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Communications of the Association for Information Systems

Volume 17 Article 44

June 2006

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Recommended Citation

Nakatani, Kazuo; Chuang, Ta-Tao; and Zhou, Duanning (2006) "Data Synchronization Technology: Standards, Business Values and Implications," *Communications of the Association for Information Systems*: Vol. 17 , Article 44.
DOI: 10.17705/1CAIS.01744
Available at: https://aisel.aisnet.org/cais/vol17/iss1/44

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Communications of the Association for Information Systems

DATA SYNCHRONIZATION TECHNOLOGY: STANDARDS, BUSINESS VALUES AND IMPLICATIONS

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ABSTRACT

The Internet-enabled connectivity has created opportunities for businesses to conduct various forms of collaborative activities. However, the findings of several surveys indicate that the deficiencies in data quality might compromise the potential benefits of joint efforts. Global data synchronization (GDS), the process of timely updating product data to maintain the data consistency among business partners, is viewed as the key to materializing the benefits of e-collaboration in the global supply chain setting. In the paper, we present the need for data synchronization, discuss the evolution of technical standards of data identification schemes, and introduce the Global Data Synchronization Network (GDSN), the platform on which global data synchronization is substantiated. We detail the structure of GDSN and the protocols for the process of GDS. Furthermore, we discuss business and management implications of GDS, different approaches to implementing GDS, and challenges to the implementation of GDS. The emergence of GDS and GDSN presents research opportunities on issues relating to the implementation of GDS, the relationship between GDSN and EPCglobal Network, the impact of GDS on inter-organizational relationships, the network effect of global standards, and evolution of complementary standards. We discuss these research opportunities. In brief, the article covers the history, present status, and future of GDS and GDSN, as well as their potentials, benefits, and implementation issues.

Keywords: global data synchronization, global data synchronization network, EPCglobal Network, collaborative commerce, e-collaboration, supply chain management.

I. INTRODUCTION

The Internet-enabled connectivity has fostered a variety of collaborative activities between businesses, ranging from collaborative design of new products to collaborative logistics management and order fulfillment. Those Internet-enabled activities are generally referred to as e-collaboration [Johnson and Whang, 2002] or collaborative commerce [Chuang et al., 2006]. While e-collaboration takes place in different forms, the nature of the industry may determine the utility of one particular form of e-collaboration to that industry [Chuang and Nakatani, 2004]. For example, in the industries of consumer packaged goods manufacturing and retailing, collaborative transaction management and supply chain management are particularly critical to the efficiency of business operations. The importance of this form of e-collaboration is witnessed by the increasing attention to its underpinning technology such as Radio Frequency Identification (RFID) technology and Electronic Product Code (EPC).

The basis of collaborative supply chain management is the exchange of accurate, complete, and consistent data about products and transactions between business partners. Deficient data could be costly. A survey conducted by UCCnet shows that problems, such as delivery errors and lost sales, caused by incorrect or outdated data in invoices or purchase orders cost the industry $50 billion annually [UCCnet, 2005b]. Another survey shows that about $40 billion or 3.5 percent of total retail sales lost each year, owing to supply chain information inefficiencies [Stelzer, 2003]. Due to the magnitude of the loss, the industry calls for remedial actions where joint effort between trading partners is necessary. A study done by A.T. Kearney for GMA [GMA/FMI Trading Partner Alliance and A.T. Kearney, 2002] indicates that the potential benefits of e-collaboration in supply chain management are significant. The study estimates that the total benefits for manufacturers are in the range of $1 million additional earnings for every $1 billion of sales. For retailers, the figure is in the range of $500,000 additional earnings for every $1 billion of sales. Detailed benefits are shown in Table 1.

Table 1. Summary of GDS Benefits (Source: GMA/FMI Trading Partner Alliance and A.T. Kearney, 2002)

Manufacturers	**Retailers**
3% to 5% reduction in shelf out-of-stocks.	3% to 5% reduction in shelf out-of-stocks.
Two-week reduction in speed-to-market for new items (i.e., 14 extra days' sales of faster-moving items).	Two-week reduction in speed-to-market for new items (i.e., 14 extra days' sales of faster-moving items).
7% to 13% reduction in sales force time spent communicating basic item information to customers, following up, resolving queries, etc.	10,000 to 30,000 hours saved in store labor costs resulting from shelf-tag and scan errors.
Reduction in call center and website queries regarding basic item information.	5,000 to 10,000 hours saved in merchandizing and data entry time dealing with new item introductions and updates.
5% to 10% reduction in sales force and accounting time spent dealing with invoice disputes.	1,000 to 2,000 hours saved in finance time dealing with invoice disputes related to basic item information.
Reduction in invoice write-offs incurred as a result of data discrepancies.	Reduction in invoice auditor fees.
Elimination of basic item data errors, currently found in up to 8% of total purchase orders.	0.5% to 1% reduction in inbound freight costs.
0.2% to 0.7% reduction in outbound logistics costs.	1,000 to 2,000 hours saved in warehouse and DSD (direct store delivery) time dealing with item discrepancies.
0.5% reduction in inventory.	1% reduction in inventory.

Data synchronization, the process of timely updating product data to maintain the data consistency [O'Neill and Williams, 2003], is the key to solving the inefficiency in product information sharing and materializing the benefit of e-collaboration. Data synchronization is considered to be fundamental to e-collaboration between business partners [A.T Kearney and Kurt Salmon Associates, 2004]. In fact, the implementation of data synchronization might have impact on other IT-related initiatives. For example, because of mandates from strong proponents like Wal-Mart and the Department of Defense, issues surrounding the adoption of radio frequency identification (RFID) and EPCglobal Network have been widely discussed [Asif and Mandviwalla, 2005]. RFID is believed to influence all aspects of supply chain and is expected to significantly improve efficiency of supply chain. EPCglobal Network, which consists of Electronic Product Code, RFID and supporting Internet technologies, is for real time data about individual items as they move through supply chain. However, without data quality assured by data synchronization, RFID and EPC technologies may not fulfill their potential benefits because, in nature, RFID and EPC are data carriers and do not provide mechanisms to assure the consistency of data conveyed by them. A.T. Kearney and Kurt Salmon Associates [2004] further indicates, "Electronic collaboration without data synchronization could be translated as: 'Garbage in faster, garbage out faster.'" (p. 11). Data synchronization, with data specification standards and item global registry, is substantiated as the concept of Global Data Synchronization (GDS) in which only sole version of up-to-date basic (commonly used) product data is published at a single place for sharing [Intel Corporation, 2004]. GS1 (formally known as EAN/UCC) is a global organization that is leading an effort in creating a global platform for data synchronization, Global Data Synchronization Network (GDSN), by developing and implementing global standards. As of April 2005, more than 4,200 leading worldwide retailers and suppliers, including major companies such as Wal-Mart, Proctor and Gamble, are participating in this effort [UCCnet, 2005a] and as of June 2004 more than 239,000 products are registered [Sullivan, 2004].

Despite significant effort from major companies and governments all over the world, many barriers need to be overcome in order to make GDSN a truly global synchronization system for all participating businesses. Those barriers include cleansing internal data, slow adoption, and so on [A.T. Kearney and Kurt Salmon Associates, 2004]. Previously mentioned EPCglobal Network with RFID is also experiencing similar challenges to global standardization process. While relevant technologies like RFID increasingly attract researchers' interests [Smith and Konsynski, 2003; Asif and Mandviwalla, 2005], GDSN receives scant attention from IS academia.

The purpose of this paper is to present an analysis of technical standards and business implications of GDSN. More specifically, the article covers the history, current status and future of GDSN, as well as its potential, benefits, and remaining issues. The IS academic field needs to pay attention to GDSN because of its potential and because the IS academic field can facilitate the adoption of GDSN:

- by participating in the effort to design and develop standards,
- by educating business managers the importance of emerging global standards and systems, and
- by conducting research to
    - identify critical success factors for the diffusion and deployment of such a global system and standards,
    - develop metrics for performance indicator,
    - investigate the impact of such a global system on the supply chain management, and
    - prescribe the Product Information Management process and system for internal data cleansing, automating related internal transaction processes.

The article is organized as follow: The next section describes the need for Global Data Synchronization. Section III presents the history of standard identification codes including UPC, EAN, GTIN, GLN and EPC. These are essentials to understand GDS. The following section describes Global Data Synchronization Network (GDSN), including global registry, data-pool services, and functional mechanisms of GDSN. Section V discusses options for companies to implement GDS and challenges for implementing GDS. It also provides a checklist for GDS implementation. Section VI discusses the research implications of GDS. The last section presents conclusions.

II. NEEDS FOR GLOBAL DATA SYNCHRONIZATION (GDS)

GDS is "the timely and accurate updating of any finished product information across enterprises and borders based on a single, global registry that connects data sources from around the world, enabling data to be standardized and synchronized by trading partners on a near real-time basis" [Bowling et al., 2004, p. 7]. The need for GDS comes from data inconsistency about items existing in a supply chain. GDS is a process that provides "a mechanism to keep the extended product attribute information consistent across the various participants in the supply chain" [Intel Corporate, 2004, p. 4].

Traditionally and currently, product data are stored at each business organization in a supply chain. Each organization, regardless of a manufacturer, a distributor, or a retailer, maintains its own version of data about the items they handle. Moreover, several departments of each organization, such as accounting, sales, purchasing, and receiving, may have their own versions of data about the same item. Discussed extensively as a database topic, data redundancy is a main source of data inconsistency if appropriate care is not applied whenever the data is updated somewhere. Thus, the essential concept of data synchronization is truly not new. It is widely used by business organizations that own heterogeneous or distributed databases. However, many organizations are still experiencing data inconsistency [Intel Corporation, 2004]. While data synchronization within an organization is a tough issue that plagues many organizations, the one between business partners in a supply chain could be quite daunting. The data synchronization process between business partners is typically done manually, in an ad-hoc manner [Bowling et al., 2004]. Although EDI (electronic data interchange) provides a way to electronically exchange data between business partners, the notification of changes and initiation of update at a partner's location requires human intervention. Furthermore, most likely, data synchronization between business partners is conducted at departmental levels. As shown in Figure 1, in a typical supply chain, there are many suppliers, distributors, and retailers. A change in product data initiated by a supplier, such as change in price or discontinuation of a certain model or color, may need to disseminated to all of its trading partners. This kind of departmental manual data change notification and updating process is cost-ineffective due to the complex relationships between business partners. Often, the necessary notification is delayed, unnecessary change is mistakenly notified and there may be a significant lag time to disseminate necessary change to all partners.

The consequences of manual data synchronization include [GMA/FMI Trading Partner Alliance and A.T. Kearney, 2002; Bowling et al., 2004]:

- Errors in generating purchase orders.
- A large number of invoice reconciliation between suppliers and buyers (50% or more according to one study, mentioned in GMA/FMI Trading Partner Alliance and A.T. Kearney, 2002).
- Invoice deductions.
- Errors in shelf-tags (such as price-per-unit discrepancies).
- Errors at POS scanning (such as not-found items or not-found coupons).
- Lost sales due to out-of-stocks at retailers resulting from supply chain delays.

- Delay in introducing new items on retailers' shelves (delay in catalog updates, and supply chain delay).
- Inefficient use of trucks.
- Delays in receiving, handling and slotting at warehouses or distribution centers.
- Unexpected loads and re-pallet loads that require additional labor and equipment.
- Delays in direct-store-delivery (DSD) receiving.
- A huge amount of buffer stock inventory.
- Dissatisfied customers.

