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"AN INNOVATIVE FRAMEWORK BASED ON PLM, RFId AND XML TECHNOLOGIES FOR PROMOTING INNOVATION"

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ABSTRACT

In this paper we propose an innovative framework with the purpose of promoting innovation in three main directions (technological innovation, business model innovation, product innovation). The framework is defined trough the Product Lifecycle Management methodology, and we discussed the possibility of implementing innovative technologies as RFId (Radio Frequency Identification), considered like enabled technologies for PLM and representing an informative support on the product for both producers and customers, and XML (eXtensible Markup Language and derivation), considered like an essential component to obtain shared information on the product between producers and customers over the different phases of the product lifecycle. By considering holistic property the proposed system achieves not only a valid and innovative framework for product innovation support, but also a framework that allows costumer participation in the supply chain. The paper is supported by a case study of an Umbrian company which tested the framework proposed.

1. INTRODUCTION

In the present global economic scenario, following radical changes that shifted the competitive advantage's resources, the new essential source for creating value is the progress and the strategic use of methodologies, models and tools for the optimization of value creation. Such a scenario entailed the diffusion of models for management product optimization from "the cradle till the grave [1]". The most important factor in the life of enterprises is competitiveness. World Competitiveness Yearbook[1] gives this definition for competitiveness: "A field of economic knowledge, which analyses the facts and policies that shape the ability of a nation to create and

[1] *The IMD World Competitiveness Center has been created in 1989 by Prof. Stephane Garelli and has been publishing the IMD World Competitiveness Yearbook for 17 years. Countries manage their environment according to what we call the four fundamental forces: these four dimensions shape the country's competitiveness environment. We have integrated them into an overall theory which is systemic, describing the relationship among them; we aim to highlight a country's competitiveness profile, which characterizes an economy and anticipates how it may behave. Here these four dimensions: Attractiveness vs. Aggressiveness, Proximity vs. Globality, Assets vs. Processes, Individual Risk Taking vs. Social Cohesiveness. http://www.imd.ch/research/centers/wcc/about_wcc.cfm*

maintain an environment that sustains more value creation for its enterprises and more prosperity for its people".

A first consideration regards the fact that competition has become global and that in the less developed economies it is possible to lever the monetary exchange and the labour costs. This factor has given the developed countries SMEs (Small and Medium Enterprises) just one road to follow, that is the technical, product and process innovation way, and also organisational flexibility.

A second consideration regards the fact that the market of the developed countries is composed mainly by a knitted network of SMEs that has more difficulty in this new global scenario because of various problems such as the pruned investment capacity, the shrunk contractual power with the suppliers, the cultural opposition of the entrepreneurs to change. Related to the moderate capacity of investment is that undertaking an informational project (introduction of ERP, SCM, CRM, MRP tools) implies risks for the SMEs [2]. Connected to the cultural opposition of the entrepreneurs is the engineering process's issue (BPR, Business Process Reengineering) seen as "deep rethink and radical reshape of the enterprise processes, settled to accomplish great improvements for the critical parameters of performance such as costs, quality, service and utility" [3].

If we focus on large consumer goods industry (food, drinks, home products, cosmetics, toys, etc.) the following assessments can be made to give an example; recent researches reveal that a six month delay for a new product launch can reduce by a third the potential pay-off in the first five years of life, and just one out of 3000 becomes a commercial success that remains on the market on a long term [4]; the fundamental innovation is seen more and more as the only possibility of success for the new product, in spite of upgrades and simple extension of the existenting production lines that represent the norm and not the innovation, make up, on average, up till 70% of the activities; moreover, for protection of the consumers and environment, new norms and laws which oblige the enterprise to outline and control everything it " touches" each product is continuously introduced; new initiatives as Global Data Synchronization (GDS), held by the most potential

international chains of distribution, are seen by the large consumption products industry as additional costs without any additional value [5].

In this more and more complex scenario, no company can consider itself all-content; consequently, attention must be shifted from the cost control initiatives put in practice during the last years to initiatives which have as main purpose a pay-off increase. Having this goal in mind the article intends to define a system that allows the SMEs to realize technological, process and product innovation. As a matter of fact, the architecture of the system turns out to be the following: PLM+RFId+XLM. In the following paragraph the philosophy referred to the article, i.e. the Product Lifecycle Management (PLM), will be discussed. It regards an innovative model for the management of product lifecycle. The PLM is carried out by managing and, therefore, trying to optimize all the product lifecycle stages, seeking a major control on it in order to prevent a malfunctioning or danger for people and goods. Having more control on their own products allows the company to understand the informative flows which will allow it to investigate which direction to go with product improvement research [6,7, 8, 9, 10, 11].

In the third paragraph the issue of RFId technology will be addressed, i.e. the informative support for the product that will allow the PLM to be enabled. RFId stands for Radio Frequency Identification and it is an innovative technology that allows to automatically identify people, animals and things. This technology will play the role of informative support for the product during all the stages of its lifecycle in order to seize the informative flows [23, 24].

