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Supply Chain Management Standards in Ubiquitous Commerce

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2.1 Introduction

On Thursday the 29th of November 1951 at the offices of J. Lyons & Co[1] LEO (Lyons Electronic Office) became the first ever software used to conduct business. The purpose of this software application was to calculate the amount and cost of raw materials required to meet the nationwide orders for bread placed with the company [5, 8]. Until then, the massive computing machines of the time had only been used for military or scientific applications.

To be sure, LEO was a far-sighted application of information technology for business that initiated a trend which resulted today in having computer systems embedded into and controlling many supply chains. Yet, it is also true that in other ways we have not truly met or progressed much further than LEO's aims. These laudable aims were for computers to support and improve the efficiency of business processes through a thorough understanding of the objectives of those business users.

Indeed, the Holy Grail sought by businesses and government alike in supply chain applications – ranging from supplying fresh food from the farm to the supermarket shelf to delivering uniforms from the manufacturer to the soldier in the desert – is to keep the process simple, standard, speedy, and certain [9, 10]. To achieve this goal, it is necessary that all participants in the supply chain exchange information frequently and accurately, that supply chain costs be minimized, and that all goods and services moving through the supply

[1] J. Lyons & Co. was founded in 1887 to became one of the largest catering and food manufacturing companies in the world. Lyons made its name as the provider of cupcakes served at its tea shops and Corner House cafes by their historic 'Nippy' waitresses. At its height, Lyons owned the ubiquitous Baskin Robbins and Dunkin Donuts brands. However, in the 1970s the company was severely affected by the high interest rates due to the UK being hit by recession and an oil crisis and in 1978 was acquired by Allied Breweries Ltd. Lyons survived for several years under new management but eventually was sold in parts to pay for acquisitions associated with the drinks trade, and finally became defunct in 1998.

chain be unequivocally identifiable at all times. An essential element to any solution that can meet these requirements is the use of open, worldwide data standards for globally unique product identifiers and product classification systems, combined with internetworked information services that can be used to track and trace goods and services.

The role of open supply chains is becoming even more important with the emergence of ubiquitous and pervasive commerce. Indeed, high product visibility and the free-flow of information across the supply chain are required elements of highly automated systems that can link physical product items to their associated information. Only this level of interoperability and internetworking can support the machine-to-machine interactions that form the basis of ubiquitous commerce systems. Thus, open shared specifications describing every aspect of business activity are at the heart of pervasive commerce systems and effectively compose the fabric of all types of business activity built upon ubiquitous computing infrastructures.

In the remainder of this chapter, we will first review the history of unique identifier and product classification systems and their use in supply chain management applications. Then, we will provide an overview of the EAN.UCC system, including its more recent specifications for the wireless auto-identification of products at the item level as well as related information services for tracking and tracing products on the Internet. Finally, we will examine global cataloguing schemes and standards for inter-organizational information exchange. We will conclude with a brief discussion of the role of standards for the development of open supply chains and how these contribute to the construction of value networks.

2.2 Unique Identifiers in Supply Chain Management

Unique product identifiers are not new: almost every person in the world is familiar with the use of bar codes and bar code scanners in retailing. It is already over thirty years since the first bar code was scanned on a 10-pack of Wrigleys Juicy Fruit chewing gum in a supermarket in Troy, Ohio, and the collected identifier used for a commercial transaction. Since then, supply chain automation has become ubiquitous and the use of bar codes has spread from retailers to suppliers and ultimately to the suppliers' supplier. Moreover, recent developments have defined other varieties of printed bar codes to carry additional information (for example, sell by dates or product weight) and to deal with different environments (including pallets, locations, and returnable assets). Of late, specialist formats have also been employed in specific situations, for example the datamatrix standard for small items used to mark surgical instruments, and new services have been introduced as in the case of global data synchronization (more on this in Section 2.3).

