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# Supply Chain Management in International Logistics – RFID Applications

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## 1. Introduction

The evolution of international transport is linked to the requirement of its customers and their needs. Modern logistics require compliance with a demand-based planning, hence the current management disciplines are grouped around the supply chain management (SCM) and seek to optimize the resources available to the transport, ie., ordering of supplies, time, cost and information. Production needs condition the next supplies the place of consumption, and the sequence or order of delivery. Information systems have played a key role in responding to these requirements and the Electronic data Interchange (EDI) has provided the necessary technologies to do so. Nevertheless, despite the extent of EDI systems that normalize the content of messages required for synchronization between systems, we encounter the difficulty of consolidating information between customers and suppliers with different software.

The intermodal traffic truck-boat-truck and stores (consolidation of cargoes in containers) and destination (deconsolidation and service picking/kanban) to Tier1 factories in automotive industry, is managed so that local optima are obtained in each of the processes involved in each of transport modes, storage and management of load / unloading of containers at ports of origin, transit and destination (Moyano, 2009).

The RFID applications provide an advantageous solution to specific scenarios and industrial sectors, especially those who are currently based on international standards as automotive industry. This chapter discusses, throughout a real case application as a representative scenario of “digital gap”, which is challenging the usability of those information tools. After a description of using “best effort” solutions in real applications, a more integrated information model is proposed where several agents must be involved, from network operators to service providers.

This chapter begins by analyzing logistic services in International Transport of goods. This is supported by standardized models based communication system in some cases, i.e. automotive sector, through EDI/ODETTE messages or alternatively ad-hoc messages based on FTP or SMTP. A key part of this study is the infrastructure of the Wireless Sensor Networks (WSN) and operating standards that make operating in many different conditions.

In terms of information system, the change means moving from a "push concept", in which events are transmitted by collecting the information by the means mentioned above, to a "pull concept" in which interested parties consult the information at the time that the need to replenish their stocks, and flows of goods, as close to real time. This new approach is based on information directly supported by RFID tags (Ahson, 2008) (Morreale, 2010), retrieved through WSN, (Dargie, 2010), (Akyildiz, 2010), (Verdone, 2008) which in turn have the IP address which will be recognized on the Internet.

Tags based on RFID technologies (Fig. 1) provide the opportunity to incorporate the same content and routing information, which would not necessitate the transmission of messages or files between different actors. Complete information would be captured by WSN sensors and available for SCM. There are five major areas where RFID can be effectively used in a port cargo terminal: Access controls, Container security, Container identification and Location, Activity Tracking and Regulatory Compliance (Mullen, 2007).

Fig. 1. Tag UHF RFID. Courtesy of AV Converter RFID Company.

Regarding contents, we study the evolution from based systems barcode to RFID technology. The Electronic Product Code (EPC) standards and RFID technology give the global coding object to each entity as a unique code, and construct a global real-time network for sharing material goods information. EPC code + RFID + Internet put together Internet of things (IoT) (European Commission, 2009), (Forum Europe, 2010). EPC could be made by a bar code or RFID based. RFID technology is a cornerstone of the EPC, and it has become a Global Identification System (EAN.UCC System) (Laowe, 2010).

Finally the chapter will address issues related with a wide insight over the state-of-the-art of relevant international standards in the field of International Logistics provided from several institutions like: ODETTE, AIAG, European Union, IEEE, ISO, IEC and others; A proposal from the ICT market giving new information codes for RFID tags, better sensors deployment (WSNs) in the access network) freight containers and vehicles; An open network structure in order to provide the basic rationale for potential users, network operators and service providers, in order to have a clear framework where new offers (infrastructure networks and ICT services) could be better integrated in existing business software tools.

## 2. Logistic services in international transport of goods

The evolution of international transport is linked to the requirement of its customers and their needs. Modern logistics require compliance with a demand-based planning, hence the current management disciplines are grouped around the Supply Chain Management (SCM) and seek to optimize the resources available to the transport, ie., ordering of supplies, time, cost and information. Production needs condition the next supplies the place of consumption, and the sequence or order of delivery. Information systems have played a key role in responding to these requirements and the EDI has provided the necessary technologies to do so. Nevertheless, despite the extent of EDI systems that normalize the content of messages required for synchronization between systems, we encounter the difficulty of consolidating information between customers and suppliers with different software.

In the past 50 years the greatest innovation in international transport has been containerization. That it has done so can be attributed to the beneficial interaction of three broad kinds of factors: technical, economic and organizational (Frémont, 2009). We address the further case study, exclusively to transport in "containers" because the feature "multimodal" and the type of supply chain itself.

Since its advent of containerization this has been bringing about the integration of the transport chain (Brooks, 2000). On the other hand, shippers´ and logistics operators needs have been increasing steadily as they take advantage of the opportunities offered by globalization, to develop their production and /or distribution activities at an international scale, and this necessitates synchronization of their activities in space and time through the introduction of logistics chains. The management of these chains is a source of control as well as providing a source of profit for all actors involved in these chains (Heaver T.D., 2001). All international transport companies now claim to be logistics operators capable of providing a customized response to the needs of their shipping clients (Frémont, 2009).