The fourth paragraph will deal with XML technology necessary to achieve interoperability among the different systems of the different actors who intervene during the various stages of the product lifecycle. XML stands for Extensible Markup language. XLM is a meta-mark-up language [12]. The XML will allow all the actors that intervene during the product lifecycle to gain the information that will be memorized on the product tag, promoting information sharing [32, 34].

In the fifth paragraph the meta-holistic approach that characterizes the system will be proposed. In the sixth paragraph a case study for the validation of the proposed meta-holistic system will be illustrated. In the seventh paragraph the achieved results will be discussed.

In this way the necessary information for the product's production chain optimization will be obtained. In addition, it will be possible to have the control of the product which will allow to obtain information from which the necessary knowledge may be attained to improve the product.

2. PLM – PRODUCT LIFECYCLE MANAGEMENT

2.1 PLM Concept: Origin & Evolution

PLM acronym was originally introduced in environment compatibility studies for industrial products – in the '70s – to suggest that a physical asset must be designed and realized for environment sustainability, by considering product life-cycle phase, including mainly disposal and recycling. Life-cycle can be thought as the different phase of product life: conception, design, production, distribution, sales, disposal and/or recycling. At the end of the '90s PLM-mean start to evolve on entire system product management and traceability, during the different life-phases, changing in this way the mean of the acronym [13].

2.2 PLM Definitions

Now we try to compare the different views of the most important vendors and researchers of PLM:

- Daratech [14], consistent with the origin of analyst of CAx Systems, intends PLM as an extension of PDM and the Digital Manufacturing, without any distinction;
- NIST (National Institute of Standards and Technology)[9], defines PLM as "a strategic business approach for the effective management and use of corporate intellectual capital";
- For AMR Research PLM stands for Product Lifecycle Management, which is a blanket term for a group of software applications used by engineering, purchasing, marketing, manufacturing, R&D, and others that work on NPD&I [15];

- QAD [16] defines PLM as the means to ensure performances product control, on attributes functional and physical. These include activities planning and coordination, an accurate and well detailed documentation to support the product life cycle and the information and data users. This definition is not focused on technology but is focused on planning, coordination and control functionality correlated to PLM;
- For ARC Advisor Group [17], a PLM Solution helps enterprises to obtain the right product, at the right moment, in the right place. So for ARC, PLM is not a product and is more than a strategy: a PLM Solution uses collaborative software for product and product lifecycle data creation; PLM enables and coordinates the interaction among whoever has the information and whoever needs to have them, both inside and outside of the enterprise. ARC defines PLM as the composition of 6 elements: products portfolio management and innovation management, projects management, collaborative planning, product data management (PDM), productive processes planning, support service management.
- For CimData PLM is a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination and use of product definition information across the extended enterprise from concept to the end of life – integrating people, processes, business systems, and information[18];
- For J. Stark PLM is the business activity of managing a company's products all the way across their lifecycle in the most effective way. PLM helps a company get its products to market faster, provide better support for their use, and manage end of life better [1];
- For D. Kiritsis, A. Bufardi and P. Xirouchakis, PLM is a flow from the Beginning of Life (Design/Production) phase to Middle/End of Life (Sale/ Use/ Disposal) phase of the product life cycle. To be more precise PLM is a means to transform information in knowledge and in doing so prove quality, efficiency, product sustainability and service [8];
- Garetti [13] defines PLM as an integrated business approach that, with information technology aid, creates an integrated, cooperative and collaborative information product

management throughout the life-cycle. For this reason it can argue that PLM include: a strategic orientation for value creation "on" and "across" the product; a collaborative approach application for core-competences exploitation of different actors; an important utilization of IT solutions to create an integrated, coordinated, safe information management for value creation. PLM is complex and full-comprehensive, a new integration phenomenon that actually runs in industrial context and that joins organizational dimensions (processes), economical dimensions (costs and proceeds), technical dimensions (IT systems);

- For M. Grieves PLM is an integrated, information-driven approach comprised of people, processes/practices, and technology to all aspects of a product's life, from its design through manufacture, deployment and maintenance – culminating in the product's removal from service and final disposal. By trading product information for wasted time, energy, and material across the entire organization and into the supply chain, PLM drives the next generation of lean thinking [19];
- For Ford company, Product Lifecycle Management is: (i) concerned with processes, methods, and tools used from a product's inception through the end of its service; (ii) the science of bringing these three disciplines together to create an environment that enables creation, update, access, and, ultimately, deletion of product data; (iii) extends across traditional boundaries, PD-Manufacturing, Inter-Intra Enterprise, North America-Europe, etc.; (iv) not CAD,CAE or any other disciplines that exists to author or analyze narrow subsets of product data [20].

2.3 PLM Justification:

In this paragraph we try to show which are the most important areas that PLM involves.