The most recent interest in radio frequency identification (RFID) and the use of electronic product codes through the EPCglobal system in supply chain activities is in essence the extension of the concept of unique identifiers to ubiquitous commerce. For example, TESCO, one of the largest UK retailers, are carrying out extensive trials of RFID for which they have already coined the term "radio bar codes"[2] while Accenture, a business and innovation consultancy, view the use of RFID in supply chains as the introduction of "silent commerce."[3]

2.2.1 The Early History of Bar Codes

The history of modern bar coding begins in the 1940s, when the president of an American food chain raised the possibility of a system that could read product information automatically at the checkout. Norman Woodland and Bernard Silver at Drexel University, Philadelphia, created such a system by encoding information in combinations of concentric circles printed on paper which they subsequently patented in 1949. However, a critical problem with this solution was the inability at the time to automatically input the encoded product identifier in a computer system. It was the advent of lasers during the mid-1960s that made reading bar codes practicable. For this reason the initial idea received little attention in the grocery sector until 1968 when RCA (which in the meantime had acquired the Woodland patent) developed a similar symbol and corresponding scanner. This early system was operational for 18 months in 1972-73 in a Kroger store in Cincinnati, Ohio [1].

Bar coding was also investigated in the rail industry as a means of tracking individual railway wagons. By 1962, Sylvania Corporation had designed a system using optical scanning devices to read orange and blue colored bars on a non-reflective black background. By 1968 the colors were eliminated, and by 1971 about 95% of all railway wagons had been bar coded. At that point only 120 scanners had been installed, and recession in the mid 1970s led to the system being abandoned.

Because of these and other efforts in this area, it became apparent that separate groups could develop different and incompatible systems for product identification that could considerably hinder the wider acceptance of a common standard in the long run. For this reason, in 1969 the American National Association of Food Chains (NAFC), assisted by McKinsey & Co, a business consulting firm, proposed a product marking system to a group of senior representatives of all sections of the grocery industry, including manufacturers, retailers, and retail associations. The result of these efforts was the recommendation in 1973 by the Ad Hoc Committee of the Grocery Industry of the Universal Product Code (UPC), a ten digit code (five digits for the manufacturer and five for the product line) and a symbol design that would be printed

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[2] The vision of TESCO for RFID is discussed at: `http://www.tesco.com/radiobarcodes/`

[3] The vision of Accenture on silent commerce is discussed at: `http://www.accenture.com/silentcommerce`.

on products by the manufacturer. By the end of 1973 over 800 manufacturers had been allocated prefix numbers, and the following year scanners from IBM and NCR were supplied to retailers. History records the first commercial scanning of a UPC bar code took place at 8.01 am on 26 June 1974, when Clyde Dawson of Marsh Supermarkets bought a 10-pack of Wrigley's Juicy Fruit chewing gum in Troy, Ohio [4].

2.2.2 Bar Code Maturity

One of the main ingredients of the bar code success was indeed the development of UPC, a common standard for the representation of the information held in bar codes. A critical aspect of this work is the allocation of prefix numbers to companies, a task that was assigned to the Uniform Grocery Product Code Council established for this purpose in 1971. When in 1974 the council changed its name to Uniform Product Code Council it had over 3,000 members. Since 1984 the council is known under its current name, the Uniform Code Council (UCC). It is perhaps characteristic that typical American humility dictated naming this solution the *Universal* Product Code. The trouble was that not only was it not universal, but it did not even extend beyond North America. Soon after their introduction, Europeans took over these ideas, made them truly international, and improved upon them in several ways: where the UPC concentrated on the retail point of sale, Europeans took a supply chain perspective. Where UPC insisted on a code containing system identification, manufacturer identification and product identification, Europe decided on a "blind" identity number: one where you cannot read meaning into particular digits.

The decision to adopt this approach rather than UPC was made by a core group of collaborating companies, which formed for this reason as early as 1977 under the European Article Numbering (EAN) system. EAN worked closely with its national counterparts such as the UK based Article Number Association[4] (ANA). This collaboration was uncommon within the fiercely competitive consumer goods sector, and they clearly identified the necessity of collaboration on common open standards which would allow for a bar code to represent beyond doubt a particular product.

