn as another. For instance, one specific kind of raw material could have several different identities in the system, while only one of these was registered in the bill of materials. The identity registered in the bill of materials was the only identity that was used by the ERP system to calculate receipts when a production order was finish-marked. Therefore this item identity would usually have a large negative on-hand quantity registered in the ERP system. While other identities on the same raw material could be used by the purchasing responsible for registering purchase orders and goods receipts, and therefore could these have a large positive on-hand readings. The same tendency of double registering had also happened in the ERP systems supplier registry. Which means that the different purchasing responsible did often create own identities of suppliers that already were registered in the system.

These problems with double registration had to be sorted before the centralisation of purchase agreement management could be imitated. This because the purchase agreement functionality of the ERP system were connected to both the supplier- and item registers.

When the purchasing responsible in the different bakeries was presented the problems with the multiple identifications, they claimed that the reason they had made new identities in the system was that the numbering of the item- and supplier registers were made up in an illogical manner. It was therefore usually faster to create a new identity instead for searching for the "correct" one. However, they promised to make more effort in finding the right identity.

Two activities were the initiated to help these problems. First, corrections to the ERP system were made to solve the problems with the logic of the numbering systems. Second, new, centralized routines for maintaining- and adding new item- and supplier identities in the ERP system were prepared. These routines would make it impossible of the individual purchasing responsible to create a new item- or supplier record in the ERP system's database without clearance from the general manager.

Improvements of the purchasing routines within earlier discussed bakery were performed simultaneously as these actions of the centralisation of the purchasing data management were executed.

These process improvements were executed by that a consultant from the software supplier prepared a suggestion for how the system could support the purchasing routines. Then, this solution was presented the purchasing responsible, and reworked in a test system by both the purchasing responsible and the consultant before it was put into use.

A new solution was soon outlined. This solution dictated that the ERP system should automatically create purchase order proposals through a reorder point methodology. Through time, this solution should completely replace the hand written lists and the manual systems for triggering the purchase requirements. However, automatically generated purchase order proposals from reorder points require correct on-hand readings, and correct on-hand readings could only be achieved by that the bakers reported their actual receipts instead of letting the ERP system calculate this from production orders[130]. Therefore, new routines for raw materials receipts were prepared. These dictated that the bakers had to report their actual receipts every time they took something from the raw material stock. However, the purchasing responsible were not sure if all

[130] Of course, the problem with the multiple item records had to be solved also.

of the bakers would actually do this, and therefore he considered to close the access to the most important items so that the bakers had to confirm with him every time they needed such an ingredient.

The new solution suggested also that the purchase order printouts from the ERP system should be sent directly to the supplier without copying these into the hand-written forms. Initially, the purchasing responsible meant that this could not be done, because the printouts did not contain enough information. However, by confirming with the suppliers, it became evident that only small adjustments of these printouts were needed before they would accept these.

The person that received the goods should immediately report this receipt into the ERP system. In this way everybody with access to the system could see which items that have been received, but was not yet controlled and placed into the shelves. Thereafter, the purchasing responsible should inspect the delivery, placed the items into the shelves, and report these towards the purchase order record in the ERP system as before.

The centralisation of purchase agreement management was performed within all units simultaneously, while the new production- and purchasing solutions was initially only implemented within one bakery. However, solution within this bakery functioned so well that the top management of the Norwegian branch of the enterprise initiated a project for copying this solution into all of the other Norwegian bakeries within the enterprise.

7.1.4 Case study one seen from a demand transfer perspective

The company in case study one used networks consisting of diverse material to transfer (and transform) customer demand throughout the logistics network. These demand transferring networks were formed by human and non-human actors, like; the ERP system, the production planners, the hand written lists, and the product itself. Before the improvements, these demand transfers formed intangible streams of demand that flowed from the customers, through the sales office, towards the packing and delivery department, and then back to the customers. Another stream of demand was initiated to meet these first streams of demand. These demand transfers started in the production planning process as anticipated demand generated from forecasts, and ended as products at the finish goods stock. Finally, a third kind of demand transfers were identified in purchasing department, these streams of demand was initiated through the issue of purchases orders from raw material requirements and sent towards the suppliers. This demand returned to the bakery as raw materials. The streams of demand within the bakery are illustrated in the figure below.

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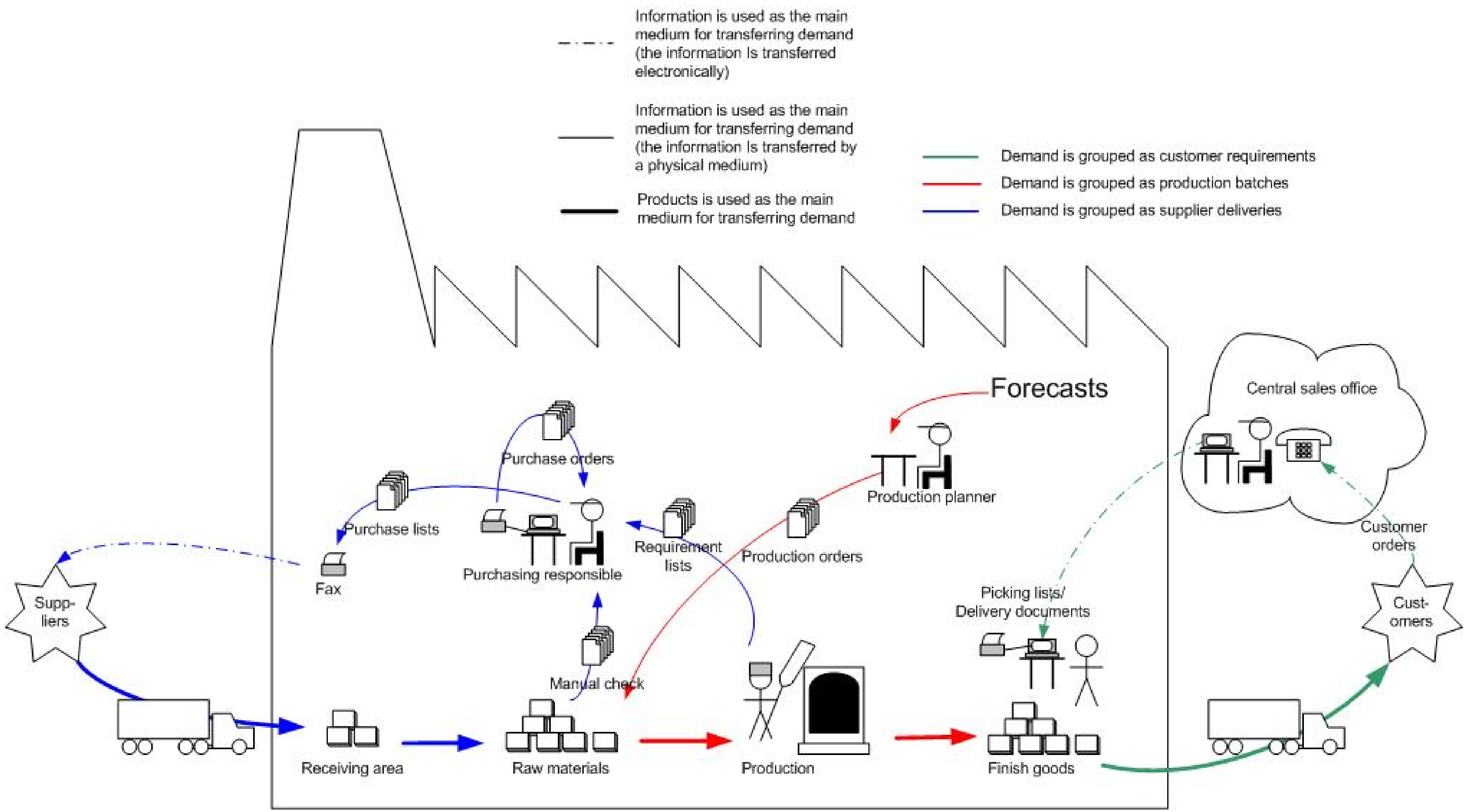

Figure 27. Streams of demand within the bakery before the improvements.

Figure 27 outlines how the demand was transferred throughout the bakery. The solid thin lines indicate that the demand is transferred by a physical information carrier, while the broken thin lines indicate were this information is transferred automatically/electronically. In addition, the thicker lines indicate that the demand is mainly transferred through the flow of materials.

The figure illustrates that the demand forms several loops as it streams throughout the bakery. The streams of demand is transformed or regrouped between each of these “whirls”. The green arrows indicate that the streams of demand that are grouped according to the customer demand. The red arrows, represents demand that are used to drive the production process. These demand transfers were influenced by things like the total number of bakery products anticipated to be sold the next day and capacity restrains within the production units. The demand illustrated as blue arrows indicates the streams of demand that are formed to meet the consumption of raw materials.