Figure 1. Requirements for manufactures [21]

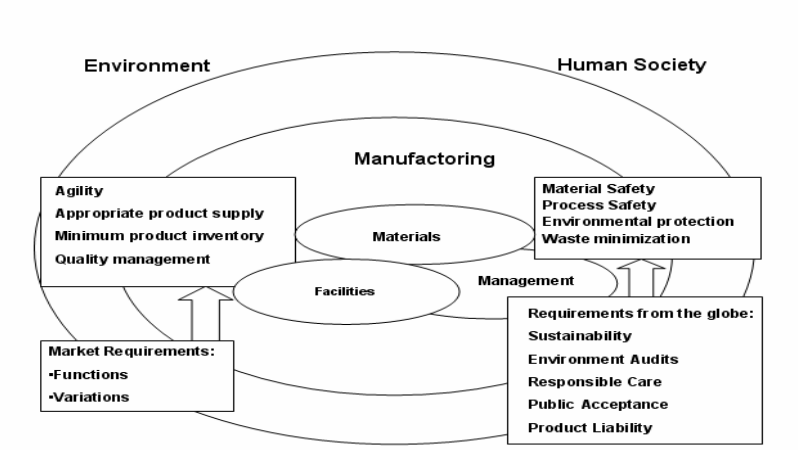

Figure 1 shows all the areas where requirements for a proper, efficient and effective company management in current economical context are necessary. In fact by the one hand, it shows environment sustainability requirements, on the other it turn to human society, and consequentially to markets that always impose to different organization that argue in global context, innovation products for satisfy customer needs and, by means of this innovation action, companies can target customer fidelity. From the company's point of view it must meet an efficient and effective supply chain management, and consequentially extended supply chain, i.e. all the actors that attend from concept/design phase to distribution/sales phase [22].

3. RFId – RADIO FREQUENCY IDENTIFICATION

3.1 Radiofrequency technology, origin and evolution

We consider as origin of RFId Technology the second half of the'40s. A scientist, Harry Stockman, published a paper concerning RFID strictly related to "Friend or Foe Trasponder Identification Systems" utilized by British Royal Air Force (RAF) during war world II. At the end of the '60s the first RFId application was developed, Electronic Article Surveillance (EAS), with antishoplifting functions. The '80s and '90s other RFId applications were developed. RFId Technology is peculiar because its use is often transparent for the user; in fact RFId are used in warehouses, or on toll highways, or in shops for antishoplifting; in all of these applications, users use RFId but they don't

know how it really works. In the beginning of the 21 th century RFId expansion is set back from consumer associations, for privacy right violation, and this is called "the mark of the beast[2]".

Why do RFId have this high profile? Firstly, it is important to note that RFId is a mature technology, i.e. it is ready to be applied in different contexts; moreover, the technology is becoming less expensive and more useful than in the past. Internet has changed, in some cases a radical way also, the ways of doing business and with the rise in use from enterprises, it is becoming an out and out communication platform.

Considering that this technology is becoming less expensive, more useful, and simpler to use, that hardware and software are becoming less expensive, that processors computational capacity is not a hurdle today (consequences of Moore's law), that store capacity is not a problem today and that databases are cheaper than in the past, that Internet enables data copying from computer to computer, from enterprise to enterprise, from place to place, it is easily understandable how RFId technology can still grow. In such a scenario, mention should be made to chipless RFId tags, although the issue is not addressed fully in this paper.

3.2 RFId Definition

Radio Frequency Identification allows the automatic identification of people and things with the use of radio waves. Through the development of technologies and instruments, allowing the realization of micro-systems of distributed memory able to answer wire-less interrogation, information flows management and information systems structures can be entirely changed. RFId technologies allow

[2] *In the context of RFID, the "Mark of the Beast" is a reference to RFID tags (contained in tiny glass capsules) being implanted into people. However, some people associate RFID with a passage in the New Testament's "Book of Revelation," that prophesied the Mark of the Beast, "[The Beast] causes all, both great and small, rich and poor, free and slave, to receive a mark on their right hand or on their foreheads."Various iterations of the Mark of the Beast theory are discussed on the Web. Snopes.com debunked the Mark of the Beast in connection with RFID as an urban legend, but the theory hangs on and maintains a following among the small segment of the population who believe RFID is harmful. The practice of implanting RFID tags into people is limited. As of 2006, VeriChip Corporation, the supplier of the only patented Food and Drug Administration (FDA)-approved human implantable chips, estimated that there are a few thousand people worldwide with implanted tags, the majority of which are used for medical purposes (e.g., to alert medical personnel to medical conditions a person has, in the event he or she isunable to communicate. http://www.av1611.org/666/biochip.html.*

to install, at low costs, on a product or bin, a tag (chip + memory) that can memorize all information necessary to identify the product, in addition to other information that can be modified during operative processes [23, 24, 25, 26]. This 'mobile memory' not only can it keep track of product history, but it can do so without maintenance or charges. This utilization facility and low costs allow to these new technologies to expand itself in industrial and commercial sectors. New features are added to basic functions: measurement of physical metrics, actuators command, etc. The increasing utilization of these new technologies lays the ground for an "Ubiquitous Society that will change a lot of existing paradigms" [27, 28, 29, 30, 31].

3.2.1 RFID System Architecture

Tag is the main component in the RFId system: it can be connected in different ways to the object. A static or mobile reader sends a signal by an electromagnetic field generated through an antenna. This signal allows the tag charge (if we consider a passive tag), in a brief time, about hundreds of microseconds.

The tag, after this interrogation operation, sends the reader a signal that contains its Id code and some useful information for the RFId application, stored in its memory. RFId systems are part of Auto-ID (automatic identification) technology that allows: automatic data identification capture, automatic data insertion in data repository.