The output of the European work was the EAN system, which still has the idea of blind identity codes at its very core. This design decision has enabled the system to expand well beyond fast moving consumer goods into many different sectors, notably defence, healthcare and construction. Moreover, the separation of data from the data carrier has enabled the introduction of more types of bar code symbols in addition to the original EAN specifications. This flexibility extends to the new radio frequency tags (cf. Section 3.2), whilst maintaining stability in the standard and backward compatibility. The focus

[4]EAN has evolved today into GS1 (previously the e.centre) which is responsible for the EAN.UCC system in the UK.

on *item identity* rather than *product information* in automatic data capture has provided great efficiencies over the years, and yet it seems to suit well operation over the Internet.

The success of the EAN system extends well beyond Europe. In 1981, EANA was renamed to International Article Numbering Association (IANA), but is still frequently known as EAN International. Today, EAN codes are used across the world except North America, where UPC is still the dominant form, although several provisions ensure that the two systems are compatible. In 1990, EAN and UCC formalized this status-quo and co-managed global standards for identification of products, shipping units, assets, locations, and services, as well as a variety of other business standards that have become known as the EAN.UCC system (discussed in some detail in Section 2.3). In 2003, EAN International and UCC agreed on a 'sunrise' date of January 2005, after which time all systems in the USA should be able to scan an EAN-13 number. In addition, UCC formally joined EAN International and to complete the global integration of EAN International have re-launched globally as GS1, resulting in UCC being re-named GS1 US in June 2005.[5]

2.2.3 The Anatomy of an EAN Bar Code

At this point it is worth examining a typical EAN bar code (cf. Figure 2.1). An EAN bar code is a symbol which represents a unique identifier for a product following the Global Trade Item Number (GTIN) specification, as a string of 13 digits. This symbol can be read into a computer system using a (portable or fixed) low power laser scanner which can translate the sequence of white and black bars into the corresponding digits.

While the encoded number has no meaning, it follows a defined structure to ensure that each number for a product line is unique, including a unique number assigned to each user. The first two digits indicate the numbering system used (in this case EAN-13), the following five digits represent the manufacturer of the product, the next five digits are the product code, and the last digit is the checksum digit used to confirm that the code has been retrieved correctly. The manufacturer code is assigned to the particular business by EAN, while the digits corresponding to the product code are selected by the manufacturer.

It is important to observe that this number does not include any classification information in it – information about the industrial sector, the country or the region where the product was manufactured, or the type of product (for example clothing, food, electronic device, and so forth) cannot be retrieved from the code. It is simply a unique identifier (a key in database parlance), and to obtain associated product information it is necessary to query a related product information repository. Moreover, the unique identifier characterizes the product (one can of orange juice made by the Squeezed Juice company)

[5] Visit `www.gs1.org` for more details.

Fig. 2.1. A typical example of an EAN-13 bar code.

rather than a particular instance of the product (the can of Squeezed Juice orange juice I hold in my hand at this moment).

2.2.4 Application-Specific Identification Schemes

Outside the EAN.UCC development, other bar code symbols have been developed, mostly designed to address particular industrial applications. Some of the most widely used schemes are briefly discussed in this section.

Codabar, invented in 1972, is a variable length symbology which uses the ten digits plus six additional special characters. It is often used in libraries, medical facilities, photo-finishing, and airline tickets. In particular, the American Blood Commission selected codabar in 1977 as the standard for use in blood banks.

Code 39, also invented in 1974, uses both letters and numbers and is widely used internally by vertical industrial sectors. *Code 93* and *Code 128* are updates of Code 39 introduced in 1981 and can represent the 128 ASCII (American Standard Code for Information Interchange) characters. Code 128 in particular represents pairs of numbers in one character symbol to reduce the space required to print numeric data. *UCC/EAN-128* is a special subset of Code 128 reserved for users of the EAN.UCC system and was introduced in 1989 to allow users to provide extra information about products in a single bar code.

Interleaved Two of Five Code (ITF) was first developed in the mid-1970s, and in its current form ITF-14 is used widely by companies as part of the EAN.UCC system to mark outer cases. This bar code is well suited to printing on corrugated board because of its simplicity since it uses only two different widths of bars and spaces.