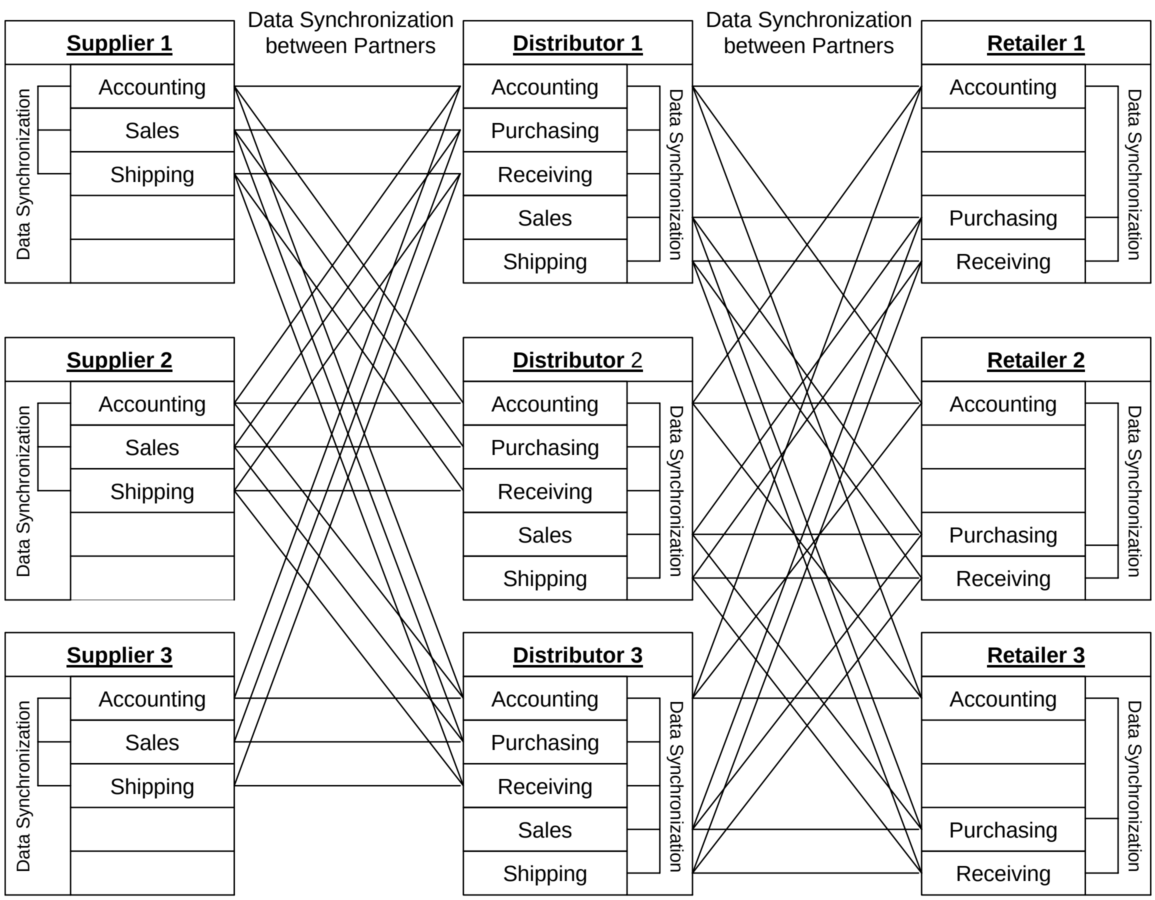

Figure 1. Necessary Data Synchronization in a Supply Chain

The following example illustrates some of the potential problems stated above. A typical on-line retail store maintains a list of items for sale in its database where catalogs from many manufacturers are consolidated. When the Marketing department of a manufacturer decides to discontinue an item with a certain color due to its unpopularity and the item is finally sold out, it must notify all retailers immediately. If there is a time lag, the discontinued item could be ordered by a customer of the retailer requesting a next day delivery. The retailer creates a purchase order to the manufacturer for direct shipment when they don't have the item in stock. Often, the manufacturer processes such an order in a batch. When they realize that the order requests the discontinued item, they must notify the retailer, who then notifies the customer. This process could take more than one day, while the customer is expecting the item the next day. In a common, worse-case, scenario the manufacturer's warehouse mistakenly sends the wrong color to the customer, who then complains to the retailer to re-send an item with the correct color. The retailer complains to the manufacturer, finally realizing that the color of the ordered item is discontinued. Meantime, the customer may return the item to the retailer without knowing that it was sent directly from the manufacturer. When the retailer receives the item, it must then return it to the manufacturer. All of the accounting logs, payments, and invoices must be cancelled and additional shipping documents must be processed. All of these steps waste the time of everyone involved.

In order to prevent cases like the above-mentioned scenario from happening, real-time data synchronization within the manufacturer and throughout the supply chain is necessary. However, when an organization develops its own automated computerized system, it may need to integrate several systems into its own internal system which may be cost prohibitive, if at all possible. With the globalization of supply chain, data synchronization now is conducted on a global scale, which means that any entity in the world can participate in the data synchronization about the product and all related transaction information. The achievement of global data synchronization requires standards, a platform, and systems that are accepted by every participant. All participants, as well as their branches, warehouses, and other locations must be uniquely identified. Furthermore, each item and transaction must be uniquely identified. An operational logic and coordination mechanism of data synchronization must be established. Standards for data format must be defined. Many organizations have been working on these issues. Notable standards-building efforts include [Bowling et al., 2004]:

- Global Data Synchronization (GDS) The Global Commerce Initiative (GCI), European Article Numbering (EAN International, now GS1) and the Uniform Code Council (now GS1 US) established this initiative to define the process and standards for information cleansing and synchronization including the standards and protocols for synchronization messaging.
- Global Standards Management Process (GSMP) The EAN/UCC established the Global Standards Management Process to define a single set of item standards that would be used across the industry. The GSMP has defined the Global Trade Identification Number (GTIN), which identifies unique products and the Global Location Number (GLN), which identifies unique locations of business entities. January 1, 2005 was a sunrise date to adopt GTIN.
- Global Product Classification Schema (GPCS) The GCI and EAN/UCC have worked to establish the Global Product Classification Schema in order to consistently classify products between retailers and manufacturers. Global Data Dictionary (GDD) specifies what attributes an item should have and identifies the attributes of a party [Cap Gemini Ernst and Young, 2002].

These standards are elaborated in the following sections.

III. GTIN, GLN, EPC AND HISTORY OF STANDARD IDENTIFICATION CODES

As mentioned previously, successful implementation of GDS requires unique identification of participating organizations, their branch and warehouse locations, items, and transactions. Those unique identifiers must be standardized and accepted globally. GLN (Global Location Number) and GTIN (Global Trade Item Number) are currently used for this purpose. With the conjunction of RFID technology, EPC (Electronic Product Code) is receiving attention in tracking items in a supply chain. This section presents the history of those standard identification codes to understand their roles in GDS.

Standard product codes are typically implemented as barcodes. The barcode was invented in 1949 by Norman Joseph Woodland, a graduate student at the Drexel Institute of Technology in Philadelphia. Woodland's original barcodes used thick and thin lines instead of dots and dashes [Kantor, 2004]. In 1952, Woodland and Bernard Silver filed a patent for the system [Kantor, 2004]. An IBM team led by George Laurer redesigned it into the current format on April 3, 1973 for the UCC (Uniform Code Council, then called Uniform Grocery Product Code Council: UGPCC) as UPC (Universal Product Code) [Kantor, 2004]. This 12-digit item identification standard is also called UCC-12 or UPC-A, and it was used for the first time in 1974 in the United States [Jilovec, 2004]. Since then, this standard has been adopted by businesses in North America. Following UCC-12, EAN (European Article Numbering system), a 13-digit item identification standard renamed EAN/UCC-13, was introduced in 1977 in Europe [Jilovec, 2004] as a superset of UCC-12 by adding one more digit to UCC-12 to accommodate more products supplied by manufacturers around the world and the first digit was set 0 for UCC-12. Many countries use EAN/UCC-13 with different names. For example, JAN (Japanese Article Numbering system) is a Japanese version of EAN/UCC-13 and its country code was set to 49. Since then, EAN/UCC-13 system has been used worldwide, except for the U.S. and Canada. Later, EAN/UCC-8, an 8-digit standard adopted by EAN, was introduced as a shorter version of EAN/UCC-13 for items too small for the EAN/UCC-13. The multiple standards used in different regions of the world caused some issues as globalization of trading became more common. In order for manufacturers in countries other than North America to sell their products in North America, they must have re-labeled with the UCC-12, creating additional expenses and time-to-market issues [UCC Inc., 2003].

To improve global supply chain efficiency, the UCC proposed an initiative called 2005 Sunrise in 1997, which required that by January 1, 2005 all U.S. and Canadian companies must be capable of scanning and processing EAN-8 and EAN-13 symbols, in addition to 12-digit U.P.C. symbols at Point-of-Sales [UCC, 2003]. Meanwhile, UCC/EAN[1] attempted to make the standard globally applicable by proposing a 14-digit all-numeric scheme called Global Trade Item Number (GTIN or often called EAN/UCC-14) [Jilovec, 2004]. GTIN is capable of uniquely identifying products and services up to 151 attributes [Intel Corporate, 2004]. Nevertheless, GTIN is not a new symbology or a new standard. It is rather a structure to globally standardize several different symbologies. Thus, the GTIN structure encompasses EAN/UCC-14, EAN/UCC-13, UCC-12 (UPC), and EAN/UCC-8. As shown below (Table 2), a GTIN can be one of the four numbering standards that are right justified and 0's are filled in front of them.

Table 2. GTIN Structure (Source: EAN International and UCC, Inc. 2005. Figure 1.3.1-5)

Data Structures	**GTIN Format***													
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}
EAN/UCC-14	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}	N_{14}
EAN/UCC-13	0	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}
UCC-12	0	0	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}
EAN/UCC-8	0	0	0	0	0	0	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8

The first digit of GTIN represents the packaging indicator: 0 is no package hierarchy or for mixed case; 1 though 8 means package level of the base GTIN; 9 means variable measure item [Jilovec, 2004]. The second through 13th digits represent company prefix (can be 3 to 10 digits) plus item references [Jilovec, 2004], identifying each product of every company uniquely. The last (14th) digit is a check digit [Jilovec, 2004]. The company prefix, has a variable length (UCC used a fixed 6 digit code for company before 2005 Sunrise). GS1 assigns a shorter company prefix for a company who produces a larger number of items and a longer company prefix to a company who produces a small number of products. When GTIN is implemented as a barcode,

[1] In 2002, UCC joined EAN International as a member of UCC/EAN, which became GS1 in 2005.

in addition to the indicator, company prefix, item number and check digit, an application identifier might be needed in order to define the type of barcode or symbology being used [Jilovec, 2004].

There are several important properties of GTIN that deserve further discussion. First, although the company prefix code is assigned by GS1, each company is responsible for selecting one of EAN/UCC-14, EAN/UCC-13, UCC-12, or EAN/UCC-8 and assigning the item number [Jilovec, 2004]. Each company must be responsible for adjusting its own files and database to accommodate 14-digit item numbering scheme. Also, it is the company's responsibility for the decision on whether it uses different item numbers with the same package indicator (Method 1 in Table 3), the package indicator with the same item number (Method 2 in Table 3) for a pallet, package, case, and unit of an item or the combination of the two (Method 3 in Table 3) [Jilovec, 2004].

Second, the Company Prefix is no longer issued as a 6-digit number; its length varies. Because of this, business applications may need to be modified to accommodate this practice [UCC Inc., 2003]. Third, the GTIN is used with Reduced Space Symbology (RSS), which is an emerging method for tagging small items [Intel Corporation, 2004]. RSS are often used in fresh meat, pharmacy, and medical/surgical products [UCC Inc., 2003]. Fourth, being "2005 Sunrise Compliant" requires only having an ability to scan EAN/UCC-8, EAN/UCC-13 and UCC-12 at POS by January 2005, but not EAN/UCC-14 [UCC, 2003]. Meantime, being "GTIN Compliant" requires having an ability to scan all of the four numeric schemes, including EAN/UCC-14 at POS; however, it does not require an ability to scan RSS although RSS is under the umbrella of GTIN [UCC Inc., 2003]. Emerging Electronic Data Interchange (EDI) standards may be capable of distinguishing and recognizing the 14-digit GTIN structure [Intel Corporation, 2004].