RFId units –tag- are also called transponder. A trasponder is created by receiver and transmitter combination, that are designed to receive an appropriate radio signal and to automatically reply the reader. In the most simple implementation trasponder waits for a signal –beacon- and after sends a signal –beacon- to reply. More advanced systems can perform a cryptographic action on data exchanged by tag and reader to prevent intruders that can understanding information being exchanged.

Tags are divided in two categories: active and passive. Passive tags do not have a battery inside or any other alimentation sources; these tags must wait for a signal from the reader to obtain the

necessary power to respond. Tag contains a resonant circuit able to absorb power from the reader antenna. To obtain power from the reader we use near field[3] property. This implies that the distance between tag and reader must be calculated, i.e. there must be proximity. The near field effect supplies power for tag reply to reader. Active tags have a power supply inside, usually a battery. For this reason they do not use power emitted from reader, so they do not use the near field effect. For this reason, active tags are not affected by proximity issue; active tags action can cover longer distances than passive tags. At the end, there are tags called semipassive that have a battery for memory power supply, while the power needed to respond to the reader is supplied by near field effect [23,25].

Interrogator or reader is the second component of an RFId system. In fact they can be defined as "Reader of tags". Readers can have an integrated antenna, or antenna can be separated. Usually palm devices have a reader with integrated antenna while other devices, bigger than palm devices, have an antenna separated from reader. Other components that are part of the reader are a system interface like the RS-232 serial port[4] or Ethernet[5]; code and cryptographic circuits; battery or power source; control communication circuit.

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3 The Near Field is a phenomenon that occurs in a radio transmission, where the magnetic portion of the electromagnetic field is strong enough to induce an electrical field in a coil. As the name implies, the Near Field occurs in an area near to the antenna. Just how big the Near Field is, depends on the wavelength of the radio signal being used. r = ë/2ð where ë is the wavelength. For example, a common RFID frequency is 13.56 MHz and the wavelength of 13.56 MHz is approximately 22 meters. Therefore: 22/2ð= 22/6.28 = 3.5 meters. The Near Field for an RFID device operating at 13.56 MHz is 3.5 meters or 11.5 feet. Passive tags requiring the Near Field, have to be within that area in order to operate correctly. http://www.nfc-forum.org/aboutnfc/

4 The RS232 standard is one of the oldest physical communication standards in computer world. The standard defines low-cost serial communication in a robust way where bits are sent sequentially on a copper line. It was originally defined for connecting devices such as computers, terminals and printers to modems. This equipment is connected through their serial port. Nowadays, the computer to computer link with a so-called null modem cable is commonly used. The original serial port definition limited the maximum transfer speed to 20 kbps, but practice has shown that higher bandwidth is possible. To overcome these limitations, the RS232-E standard allows much higher communication speeds than its predecessor. These pages provide not only information on the standard itself, but also on how to use serial communication in practice, several connection possibilities to the serial port etc. This includes handshaking and how to choose the right null modem cable for computer to computer communication. http://www.lammertbies.nl/comm/info/RS-232.html

5 A local-area network (LAN) *architecture developed by* Xerox Corporation *in cooperation with* DEC *and* Intel *in 1976. Ethernet uses a* bus or star topology *and* supports data transfer rates *of 10* Mbps. *The Ethernet specification served as the basis for the* IEEE 802.3 standard*, which specifies the* physical *and lower* software *layers. Ethernet uses the* CSMA/CD *access method to handle simultaneous demands. It is one of the most widely implemented LAN standards. http://www.webopedia.com/TERM/E/Ethernet.html*

The reader receives information from RFId tags. The reader can register information and stand alone; or it can be part of a localized system like a Large Local Area Network (LAN), or a Wide Area Network (WAN). The reader can send data to LAN or to another system utilizing Ethernet or RS-232 as interface. Readers, and their antennas, can have different dimensions, from stamp dimensions, to table dimensions.

The middleware software manages readers and data originating from tags, addressing them to information systems on which RFId system reside. Middleware is in the middle of the data flow from reader and back-end, and the middleware manages this flow. Middleware perform information basic filtering, reader integration, and control. The development of RFId technology has entailed the development of the data, systems and readers management functions too. The back-end can be represented by a standard database like SQL, MySQL, Oracle, Postgres etc... Depending on application, the database can stay on a single PC in an office, or in different mainframes linked to each other through a global communication network [23,25].

3.2.2 Data Communication

Data, that can be stored in tag, depend on tag memory capacity, from a few bits to many MBytes, and on application too. These data can have a different format, depending on the reader data format rules. Actually some standard formats are emerging. One of these, is Electronic Product Code (EPC^{TM}). EPC is considered the same as a UPC utilized in bar code for RFId technology. Every bar code contains basic information related to the bar code system of which is part, the producers, the object and the check digit. Electronic Product Code utilized EPC General Identifier (GID-96) format. GID-96 has 96 data bits (12 bytes). Every EPC consists of four separated fields: 28 bits General Manager Number for enterprise identification; 24 bits Object Class for identification of product categories; 36 bits serial number for object identification. Finally 8 bits header for grant EPC uniqueness.

