4.1 New Quality Partnership along the Textile Chain

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Abstract One core characteristic of the Textile and Clothing Industry (TCI) is networking. The Extended Smart Garment Organization **(**xSGO) framework will improve the inter-organisational knowledge networking in a holistic way. Applying this xSGO framework, a new quality (of) partnership in the textile and clothing value creation chain will be enabled.

The xSGO framework comprises a configuration toolset, which allows to model and analyze an existing network for innovation and production, and to select and configure appropriate measures in order to improve the integration of activities and actors. Integrative components enable knowledge communication based on Moda-ML, and involve adapted RFID technologies, combined with a system for Product Tracing and Tracking. In particular fast ramp up of new garment products in supply networks is conceptually and methodically improved.

This paper gives an overview about the holistic, system-oriented xSGO framework, explains details of Quality Harmonization as one major component, and presents results of practical applications in the Textile and Clothing Industry.

1 Introduction

Enterprises of the Textile and Clothing Industry (TCI) today are typically collaborating in worldwide networks with a high degree of dynamics. At the same time development and manufacturing costs and time for providing textiles and garments of high quality, combined with decreasing innovation cycle times, and the emerging demand for personalized and individualized garments require a structured and transparent way of collaboration in networks.

Significant progress has been made in manufacturing technologies for textiles and garments, in garment production automation of cutting, sewing and finishing.

This progress – in particular in robotized handling of soft material or for joining of fabric pieces – is documented in some detail in paper 1.1 and paper 1.2 of this anthology.

New systems for product design and development enable Collaborative Virtual Prototyping (CVP, for details see paper 3.3) by virtualization of new garments. Textiles and garments with new and/or improved functionalities are also available or under development. In LEAPFROG for instance new shape memory fibre-based textiles (for details see paper 2.1) have been developed.

Also new components and services for logistics and material flow are available today. World-wide acting logistic service providers enable a reliable and prompt delivery of garments, textiles and trimming materials. Significant progress has also been made during the last decade in information and communication technologies (ICT) for advanced product design, development, production planning and production control and for communication. Furthermore process control and even production itself (e.g. digital printing) is more and more digitized.

Each of these innovative technologies contributes to the improvement of the garment business, in particular to shorten lead times, to reduce costs of design, development and production, and to reduce stocks. But there is a significant need for a seamless integration of all of these components into existing or newly configured textile value adding networks. The development of an appropriate framework for integration was significant part of the LEAPFROG project.

2 Integration for networked TCI organizations

2.1 Current Situation

As stated before the TCI is traditionally networking across a wide spread textile community. Due to the complex production process of fibres, yarns, fabrics and garments the value creation chain for the new product development and/or production of garments is sometimes composed of up to twenty partners.

In particular garment development and manufacturing is carried out in world-wide networks. A typical situation is the following: Garment design and development are made in Europe, supported by world-wide spread design offices. Fabrics and other raw materials are sourced in the Far East and stored in the central storehouse at headquarters' site. Assembling is performed in Eastern Europe, and distribution to shops and wholesalers is conducted also centrally or at distribution centres. Fabric and garment conditioning (like testing, washing or repair) is executed by quality checking organizations in Europe or in the Far East. For innovative garments often weaving/knitting and finishing mills have to be involved directly in the new product development process. Finally transport and shipment is carried out by world-wide logistic organizations.

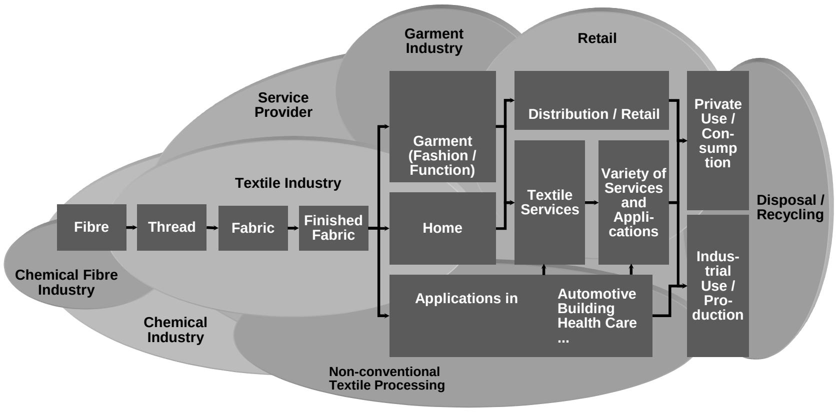

Fig. 1. The complexity of the textile world [1]

It is obvious that business in such extensive networks is not easy to plan and to control. Networking requires co-operation and interfacing, physically and electronically as well. Physical interfaces, e.g. the dimension or the sizes of the transport pallet or containers for garments and textiles, are required to be identical at the sending and the receiving partners. The material data have to be harmonized: Weight, length or density of fabrics (and all other quality parameters) should be measured and declared in a standardized way.

Also electronic interfaces have to fit, in particular in e-business/electronic communication. In particular the meaning of information to be exchanged has to be identical. For instance can the term "delivery date" of a purchased good refer to the arrival at the warehouse, the electronic registration, or the release for further processing. Last but not least also organizational and cultural interfaces are of interest, in terms of language, time zone, or co-operation behaviour.

For some of these interoperability issues standards are available and widely used, such as e.g. container dimensions, and no specific interfaces are required. But for many of these interoperations, e.g. those related to quality features or to order processing, efficient and effective interfaces are still needed for the harmonization of quality procedures or the set-up of electronic communication.

A comprehensive and systematic analysis of existing and potential fields of co-operation for global development and supply of textiles and garments can be based on the structure of figure 2.

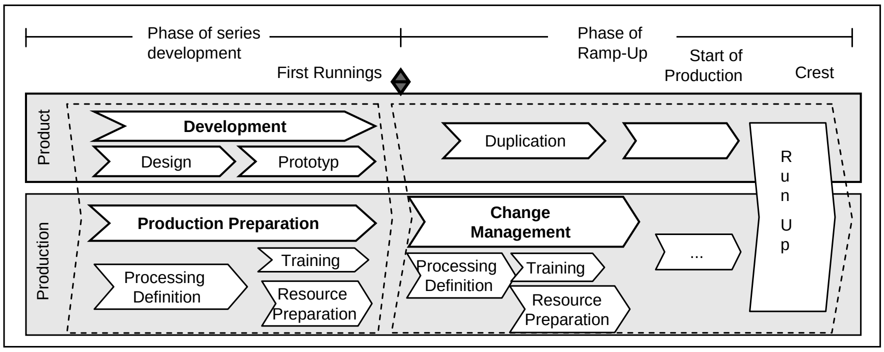

Fig. 2. Basic model for co-operation analysis and synthesis in the garment industry

Four typical business cases in the textile and garment sector have been identified:

- Case 1: Prototype development and prototype production inside of the company; duplication and production in distributed own factories;
- Case 2: Prototype development and prototype production inside the company; external duplication and production by third parties (Cut-Make-Trim - CMT);
- Case 3: Collaborative prototype development and prototype production together with partners; duplication and production by third parties;
- Case 4: Full Merchandise Business.

For each business case an individual configuration of the network structure and appropriate tools are required. This is in particular necessary if new technologies are to be integrated.

Altogether networking is not a self-fulfilling or self-organising process. A lot of preconditions have to be met in order to set-up networks and specific tools are necessary in order to operate a particular organization in a particular network. The situation becomes even more difficult as new technologies for design, development and production become available, as developed in the LEAPFROG project. Accordingly for networking organizations along the textile value chain the aspect of integration is of significant importance.

Inadequate integration (of technologies) reduces performance not only if new technologies are wrongly introduced, but also in existing supply chains where technologies for design, production and logistics are not carefully harmonised. Today the mismatch between the potential performance of a certain technology and its real application is often enormous. Reasons for this are for instance unfulfilled preconditions, a lack of information and insufficient training of personnel or sub-optimal configurations, in particular with respect to fast changing product requirements in the textile and garment world.

2.2 Conceptual Framework for "New Quality (of) Partnership"

In order to improve the current situation in the TCI and to facilitate the set-up of partnerships and the operation of enterprises of the textile and clothing industry in networks, we developed in LEAPFROG the holistic framework of the 'Extended Smart Garment Organization' (xSGO), together with related components and guidelines for its implementation. This framework enables a consistent and coherent integration of already existing and/or new technologies into textile networks. The application of this framework in TCI networks will lead to a sustainable New Quality (of) Partnership.

The xSGO follows the conception of the Smart Organization [2,3]. According to Filos a Smart Organization requires networking in three dimensions: organizational networking, knowledge networking, and ICT networking. Further details are presented in paper 4.2 and paper 4.3.

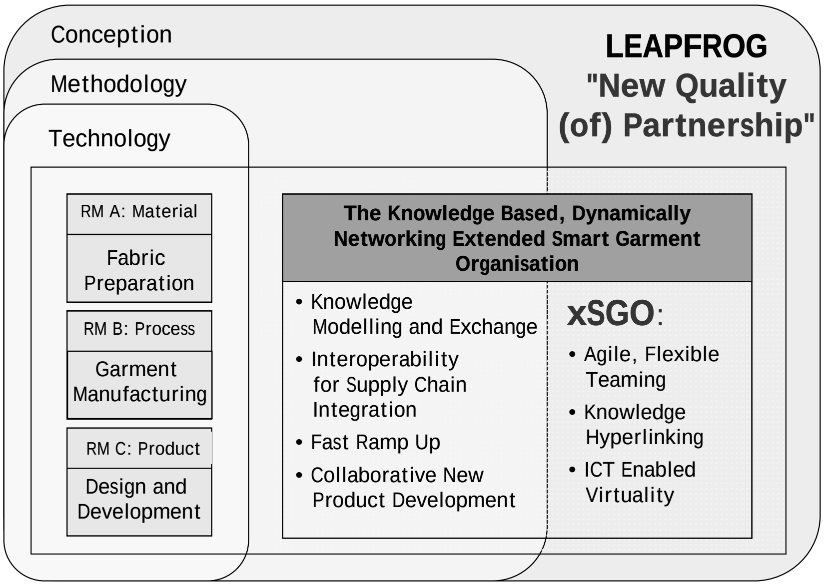

Fig. 3. LEAPFROG integration by the Extended Smart Garment Organisation conception

This initial conception has been adopted, attuned to characteristics of the TCI and extended by appropriate methods and tools for networking and integration of product development and production. Particular focus is put on definition of and communication for inter-organizational business processes as well as to product and process quality.

Knowledge networking features are at the core of the approach. Shared knowledge is being considered as an important resource, in particular in networks, where it is necessary to provide all required knowledge for an initiated process at the right place and time. Therefore the xSGO methods and tools contain major knowledge networking functionalities.

All together a new quality (of) partnership in TCI will be enabled in terms of:

- new quality of organizations collaborating in networks,
- new quality of interoperation based on knowledge networking, and
- new quality of communication using ICT networking.

3 The xSGO Integration Toolset

The framework is functionalized by the components of the xSGO Integration toolset that practically prepares and supports the integration of new technologies within TCI networks. These methods and technologies (see the components (1) to (8) in table 1) have been developed by the LEAPFROG partners.

			Supporting ….			
Component	**Name**	**Type**	**Organisational networking**	**Knowledge net-working**	**ICT networking**	**Application in TCI**
(1)	Quality Harmonization	Method	**X**	**X**	**x**	Product design and development, production
(2)	Quality Wiki	Technology		**X**		Product design and development, production
(3)	Knowledge Exchange Infrastructure	Technology		**X**	**x**	Electronic communication
(4)	Product Tracking and Tracing	Technology			**X**	Supply Chain Management
(5)	RFID	Method			**X**	Supply Chain Management, MES[1]
(6)	AutoCost using Web Services	Technology			**X**	Development, production
(7)	xSGO Modelling Set	Method		**x**		Analysis and synthesis of networks
(8)	xSGO Configurator	Technology		**x**		Synthesis of networks

Table 1: Components of the xSGO Integration Toolset

[1] Manufacturing Execution System: Production management system operating near to processes

Quality Harmonization (see component (1) in table 1) is one key issue of efficient collaboration in textile networks. Therefore appropriate tests have been implemented, which assist Supplier Relationship Management. Details are described in the next section.

Knowledge orientation is supported by the Quality Wiki (2) containing information about quality and colour management. It consists of Wiki pages containing know-how about textile materials, textile processes and testing procedures, as well as the description of competences the staff members need, and learning material to achieve these competences, and also significant information about colour aspects in textiles and garments. It is used for documentation, and for information and training of involved personnel.

The concrete definition and set-up of e-business collaboration is facilitated by the Knowledge Exchange Infrastructure (3), that uses a common ontology. It enables to share knowledge on materials, products and processes between partners along the textile chain. For details see paper 4.4

Organizational networking and knowledge networking are closely related to ICT networking. Therefore the toolset contains a number of technological specifications and software systems, like the Product Tracking and Tracing system ((4), for details see paper 4.5). This system enables a complete and seamless single-part follow-up along the value chain, from supplier of fabrics (and all other materials) to production partners up to the end consumer. One industrial application of the this functionality is offered by the LEAPFROG partner Bivolino (http://www.bivolino.com), who is provider of mass-customised garments for the consumer over the Internet.

RFID (5) is used for identification of textiles and garments, which are transported within and between factories, warehouses, and shops. Major information about the individual fabric is available directly, and can be read contactless and regardless of orientation/direction of the fabric. UHF RFID tags have been adapted to be robust enough not to be destroyed during process treatment for fabrics and garments finishing (e.g. dyeing, washing, or tumbling). One type of tags is integrated into the garment label and is based on a textile substrate, while the second type of tags is fixed on a plastic substrate. Both commercially available tag types are suited for textile and garment production and logistics. Additional data can be stored on the tag, for the purpose of quality management or as an anti-counterfeiting task.

Moreover ICT networking today is based on Web Services. This technology for flexible interoperation of software has been implemented into appropriate product data management systems (PDM) for garments. Based on this technology LEAPFROG partner Assyst has developed and implemented the web based tool AutoCost (6, see http://www.autocost.de). This tool makes it possible to minimize the cost of a production order at hand by an optimal combination of markers with different size combinations and the corresponding spreading of fabrics. The Collaborative Virtual Prototyping (CVP) platform and its components developed in another research module of LEAPFROG are also using Web Services. (for details see paper 3.3).

The xSGO framework comprises two tools for the establishment of new quality partnerships in textile supply chains. The xSGO modelling set (7) allows to model and to analyze networks for innovation and production, with particular focus to the coherent description of the knowledge networking issues. Details are described in paper 4.3. The xSGO Configurator (8) is a web-based decision support system, enabling visualisation and navigation for identifying, selecting and designing innovative methods and technologies for the TCI, in order to improve the integration of activities and actors.

4 Improved Collaboration for Quality Assurance

An important aspect of interoperation of enterprises applying the xSGO framework is the assurance of quality. The fulfilment of certain fabric characteristics has a big impact not only on the quality of the garments itself, but also on the manufacturing processes of the garment industry.

A typical process of fabric sourcing is as follows: A garment company orders fabrics from a supplier of appropriate textiles, e.g. from a weaving company or a knitwear producer. Regularly the raw fabric is sent to a finishing company for further treatment, which often is predefined by designers of the fabric producers. After the finished fabric has been checked for certain physical and optical requirements, it is sent to the (central) raw material warehouse of the garment company. There, further tests are executed. Finally, this fabric is delivered to a garment manufacturing site, where it will be cut into fabric pieces, which are joined to the final garment.