It is important to notice that Figure 27 do only provide a rough description of the demand transfers. A figure can only present a simple-, two dimensional-, and static pictures of how the demand is transferred and therefore it cannot fully illustrate the route each individual piece of demand follows throughout the network of predetermined and unforeseen pathways. These individual pathways are affected by thing like, the location of the end customer, the numbers and type of ingredients used in each product, the purchasing responsible route through the raw material stock to note raw material shortages, and the bakers de-tour to pick a new sack of flour because the one they just fetched did burst and scattered flour all over the front yard. All of these pathways are impossible to illustrate, which means that demand transfers can only be fully understood through firsthand observations.

Nevertheless, Figure 28 illustrates the main patterns the demand transfers formed the in the bakery after the improvements were done.

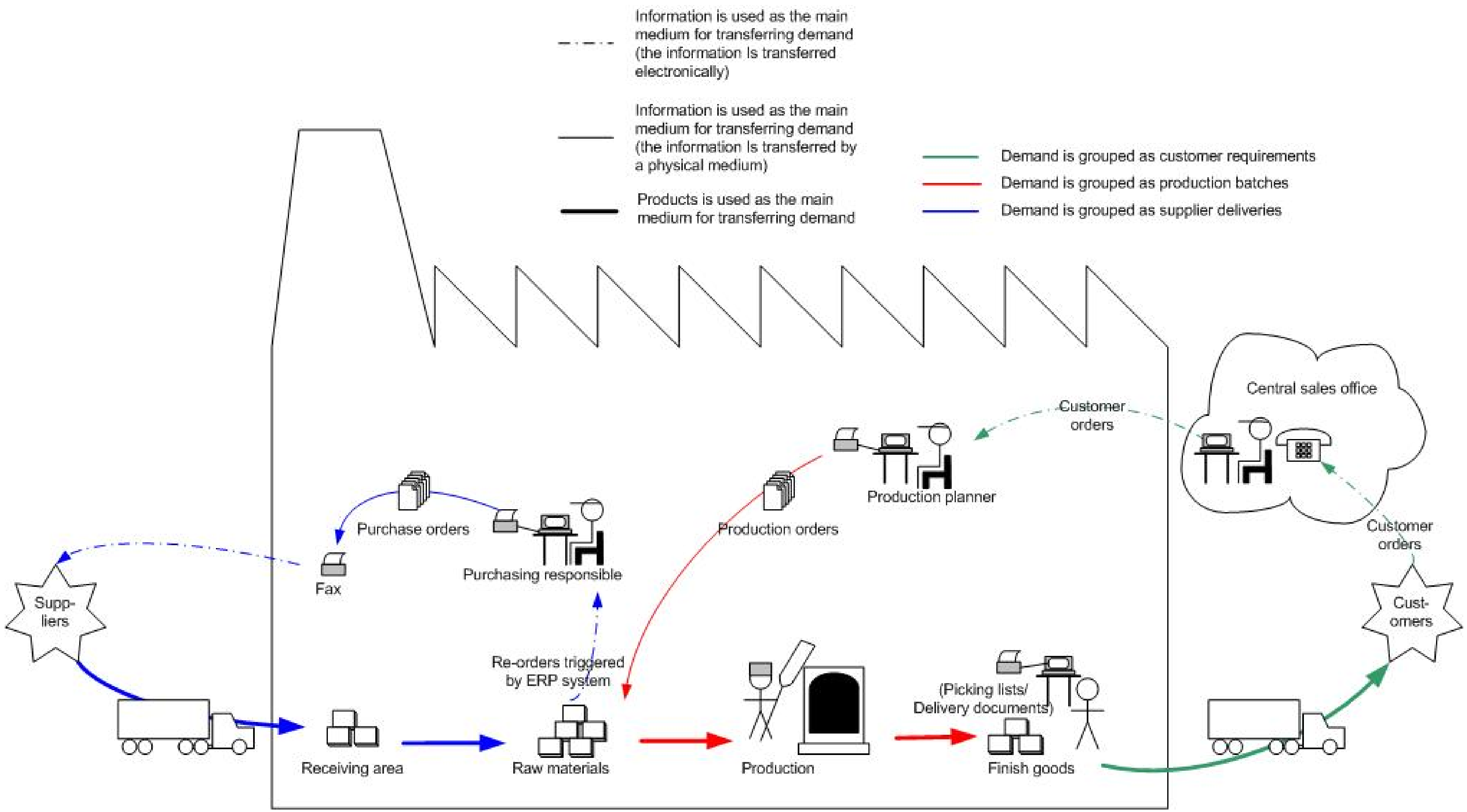

Figure 28. Streams of demand within the bakery after the improvements.

The new solution indicated in Figure 28 outlines that the customer orders has become the main driving force for the demand that streams throughout the bakery. In addition, the demand transfers through purchase ordering routines has been simplified by letting the ERP-system initiate the purchases orders and by faxing the printouts directly to the customers. However, the figure does not illustrate all changes in how the demand is transferred, like; the impact of the reduced number of suppliers caused by the centralisation of management of purchase agreements; the reduced number of rush orders- and wreckages caused by inaccurate forecasts; or the savings each time a baker looks into the ERP system and finds that the ingredient he has been waiting for has been received but not yet placed into the shelves.

7.2 Case study two; Metal component maker.

Case study two discusses a metal component maker that produces brass components for the international market. The company has two production sites, one in Norway and one in North America. This case study discusses an improvement project performed at the Norwegian production site from 1999 to 2000. In this period the company had around 130 employees and a yearly turnover on approximately 100 million NOK.

This production site was world leading within their specific area, and all of their customers was sited abroad. They processed 70-100 customer orders daily, which mainly were on order unique products or products that only were ordered a handful of times. All of their sales items had the same basic structure, which meant that the products had to go through the same basic steps within the production process. These steps were:

- Melting/Casting
- Sawing
- Machining through various production cells that included operations like; rough turning, fine turning, milling, drilling, and deburring.
- Washing/Packing

The company had their own foundry where they made all castings needed for production[131]. After the foundry operation, the castings were sawed into different pieces, depending of the type of product that was to be

[131] A small number of castings were purchased, but these and other purchasing functions will not be discussed in this case study.

produced. Then, the brass components were processed through various manufacturing cells before they were packed and shipped to the customer. The manufacturing cells were composed of various kinds of machines, and the same operations could be performed within different cells. This meant that identical products could use different routings as they moved throughout the production process.

The production site disposed a building that was separated into three parts. One of these housed the administration functions, and included offices for planners, managers, and various administrative workers. The physical work was performed in another part of the building. This part housed the workshop, the foundry, stock locations and offices for foremen and the CNC[132]-programmers. These two parts were connected through a third section consisting of a canteen and a long hallway.

7.2.1 The initial solution

The customer orders were the result of some sales activities before they were put into production. These activities were usually initiated by that a customer phoned the company and asked for a price estimate on a certain order. Then, with the help from people at the engineering department and a special made spreadsheet, the customer- and sales responsible prepared an offer, which he sent back to the customer. If the customer accepted the offer, the sales and customer responsible made new item- and product structure records in the ERP system[133], which again were used to prepare a production order. The customer order was not made before the products were finished and ready to be delivered.

When a production order was made, a production order receipt was printed and attached the drawings (if these were available). Then, both were sent to the engineering department that performed the required engineering work, either by making new drawings or by adjusting old ones if the product has been ordered before. The drawings were then sent back to the sales and customer responsible, where they usually laid until the production planning was completed.

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[132] CNC = Computer Numerical Control: A technique in which a machine tool controller uses a computer or microprocessor to store and execute numerical data (APICS Dictionary ninth Ed.).

[133] A computer program had been made to automatically transfer the information from the spreadsheet to the ERP system, but this was not put into use.

All new production orders in the ERP system were made with a certain operation as the last operation. This was done to identify all new and unplanned orders. The production planner had made a special function within the ERP system that listed all production orders with this particular operation as the last operation. In this way, he could find all orders that should be included in the next production planning run. Then, he used these orders to plan the production and to create new casting- and drilling plans. Thereby, he changed the last operation of these production orders so that they were excluded in the next planning round. This last operation was changed to an operation that indicated which customer that had ordered the goods. In this way the people at the packing and delivery department could see where the order was heading by looking at the job shop card. The casting- and drilling plans was then printed and sent to the foremen offices at the foundry- and production departments.

When the production planner was finished with the orders, the working cards and the job shop card were printed in the office area and attached to the drawings. The production foremen had to regularly come into the office area to check if new any orders had been prepared. The working cards, the job shop cards, and the drawings were then taken to the foreman office in the production part of the building. Thereafter, the CNC programming was started.