For container identification, the current standard which deals with the coding, identification and marking of containers is DIN EN ISO 6346, dated January 1996. (Fig 2) (BIC, 2010).

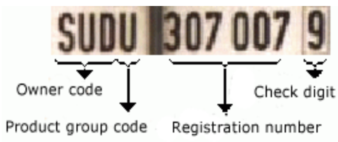


Fig. 2. Container’s codification

In any case, these codes are targeted in preference to identify the physical units of containers and some supplementary information on the load (weight, dangerous load, etc.), but nothing about its actual content, or their origin or destination.

The current trend in port terminals, is to identify these codes using techniques of optical character recognition (OCR), with great difficulty due to positioning, light and contrasts that occur outdoors.

One important advantage of containerization is the development of logistics services. The entire logistics chain extends from supplier to end client. It must enable the overall management of resources in order to provide the best service for current and forecast customer demand, including physical transport flows, with their associated information flows and interfaces management between different actors in the chain from producer to consumer.

In sea transport there are a large number of intermediate agents (IA) involved, causing a large flow of information from the logistics operator to each of them. The only information physically available is the number (code) that identifies the container, so that all information associated with their content and routing has to be transferred in parallel throughout EDI messages, EDI / XML, EDI / SMTP, to update the databases for each agent.

This approach would provide new services throughout the supply chain based on a container with extended encoding information relevant to such services (Table 1):

| **Logistic Services** | Identification of container **Current** | Extended Container Identification **Future** |
|---|---|---|
| Container management | Tracking | Tracking and tracing + stowage + priority |
| Parcel | No | Pallet tags; Routing |
| LTL&LT. Consolidation warehousing | No | Cargo consolidation + routing |
| Location Tracking | CCTV/GPS/RFID | RFID/EPC/WSN |
| Activity tracking | GPS/RFID | RFID/EPC/WSN |
| Multimodal Transport | EDI/XML/SMTP | WSN/IoT |
| Logistic reception | EDI/XML/SMTP | WSN/IoT |
| Clearance | EDI/XML/SMTP | WSN/IoT |

Table 1. Logistic services and technologies (Cárdaba, J., 2008) and own elaboration

### 2.1 Intermodal traffic in automotive industry

The automotive industry employs some of the most sophisticated networks of suppliers worldwide. Automobile manufacturers demand supply chains becoming more streamlined and efficient to support new models of development and shorter product life cycles. Logistics Services Provider (LSP) must manage "just-in-time" applications for distribution centers and transportation, as well as services related to receipt of goods by multi-modal transportation, consolidation or de-consolidation package, storage, inventory control, "picking" and sequenced synchronous or “Kanban” deliveries.

The current case study refers to companies acting as Tier 1 in supplying parts to assemblers of cars and trucks. This companies use the services of a global logistics providers for the supply of component parts of its products, from its factories in Asia to its plants in Europe, including consolidation centers and picking services from a store (MAF) close to its assembly plant, which also is the safety stock of components, for possible stock shortages driven by transportation and other incidents since the beginning (Fig. 3).

The physical flow of goods is based solely on the use of Odette standards (Odette Transport Label v3). The information about the part must be accessed via the relevant back-end system or other databases from each of the actors involved throughout EDI transmissions.

The data structures on the RFID tag in Odette recommendation permit three fundamentally different scenarios of the process design with RFID support, which place different demands on the total system (tag, reader, network, middleware, applications, organization, etc.) (Fig. 4).

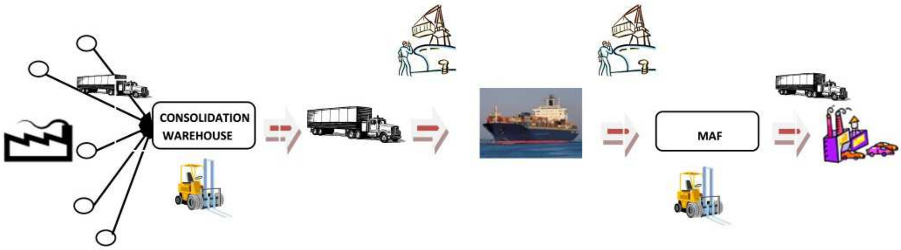


Fig. 3. Flow of freigths between Asia and Europe

Fig. 4. Reader RFID for logistics purpose. Courtesy Deister Electronic.

For some processes in the automotive sector, RFID is already superior to other identification procedures in terms of process efficiency and quality criteria. This technology distinguish as before the class of parts (code number, type of container), but individual entities of a class (code number and serial number, or type of pallet cage).

The real potential of using RFID with automotive parts occurs when the different elements of the value chain use the same standards and technologies, and information is processed at every stage in an *open loop system* (Odette, 2010).