4. XML – EXTENSIBLE MARKUP LANGUAGE

4.1 Origin and evolution of XML

Extensible Markup Language (XML) is a meta-language that allows to create customized markup language; it begin from the need to have the Standard Generalized Markup Language (SGML) in World Wide Web, the international standard for structure and content description of every kind of document. It is characterized from the simplicity with which it is possible write documents, share them and transmit them on Web. The use of XML allows to overcome the dependency on HTML standard. This language is created to allow different users of the WWW to share information about different systems: the postulate was that that information was text with some images and hypertexts. Instead actually, information on World Wide Web are texts, images, sounds, videos, audios database. Hence HTML must supply solutions to problems that it did not solve, like to define complex relations of document links, or transmit information in different formats. To overcome these problems, it have been created different versions of HTML, often incompatible with each other.

XML was developed by an XML Working Group (originally known as the SGML Editorial Review Board) formed under the auspices of the World Wide Web Consortium (W3C) in 1996. It was chaired by Jon Bosak of Sun Microsystems with the active participation of an XML Special Interest Group (previously known as the SGML Working Group) also organized by the W3C. The membership of the XML Working Group is given in an appendix. Dan Connolly served as the Working Group's contact with the W3C.

The design goals for XML were:

1. XML shall be straightforwardly usable over the Internet.
2. XML shall support a wide variety of applications.
3. XML shall be compatible with SGML.
4. It shall be easy to write programs which process XML documents.
5. The number of optional features in XML is to be kept to the absolute minimum, ideally zero.

6. XML documents should be human-legible and reasonably clear.
7. The XML design should be prepared quickly.
8. The design of XML shall be formal and concise.
9. XML documents shall be easy to create.
10. Terseness in XML markup is of minimal importance.

4.2 XML Definitions

XML stands for Extensible Markup Language (often written as eXtensibleMarkup Language to justify the acronym). XML is the universal format for structured data. XML is a set of rules for designing text formats for data in a way that produces files that are easy to generate and read, unambiguous, and platform-independent. In particular XML is a set of rules for defining semantic tags that break a document into parts and identify the different parts of the document. It is a meta-markup language that defines a syntax used to define other domain-specific, semantic, structured markup languages. The first thing you need to understand about XML is that it is not just another markup language like the Hypertext Markup Language (HTML). These languages define a fixed set of tags that describe a fixed number of elements. If the markup language you use does not contain the tag you need—you are out of luck. You can wait for the next version of the markup language hoping that it includes the tag you need; but then you are really at the mercy of what the vendor chooses to include. XML, however, is a meta-markup language. It is a language in which you make up the tags you need as you go along. These tags must be organized according to certain general principles, but they are quite flexible in their meaning. For instance, if you are working on genealogy and need to describe people, births, deaths, burial sites, families, marriages, divorces, and so on, you can create tags for each of these. You do not have to force your data to fit into paragraphs, list items, strong emphasis, or other very general categories [12, 32,].

XML is a universal method for representing information that is especially well suited to distribution over the Internet. It is a technology that, aside from having a lot of hype, has the real potential to

change the way we compute today and a technology that has the backing of virtually every major industry player. From a lifecycle perspective, XML today is where HTML was in 1992. Between then and 1995, if you knew anything about HTML, you were in for the ride of your life. While it is dangerous to draw parallels in the technology business, we're confident saying that now is a good time to know how to use XML[33].

4.3 XML Derivations

L'XML, as a meta-markup language, allows to define the structural rules of different type of document, so that groups and organizations can use a language that is designed for their needs. For example, Boston MIT has developed Physical Markup Language (PML); it is intended to be a common "language" for describing physical objects, processes and environments. Much as the Hypertext Markup Language (HTML) has standardized the way in which information is presented on the Internet, PML is designed to standardize descriptions of physical objects for use by both humans and machines. The primary objective of PML is to serve as a common base for software applications, data storage and analytic tools for industry and commerce [34]. PML is based on XML that define its syntax; PML is relative to semantic, i.e. supplies components that give mean to the language. PML describes only the basic characteristics that are shared by physical systems, realizing a single physical product description. By this side PLM is a communication method for different databases ,enterprises, organizations. PML differs from the previous languages for data interchange (EDI, ebXML, UDDI), because the target for which it was developed is different.

EDI - Electronic Data Interchange – is a direct exchange of commercial messages between different Systems Information, using national and international networks. EDI key elements are the applications software of the partners involved in the information exchange, integrated with management software of EDI messages, integrated with telecommunication networks. Instead the ebXML target is to supply an open infrastructure that allows the global use of the information relative to electronic commerce in interactive, secure and consistent way. UDDI (Universal

Description, Discovery, and Integration) is an XML-based registry for businesses worldwide to be listed themselves on the Internet. Its ultimate goal is to streamline online transactions by enabling companies to find one another on the Web and make their systems interoperable for e-commerce. UDDI is often compared to a telephone book's white, yellow, and green pages. The project allows businesses to list themselves by name, product, location, or the Web services they offer. PML is focused “on physical objects, physical processes and environments”.