Multi-row or two-dimensional bar codes have been developed in the 1980s and 1990s as a means of reducing the space taken up by conventional linear bar codes. Examples of these include Code 49, Code 16K, Code 1, Codablock, MaxiCode, and PDF 417. In 2002 EAN.UCC published details of new reduced space and composite symbologies which were in development since the late 1990s. These symbols are two-dimensional and are designed to be used alongside the existing EAN.UCC bar codes in specific industrial and retail applications, where either very small bar codes or detailed information is required.

2.3 The EAN.UCC System

EAN.UCC is a system for uniquely numbering and automatically identifying products, services, companies, trading locations, logistics units, and assets (for a history of this system refer to Section 2.2). Today, EAN.UCC forms the basis of interoperable solutions for asset tracking, traceability, collaborative planning, order management, and logistics.

The EAN.UCC community currently consists of more than 100 national organizations operating across 133 countries, employing over 1,500 staff. Over a million member companies worldwide use the EAN.UCC system and every day more than five billion transactions are made using EAN.UCC standards. EAN national organizations play a critical role within this community. On the one hand they help their members implement current bar coding systems and business-to-business communications such as Electronic Data Interchange (EDI), and on the other, they represent their corresponding countries in international initiatives for new standards and solutions, including the emerging Electronic Business Extensible Mark-up Language (ebXML) for business communications, reduced space symbology (RSS) bar codes, radio frequency identification (RFID) tags, and the EPCglobal network. In the UK in particular, GS1 UK is the EAN national organization and one of the founder members of EAN International. GS1 is a not-for-profit association and serves more than 17,000 member companies by supporting and further developing the EAN.UCC system in this country.

EAN.UCC standards address three areas: Part I deals with unique identifiers for products, companies, and so forth and data standards for attribute encoding. Part II relates to the encoding of this information into data carriers such as bar codes and RFID tags. Finally, Part III sets data standards for automatic electronic communication through supply chains, including conventional EDI standards that are still mostly employed for business-to-business communications in closed networks as well as the emerging ebXML family of standards for open supply chains based on the Unified Modelling Language (UML) and the Extensible Markup Language (XML).

Overall, the aim of EAN.UCC is to support the efficient operation and management of supply chains and thus create added value for the consumer (cf. Section 8.2 of Chapter 8 for a more detailed discussion of value chain efficiency and the Efficient Consumer Response initiative). EAN.UCC is a complex system in perpetual development. In the following section we will discuss each aspect of this system in turn and show how the different components combine to construct a universal “language” to conduct business.

2.3.1 Types of EAN.UCC Unique Identifiers

In addition to the product codes that we have discussed at length in Section 2.2, the EAN.UCC system[6] provides unambiguous numbers to identify goods containers, services, companies, locations, and assets worldwide. These numbers can be represented in bar code symbols or stored in RFID tags and transmitted wirelessly to enable their electronic reading wherever required by business processes. EAN.UCC also provides standard data structures characteristic for different supply chain applications. While an application is free to determine how EAN.UCC numbers are used, it is critical that each number be used in its entirety and not broken into constituent parts. Hence, EAN.UCC data structures guarantee worldwide uniqueness within a particular application area. In this section we will briefly review some of the EAN.UCC identifiers that are relevant to ubiquitous commerce since they provide digital representations to physical objects, locations, and organizations, as well as define corresponding rules of interaction.

An EAN.UCC code is made up of different parts, but it always contains the *company prefix* number. As the name implies, this is a unique number that has been assigned to the manufacturer of a product. Using the company prefix number is a core requirement of all EAN.UCC standards. The *global trade item* number (GTIN) is used for the unique identification of trade items worldwide. A trade item is any item (product or service) upon which there is a need to retrieve pre-defined information and that may be priced, ordered, or invoiced at any point in any supply chain. This includes individual items as well as all their different configurations in different types of packaging.

