Modelling of Interorganisational Operations

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Abstract

In this Paper a model for interorganisational operations in the automotive industry is defined. It is based on the definition of logistic chains. The model Lilly focuses on interorganisational operations which lead directly to the requirement for intelligent communications between organisations. As a result a reference model for interorganisational communications will he introduced.

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1 Introduction

The objective of the ESPRIT II project 2277: CMSO CIM for MultiSupplier Operations is to improve the competitiveness of the European automotive industry through the application and development of methods, tools, interfaces and architectures which facilitate the exchange of technical and commercial data between independent organisations working together in a manufacturing and/or distribution environment.

Major parts of the project work focus on the interorganisational communication aspects between supply chain entities. This leads to an integrated EDI reference model and the idea of the CMSOBox architecture. The integrated EDI reference model incorporates the OSI reference model and expands the application layer by five new layers. The new layer structure enables applications at different supply chain entities to interact regardless of their underlying procedures, algorithms and data bases [Hayward' 1989], [Schneider 1990a], [Schneider, 1990b].

The project does not concentrate solely on operational procedures but also examines strategic and tactical issues. The major project benefits and tradeoffs should include:

- Reduction of the product introduction time
- Shorter, more reliable delivery lead times
- Reduced costs
- Lower stocks
- Improved product availability.

Chapter 2 sets the scene by defining the general CMSO model of the supply chains. The specific problems of interorganisational communication are addressed in chapter 3. The EDI reference model is introduced in chapter 4. Finally in chapter 5 a brief overview is given about the ongoing project work.

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2 The CMSO Logistics Chain Model

2.1 Introducing the Basic Model

To understand the situation in the European automotive industry, a model of supply chains is introduced. The main characteristic of the model is the combination of the different companies which deal with the business of the automotive industry to supply chains.

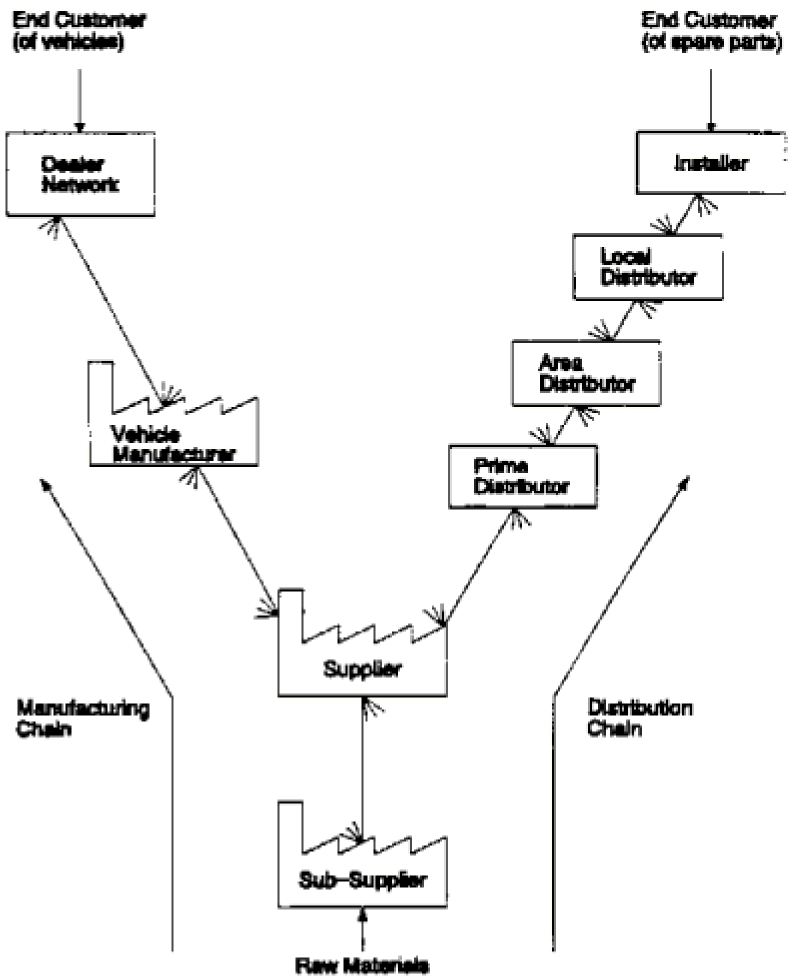


Figure 2.1: Model of the Manufacturing and Distribution Chain

To distinguish between the requirements for the production of cars and the aftermarket operations, several types of supply chains exist:

- Manufacturing Chain
- Distribution Chain
- Product Development and Support Chain.

Each of the chains consists of a set of elements. An element represents a specific entity (organisation) of the automotive industry, such as supplier companies, parts distributors or vehicle manufacturers. Figure 2.1 shows an overview of the chains. Here only the manufacturing and distribution chain are outlined to keep the emphasis on the network of the organisations in the logistics chains.

The manufacturing chain models the logistics and all related business processes which are required to produce a vehicle. The chain itself starts at the lowest level with subsupplier companies. Further links to supplier companies, vehicle manufacturers and dealers build up the chain, which is completed by the end customer of the vehicle.