With PML it is possible to store information about supply chain of products, like packaging, delivery, tracking, mobility inside store, delivery history, temperature control, inventory (real time), etc.

5. META-HOLISTIC APPROACH (PLM, RFId, PML)

5.1 The Information Central Role

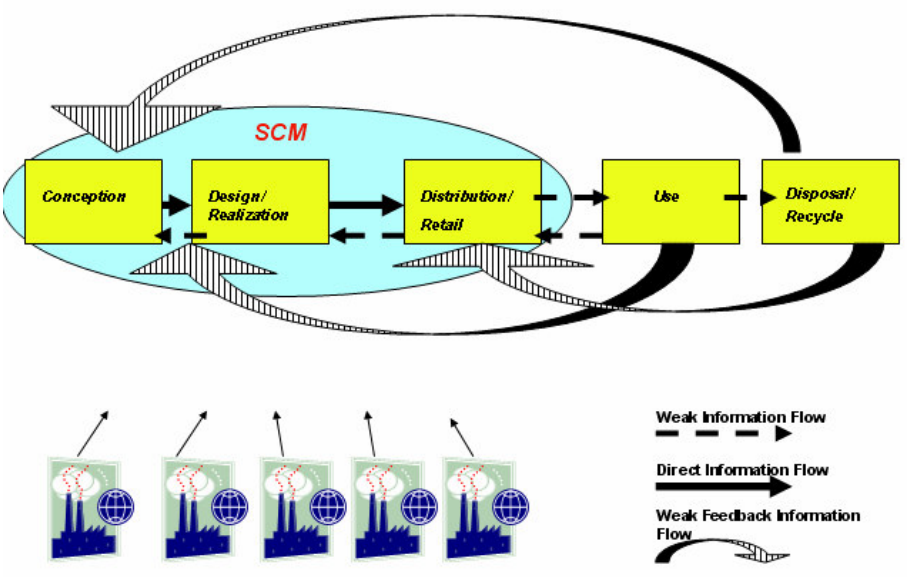
In organization’s life information plays a primary role: in fact information allows to reduce waste, obtain competitive advantage compared to the other organizations in the market, reduce manufacturing and inventory costs, reduce lead time, etc. The Product Lifecycle Management and Information relationship is very strong and very important too; in fact from information analysis and from increasing control on product, it’s possible to understand how to optimize product production, how to make product lifecycle management efficient and effective, how to innovate products, etc. [1]. RFId technology and information relationship is very important too: in fact RFId is the instruments on which it is possible to store information about one product, and this information can be modified along the different product lifecycle phases, memorizing, from time to time, significant and useful information. Finally, Physical Markup Language and information relationship is very strong too: in fact PML allows, through the property of being understandable both, human and machine, to obtain interoperability between different information systems of different actors that attend in the different lifecycle phases; PML allows share information between the constituting supply chain actors.

5.2 Extended Supply Chain Information Flows

A typical supply chain is defined by suppliers, partners, producers, carriers and product sellers networks [35, 36, 37, 38, 39]. Hence Supply Chain Management (SCM) implies product management until its retail. One of the problems in the apply PLM approach is the lack of product feedback information, that come from users. So we try to define product lifecycle by management information on product instruments during the different phases of product lifecycle. In so far as we imagine a lifecycle split in two fundamental parts, one from conception to product distribution/retail, that we could argue be cover by supply chain management applications, and the other one, from distribution/retail to product disposal. So the extended supply chain is defined by all the phases before retail, with in addition, use and disposal/recycle phases [40, 41]. How much saying is shown in figure 2.

Figure 2 shows primaries information flows concerning product life, from conception to disposal, that propose distribution/retail phase like the central divider. Weak information flows are in dot-black; they are from the design/realization phase to conception (as an example during given product realization you can image a different version of the product), from the distribution/retail phase to design/realization (as an example distributors needs can change product realization phase), from utilization phase to distribution/retail phase (as an example a costumer can explain needs that change product distribution, and going back in the different phases in design/realization, conception phases too).

Figure 2. Information flows in extended supply chain



These information flows are defined weak because their capacity to have a positive impact on product improvement processes is very low, given the difficulty to be received and intercepted. Possible causes can be the lack of communication between different partners of collaborative product development, the difficulty of receive information from costumer without adequate technology, etc [1, 8]. Bold information flow represents instead the classic information flow through product lifecycle; such a flow goes forth from the conception product phase throw design/realization phase, until the distribution/retail one. As it can be seen from the figure, the information flow from conception phase to distribution/retail phase (that is what we have defined SC) is well structured, while information flow from distribution/retail phase to disposal/recycling phase is still very weak because, generally, available information after product sale decreasing in considerable way and even more after its utilization, in disposal/recycling phase [1]. Traditionally, information flow direct to costumers could be defined like “static” because once given (as an example with tag or with handbook) this information flow doesn’t change, i.e. it couldn’t be adapted to the different lifecycle phases. These features determine that, sold product, producers have no control in product life and there is a risk that users don’t have adequate support for the correct use/functioning of the product and consequentially they perceive negligence from producers to themselves.