The matrix of considered scenarios is made in Table 2.

| | | Read/Write permissions on Tag | |
|---|---|---|---|
| | | No | Yes |
| User-Data used | No | Scenario: 1<br>Tag contains only part ID | |
| | Yes | Scenario 2:<br>Read access to user data | Scenario 3:<br>Read/Write access to user data |

Table 2. Matrix of considered scenarios

In Scenario 1, the only data field used is "part ID", it is protected and cannot be overwritten.

The Scenario 2 cover other user data requirements, whereas in the Scenario 3 the user data can be modified in the process.

The principal structure of the data stored of the tag has been defined in the "air interface" standard according with ISO/IEC-18000-6C.

### 2.1.1 A model for data integration

The current model of information is based on the willingness of each event logistics management, to send to the recipients of that information by means, from traditional fax, e-mail or more advanced such as FTP that allow integration with their own information systems (like ERP, CRM,…).

This model used in intermodal transport and storage in automotive sector, it is based on a "push concept" in which events are collecting the information from intermediate for the management of each unit or flow control and transmitted through conventional means (Fig.5).

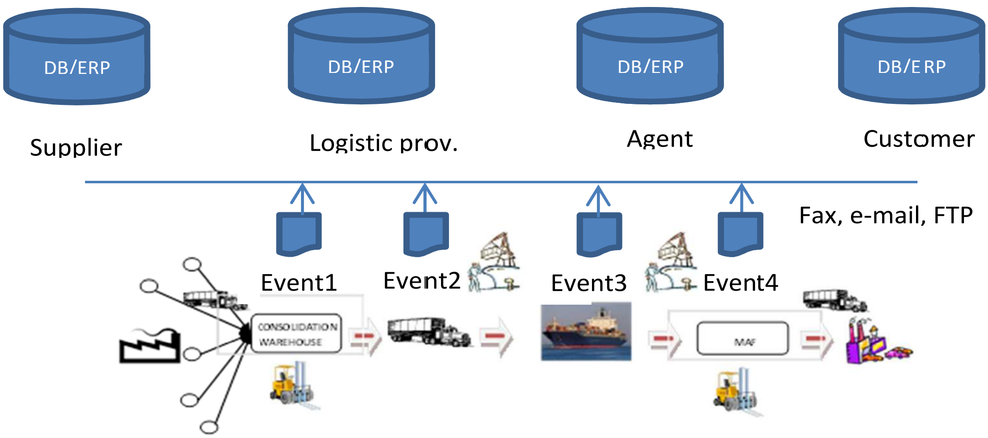


Fig. 5. Flow of information: push model

Introducing concepts and technologies such as Wireless Sensor Networks, Internet of Things, Cloud and IP Networks, we can move towards a "pull model", where each entity can purchase your information when they want or need.

This new model based on Radiofrequency Identification (RFID) and Wireless Sensor Networks (WSN) and Cloud computing, is characterized by the ability to provide the information necessary to demand of each of the actors involved, and real time (Fig.6).

### 2.1.2 Data structure on the tag (Air Interface)

The principal structure of the data stored on the tag has been defined in the ''air interface' standard in accordance with ISO/IEC18000-6C.

ISO/IEC 18000-6C assumes a logical division of the tag storage into 4 data segments, which are represented in the diagram below (Fig. 7):