After the order was CNC programmed, the goods were finished in the foundry and the sawing operation, and when the production foreman meant that there was sufficient capacity; the first working card was sent to the first production cell and the production order was started in production.

The workers reported the production by writing things like the produced quantity- and the working time for each operation directly on the working cards. The working cards could thereafter be sent several times back and forth between the production department and the sales and customer responsible in order to keep production order record in the ERP system updated.

It was not unusual that the customer called in to get the status of the order or to change something in this. A change note was automatically written out in the office area if customer had altered something in the order. This note was then sent to the production foremen office, which performed the necessary actions to meet the new customer requirements.

After the production order were finished, all remaining working cards were gathered in the production and send to the office area so that the production order recorded in the ERP system could be finish marked. Then, a customer order record was created in the ERP system, and the delivery documents were printed and sent back to the packing and delivery department.

7.2.2 The need for a new solution

The company was known for their excellent product quality, and had steady group of satisfied customers. Nevertheless, both their delivery precision and their earning could be improved, and therefore they had started to look for solutions that could improve their logistics performance without putting the quality of the products and the relations to their customer into jeopardy. Therefore, they contacted the supplier of the ERP system to se if they could suggest an improved solution.

The ERP-supplier sent a business consultant that had several meetings with the company's staff. In these meeting it were concluded that the company should upgrade their old system into a newer version in order to open new possibilities for improving the logistics performance. A report was perpetrated that suggested several changes in how this upgraded ERP system could improve the work routines. The main issues in this report are summarised below:

- *Demand planning*: The company received forecasts (on paper) from their customers that by that time only were used to get a rough picture of the demand situation. These forecasts should directly be applied within the production planning routines.
- *Capacity planning*: The Company wanted to make better use of the ERP system's capacity planning functionality.
- *Production order management*: The report included a rough sketch of new production order management routines, which among other things, included the use of a data acquisition system (see below).
- *Data acquisition in production*: The upgraded version of the ERP system had extended possibilities of data acquisition in production. If these were employed, it would ease the administrative work for handling production orders and improve the responsive time for updating these.

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- *Forecast driven casting process*. There had been discussion about making an intermediate stock between the casting processes and the rest of the production. This meant that the casting operation should be initiated by the forecast from the customers, while the rest of the production should continue to be driven from customer orders. However, these were just discussions and a final decision had to be made by the plant manager.

It was made clear in the report that these suggested improvements were not meant as final solutions, but rather as a starting point for designing new routines.

7.2.3 Towards a new solution

An improvement project was initiated. This project included five members from the supplier of the ERP system, in addition to the company's own people. Two of these members from the software supplier were business consultants that should support the company with applying the logistics functions of the ERP system. Another business consultant was allocated for updating the financial module of the ERP system. The forth and last consultant, was a technical consultant that were hired to clarify the ICT technical issues in the ERP system. In addition, both the company and the ERP supplier had an own project manager that were responsible for the administrative processes and the progress of the project. This case study will only focus on the work in the logistics part of this project, which also was the main share of this.

The project was performed by first copying the basic data from the current system into a test version consisting of the new version of the ERP system. Then, the project members started to prepare a new solution within this test environment, which should overtake the role of the current system when all of the involved parts were satisfied with how it worked.

New solutions were constantly redefined through discussions between the consultants from the ERP-vendor and the employees at the firm, while new versions of the configuration were continuously made in the test system. Approximately nine months after the project had started, the final solution of the test system was converted into an operational database and the new system was ready to go live. This system represented a solution that was quite different from the improvements outlined in the report that were presented in section 7.2.2. This new solution is described below.

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First, the price estimate was calculated by using the same routines as before. Then, if the customer accepted the offer, new item- and product structure records were entered into the ERP system and a customer order was prepared. The customer order generated a production order proposal that were logical connected to this specific customer order. Then, the person that received the order should immediately perform a capacity check and schedule the production order proposal into an available capacity window and thereby convert this proposal into a "real" production order. This capacity check was performed by verifying the available capacity on the bottleneck operations in the production through the use of the ERP systems capacity planning functionality. In this way the customer could immediately get the delivery date confirmed and the capacity planning were performed already at order entry.

Then, the production order receipt was printed and attached the drawings[134], before both were sent to the engineering department. The drawings could be sent directly to the CNC programmer after they were finished in the engineering department. This because the manual production planning was as good as eliminated. The capacity planning had already been performed, while the casting- and drilling plan were automatically created by the ERP system through mapping the casting and drilling operations in the production orders into dispatch lists. These lists should be updated -automatically and constantly, and appeared on the PC-screens at the foundry- and the production foreman offices.

The production could start as soon as the castings were finished in the sawing operation and CNC programs were programmed. A data acquisition system was to be installed in each production cell. This system included a PC-screen were a time phased dispatch list that listed all operations that was to be processed in that particular cell. This dispatch list should provide the workers with all the information they needed to perform and prioritise their work. These lists included information like the planned start date of each operation; if order were finished in the previous operation; and which production cell the order should be sent to next.

The workers were then to choose the operation with the most recent start date, and report this operation after the work was done by using the data

[134] …if the product had been ordered before…

acquisition system. The production orders were therefore only managed electronically, which meant that these were updated immediately and automatically without the need for sending things like working cards and change notes.

The status of customer order in the ERP system should become automatically updated to "ready to delivery" when the last operation of the production order were reported as finished in the production department. This because the customer order were created first in the sequence and was logical connected to the production order. The delivery document could therefore be printed as soon as the products reached the packing operation, without having to wait for that the working card should be sent to the office area for manually updating the production order so that the customer order could be created and the delivery document printed and sent back to packing operation.

All of the involved parties had agreed on these work routines and three kinds of tests had been made to verify the solution: First, a pilot test that tested each individual function within the system. Then, a test of the whole configuration by using selected test- "products" and "customers". Finally, a full scale test were as good as all of the users tested the system simultaneously and as close as possible to how would be applied after the start-up.

However, despite of these efforts, several adjustments had to be done to the solution after the start up. These adjustments were caused by things like new requirements for management reports, problems connected to the backup of the main server that forced a delay on the implementation of the production data acquisition system, and faulty (and fixed) lead time data that made the production capacity check unreliable.

This case study ended right before the new solution did go live and before all of these start up problems was cleared. However, the company did overcome these problems and the new solution helped them to improve their logistics performance as well as their overall earnings[135].

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[135] According to their financial statements, the company had gone with a considerable loss during the last years before the millennium shift. Their earnings were soon improved after the project, and by 2002 their yearly losses they had turned a corresponding yearly profit.

7.2.4 Case study two seen from a demand transfer perspective

In case study two, the customer demand was transferred (and transformed) in a network that was made up of several kinds of actors, such as; the drawings, the ERP system, the working cards, and various production workers. After the demand came in from the customers, the stream of demand was divided and transferred to the engineering department, as well as to the production planning functions. Thereafter, the demand was sent towards the foremen and the CNC programmer, before they merged again and transferred back to the customer in form of finished products. The way these streams unfolded themselves within the different part of the production site is illustrated in the figure below.