Figure 3. After sale product information flows

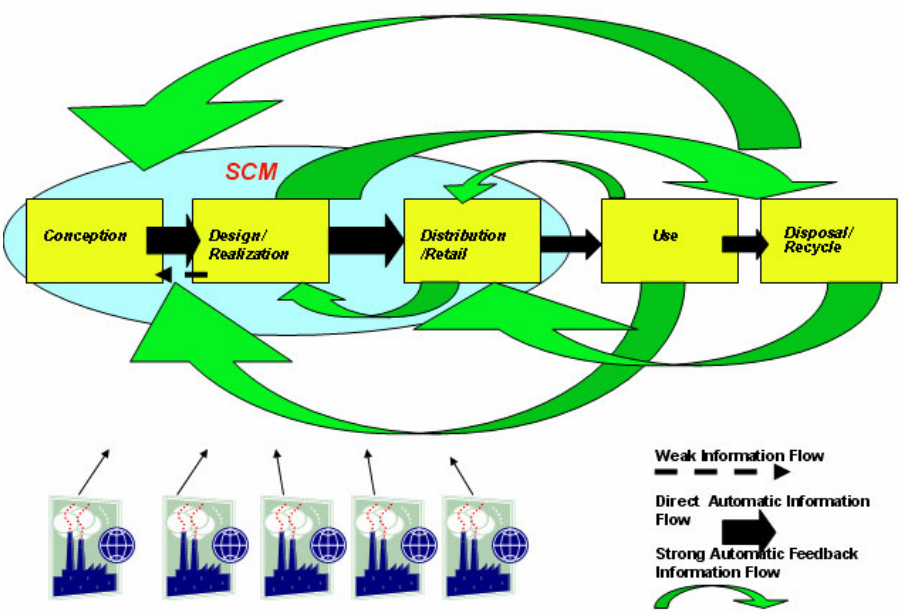
Moreover it must be considered a feedback flows that can't be realized without a right technology support. Feedback flows (as an example information in product disposal, or products with reduced life due to design or manufacturing errors) are very important for improvement product processes. Actually, by information obtained by feedback flows, it is possible to think, design, obtain improvements for the products (for example Design for disassemblies).

Now we try to demonstrate what we mean with "feedback flows are not determining for improvement product processes without a right support technology" expression; collecting feedback information is very difficult due to its nature; indeed the primary feature we must considered is that information is "distributed", i.e. it is linked to every single customer who buys and uses the product. Another important feature we have to consider is that information is rarely formally recorded, so in many cases it could be very expensive to gather (for example some customer relationship management methodologies are based on phone interview). Considering these features, is easily understood the importance of having a common data storage and a central repository allowing the memorization of the different point of view of the different actors attending along the product lifecycle. In the next lines we discuss the information flows collecting problem by RFId and PML technology support in PLM environment. Hence figure 4 shows information flows in extended enterprise with proposed system implemented.

Observing figure 4, it can be seen the primary importance that automatic identification technologies (RFId) and interoperability technologies (PML) can cover all product lifecycle. As first, you can notice an increasing direct information flows manageable. In fact on an RFId tag, where it can be memorized for example an EPC code (Electronic Product Code, an unique identifier for

product)[42], it is possible to memorize any other useful information during the various phase of life In this way, the first part of the problem, that is the centralization of information could be solved: the product itself (the RFID within it) is the repository of data.

Figure 4. Flows information with technological and methodological support



Hence it is simple to understand how the most part of information needs could be satisfied when the product "lives from the cradle to the grave". As an example you can memorize information for customer use of the product, you can memorize information to suggest disposals on how to manage the different parts of the product in recycling phase, etc. Moreover, since it is possible to modify tag information, this allows "dynamic information flows", i.e. information flows can change respect to the different phases of product lifecycle. In this scenario, allowed by RFId technologies, insert itself the integration role of PML technologies (in this specific case) or XML become fundamental, indeed, one of the problems related to the effective integration of the different actors participating in extended SC is the lack of an integrable information/data management system [43].

Since those information flows are "dynamics" it will be possible to customize not only the physical object but the object information flows too.

By using this proposed system it will be possible to have an information system shared and integrated among all actors in product lifecycle or at least from the conception phase to retail/distribution phase; in this integrated database/repository it will be possible to realize a knowledge merge of the different actors, that is, for example, whoever designs products can know, and so consequently behave, the problems that occur in retail/distribution phase [13]. It is important to note that the most significant advantage is to recover information, in this system is performed automatically by RFId and PML technologies use.

If we use automated identification technologies (RFId) and interoperability enabling technologies (PML) it is important to note that feedback information flows is more significant than the feedback flows without this technological support; in fact considering the phases from the conception to retail, information flow is automatic given that it is memorized on smart tag and moreover because PML enables system interoperability for the different actors that participate in the extend supply chain. For example if we recognize that a product in the manufacturing phase is not reliable, this important information immediately comes back to whoever designs products and therefore they start to try to correct the error; or if the product sales are beyond expectation integrated information system alert product manufacturers that it is necessary to produce more products to satisfy market (better demand plan reducing bull-whip effect) [44].More important is that it could happen in real time. If we look at figure 4 we can note that still external extended supply chain phases have important advantages from feedback flows. In fact information that can be read from users and disposals of the product can allow them to communicate their comments, their questions, their opinions to whoever produces and manages products by different services that can performed and built to support product utilization and disposal exploiting RFId and PML technologies. As an example, considering that a famous mobile telephone organization starts producing a mobile telephone with integrated RFId reader [45],we can think to built an application that allows users that read information memorized in product tag to send their opinions, advice, claims, inquiries directly to product producers. The same reasoning can be performed by those who recycle products, in fact

they can read information in tag (direct information flow), but they can give in a very efficient and timely way advice/suggestion to product producers for better recycling/disposal (feedback information flow).