Today finished fabrics are checked several times for the same requirements by various partners along the supply chain. Because of this procedure of multiple testing, it is currently necessary to ship the finished fabric to the fabric storehouse of the clothing company. If the quality is adequate, the fabrics will be passed to the garment assembling sites which may be located anywhere in the world.

This costly and time-consuming procedure is going to be changed. Quality Harmonization (which is component) (1) of the xSGO Integration Toolset) enables to remove multiple tests, as well as the unnecessary shipment to central fabric warehouses. Such processes that do not add value can be eliminated.

An approach that will strengthen the co-operation between the textile and garment industry will lead to an industrial partnership, in which the partners will perform Direct Delivery from supplier sites to customers manufacturing sites. Fast provision of perfect material to the production site, in both the product development phase and the regular manufacturing phase of garments will significantly improve the business relationship. Key components of the approach are:

- An audit component that enables the collaborative analysis of the specific role of the textile partners for the requested quality of the garment, the identification of gaps, and the definition of steps for improving supplier quality. This component relates to organizational networking.
- A quality component that comprises a global quality and product guideline based on quality standards, specific testing methods and clearly defined processes within the quality management network (knowledge networking). The starting point is a round robin test, which enables the matching of the inspection systems.
- A communication structure for the identification and specification of quality related communication processes and rules during the development and production phase (ICT networking).

Audit Component:

The collaboration between supplier (weaving company) and producer (clothing company) establishes a certain degree of organisational networking, based on a status classification of each supplier. This classification results from an appropriate auditing, where the status can vary from zero (0) to three (3). A status (0)-supplier is using an adjusted visual fabric inspection system, has signed specific delivery agreements, and has offered sufficient information about his quality management. An audited supplier can reach status (1), when his quote of reclamation is less than a certain limit. A status (2)-supplier has attended a round robin test and is using an audited testing system with adjusted testing methods, tools and documentation. The process capability is guaranteed due to a Process Failure Mode and Effects Analysis (Process-FMEA), which deals with the production processes and their possible failures during weaving, preparation of weaving and post-processing.

The highest level a supplier can reach is status (3) allowing the Direct Delivery of fabrics via distribution centres or to production sites in the supply chain. This includes also tracking and tracing of goods at production, logistics and warehouse sites, a well organised management of deviations and regulations for order management.

Quality Component:

One key issue is to ensure the matching of the inspection systems used by the participating partners. They need identical reliable information about the specifications and the quality of the finished fabric. This means that they have to use the identical test equipments, the same standard of testing procedures, and comparable measurement methods.

Therefore a round robin test has to be performed: The network partners will make several tests with different types of finished fabrics. The tests comprise mechanical inspections (e.g. pilling tendency, or abrasion resistance), chemical inspections (e.g. cleaning fastness, light fastness or acid fastness), geometric inspections (e.g. mass per unit or edge symmetry) and fabric inspections (e.g. defects). Before starting the test the participating partners have to identify the testing methods to be applied, the minimum requirements, and the material information.

After these inspections, the results will be compared. If the discrepancies are in a tolerable range, the round robin test is regarded to be successful, and the major requirement for Quality Harmonization is fulfilled.

<u>Communication Structure</u>

Supplier relationship management and quality partnership in general requires appropriate adaptation of internal data model of the ICT systems involved in the data exchange process. Quality data must be recorded, processed and communicated to partners along the textile supply chain. This can be done by the following means of ICT and Knowledge Management Technologies:

- The Knowledge Exchange Architecture (KEI) for a standardized e-business collaboration along the supply chain in the TCI.
- The Product Tracking System (PTS) enables to communicate data, and to plan and control the fulfilment process and the related flow of material and products in the supply chain.
- RFID technology enables to identify the fabrics in production and logistics, and to store the individual (quality) data directly on the fabric.

All components together enable Direct Delivery of fabrics from the weaving company to the garment production site, avoiding double tests and saving time and cost. As a first step of implementation of a Quality Harmonization in a textile supply chain, the current state of the material flow, the value creating processes, and the quality inspection processes of involved partners have to be analyzed and visualized using xSGO models in order to describe the as-is situation.

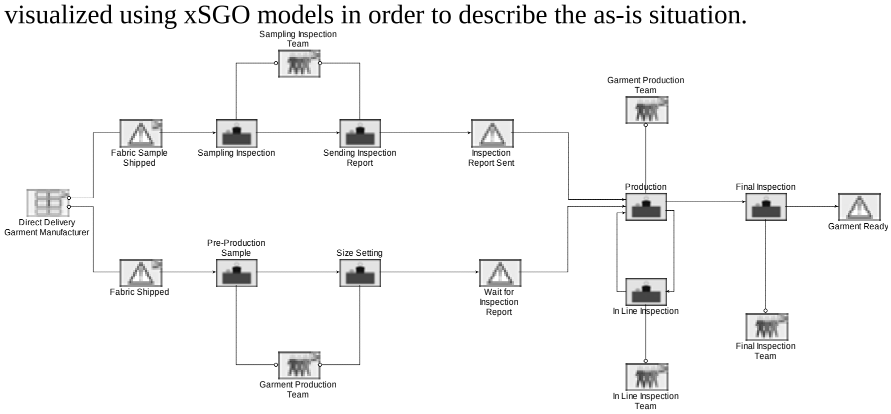

Fig. 4. The xSGO activity diagram of the organisational layer for Direct Delivery in a garment organisation

The next step is the round robin test, followed by the implementation of the supplier qualification. The FMEA has to be performed by textile suppliers, the required communication structure can be implemented in parallel. Finally the direct delivery can be agreed between the partners and subsequently applied. These new procedures will be described and documented with the xSGO modelling tool (see Figure 4).

5 Practical Experiences

The New Quality (of) Partnership was implemented 2007 in an industrial environment at the Hugo Boss headquarter in Metzingen, Germany, together with the fabric supplier Zuleeg in Helmbrechts, Germany, the supplier of finishing services Knopfs Sohn, and the quality test organisation Profitex, both Germany (see figure 5). The Centre of Management Research at the German Institutes for Textile and Fibre Research Denkendorf (DITF-MR) provided the conceptual and scientific expertise and managed this pilot implementation.

The objective was to enable direct supply of fabrics to the production sites of Hugo Boss using in particular Quality Harmonization (component (1)).

Fig. 5. The pilot value creation chain applying New Quality (of) Partnership

At the beginning of the project a co-operation agreement was signed. This included e.g. the specification of the garment types (in this case men’s suits) and of the fabrics and the finishing type (coloured woven woollen fabrics), the selection of the involved testing locations (Helmbrechts, Germany; Metzingen, Germany), and the classical project issues (timing, responsibility, resources, …)

- Quality Component: A comprehensive round robin test has been executed. First the team selected the fabric parameters that had to be checked. Then they documented the testing methods and instruments. The fabrics were selected, and measured at the different testing locations. The testing values were documented and compared. After some corrections and modifications, the testing methods were harmonized.
  Zuleeg performed the Failure Mode and Effects Analysis (FMEA) for the weaving process. During workshops for 5 process steps critical failures and more than 50 measures for prevention were identified. Half of them were implemented immediately, leading to a reduction of quality costs for weaving of approx. 75%.
- Audit component: The structure of the supplier classification has been implemented in the structure of the Hugo Boss supplier relationship management system, which is part of their SAP application system. More than 300 suppliers were assessed, and Zuleeg became one out of 10 suppliers with reliable processes (status (2)), who received status (3)"Enabled for Direct Delivery".

Since 2007 Zuleeg is certified to deliver its fabrics directly to the production sites of Hugo Boss. Thus a significant amount of time and cost can be saved. Hugo Boss has communicated this concept to its suppliers, and in 2008 further German weaving companies started with the implementation of the New Quality (of) Partnership. Information and training of the involved actors is done with the Quality Wiki.

Also in 2008 the transfer to Ermenegildo Zegna, a world leader in luxury men's clothing headquartered in Italy, has been started. The structure and methods were adapted for the processes of production and supply at Ermenegildo Zegna with the support of DITF-MR. Further available practical experiences of establishing components of the xSGO framework in industrial environments are reported in the following papers.

6 Outlook

The framework of the Extended Smart Garment Organisation (xSGO) for networking of TCI enterprises enables a New Quality (of) Partnership. Flexibility and adaptivity to fast-changing market requirements and new technologies will be enhanced, quality problems, throughput times, stock levels and related costs reduced. A coherent integration of new technologies, in particular of the LEAPFROG results, into networking industrial organizations will be simplified.

Major focus is the quality assurance along the textile value creation chain. In order to reduce quality problems, to remove double tests, and to enable a direct supply of fabrics to the garments production site, the round robin test for testing harmonisation, the FMEA for process capability and the supplier classification have to be applied. The xSGO modelling set is best suited for analysis and during the design and set-up phase of the New Quality (of) Partnership. A Quality Wiki is used to inform and to train the personnel involved in the implementation and in daily application. This Quality Wiki includes also information about a new colour management structure, which consists of a virtual colour model based on real colour books using the L*a*b colour spaces.

The xSGO framework and the methods were developed with and are successfully implemented at industrial LEAPFROG partners. They expect the following benefits:

- A reduction of production errors and quality faults from currently 15-20% to nearly zero;
- A decrease of processing time in geographically dispersed production networks due to the removal of testing processes, direct delivery and reduced rework;
- A reduction of average lead times of up to 25%; and
- A decrease of fabric stocks at textile and garment manufacturers' warehouses.

The holistic, system-oriented concept allows flexible networking, in terms of organizational networking, knowledge networking, and ICT networking. The demonstrated economic benefits of networking industrial communities show interesting potential for strengthening of the European Textile and Clothing Industry.

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4.2 Engineering Value Networks in the Fashion Industry

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Abstract: The chapter starts with an overview of the extended Smart Garment Organization (xSGO) concept. Under the name xSGO we refer in LEAPFROG to innovative value networks that can achieve and sustain competitive advantage in today's turbulent fashion market. The xSGO is at the intersection of the advanced information and communication technologies (ICT), the new collaborative cross-organizational models and the knowledge driven orientation as the main source of competitive advantage. First we analyze the role of value networks in fashion with an overview of the principles of Organizational Economics. Then the role of ICTs as enablers of the new business models is analyzed and some real fashion value networks are quickly presented. Finally a generic methodology is presented on how to take the architectural decisions to engineer fashion value networks.

1 The Emerging Organization Models

The worldwide liberalization of trade, finance and investment coupled with the worldwide spreading of technical knowledge and the advances in ICT, transport and other technologies, is accelerating the pace of change and opening vast opportunities and challenges for enterprises, in all economic sectors.

Dynamic enterprises have responded to these opportunities and challenges, by exploiting the expanded base of competitive partners and suppliers and establishing with them a more proactive and collaborative relationship than the traditional onetime supplier-purchaser relationship. One of the most significant developments in management and business thinking has been to recognize that networks of closely collaborating companies operating as an integrated value network or supply network, can exhibit in an excellent degree sustainable economic performance, consumer responsiveness, flexibility and adaptability to changes in market conditions. Furthermore new interactions and collaborations are causing an accelerated growth of knowledge that is the basis for futures advances.

The xSGO “Extended Garment Organization” concept was introduced in LEAPFROG [1] to provide organizational reference models useful for companies to think about how the industry, the companies and their value network will change in the future and in this way promote the competitiveness of the European fashion industry. We explored in LEAPFROG the features of these new models, the opportunities and challenges they represent for the fashion industry and the organizational and technical changes the companies should undertake to develop the competences required to benefit from them. The aim was to design fashion supply networks that manage knowledge to achieve competitive advantage.

Traditionally the competitive advantage of a business is considered to come from its core internal competences and its internal business processes that are considered as somehow static and permanent, and the strategy of a company is aimed at improving their core competences and their business processes. However in the new business models, the core competences of a business need to be continually adapted to the network conditions and acquire a dynamic nature.

The business has to be considered as an entity in continuous communication with its network partners. To gain and sustain competitive advantage the business must focus on leveraging the collective capabilities of the network as much as its internal capabilities. The potential gains of inter-enterprise collaboration are so significant that a business strategy focusing just on the direct customers and internal functions risks to be short-sighted.

One AMR-Research study [21] quantifies the advantages associated to first class networking enterprises as: 15% less inventory; 17% stronger order fulfillment; 35% shorter cash-to-cash cycle time. These advantages translate into: a 60 % increase in profit margins; 65% better EPS (Earnings per Share); and 2-3 times better ROA (Return on Assets).

2 The xSGO Paradigm

Smart organizations (SO), Filos [2], [5] are new forms of industrial organizations that exploit the great number of exchanges and relationships, “the wisdom of networks”, for enhanced learning, improved competitive advantage. In the European Commission’s research program Information Society Technologies IST -2002 [2], a SO is defined as: a knowledge-driven, inter networked , dynamically adaptive to new organizational forms and practices, learning as well as agile in their ability to create and exploit the opportunities offered by the new economy. The main features of the SO are:

- The SO is based on networking at different levels: technological, organizational and learning through knowledge acquisition and sharing.
- The SO focus moves from ownership and control of tangible assets to the exploitation of knowledge as the key source for competitive advantage.
- The SO is capable of continuous knowledge interactions with external partners. These interactions, referred by [2] as “knowledge hyper-linking”, are consid-

ered in LEAPFROG as human-centric, driven by people who share common interests and objectives and are not envisaged as limited to just ICT interactions.

- The SO departs from the strictly functional hierarchy, towards a more effective and efficient combination of functional hierarchy and cross functional project-teams who act based on coordination and inspiration led by authority of competence, and guided by trust and integrity.
- The capacity to collaborate is a core competence of the SO, because of the acknowledgment, that many of the skills and resources essential to the organization's competences are external and outside of the direct control of the management. This fact demands for a wide variety of collaborative partnerships.
- The SO is fully committed to empowering and leveraging people through an entrepreneurial culture.

A smart extended organization (xSO) is a Smart Organization which develops its business in a network of more or less loosely tied companies that cooperate as if they were a single virtual company. The vision is that in the global environment competition is no longer a question of one company against another company but of one network against another network. When an xSO leads a network, usually, it does not own nor control the resources of the other partners nor can it impose coordination by command as in a vertically integrated company, but it has the ability to connect to the resources when needed and to design a space of collaboration and commitment among the partners in the network. Summarizing, an xSO is an organization having the following features [1]:

- Ability to design, implement and run business networks and/or ability to quickly establish cooperative relationship in a business network.
- A business culture focused on customers' needs and centred on collaboration and knowledge improvement.
- Ability to respond flexibly to market changes and to adapt its internal and external behaviour to widely changing business conditions.

Extended smart garment organizations (xSGO) are xSOs operating in the fashion industry. Achieving smartness in the fashion industry requires leveraging the right ICT and fashion technologies, such as: Web Collaboration, 2D and 3D CAD, Virtual Prototyping, Product Lifecycle Management (PLM), or workflow management,. These technologies play a crucial role as enablers of this new organization models envisaged in LEAPFROG [6].-

The role of ICTs is an enabling one but its benefits can be realized only redesigning the business processes and reorganizing the knowledge flows that support them. This is why the xSGO Modelling Set (see chapter 4.3) provides three integrated cross-organization views: the process/organization view, the knowledge view, and the technology view. The relevance of the holistic approach both technical and organizational is seen for example in Benetton's success that came from simultaneous innovations in product (meeting customer's colour preferences), in process (POS data acquisition and dying full knitted sweaters) and in supply chain (achieving volume managing a network of subcontractors.) Business processes distributed through the network should behave like a unique process inside a single virtual organization. This is a must for the creation of competitive advantage from the linkages with the other partners. The LEAPFROG's Knowledge Exchange Architecture (see chapter 4.4) initiative supporting this level of integration.