Table 3. Different Methods of Item Numbers Assignment (Source: Jilovec, 2004)

Method 1	**Package Indicator**	**Company Prefix**	**Item Number**	**Check Digit**
Pallet of items	0	XXXXXXX	12345	C
Package of items in a pallet	0	XXXXXXX	23451	C
Case of items in a package	0	XXXXXXX	34512	C
Unit of item in a case	0	XXXXXXX	45123	C
Method 2	**Package Indicator**	**Company Prefix**	**Item Number**	**Check Digit**
Pallet of items	7	XXXXXXX	12345	C
Package of items in a pallet	5	XXXXXXX	12345	C
Case of items in a package	2	XXXXXXX	12345	C
Unit of item in a case	0	XXXXXXX	12345	C
Method 3	**Package Indicator**	**Company Prefix**	**Item Number**	**Check Digit**
Pallet of items	4	XXXXXXX	12345	C
Package of items in a pallet	2	XXXXXXX	12345	C
Case of items in a package	0	XXXXXXX	12345	C
Unit of item in a case	0	XXXXXXX	23451	C

In addition to GTIN, Global Location Number (GLN) is another key component for GDS and collaborative supply chain management. GLN, like GTIN, is not a new symbology, but it is a new way to identify the location of a physical, functional, logical or legal entity in a supply chain [Jilovec, 2004]: (1) Legal entities include the whole company, subsidiaries or divisions, such as suppliers, manufacturers, distributors, customers, banks, forwarders, and retailers; (2) Functional entities include a department within a legal entity that performs a specific function, such as accounting and production departments; and (3) Physical entities include a particular structure in a building, such as warehouse, warehouse gate, delivery point, transmission point, and receiving point [UCC Inc., 2002]. The GLN structure includes EAN/UCC company prefix, location reference and check digit (Table 4). EAN/UCC is responsible for assigning the company prefix, but each company is responsible for assigning the location reference number. The main use of GLN is as a reference key for the retrieval of information of an entity from a database, such as postal address, type of the entity, contact person, and contact phone [EAN International, 2005].

Table 4. GLN Structure (Source: Jilovec, 2004)

EAN/UCC Company Prefix								**Location Reference**				**Check Digit**
N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}

The widespread deployment of Radio Frequency Identification (RFID) can be attributed to the development of Electronic Product Code (EPC) [Intel Corporate, 2004], which in turn is based on GTIN code. The EPC consists of the GTIN for a product and a serial number. The EPC, combined with the RFID technology, is mainly adopted by the Consumer Packaged Goods industry and major retailers to identify each instance of a unique product [Jilovec, 2004]. Along with GLN, the EPC is capable of identifying individual instance of a product item at specific locations, at a specific point of time [Intel Corporation, 2004]. The success of the EPC relies on its integration with GDS, which provides a mechanism to retrieve the extended product and company attribute information as items move through a supply chain [Intel Corporation, 2004]. In 2003, EAN and UCC acquired the EPC technology from MIT and initiated EPCglobal to support the interaction of GDS and the EPC network [Intel Corporation, 2004].

Without standards for data format, efficient data exchange among partners in a supply chain is impossible. GTIN and GLN are key components of identifying each item and each location of a supply chain. These data standards are essential to GDS. This section described in-depth GTIN, GLN, EPC and history of standard identification codes. The next section will discuss the components and process of GDS in detail.

IV. COMPONENTS AND PROCESS OF GLOBAL DATA SYNCHRONIZATION NETWORK

DEVELOPMENT HISTORY OF GDSN

Traditionally, exchange of paper documents (such as catalogs) has been the major mechanism for synchronizing data about items between trading partners. Then EDI replaced paper exchange at many organizations and reduced a significant number of errors, omissions and inaccuracy of data; however, EDI does not eliminate situations of “garbage in, garbage out” and “data obsolescence” from time lag of synchronization. This is because, in order to be cost-efficient, EDI is a batch process [Jilovec, 2004]. Quick Response Services (QRS), an online catalog provider, tried to reduce the time-related issue associated with EDI, but it did not address the issue for non-EDI-compliant partners because its services needed to use Value-Added Network (VAN) or direct links [Jilovec, 2004]. To handle the above issues in 1999 UCC formed UCCnet, a global, Internet-based service to define standards for data compliance and synchronization [Jilovec, 2004].

Meantime, nationwide initiatives have been launched to provide efficient mechanisms to support master data synchronization between trading partners. There have been various data pools, databases that contain manufacturer and product information for sharing, created around the world, most of which are affiliated with EAN/UCC organizations [Global Commerce Initiative, 2001]. Following EAN International recommendations, the EDI project team of ECR (Efficient Consumer Response) Europe initiated a pilot project of "Master Data Alignment" with a central data pool in 1997 [ECR Europe, 1999a]. Since then, several EAN compliant data pools have been developed with a variety of structures, rules and functions. The ECR Europe EDI committee concluded in 1998 that there would be a problem of interoperability among those data pools in the future [ECR Europe, 1999b]. ECR Europe Inter-Operability of Data Pools (IODP) project team in 1998 recommended the creation of a network of identical inter-operated data pools, each of which is a single local (national, regional, or private) International Data Pool to use the already existing local data pools.

In July 1999, EAN and UCC together initiated the development of an international standard for master data alignment, called the Global Data Alignment System (GDAS) and its first version was published in January 2000 [Global Commerce Initiative, 2001]. GDAS, representing Global Master Data Dictionary, was considered as one of the most important industry standards that all existing and future data pools should follow to achieve the objective of a Global Data Synchronization supported by GDAS compliant data pools [Global Commerce Initiative, 2001]. In 2000, the Global Commerce Initiative (GCI) endorsed GDAS as a global standard [Global Commerce Initiative, 2001]. In 2001 and 2002, the Global Data Synchronization Group of GCI produced three reports [Global Commerce Initiative, 2001, 2002a, 2002b] detailing the vision, business requirements, and specifications of Global Data Synchronization process.

Under the GCI, the UCC and EAN further developed necessary standards for GDS through Global Standards Management Process (GSMP), which was launched in January 2002 to maintain standards-based solutions for global trading using EAN/UCC System technologies [Cap Gemini Ernst and Young, 2002]. GSMP is a global consensus building process to develop supply chain standards by identifying business requirements from users in all industries, all over the world, to establish a uniform approach and methodology for global standards management [EAN/UCC System, 2005]. It ensures that the standards are independent of any single specific technology and that all participants are certified for compliance with those standards [Cap Gemini Ernst and Young, 2002]. GTIN and GLN mentioned in Section III are part of the GSMP initiative [O'Neill and Williams, 2003].

In 2004, the Global Data Synchronization Network (GDSN), an Internet-based supply chain initiative, was created by UCC and EAN for smooth communication of product information over the Internet [Intel Corporation, 2004]. The GDSN implements extensible markup language (XML) to improve the interchange of product data among the various data pools by translating data in a variety of formats such as XML, EDI, and spreadsheet formats provided by suppliers into a common set of XML schema [Intel Corporation, 2004]. GDSN includes a global registry (the GS1 Global Registry), data-pool services, and functional mechanism of GDSN. GS1 Global Registry functionality required for the operations of GDSN became effective on August 1st of 2004 under the jurisdiction of EAN International. The registry is being operated as a separate, neutral entity by EAN International [Global Commerce Initiative, 2002a]. At that time, a GDSN data pool communication test conducted by the Drummond Group Inc. (DGI) under the supervision of the GDSN Oversight Committee ensured that the data pools created by the initial group of companies (bTrade, Inc., CABASnet, Global eXchange Services (GXS), WorldWide Retail Exchange (WWRE), Sterling Commerce, Transora, and UCCnet) were interoperable with at least two other data pools and the GS1 Global Registry. By December 17, 2004, ten data pools successfully passed the GDSN Interoperability Certification test [GS1, 2005b], and those ten are:

- Click Commerce Data Pool v2.0 from Click Commerce, Inc.,
- GS1 UK Data Pool v5.0 from e.centre,
- ECCnet v5.0 from Electronic Commerce Council of Canada (ECCC),

- Data Pool Manager v5.0 from Global eXchange Services, Inc.,
- Data.Cod v1.0 from GS1 Argentina,
- CABASnet v2.0 from IAC Colombia,
- SINFOS Data Pool Germany - Food/Non Food v4.1 from SINFOS GmbH,
- Transora Data Pool v5.0 from Transora,
- UCCnet™ Data Pool Services v2.4 from UCCnet™, and
- WorldSYNC DX Release v3.2 from WorldWide Retail Exchange (WWRE).

As of September, 2005, there are 26 certified data pools [GS1, 2005c]. Figure 2 shows the timeline of the development of GDS and GDSN standards.

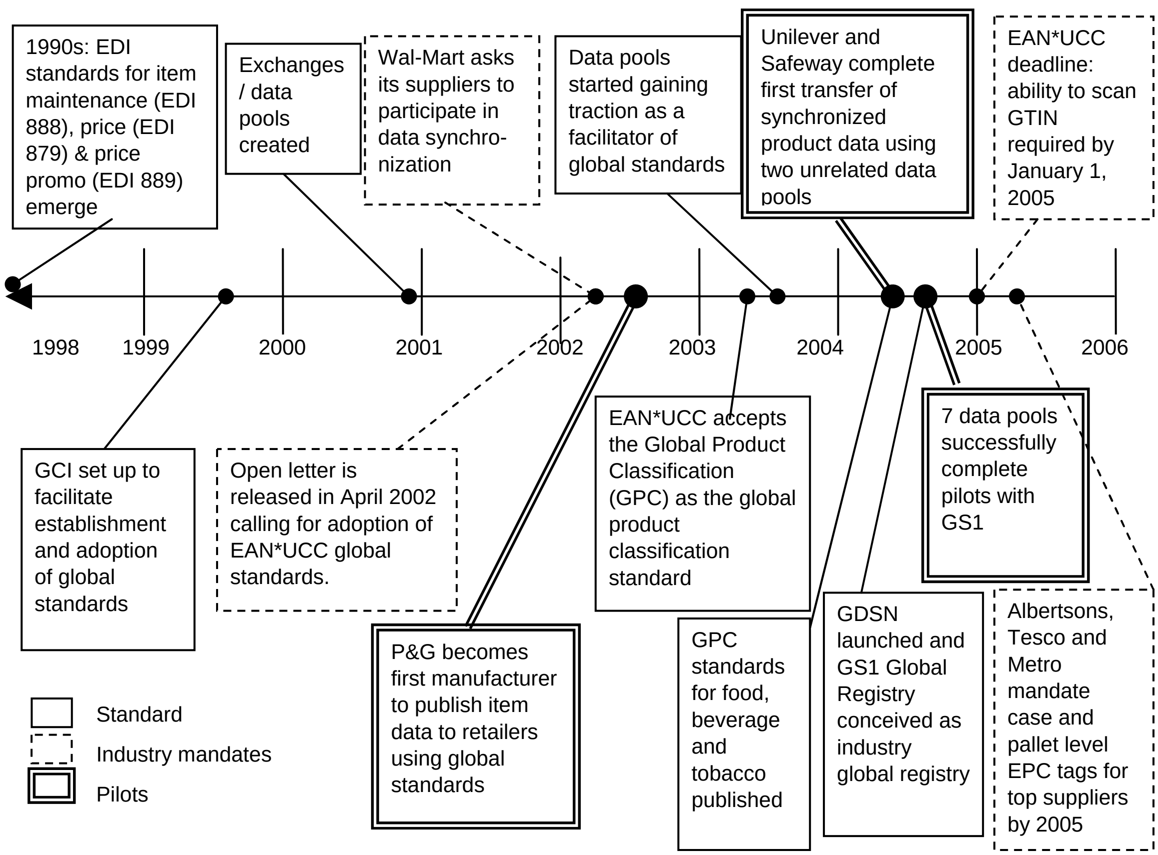

Figure 2. Timeline of GDSN Development (Source: Bowling, Lincul, and Van Hammond, 2004, p. 9)

COMPONENTS OF GDSN

There are two primary components in GDSN: data pools and the global registry. GDSN was developed under the Global Commerce Initiative (GCI); thus, the global registry and data pools follow the technical specifications detailed in three reports published by GCI [Global Commerce Initiative, 2001, 2002a, 2002b]. The global registry and data pools are two pillars of GDS.