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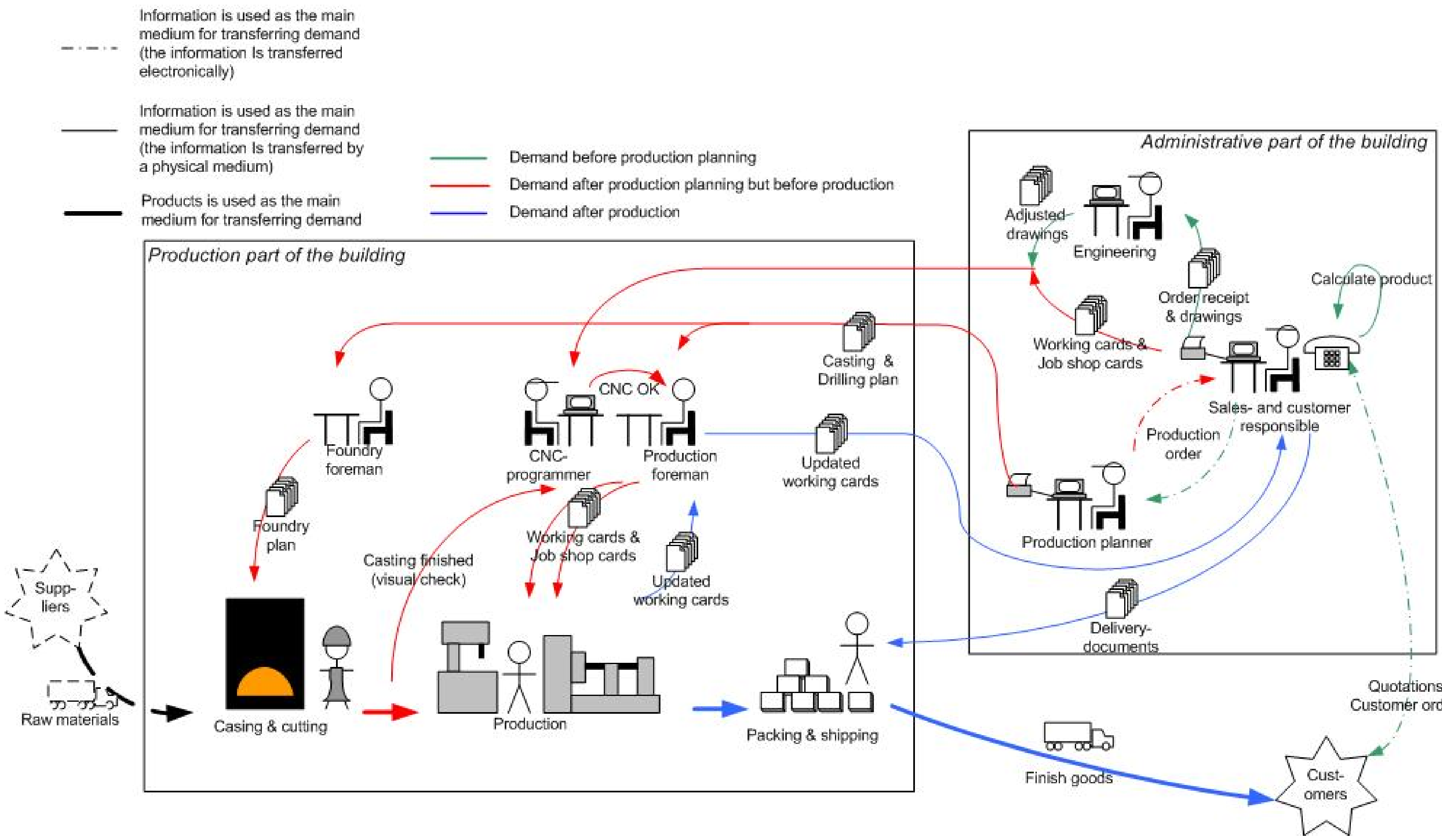

Figure 29. Streams of demand within the production site before the improvements

Figure 29 uses the same notation as the figures in the previous case study, but with some exceptions: The green arrows indicate streams of demand that has not yet been planned for production. The red arrows represent streams of demand that are planned, but have not been transferred through the production process. Finally, the blue arrows indicate the streams of demand that are performed after the production process.

Figure 29 illustrates that the streams of demand branched- and merged several times before they were sent back to the customer. The figure does also indicate that a large part of these demand transfer were handled through manual information carriers, like the working cards or the paper based casting- and drilling plans. The new solution eliminated much of this physical information handling. This solution is outlined in Figure 30.

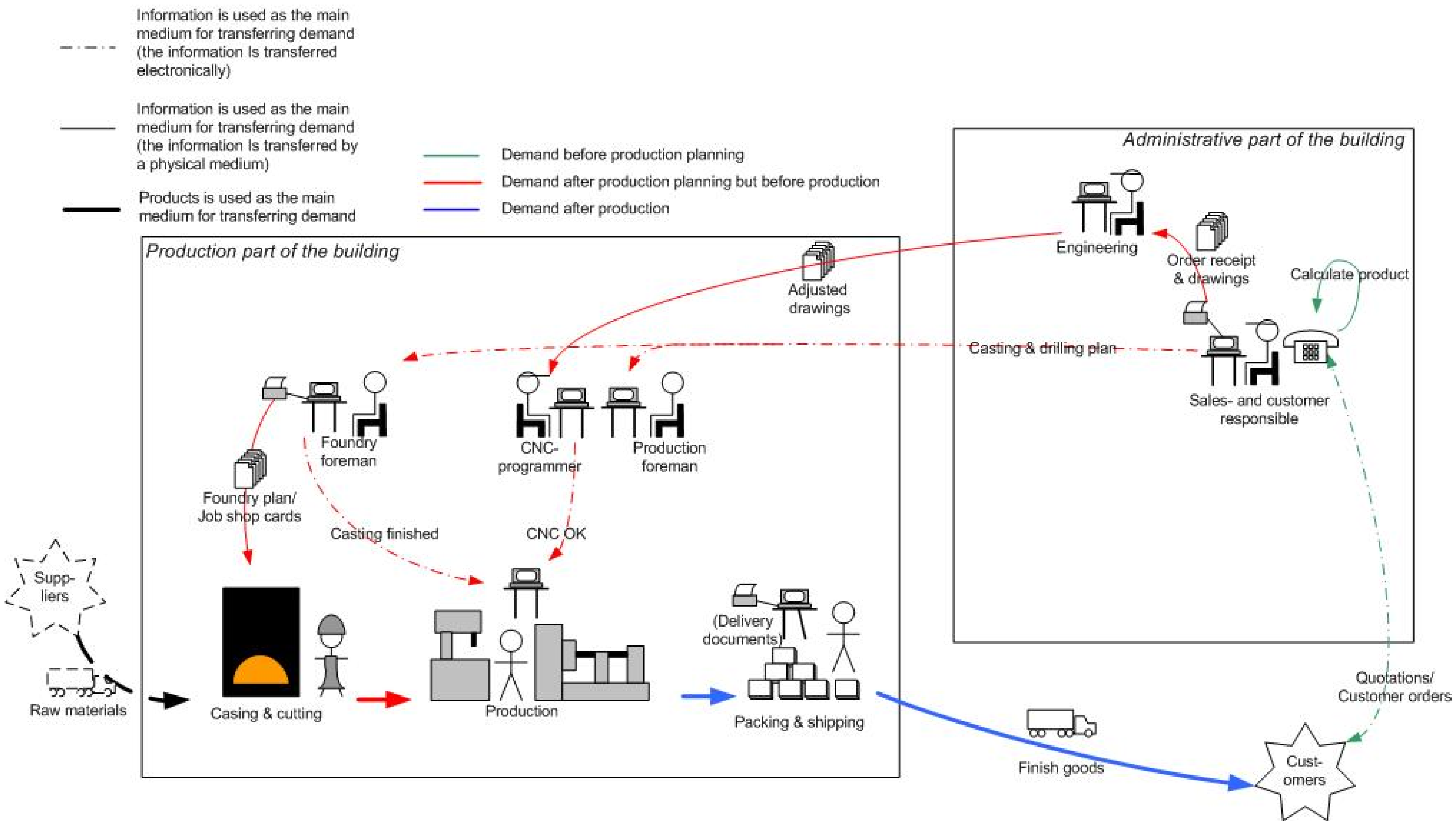

Figure 30. Patterns of demand transfers within the production sites according to the test system.

Figure 30 illustrates a logistics network where the total numbers of demand transfers has been reduced. In addition, a larger portion of the demand transfers are performed more effectively through the use of ICT systems. For instance, the paper based routines for updating the production orders is eliminated by using the data acquisition system; the production planning has been automated and simplified; and the delivery document can be printed directly in the packing area.

7.3 Conclusions drawn from the case studies

The purpose of the case studies was to confirm if the alternative perspective could be used to study real life events. Three success criteria for validating this were presented in the beginning of this chapter. Each of these success criteria will be discussed below.

- In the case studies; is it possible to find patterned networks of diverse materials that transfers and transforms customers demand?

Networks of human and non-human actors that hold patterns for the transfer- and transformation of customer demand were illustrated in both of the case studies. These networks included actors like the hand-written lists, the ERP system, the purchasing responsible, the job shop cards, the production workers, and so on. Some of the actors were less obvious than others, like the chalk mark on the wall in case study one that indicated when a new load of flour had to be ordered, or the layout of the building that separated the production and the administrative functions in case study two.

- Do these demand transfers create intangible streams of demand, which alter as they flow through both predetermined- and unforeseen pathways throughout the logistics network?

Intangible streams of demand were identified in both case studies. The most important of these were sketched in Figure 27 to Figure 30. The main share of these streams of demand flowed through predetermined pathways. However, there were indications of that some of the demand was transferred in unexpected ways. For instance, in case study one, the people in the production and purchasing department did not follow all aspect with the solution that was made by the first improvement project. Instead the used their own routines, like the manual production planning process and the handwritten lists that were sent between production and purchasing department. While in case study two, the solution made in the test system had to be reworked in several areas after the start up because it did not function as intended.