3 Value Networks

Porter defined value as [4]: "What buyers are willing to pay for a product or service", this concept has been extended to include other aspects as: co-worker value, social value, environmental value and shareholder value. Porter also introduced the value chain concept as a tool for designing the strategy of the firm that is "a general framework for thinking strategically about activities involved in any business and assessing their relative cost and role in differentiation". The Porter value chain is extended to the value network concept consisting in the set of activities carried out by the different companies involved in the design, production and marketing of a product. Child and McGrath, [5] define a value network as a "value creating system of several organizations possessing complementary strengths and coordinated through a combination of contractual provisions and mutual beneficial relationship that are often orchestrated by a leading member".

Figure 1 shows one type of loose fashion network composed of a universe of potential suppliers. The orchestrator configures one specific "supply chain", for each customer order by selecting the right companies and coordinates the activities of the partners to assure that the customer order is properly fulfilled.

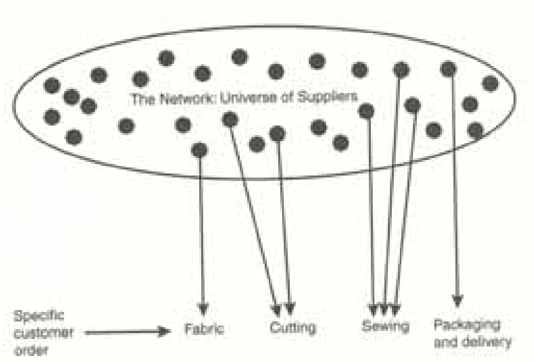

Fig. 1. Typical Fashion Networking (Source: Victor K. Fung 2008 [17])

The focus of the value network is not the manufactured product nor the manufacturing costs but the value created for the end customers. The only reason for the network is to deliver value to customers in the form of the right product, at the right time, at the right place and at the right price.

A value network is supported by three pillars: The value adding activities or process, the organizational structure and the enabling technologies and require the precise coordination of four different flow exchanges: Materials, Information, Financial and Knowledge.

All these flows are described by the xSGO modeller. In particular, the knowledge flows have been accorded a significant role because scientific, technical and organizational knowledge is essential to achieve continuous economic growth. At the level of the firm, the organizational interaction between "explicit knowledge" which is easily communicable and "tacit knowledge", that comes from experience and cannot be communicated by workers under excessively formalized management procedures is at the source of innovation and [23] [3]"sources of innovation multiply when organizations are able to establish bridges to transfer tacit into explicit knowledge, explicit into tacit knowledge, tacit into tacit and explicit into explicit". ICTs are instrumental in building these bridges.

The key property of knowledge is that once it has been created it can be used by any number of firms at the same time and can accumulate without bound. This is described as knowledge being a non-rival good not subject to diminishing returns as physical goods. Knowledge is also a partially excludable good, meaning that people who create new knowledge have the capability to exclude others from using it to their benefit and so, knowledge gives the owner some market power to recover the investment made. Excludability is only partial because knowledge necessarily spills over in time through diffusion.

Because knowledge is not subject to diminishing returns, firms exploiting knowledge can be price makers rather than remaining price takers, and the markets for their differentiated products are, as a rule, competitive monopolistic markets.

Market vs. Hierarchies

The Organizational Economics (OE) provides the theoretical framework to analyze which activities are better conducted within firms and which between firms, that is: when to make, when to buy and when to cooperate. OE is considered to have started with the Coase's paper: "The nature of the firm", 1937 [18] where he asked why certain activities are done inside the firms while others are contracted in the market and even why firms existed at all.

Williamson [12, 13] considers the transaction costs (TC) as those costs incurred by agents due to the non ideal nature of the economic system. In an ideal perfect market with complete information shared by all agents and perfect competition among all factors, there would be no TCs; TCs are the costs due to the departure of the real market from the ideal. Using the market has costs, and using the hierarchy of management inside the firm has also its own coordination costs as happens to all the hybrid schemes like: joint ventures; network partnering; strategic alliances etc. Basically, what TCE has to say on whether to make, buy, or cooperate is that a given transaction will be done in the kind of organization with lower transaction cost. Williamson points out that there are two features of human nature: bounded rationality and opportunism that create risks in cooperation.

TCE advises on whether to perform an activity in the firm or to perform it in the market according to the transaction costs in each case. The variables that determine TCs are: *Frequency, Uncertainty* and *Asset specificity*. TCE predicts that the higher the uncertainty and the asset specificity, the transaction costs are lower in a hierarchy than in a market. Therefore assets specific transactions are more efficiently done inside the firm.

The Role of ICT in Value Networks

ICTs in LEAPFROG are considered as tools to enable coordination and lower its costs. ICTs have the capability to dissolve tradeoffs of the clothing business: The tradeoff between increasing differentiation and shorter time to market, the tradeoff between low inventory levels and high customer service level and the tradeoff between higher flexibility and lower manufacturing costs.*”*: There are two basic ways of deploying ICT in a business network: Deployed by the lead company or interconnecting the IT systems of the partners. Example of the first approach is the Retail Link from Wal-Mart. The LEAPFROG KEI has been developed to facilitate the second approach of interconnecting the IT systems of the partners through extensive use of international standards such as ebXML. But there is a critical fact, as stated by Bar and Borrus [22]*:”IT often automates inefficient ways of doing things. Realizing the potential of IT requires substantial reorganization.“* This is why ICT networking is only the enabling technology, but not sufficient in order to exploit the full potential of networks.

Performance Metrics for Value Networks

The classical performance metrics for supply networks have been: Cost, Quality and Speed. Lee H. [6] introduced the so called triple A metric, best suitable for the Textile and Clothing Industry:

- Agility (Time-To-Market, Time-To-Serve, Time-To-React)
- Adaptability of the network structure to structural market changes or to shifts in strategies, regulations, products or technologies.
- Alignment determined by the right economic incentives for the partners to collaborate.

Typology of Value Networks

As a guide in the analysis and engineering of business networks, it is useful to classify them according to the following criteria:

- Planned duration of the network. *Temporal, Permanent,* or *Hybrid*.
- Geographical extension. *Worldwide, Regional or local* as in clusters of economic districts.

- Origin. *Family-based networks,* as in China or Italy*; hierarchical communal networks* as the Japanese *keiretsu; decentralized corporate units* for former vertically integrated companies; *Cross border networks* from strategic alliances.
- Sectors of activity. H*orizontal networks* operate in all main economic sectors, and have own sources of financing. The Korean *chaebol* is controlled by a central holding, owned by a family and backed by a government bank (e.g. Hyundai, Samsung, etc..). The Japanese *keiretsu* are *vertical networks* with hundreds of partners built around large corporations (as Toyota, or Nissan).
- Structure. *Static* (no change of partners*) or Dynamic* (membership can change).
- Operational principle. *Supply-Driven* networks and *Demand-Driven* networks (this is typical for the Textile and Clothing Industry.
- Participation. *Exclusive (*participation in only one network) versus *Non-exclusive*.
- Governance (terms according to which control, responsibilities, benefits and risks are shared among the members of a network): *Free Market* where the relationship is limited to market transactions that do not require further collaboration. *Pure Integration* when one of the companies is vertically integrated inside the other. *Orchestration* when one of the players coordinates all the other in the network and keep them aligned through a set of incentives. *Coercion* when a lead company exercises its buying or other power to force all players to take coordinated actions.
- Information visibility Level: *High or Low*. Visibility is necessary to avoid inefficiencies such as duplicated inventories, and the consequences of the bullwhip effect [7].

4 Fashion Networks

4.1 Fashion Products

The goods sold in the fashion market are garments or accessories that can be classified in different categories, according to Abernathy, et al. [22] as:

- *Basic Products* are commodities as knit underwear, hosiery and home textiles that change little from year to year and are purchased mainly on price, with relatively stable demand along the year, and sold at low margins. The supply network is oriented to mass production trying to minimize total costs.
- *Fashion basic products* with low quality fabrics and some element of style like dress shirts, or knit sportswear are offered in many different styles with small

variations. They are sold at relatively low prices, their supply is not much connected to fashion trends, and are well adapted to be mass produced in not very fast overseas supply chains.

- *Fast Fashion products* are more fashion conscious and were introduced to get improved margins, better brand image and higher turnout at retail. They follow fashion trends and quickly make new designs to be delivered in few weeks to the stores, at affordable prices with intended shelf life of just 2 to 3 weeks.
- *High Fashion products* have a lot of style and design and use quality fabrics. Examples are high quality ready-to-wear women's dresses, fashion skirts, designer collections and "haute couture".

The demand of products with significant fashion content depends on volatile consumer tastes and fashion trends that could last for just a short time window and are often connected to ephemeral events like a catwalk, a celebrity style, or a music event. In particular Fast Fashion demand cannot be forecasted. The uncertainty on styles, colours and quantities is greater the farther ahead from the season these decisions are taken. Forecast errors can be up to ±40% if done 5 months ahead and worsen with product variety because there is less demand history to use in forecasting. This stresses the importance of capturing true customer demand.

As stated before the design, production and provision of textile and fashion goods is performed by a network of companies. The activities in these fashion value networks can be grouped in the following segments: Raw material suppliers: natural and synthetic fibres; textile companies that supply yarn and fabric; garment manufacturers including domestic and overseas contractors; export channels and retailers, as indicated in Fig 1 in the previous chapter.

4.2 Real Fashion Networks

The Traditional Fashion Supply Chain and the Quick Response (QR) movement

The traditional fashion supply chain was push oriented [8] and had the following features: New collections were designed about one year ahead of the season; the stores placed orders to manufacturers from five to seven months ahead of the season, based on their forecast of styles, colours and quantities; the manufacturers produced most of the goods before the season and accumulated inventory; during the season, replenishment was very limited and at the end of the season more than 30% unsold products had to be heavily marked down to be sold.

The Quick Response movement (QR) started in the U.S. in the 80's and tried to move the retailer buying process closer to the selling season by the systematic introduction of ICT, such as CAD, PDM, CAM, marker optimisation, and flexible and manufacturing technologies enabling production in small batches in different stages of the apparel supply chain. Stores would commit only to a percentage of the merchandise before the start of the season, deciding on the rest of the preferred styles and colours after observing the real customer demand.

The Fast Fashion Supply Chain

To analyze this segment we focus on Inditex (better known by its brand Zara) supply chain that is extensively documented. The main characteristics of the Inditex supply chain are as described in [9], [10], [11], [12], [13] and [19], are:

- The total revenue in 2007 was €9,435 billion. In September 08 they opened their 4000th store worldwide. Inditex markdowns only 2.6%, while industry average is 10-20%. IT budget is of 0.5% and advertising is 0.3% of sales
- Inditex is mostly a vertically integrated company that outsources only the sewing operations or the base products like sweaters in classic colours, mainly to Europe. 60% of the fabrics are externally sourced, mostly as un-dyed. The supply chain is a mix of push and pull, Inditex delivers only 50% of the goods at the start of the season while the rest are freshly designed in-season.
- Low performing products are quickly slashed and new fresh designs are introduced (over 30000/year) by its more than 350 designers. They create a scarcity premium, to stimulate impulse purchase and visits.
- Inditex's stores are uniform, upscale and located in premium shopping streets. Most of them (90%) are own managed, and 80% of its business is in Europe. Store managers are highly empowered and manage the store's inventory, ordering products weekly and providing daily customer feedback. All stores receive goods twice per week from the company distribution centres (DCs).

The Prato Textile District

One very efficient cluster in the textile sector is the Prato district in Tuscany Italy [14]. Prato is a town of about 300000 inhabitants with a long textile tradition from the 12th century that was once based mainly on vertically integrated companies formed around large woollen mills. In the 1980's Prato suffered a deep structural crisis, which overcame by shifting from few low-price and low margin products to a higher variety of innovative woven fashion fabrics and garments, supplied quickly and at competitive prices. There are in Prato over 7000 companies, employing over 50000 people producing a total of 4,2 billion €. Knowledge of textiles and clothing is socially appreciated and there are good technical education sites. Small family businesses specialized on parts of the production process are collaborating and orchestrated by the "impannatori". The impannatori rely on the specialized small-scale weavers who supply them at competitive prices and experiment with materials and equipment. The relationship between the impannatori and his network is very fluid, based on complementary skills and trust, what enables the fast dynamic configuration of a network and its adaptation to changing customer demand and which can expand its capacity to respond to peaks by incorporating new subcontractors through their horizontal links without the need of complex negotiations. The impannatori often even provide informal credit to their subcontractors to be later deducted from the amount the impannatori pays to the subcontractor for the goods they manufacture. The trust relationship strongly reduces the risk.

The Li & Fung Orchestration model

Li & Fung Ltd. (L&F) was founded in 1906 in Guangzhou, today it is based in Hong Kong and is the largest trading company in the world in outsourcing apparel. L&F made a total turnover of US$ 11 billion in 2007 [20]. L&F operates 80 offices covering 40 countries. L&F does not own a factory, but produces over 2 billion garments on behalf of over 1000 American and European retailers orchestrating a network of more than 8000 factories in Asia and other continents. L&F provides to retailers a total Value-Added Package and relies heavily on ICT (L&F was listed in 2005 in the Wired 40, side by side with Google, Yahoo). The relationship of L&F with the contractors on long term contracts akin to the so called "30/70" [17]: "L&F to have more than 30 percent of the business of a given supplier, to be meaningful and ensure commitment, but no more than 70 percent of its capacity, to ensure flexibility and encourage learning".

5 The Design of Fashion Networks

The design of fashion value networks consists in taking the right set of decisions at strategic, tactical and operational levels to optimize the value delivered to customers. At a strategic level, the main issue is to decide on what capabilities to invest and develop internally and what capabilities to allocate for development by suppliers; combined with this decision is the formation of partnerships with the suppliers. The following methodology on the high level design of fashion value networks is based on Fine [7], Diaz [15] and Christopher et al [16]. It consists of the following steps:

1. Identification of strategic parameters to be decided in the design process.
2. Statement of the competitive strategy approach of the firm.
3. Mapping the external competitive environment of the firm.
4. Mapping the internal capabilities and constraints.
5. Prescription of the architecture of the value network.

Step 1: Some of the most important strategic parameters are:

- The flow model: forecast driven, demand driven or hybrid
- The location of inventory: centralized or distributed
- The make/buy decisions.
- The relationship with the partners should be: transactional or long term
- The geographical distribution: local or global

<u>Step 2</u>: The competitive strategy of the firm that consists in prioritizing the objectives the firm should excel at is the first input in taking these strategic decisions. Shapiro identifies three generic objectives for a firm:

- Competition in cost
- Competition in customer service
- Competition in innovation

This classification is considered exhaustive and supported by empirical evidence. Companies may aim at more than one strategic objective. The highest priority objective (A) should be the one to be optimized; the second (B) would behave like a constraint that must be met, and the third (C) is free. Typical examples are shown in table 1.

		Zara	H&M	Gap
Optimize on	**(A)**	Innovation	Cost	Cost
Bound on	**(B)**	Cost	Innovation	Service
Best-Effort on	**(C)**	Service	Service	Innovation

Table 1: Priorities of strategic objectives of selected fashion groups (adapted from [15])

The strategic objectives are translated into to specific metrics: Cost is related to efficiency; customer service to reliability and responsiveness and innovation to flexibility, sensitiveness and adaptability. For example, to focus on innovation it must be possible to frequently introduce new products and to ramp up production or slash the product according to performance, therefore network flexibility is a must; the network must sense the real customer demand (sensitiveness); and be ready to support the introduction of new products (adaptability). If cost are the strategic priority then the network should be geared toward efficiency.