The same diagram shows the distribution chain. All logistics operations concerning the spare parts handling are combined in this chain. Again, the lowest level is created by subsupplier companies. The next links connect supplier companies, prime distributors, area distributors, local distributors and installers. The chain is terminated by the end customer of the spare parts.

Subsupplier and supplier companies are, generally speaking, identical for the part production for vehicle manufacturers or aftermarket operations (spare parts). Therefore CMSO will not distinguish between them. This part of both chains is combined in one representation within the model.

2.2 Process Chains

A refinement of the model in figure 2.2 identifies all types of logistics chains. Besides the manufacturing and distribution chain already mentioned, the product development and support chain is also shown. The operations in manufacturing logistics and distribution logistics are identified as individual chains. The product development chain handles technical and commercial information for oneofakind production. The product support chain comprises information required at the installer sites of the distribution chain, like manuals, part lists or fault diagnosis.

The elements of the logistic chains are linked together by interorganisational communication processes. The handling of the communication processes is managed by a function called CMSOBox. Later in this paper the CMSOBox characteristics will be discussed in more detail.

The individual chain elements (organisations), no matter what kind they are, will be considered by CMSO in a similar way. In each organisation three management layers can be identified the strategic, tactical and operational level. Nowadays this is the classical view of an enterprise. Each of the management layers controls logistics and technical functions. CMSO concentrates on the logistics functions: initial information phase, order, delivery, and settlement. The single technical function is product development and support. Each of the functions is divided into the business processes 'buy', 'produce/store' and 'sell'.

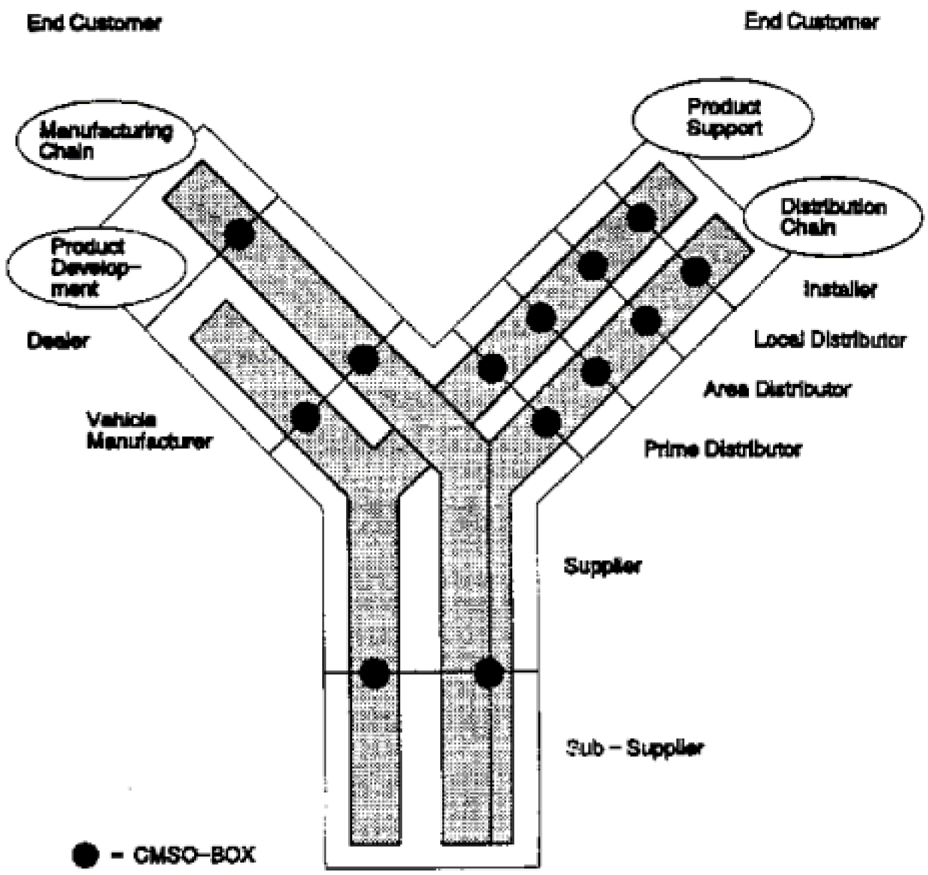


Figure 2.2: The Logistics Chains

Taking into account the link between the specific chain elements, process chains can be identified within the manufacturing and distribution chain. Figure 2.3 illustrates the process chains including the structure of a chain element as defined above.

A reference to the ESPRIT project CIMOAS should be made here. This project aims to develop an open systems architecture for enterprises including the definitions of requirements, building blocks and a method for the migration to CIMOAS. In this, the work concentrates on the internal view of an enterprise. In addition to CIMOAS, the CMSO project deals with the interorganisational (external) problem areas. The enterprise itself is more or less seen as a black box and not further investigated in its structure and behaviour. For this reason no further breakdown of management layers and technical/logistic functions is undertaken.