- Data pools: "A Data Pool is a repository of GCI/GDAS data where trading partners can obtain, maintain, and exchange information on items and parties in a standard format through electronic means" [Global Commerce Initiative, 2001, p. 8]. In essence, a data pool is an electronic catalog of standardized item and price data. Also, a data pool functions as a transport service of standardized data between trading partners. A data pool can be maintained either externally by a third party or internally as part of an integration engine or collaborative product information management (CPIM) system [O'Neill and Williams, 2003]. Third-party maintained data pools include: ECCC (Canada), e-centre (UK), Gencord (France), GDSN Service GS1 (Taiwan). SINFOS (Germany), Global eXhange Services, UCCnet, Transora, WorldWide Retail Exchange, Sterling Commerce, bTrade, and CABASnet. It is noteworthy that the consolidation of the industry is underway. For example, UCCnet and Transora are considering a merger.
- Global Registry: "A Registry is a global directory for the registration of items and parties. It can only contain data certified to be GCI compliant. It federates the GCI/GDAS compliant data pools and acts as a pointer to the data pools where master data has been originally and physically stored" [Global Commerce Initiative, 2001, p. 8]. This registry works as the "single" item registry where suppliers register their trade items by standardized classifications and retailers can look up and access core item information [O'Neill and Williams, 2003].

As shown in Figure 3, data pools and the global registry proposed by GCI are connected as one logical data pool, constituting the GCI GDS Network, to make all required master data available to users in a standardized and transparent way [Global Commerce Initiative, 2001]. The global registry is accessible only from a GCI certified data pool. The data flows between the registry and data pools are based on GCI certified XML messages [Global Commerce Initiative, 2001].

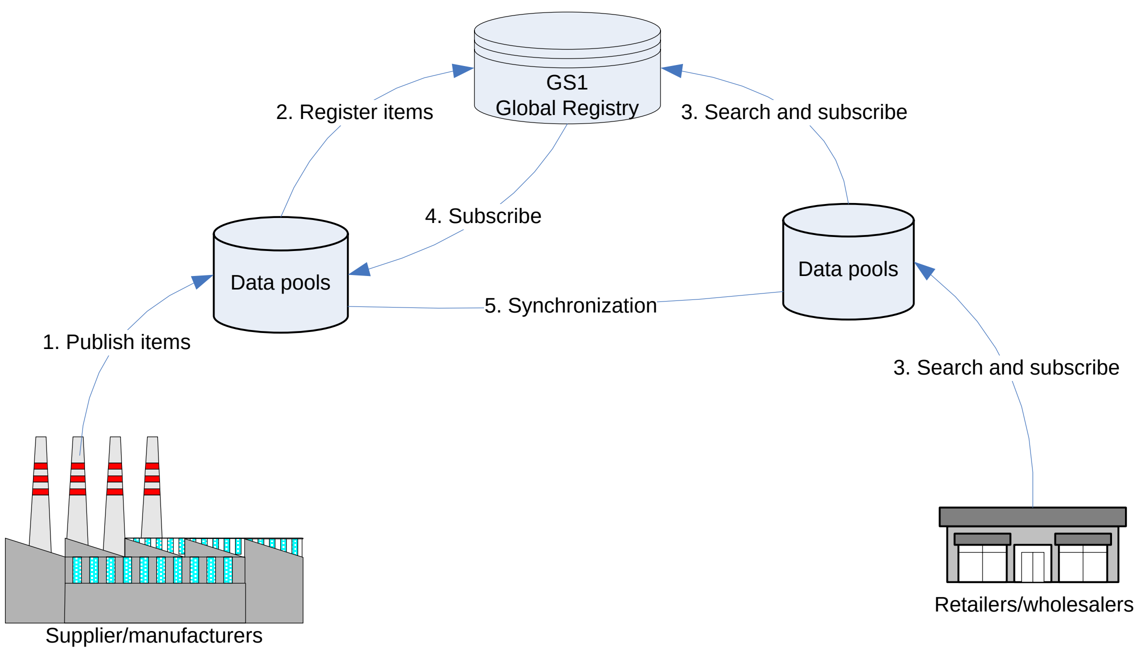

Figure 3. Major Components and Process of GDSN

In addition to the global registry and data pools, two additional components, which undertake the synchronization and integration work, are necessary to implement GDSN [O'Neill and Williams, 2003]:

- Publication and synchronization engine: While the global registry provides a comprehensive catalog which is accessible to all data pools and trading partners, the job of publishing and synchronization between trading partners is usually carried out at the level of data pools. The publication and synchronization engine at the supplier's data pools publishes the data to the retailer's data pool. Following the EAN.UCC rules, the engine verifies accurate exchange of updates to item and party records between trading partners. Meanwhile, the engine ensures the accuracy of syntax of all GCI/GDAS data elements with the Global Data Dictionary [Global Commerce Initiatives, 2001]. In other words, the major function of the engine is to facilitate external synchronization [Sterling Commerce, 2004], which will be discussed later.
- Integration engine/collaborative product information manager (CPIM): Ideally, before the item data is submitted to a data pool, the publisher needs to assure internal synchronization [Sterling Commerce, 2004]. The submitted data should be consistent and accurate across different departments and systems. Internal synchronization can be manually carried out or achieved through an internally maintained integration engine or CPIM system or a separate, external data pool. The integration engine collects data from multiple databases of an organization and creates an internal master item data catalog. Item information can then be cleansed and standardized for publication to the data pool. A CPIM system can be used to customize data for specific partners who require additional item information beyond that defined by the core standards.

DATA ATTRIBUTES IN DATA POOLS

Business organizations generally need two types of data: neutral data and relationship-dependent data. Neutral data are those publicly shared with any partners. Relationship-dependent data are those available for only a particular partner. There are three categories of neutral data:

- Core product data - data attributes describing all instances of any product (e.g., description, brand name, packaging, dimensions, etc.)
- Category specific data – data attributes applicable to specific product categories only (e.g., the color, grape, and strength of a bottle of wine)
- Target market data – data attributes specific to products in a particular market (e.g., packaging indicators in a specific country) [Bowling et al., 2004]

Relationship-dependent data are "attributes that concern all terms bilaterally agreed and communicated between trading partners such as marketing conditions, price information and discounts, logistics agreements and more" [Bowling et al., 2004, p. 5]. The initial implementation of the GDS vision focused on the neutral data as shown below [Global Commerce Initiative, 2001; Bowling et al., 2004]. Currently there are 151 plus attributes to support EAN/UCC System standards, 44 of those are mandatory.

The minimum data contents about items in a data pool include:

- GTIN
- Item description
- GLN of data source, owner of the data
- Party name of the data source
- Merchandise Classification Code (breaking levels) and description
- Start availability date of the Item
- Target market
- Public / private item flag (Y / N)
- Date and time of last change
- Pointer to the data pool where original master data are stored

The data contents about the Party include:

- GLN, party name, state, country
- GLN of data source, owner of the data

- Name of the data source
- Party classification (not yet available)
- Role of party
- Party capabilities / profile
- Start availability data of the Party
- Date and time of last change

Companies, such as Wal-Mart [Wal-Mart, 2005] and Staples [Staples, 2004], decided what attributes were mandatory based on the standards, considering their own data requirements, and the readiness of their business partners.

The industry is also making an effort to establish standards around price sharing. Following the GDS vision, prices can be shared when using the following three criteria together:

- The condition document: This lists the requirements associated with a component of the price.
- The trading partner profile: This captures the basic “rules” which trading partners agree will govern their exchange of data.
- The monetary document: This includes actual numerical amount of a price component [Bowling et al., 2004, p. 8]

As of August 2004, several standards including Price v1.3.1 (attributes describing the price such as gross or net price, period of validity for the price, etc.) have not been implemented [GS1, 2005a]. Once these standards are implemented, synchronized pricing data help resolving issues such as manual data entry errors, discrepancies between orders, and invoices [Bowling et al., 2004].

PROCESS OF GDSN

The basic process of GDSN works as follows [Global Commerce Initiative, 2001; EAN International, 2004]:

1. A data source provider (called publisher), such as a supplier, manufacturer or distributor, prepares the data about their organizations and/or data about their items by following the GDSN standards for publication. In a typical case, data source providers may use the integration engine/collaborative product information manager (CPIM) described above to prepare the data.
2. The data source then sends the data to the data pool that it subscribes service from, and the data are stored in the data pool.
3. Optionally, the data source may specify whether the data will be available only to selected parties or to all parties in a given market using its data pool.
4. The data pool validates the (new or updated) data for compliance with GCI/GDAS Data Standards, Principles and Rules. The uniqueness of its GTIN and GLN is checked by the Global Registry.
5. The data pool registers the data with the Global Registry, which will hold the information about which data pool owns the data. It should be noted that the registration process is initiated by the data pool and executed by the Global Registry.
6. A retailer or buyer (called subscriber) may search items or parties it wants to subscribe to in the Global Registry through its data pool. The items are identified with GTIN, GLN, Target Market and parties with GLN by the Global Registry.
7. Once the data are subscribed, the synchronization engine (typically implemented in data pools) automatically performs publication/ subscription processes as follows without involving the Global Registry:
    - The data source’s data pool sends an electronic notice to a subscriber when a data is added or changed based on the subscriber’s (retailer’s) subscription profile.

- The subscriber sends, through its data pool, to the data source "agreement (or rejection) to synchronize" in order to regularly integrate new information into its back end system.
- The data source accepts the notification of authorization from the subscriber.

Communications between subscribers and their publishers are mainly conducted through data pools. For example, when a subscriber needs to know the status of a particular event or data, instead of directly contacting the publisher of the item, the subscriber submits the inquiry to his/her data pool, which in turn relays the inquiry to the publisher's data pool. Also, a subscriber can search and browse parties and items in the Global Registry via their data pools. Security and authentication data are stored in data pools and the processes of the security and authentication are executed in the data pool too [Global Commerce Initiative, 2001].

All the above synchronization processes are enabled using EAN.UCC XML communication standards (called Business Message Standards). Here, we summarize the major characteristics of the communication standards specified in various reports published by GS1 (The EAN.UCC System standards for the GDSN are available at www.gs1.org/GDS under the Technical Section):

The schemas are organized into three distinct layers: Envelope, Message, and Document. Every layer is wrapped inside the other and combines to form an XML message. The schemas are applied to make each layer independent of each other. A change in one layer does not affect other layers, achieving higher reuse. Several business documents can be packed and transmitted in one envelope, making a transmission more efficient.

The Envelope layer carries fundamental transport information such as sender, recipient, message identification, security, and guaranteed message delivery information. It allows for using standards such as EDIINT-AS2, SOAP or ebXML although the currently recommended and supported standard is AS2 Envelope. The transport method used by AS2 standard is HyperText Transfer Protocol. The Message layer specifies actions as commands (e.g. "Add", "Delete", "Change", etc.) to be performed on the specific document or documents by an application at the destination. The Message layer has three primary components: transaction, command, and an interface to the Document Layer. Document layer holds the actual business documents that are exchanged between trading partners by containing either the complete document itself, an internal reference to a document (GLN, GTIN), or an external reference to a document (URL). The documents are organized following typical business processes, such as order business process and delivery business process. Manufacturers and retailers need to make necessary implementation and adjustment on their systems, such as the back-end connectivity, transaction management, data validation, mapping and translation, messaging process, security, and transport management including guaranteed delivery and protocol handling [Joshi and V, 2003], to enable the messaging with the Registry and Data Pool.