As it was emphasised in case one, the descriptions and illustrations of the case studies do only provide simplified pictures of how the demand is streaming throughout the logistics network. The case studies cannot illustrate all the events that have an impact on the demand transfers, like wreckage in production and -transportation, machine breakdowns, and rush orders. It is also important to notice that the solutions presented in the case studies must not be seen as final designs, but rather as intermediate states. The logistics network is always being negotiated between the various actors, which mean that the streams of demand will continuously seek new pathways.

- Are applications of ICT systems utilised as an actor in interaction with other actors to manage and control these streams of demand?

Several applications of ICT system that both managed and controlled these streams of demand were mentioned in the case study. However, in both case studies the ERP system was one of the most important actors for how the streams of demand were transferred and transformed throughout the logistics system. For instance, the ERP systems enabled production from real demand in case study one, while it were used to simplify the production planning and order management routines in case study two.

Therefore, the three success criteria for the case studies have been confirmed. Consequently, it has been successfully confirmed that a Demand Transfer perspective on the role of applications of ICT systems for logistics can be used to observe real life events.

8 Six conceptual guidelines for improving logistics performance through application of ICT systems

In chapter 2.2.1, the main problem of this thesis was defined to be:

How can logistics performance be improved through applications of ICT systems?

Using the Demand Transfer perspective to find solutions for how to improve logistics performance through applications of ICT systems is actually quite easy. This can be illustrated through one of the many stories involving Dr. Shigeo Shingo:

One time, a company came to Shingo for help with a one of their machines. The problematic machine twinned a steel wire around a hose and the problem was that this steel wire was often cut during an operation. This resulted in long repair times and loss of production capacity. Therefore, a manager from the company asked Shingo of what he suggested them to do with this problem, whereupon Shingo replied that manager should ask the machine why it did cut the wire. The manager did not understand what Shingo meant, so he asked him again, and Shingo replied that if he observed the machine carefully for at least half a day, it would start talk to him. Thereby, the manager went down to the machine to observe and document what happened when the wire was cut off. Through these observations the manager found that the device that guided the wire into the machine, twisted this in 90 degree angles in two different places. The Manager changed the guiding device and the problem was solved.

This idea can also be used when it comes to applications of ICT systems for logistics. If you carefully observe how the demand transfers actually are performed, they will start to talk to you of how they can be improved. However, the resemblance between improving a machine and improving the organisation's logistics performance through applications of ICT systems for logistics ends there. An organisation includes people and therefore, in difference to improving a machine, improvements done through applying ICT systems in organisations is usually not that straight forward and accurate. The solutions are always negotiated between interests, which means that improving logistics performance through applications of ICT systems should rather be seen as dynamic process than an implementation of a given solution or design.

However, the approach described through the example above may be too abstract to be termed a guideline for how applications of ICT systems be used to improve logistics performance. Therefore, the Demand Transfer perspective has been used by this research project to suggest the following six conceptual guidelines for how logistics performance can be improved through applications of ICT systems:

1. Information is just a mean, not a purpose in itself.
2. Think total network, but do improvements within your own domain.
3. Applications of ICT systems for logistics should contribute in fulfilling the customers demand.
4. Separate real- and anticipated demand.
5. Seek simplification and reduction of the total demand transferring network.
6. When improving logistics performance through applications of ICT systems; stay close to the actual demand transfers.

The first of the guidelines concerns with the attitude towards the applications of ICT systems for logistics. The second deals with the range of the improvements. The third guideline outlines the purpose of applying ICT systems for logistics. The fourth and fifth are about the strategies that can be used to improve logistics performance through applications of ICT systems. The sixths and last of the guidelines, tells something about the approach that can be used when improving logistics performance through applications of ICT systems.

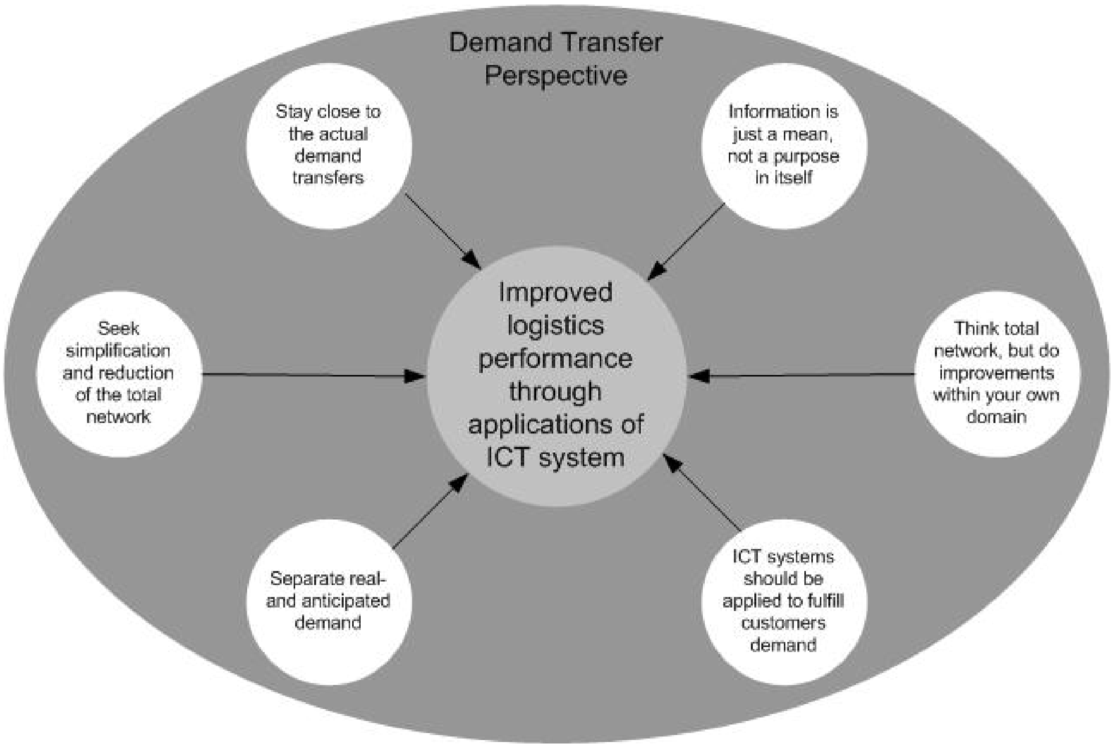

Figure 31. The six guidelines and the Demand Transfer perspective.

Figure 31 illustrates the relations between the six guidelines and the Demand Transfer perspective. All of the guidelines are based on the demand transferring perspective, but their approach towards improving logistics performance through applications of ICT systems is slightly different. Therefore, these must not be seen as individual guidelines, but rather as elements within the larger context of the Demand Transfer perspective.

8.1 Information is just a mean, not a purpose in itself

As emphasised earlier in this thesis: machines and organisations are not similar. However, being an engineer, this author finds it natural to do such metaphors. Like this one; an engine need a particular operating temperature to perform at its best. However, an engine that produces too much heat is not an effective engine, because the excess heat represents consumption of energy that does not contribute to the output of the engine. The same can be said about logistics organisation and how they generate information. Logistics organisations need information to perform at their best. However, a logistics organisation that produced too much information is not an effective organisation, because this excess information does not contribute to the output of the organisation. Or said in another way: *too much information costs money*, both through the making and management of this, as well as an object of distraction.

The Demand Transfer perspective suggested that *applications of ICT systems for logistics only are means for transferring the demand throughout the logistics network*. However, there are other means or actors that can be used in these transfers as well, like in Ohno's (1988) example where the worker's physical observations of the product were used to initiate the production[136].

This means that alternative solutions for transferring the demand should be considered before applications of ICT systems are put into use. For instance, before a company establishes an EDI connection to one of its suppliers, they should consider things like making a contract with the supplier that specifies deliveries through a time phased schedule, or moving parts of the supplier's production within their own production facility. This way of reducing the need of information is quite clear in Japanese production philosophy, which suggests things like that suppliers should be moved towards the wall of the production site and that manufacturing facilities should be made as small and focused as possible.

In addition, the Demand Transfer perspective suggests that applications of ICT systems for logistics should be used to transfer demand, which means that all other logistics applications of ICT systems that – both directly and indirectly – are not contributing to the transfer of demand should be a subject of a critical examination. Such a view does also correspond with the Japanese thoughts of using computers in the industry. Vollmann et al. (1997) for instance claims that computer systems can, and often should-, be used to analyse and solve various problem within a JIT environment, but "*when the problem is clearly solved, the detailed computer system might well be abandoned*".

Therefore, the use of information and applications of ICT systems for logistics must not be seen as a purpose in itself, by only as tools that may help the company towards improved logistics performance.