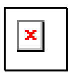


Figure 2.3: CMSO Process Chains

2.3 The CMSO Toblerone Model

The combination of chains, organisations and functions results in an overall model, termed the CMSO Toblerone Model. Figure 2.4 gives an impression of the overall structure. Again, the manufacturing and distribution chain are outlined in the three branches. The technical and logistics functions as well as the management layers are indicated. Each typical organisation is shown as a pyramid in the model. The shaded areas between the organisations should indicate the interorganisational operations CMSO is dealing with.

The model also shows the future situation in the European automotive industry for which CMSO is aiming. Through EDI communications the chain elements grow together in such a way that today's differentiation with all known disadvantage is no longer valid. A close interworking within the chain providing the major benefits should be the result.

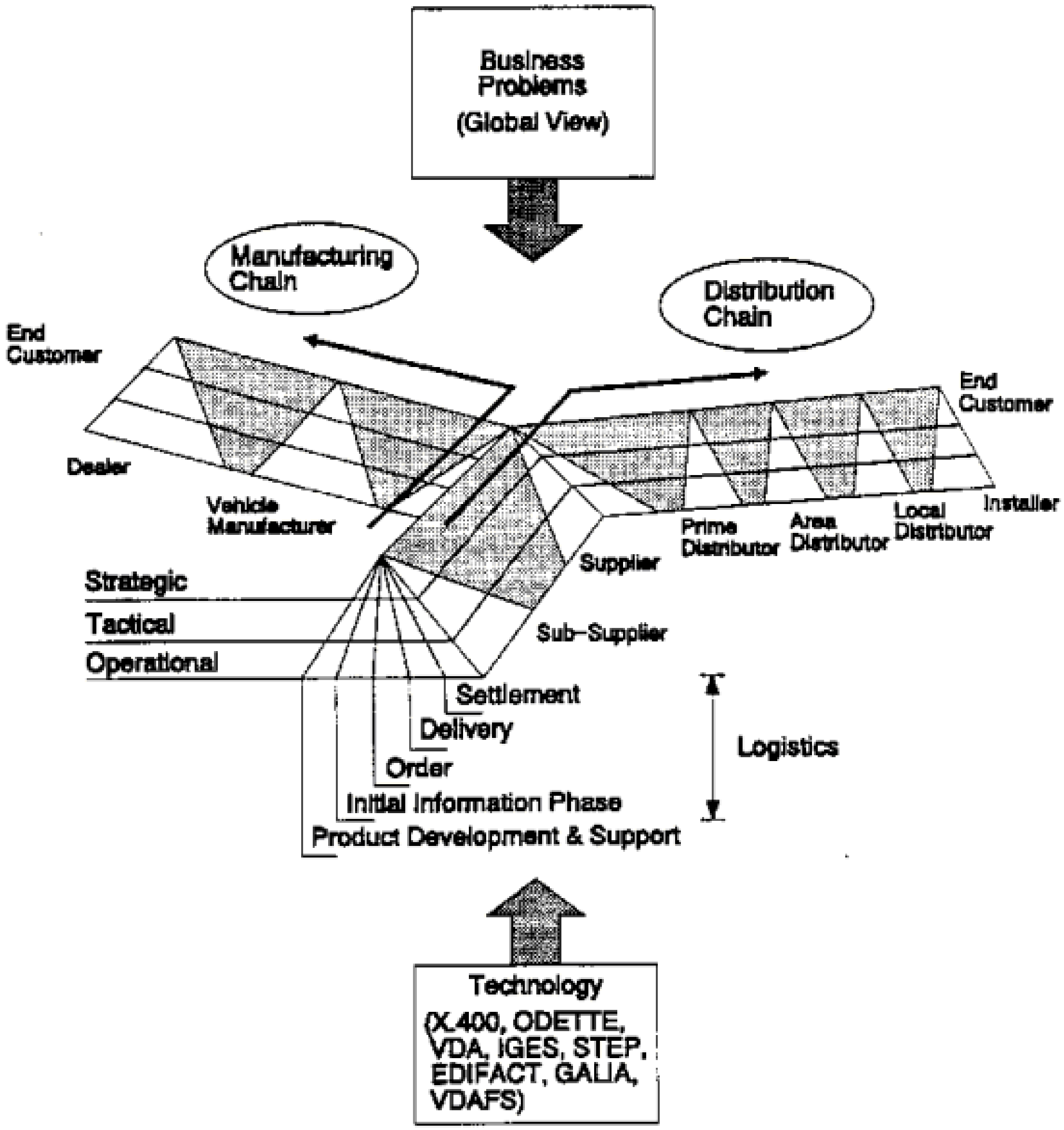


Figure 2.4: The CMSO Toblerone Model

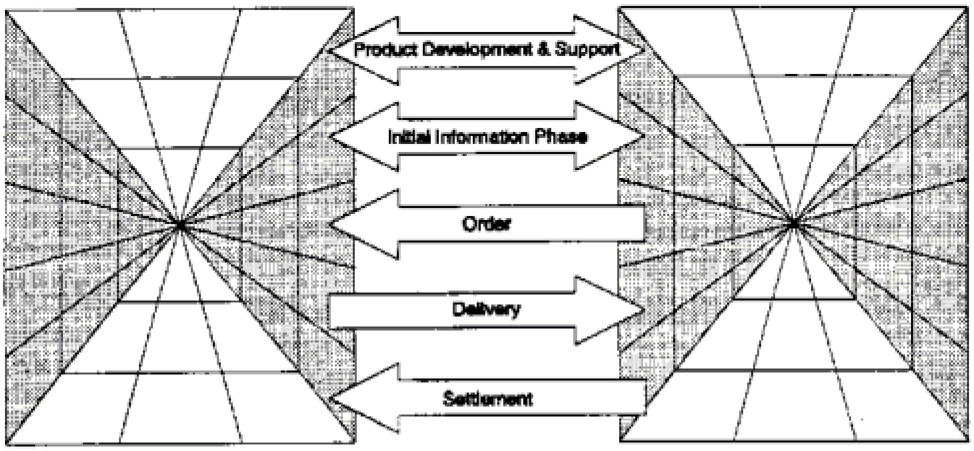
3 The Problem Domain of Interorganisational Communications

3.1 EDI as a Requirement Within Logistics Chains

Today's market situation forces the automotive industry among other things to reduce lead times, reduce production costs, reduce product introduction times and improve quality. One major solution to achieve these ambitious objectives are the usage of electronic data interchange (EDI) for information transmission in the logistics chains. Furthermore, EDI is a prerequisite for the application of the popular Just in Time (JIT) production methods.

As a consequence EDI is used more and more in the logistics processes to exchange business information like delivery instructions, invoices, despatch advices and remittance advices as electronic messages rather than paper documents. In the product development process, the transfer of technical data (geometry, quality, bill of material, release information) via EDI offers the possibility of further reductions to the product introduction time. In the distribution chain, EDI may be used for exchanging technical information during product support like installation manual (text and graphics) and parts catalogues.

The analysis of the major information flows between the particular organisations of a supply chain described above can be drawn up as illustrated in figure 3.1. The diagram shows the direction and type of the flow for typical organisations as defined in chapter 2.



left: Organisation N (Supplier), right: Organisation N+1 (Vehicle Manufacturer)

Figure 3.1: Interorganisational Information Flow

Mainly driven by the vehicle manufacturers, the companies in the logistics chains are connecting their different computer systems via EDI in order to enable direct data exchange. The information islands of the stand alone systems arc increasingly becoming a thing of the past.

3.2 Technical Problems

It is very easy to imagine the enormous problems which will occur when creating heterogeneous computer system networks:

- Different companies use different systems based on different concepts
- One company has relations to hundreds of different companies with different incompatible systems