<u>Step 3:</u> Mapping the competitive environment

The competitive environment [7] is shaped by constraints that may limit the feasible values for the configuration of the supply chain, such as: Regulations or public rules that the firm must comply; industry structure, for example, the existence of a lead firm; capital markets that might limit potential configurations; technology dynamics; business dynamics, like the existence of cyclical dynamics; and customer preferences that make demand for fashion uncertain and volatile.

<u>Step 4. Mapping the internal capabilities</u>

The internal capabilities of the product development systems, the production system and the distribution systems have to be mapped.

<u>Step 5. Prescription of the value network architecture</u>

Following are some rules that can be used in order to select prescriptions for strategic configuration variables based on the strategic priorities of the firm and the internal and external constraints.

Rule 1: Strategy and Supply Chain Architecture:

If the strategy is to compete on innovation then the rate of product change must be high (case B or D), and if strategy did not ask for high service level (case D) the network should either provide quick make to order or keep some inventory centrally (at the distribution centre), this is the case in Fast Fashion. If strategy is oriented to compete in service then (case C or B) safety stocks are necessary, the amount being conditioned by the risk of obsolescence. For a strategy oriented to compete on cost, applicable only if products are stable and service level is not a main objective, service would be done from safety stocks carried centrally as finished goods or raw materials depending on the cost.

	Rate of Product Change	Required Service Level	Description
Case A	Slow	Low	Some safety stocks carried centrally as finished goods or raw-materials depending on value of the items
Case B	Fast	High	Trade-off between cost of obsolescence and cost of lost sales
Case C	Slow	High	Safety stock level high and distributed
Case D	Fast	Low	Produce to order or carry limited inventory centrally

Table 2: Linking strategy with a potential supply chain architecture (adapted from [15])

Rule 2:Product Demand and Supply Chain Architecture

The SC is lean if waste has been eliminated (Ohno 88). The SC is agile if it has the capacity to match supply and highly variable demand. Both concepts are not exclusive and could be complementary (leagile).

For predictable demands and long lead times select (A). The supply network should be engineered according to lean principles. In fashion this scheme is only applicable to basic goods. The right supply chain is push oriented.

For unpredictable demands and short lead times select (D). The best possibility is to manufacture in proximity and use numerous flexible workshops to absorb the demand fluctuations, this is the concept of pull as implemented by Zara.

	Demand Variability	Replenishment lead times	Description
Case A	Low	Long lead time (months)	Lean: Make or source ahead of demand in the most efficient way
Case B	High	Long lead time (months)	Leagile: Carry generic inventory and assemble on demand.
Case C	Low	Short Lead Time (days)	Lean Continuous Replenishment
Case D	High	Short Lead Time (days)	Agile

Table 3: Linking product demand with a potential supply chain architecture (adapted from [16])

For predictable demands and short lead times select (C). It is the situation of Procter&Gamble and Wal Mart using VMI (Vendor Managed Inventory).

For unpredictable demands but long lead times select (B). The best approach is to keep inventory in a generic form and assemble on demand. This is a push/pull hybrid scheme where lean methods are applied upstream the decoupling point (the generic inventory) and agile methods downstream of the generic inventory. This scheme is used quite often in fashion, where un-dyed yarn and greige fabrics are carried out as generic and sourced from a push efficient supply chain to reduce the effect of demand variability and after this point the chain is designed according to the agility concept.

Rule 3 Product Characteristics and Supply Chain Architecture

This rule (Table 4) compares functional products (stable demand, low margin, high efficiency) with innovative products (high margin, less responsiveness).

Product characteristics	**Nature of Demand**	
	Functional	Innovative
Product life cycle	More than 2 years	3 months to 1 year
Contribution to margin	5-20%	20-60%
Product variety	Low (10 to 20 variants per category)	High (often millions of variants per category)
Average error in forecast when production is committed	10%	40% to 100%
Average stock out rate	1-2%	10% to 40%
Average markdown as percentage of price	0%	10% to 25%
Lead time for made-to-order	6 month to 1 year	1 day to 2 weeks

Table 4: Linking product characteristics with a potential supply chain architecture

Rule 4: Product Variety and Production Sites

This rule (Table 5) distinguishes two sources for variety: production dominant variety and mediation dominant variety. The first affects the production costs but not directly the consumer choice. The second is introduced to provide more choice to the consumer and affects little the direct production costs. The main lesson is that proximity enables real advantage in terms of mediation variety.

Scale Economies	**Production Location**	**Description**
Small	Far	Low production and mediation variety
Large	Far	High production variety, low mediation variety
Small	Close	Low production variety, high mediation variety
Large	Close	High production and mediation variety

Table 5: Linking strategy with a potential supply chain architecture (adapted from [15])

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4.3 Modelling Textile Networks

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Abstract

Europe’s textile and clothing companies face strong and growing international competition. To survive and thrive companies have to build new types of production and organisational networks like the ‘Extended Smart Garment Organisation’ (xSGO). This concept has been developed in the European research project LEAPFROG, with at its core the concept of Smart Organisations, which offer the companies additional possibilities to improve their competitiveness. The ‘Smart Network Modelling’ method supports the description of organisations which incorporate the idea of the Smart Organisation. The structure of this modelling method and first hand practical experiences are the main topics of this paper.

1 Textile Industry and Textile Networks

The Textile and Clothing Industry has a long tradition of networking. The value chain starting from fibre production up to garment or technical textile manufacture consists of many steps usually performed by individual companies, typically SMEs, which need to network with each other. Figure 1 in paper 4.1 (see also [7]) demonstrates the complexity and the dependencies within the textile production chain.

The rapid development of information and communication technologies in the last decade enables new opportunities in this digital age but also frequently requires changes in the structure of organisations and networks. According to Filos [8] the digital age is characterised by increased networking in a global economy, a new perception of value and intangible assets which emerge as an important source of economic value creation. In the last years new concepts for collaborative networking have been developed to exploit the various opportunities of the digital age. Camarinha-Matos and Afsarmanesh [4] identified a large variety of collaborative network concepts from the Virtual Enterprise to the Agile Shop Floor. Of particular importance are the concepts of Extended Enterprise, Virtual Organisation, Dynamic Virtual Organisation and Virtual Organisation Breeding Environment. For these concepts various different approaches exist but no clear favourite has emerged so far. In the following a short overview of the more sophisticated networking concepts will be presented.

The concept Extended Enterprise describes the extension of an organisation with functionalities provided by suppliers. Kalakota and Robinson [11] focus on online business processes with a shared information infrastructure in a multi-enterprise supply chain as constituent element. For Michaelini and Razzoli [15] co-designing, co-manufacturing, co-marketing, etc. are the opportunities of a shared infrastructure resulting from an alliance of partners called Extended Enterprise. According to Camarinha-Matos and Afsarmanesh [4] a dominant enterprise extends its boundaries to form an Extended Enterprise, which describes a specific type of a Virtual Organisation.

One early definition of Virtual Organisation by Byrne [3] is that of an enterprise that marshals more resources than it currently has on its own, using collaborations both inside and outside of its boundaries. Another definition by Bullinger [2] describes a Virtual Organisation as temporary horizontal and/or vertical cross-site cooperation between different companies, which organises the flow of activities based on efficiency aspects and not on organisational affiliation and also presenting itself to the customer as one unit. Camarinha-Matos and Afsarmanesh [4] skip the idea of one face to the customer in their definition, which describes a Virtual Organisation as s set of (legally) independent organizations that share resources and skills to achieve a mission / goal.

Virtual Organisations, which are established in a short time to respond to a market opportunity and have a short life-time, are Dynamic Virtual Organisations following the definition of Camarinha-Matos and Afsarmanesh [4]. The European research project ECOLEAD [5] refines this definition and states the necessity of a Virtual Organisation Breeding Environment to quickly assemble enterprises to a business entity.

Ellmann and Eschenbaecher [6] define a Virtual Organization Breeding Environment is a cluster or pool of potential partners with the ability and the will to cooperate and are therefore crucial to Virtual Organisations. Camarinha-Matos and Afsarmanesh [4] refine this definition by describing the necessity of long-term cooperation agreements, interoperable infrastructure and the availability of a broker, normally the partner identifying the business opportunity, for forming a Virtual Organisation.

All these sophisticated concepts are concentrating on organisational or ICT aspects of cooperation extensively neglecting the intangible asset knowledge, which is a core value for the information society and the digital age.

Therefore Filos and Banahan [9] identified new important characteristics for networking based on the term ‘smart’ (e.g. smart resources or smart competencies) for successful collaborative networking leading to the new concept Smart Organisation. The constituent elements of a Smart Organisation are ‘Knowledge Networking’, ‘Organisational Networking’ and ‘ICT Networking’.

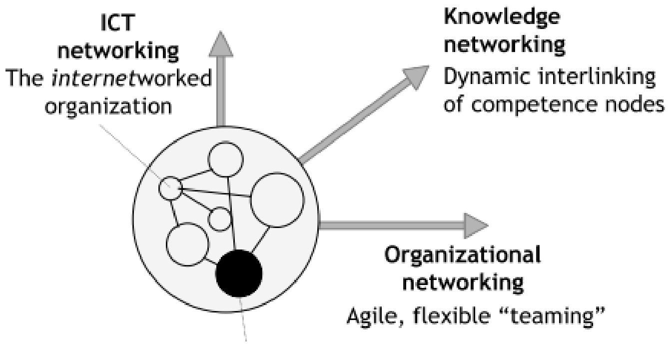

Fig. 1. Smart Organisations are networked in three dimensions [8]

Filos [8] defines the term ‘Knowledge Networking’ as the capability to use external knowledge and the continuous and dynamic knowledge interaction with partners. He calls this knowledge handling, according to the linking of information in the internet, ‘Knowledge Hyperlinking’. The term ‘Organisational Networking’, also called ‘Organisational Teaming’, describes organisations, which are able to conceive, shape and sustain a wide variety of collaborative partnerships. The last term ‘ICT Networking’ or ‘ICT-enabled Virtuality’ depicts ICT architectures, which are able to support the organisational structures and the knowledge exchange.

The Smart Organisation is the core concept of the ‘Extended Smart Garment Organisation’ (xSGO) developed in the framework of the European research project LEAPFROG (http://www.leapfrog-eu.org). In paper 4.2 ‘Engineering Value Networks in the Fashion Industry’ the xSGO and additional background information about networking has been presented. The modelling of textile networks with the ‘Smart Network Modelling’ method presented in this paper offer the possibility to describe organisations following the three constituent elements of the Smart Organisation.

2 Modelling Networks

What is the purpose of modelling? This is always the first question you have to deal with when modelling, which Mulligan and Wainwright tried [17] to answer. They identified the following purposes of modelling:

- as an aid to research,
- as a tool for understanding,
- as a tool for simulation and prediction,
- as a virtual laboratory,
- as an integrator within and between disciplines,
- as a research product or
- as a means of communicating science and the results of science.

Holt [10] found different answers to this question. According to him, modelling is an instrument to cope with the complexity of systems. It can assist the communication by offering a common language and common understanding of system elements. It also helps to understand the systems and its behaviour. According to Kay [12, p. 19], the usual purpose of modelling is not to make predictions, but to enhance our understanding of complex systems. Such universal answers to the question of 'why modelling?' are not satisfactory to the practitioner. Therefore an individual answer for the ‚Smart Network Modelling' method has to be given.

First of all ‚Smart Network Modelling' should provide a common basis for discussing organisations within a Smart Organisation context. This basis includes a common language, a common mindset and a common understanding of the principal relation and activities in the organisation. The modelling is also a solution for the problem described by Abdullah et al. [1]:

> 'It is very difficult for the human mind to be able to capture features of a system as a mental model and then convey those features verbally. The human mind often works better with a visual representation.'

Beside this more general purpose of ‚Smart Network Modelling' the modelling should assist the following four topics:

- analysis of networks,
- design of networks,
- coordination of networks and
- design of collaboration systems.

The modelling should enable the analysis of organisations e.g. by providing the possibility to learn about the current structure and to compare it with the target structure of organisations. Another analysis aspect should be the performance of organisations. Are there any media breaks? Are there any activities, which could be eliminated by restructuring the organisation, e.g. activities to externalise knowledge in one company and a corresponding activity to internalise it again in another company could be replaced by a socialisation activity with reduced risk of misunderstandings and lack of information? Another analysis aspect supported is the completeness of the organisation model. Are really all necessary knowledge domains covered? Are there any activities missing? However, the analysis of 'Smart Network Modelling' does not cover the simulation of business activities. The models are not intended to give any information about the time behaviour.

The first step of cooperation is the design of the network covering the flow of activities, the flow of information and the provided knowledge. The modelling should be an instrument for discussing, designing and adjusting the structures of the aspired network, taking into consideration the individual goals of the network. Various variants of the targeted network structure can be analysed and discussed.

This analysis of design variants of the network can be performed regularly or event-based as an instrument for the coordination of the network. Changing requirements of the environment result very often in the necessity to change the structure of the network to cope with the new situation. Situations like a network partner leaving the network become better manageable. The effects can be easier identified and appropriate measures can be initiated.

A further, ambitious goal of 'Smart Network Modelling' is to be the first modelling level of the approach 'Model-Driven Application Development' for the configuration of collaborative systems developed in the European research project AVALON, which is similar to the model driven architecture [16]. The 'Smart Network Modelling' represents the Computational Independent Model, which will be transformed via a Platform Independent Model and a Platform Specific Model to a network specific configuration for a collaborative system, providing a tailor-made solution covering all the specific needs of the targeted network.

3 Smart Network Modelling

'Smart Network Modelling' allows the description of organisations, which could be a hierarchical entity but also a network, following the idea of Smart Organisations thus meaning a holistic view on organisation, knowledge and ICT. The modelling is targeted to individuals, which are able to influence the structure and design of organisations that could be for example the management of a company, an employee of the organisational development department, a manager of a department or a management consultant. With this basic condition in mind the following modelling structure has been developed.

The core elements of 'Smart Network Modelling' are three dependent basic model types called 'Business Compendium', 'Structure Diagram' and 'Activity Diagram'. The 'Business Compendium' describes the various business activities and their relations. This model type defines the setting as well as the context in which the 'Smart Network Modelling' will be performed. The 'Structure Diagram' illustrates the topology of the organisation, e.g. organisational chart or ICT architecture, within the settings and context outlined in the 'Business Compendium Diagram'. Finally the 'Activity Diagram' defines the processes and activities performed in the defined setting and context with the help of the topology of the organisation. For the 'Structure Diagram' and the 'Activity Diagram' three views, corresponding with the three constituent elements of the Smart Organisation, are available. These three views are called 'Organisational Layer', 'Knowledge Layer' and 'ICT Layer'. Figure 2 demonstrates the structure described above.