[136] See section 5.3.

8.2 Think total network, but do improvements within your own domain

The alternative perspective presents the demand transfers as continuous, which means that the improvement of the total demand transferring network is the sum of all individual efforts. This does also mean that an improvement one place will have an effect on how the demand is transferred in another parts of the logistics network.

No one can improve the total network by themselves, but everyone can improve how the demand is transferred in within their own area of responsibly. This area may be a work centre, a department, a factory, a whole enterprise, or part of a total demand chain.

Such areas of responsibility do overlap. For instance, in case study one the improvements in the individual bakeries were done by the production planners and the purchasing responsible, while the general manager of the purchasing functions administrated the improvements on the behalf of the whole Norwegian part of the enterprise. This means improving logistics performance through applications of ICT systems for logistics may include decision in different levels, areas, and/or fields, like the sales strategy, the tactical placement of stock locations within a production facility, or the operational execution of tasks on the shop floor within a department[137].

This means that different people can use applications of ICT systems to do improvements within different domains. However, all improvements must be aligned in order to increase the logistics performance of the total network.

8.3 Applications of ICT systems for logistics should contribute in fulfilling the customers demand

In section 6.2 it were outlined that the Demand Transfer perspective looks at the logistics network as a reflection of a market, which means that *the logistics network and the marketplace are mutually dependent of each other*.

[137] See e.g. the Håg and Dell example in section 2.2.2 or the case studies in chapter 7 for examples of efforts that requires improvements within different domains of the logistics network.

This can be illustrated through in the historical development of the car industry. The first cars were handmade by artisans and tailored towards each specific customer. This meant that the customer could influence the shape of his car, but unfortunately this way of production made the cars both expensive and unreliable. Only the wealthy could afford such a car.

During the industrial revolution the innovation of interchangeable parts opened possibilities for mass-producing cars. This paved the way for a new approach of manufacturing which reduced the cost for each car that were sold, and opened a market for selling cars to the ordinary man. This resulted in that the market of the hand made cars collapsed, and most of these manufacturers vanished. However, the first mass produced cars had a mayor problem; they were highly standardised products. A good example this is the famous words of Henry Ford, which stated that the customer could order any colour he wanted, as long as he choose black.

When General Motors changed their strategy towards producing different cars to fulfil different market segments, the market for the standardised Ford's shrunk, and the Ford Company went almost into bankruptcy (Hopp & Spearman, 2000).

The next (and last) great paradigm shift in car manufacturing came from Japan during the 1970's. The Japanese (and Toyota in particular) won market shares by fulfilling the demand of their customers through a manufacturing system that were able to produce affordable cars, in more variants, and often with a higher quality than their competitors in the West (Banken & Aarland, 1997; Womack et al., 1990; Hopp & Spearman, 2000).

This short story indicates that the market and market share is affected by an organisation's abilities to fulfil the demand of the customers within the marketplace (and vice versa). Alternatively, it can be said that an organisation that is able to fulfil the individual demand from the customer better than its competitors, will win market shares and prosper. While an organisation that is not able to fulfil the individual demand of the customers as good as its competitors, will eventually loose its market shares and start to decline.

This means that increased market shares can be achieved through following the ideals of the Demand Transfer perspective for applying ICT systems to transfer the individual demand from the customers within the marketplace in such a way that it can be fulfilled in the best possible manner.

However, winning market shares is not the only reason for focusing on the demand transfers. The profitability of a logistics network may be seen as the difference between the resources and costs consumed in the logistics network and the value realised within the marketplace. This means that the profitability of a company will increase if it is able to fulfil the demand of customers with a logistics network that requires less resources and/or costs. Both of the case studies in this thesis were examples on such efforts of improving profitability.

Therefore, applications of ICT systems for logistics should be aligned with the rest of the organisation to fulfil the demand of the individual customer within the marketplace in the best possible- and most efficient manner.

8.4 Separate real- and anticipated demand

There can be separated between two types of demand; real- and anticipated (see Shingo, 1989). Anticipated demand is demand that is based on anticipation of the future, like forecasts or demand generated to fill a safety stock. While real demand is demand that reflects what actual is in need. Both kinds of demand are needed within a logistics network, but logistics tasks should preferably be driven by real demand. This because real demand reflects what actually is in need and does contain inaccuracies that may lead to thing like unnecessary stocks, wreckage of obsolete goods, and shortages of certain products.

One of the most important factors behind Toyota's success was that that they began to assemble cars from real customer demand when the car manufacturers in the western world made cars to stock from anticipated demand (forecasts). Alternatively, it can be said that Toyota was the first car manufacturer that went from a "push-" to a "pull" strategy.

Today, manufacturers try to use application of ICT system to initiate production from real customer demand as far back in the logistic network as possible. Some of the best logistics performers of today do this by sending their actual customer orders to their nearest suppliers. For instance; Dell passes their customer orders to their first tier suppliers so that the exact amount of components is ready when the assembly of the computers starts two hours later. In this way, Dell manages to make products with no stocks inside their plants (Jacobs, 2003). Another example is Håg that transmits their customer orders to one of their sub-contractors so that the exact amount and -type of components can be produced by this contractor before they go into the customer configured swivel chair (Alfnes & Strandhagen, 2000).

The same principle of exchanging production from anticipated demand with production from real demand was used to improve the planning routines within the bakery in case study one. The forecasts based production planning routine was rejected in favour of a routine that used the real demand derived from the customers orders to drive the production processes.

However, production after real customer demand has its limitations. First, the logistics network needs to be flexible, because real demand does not provide indications about future demand. Second, production from real customer demand can not be applied where the product's throughput time is longer than the customer's lead-time. This means that a product that takes three days to produce cannot be produced from real customer demand if the customers want these within two days.

Toyota tried to solve the problem with the customers lead-time by reducing the production lot towards the size of one, so that the throughput time for each a car was minimised. Despite of this, Toyota were only able to drive the assembly from the real customer demand. However, upstream the assembly, they initiated the production in each operation by the real demand from the succeeding operation[138], and by keeping the stock levels down and reducing the lot sizes, Toyota tried to get as little anticipation as possible into the streams of real demand. In other words they tried *to keep the real demand as close to the real customer demand as possible*.

However, Toyota needed also to predict future variations in the demand situation. These anticipations were provided by production rates that were formed through a planning routine which were based on a market research. These production rates were communicated to both internal- and external units, but were held separated from the real demand that were

[138] This was done through the use of Kanban cards.

transferred by the Kanban system. This means that they also tried to *separate real- and anticipated demand*[139].

The Demand Transfer perspective focuses on demand transfers that originates from the customers and are sent throughout the logistics network. This means that this perspective suggests that the logistics processes should preferable be driven by the real customer demand and hold separated from any kind of anticipations of as long as possible. However, it is important to notice that anticipated demand is still needed within most logistics networks, for doing things like providing anticipations on future demands or to smooth the streams of demand within the total network.

8.5 Seek simplification and reduction of the total demand transferring network

The Demand Transfer perspective suggested that applications of ICT systems function is an actor among other actors that transfers customer demand throughout the logistics network. This means that this view presents the core function of applications of ICT system as a set of individual demand transfers. A demand transfer between two points (A and B) performed by an actor X is illustrated in Figure 32.

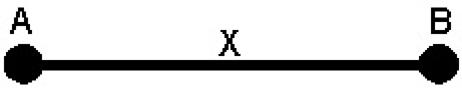

Figure 32. A demand transfer between A and B performed by actor X.

Such transfers may both delay- and generate flaws in the original demand. For instance, a manufacturer that communicates component requirements to a supplier through an internet site: In this case, delays in the demand transfer are represented by factors like the frequency in which the internet site is updated or the method used by the manufacturer to enter the actual requirements into this internet site. Flaws in the demand can appear through thing like; incorrect readings at the supplier side or insufficient possibilities for describing the requirements through the web-site.

[139] See Chapter 4.1.2 for a more intimate description of the planning routines within Toyota Production System.

A transfer of demand would also allocate- and consume various kinds of resources. Using the same example as above, resources are consumed through things like: investments in computers and commutation devices, the efforts to establish and maintaining the relationship between the companies, costs connected for establishing and maintaining the communication link, and expenses paid to the internet site provider for each transaction that are transferred through the site.

A demand transfer that represents a high degree of delay, flaws, or consumption of resources, will have a negative effect on the performance of the total logistics network. This means that a demand transfer should seek to fulfil tree properties:

- The transfer should happen immediately and with no delay. Delays in the demand transfers may impede the realisation of the value creating processes and lock assets. Therefore, there should be no waiting time between the demand appears and until it is sent to the receiver.
- The transfer should be performed flawless. The demand and demand representation may change in form, but no deterioration of the original demand should happen.
- The transfers should not consume or -allocate any kind resources. The demand transfers should therefore be performed with a minimum amount of resources involved.