- A heterogeneous communication infrastructure exits, thus a set of different interfaces must be supported
- EDI standards are national
- EDI standards will become international but are still under development.

One solution is to introduce 'intelligent' communication. Intelligent communication requires knowledge (interpretation capabilities) about the applications and a clear harmonisation between the components involved (local and distributed). This is a much more ambitious approach than the usual form of communication, which deals only with data exchange without interpreting the content of the messages.

A lot of examples for the use of intelligent communication can be found. In a manufacturing planning and control environment there exist planning systems based on a five day timescale which have to be understood by other systems based on a one day timescale and vice versa.

There are situations, especially in Europe, where production planning and control (PPC) systems following the cumulative figures approach have to understand and process delivery instructions sent out by systems which are based on other procedures, like **kanban**.

PPC systems processing inhouse or national message formats like GALIA or VDA should be able to process ODETTE or EDIFACT messages, even if their formats do not contain all the necessary data elements.

The integration and extraction of the data to be exchanged between the applications has to be as direct and automatic as possible. It has to be supported by powerful security and integrity checking algorithms informing the user about any abnormal situations.

Taking a closer look at the technical problems, a set of requirements for a general interorganisational communication concept can be identified. These requirements are derived from first experiences when creating the networks in the logistics chains, and from future needs.

It is obvious that the systems have to be operational in a heterogeneous application environment. They must be conceptionally capable of supporting national guidelines like the German VDA standard, European approaches like ODETTE and the international EDIFACT standard. Solutions should be provided to bridge different application systems paradigms.

In addition to the typical asynchronous (batch) operation, a transaction oriented or interactive EDI has to be possible.

The model to be developed has to provide a concept for accessing existing application systems (e.g. PPC systems) by providing a flexible interface to interorganisational EDI. It is an important precondition for the acceptance of the new EDI model. No company will completely change the internal organisational structure for a new approach which has not yet been proved in practice. The loss of the investment would be too risky. Therefore a smooth evolution path must be offered just by involving the existing structures as much as possible.

Differences between application systems within the domains should be hidden by individual applications transforming the EDI data between standards and application specific requirements.

The model must be applicable to all interorganisational communication needs, including intra-organisational communication between different company sites.