The *global location* number (GLN) is used to identify any company or physical, functional, or legal location. The *serial shipping container code* (SSCC) is a unique serial number used to identify logistics units individually. The *global returnable asset identifier* (GRAI) is used to identify a reusable entity that is normally used for transport and storage of goods. The *global individual asset identifier* (GIAI) is used to identify individually any entity that is part of the inventory of a given company, and whose lifetime history needs to be recorded. The *global service relation number* (GSRN) is used to identify the recipient of services in the context of a service relationship, for example a customer or patient.

The data structures and data carriers of the EAN.UCC system have been fully considered and approved by ISO. There are too many ISO standards to list here, but all developments have been considered under the aegis of the ISO/IEC JTC 1 Committee (Information Technology) and its sub-committee, SC 31, that is concerned with automatic identification and data capture techniques.

Recently, radio frequency identification (RFID) technology has reached maturity, and passive RFID tags can be produced at relatively low cost. Unlike

[6] The full EAN.UCC system standard specifications are freely available and can be found online at: `http://www.gs1uk.org/txt_temp.asp?fid=294`.

01. 0000A89. 00016F. 000169DC0

Header	EPC Manager	Object Class	Serial
8 bits	28 bits	24 bits	96 bits

Fig. 2.2. An example of the Electronic Product Code.

bar codes, which are still the primary data carriers for EAN.UCC codes, RFID tags do not require line of sight between tag and reader to transmit their content and are more resilient to damage during product transit. This new type of data carrier (discussed in more detailed in Section 3.2) created the need for a new numbering scheme which has become known as the *Electronic Product Code* (EPC).

Due to the higher data capacity of RFID, EPC can carry considerably higher information content across the supply chain. The current EPC Type 1 specification[7] defines a key length of 96 bits and in addition to manufacturer and product type codes incorporates a serial number which identifies unique items. Thus, using EPC it is possible to carry out *item-level tagging*, a capability that far exceeds that of bar codes. It is this aspect of the EPC system and the fact that RFID chips can be read from a distance without any visible effect that has created considerable concern with consumers (cf. Chapters 8 and 12 for a more detailed discussion of the implications of item-level tagging in consumer applications).

Each EPC number is made up of at least four parts (cf. Figure 2.2):

- The *header* (bits 0–7) identifies the length, type, structure, version, and generation of the particular EPC.
- The *manager number* (bits 8–35) identifies the supplier of the product.
- The *object class* (bits 36–59) identifies a product grouping within a particular scheme defined by the manager, and most often it would be a stock keeping unit (SKU) or a lot number.
- The *serial number* (bits 60–95) is the specific instance of the particular product within its object class, and it is exactly this field that allows for item-level tagging.

Additional fields may also be used as part of the EPC, for example to identify the shipping method such as the Shipping Container Code (SCC-14) and the Serial Shipping Container Code (SSCC-18). Application Identifiers (AI) can also be included as well as data used to encode and decode information from different numbering systems into human-readable forms.

[7] Complete EPC and other EPCglobal specifications are available online via: `http://www.epcglobalinc.org/standards_technology/specifications.html` and archived at: `http://www.epcglobalinc.org/about/AutoID_archive.html`.

Fig. 2.3. Clockwise from the top left: samples of UCC/EAN-128, EAN-13, EAN-8, ITF 14.

Following the traditional EAN.UCC approach, EPC codes are embedded within Physical Markup Language (PML) structures for transmission across the supply chain. PML is a simple XML-derived language that provides for other attributes of the physical object in addition to the EPC, including date, location, history, and access control credentials. In particular, PML messages are used to communicate with enterprize resource planning (ERP) middleware (cf. Chapter 3) and to query the Object Naming Service (ONS) (cf. Section 3.3).

2.3.2 Physical Representation of the EAN.UCC System

Bar code symbols, machine readable symbols printed to well defined specifications, are the primary data carriers used in the EAN.UCC system. Bar codes represent GTINs, the unique identifiers for a particular product line. The bar code itself consists of a rectangle comprising a series of light and dark parallel bars and is normally incorporated as part of the original packaging design or printed onto labels. Figure 2.3 shows four common bar code symbols: UCC/EAN-128, EAN-13, EAN-8, and ITF 14.