V. GDS IMPLEMENTAION AT BUSINESS AND CHANLLEGES

STEPS FOR GDS IMPLEMENTATION

While variations exist among the implementation procedures proposed by different vendors [e.g., GS1, 2005a; Cap Gemini Ernst and Young, 2002; Joshi and V, 2003; O'Neill and Williams, 2003; Bowling et al., 2004; EAN International 2004], the basic steps to implement GDS could be summarized as follows:

1. The company that is implementing GDS must ensure that its trading partners and itself adopt the EAN/UCC GTIN, GLN, GDD, and GPC standards by following the following steps.
    - Define and implement the process of assigning GLN to all locations in the company and GTIN to all items.

   - Ensure that the company's item numbering is "GTIN compliant," (at least "Sunrise 2005") and able to read all the numbering schemes specified in the GTIN structure.
2. The company needs to decide on whether to use its own data pool or connect to a third party data pool. It might be more cost-effective for small/medium-sized enterprises to use a third party data pool.
   - Ensure that the data pool with a synchronization engine is certified as EAN/UCC standard-compliant and is interoperable with other data pools and the GS1 Global Registry.
3. The company must clean up its internal data and make sure that it can send/receive all data attributes to/from its trading partners in a Global Data Dictionary (GDD) compliant structure. This process is often called the internal data synchronization, which will be explained in detail later.
4. The company needs to subscribe to the GS1 Global Registry.
5. The company should start pilots with a small number of partners that are committed to developing the capabilities required to exchange clean and standard compliant data.
   - Monitor results and make necessary changes in workflow, processes, and information systems before moving to full production.
6. Finally, the company should move to the full adoption of GDS.

The implementation procedure may vary, depending on which external data synchronization model the data source chooses. Those external data synchronization models are discussed in the next section.

CHALLENGES TO GDS IMPLEMENTATION

Companies may face several major challenges when they attempt to implement GDS. Challenges include: (1) How to achieve the internal data synchronization as a pre-requisite to GDS; (2) How to achieve external data synchronization; and (3) How to obtain and sustain support from the management and from trading partners.

Internal Data Synchronization

The first, and most, critical challenge is the need to achieve internal data synchronization as a pre-requisite for GDS. The meaning of internal data synchronization is twofold: First, the organization needs to clean the data and have a single version of item and partner data that its internal information systems can rely on. Second, it needs to establish an organization-wide, on-going business process, and a set of rules to maintain the data in that manner [Intel Corporation, 2004]. The need for internal data synchronization is critical. Many organizations have not built corporate-wide data integrity, having several versions of item and pricing information at different sections/locations. Moreover, data are sometimes incorrectly keyed-in and the data validation process is not performed in a timely fashion. All of these contribute to the problem of different versions of the same story. Furthermore, the organization needs to determine what information about the item should be maintained internally and shared with its business partners in respect of the EAN/UCC attribute standards and partner's information requirements.

The company needs to determine how to manage data to maintain their quality. This process is generally called Product Information Management (PIM). Achieving PIM requires the identification of all internal data storage locations (e.g. files, databases, catalogs, look-up tables) in which the information elements can be found, every business application that uses them, and every point where they can be modified, including input, updates, and deletions. After the internal data are identified, they need to be mapped to a set of attributes that the company has decided to track and share. The accuracy and completeness of the data must be assessed and the data must be cleansed, if necessary. In case the required data do not exist in the organization's current systems, the sources of the data must be identified. If data are in multiple locations, the primary owner, who is responsible for modifying the data, must be identified and rules for the data modification must be established. Unauthorized modification should not be allowed.

Specifically, issues related to internal data synchronization include: (1) the continuously evolving standards regarding data attributes, (2) data requirements specific to certain business partners, (3) data currently not-maintained internally but required by standards and/or partners, (4) assessment of the current compliance level of GTIN and GLN, (5) developing a strategy to assign GTIN and GLN because any change could affect the current applications and data sources, (6) integrating heterogeneous applications, databases and IT resources, and (7) upgrading IT infrastructure to handle an increasing volume of data exchange within the organization for mapping, transforming and synchronizing [Joshi and V, 2003; Intel Corporation, 2004, Sterling Commerce, 2004].

Large companies may need long-term projects to achieve internal data synchronization. Jilovec [2004] stated that such projects took, on average, 12 months or longer. Deploying the standard-compliant data structure across the organization requires a substantial effort in data cleansing [Cap Gemini Ernst and Young, 2002] and it is important for the organization to feel confident in the quality of the internal synchronization before progressing to external synchronization [Sterling Commerce, 2003].

To resolve this issue and automate the process, some consulting companies, such as Velosel Corporation, as well as ERP providers, such as SAP, introduced a structured approach to implement a product information management system (PIMS) and create a central data repository to integrate all business applications [Intel Corporation, 2004]. PIMS has the following characteristics [Bowling et al., 2004]:

- PIMS creates one master catalog by aggregating, cleansing, and standardizing data stored in multiple databases and by eliminating data inconsistency and making the data ready for trading partners as well as internal applications.
- PIMS distributes new product data wherever necessary once they are entered into an originating system.
- PIMS often contains centralized industry-standard validation processes, making the execution of logic at individual applications, such as ERP, customer relationship management (CRM), and supply chain management (SCM), unnecessary.

Maintaining internal data to the quality required for external synchronization is not an easy task since the internal information requirements, partner's information requirements, and the standards set in the GDSN are all continuously changing. Moreover, the business environment as well as production and operations technologies keep changing and new products are constantly invented. Due to those changes and inventions, no matter how thoroughly data attributes are analyzed and necessary attributes are identified, new attributes will emerge over time. The constant monitoring of the evolving standards and the partner requirements, as well as adjustment to the internal systems, is essential.

External Data Synchronization

External data synchronization refers to "the process of linking two or more separate and independent companies so that they can readily share consistent and accurate product information" [Gopal and McMillan, 2005, p. 60]. As discussed previously, external data synchronization is mainly achieved through the interaction between the publisher's and the subscriber's data pools. External data synchronization ensures that the publisher's copy of its product data and the subscriber's copy of the product data are consistent. Joshi and V [2003] identified several challenges related to external data synchronization: (1) managing multiple and varied needs of partners in terms of data and protocols, (2) deciding between a public or private data pool, (3) developing a strategy for integrating the data pools, (4) developing a B2B security strategy, (5) developing a reuse strategy to minimize effort for every incremental integration or partner addition, and (6) building B2B messaging capability of complying with EAN.UCC standards.

The most critical of these issues appears to be that of building B2B messaging capability of complying with the EAN.UCC standards because the messaging capability is the vehicle by which the publisher and the subscriber communicate. The building of this capability requires adjustment or new implementation on organizations' internal information systems. Two available options are (1) to purchase UCCnet software and integrate it with internal systems in house, and (2) to use a third-party service provider [Jilovec, 2004]. Several service providers offer PIMS or software that has the messaging functionality for creating and deciphering EAN.UCC XML messages.

One relevant issue is that not all business partners join GDSN and those partners mainly conduct their B2B transactions based on EDI standards such as X12 and UN/EDIFACT. However, it should be noted that through mutual agreements, those companies while not utilizing GDSN, might be able to reap the benefits of data synchronization to a certain extent. Consequently, in order to achieve external synchronization with those companies, organizations may need to support multiple standards, in addition to messaging capability for GDSN. For many companies who require only limited needs or quick implementation of the data synchronization, outsourcing to a service provider can be cost-effective [Jilovec, 2004].

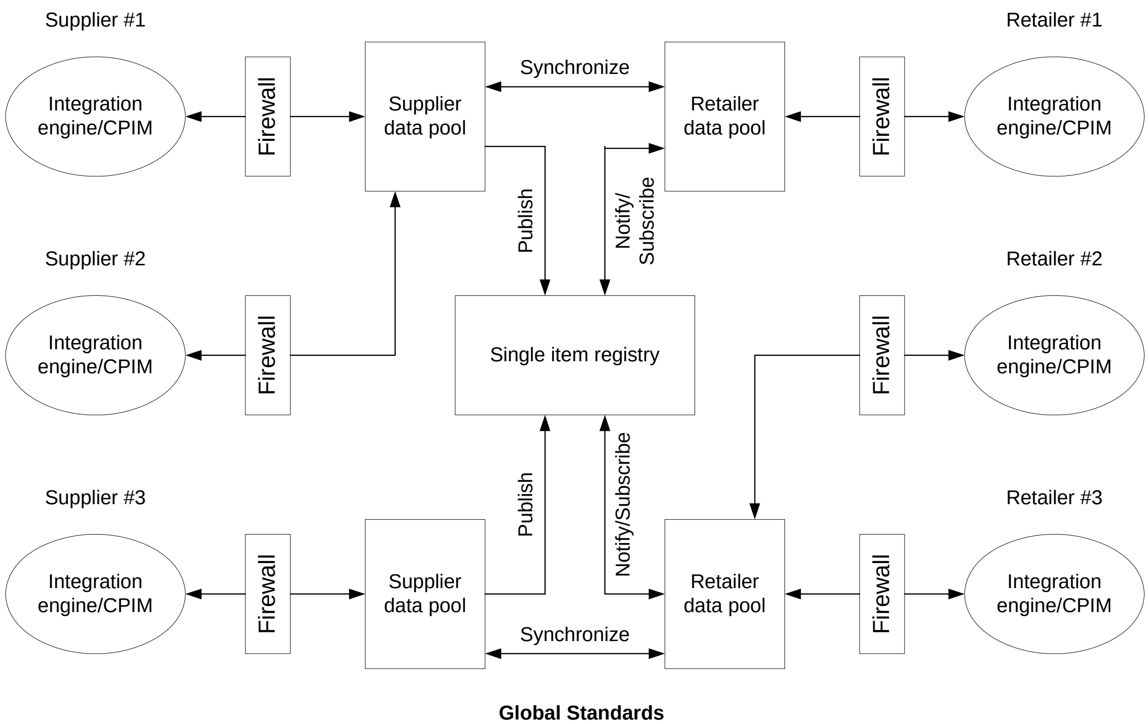

Figure 4. One-to-Many Data Synchronization (Source: O'Neill and Williams, 2003, p. 7)

Another issue is to choose a proper data synchronization model. It should be noted that the choice of model also affects the way business partners handle exchange of relationship-dependent data, such as prices and promotion. There are three different models [O'Neill and Williams, 2003; Bowling et al., 2004]: the one-to-many model, the peer-to-peer model, and the hybrid flexible model. In the one-to-many model, as shown in Figure 4, one publisher might conduct data synchronization with multiple publishers or vice versa, using interoperable data pools by following global standards. In general, those interoperable data pools are operated by third-party and are linked to the Global Registry. An advantage of adopting this model is that business partners can operate not only on the core data, but also on any extended attributes that are supported by those service providers. Because of the interoperability between data pools and single item registry, a publisher or a subscriber can easily scale data synchronization with multiple partners. A disadvantage is that because the interoperability must be based on global standards, companies adopting the one-to-many model might need to employ other measures to handle relationship-dependent data that are not supported by the standard. Also, trading partners might be concerned with the possibility that their trading data might be accessible to competitors.

The peer-to-peer model, as shown in Figure 5, is mainly used by companies that are concerned with the issue of security in the one-to-many model. In addition to security, another advantage of the peer-to-peer model is the management of relationship-dependent data. Because only two parties are involved in data synchronization, they might commonly select a GS1 certified data pool service that handles this type of data. The company may need to use the peer-to-peer model if a few key partners require relationship specific information that is not supported by a data pool.