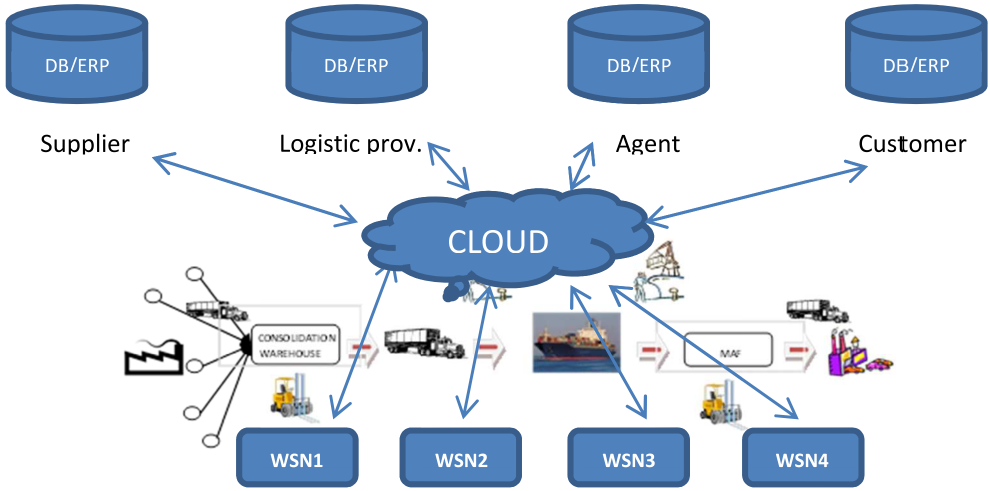


Fig. 6. Flow of information: pull model

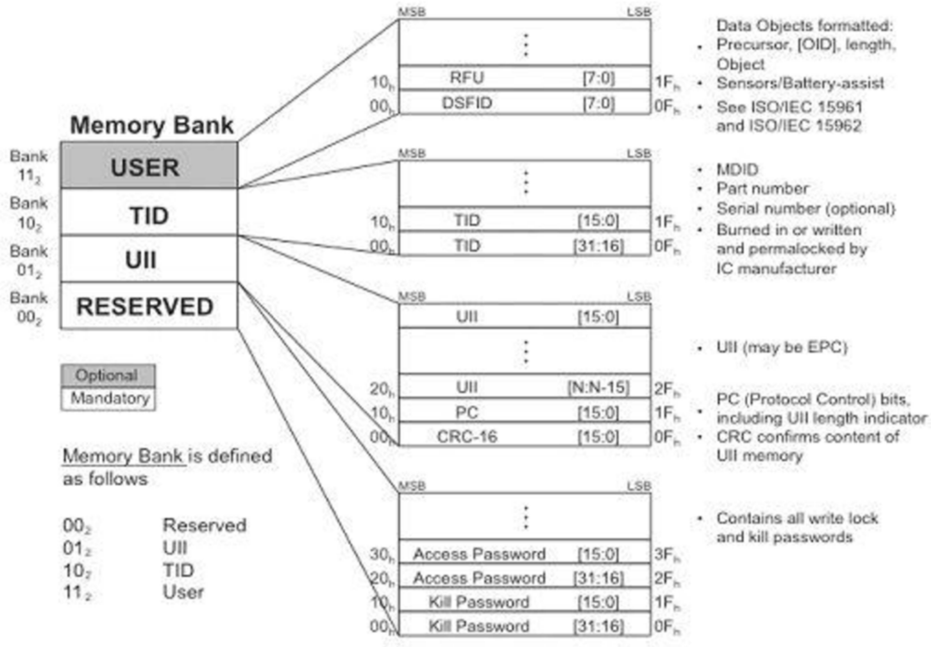


Fig. 7. Memory Structure of ISO/IEC 18000-6C tag

For some processes in the automotive sector, RFID is already superior to other identification procedures in terms of process efficiency and quality criteria. This technology distinguish as before the class of parts (code number, type of container), but individual entities of a class (code number and serial number, or type of pallet cage). (is a part of Odette Recommendations).

USER: formatted and organized freely by the user.

TID: Unique part and serial number of the tag. Permanently locked.

UII: Unique Item Identifier.

RESERVED: Access and kill password.

## 3. Wireless Sensor Networks (WSNs)

### 3.1 Introduction to WSN

A WSN is a wireless network of sensor nodes oriented to the monitoring of real world measurable parameters, whether physical, biochemical, chemical, industrial, medical or anything others, for a data collection application. In that way a WSN is “data centric”, not “address centric” like Internet. A sensor node can include at least one sensor and actuators with capabilities for processing data and networking to manage the wireless access. An actuator can execute an action over the real world (i.e, trigger and alarm, turn on an electric motor, turn off a robotic arm, etc.) as a response to an input electric signal.

In data collection applications there are one or more nodes oriented to gathering, processing and controlling the received data from the sensor nodes. Those nodes are called “sink” ones. Therefore a typical WSN is a set of “wireless sensor nodes” delivering their data, also wirelessly, towards one or more “sink” nodes (Gómez, 2010).

The topology of a WSN can be “ad-hoc” if no connection is provided outside itself, or on the contrary “with-infrastructure” if it is connected to other networks ( by wire or wirelessly) for remote access and management. An “ad-hoc” WSN is called MANET (Mobile Ad-hoc Network) when its nodes are also in motion (Conti, 2007), (Capps, 2001). When a WSN is “with-infrastructure”, its connection with the other network is made through an intermediate equipment called BS (Base Station), or AP (Access Point) or even, more technically “Gateway” (Misra, 2009), (ZVEI, 2010).

The three main topologies for WSNs are: Star (i.e., a “sink” node gathering all data from all surrounding “sensor” nodes), Tree (i.e., all “sensor” nodes are clustered over an specific “sink” node, and all the “sink” nodes are also connected like a star network centred over a global “sink”), and Mesh (i.e, all “sensor” nodes are connected like a grid where “sink” nodes are not required).

Like other computer network protocol architectures the WSNs follow a layered approach based on the OSI (Open Systems Interconnection) model (Mariño, 2003), where a bottom layer gives a set of services to the upper layer. Typically these protocols are: physical, link (MAC: Medium Access Control), routing, transport, data encoding and aggregation protocols.