The latest developments in the system include new smaller bar codes, especially designed for use when space for bar codes is at a premium, such as on very small packages. These reduced space symbology bar codes are linear symbols, similar to the ones shown above, and can encode the GTIN for a product. A version of this bar code, namely RSS-14 expanded, can represent a GTIN and extra information about the product.

Composite components, which are small two-dimensional bar codes that can encode up to 2,338 data characters, have also been introduced. These will be usable above any of the EAN.UCC bar codes (except ITF-14) to provide extra information such as batch numbers, expiry dates, and so on. The main linear symbol acts as a finder pattern for the $2D$ element, so that the extra information cannot be decoded without decoding the linear component at the same time. The so-called Data Matrix format has also been defined and is specially designed to be used on healthcare equipment, such as scalpels and other surgical tools.

In the past few years a radically new type of EAN.UCC data carrier has been introduced based on radio frequency identification (RFID) technology, which uses radio waves to communicate EPC information as discussed in Section 3.2. Unlike bar codes, which encode data at optical or infrared wavelengths, RFID carries data programmed into its chip and operates at radio frequencies, typically 125 KHz, 13.56 MHz, 900MHz, and 2.45GHz. Although such chips can also integrate a battery, the most interesting case is that of the so-called passive tags, which use inductance to power up, process requests and transmit their EPC. This approach allows for tags to be independent of a power source and thus cost far less and be used for any period of time.

However, several incompatibilities and other technical problems were identified in the use of these frequencies, and currently work is underway for the so-called Generation 2 Class 1 RFID Interface specification, which operates at the UHF band. One of the principal advantages of the UHF band is that the effects of power absorbtion from the environment and the product itself are far less pronounced. This specification is intended for submission to ISO for acceptance as a standard, but several problems have hindered this process, not the least the existence of patents covering RFID in this frequency, which imply that the cost of the tag would be far higher than what was initially expected.

Similar to bar codes, RFID tags require a corresponding reader. In this case, however, in addition to querying and receiving EPC codes transmitted by the tags, the reader also provides power to the RFID chip. Reader specification and communication protocols have also been defined by EPCglobal. A notable recent addition to this specification has been the inclusion of the so-called "destroy" command which makes the tag incapable of transmitting its EPC (more details of its use and application can be found in Chapter 12). The way in which EAN.UCC-compliant RFID tags can be used in open supply chains is described in the immediately following section.

2.3.3 Data Communication on the EAN.UCC System

Defining unique identifiers, their physical representations and corresponding data structures is only the first of the required ingredients to deliver supply chain integration and improve its efficiency. What is also required is a common means to manage, exchange and aggregate this information in ways that promote visibility and thus openness across the supply chain. Several additional data communication components are required to achieve these tasks: messaging vocabularies, languages to describe business processes, electronic catalogues, global data exchanges, and last but not least repositories of global scale that can map codes to specific product items. EAN.UCC standards address all these requirements, and in this section we will discuss each component in turn.

Electronic Messaging and Closed Supply Chains

Since the early 1960s the United Nations Directories for Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) has been developing a comprehensive set of electronic messaging standard to promote business. The result has been a particularly complex and overloaded system that is hard to deploy and often leads to unnecessarily irksome implementations. For this reason, over the years several groups have defined subsets that satisfy the particular needs of specific industrial sectors, specific business processes, or specific supply chains. For example, EANCOM is an EDIFACT subset developed within the EAN.UCC system to support cross-border trade and covers the functions required to effect a complete trade transaction.

Another case of EDI vocabulary within a specific market segment of the EAN.UCC system is the Trading Data Communications standard (TRADACOMS). TRADACOMS was developed in the early 1980s by ANA, the predecessor of the the EAN National organization in the UK, and employs EAN codes for product identification. At the time, several leading companies including Woolworth's, Boots and Tesco were attempting to establish electronic communications with their suppliers but encountered resistance because of different and incompatible message structures and content. Successful implementation of TRADACOMS in trials allowed electronic invoicing to become law, and indeed the system is still widely used in retail applications.

ebXML and global repositories

EDI was created for closed, proprietary networks and in many ways it is not suitable for use over the Internet. It has been designed primarily as an one-to-one technology and has limited flexibility. Moreover, the requirements for the development and operation of an EDI-based system have proven in practice to be quite significant and hardly affordable by small and medium sized companies. As a result, until recently relatively small businesses have been excluded from participating in electronic data exchanges.