Different communication infrastructures have to be supported. A selection of possible environments is a public switched telephone network (PSTN), a packet switched data network (PSDN) or the integrated services digital network (ISDN). The approach has to be in accordance with the OSI framework. It is important to note that emerging international standards have to be adaptable, e.g. the new OSI/CCITT work of an EDI messaging service (**'Pedi'** - Draft recommendation of CCITT **X.edi)** [McKnight, 1989], [Lundberg, 1989].

The fact that heterogeneity of standards will be around for a while should be taken into account, but allowance should be made for a smooth migration towards public standards.

Reliable system management functions have to be provided to handle exceptions, faults, performance, security, configuration and/or accounting. It includes the flexibility for configuration and parametrization according to the specific requirements in the chain and a particular organisation.

The concept has to allow a mapping onto different hardware platforms in a distributed systems environment, in particular front end processing.

Other technical problems exist, but the above mentioned selection already shows the major problem areas. The next chapter will show how the CMSO EDI reference model will be set up. It is done in such a way as to offer possible solutions for the technical problems.

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4 The CMSO EDI Reference Model

4.1 Introducing the CMSOBox

The CMSO approach in EDI as illustrated in figure 4.1 tries to eliminate most of these problems for the future by applying a mechanism to bundle all interorganisational communication functions conceptionally in one EDI communication server, termed CMSO-Box, (see figure 4.1). In this CMSOBox are located all functions which are related to the analysis, preparation and transmission of EDI messages This approach enables different companyspecific CIM applications to communicate transparently with each other.

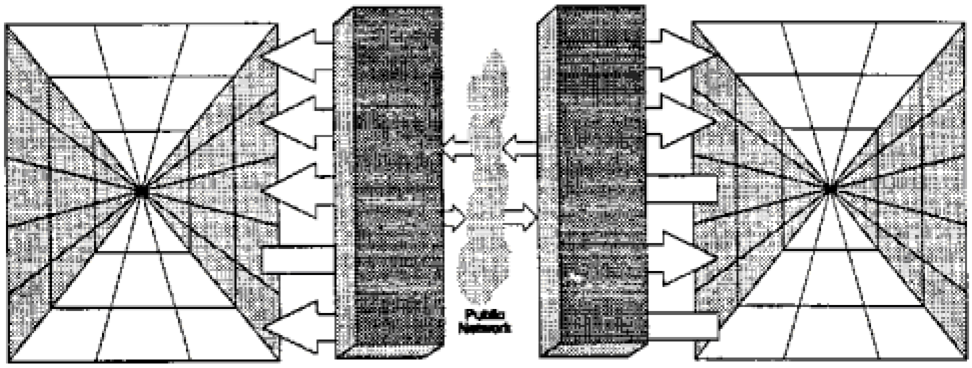

Figure 4.1: Introducing the CMSOBox

Below a multilayer reference model for structuring the EDI functions located in the CMSO-Box (see figure 4.2) will be introduced. This EDI reference model which is fully located within OSI layer 7 provides a conceptual framework for services related to the exchange of commercial as well as technical EDI messages.

The services are structured into five layers ranging from communication support functions (e.g. OSI protocol stacks up to the Application Service Elements of OSI layer 7) to CIM applications (e.g. PPC applications, CAD) on the highest layer. This model does not impose any restrictions on the systems configuration on the communication partner side (e.g. PC based frontend EDI server, host based system, distributed system). Moreover, a layer may be empty for a specific EDI application or the communication partner's system may even be implemented regardless of the layered model.

The services provided by the lower layers peer entities are symmetric and fully definable in OSI terms. On the other hand, layer 5 services are today only understood in business terms, (they may be subject to local reinterpretation) and are thus to a lesser extent formal. Figure 4.2 attempts to indicate this difference graphically.

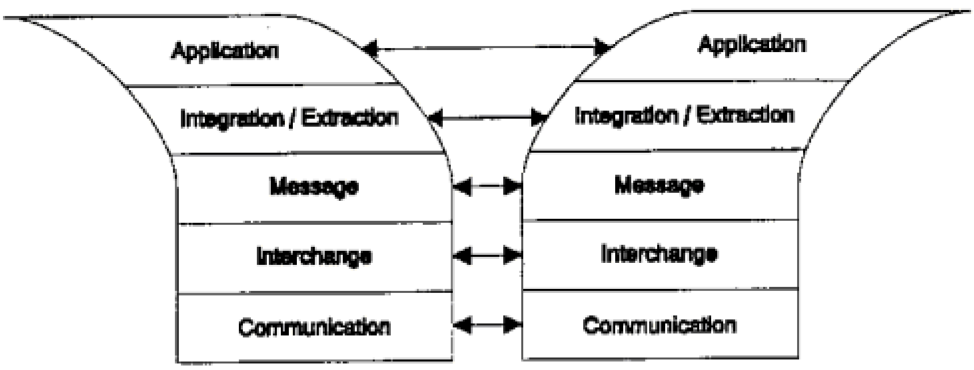

Figure 4.2: The CMSO EDI Reference Model

This very abstract reference model is an open framework for locating and restructuring EDI functions as they are in practice today, but also for new functions coming up with the increasing usage of EDI. Below the characteristics of each of the layers and some typical examples of layer functions will be briefly described.