The main areas of applications for WSNs are among others: environmental monitoring (Perry, 2002), health care (Cao, 2009), sports and fitness, assisted living, structural monitoring (Bur, 2010), automotive, logistics, home and building automation (Gómez, 2010), industrial monitoring and control, smart utility, urban monitoring and control, road usage charging, disaster recovery, rural monitoring and control (Mariño, 2010), telecommunications applications, gaming, robotics and contextual awareness.

### 3.2 Operation and powering

Given their wireless nature WSNs are intended for “field applications”, that is to say, their deployment can be made in places with difficult access, or where wired infrastructures are impossible (very remote or wild zones) or not justified (economic or ecological impact, regulatory barriers, etc.). This rises a specific demand for this kind of networks about low power consumption (mW), because all energy for the sensors and sinks nodes in the network (whether “ad-hoc” or “with-infrastructure”) must be provided by batteries. Nevertheless battery replacement could be impractical or impossible for particular requirements from the WSN architecture (very high number of nodes, remote placement, etc.), rising the question about energy conservation for network survivability, as a fundamental restriction in WSN´s design (Schmidt, 2011).

Designing nodes for a WSN must balance consumption between communication tasks (protocols) and processing ones. Usually consumptions for communications are bigger than processing ones. Commercial microcontrollers embedded in sensor nodes have different power consumption modes like “active”, “idle” and “sleep”, in order to reduce the power when a full processing operation is not required. Also communication protocols in WSN´s nodes are more lightweight designed using a reduced number of bytes, short bandwidth requirements (kHz), reduced duty cycle (less than 1%), and low data rate transmissions (kbits/s).

Alternative sources of energy replacing batteries are well known such as solar (photovoltaic panels, 10mW/cm2), ultra-capacitors and fuel-cell. Other new approaches come from “harvesting” or “scavenging” energy timely on the environment and storing it for later use such as: vibration (100microW/cm2) (Buckley, 2009), heat (25microW/cm2) (Hammerschmidt, 2010), wind flows and electromagnetic radiation (0.1microW/cm2) (Neuquelman, 2011). Transducers that created electricity from readily available physical sources can be thermoelectric generators (TEG) (Armstrong, 2010) or thermopiles (temperature differences), and mechanical vibration or strain (piezoelectric or electromechanical devices) among others (Despesse, 2011), )Jerez, 2011), (Ling, 2011).

### 3.3 Communication topics and RF bands

Propagation of radiofrequency (RF) signals is impaired by phenomena like interference, multipath and attenuation (TSE, 2005). In a WSN two nodes are linked when the signal power at the receiver antenna is above the receiver sensitivity. Therefore that signal power can be reduced with the distance between the nodes (attenuation), interference sources (multipath and undesired external signals) and the influence of materials in the propagation medium causing phenomena like reflection, diffraction and scattering (Pérez, 2008).

Robust modulation techniques provide to RF signals some mitigation of above mentioned impairment effects. Physical protocols for WSNs are intended for giving modulation schemes improving bandwidth, robustness against interference and enough data rate.

Radiofrequency bands are used worldwide using those intended for free use (unlicensed bands) on industrial, scientific and medical applications (ISM bands). Defined by the ITU-R (International Telecommunication Union-Radio) these bands may depend on regional or national regulations (i.e., about transmit power, duty cycle or modulation schemes). The acronym RFID (Radiofrequency Identification) is a WSN´s particular application for product identification.

A subset of the ISM and other unlicensed bands (or “free” bands) available for WSNs are (band, availability and applications) (Gómez, 2010):

- 125-134.2 kHz, low RFID
- 140-148.5 kHz, RFID
- 6.765-6.795 MHz, worldwide, ISM
- 13.553-13.567 MHz, worldwide, ISM, high RFID
- 26.957-27.283 MHz, worldwide, ISM
- 40.66-40.70 MHz, worldwide
- 314-316 MHz, China, RFID
- 430-434 MHz, China, RFID
- 433.05-434.79 MHz, Europe, Africa and part of Asia, ISM, RFID
- 779-787 MHz, China, WSN
- 840.5-844.5 MHz, China, RFID
- 865-868 MHz, Europe, WSN, UHF RFID
- 868-870 MHz, Europe
- 902-928 MHz, Americas, Greenland and some Pacific Islands, ISM, WSN, RFID
- 920-926 MHz, Australia, RFID
- 950-956 MHz, Japan, RFID
- 2.400-2.4835 GHz, worlwide, ISM, WSN, RFID
- 5.725-5.875 GHz, worldwide, ISM
- 24-24.25 GHz, worldwide, ISM
- 61-61.5 GHz, subject to local acceptance, ISM
- 122-123 GHz, subject to local acceptance, ISM
- 244-246 GHz, subject to local acceptance, ISM

New band assignments from international and national telecommunication authorities have been studied for unlicensed usage, based on current paradigms such as cognitive radio (CR) technologies (Fette, 2009), (Wyglinski, 2009), (Zhang, 2010), by using licensed bands under strict requirements (Ray, 2011), or giving a “digital dividend” enabling the use of former UHF analogue TV bands ( 790-862 MHz) (Fitch, 2011), (Zhang, 2009).