However, all three properties must be simultaneously taken into consideration. This means that improving one property of a demand transfer should not result in a corresponding worsening of the two others. A perfect demand transfer can therefore be described as a transfer where all of these three properties have been eliminated. Using the notations in Figure 32 this means that actor X should transfer the demand so that: *Demand A = Demand B*.

However, all transfers represent some kind of delays, flaws, and/or consumption of resources. This indicates that the best way of making sure that the logistics network is improved, is to remove the transfer completely without reducing the total networks abilities for fulfilling the customer's demand.

If these properties are fulfilled by all transfers performed by all actors; the customer should get what he demands, exact when he demands it, and with no costs accrued. Of course, this is impossible to achieve in real life, but the idea can be used as a principle for improving logistics performance. This way for thinking is presented in the figure below.

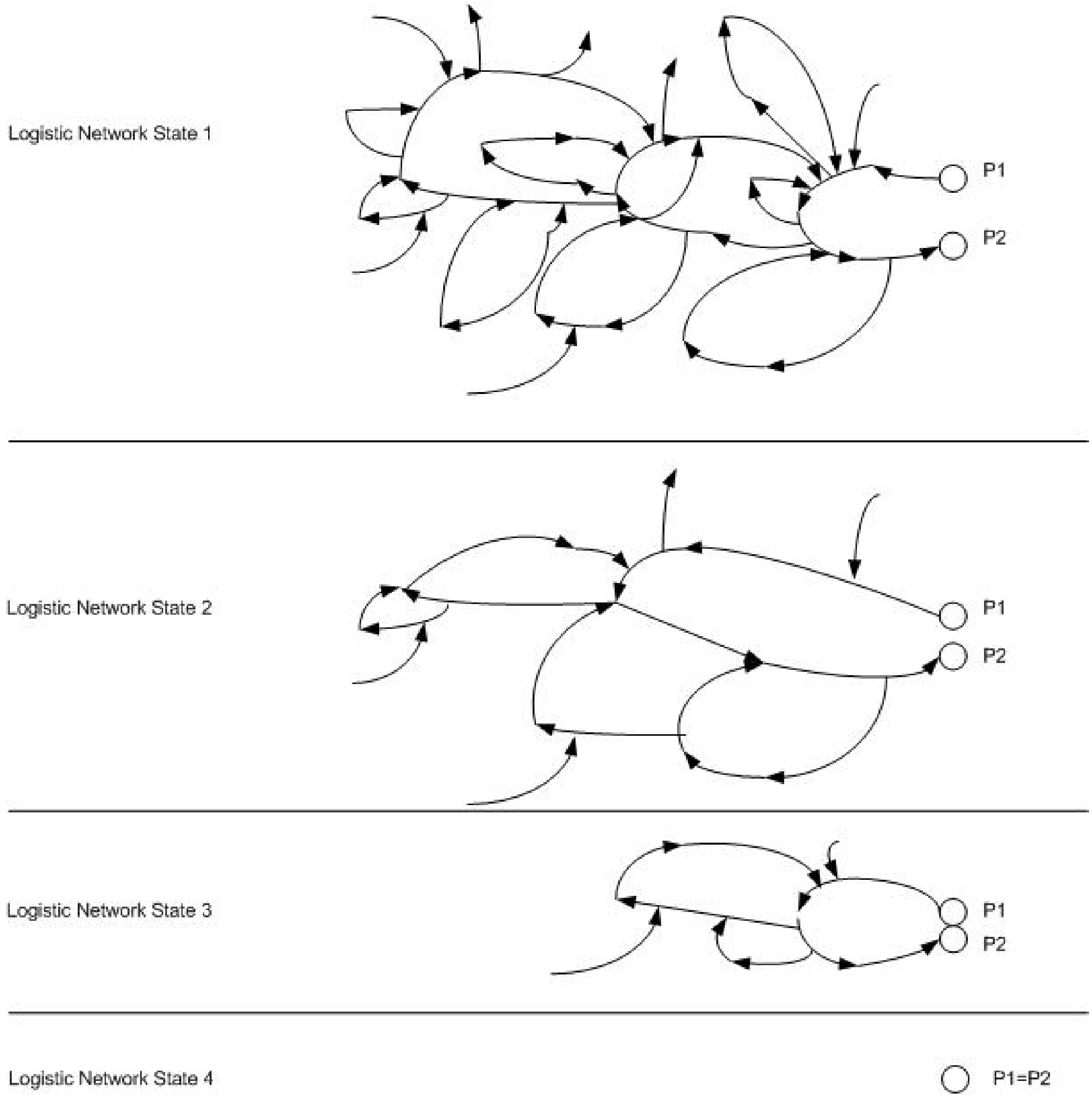

Figure 33. Improving the logistics network.

The figure represents a logistics network that is improved through three states. In the first state, a large network consisting of many interrelating demand transfers is used to transfer the customer demand. The fulfilment of the customer's demands relays upon the all of these demand transfers, which again generates various kinds of delays, flaws, and consumption of resources.

In the second state, the network that transfers the demand is organised in a more efficient manner. The gap between the customers demand and its fulfilment has become smaller, while the total network for doing this has been reduced so that the total amount of flaws, delays and consumption of resources have gone down.

The same goes for the third state. The network is reduced simultaneously as the fulfilment of customer demand is improved.

The forth state represents the ultimate state, which only is a theoretical state. Here the customer gets his demand fulfilled immediately without communication this to other parties. This forth state does also indicated that there is no such thing as an optimal logistics network. This means that the Demand Transfer perspective looks at improvements of logistics performance as a continuous search towards an unattainable goal.

According to the Demand Transfer perspective, the reduction and/or simplification of the total demand transferring network is always advantageous as long as it not reduces the networks abilities to fulfil the end customers demand. Reduction and/or simplification of the demand transferring network will in most cases lead to a logistics network that are more profitable, manageable, flexible, and effective. Simultaneously as it might help a company to gain profitability and win market shares.

Application of ICT systems for logistics can be an important actor in such a reduction of the total demand transferring network. For instance, Dell skipped the whole retail distribution network when they enabled direct sales of personal computers through the internet (See e.g. Christopher, 1998). While both the case studies in this thesis illustrated similar examples, but only in a smaller scale: In case study one the logistics performance within the bakery were improved through simplification and reduction of things like the production planning- and the purchase order routines. Simultaneously, the general manager of the purchasing functions wanted to bring down the total number of suppliers by using the ERP-system to centralise the management of the purchase agreements. The same goes for case study two; the solution were improved through simplification and reduction of the total demand transferring network by applying ICT tools to reduce things like the need for production planning and the number of manual information carriers.

This outlines main principle for how the Demand Transfer perspective suggests how logistics performance can be improved through applications of ICT systems:

Logistics performance can be improved through applications of ICT systems by using these as one tool for inscribing a total network of demand transfers, where the individual demands from the customers in the market place are fulfilled with a minimum of delays, flaws, and resources spent and –allocated within the total network.

8.6 When improving logistics performance through applications of ICT systems; stay close to the actual demand transfers

The Demand Transfer perspective suggests that the customers within the marketplace are the main originators of the streams of demand that flows throughout the logistics network. This means that the way the demand is transferred close to the customer will affect how the demand is transferred in rest of the network. Therefore, efforts to improve logistics performance through applications of ICT system should always start as close to the customers as possible.

It is important to notice, that the Demand Transfer perspective provides a clear view of that improving logistics performance requires more than a customer focus, this because a unilateral focus towards the customer is like driving a car without looking at the rear-view mirrors. For example, a company that only focus on how the demand is transferred within itself and towards its customers might experience problems with their logistics processes. This because the streams of demand the company are sending to their suppliers will directly reflect how the materials are coming back to them. Improvements should therefore insure best possible basis for transferring demand throughout the total network, and not only within the "local" area.

The alternative perspective suggested also that the logistics network is always negotiated between interests. This means that actors can both transfer demand simultaneously as they may change how the demand is transferred. Therefore, applications of ICT systems for logistics must not be understood from how they are configured or ought to function, but from how they actually are used in practical life.

The future users of the ICT system have usually detailed knowledge of how the demand can be-, and often should be, transferred. These people are also the ones that eventually will decide how (or if) the ICT system will be applied. It may therefore be a good idea to include these in the design on the new solution, or maybe letting they make parts of the improvements by themselves.