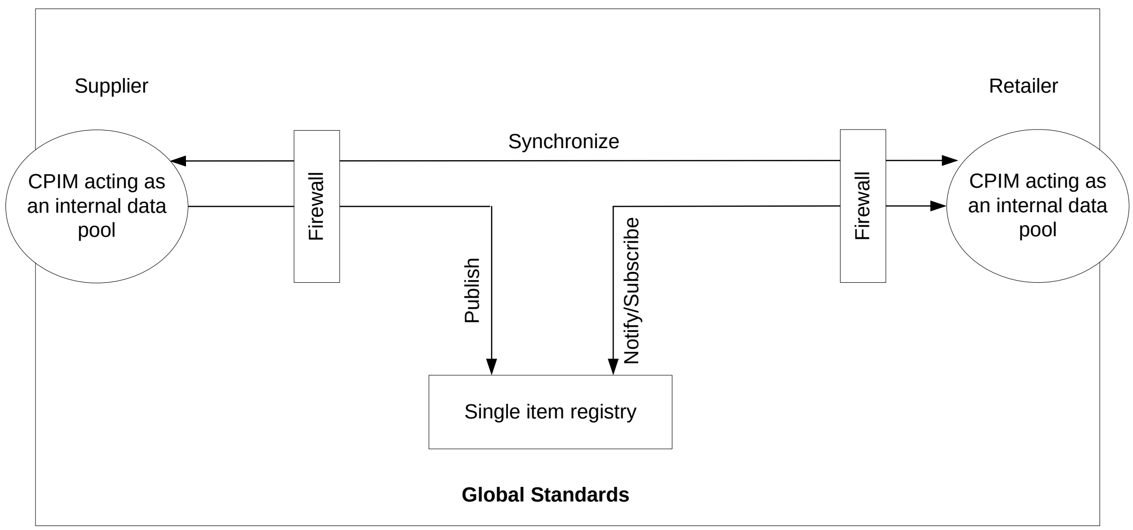

Figure 5. The Peer-to-Peer Model (Source: O'Neil and Williams, 2003, p. 7)

The third model is a hybrid that combines the system based on global standards and proprietary systems, as shown in Figure 6. The company can use a third-party value-added data pool to manage selected partners [O'Neill and Williams, 2003]. This data pool may not follow the global standards. O'Neill and Williams [2003] suggest that the third-party value-added data pool may be used by those who cannot afford investing in the system that meets the global standards, or those who need a relatively easy way to synchronize with less strategically important partners.

Some of business partners, especially small local retailers that do not currently possess IT infrastructure and expertise, may find the GDS impractical or not cost-effective and may continue to use paper-based information exchange. Thus, an organization that implements GDS may have to run EDI, GDSN, peer-to-peer, third party value-added data pools, and paper-based systems. Consequently, Bowling et al. [2004] propose a flexible GDS approach to incorporating those existing technologies and handle relationship-dependent requirements as shown in Figure 7 that uses all of GDSN, peer-to-peer, and third-party value added data pool.

However, it should be noted that as other technologies underpinning B2B activities, the choice of data synchronization technology might be determined by the market structure. For example, Home Depot sent out a letter to its suppliers, "we require your company to electronically publish this data to The Home Depot directly from your company, your data pool or through one of our Preferred Data Sync Partners" [The Home Depot, 2004, p. 2]. Furthermore, Wal-Mart, Albertson, and the Department of Defense mandate the use of EPC for their top suppliers. However, this “mandatory” strategy could affect the trust level of business partners, which is essential for successful e-collaboration [Welty and Becerra-Fernandez, 2001].

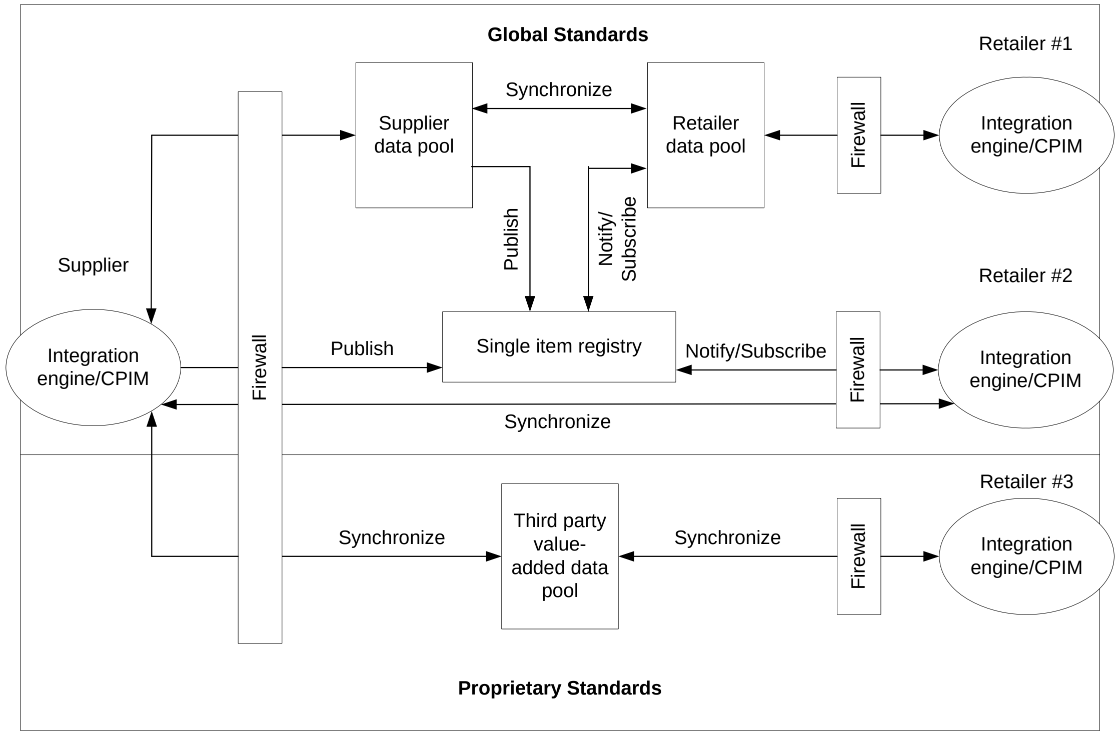

Figure 6. A Hybrid Model for Data Synchronization
(Source: O’Neill and Williams, 2003, p. 7).

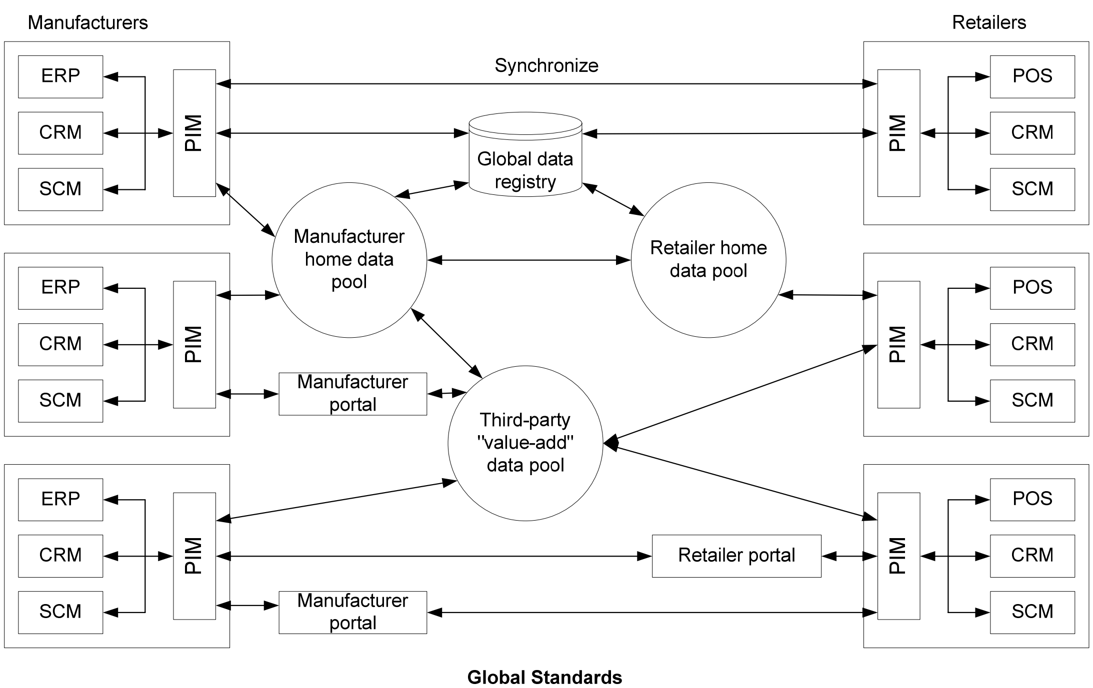

Figure 7. A Flexible Approach to GDSN (Source: Bowling, Licul and Van Hammond, 2004, p. 23)

Management and Business Partner Issues

GDS requires an organization-wide effort to achieve internal data synchronization and adjustments to its internal information systems. The commitment from senior management is essential and must be communicated internally throughout the organization. Furthermore, just like other inter-organizational relationships, the relationship built upon GDS demands a long-term commitment. Additionally, GDS cannot be achieved without commitment from business partners. Mutual commitment and trust are pre-requisite to the success of GDS between trading partners. To obtain commitment from management, GS1 [GS1, 2005a] recommends building company-specific business case key performance indicators. Also, GS1 advises defining the benefits by assessing the current business processes and estimating the implementation costs by evaluating current IT infrastructure. Finally, GS1 recommends building a project plan, tracking the benefits, and maintaining visibility of the overall progress. The implementation cost of GDS could be expensive. The end users of GS1 Global Registry must pay an annual subscription fee (see Table 5). The fee is currently determined by the parent company's annual sales/turnover, adjusted by the gross national income per capita index of the country where the company's headquarters are located in order to make pricing consistent with local economies [GS1, 2005a]. In addition to the Global Registry subscription fee, companies may need to pay fees for a data pool [Bowling et al., 2004].

Table 5. Annual Fee for Global Registry (Source: GS1, 2005a)

Worldwide Annual Sales (In Millions $)	GS1 Global Registry Annual Fee (U.S. Dollars)
Less than or equal to 5	$ 100
Greater than 5 to 10	$ 150
Greater than 10 to 15	$ 225
Greater than 15 to 20	$ 300
Greater than 20 to 25	$ 375
Greater than 25 to 50	$ 625
Greater than 50 to 75	$ 1,250
Greater than 75 to 100	$ 1,875
Greater than 100 to 500	$ 2,500
Greater than 500 to 750	$ 3,125
Greater than 750 to 1,000	$ 4,375
Greater than 1,000 to 3,000	$ 10,000
Greater than 3,000 to 5,000	$ 20,000
Greater than 5,000 to 10,000	$ 37,500
Greater than 10,000 to 15,000	$ 62,500
Greater than 15,000 to 25,000	$ 75,000
Greater than 25,000 to 50,000	$ 87,500
Greater than 50,000	$ 100,000

CHECK LIST FOR GDS ADOPTION

This section provides a checklist created based on a six step approach proposed by Bowling et al., [2004] and by the summarizing discussions in the previous sections. The checklist is divided into the initiation, planning, requirement determination, design, implementation, and maintenance phases.

Initiation

- Assess the current business goals and strategy and develop a vision for GDS.
- Obtain commitment from senior management and assign a respected executive to define and oversee enterprise-wide data management strategy.
- Develop a business case for GDS with appropriate performance indicators.

- Deploy the importance of PIM (Product Information Management) throughout the organization by emphasizing product information as a business asset and revenue impact of bad data.
- Establish culture of sharing and collaboration.
- Ensure that the company and its trading partners have adopted the EAN/UCC GTIN, GLN, GDD and GPC standards.