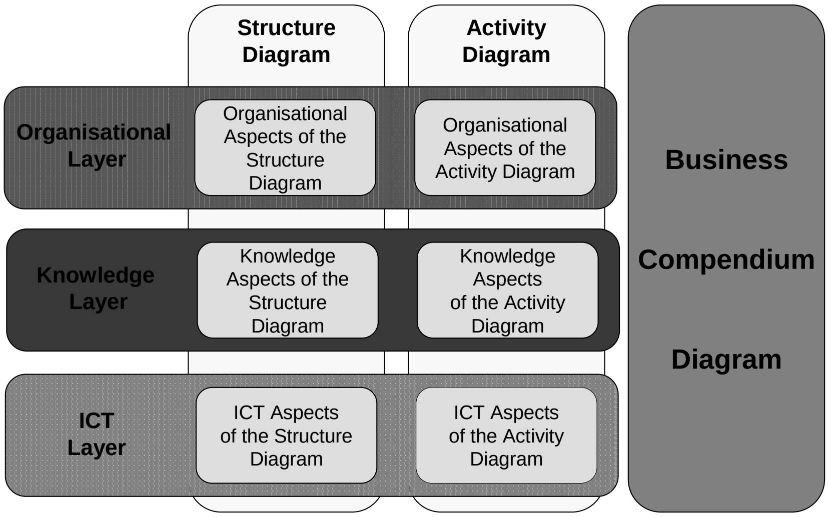

Fig. 2. Structure of the 'Smart Network Modelling' method

The core element of the 'Business Compendium' is the 'Business Activity' representing business processes. This element is extended by other elements for identifying individual goals, groupings of 'Business Activities' for special purposes and alignments of 'Business Activities' to the individual needs of customers.

The 'Organisational Layer' of the 'Structure Diagram' presents a view on the topology of the organisation focusing on the organisational aspects. It allows modelling hierarchical organisational structures and non-hierarchical organisational structures like teams. The same type of view is also available for the 'Activity Diagram'. In this view the flow of activities and the organisational responsibilities as well as the required technical resources can be described.

The main difference of the Smart Organisation to other networking concepts is the consistent integration of knowledge management. This important issue is realised in 'Smart Network Modelling' with the view 'Knowledge Layer'. This view identifies in the 'Structure Diagram' the various knowledge domains. It allows detecting development potential available in the organisation that means to evolve from an available knowledge domain to a core competence from the organisation. In the digital age knowledge and information derived from this knowledge is a valuable resource which needs to be protected. Activities of protecting and conserving the knowledge are also part of this view in the ‘Structure Diagram’. In the ‘Activity Diagram’ the link from the identified knowledge domains to the individual activities is established. This demand of knowledge has to be covered by persons, which are also assigned to the activities. It therefore describes the generation and exploitation of knowledge in the organisation.

The last view ‘ICT Layer’ deals with the information and communication systems supporting the activities and the knowledge management. In the ‘Structure Diagram’ the view explains the architecture of the information and communication systems as well as the principal interfaces between the individual systems. These systems satisfy the information and communication demand of the individual activities described in the ‘Activity Diagram’.

This ‘Smart Network Modelling’ method has been realised with the software tool Generic Modelling Environment (GME) [13], developed at the Institute for Software Integrated Systems at Vanderbilt University in Nashville (Tennessee, USA). GME is based on a concept which is similar to Meta Object Facility (MOF) [18], developed by the Object Management Group (OMG). This software tool allows graphically defining the run-time and build-time modelling rules and to interpret them enforcing them during modelling. The rule set for the ‘Smart Network Modelling’ method was complemented by a modelling style guide dealing with run-time rules not supported by GME.

4 Experiences with Smart Network Modelling

The ‘Smart Network Modelling’ rule set was used to visualise typical network situations in the Textile and Clothing Industry as well as new organisational and product innovations. The technical and industrial partner of the LEAPFROG project, in close cooperation with the scientific partners and the project AVALON, elaborated models for:

- garment product development,
- a tracking system in a Made-to-Measure environment,
- organisational innovation ‘Quality Partnership’ and finally
- product innovation ‘SMA Motorcycle Helmet’ (in collaboration with the project AVALON).

The experiences gained with modelling these networks during the LEAPFROG project will be explained in the following.

Garment product development is one of the core business activities of the clothing industry. It consists of structured and ad hoc sequences of activities. Also many different players (internal as well as external) are involved. Therefore it is a challenging task to organise this business activity in a smart way.

The model of the garment product development is based on the six-phase Apparel Industry Product Development Process presented in the article of May-

Plumle and Little [14]. This model has to be extended and adapted to reflect the idea of ‘Smart Organisations’. Core aspects concerning organisational, knowledge and ICT aspects are missing in the original model.

During the project LEAPFROG, the model was restructured to fit the structure of the ‘Smart Network Modelling’ method explained above. Missing or incomplete information, e.g. organisational responsibilities, involved ICT systems or the necessary knowledge domains, have been elaborated by industrial and technology partners with long experience in garment development. This additional information was integrated into the smart network model of the garment product development.

The most difficult tasks in modelling the garment product development were the identification of the involved knowledge domains and the handling of this knowledge. Many companies were not aware of the extent of knowledge required for product development. Knowledge with technical background like knowledge about marker making was easier for them to identify than the more abstract but also very important knowledge about interpretation of market analysis. The modelling also created the awareness of networking due to the strong dependencies on many other partners, e.g. market analysis or fabrics, even if the core activities are performed within one company.

The next network described with the ‘Smart Network Modelling’ method was the production network of a Made-to-Measure Internet mail order shop, see figure 3 for the first steps of the performed business activities. In this network the customer is directly involved in the configuration and sizing of its ordered shirt. The communication between all network actors is performed via Internet. This puts an emphasis on the ICT systems. But due to direct the involvement of the customer in the design of the shirt, non-rational aspects are playing an important part in the business activity. The emotional link from the customer to its shirt requires a different kind of knowledge than standard mail order. The advantage of such an emotional link is a strongly reduced return rate with about 5% for Made-to-Measure shirts in contrast to up to 40% for standard products. To strengthen this link a constant feedback about the status of its personal product was given.

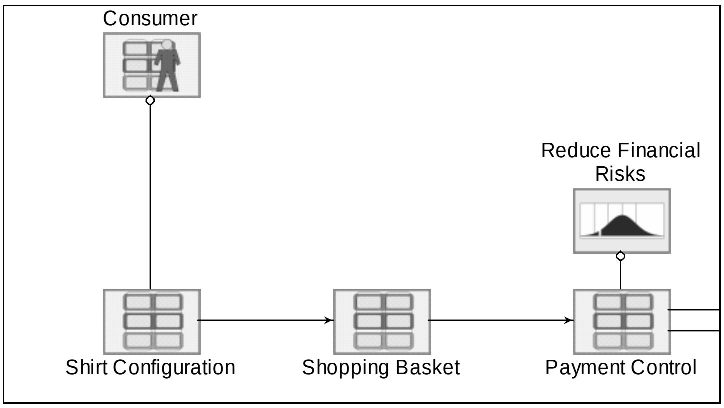

Fig. 3. Excerpt of the Business Compendium of a Made-to-Measure Internet shop

The ‘Smart Network Modelling’ method was used to describe this ICT focused production network. For this special network a more detailed description, e.g. more details about interfacing, of the ICT architecture would be useful but the available modelling elements are sufficient to have a general impression of the involved ICT systems. The ‘Knowledge Layer’ enabled the identification of suitable activities to integrate additional knowledge domains into the ICT systems thus improving the comfort of customers and creating positive emotions, with the Internet shopping system as the gateway to the production network.

The idea of the organisational innovation ‘Quality Partnership’ was to reduce the lead time of the production network by minimizing quality tests. To reach this goal a series of activities had to be performed preparing the network participants for eliminating double testing activities.

The first and very important activity to reach this goal was to harmonize the testing systems between the network partners to obtain comparable results. All testing systems in the network had to be reviewed and standardised concerning testing environment and testing method. The second step was to create a common mindset in the whole network about quality of textiles. Extensive testing was performed to validate the new production and testing process. If the validation process is successful the suppliers in the network will be validated for direct delivery (see figure 4) and can change the delivery processes accordingly, including the integration of the suppliers in the development process, skipping unnecessary testing.

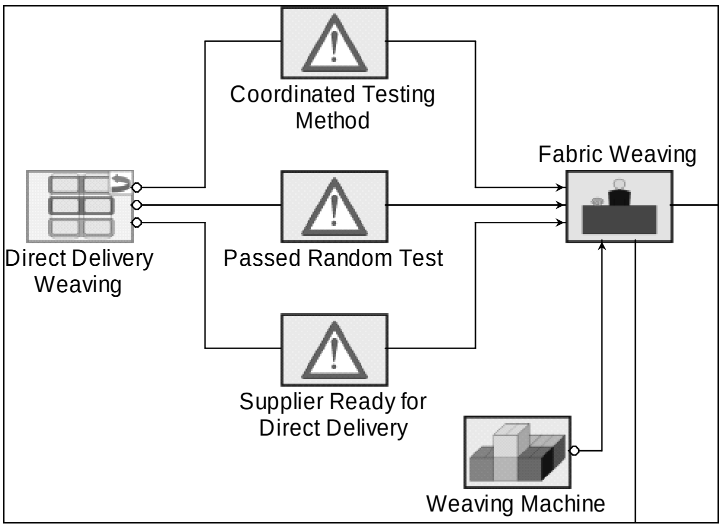

Fig. 4. Excerpt of the prerequisites for direct delivery (‘Organisational Layer’) in a weaving company

The organisational changes and training of all involved partners could be represented by the ‘Smart Network Modelling’ method. One core aspect, the harmonisation of the testing activities could be described only insufficiently due to the technical nature of this subject. The principal idea of this innovation could be transferred via ‘Smart Network Modelling’. Also the increased demand of knowledge and information for the ‘Quality Partnership’ is visible.

Finally a production network for a new product innovation, involving shape memory alloys, was modelled. The network consists of a bicycle helmet producer, a weaving company and a wire producer forming a cross-sectoral cooperation. This production network requires extensive use of knowledge due to the innovative material (Ni-Ti). In the European research project AVALON (http://www.avalon-eu.org) it was tried to identify the Total Cost of Ownership (TCO) of this production network based on ‘Smart Network Modelling’. In the TCO analysis the costs for establishing the production network or for ending the cooperation were not considered, i.e. the TCO were mainly reduced to the transaction costs. In a first step the production network was modelled. The used modelling objects were analysed and the corresponding TCO cost categories assigned to them. For each object the costs were calculated or, if not possible, estimated. Especially for the objects of the ‘Knowledge Layer’ it was difficult to determine the cost due to missing comprehensible information. Many information systems are not prepared to deliver this type of information.

The ‘Smart Network Modelling’ method was originally not designed to support TCO but worked well for identifying the most important cost drivers. Beside the TCO aspects the modelling was able to describe the cross-sectoral production network and also the extensive knowledge demand could be represented.

5 Summary

The experiences gathered by industrial, technical and scientific partners in the LEAPFROG project proved that the purpose of modelling could be reached by the ‚Smart Network Modelling’ method. It is a useful tool for analysing, designing and coordinating organisations considering the concept of the Smart Organisation. The ‚Organisational Layer’, ‚Knowledge Layer’ and ‚ICT Layer’ provide a comprehensive view, reducing the complexity of the overall systems to manageable parts thus allowing a better understanding of the system. The layer structure gives the organisation the flexibility and agility to become smart.

The support of ‚Smart Network Modelling’ by GME and the possibility to store the models in a machine-readable format (XML) is necessary for the ‘Smart Network Modelling’ method to be part of the approach ‘Model-Driven Application

Development' for the configuration of collaborative systems. It enables the automatic transformation of a Computational Independent Model via a Platform Independent Model to a Platform Specific Model.

At the moment the analysis, design and coordination of organizations is made manually. In the future, due to the machine-readable format, these tasks could be supported or performed by information systems evaluating the models and proposing design changes.

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4.4 A Knowledge Exchange Infrastructure to Support Extended Smart Garment Organizations

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Abstract In this paper the authors present the activities of the LEAPFROG project aiming to the definition of a knowledge-based exchange infrastructure, to improve ICT interoperability and then to enable the rise of a new paradigm for e-Business: the Extended Smart Garment Organization (xSGO) model. This effort exploited mainly the experience and results maturated in previous projects concerning the textile/clothing sector, but produce results that can be applied also in other production sectors. The key points of our work have been the integration of technological and organizational aspects building enterprise networks and the creation of open communities that exploit standardization mechanisms. The result has been the definition of the basic bricks for the Knowledge Exchange Infrastructure (KEI) and the development upon them of a set of tools that simplify the definition of e-business collaboration among enterprises.

Keywords: interoperability, xSGO, e-business, standard, ebXML, ontology

1 Introduction

In this paper we focus our attention on the aspects related to the implementation of an Extended Smart Garment Organization (xSGO), as defined in [1], that is considered as the organizational paradigm that should be built in parallel with the introduction of new productive methodologies and paradigms.

The xSGO is characterized along three dimensions: the organizational/procedural dimension, the knowledge/semantic dimension and the technological/ICT dimension.

Our focus, in this chapter, is on the ICT aspects related with organizational aspects of the manufacturer networks, especially clusters of enterprises, and, among them, clusters without a leader ‘prevalent’ enough to impose its internal organizational and technical solutions to its partners.

The crucial point is that adequate ICT infrastructures and the related organizational procedures must facilitate the flows of data and knowledge that have to be exchanged between different firms. This is becoming crucial also in order to assure the governance of the processes of outsourcing and delocalization.

Concerning the development of ICT solutions, we observe some relevant criticalities in the industry of the T/C sector, probably related to the large presence of small and medium enterprises (SMEs) that have to work together with large enterprises:

- difficulty to establish/understand collaboration processes and the related ICT tools (due also to absent or poor organizational and technical skills inside the manufacturers) that result in a high threshold for the firms to start business collaborations;
- the lack of a critical mass of participants limits the benefits perceived by the enterprises;
- long time to develop and test a solution before the release for real use;
- costly scaling due to the absence of a common understanding and background between different solution providers and organizations, even when implementing the same processes.

To tackle these problems in other industrial sectors, for example the automotive or chemical sector, there has been an effort in order to establish sectorial standards able to depict the procedural and technical aspects of the inter-company collaborations.

Several actors in the Textile and Clothing industry have proposed some standardization results [2],[3],[4],[5],[10] but they suffered by a poor adoption (the benefits are tangible only when a critical mass of adopters is in place) and by the fragmentation in small and separate communities with very specific needs and different technical solutions. Thus, what emerges is the correlation between technological and organizational problems.

While there is an effort to achieve interoperability through standardization [9], even with specific sectorial initiatives like the BIZ-TCF project [5], in parallel, on the side of the ICT research, there are researches in the Enterprise Interoperability field [6],[7] that attempt to improve the capacity of the systems to interoperate and to answer to these problems through semantic tools and services.

It is already known that ICT standardisation processes [11],[20],[21] do not meet the needs of the industry, especially of SMEs, at least in two key aspects: time to produce standard specification (the process to establish a standard takes too much time) and resources needed to participate in standardisation processes and to implement the outcomes (often very complex). Moreover, a third aspect is that the outcomes of standardisation processes are not flexible enough to support every specific process [22].

On the other hand the novel approach based on ontologies and semantic technologies requires skills that are not easily available for the industry and lacks of a common background and guidance so that real interoperability between owners of different solutions appears poorly scalable.

This paper presents a way to pursue the following two objectives:

- Reduction of misalignment between systems and organisations through a simple and automatically supported way to model the collaboration processes and the related ICT support.
- Fast setup of collaborative procedures and definition of customised data models starting from existing standardised background through semantic tools.

The outcome of this work has been defined as a Knowledge Exchange Infrastructure (KEI) and has been described in [13],[14]. Its purpose is to support the creation of "open communities" of collaborating firms without being constrained to a proprietary solution.