A new trend in the use of electromagnetic spectrum for WSNs is the VLC (Visible Light Communications) proposal (Johnson, 2010). Like the IrDA (Infrared Data Association) standard (Mariño, 2003) from 1994 for remote control in home electronic products, VLC proposal intends the use of “vision band” (380-760nm wavelength) by means of cheap photoemissors (LED: Light Emission Device) and photodetectors (i.e: a photodiode), for avoiding the crowded RF bands from ISM.

Therefore a WSN based on VLC proposal will have “sensor” and “sink” nodes without RF antennas, only a couple photoemissor-photodetector for each node. The IEEE 802.15.7 will be the reference standard for VLC applications.

### 3.4 Software tools for WSNs

In a WSN a “sensor” node includes hardware elements like memory, input/output and communications. Therefore the resources of a “sensor” node must be managed by an operating system (OS) to make the hardware independent from the executed applications. Given that a WSN is a distributed scenario the OS should provide additional distributed capabilities as a “middleware” placed in the elements of the network. There are in the market a large range of OSs for “sensor“ nodes like TnyOS and Contiki (Gómez, 2010).

Software tools intended for enabling the development, maintenance, deployment and execution of WSN applications, are useful for designers before and after implementing the real distributed wireless network (Dwivedi, 2011).

As a basic summary of requirements for implementing a WSN can be stated the following ones (Misra, 2009):

- Sensor node capacity
  - Power supply: battery power or harvesters
  - Size of on-board memory
  - Radio features (radio range, type of antennas, data loss rate, propagation impairments, etc.)
- Network scale and deployment setting
  - Size of the network and coverage zone
  - Node density (“sensor” nodes/km2)
  - Node distribution uniformity (existence of routing voids or not)
  - Homogeneous nodes or heterogeneous ones
  - Accessibility of the network
  - Availability of sensor node locations
- Application requirements
  - Traffic pattern (many “sensors” to a “sink” like in a “star”, or one-to-many as in a “mesh”, point-to-point routing or data-centric routing)
  - Traffic load (high “duty cycle” or low one like in message delivery)
  - Expected network lifetime
  - Data packet size and format
  - Quality-of-service (QOS) requirements on latency and throughput

Among the software tools can be found the following, intended for different or complementary purposes along the WSN´s designing cycle such as: simulators, emulators, data display, testbeds, debuggers, code-updaters and network monitoring.

A simulator is a software that imitates selected parts of a real WSN´s behaviour and is currently used as tool for its research and development. Depending on the simulator´s intended usage, different parts of the WSN are modelled and imitated, and these parts can also be of varying abstraction level. A simulator for WSN can imitate the wireless media and the restrictions of nodes in the network.

As a networked embedded system a WSN application involves sensor node hardware, its drivers, operating systems and communication protocols. As a result, the performance of the WSN application depends on all these factors in addition to its implementation. An emulator is a kind of simulator intended to enable realistic performance evaluation for

WSN applications, which can be directly run for testing, debugging and performance evaluation.

Visualization tools can support different data types gathered from WSNs, and usually saved as a numerical form in a central data base (DB). There are many programs that enable the viewing of these large amounts of data.

Testbeds are like an experimental benchmark for WSNs that provides support to measure a number of physical parameters in controlled an reliable environment. This environment contains the hardware, instruments, simulators, various software and other support elements to conduct a test. By providing the realistic environments for testing the experiments, the testbeds bridge the gap between the simulation and deployment of real devices.

Debugging tools in WSNs are aimed for diagnosing specific faults, such as detection of crashed nodes, sensor failures, or identifying faulty behaviour in nodes.

Code-updaters for WSNs can change the requirements from the network or the environment in which the deployed nodes may change after long periods of time. This may need modifying the executing application, or re-tasking the existing one with a different set of parameters.

Network monitoring tools enable accurate knowledge of network health status, including nodes and links of each type, for correctly configuring applications on real implementations or over testbeds for assessing the data collected from them.

### 3.5 International standards and RFID

Standardization development organizations in the world allow for global harmonization about the different communication protocols intended for WSNs. Some international agencies provide the “jure” standards from IEEE, IETF, ISO, CEN, CNELEC, ITU, ETSI, or the “facto” standards from industry alliances such as ZigBee, Bluetooth Special Interest Group (SIG), Z-Wave, Wavenis Open Standard Alliance (OSA), INSTEON, EnOcean and others. Each alliance creates “working groups” (WG) with specialized tasks for each protocol development (Festag, 2009).

A typical international agency is the Institute of Electrical and Electronics Engineers (IEEE), a professional association which develops and promotes engineering, computing and technology information. The IEEE has a particular committee (or WG) devoted to develop network communication standards, which code number is “802”. Therefore a code for any proposal from this committee is published under the format “IEEE 802.n.m”, where “n” stands for coverage (in wireless networks), and “m” indicates the kind of application intended for. For example, the “jure” standard IEEE 802.15.1 stands for WPANs (Wireless Personal Area Networks), where number “15” indicates a coverage until 30 meters, and number “1” means for applications in wireless audio, harmonizing with “Bluetooth”, an equivalent the “facto” standard promoted by Ericsson company.