6. SOLUTION APPLICATION

In this brief section we argue a possible implementation of the proposed system. We try to apply this system in an Italian product characterizing sector, wine sector. When we talk about wine, we must consider that wine product is highly related with customer opinions and sensations. The aim of this system is to make customer participant to weaving factory. The objective of the product is to provoke in customer emotions, experience that are not limited in entertain customer, but that can train, involve and delight customer exploiting every contact moment: before, during and after sales, through product, service, organization staff and clearly communication [46].

For this reason it is performed installing RFId chip inside wine bottle cork. The cork can contain, in addition to wine information, information about organoleptic features, barriques passage, wine grape, soil, bin etc. In the same way, it can contain information like, for example, wine food matching, wine colours table matching, tale from wine production region or music from wine production region for allow customers, for example, an Australian one, to feel, for some minutes, absorbed in the typical context where wine come from, in this case Italy. To obtain integration a new markup language was designed, Wine Markup Language,as shown in figure 5.

Another important justification that has contributed to make interesting this work is that wine product is strongly linked to customer feedback, because if it is a positive feedback then customers will be faithful to the product and to the organization-brand that make product, if instead it is a negative feedback, more than in other product sector, organization must change immediately to avoid losing customers. In fact if wine takes on a bad reputation it will be very hard and difficult that customers will taste the product again in the future, hence it will become necessary to start a large advertising campaign to promote product, and this action could be not sufficient to destroy

customers diffidence Feedback information will concern polls submit to product users or concerning to product preferences for customer, or also to obtain a customer judgement on the product. That is why an application is been designed that by means of WML technologies allows interoperability and communication between producers system information and customer mobile telephone.

Figure 5. Wine Markup Language

```
<wine>
    <name> Sangiovese </name>
    <year> 2001 </year>
    <date> 2345546443 </date>
    <general-features>
          <fermentation bin > acciaio inox nº42 </fermentation bin>
          <fermentation days> 23 </fermentation days>
          <barriques passage> 45532456267</barriques passage>
          <barriques typology > 26 Tonnellerie Saury MT,2
          Tonnellerie Boutes TM+ 1º  </barriques typology>
          <decant> 46678448796</decant>
          <bin pre-bottle in> 4607892345</bin pre-bottle in>
          <bottle in> 48345634543 </bottle in>
          <wine grape> Sangiovese 100%  </wine grape>
          <alcool> 14,45  </alcool>
          <ph> 3.4 </ph>
          <total acidity> 5.67 </total acidity>
    </general-features>

    <organoleptic features>
          <colour> rubino molto carico con tenui riflessi aranciati; </colour>
          <aroma> ampio con sensazioni molto intense di frutti di bosco,
          confettura e di spezie unitamente a delicati aromi vanigliati;
          </aroma>
          <flavour> pieno, di grande corpo, persistente e ben equilibrato;
          </flavour>
    </organoleptic features>
</wine>
```

7. CONCLUSION AND DISCUSSION

In this economic context principal organizational features must be flexibility, adaptability, rapidly alignment in new competitive scenarios. The old organization models are characterized by different critical aspects, like rigid structures that do not comply market requirements. A new methodology for extended enterprise management was studied, PLM (Product Lifecycle Management), that could represent an efficient and effective model to take out SMEs from crisis situation and to reinforce

their market position in global market, obtaining improvements in competitiveness. Others advantages that originate from PLM implementation are: a better control on products for producers, a better informative action for customers, a more efficient and effective extended supply chain management, a more incisive environment sustainability action, a support effort for continuous innovation inside organization, a considerable resources saving in terms of staff cost and time [47]. In order to enable in the most efficient and effective way PLM methodology, RFId technologies (Radio Frequency Identification), as physical framework for information memorization that allow automatic identification of product, cans, pallets on which RFId tag is applied, have been implemented. The most important potential benefits from RFId implementation are savings along the value chain, obtained by a significant out of stocks reduction, a strong waste reduction, a strong workforce reduction , a remarkable inventory costs reduction, the possibility to effect a real time inventory, the possibility to control the product during its lifecycle, to realize a complete traceability of the product. Next step was to identify a technology that could allow integration and interoperability between the different applications that have to use RFId tag memorized data. This technology is called XML (eXtensible Markup Language), and in particular a derivation, PML (Physical Markup Language); PML allows integration of the different actors participating in product life, “from the cradle to the grave”, moreover it is simple to understand by both human and machine. Finally we presented a particular application of this framework in the wine industry, where we defined a markup language (WineML) that could allow wine data interchange between different actors in extended supply chain.

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