The first part of the chapter will address the technological framework and the related status of art; the second part is dedicated to a more detailed description of the tools and components of the framework.

2 State of Art

In the analysis of the state of art of models and solutions, we identified, first of all, the fundamental aspects to consider building a complete and successful interoperability framework [15],[16],[17],[18]. This analysis allowed us to clarify the complex scenario related to the world of interoperability solutions: on one hand, we identified the abstract components that have to be part of the solution; on the other hand we investigated existing solutions, the actors that provide them and their role.

Concerning the first point (the abstract components implementation) we can observe that (according to many definitions of the term "interoperability") a solution must provide three different interoperability layers:

1. the definition of a syntax for information and data exchange in a business collaboration,
2. the definition of a common shared semantics related to the syntax,
3. the definition of business processes.

1. In order to define a proper **syntax** for information exchange, XML is the most popular standard in the definition of data formats for communication interchange between heterogeneous systems. XML syntax definition has been often bounded with the definition of standards (like eCO, cXML, UBL, and many oth-

ers) that play a relevant role in the definition of a really usable and accepted interoperability framework.

There is a huge number of standards and standardisation initiatives. [19] provides just an idea of this wide and dynamic world. In any case standards are relevant for interoperability, but also difficult to manage [20],[21] and often hard to match with specific needs of the enterprises [22]. Our work has considered fundamental to operate in synergy with proper standardisation initiatives, in order to bring out the framework definition and to define tools to exploit standard definition.

2. Syntax definition is not enough, however. Together with the syntax, a shared **semantic view** of the data must be defined. This means basically the definition in an ontology of a set of concepts/relationships that are associated with data formats in order to clarify the meaning and the use of the formats. Semantic modelling is strictly related with the vision of the Semantic Web, but can also prove useful in ecommerce scenarios [23]. Because of the different data formats, document structures and vocabularies of business terms adopted by each enterprises, the Semantic Web technologies are exploited to make two enterprises interoperable to each other adopting mapping mechanisms (via internal or outsourced services) to compose semantic differences. [24] presents a list of the main activities in this field. What is important to highlight is that, considering the development of the Semantic Web technology, an interoperable framework can improve its exploitation providing a way to ease both its “comprehensibility” and the mapping towards different systems. In this scenario, OWL represents the W3C recommendation for ontology definition.

3. Finally, the specification of an interoperability framework requires the definition of shared **business processes** upon which to exchange business documents. In [15],[16],[17],[18] there is a comparison about the most relevant ones. What emerges is that the ebXML framework represents the most complete one. The ebXML approach for the definition of agreement between partners is considerably different from other initiatives since ebXML defines a clear process and modelling infrastructure for the definition of collaborative scenarios. This means that not only ebXML allows (as others platforms) to define standard business transactions that can be used as a reference by the actors of the sector, but allows also the enterprises to personalize and publish their own profiles in order to customise electronic exchange mechanisms (with all their characteristics) for their needs. In fact often, an “external” definition of classic business scenario does match neither with the requirements nor with the skills of the real partners that have to adopt them.

The previous analysis and considerations have strongly impacted on the definition of the framework developed in the Leapfrog-IP project (see figure 1) and resulted in the identification of the basic components that constitutes the proposed solution. These components will be explained in the next sections.

3 The approach: the Knowledge Exchange Infrastructure (KEI)

The Extended Smart Garment Organisation (xSGO) is a complex collaborative model for enabling textile and garment industries to cooperate together in a common business scenario [1].

This model intrinsically requires the involved industries to exchange knowledge or information among each other in a fast and shared way, that should be based upon common standards: in other words, following the definition of the term "interoperability" these industries should be able to "interoperate" together.

But the interoperability capability of a network of industries does not guarantee the creation of an xSGO: in fact it covers only one of the three dimensions that characterize the xSGO, the technological/ICT dimension and does not apply to the others. In other words, the interoperability between cooperating industries is a requirement and is not strictly sufficient for the creation of an xSGO.

The first step to allow networked industries to become xSGOs is to facilitate the processes enabling industrial interoperability: a set of tools easy to use, flexible and able to include the future ICT developments and requirements from industries.

The analysis of the status of art, based on the interoperability requirement for an xSGO, suggests that:

- each identified aspect (syntax, semantic view and business process definition) can be approached separately finding an "ad hoc" solution for a specific situation that does not involve the others two ;
- separated approaches created, in the past, a large number of different standards, mainly based on XML dialects, for each different aspects (different languages for document syntax, different ontologies or non compatible languages for business process description like BPEL and ebBP);
- a practical solution of the problem requires an integrated approach to the different aspects, a selection of specific languages and the creation of a common infrastructure that exploits the potential of each tool or language.

The way is to create an integrated framework, called Knowledge Exchange Infrastructure (KEI), able to support ICT and industry experts in implementing interoperability between partners, based on existing standards (when possible) and open to industrial requirements.

We started the KEI design with the identification of the active subjects in the actual e-business scenarios: from one side we have standardisation or 'community level' initiatives, public bodies and research centres, on the other side manufacturers and solution providers. The design of the KEI (Fig. 1. Integration of semantics and syntax in the architecture) gives an overall vision of the KEI) consists in a set of different layers, each of them providing different actors with different functionalities, that are used to create and to develop integrated and more complex tools.

The first two layers, **"Core Concepts"** and **"Tools & Specification"** are mainly constituted by the results of the work made by a generic public or community level entity, like the Leapfrog Community, and concern the *Specification Phase* of the collaboration (for example the modelling of the collaboration or the creation of a common dictionary).
The other layers relate to the *Operational and Network Setup Phase* where industries and solution providers build up the business network and dynamically set up business collaborations by exchanging documents and using other features and services supported by the framework (i.e. automated mapping of different data formats or searching business partners, etc.).

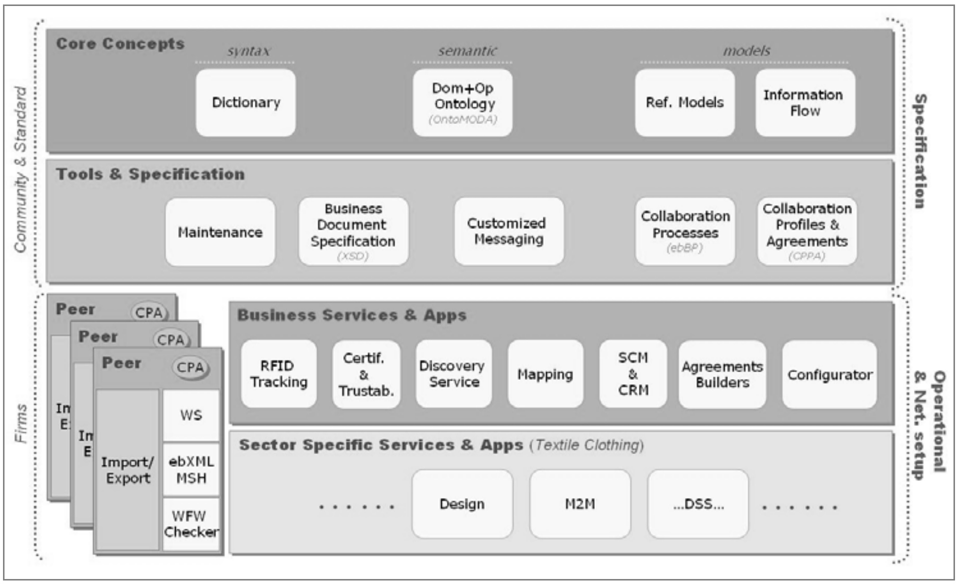

Fig. 1. Integration of semantics and syntax in the architecture

Finally we defined the **"Peer"** level as an important support level for the Business Services and Sector Specific Services layer defining, from the ICT point of view, the way to exchange information between networked industries.

The strong involvement of the firms is needed for requirements collection, optimised set up of the framework, but also for the spread and deployment of the results.

The **Core Concepts** layer includes all the basic components that play a central role in each framework activity and is defined in concert with the target users: it contains the "common reference" elements like the Dictionary or the Ontology and represents a shared Knowledge base that underlies each human community.

The **Tools & Specification** layer, on top of the Core Components layer, supports the community in the framework specification or maintenance phase. For example the Business Document Specification component exploits the terms stored in the Dictionary to define templates for Business Documents used in transactions, while the Maintenance tool allows the creation of new entries in the Dictionary. The idea of this layer is to simplify drastically both the creation of new Specifications (for example a new Document model required in a specific business transaction between two industries) and the maintenance process that typically requires a lot of human effort.

The **Business Services and Applications** layer represents a level of base services and applications directly or indirectly used by firms for real business activities. Some of these components (i.e. the Configurator) are used only one time by the firms for setting up the business network, while some others (i.e. RFID Tracking) are used daily in the operational phase. Most of these components are supposed to be provided by software houses or by big industries. These tools are sector independent; in other world, they implement generic functionalities not tailored for a specific business sector but useful in different areas. In some cases these components can be specialized or adapted for different sector requirements maintaining also a “general purpose” design.

The last layer in order of specialization is the **Sector Specific Services & Applications** that includes those components that provide specific services for the Textile/Clothing sector. All these components should easily interoperate with each other taking advantage from the three previous levels. As for the Business Service and Applications components, these are supposed to be provided by software houses or by the firms, exploiting common standards and specifications.

In the overall KEI framework diagram we included also a **Peer** component. It represents the architecture and the ICT infrastructure needed by an enterprise for setting up the effective communication with another partner without passing by a central node. As in a classic P2P scenario, the application plays both the client and server roles to send and receive business messages.

During the Leapfrog project we focused our attention on the first two layers that represent the basis of the whole framework. In the next section a more detailed discussion of the realized components is provided.

4 The components of the framework

The development phase performed during the project resulted in to a set of software components that represent the practical translation of the abstract model detailed in section 3.

Within the project, the syntactical definition has exploited the experience maturated in other activities. More specifically, the data formats for business messages is based upon a dictionary defined in the Moda-ML project [8],[12], that comprises a wide set of documents and specifications tailored for the Textile/Clothing sector. This dictionary has been used in the TexWeave [3] initiative and the successive eBIZ-TCF initiative that represent two efforts to produce a practical, formal and standardised set of data structures for the sector. Moreover, adopting the Moda-ML/TexWeave vocabulary we have also reused and exploited all the tools available for its further development and maintenance [4], and not only the syntax. All these aspects represent a guarantee about the trustworthiness in the adoption of the document defined upon the Moda-ML/TexWeave vocabulary.

On the other hand, the problem of a clear definition of the semantic model, arises when we imagine a dynamic environment (like that of Leapfrog IP) where we are continuously requested to manage new types of data flows or to improve the existing data models with other taken from new domains in respect of that modelled in TexWeave. To facilitate comprehension and improvement of the data models we developed a set of OWL ontologies that describe the concepts and the relationships that characterize the wide set of terms contained in the vocabulary. In this way we can describe the semantic model of the data format.

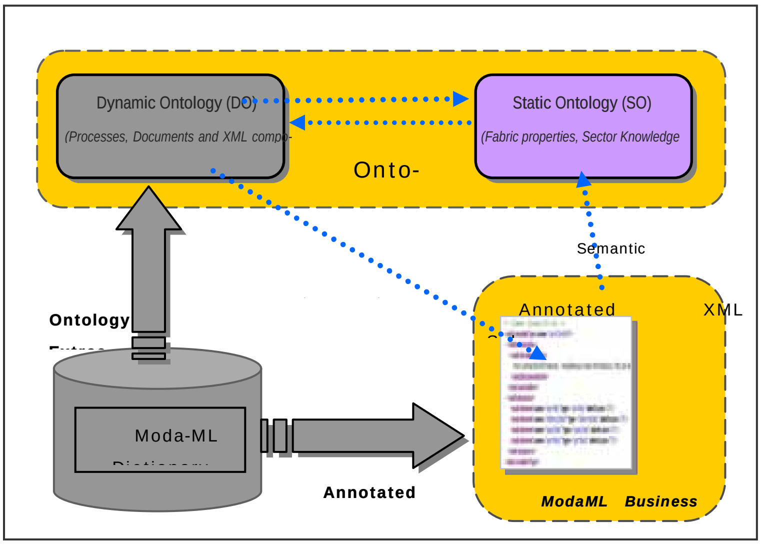

Fig. 2. Integration of semantics and syntax in the architecture

Moreover, the interconnection between the set of the TexWeave terms and their ontology description required the definition of a proper architecture to maintain all types of information linked together, as for example in the case of maintaining the alignment between the ontologies and the successive versions developed by Moda-ML. The definition of such architecture has also considered the different characteristics of the different part of the information collected

As depicted in fig. 2, the semantic description of the information is defined thanks to:

- Moda-ML Dictionary: this is a dictionary of business terms upon which it was based the TexWeave standardisation specifications.
- The OntoMODA, that is mainly composed of two sub-ontologies: *Dynamic Ontology (DO), Static Ontology (SO).*
- Annotated XML Schemas and Type Libraries: this is a library of XS types and a set of XS documents annotated with the concepts defined in OntoMODA.

The Moda-ML Dictionary is the basic component upon which we base the whole syntactic and semantic description.

We decided to divide the OntoMODA ontology in two different sub-ontologies in order to respond to two different requirements: on one hand the fact that basic knowledge related to the sector knowledge does not change substantially over the time: concepts like "*fabric* ", "*machine*", and "*yarn*" remain always the same. This kind of concepts are those that constitute the "static ontology"; the static ontology is built by domain experts manually. To improve usability and maintenance, the static ontology is modular and therefore composed of several sub-ontologies, each of which addresses different modelling and meta-modelling aspects (i.e. the real sector knowledge, the ISO11179 standard, the XML Schema meta-modelling).

On the other hand, the information and the definition of the practical data formats are much more subject to change over the time (for example o comply with new standardised releases). Then, the semantic description of this information should change over time following the modification of data formats. This semantic description is maintained in the "*dynamic ontology*": it models the XML components (types, elements and attributes) used as interchange data format in e-business transactions. This "dynamic ontology" is generated in automatic manner from the set of terms contained in the ModaML Dictionary using automatic application and is split in three sub-ontologies concerning Business Documents (like Order, Invoice, etc…), Business Processes (i.e. Fabric production, Supplying etc.) and the XML Schema Components defined in the real XML Schema files.

The Static and Dynamic Ontologies are bi-directionally interconnected: in this way each abstract concept modelled in the Static Ontology is connected with the ontological description of the representation mechanisms adopted to exchange the information (i.e., the XSD components - element or type - used for its representation), and vice versa. These connections are modelled using OWL properties.

We implemented also connections between the Moda-ML documents (the XSD templates built upon the Moda-ML dictionary) and OntoMODA. In this way it is possible to provide for each document a semantic description of the meaning of each element or type. This interconnection is implemented adopting the W3C recommendation for semantic annotation that allows adding the semantic information to XML Schema documents.

OntoMODA represents a great knowledge source that could be used for documentation purposes. Thanks to the textual description of many concepts it can offer interesting information useful for people who need to know product definitions, industrial treatments, processes and fabric properties.

In order to search and read information through the OWL ontology we developed a web application named Ontology Explorer. The tool lets the user surf the entire OntoMODA, starting from the taxonomy and picking up from it the desired concepts to see more detailed information through appropriate panels.

There are many tools to edit and browse ontology. Protégé is one of the most used, but there are many others. On the other hand, our aim is to simplify the operation of ontology browsing.