Among the communication standards proposed for WSNs are the following (Willig, 2005):

- Bluetooth Low Energy from Wibree Forum
- Dash-7, based on ISO 18000-7 standard (Schneider, 2010)

- INSTEON form Smart Labs company
- MeshScape, based on IEEE 802.15.4 for automation from Festo company
- nanoLOC, based on IEEE 802.15.4 for automation from Danfoss company
- SP 100.11a based on IEEE 802.15.4 from ISA (International Society for Automation)
- Wavenis from Coronis System company
- WINA (Wireless Industrial Networking Alliance) for automation applications
- WirelessHART, based on IEEE 802.15.4 standard for automation applications (Hodkinson, 2008)
- WISA (Wireless Interfaces for Sensors and Actuators) from ABB company (ZVEI, 2010)
- ZigBee , based on IEEE 802.15.4 standard also for automation (Steigmann, 2006)
- Z-Wave from ZenSys company
- 6 LoWPAN ( Low-Power WPAN) based on IETF standard for connection to IPV6 Internet (Ogden, 2009)

For applications in logistics a particular WSN´s technology is called RFID (Radio Frequency Identification), as a means of identifying objects via radio frequency transmission (Bollic, 2010), (Finkenzeller, 2010). A typical RFID system comprises a tag, a reader, a host computer and a middleware (Hartmann, 2010). Middleware is a software that performs a connecting function between lower level objects, such as the readers, and the applications they support. For RFID applications the middleware sends control commands to the reader and responds with tag data received from the reader. In the WSN architecture the "tags" are the "sensor" nodes, and the "readers" are the "sink" ones.

In the enterprises world RFID is a third evolution on asset tracking by optical reading technology, from "bar codes" (1981) in the beginning, and "QR"(Quick Response) codes or 2-D codes after (Toyota 1994). In RFID based on relative distances from tags and readers, their respective antennas might operate in Near Field (NF) or Far Field (Radio Frequency or RF). In NF (ZVE, 2007), (Fischer, 2009), (Mager, 2011) operation distances between antennas are lower than 4cm, and the transmission effects are mainly inductive or reactive as in a transformer (Magnetic Field). In RF operation the respective distances could be bigger than 10m like in a typical WSN. An industrial RFID standard based on NF is RuBee (IEEE 1902.1, 2007) operating in the 131kHz band (ISM).

In RF operation, the tags are classified by their capacity for storing power as: Passive (without battery and the power comes from the reader only up to 10m), Semi-active (battery only for activation and the reader makes data transmissions up 30m) and Active (battery for activation and transmissions larger than 100m). In NF transmission the tags are active.

## 4. A model for data integration in case study

### 4.1 Rationale for Automotive International Logistics (AIL) and description of basic operations

Relying on new ICT standards and available technologies, the authors propose to modify the operational support as follows (Fig 8):

- Planning the shipment according to production needs and safety stock located in the MAF (transit time forecast from port to port about 31 days).

- As supply chain pallets are being built, transport unit tags are loaded to pallet tags identifying contents, which built the shipment, purchase order number, and when the shipment was built. Pallets are sent to storage consolidation.
- In consolidation warehouse, as pallets are loaded into the container, pallet tags are loaded to container supply chain tags identifying contents, which built the shipment, purchase order number, container ID, eSeal ID, and when the container was stuffed.
- Container loaded onto chassis. When the tractor connects to the chassis, container information, chassis ID, and tractor ID is loaded to the On-board Unit (OBU) through Communication Air Network (CAN).

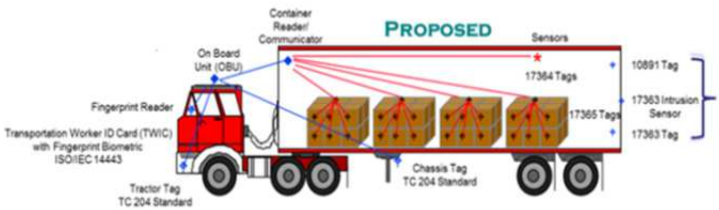


Fig. 8. On-board proposed operational support (Harmon, 2010)

- At the border crossing point in warehouse exit, the contents of the OBU are transferred to the Road-side Unit (RSU-WSN). The Road-side Unit (RSU) might also capture information from the Container ID, eSeal, and Supply Chain/Manifest tag.
- Well known wireless communication standards for Intelligent Transportation Systems (ITS) are CALM and WAVE. (ITU-T , 2007), (Uzcategui, 2009), (Williams, 2008)
- OBU also able to drive GPS system
- Information is available in the WSN through an IP network to be read from the management point LSP (Fig. 9).