To cater to the new business opportunities opened up by the Internet, the Organization for the Advancement of Structured Information Standards[8] (OASIS) has been developing the electronic business extensible mark-up language (ebXML). Unlike EDI, ebXML assumes that the communications substrate is the Internet and aims to provide a modular rather than a rigid set of specifications for conducting business. An additional benefit is that by being developed on open, well understood Internet standards, expertise on ebXML can be relatively easily developed and supported on the same systems used

[8] OASIS web site at: `http://www.oasis-open.org`

to support consumer electronic commerce. Thus, the cost for business can be considerably reduced.

ebXML is a massive set of specifications which aims to make e-business possible anywhere on the globe, for any company, of any size, in any industry [7]. It is thus impossible to even summarize the different areas it covers in the space of this chapter, but a brief overview of the different areas covered by the specification is in place here:

- **Messaging.** The ebXML messaging functions are a straightforward extension of the EDI functionality and follow the standard envelope-and-message format developed for the Simple Object Access Protocol (SOAP). In ebXML, business data are enclosed in SOAP envelopes and transmitted over the Internet.
- **Business Processes.** ebXML uses standard modelling languages and charting tools, notably the Unified Modelling Language (UML), to systematically capture the flow of business data among trading partners and to represent this business knowledge in a standard format. The systematic definition of specific business processes is then used as the basis for common message sequences across industry boundaries, and several such processes have been recorded in detail.
- **Trading Partner Profiles and Agreements.** In addition to the modelling of specific processes, ebXML also provides systematic representation of company capabilities to conduct e-business in the so-called Collaboration Protocol Profile (CPP). Using the CPP, a company can list the industries, business processes, messages, and data-exchange technologies that it supports. Then, trading partners can use their CPPs to specify Collaborative Protocol Agreements (CPA) that define the business processes, messages, and technologies used to exchange business messages.
- **Registries and Repositories.** ebXML Registries are shared repositories that hold descriptions of industry processes, messages, and vocabularies used to define the transactions exchanged with trading partners in CPP and CPA formats. Such repositories can be queried by other business to retrieve details of e-business capabilities for inspection so as to locate companies with the capabilities desired in forming partnerships.
- **Core Components.** ebXMl Core Components (CC) are standardized XML schemas that represent the core entities involved in ebXML scenarios. CCs are lower level descriptions of the main entities that participate in business transactions and can be viewed as the extension of the traditional EAN.UCC data structures, updates for use on the Internet, and open supply chains operating on the Internet.

The final component required for effective data dissemination in the supply chain according to the EAN.UCC vision has been developed by the Global Commerce Initiative (GCI) working group of EAN, in the form of the Global Data Synchronization (GDS) repository specification [2]. GDS supports master data alignment, that is accurate and synchronized databases for products, prices, promotions, and locations across a supply chain. In practice, the GDS repository forms the basis of a shared electronic catalogue between supply chain partners and plays a critical role in increasing the efficiency of transactions by increasing the quality of information across all supply chain activities. In particular, GDS improves the accuracy of orders, invoices and other business documents; reduces the number of delivery errors; and last but not least, reduces the administrative work related to the maintenance of product and location information.

2.3.4 EPCglobal

In Section 1.2 we briefly discuss RFID tags, the most recent data carrier for electronic product information, which allow for the automatic identification of objects without the need for any manual intervention. Yet, although the storage capacity of an RFID chip far exceeds that of a bar code, it is still limited and thus it is hardly feasible to store on it more than simple information, for example the EPC number that corresponds to the product as discussed in Section 3.1. As a result, similar to bar codes, unless product identifiers can be mapped to the physical description and the other product information details, this information is of limited usefulness. Of course, it would be desirable that this mapping would also be carried out automatically between the retailer and manufacturer systems, for example.