4.2 Communication Layer

The lowest layer provides all services dealing with the transmission of a complete set of communication data, known as interchange, from the local domain to an external communication partner. Therefore all information about physical communication partners (e.g. network addresses, access path, protocols, protocol parameters) is concentrated within this layer. The communication layer functions provide the transmission capabilities regardless of the content of the interchanges.

The services which are typically provided are a variety of OSI protocol stacks (e.g. **FTAM,** X.400), nonOSI protocol stacks as they are widely used in today's practice (e.g. **OFTP** - ODETTE File Transfer Program, **VDA 4914** VDA File Transfer Protocol) and **VAN** access services. Additionally, all the functions related to the transmission management and most of the security functions are located in this layer, as for example:

- selection of primary and backup access paths (line and protocol scheduling)
- transmission scheduling with special regard to economic considerations
- handling of emergencies
- exception management
- authorisation services
- security services
- legal archiving

4.3 Interchange Layer

The main task of this layer is to generate and analyse an 'EDIinterchange' which is a set of data to be transmitted or received from one physical communication partner. Such an interchange is built up of one or several EDI messages which are embedded in a data format specific envelope (e.g. ODETTE or EDIFACT service segments). The complexity of this task increases if messages of several types, structured according to different standards and addressed to different logical communication partners, have to be included in (extracted from) one interchange, as is the case in a VAN or clearing center environment.

Services identified so far in this layer are:

- Service Segment Management
  - incoming interchanges have to be split into single messages by analysing the service segments
  - outgoing messages have to be concatenated according to a set of rules (e.g. type of message, transmission windows of physical communication partner) by generating the required service segments
- address mapping
- interchange related security services.

From the above task description general characteristics of this layer can be easily derived. The characteristics which can be used for identifying further interchange services are:

- the knowledge about the relation between physical and logical communication partners,
- the knowledge about the relation between messages and interchanges and
- the knowledge about the syntax and semantics of message envelopes (e.g. ODETTE/EDIFACT service segments).

4.4 Message Layer

In contrast to the previous layer, the message layer functions deal with single messages, logical communication partners and the relation between communication partner, message type and data format standard Within this layer is located a complete knowledge about the syntax rules of different data format standards (e.g. VDA, ANSI X12, ODETTE, EDIFACT or even inhouse formats) and to some extent the relation between different standards.

The major services provided by this layer are:

- format transformation, or at least a syntax check
- handling of formal acknowledgements
- digital signature handling
- broadcast message service.

The format transformation is a task by which a message is transformed from an external representation to a unique internal representation [Rutsch, 1990] suitable for processing by the tasks located in the next higher layer (or vice versa). This task enables the EDI system to handle coexisting data format standards (international, national, inhouse) from an external point of view.

During the transformation process not only can record structures, record lengths, field lengths and field types be changed, but also keys and field content can be mapped as far as possible on a syntactical basis.

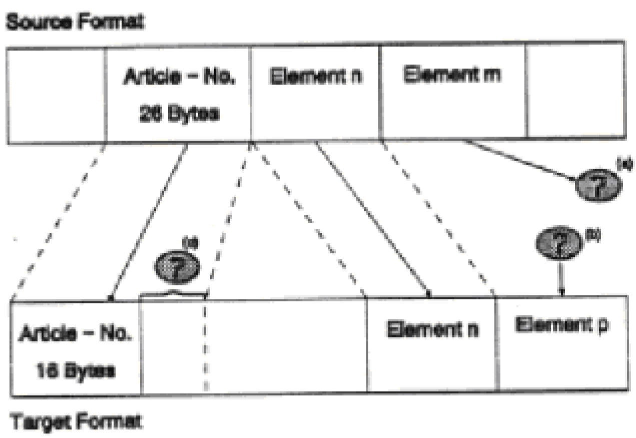

Figure 4.3: Format Transformation Problems

The three major problems in the context of format transformation arising from incompatibilities between data formats are (see figure 4.3):

1. An element of the source format does not exist in the destination format.
2. There is no element in the source format which can be transformed into a mandatory element of the destination format.
3. The source element is longer than the destination element (loss of information).

These problems become more evident with the increasing usage of very powerful data format standards like ODETTE or EDIFACT for external representation, and the continuing existence of CIM applications capable of processing messages structured according to less powerful data format standards (e.g. VDA).

4.5. Integration/Extraction Layer

The functions of this layer deal with the semantics of EDI messages which are structured according to one unique data format syntax. The services which are located in this layer are:

- integrity and consistency check against the application data base
- making message data accessible for the application
- handling of commitments
- message management and control
- handling errors and emergencies.

The main idea of the message management and control service is to monitor messages in the context of business tasks. For example, the sequence of messages sent out and received for one order procedure may consist of delivery instruction, reply, despatch advice, transportation advice, acknowledgement, invoice, and credit note. For a correct processing of the business task, it is essential that the message flow is according to the expected sequence and time constraints. If an exception occurs, an emergency message has to be processed.