Planning

- Develop a clear plan with key achievement milestones.
- Start with a small number of key partners and move toward full implementation.
- Identify the internal and external resources needed to execute the plans.
- Communicate the company's commitment to GDS and willingness for sharing and collaboration to a selected number of key business partners.
- Understand the status of the company's key trading partners' GDS initiatives and develop approaches to different types of partners.
- Define how the company will participate in industry activities and bodies, such as GS1, GCI and GSMP, and collaborate with other users of product information management software to communicate its business needs to industry standards bodies and partners.

Requirements Determination

- Define the company's data needs in respect of the standards, such as product attributes, classifications, partner/location data and hierarchy.
- Consider not only current requirements but also future business goals, such as the needs of the company's e-commerce and EPC initiatives.
- Determine the source of data.
- Identify all applications/people that use and change the data.
- Determine the owner of data who is responsible for the quality of the data.
- Identify source of data that do not currently exist.
- Be ready to adjust the company's data definition process so that it can easily adapt to the evolving industry landscape.
- Establish rules and business process to maintain the quality of the internal product data.

Design

- Understand relevant industry standards, product information management and data pool requirements.
- Determine whether to build or buy a GDS solution to connect to data pools.
- Design an enterprise data management solution using flexible solution architecture for evolving standards and information needs.

Implementation

- Assure that the company's IT infrastructure, especially networks, can handle an increasing volume of data exchange.
- Clean the internal product data and populate the central repository.
- Select a data pool or build its own. See Appendix I for a question list for the choice of a data pool [Bowling et al., 2004].
- Implement PIMS (Product Information Management System) by building, buying, or outsourcing. See Appendix II for a question list for the selection of PIMS software [Bowling et al., 2004].
- Implement messaging capability; integrate it with the back-end system by building, buying, or outsourcing.
- Assure appropriate level of security and audit trails are implemented.

Evaluation and Assessment

- Pilot with selected key partners.
- Develop and set up metrics and benchmarks.

- Measure benefits.
- Quantify the long-term return on investment by directly connecting to stakeholder value. Don't focus solely on short-term ROI.

Maintenance

- Monitor GDSN standards and individual data pool's compliance level to the standards and make necessary adjustment.
- Drive additional internal and cross-trading partners.
- Build deeper trade relationships with business partners through new capabilities such as collaborative demand management, product lifecycle management, and CPFR (Collaborative Planning, Forecasting, and Replenishment).
- Build a link from GDSN to EPCglobal to make one integrated network for producing a synergy effect.

VI. RESEARCH IMPLICATIONS

Similar to other emerging technologies, the appearance of GDS and GDSN presents several research opportunities and implications. Here, we identify and discuss major research opportunities and implications.

Several organizations and standard bodies [A. T. Kearney and Kurt Salmon Associates, 2004] are advocating the adoption of GDS as well as Electronic Product Code (EPC) as the foundation for achieving high level of e-collaboration as shown in Figure *8*: collaborative transaction management, collaborative supply chain management, collaborative sales and promotion planning, and collaborative product development; because those activities are based on accurate product and pricing information. In addition, GDS plays a critical complementing role to RFID and EPCglobal Network. Without sharing consistent, accurate and timely information between the trading partners through GDS, the full benefit of the EPCglobal Network may not be realized [Global Commerce Initiative and IBM Corporation, 2004].

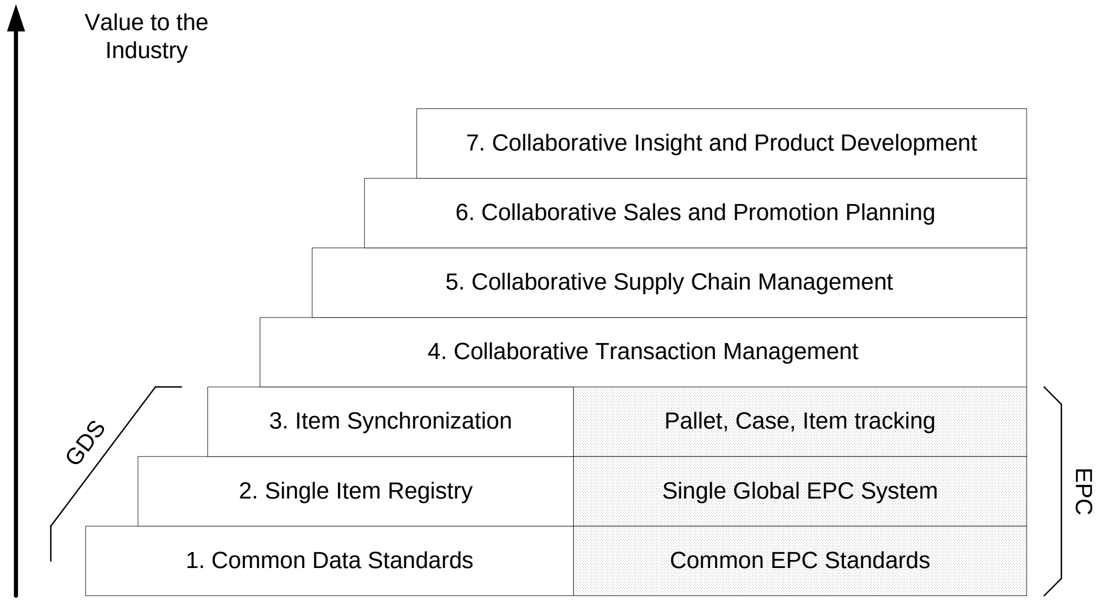

Figure 8. The Roadmap for Electronic Collaboration (Source: A. T. Kearney and Kurt Salmon Associates, 2004, p. 10)

However, the adoption of GDS has grown slowly, and many, especially small and medium-sized, organizations are reluctant to adopt it. The situation represents the path followed by many IT innovations and provides research opportunities [Asif and Mandviwalla, 2005; Beck and Weitzel, 2005; Wigand et al., 2005]. As in the case of RFID and EPC, companies with significant bargaining power on their business partners can mandate the use of GDS. This follows the adoption of EDI in the automotive industry, but is basically against the market mechanism where choice of freedom and demand-driven are premises. This method may not be the best for large-scale adoption of new technology [Gerst and Bunduchi, 2005]. With globalization of supply chains, more information systems that are standard-based and meant to be globally adopted will become necessary. As shown in Figure 9, local or proprietary standards emerge before global standards and as time passes, global standards take over local and proprietary standards. There is little research about the adoption mechanism of standards [Hovav et al., 2004] and global information systems. It is critical to find a way to shorten the time required to deploy global technology standards, as well as standard-based information systems. In this regard, the history of the diffusion of UPC standards and relevant technologies might provide several lessons [Brown, 1997, Dunlop and Rivkin, 1997], from which several issues need to be addressed.

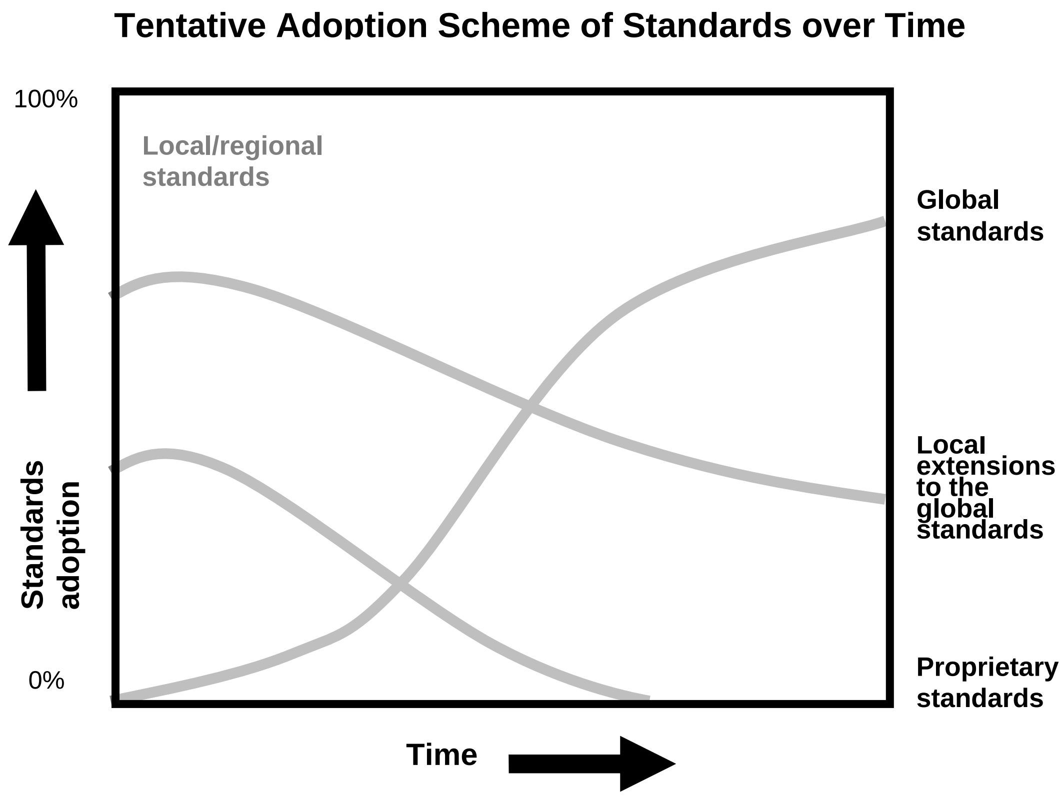

Figure 9. Tentative Adoption of Standards over Time (Source: Cap Gemini Ernst and Young, 2002, p. 11)

It could be interesting to investigate the evolution of complementary systems. The evolution of complementary systems means that the adoption of a new technology influences subsequent adoptions of other new technologies. This is an extremely important point in the context of GDSN, because GDSN and EPCglobal Network share the core product information identification standards and can be complementary to each other. GDSN provides a mechanism to synchronize static data, while EPCglobal Network addresses the need for up-to-date information. Thus, the adoption of GDSN should complement that of EPCglobal Network and PIMS, and vice versa. It can be also complemented by subsequent adoptions/substantiation of relevant systems such as collaborative transaction management, collaborative supply chain management, collaborative sales and promotion planning, and collaborative product development. A theoretical framework of evolution of complementary systems needs to be further established in order to derive actions to be taken to facilitate the global adoption of a standard-based solution. At the tactic level, how to integrate these two networks together is an issue that needs to be addressed. It is interesting to study how the adoption of one global system affects the adoption of the other.

Another research opportunity is to examine the network effect of the diffusion of new standards, where the value of a potential standard to an adopter depends on the number of other adopters of the standard. Although GS1 and GS1 US jointly work to establish standards related to GDSN, it seems they are experiencing issues similar to those during the establishment of the UPC/EAN standards [Brown, 1997]. Both standards share the network effect. UPC experienced a chicken-and-egg dilemma [Dunlop and Rivkin, 1997]. Retailers did not want to install scanners unless a significant number of products carried the UPC barcodes, whereas manufacturers did not want to place UPC barcodes on their products until a significant number of retailers installed scanners. It seems that the adoption of GDSN has been following a similar pattern. Manufacturers seem reluctant to invest their resources until a significant number of their business partners are ready to adopt GDSN standards. Brown [1997] stated that the effective enforcement of a voluntary standard without government intervention took place from relationships among trading partners, not from a standards administrator. Since EPCglobal Network and GDSN are complementary in nature and with strong support from retailers such as Wal-Mart and government agencies like the Department of Defense, the diffusion of GDSN might follow different patterns of the network effect. Meanwhile, the 2005 Sunrise Initiative proposed by UCC (see Section III for details) may create the critical mass of investments from retailers, which would provide sufficient incentive for manufacturers to get on board. However, the network effect of GDSN remains to be examined.