However, including the users may not be enough, because there are other (and often non human,) actors that also may influence how the demand is transferred[140], and the further the design of the improvements are performed from these, the less likely is it to take them into account. In both of the case studies, the final solutions were formed through a series of tries and errors that were performed close to the place where the applications of the ICT systems were to be used. For instance, in case study one, the new production planning routines was formed by production planners (with the help of a consultant) at the specific bakery, while the details concerning the purchasing routines at the same bakery were mainly done in the office at the raw material stock, with heavily influence by the purchasing responsible.

The Demand Transfer perspective is clear on that a solution will always be negotiated between interests. This means that it must always be taken into account that parts of the solution will not be used as indented. This indicates that applications of ICT systems for logistics are in fact never implemented; only negotiated.

This sixth guideline can therefore be summarised through the following steps:

1. Start as close to the customer as possible, but look towards the total logistics network.
2. Focus on how the demand actually is transferred.
3. Solutions should be made as close to demand transferring network as possible.
4. Remember that applications of ICT systems for logistics are never implemented; only negotiated.

[140] Like the layout of the factory, the marking of products and/or shelves, the machine that often break down, the problematic suppliers, the height to the top shelves, the placement of printers, the person that always forgets to report his or her receipts, and so on.

9 Conclusion

Below, the three research questions of this research are recaptured in order to discuss if these were answered during this research project.

- *What are our current perspectives on the role of applications of ICT systems for logistics?*

Three current perspectives were found. In section 4.1, the Manufacturing perspective was presented. This perspective illustrated the role of applications of ICT systems through various manufacturing planning and control concepts. Section 4.2 revealed the basics of the Supply Chain Management perspective that uses the concept of Supply Chain Management to illustrate the role of applications of ICT systems for logistics. Finally, the Supply Chain Software Package perspective was presented in section 4.3. This perspective presents the role of applications of ICT systems for logistics through the inherent properties of the logistics software packages that are currently available on the market.

- *Is it possible to present an alternative perspective on the role of applications of ICT systems for logistics?*

This research presented an alternative perspective on the role of applications of ICT systems for logistics. This perspective was termed the Demand Transfer perspective and was introduced in chapter 6.

The Demand Transfer perspective illustrates the role of applications of ICT systems for logistics as one of many actors that transfers and transforms the demand that flows through both predetermined- and unforeseen pathways within the logistics network in order to fulfil the individual demand from the customers within the marketplace. In section 2.3, two success criteria for such an alternative perspective were presented, while in section 6.3 it was confirmed that the Demand Transfer perspective fulfilled both of these.

- *Can this alternative perspective be used to develop some conceptual guidelines for how logistics performance can be improved through applications of ICT systems?*

The Demand Transfer perspective was used to prepare six conceptual guidelines for how logistics performance can be improved through applications of ICT systems. These were presented in chapter 8 and are repeated below.

1. Information is just a mean, not a purpose in itself.
2. Think total network, but do improvements within your own domain.
3. Applications of ICT systems for logistics should contribute in fulfilling the customers demand.
4. Separate real- and anticipated demand.
5. Seek simplification and reduction of the total demand transferring network.
6. When improving logistics performance through applications of ICT systems; stay close to the actual demand transfers.

9.1 Future research

In many ways, this research project is not a finishing work. The findings of this research should rather be seen as an introduction to demand transfer thinking. This means that the perspective presented in this chapter should both be a subject of-, and used as base for further research within this field. This future research can therefore be separated into two main directions:

The first of these directions is connected to further development of the Demand Transfer perspective. This can be done in many ways, like through more extensive use of Actor-Network Theory or including a greater emphasis on the impact of the *transformations* of the demand has on the logistics network.

The second direction of the future research is of a more applied character. The Demand Transfer perspective can be used to solve practical problems concerning applications of ICT systems for logistics, or –logistics problems in general. This may lead into thing like new technologies, -methodologies and/or -models. A few examples of such potential findings are sketched below:

- Models for calculating the total profitability of applying ICT systems to support logistics functions within a company.

- Models for achieving and maintaining flexible logistics processes through applications of ICT system.
- New logistics software designs.
- Models for how ICT systems be applied to support specific logistics strategies and/or -market conditions.
- Alternative methodologies for applying ICT systems for logistics into organisations.
- Methodologies for how to identify key logistics performance indicators through a demand transfer perspective.

9.2 Concluding remarks

The main contribution of this research has been the Demand Transfer perspective. This perspective has been tailored towards studies of the role of applications of ICT systems for logistics. This means that the Demand Transfer perspective is tailored for describing certain events or phenomena within the field of logistics, and of course, it does not explain all aspect concerning logistics and/or its relations to applications of ICT systems. Therefore, it must be emphasised that this perspective is meant as an alternative - and not a substitute - to the other perspectives that were discussed in this thesis.

The Demand Transfer perspectives draw the attention to something that always have been there, but have not been explicitly explained. This perspective may therefore have great relevance to other concepts, methods, or models within logistics and related fields. This may only be a strength that confirms the relevance of the alternative perspective. However, during this research it became evident that the Demand Transfer perspective separates itself from current thinking within this field in two respects:

1. Logistics thinking: The Demand Transfer perspective does not look at the material- and the information flows as two individual flows, but as elements integrated within the demand transferring network.

2. The place of the ICT systems for logistics within the organisation: The Demand Transfer perspective looks at applications of ICT systems for logistics as a part of a larger, patterned, network that are continuously being negotiated between it own constituent parts.

The first of these two are the most important from a logistics point-of-view, and will be used to form the main conclusion of this research:

When studying the relations between logistics and applications of ICT systems; the material- and information flows must not be seen as independent flows, but as integrated means for transferring customer demand. This means that this research suggests that *logistics is not about materials and material flows, but logistics is rather about demand and demand flows.*

Some Definitions

This sections lists some important definitions as they have been used by this research (sources: APICS Dictionary, Ninth Edition; Hammer and Champy (1995); Collins English Dictionary 2 Ed. (1989); Oliver et al. (1997); The Merriam-Webster Dictionary, online edition).

Actor:	Any part or unit within a logistics network.
Approach:	A method for making advances towards a desired result.
Concept:	An abstract or generic idea generalised from particular instances.
Context:	The interrelated conditions in which something exists or occurs.
Data:	Output by a sensing device or organ that includes both useful and irrelevant or redundant information and must be processed to be meaningful.
Demand:	The willingness and ability to purchase a product or service.
Eclectic:	Composed of elements drawn from various sources.
Information:	The meaning given to data in which it is interpreted.
Logistics:	The science (and art) that includes the arrangement for the fulfilment of customer demand.
Manufacturing:	A series of interrelated activities and operations involving the design, material selection, planning, production, quality assurance, management, and marketing of discrete consumer and durable goods.
Method:	A way, technique, or process for doing something.

Network:	An interconnected or interrelated unity consisting of one or several chains, groups, and/or systems.
Operation:	A job or task, consisting of one or more work elements, usually done in one location.
Perspective:	A way of observing the world.
Philosophy:	A theory underlying a sphere of activity or thought.
Product:	Any product and/or service produced to sales, barter, or internal use.
Process:	A collection of activities that takes one or more kinds of inputs and creates an output.
Production:	The conversion of inputs into finished products.
Role:	An expected function or behaviour.
System:	A unity formed of many often diverse parts subject to a common plan or serving a common purpose.
Theory:	A plausible or scientifically acceptable general principle or body of principles offered to explain phenomena.

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Appendix A - List of case documentation; Case study one

- Description, total solution.
- Estimate project phase one.
- List recommended database improvements.
- Modification report; modification one to three.
- Notes; the management of erroneous orders.
- Notes; list of needed modifications.
- Notes; preliminary item- and supplier data management routines.
- Notes; roles involved in the purchasing routines.
- Personal notes after meeting 13.06.00; 28.06.00; 090803.
- Presentation purchase routines bakery.
- Presentation routines total bakery.
- Process description; alternative purchase process, version one to two.
- Process description; production process, final version.
- Process description; purchase process, version one to six.
- Project plan.
- Report; total purchase solution.

Appendix B - List of case documentation; Case study two

- Change log; system configuration.
- Control log; required system configuration.
- Estimate; improvement project.
- Improvement report; initial.
- List of all modifications; old version.
- List of applied database files; old version.
- List of problems found in pilot test.
- Minute book; opening meeting.
- Modification report; modification four (simplified).
- Modification report; modification one to three.
- Notes; data conversion, version one and two.
- Notes; overview of the production process.
- Notes; overview of the total process.
- Personal notes after meeting 23.06.00; 20.01.00.
- Process description; production process, version one to two.
- Process description; purchase process, version one to two.
- Project definition.
- Project handbook.
- Project plan; initial and revised.
- Project schedule; production part.
- Report; sales items.
- Start up plan; new solution.
- Supplier documentation; ERP system functionality (five modules).