4.6 Application Layer

The application layer, which is the highest layer in the EDI reference model, does not deal with communication partners or EDI messages but with business partners and business data' for example, orders, invoices and credit notes in the commercial area or drawings and bills of material in the technical context. Therefore all those applications in CIM systems which are involved in interorganisational operations i.e. which are exchanging commercial or technical data with other sites in the chain according to a specific business procedure, are located in this layer.

In the CMSO project a wide variety of such interorganisational business procedures in the three chains are actually under investigation. A very typical example of such a business procedure is the handling of delivery calls in the automotive manufacturing chain [CMSO Dell, 1989]. An application known as 'Front End Sales Logistics' will be specially developed for this business procedure. It will be possible to use this in connection with existing, classical PPC systems in order to fulfil the future needs of the European automotive supplier business.

4.7 CMSO EDI Architecture

The EDI Reference Model will be applied to develop a general and integrated EDI architecture (see figure 4.4). This new layered architecture, which will be the basis of the CMSOBox, can be distinguished from existing systems by:

- a new and well structured architecture
- the fact that it is easily configurable for specific application problems i.e. a broad range of specialised CMSOBoxes can be built with less effort (e.g. for SMEs with dedicated capabilities, for large companies with a wide variety of powerful functions)
- its distribution of the overall system functionality to several computers working together transparently
- its openness for future requirements within the automotive industry and other industrial branches.

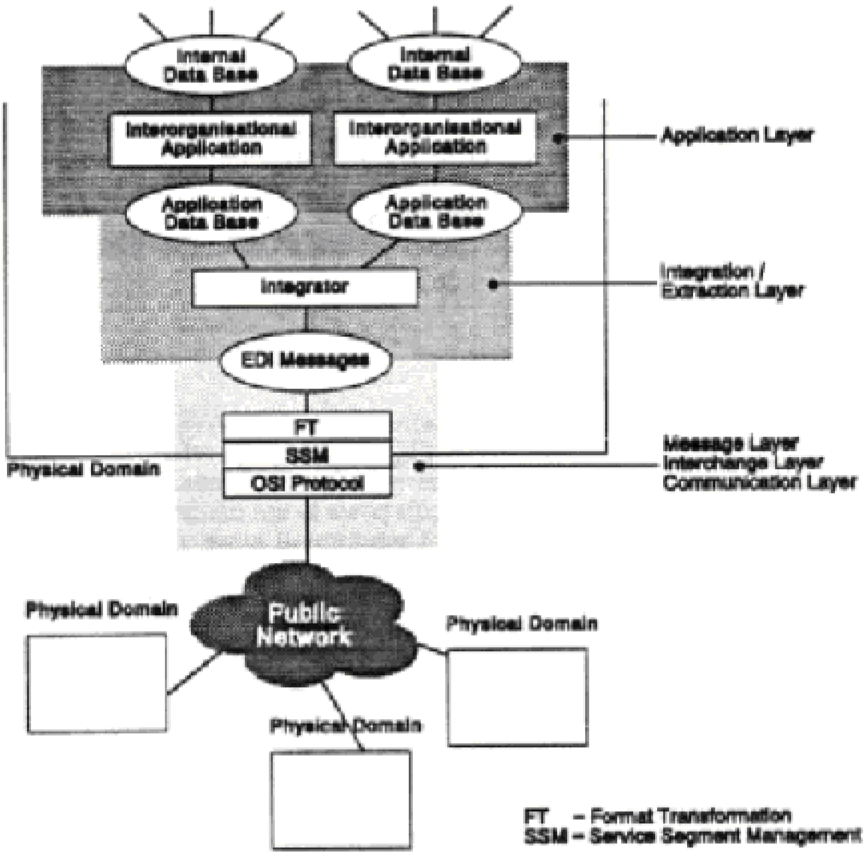

Figure 4.4: Example of CMSO EDI Architecture

Finally it will be demonstrated that the CMSO project aims not only to increase the flexibility and power of single site EDI systems or even functions, but also to increase the power, flexibility and intelligence of the overall communication and business process.

Figure 4.5 illustrates how the CMSOBox with this new EDI architecture will fit into the overall CMSO chain model and what will be in the focus of the project. Each combination of CMSOBox, CIMIAS (interorganisational CIM applications) and CIMINTRAS (intraorganisational CIM applications) in figure 4.5 represents one site in a logistic chain. The four lower layers of the CMSOBox contain all functions related to the transmission and preparation/analysis of EDI messages for enabling the interorganisational CIM applications (located in the application layer) to communicate transparently with each other. The intra-organisational CIM applications (CIMINTRAS) which do not fit into the application layer of the reference model deal only with the operation in one site and do not need to communicate with another site. They are addressed by CMSO only in terms of their interfaces (logical or physical) to the interorganisational CIM components.