Another research opportunity relating to the network effect is that a strong network effect is characterized by several important phenomena observed during the UPC adoption: excess inertia, excess momentum, lock-in, and multiple equilibria [Dunlop and Rivkin, 1997]. Excess inertia means that not many users want to take the risk of adopting new standard as first movers. Fortunately, for GDSN, it seems that Wal-Mart, and other large, influential companies, especially manufacturers, are willing to take the lead. This implies that a standard governing body must work closely with key influential organizations to quickly reduce the effect of excess inertia. Excess momentum means that companies as a group adopt a solution that may be inferior but easier or less costly to adopt. Once this movement by the group begins, no firm jumps off [Dunlop and Rivkin, 1997]. Thus the whole industry can be stranded with multiple incompatible standards. GS1 seems to be very concerned with this issue as we discussed previously. A strong relationship among local standard governing bodies (such as GS1, GS1 US and a representing organization of each country that belongs to GS1), as well as proactive actions by them, can influence each company's decision making regarding which solution it adopts.

"Lock-in" means that once a community of users adopts a particular standard, it will be difficult to change. Currently, at the initial stage, the standards around GDSN are constantly changing to accommodate new business requirements. However, once those are well adopted by the community, it will become more difficult to accommodate emerging needs. A shift from UPC/EAN to GTIN followed this pattern. Fortunately, the newly established standards are more flexible to accommodate changing needs. For example, GTIN and GLN can be easily accommodated in EPC and other coding schemes such as Global Service Relation Number (GSRN) by simply padding numbers. Designing more expandable standards becomes critical to reduce the effect of "lock-in". Nevertheless, how flexible the newly created GTIN structure is remains to be observed.

Multiple equilibria can show several different facets [Dunlop and Rivkin, 1997]. First, only one among many standards eventually prevails, but which one it will be is not clear to the adopters. All of them could appear to be a viable solution. This may slow down the adoption of an eventually prevailing standard. A related issue is a legal challenge regarding patents. As happened in UPC, several people or organizations may claim the ownership of a part, or the whole of the standard or technology. When these litigations involve royalties, the adoption of the standards or technology can be significantly slowed down because companies are afraid of the extra costs that they may have to pay in the future. This may destroy the momentum of the standard adoption as stated by Brown [1997]. Moreover, who sponsors a standard or a standard governing body is critical because users, firms, and other stakeholders often take actions to assure that the outcome they prefer becomes the one that locks in other companies. A few or even a single influential company, organization or country could change the direction of standard establishment. As learned in the case of UPC, the endorsement from a national standard organization such as ANSI in the U.S. and/or an international standard organization such as ISO can be used to reduce the effect of multiple equilibria.

Furthermore, in November, 2004, GS1 [GS1, 2004] pointed out that there was a very serious fragmentation of the user community following two different data synchronization architectures. One model requires the Global Registry and the other model synchronizes data through proprietary connections between data pools. As recommended by IBM [Bowling et al., 2004] as their flexible approach to GDS, users may choose to use both models to connect to their trading partners. GS1 wrote "[I]f we don't find a single, global model, the two models will diverge overtime resulting in serious complexities and extra costs for the future of e-collaboration, including the interconnection with EPC [GS1, 2004, p. 1].” The IS research community needs to identify an integrative framework that facilitates the establishment of a single global standard.

The establishment of enterprise-wide data management is essential to GDS. Internally, business processes and rules must be established to maintain the internal synchronization. This may require consolidation of several databases and applications. How to consolidate data and applications in a heterogeneous computing environment is a critical issue. Although PIMS software that integrates ERP, CRM, and SCM, has already been developed, implementing such systems could be a challenge.

Similar to the case of RFID [Asif and Mandviwalla, 2005], the cost and benefits analysis within the context of a single firm does not provide a true picture of GDS’s impact on supply chain management. In general, the implementation of inter-organizational information systems, such as EDI, may tighten the relationship between business partners or even lock in partners because of the standards of EDI or high cost. However, the closer relationship or lock-in might not occur in the implementation of GDS. GDS is mainly built on the centralized Global Registry, which, in one sense, plays the role of a marketplace. Subscribers (e.g., retailers) of GDS might find products and vendors through the service of the Registry. As a result, changes in the relationship between business partners following the adoption of GDS might not follow the pattern resulted from the implementation of EDI. However, existing models [e.g. Craighead and Shaw, 2003; Rai et al., 2004] should be used to empirically assess the impact of GDS on an entire supply chain and the impact of global, standard-based information systems on the market structure.

Standard-based solutions usually require governing bodies to establish the operational policies and financial model they apply. GS1 pointed out that “GDSN stakeholders are confused” and “different stakeholders have challenged the GDSN operation and financial model accepted in February ’04” [GS1, 2004, p. 1]. It is interesting to investigate what are effective operational policies, as well as fair financial models, for global technology standard governing bodies.

Trust and commitment have been a premise for effective e-collaboration [Welty and Becerra-Fernandez, 2001]. Also, trust and commitment is generally built on long-term relationship. Since, as discussed above, the wide implementation of GDS might encourage opportunistic behavior, how it impacts social relationship and subsequently, impacts the effectiveness of e-collaboration could be a critical issue.

VII. CONCLUSIONS

The emergence of GDS can be attributed to two drivers: The first is the need for a technological foundation for sophisticated collaborative initiatives between business partners, and the second is the need for a remedial measure for the loss resulted from deficient data. The advent of information and communication technologies has brought numerous collaborative opportunities to businesses. By taking advantage of these opportunities, businesses are able to perform collaborative activities beyond transaction-oriented tasks. Examples of such collaborative activities include collaborative product design, collaborative sales and promotion planning, and collaborative supply chain management. The quality of data needed for those activities certainly has impact on the value of such collaborative initiatives. On the other hand, businesses have long suffered from the loss resulting from the deficiency of data quality. Global data synchronization is a global initiative aimed to lessen or even eliminate the problem caused by out-of-sync data existing between businesses’ applications. By continuously updating data, business partners will be able to take actions based on identical versions of data. GDS will not only significantly improve the bottom-line of businesses by maintaining the consistency of product and location data, but also facilitate collaboration between business partners by providing a single entry communication network. While GDS could be done manually or with proprietary software, GDSN provides a truly global platform with the advantages of extensibility and backward-compatibility. The functions of GDS and GDSN are predicated on several newly proposed standards for data identification, components of global registry and data pools, protocols for synchronization processes, and existing technologies for data exchange.

The standards for GDS and GDSN are built upon and compatible with the existing product identification code schemes commonly used in North America and Europe. Advocating associations had diligently worked together to create standards for data identification code and techniques, as well as protocols for the synchronization process. Two major identification schemes are Global Trade Item Number (GTIN) and Global Location Number (GLN). GTIN (often called EAN/UCC-14) is intended to identify items/products involved in transactions on the global scale. GTIN provides a structure that encompasses 13-digit EAN/UCC scheme, 12-digit UCC scheme (i.e., UPC-A), and 8-digit EAN/UCC scheme. The 13-digit GLN is not a new symbology, but a new way to identify the location of a physical, functional, logical or legal entity in a supply chain. The newly created standards had been globally adopted in 2005, following the 2005 Sunrise initiative proposed by UCC, which required that all U.S. and Canadian companies must be capable of scanning and processing EAN-8, EAN/UCC-13, and UPC-A at the point-of-sales. The global registry, data pools, and the protocol for data synchronization comprise the global data synchronization network on which the process of publishing, subscribing, and synchronizing takes place. The mandate of 2005 Sunrise initiative and the global availability of data pools might generate the momentum for acceptance of GDS standards. Furthermore, GDS and GDSN would provide the data quality that is much needed to assure the benefits brought about by EPCglobal Network with RFID. The increasing adoption of EPCglobal Network and RFID would augment the need for quality data and, consequently, facilitate the acceptance of GDS and GDSN.

Introducing a new technology into an organization can be quite challenging. GDS and GDSN are no exception. Challenges relating to GDS are internally synchronizing data scattered at different applications and departments in the organization, externally synchronizing data across organizational boundaries, choosing a proper data synchronization model, and addressing management and business partnership issues. While most of the challenges seem to be tactical and technological in nature, the management and business partnership issues could be strategic and managerial as GDS and GDSN are built up mutual trust and long-term commitment from business partners. Synthesizing from extant literature, we proposed a checklist for GDS adoption. The checklist covers key issues that need to be addressed from initiation, planning, requirement determination, design, implementation, evaluation and assessment, and maintenance. The checklist provides a roadmap to companies contemplating the implementation of GDS and GDSN.

As an emerging technology, GDS and GDSN present ample research opportunities. We identify several issues that should be addressed in order to further understand the phenomena of GDS and GDSN: (1) the complementary relationship between GDSN and EPCglobal Network; (2) the evolution of complementary systems; (3) the adoption mechanism of GDS and GDSN; (4) the relationships among competing standards; (5) the network effect of diffusion of new standards; (6) the impact of contingencies on the network effect; and (7) implementation issues such as synchronization, cost/benefit analysis, and trust/commitment.

Due to the promising benefits of GDS and GDSN, their impacts on the industry appear to be significant. Unfortunately, relevant issues surrounding GDS and GDSN have received scant attention from educators and researchers. Business schools could and should play an important role in educating their students about GDS and assisting in the wide adoption of this system. Also, business schools should conduct research studies about issues discussed in the previous section to provide useful guidelines to GDS practices.

ACKNOWLEDGEMENTS

We gratefully acknowledge the anonymous associate editors for providing valuable suggestions.

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APPENDIX I. QUESTION LIST FOR SELECTING A DATA POOL

(Source: Bowling, Zlicul and Van Hammond, 2004)

- Is the technical data architecture sound?
- Does the data transported between the data pool, other data pools and GS1 meet industry standards and directions?
- Are security requirements met?
- Do value-add services meet specific company needs, such as catalog service, EDI and portal hosting?
- Does the message choreography methodology meet industry standards and directions?
- Is this data pool interoperable with other data pools?
- Are all attributes interoperable with other data pools or only a subset of attributes?
- Does the data pool support location-, party- and relationship-dependent data synchronization?
- Can the data pool articulate the linkage between GDS and EPC and provide a path to achieve that link?
- Does the data pool have adequate funding and will it be sustainable?
- Does the data pool have a vision for growing its customer bases to reduce subscription costs and make it ubiquitous?

APPENDIX II. QUESTION LIST FOR SELECTING A PRODUCT INFORMATION MANAGEMENT SOLUTION

(Source: Bowling, Zlicul and Van Hammond, 2004)

Link products to customer locations	• Uses the GTIN structure to link to Global Location Numbers (GLN) • Allows users to create customer-specific product lists • Incorporates price bracket assignment capability
Field customization and data normalization	• Flexibility to easily and quickly add customer-specific data elements to the form • Allows users input of collaborative information (i.e., suggested retail price, promotions) • Normalizes data to match internally defined standards using set normalization rules
Controlled access to data	• Defines roles to determine the ability to edit certain fields and formats (descriptions vs. price) • Allows for security level access grants
Hierarchy conversions	• Converts internally defined category hierarchy to industry recognized standard [i.e., Global Product Classification Schema (GPC)] • Allows for product relationship management by pallet, display, case/carton, pack/inner and each item
Communications in customers standard	• Assigns customer-specific link to the message standard for the data transmission (i.e., XML, EDI, AS2)
Manage messages and notifications	• Determines who receives the notification for certain data or registry messages • Determines how person is to be notified (e-mail, pager, phone) • Enables workflow management
Multichannel management	• Views customers across regions, exchanges, channels of trade as needed by the users • Differentiates the transmission format and translates to the assigned channel
Maintain internal system of record	• Verifies certification requirements are maintained for registry compliance • Keeps the original data source intact • Becomes the single source of records for external customer transactions and transmissions

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Communications of the Association for Information Systems

ISSN: 1529-3181

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