The Ontology Explorer allows the user to navigate ontologies, in a simple way (it is not strictly related to the OntoMODA ontology and it can show all the online ontologies written in OWL language) and to find concepts and information. Actually all the tools that manage ontologies are really hard to use and to understand: sectorial experts could not be so skilled in computer science or in ontology development to use these tools. Then, a relevant problem in developing an ontology for a classical industrial sector, like the Textile/Clothing, is to create tools to use it easily: the Ontology Explorer is a configurable web tool that is mainly oriented to the Domain Expert rather then to the Ontology Expert or developer. It provides more and better functionalities than other tools dedicated to the same purpose. To enable these functionalities, the Ontology Explorer is designed to be intuitive to use (also for the inexpert user) and many visualization and navigation configuration alternatives are available to the user. It also implements dynamic components that respond to user input, thus enhancing interactivity.

In order to support the whole process of business agreement establishment, we also developed a set of applications that allow the enterprises to produce standardised documents representing business profiles (Collaboration Profile Protocol, CPP) and agreements (Collaboration Profile Agreement, CPA) following the ebXML specification (already known as ISO TS 15000). In fact, once data format are defined and clearly described using both the TexWeave dictionary components and the OntoMODA ontology, these formats must be contextualised in a digital data exchange scenario.

The CP-NET (Collaboration Protocol – Networking Enterprises Technology) application set enables enterprises, that want to cooperate through a collaborative ebXML-based framework, to define and perform business collaborations.

ebXML business collaborations are based on profiles and agreements, and these concepts are defined and regulated by the ebXML Collaboration Protocol Profile and Agreement (ebCPPA) specification [25],[26].

To manage profiles and agreement following the ebXML specification CP-NET provides two web applications: the CPP Editor and the CPA Match Maker.

With the CPP Editor an enterprise can create and modify its own CPPs (Collaboration Protocol Profile), required to set up the collaboration with other industrial partners. The application reduces the risk of errors while performing this operation, and is based on a simple interface with the aid of an online help. In fact actually the CPPs are created manually, directly writing the XML, because no tool exists that provides a human friendly interface to create CPPs. With the CPP editor we want to cover this gap, allowing a non XML expert to write a correct CPP.

Once the CPPs are available, currently the two CPPs are compared by hand, to identify both the possible problems and the agreements: the problems are solved in a direct contact by human personnel, using the phone or the fax. At the end of the process nowadays one of the partners must write down all the defined agreements in a XML structured document that follows the ebXML specification. This document is the final CPA.

This process takes a lot of time, because the agreement process is, normally, not in real time: when a possible conflict arises during the CPP comparison, the CPA writer must contact the other party and negotiate about the modifications.

The CPA MatchMaker aims to simplify this agreement definition process: with the CPA MatchMaker it is possible to build the Collaboration Protocol Agreements (CPA) for a couple of enterprises, from two CPP Profiles,. The CPA MatchMaker reduces the whole agreement process and the comparison time highlighting directly the conflicts between the two CPPs. At the end of the agreement process it writes down directly the CPA in the XML format.

5 Conclusion

The work presented in this paper tackles the problems that arise when different and independent organizations attempt to collaborate in order to setup an xSGO. In particular, our analysis highlighted the difficulties to integrate existing ICT solutions, e-business standards and organizational aspects in enterprise network collaboration, especially in a sector with a prevalent presence of SMEs. This integration can prove to be a key point for the improvement of e-business collaboration.

Towards this purpose we propose the Knowledge Exchange Infrastructure (KEI), that has been designed as a conceptual framework that models, in different abstract layers, the components needed to build up an xSGO.

Some layers provide the basic functionalities of the framework itself. For these layers some tools have been developed to define/manage a shared syntax for data interchange, to build and maintain the common semantics for all the participants, to link these to the existing international e-business standardization initiatives; some others aim to facilitate the companies in modelling their business processes in a way that is able to interact with existing company information systems; some other layers, finally, are just thought to contain the operative services that can be provided to each firm or group of firm for their daily work.

These layers are considered to address the needs of the different roles and expertise (for example interoperability experts and domain specific solution experts rather than consultants or EDP personnel) that are involved to setup a collaboration between different organizations.

The abstract framework and its set of prototypical tools is a first attempt that needs further improvement and a more systematic approach to the aspects related to the different types of knowledge that are exchanged between companies.

The abstract framework and its set of tools represent an attempt to ease and improve the set-up of xSGOs between enterprises. It exploits not only the definition of common data formats and business models, but also defines a shared semantic layer that can lie behind and support a faster integration between heterogeneous systems.

In fact nowadays there is a clear trend towards more 'knowledge intensive' exchanges between firms implementing innovative models of collaborations. The governance of such models and the knowledge management in terms, for example, of protection of the distinctive know how will require an in depth analysis for their effects on the ICT infrastructure and inter-organization interface.

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4.5 Supply Chain Event Management integrated Product Tracking and Tracing

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Abstract The tracing of product data along the value chain of a company's network is a more and more important task because of an increasing complex organized manufacturing structure. The particular difficulty arises from the fact that the structure of the product data is potentially unknown, so it has to be adequate configurable and flexible. In addition, traced product data has to be compared with predefined set points to respond deviations. This article presents the within Leapfrog developed Product Tracking System

1 Introduction

The tracing of product data along the value chain of a company's network is a more and more important task because of an increasing complex organized manufacturing structure. The particular difficulty arises from the fact that the structure of the product data is potentially unknown, so it has to be adequate configurable and flexible. Within LEAPFROG a new product data tracking solution was developed. This solution is based on TXT e-solutions' SRM[2] collaborative platform TXTChain and is in particular designed with respect to the situation and the requirements of the Textile and Clothing Industry.

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[2]Supplier Relationship Management (SRM): A comprehensive approach to manage the company interactions with the organizations who supply goods and services for the company.

2 Supply Chain Event Management and Supply Chain Management

The concept of Supply Chain Management (SCM) describes the cross-company coordination of material and information flows along the entire value chain. This includes all processes starting at raw material purchasing, all producing stages of the value chain and finally the delivery of finished products to the customer. Just the coordination and optimization of this business processes in today's competition has an enormous relevance and is often a key factor for the success of a company. According to Werner [3] the main objective of SCM is “to do the right things at the right time”. By optimizing the effectiveness and efficiency of all business activities as well as the harmonization of various factors, such as costs, time, quality and flexibility, there will be lower costs, shorter lead times and a better product quality and service [3]. Fig shows a typical value chain of a clothing manufacturer.

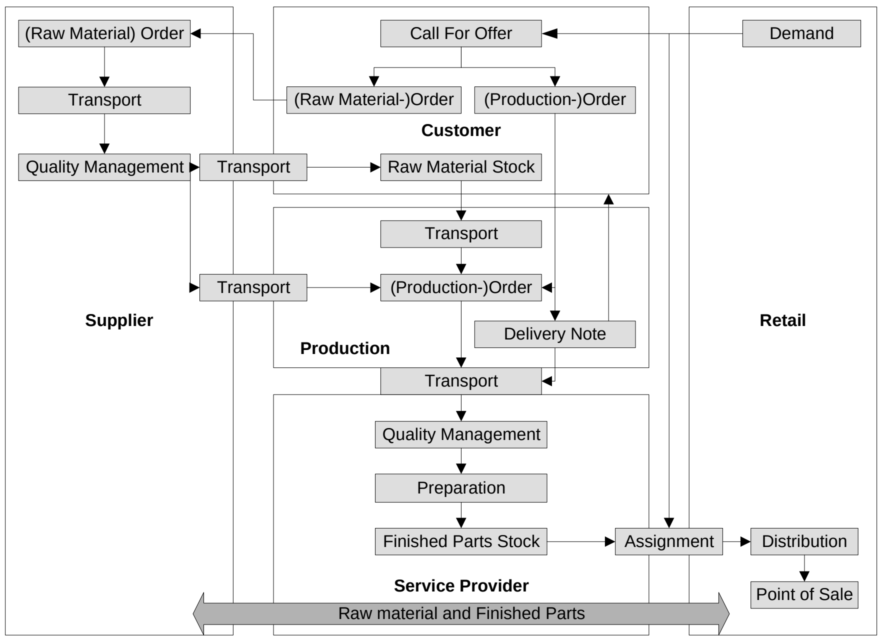

Fig. 1. Typical value chain of a clothing manufacturer

To provide the required information for such decisions dedicated application software systems are needed. The task of such software systems is to collect, process and provide all information about the processes in the value chain of a company.

An important concept of such systems is the Supply Chain Event Management (SCEM) which supervises all business processes, highlight critical issues or processes and inform defined users to react timely. This allows to switch the daily business to a “Management by Exception” business. So users are focused to those business processes which are running out of order. The parts of normal working processes are handled as automated as possible. In fact, 80% of the business transactions work normally. The remaining 20% should be detected by SCEM systems.

In addition to the concept of SCM systems there are also existing so-called SRM systems. SRM means Supplier Relationship Management and describes a comprehensive approach to manage the company interactions with the organizations who supply goods and services for the company. SCM refers to the strategic planning and operational coordination of all value chain activities and is primary focused to material and information flow. In this context SRM refers to the management of the relationships between all cooperating partners in a value chain of a company. SRM is therefore a part of SCM. Below a summary of most important features of SCM and SRM systems is given.

- Sourcing & Order Management

– *Call For Offer* supports buyers and suppliers when negotiating supply relationships (price, delivery dates, terms of delivery, etc.);
– *Order Management* automates the management and approval of production and purchase orders. It supports order generation, as well as order confirmation, updating and tracking.

- Catalogue & Document Management

– *Catalogue Data Management* allows suppliers to publish easily their catalogues in a shared electronic environment. The system acts as a translator between suppliers' and customers' master data. Customers can see product codes in the way that is most familiar to them;
– *Electronic Delivery Notes and Shipment Orders* are generated and transmitted by the system. Functions are available for order confirmation and tracking, as well as for the supervision of transportation.

- Operations Control & Performance Measurement

– *Production Progress Monitoring* enables the monitoring of subcontracted work. Reports about production progress can be shared easily and viewed with the desired level of detail;
– *Event Management* helps users to intercept irregularities and critical situations before they may cause inefficiencies. The system automatically sends a notification when determined thresholds are crossed;
– *Key Performance Indicators Management (KPI)* allows to attribute performance indicators to the activity of suppliers, subcontractors and logistic service providers and therefore to determine their reliability over time.

Workflow management associates flexible workflows to all the managed processes. Users are guided easily through a sequence of activities.

3 The Collaborative Platform TXTChain

TXTChain was selected as backbone system for the new Product Tracking System (PTS) by the LEAPFROG partners as it provides a variety of features for Supply Chain Execution and Supply Chain Event Management. It is well applied in textile and clothing industry and many other sectors, and was designed and developed within the European research project VISIT (EP29817) between 1999 and 2001

The web-based platform enables a consistent and coherent order processing and collaboration within complex supply networks. It can be connected directly to the companies' ERP[3] systems or accessed through a web front-end, allowing for seamless transactions between the participants across the supply chain. One important part of SCM is SCEM.

The system was developed to improve communication between companies involved in international business processes. Today, it encompasses a number of industry-specific processes and provides functions tailored on user needs. The most heterogeneous user groups are supported, from the management down to operational staff. In today's globalized world, users are located in more than 35 countries.

[3] Enterprise Resource Planning (ERP): Application software to support the resource planning in companies.

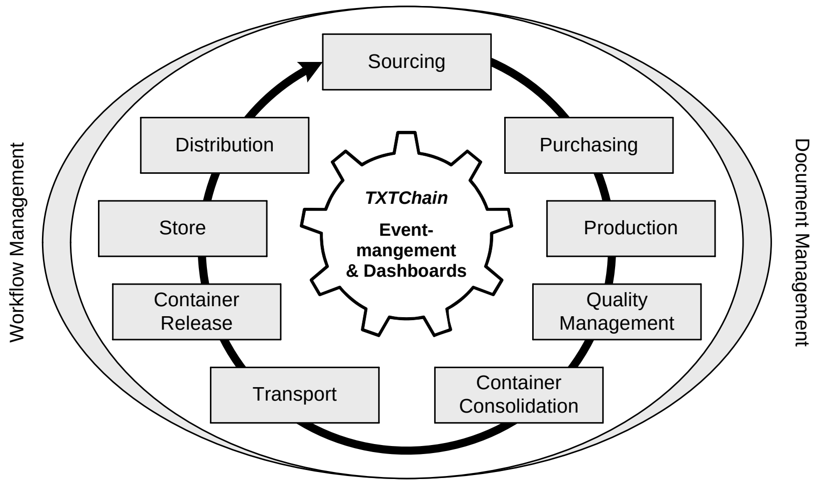

Fig. 2. Flow within TXTChai**n**

TXTChain starts where ERP systems ends. Instead of building expensive 1:1 relationships and interfaces between each single system or company, the solution manages the networking of business partners. It is user-friendly and requires only minimal training, enables companies to negotiate volumes and deadlines as well as contractual aspects of a supply with suppliers and subcontractors.

On the other hand, this SCEM system provides subcontractors, suppliers and logistic service providers with a complete overview of the orders that concern them. They can supervise progresses by flexibly setting updates on the status of an orders, issue notifications and exchange messages and documents. Figure 2 shows important functions, which can realize the following benefits:

- Improved transparency in the value chain;
- Reduction of communication and response time;
- Event Manager provides immediate and accurate information on problems and allows an early error detection;
- Reduction of delivery costs while using electronic packing lists and automatic generation of transport orders;
- Improved process efficiency and flexibility because of direct electronic information exchange with business partners;
- Improving the service delivery level (Delivery time, delivery reliability, delivery quality, delivery flexibility);
- Reduction of reserve capacity in production and logistics;
- Elimination of the bullwhip effect.

For more information about TXTChain please look for TXTPerform at http://www.txtgroup.com.

4 Requirements for the Product Tracking System

The new Product Tracking System has to be an inter-company system. The main task of the system is the collection and retrieval of data of different actors in the value chain, and the production process of an order or a single good shall be seamlessly replicable. The tracking data have a potentially unknown structure and must be available to all participants based on their user rights. The data collection takes place in three different ways:

- ICT[4] systems (ERP, MES[5]);
- Manual interaction;
- Process integrated.

The fact that the structure of tracking data is potential unknown arises from various operational requirements of each customer. Furthermore, several ICT systems from participants provide different information of the value chain. It is not possible to see which data should be traced in the future. Because of all these facts it is important that all parts of the PTS are high configurable.

Data can be collected on different levels like order, unit or item level and differs from business case to business case. So the main problem is, to trace potentially unknown data and share it with different actors in the value chain. Data to trace are for example:

- Core logistic information (quantities and dates)
- Production progress data
- Quality control data
- Transportation data

Another important requirement to the system is the fact that the user of the system should be able to configure the data which he wants to trace by his own. Due to this fact the user interface for configuration has to be as simple as possible.

- Configurable data structures: Because of the fact that the structure of data to trace is potentially unknown it is necessary to use a flexible data store. The data structures, hereinafter referred to as templates, need to be full configurable and have to work with different data types. An easy-to-use user interface is required to manage the templates.
- Data collection and data retrieval: For data collection and retrieval a flexible user interface is required which is on the selected template. Furthermore, it has to have a variety of search and filter capabilities. Additionally, a flexible

[4] Information and Communication Technology (ICT): General term for technologies in the fields of information exchange and communication.

[5] Manufacturing Execution System (MES): Production management system operating near to processes. Unlike ERP systems with a direct connection to the automation.

system interface is required in order to exchange data with third party system.