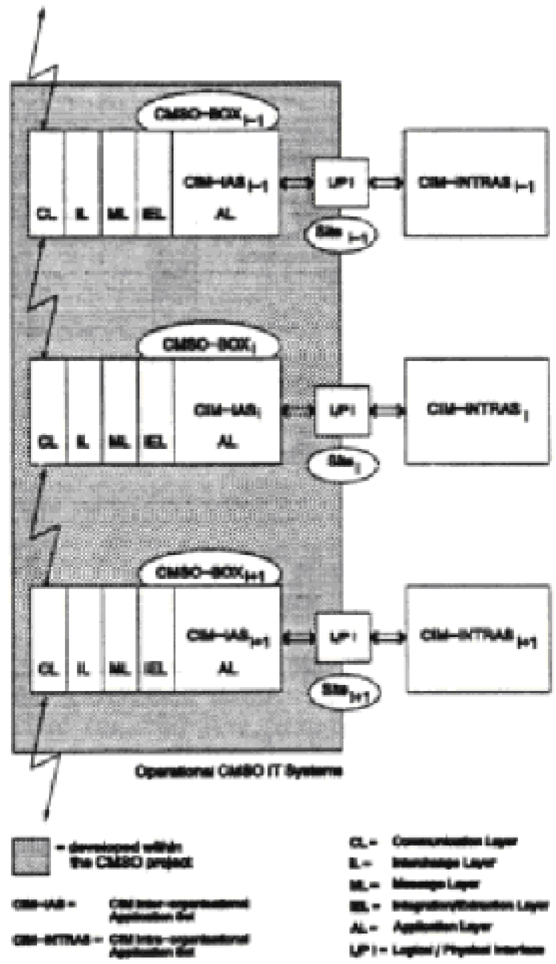

Figure 4.5: Logistics Chain Structure on Information System Level

Work on detailed specifications and first implementations for selected applications based on the EDI reference model is currently being carried out. In addition, the applicability of the reference model will be evaluated.

5 Structure of the CMSO Project Work

The work to be executed within the second half of the CMSO project aims to produce a set of prototype software to show how the CMSO ideas could be realised in practice. In each logistics chain a prototype of a CMSO-Box will be developed. The necessary work will be carried out in the work packages 11 to 14 as indicated by Figure 5.1. Most of the planned effort is located in this work area.

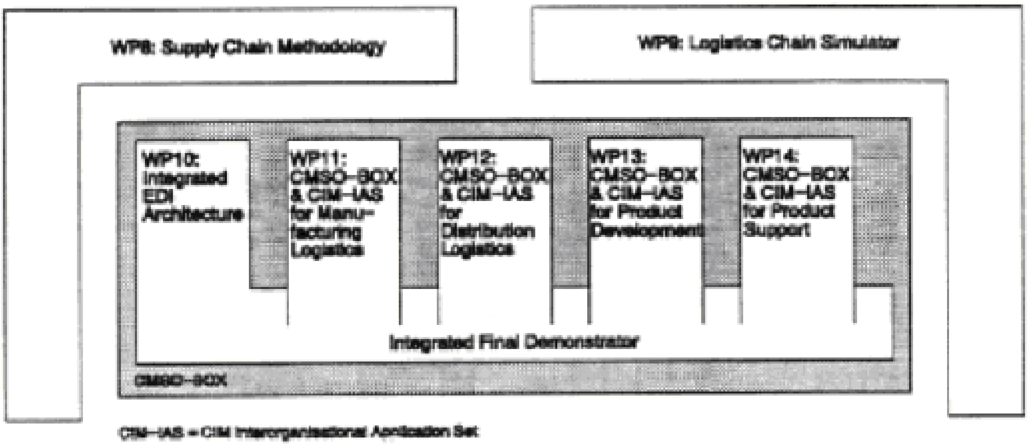

Figure 5.1: The CMSO Work Organisation

At the end of the project in 1991 an integrated final demonstrator will be built out of the different CMSOBox implementations. As an underlying reference, the results of work package 10 (Integrated EDI architecture) will be used to achieve the goal. The final demonstrator will be evaluated for further work.

In work package 8 a methodology will be developed and implemented to describe and understand the supply chain problems and to solve these problems. It will be created by means of an effectiveness framework and a set of modelling methods supported by an expert system. Finally the logistics chains will be simulated by a chain simulator developed in the scope of work package 9.

6 Conclusions

CMSO focuses on interorganisational operations in multisupplier/multimanufacturer environments and the interpretation, transformation and processing of EDI data on an application level CMSO will concentrate on VDA, ODETTE and EDIFACT standards. Technical data transfer mainly based on IGES, VDAFS, VDAIS and STEP are taken into account for the product development and support chain.

The CMSO project results will be incorporated and transferred to applications to be used in the logistics chains. The experiences gained during the evaluation of the integrated final demonstrator will act as a platform for further work in the problem areas to offer solutions far the European automobile industry in the 1990's.

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The CMSO project started in December 1988 and will end in December 1991. The consortium is formed by:

- ACTIS (D main contractor);
- ADIST ASSOCICAO PARA O DESENVOLVIMENTO DO INSTITUTO SUPERTOR TECNICO (P partner);
- AFIA ASSOCIACAO DE FABRICANTES PARA A INDUSTRIA AUTOMOVEL (P partner);
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