This is exactly the purpose of the EPCglobal network,[9] a set of draft specifications that define a network of global scale, overlaid on top of the Internet, that offers directory and information services that link any EPC code to all information available about the product from its manufacturer. In fact, this electronic directory service is closely linked to the Domain Name System (DNS) which maps computer hosts and network names to their IP addresses on the Internet.

EPCglobal has two main components, namely the Object Name Service (ONS) and the EPC Information Service (EPC IS). ONS is in essence a directory service which maps a particular EPC code to a Uniform Resource Identifier (URI), an encoding of the name and address syntax of objects on the Internet defined by the World-Wide-Web Consortium (W3C) – a special case of which is the URL. In fact, because the operation of the ONS is very similar to that of the DNS, EPCglobal envisions that ONS services will be deployed on top of existing DNS infrastructures, a provision detailed in the ONS draft specification. The retrieved URI points to the EPC IS of the product manufacturer (or more generally to the EPC Manager responsible for the particular product item) and may incorporate the access mode of the partic-

[9] The operation of the EPCglobal network is illustrated at: `http://www.epcglobalus.org/Network/Network.html` with more detailed information, including draft specification for the ONS and EPC IS services, available via the Auto-ID Labs web site at: `http://www.autoidlabs.org/`.

ular server, for example the particular ebXML CC schema that must be used to query the service or any other appropriate protocol.

EPCglobal allows for the whole process of product identification and association with particular data to be completely automated. Indeed, at no stage of this process is it necessary for a human to be involved. Combining the EPCglobal with GDS repositories provides an even more powerful capability: to access full product traceability information, that is to have a complete history of the product from the time it was created until it has reached the consumer. This information can be potentially augmented with additional information, for example regarding environmental conditions during its transversal of the supply chain to prove that storage conditions have been fully observed throughout.

It should be noted that EPCglobal is a work in progress and considerable changes should be expected to its operation. Of particular concern are trust management issues and verification of the quality of the information held in the system, and more work on this will be required in the near future.

2.4 The Role of Standardization for Ubiquitous Commerce

One of the lessons of the history of EAN.UCC is that standards are a critical component for business automation. Indeed, this chapter has already discussed many cases when market realities forced fierce competitors to collaborate to establish such standards. This need will only become more pressing with the emergence of ubiquitous and pervasive commerce systems that are fully dependent on machine-to-machine communications to carry out even the simpler transactions.

Given the central role that standardizations plays but also the considerable overhead of this globalized process, EAN International in collaboration with the Uniform Code Council agreed on the Global Standards Management Process (GSMP) to support standards development activity for the EAN.UCC system. The GSMP was developed to maintain standards-based solutions for global trade using EAN.UCC system technologies. The GSMP aims to produce a global consensus process to negotiate supply chain standards that are grounded on business needs and in consultation with users.

Standardization also has a clear business case in that it is the main ingredient for the creation of value networks, thats is combinations of internal and external resources needed to achieve the objectives of the business, that are efficient and adaptable especially to the rapid market changes observed in the modern environment [10]. Indeed, experience has shown that reducing costs, improving productivity, and increasing sales depends on visibility of the supply chain.

2.5 Summary

There is clear rationale for businesses to keep the supply chain process simple, standard, speedy, and certain. In the context of the emerging ubiquitous and pervasive computing technologies in particular, it is necessary that all participants in the supply chain exchange information frequently and accurately, that supply chain costs be minimized, and that all goods and services moving through the supply chain be unequivocally identifiable at all times.

Over the last fifty years information and communication technologies have achieved considerable progress towards open, worldwide data standards for globally unique product identifiers and product classification systems, combined with internetworked information services that can be used to track and trace goods and services. Managing this process of global scope is a major challenge and the EAN.UCC systems appears to be the most suitable candidate.

The scope and the effort required to achieve this level of standardization is certainly instructive for the pervasive computing paradigm as a whole, as it highlights the complexities and difficulties that must be overcome to provide truly seamless and indeed ubiquitous services to the end user.

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