- User rights: The system has to be an inter-company system which shares data between different business partners in the value chain. For this reason it is important that the product tracking system provides a variety of user rights in order to configure the access of the traced data. This means that not every business partner in the value chain can retrieve or collect any kind of data.
- Supply Chain Event Management integration: The Product Tracking System has to be part of the Event Management of TXTChain. During the template configuration created set points has to be evaluated at the data collection by the Event Manager.
- Workflow integration: The system uses flexible workflows to manage processes. So a user is easily guided through a sequence of activities. The Product Tracking System has to be integrated into this workflow management. So it has to be possible to create configurable activity reports or to manage a sequence of data collection.
- RFID integration: The Product Tracking System shall provide RFID integration. This means, that RFID tags should be scanned directly into PTS. In fact, there are three different work practices possible.

  1. RFID-based automatic data collection: It is possible to store data direct on an RFID tag; for example quality data of an article. So the user should import data directly by scanning an RFID tag.
  2. RFID-based manual data collection: The user should scan an RFID tag as item identification and collect data manually.
  3. RFID-based data retrieval: The user should scan an RFID tag and the system shows all traced data for the scanned item.

5 The PTS Data Model

Before creating a common data model for data storage with unknown structure it is necessary to understand the structure of those data. After analysing different data sheets [1] which has to be traced, the basic structure as shown in Figure 3 was designed.

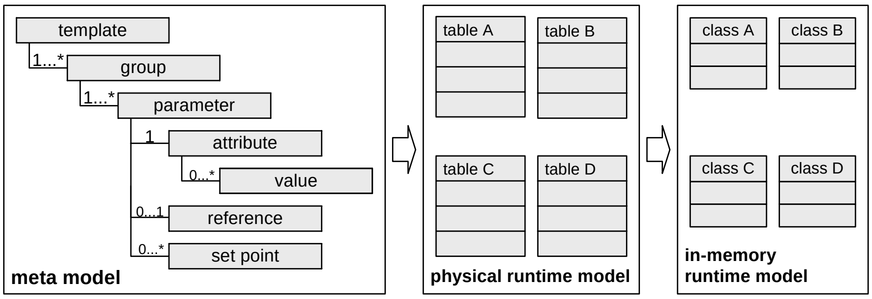

Fig. 3. Relation between meta model, physical runtime model and in-memory runtime model

Data belonging to the same pattern are called template. Templates define the data which has to be traced. A defined template is the base for data storage. Stored data based on a template called instance of a template. Each template consists of several groups which are used to group together belonging data in form of tabs. Each of these groups or tabs has several parameters which represent the values to be traced. One parameter consists of an attribute and possibly some set points or a reference. References are data which has not to be collected. It is resolved by a calculation or by accessing existing data. Individual configurable set points could be created for every parameter of a template.

Additionally, it is specified during the template definition to which entities of the master system an instance of a template should be assigned. Example entities are order, article, activity or delivery note. Also the user rights for instances of a template are defined this process.

Figure 4 shows the context between templates and instances. A template has several assigned entity-groups (order, article, delivery note), and an instance of this template has assigned the entities (order 123, article shirt, delivery note 331).

As shown in Figure 3 the Product Tracking System has a three-layer architecture. Based on the meta model, tables in the physical runtime model will be created. In fact for each group of a template a new table in the database is created. These tables contain instances of a template. The software system uses an in-memory runtime model to access the data. It has all necessary data to run the template or its instances. The benefit is that users only work with pre-selected data, which could also have another layout.

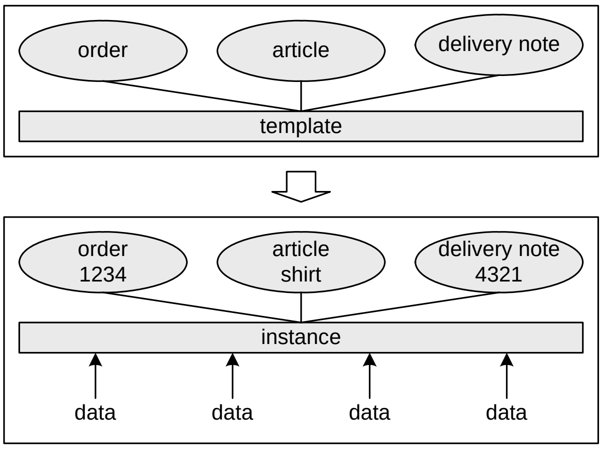

Fig. 4. Context of template and instance

The whole system uses a flexible data storage to memorize the templates and its instances. Within this data storage the well-used technique of data dictionaries[6] is used.

6 Integration of the Product Tracking System

The Product Tracking System was designed as new part of TXTChain, of which Figure 5 shows the architecture. The grey-marked components *Tracking & Tracing Configurator* and *Tracking & Tracing Engine* are the new components for the Product Tracking System. The *Tracking & Tracing Configurator* contains all functions to configure individual templates. The Tracking & Tracing Engine with its parts Data Collection Engine and Data Retrieval Engine contains all functionality to collect, retrieve and analyse data.

All these components are integrated into the existing Event Management of TXTChain. The Tracking & Tracing Configurator is able to configure set points for template parameters and can configure the behaviour at deviations from set points.

[6] Data dictionary: A "centralized repository of information about data such as meaning, relationships to other data, origin, usage, and format." (IBM Dictionary of Computing)

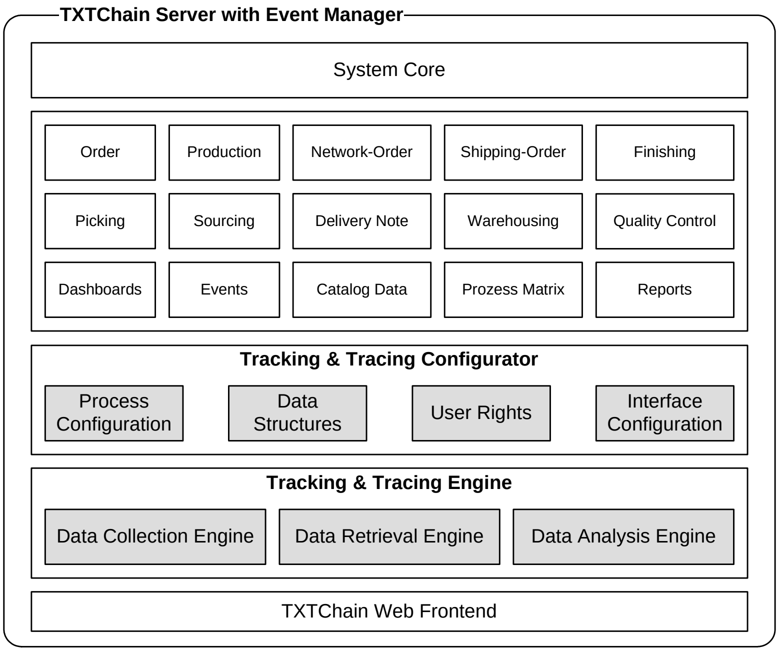

Fig. 5. Architecture of TXTChain including the Product Tracking System

Tracking and Tracing Configurator

Templates of the Product Tracking System are completely configurable. The Tracking & Tracing Configurator (see Figure 6) is a powerful tool to configure entire templates. The user can configure various groups (tabs) with a variety of parameters using different types, such as:

- Simple data types (strings, numerical data, timestamps);
- Documents (MS-Office, PDF-Files, XML-Files, images and so on);
- Lookup-tables[7];
- References to existing data and line by line calculations of values.

The user can also configure the access possibilities of the instances of a template for each business partner by a variety of predefined user rights. To observe deviations, it is also possible to configure set points and standard responses when a deviation occurs. This includes the definition of:

- Set points for a parameter (depending on data type of parameter to observe)
    - Single set points;
    - Set point ranges (min, max);

[7] Lookup-tables (LUT): In this case an amount of predefined values for example the values of a combo box or drop-down list.

- o Parameter value of an group as set point;

- Event receiver: Actor in the supply chain which shall be informed about the event
- Event message: Contains placeholders for the real value and maybe for the threshold value

Each parameter could have a variety of set points. So the user is able to configure events for some different deviations.

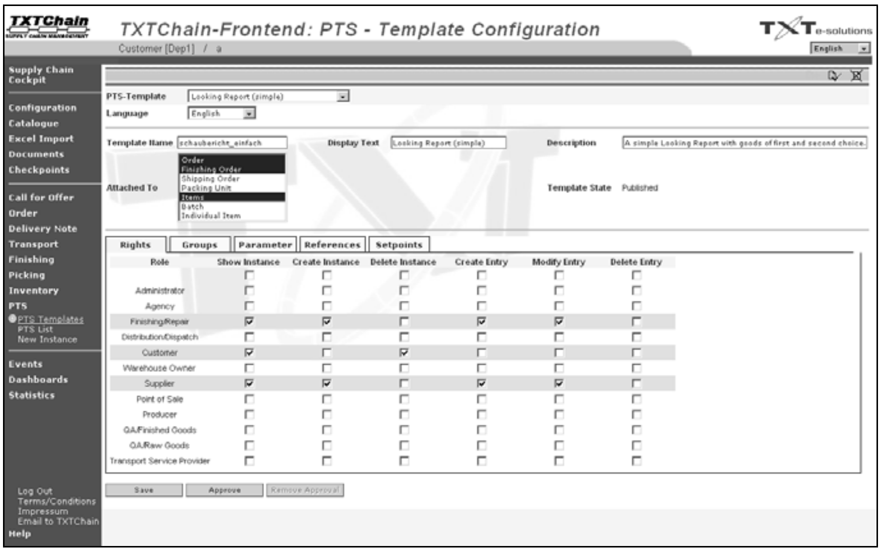

Fig. 6. Screenshot of the Tracking & Tracking Configurator

<u>Tracking & Tracing Engine</u>

The Data Retrieval Engine and Data Collection Engine have to show, create, modify and delete instances of templates in the system (see Figure 7). Therefore it exists an user interface which is self adapting in dependence to the configured template of an instance. There is also the opportunity to search for special instances by using a flexible filter. To interact with third party systems a XML system interface is available. This includes a system interface to ICT systems and a Web Service. Especially the Web Service allows an interaction of the PTS with an existing service oriented architecture, so that it can be used within a special business process.

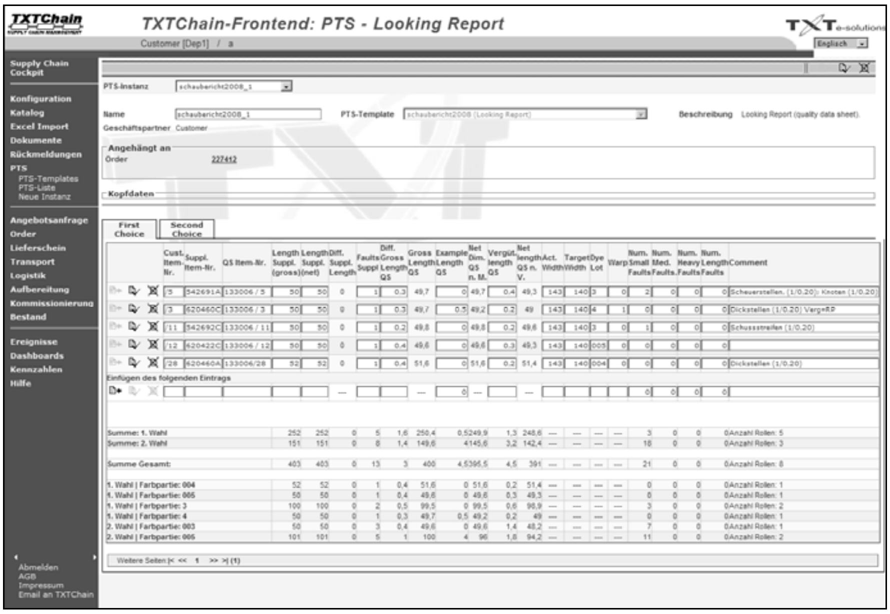

Fig. 7. Screenshot of the Tracking & Tracing Engine

Integration into the TXTChain Web front-end

The Product Tracking System is integrated with a variety of modules of TXTChain, for example order module or delivery note module. So it can be used to trace data. Furthermore is has been integrated with the workflow management component. So the user is able to configure activity reports in a workflow by its own.

RFID integration

The system provides the opportunity to scan an RFID tag, which is modelled as an entity. The Product Tracking System is able to map instances to an RFID tag, and the user can scan an RFID tag thus enabling to collect data or to show all traced data. For the future it is planned that import data can be written directly to the RFID tag.

7 Example Scenario

The following example scenario shows a typical use case for the Product Tracking System. Given that a customer has ordered some silk fabrics to produce a ladies' blouse. He orders some silk bales and delivers them to a producer who cuts and sews the fabric parts. Before the user can design the templates for tracing data, it is necessary to analyse the value chain to specify the data to be traced. Figure 8 shows an example use case and visualises the parts of the value chain

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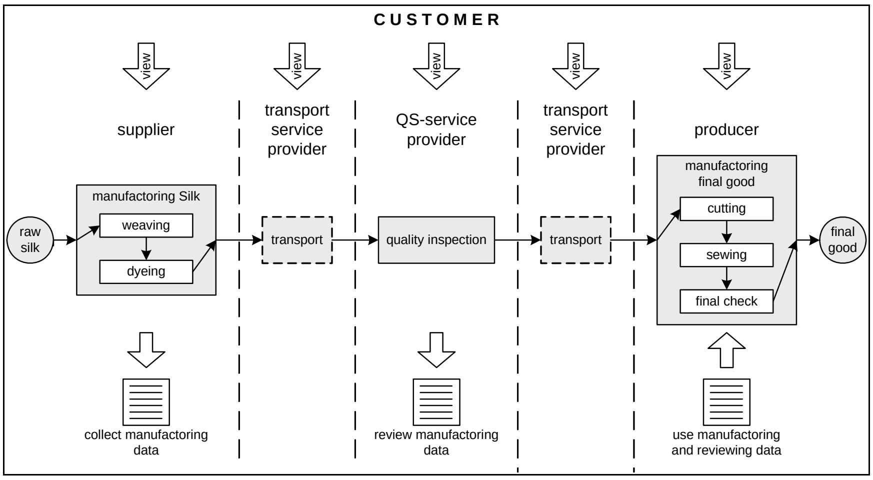

Fig. 8. Example workflow for tracing data with the PTS

With the Product Tracking System included into TXTChain the customer is able to define data templates for each stage of the value chain. The business partner has to fill in the needed data in its stage and the customer or other business partner can use this data for his purposes. So the customer is able to trace data though the whole value chain.

8 Outlook

During the Leapfrog project a prototype for the Product Tracking System was designed and developed as new module of TXTChain. Currently a part of the Product Tracing System is in use at a well-known fashion discounter. Furthermore there are some demonstration cases and industrial prototypes with different business partners of the LEAPFROG project, with the objective to get a feedback from the industry. Following some statements of test partner:

- Oui Group, Munich, Germany (one of the most successful companies in the international fashion industry with two main labels Set and Oui, www.oui.com): Because of the fact that data is electronically available we will be able to process the data faster and better.
- Zuleeg, Helmbrechts, Germany (a producer of high-quality woven fabrics, http://www.zuleeg.de): “The PTS is generally a good idea. Our customers can retrieve the data more quickly. The benefit for our company is that we

could offer our customers, who already use this system, a better service. Because of this, we expect a greater competitive advantage.”

This feedback is very important for the further development of the Product Tracking System in order to improve the concept and the system. Some of the suggestions of the test partners have been already incorporated into extension of the PTS.

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