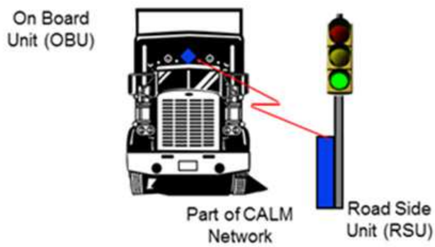


Fig. 9. Roadside operational support (Harmon, 2010)

- In MAF operations are symmetrical and inverse to the consolidation warehouse. The MAF input-output is linking to IP network through smart WSN.

The new basic operations in this case study, are affected by the following standards, under the recommendations of American Industry Association Group (AIAG) (Harmon, 2010) (Table 3):

| | |
|---|---|
| Technology | RFID (ISO/IEC 18000); Sensors (IEEE 1451); Wireless Sensor Interface (ISO/IEC/IEEE 8802-15-4) |
| Data Content | Data syntax (ISO/IEC15434); Data semantics (ISO/IEC15418); Unique item identification(ISO/IEC 15459); Encoding (six bit) (ISO/IEC29162); Unique tag ID(ISO/IEC15963); Unique sensor ID(IEEE EUI-64 – ISO/IEC/IEEE 21451-4) |
| Conformance | Conformance to Air Interface; (ISO/IEC 18000) |
| Network | Sensor Networks (IEEE 1451) |
| Application Standards | Packaging (TC122-ISO 1736x); Freight container (TC104); Ships (TC8); ITS (TC204); Anti-Counterfeiting (TC247) |

Table 3. Standards based upon ISO/IEC JTC 1/SC31

### 4.2 A new network model

In Fig. 10 is depicted a network model for AIL applications where all involved agents in the value chain, between the "product origin" (PO) and "product destination" (PD) are connected.

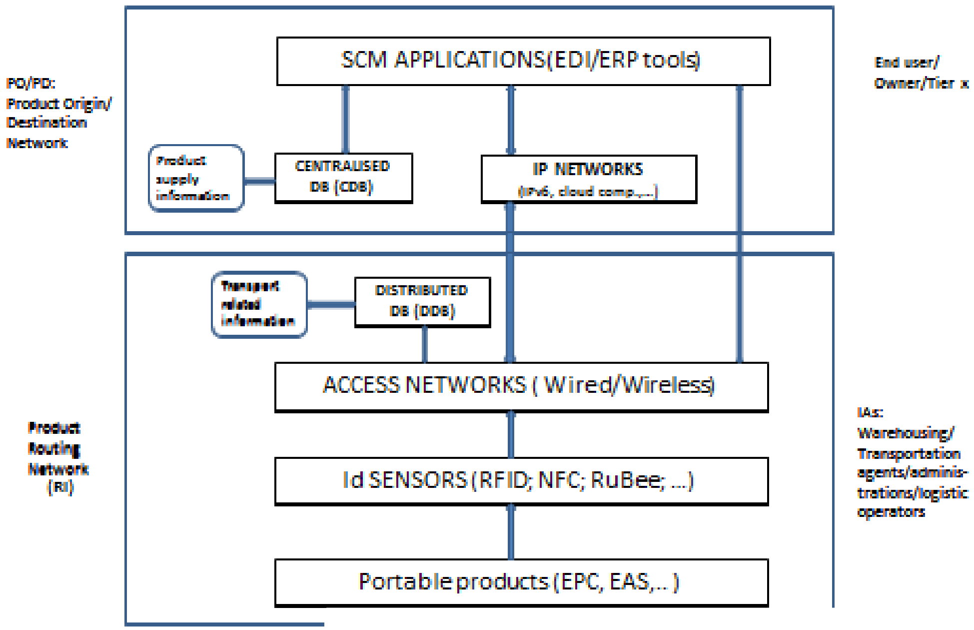


Fig. 10. Framework of SCM Information-Centric networking for AIL

Those intermediate agents (IAs): warehouses, carriers, administrations, legal advisers, logistics operators, etc., are considered "in-flight" or "on-route" producer-consumers ("prosumers") of "routing information" (RI). Therefore there is a two-ways data flow PO<->RI<->PD, with multiple input/output operations depending on the use of particular "access networks" (AN) from the diverse aforementioned IA´s. In this network model all participants can access, if it is technically possible, to a distributed data bases (DDBs) or centralized ones (CDBs), whether directly or indirectly through the "cloud", sharing real-time information about the state-of-routing from a given product between its origin and its destination.

Therefore some considerations should be made in order to assure the affordability of this model, if technical, economic and complexity barriers must be overcome for each involved enterprise. For example, in the value chain, SMEs could be not interested in complex procedures, using heavy ERP tools with specialised workers, and high communications costs, among other possible reasons.

In this model is possible given its open structure, to include other indirect partners from the information and communication technologies (ICT) providing: new ERP tools, more practical standards, affordable access networks and information-based logistic services. New ERP tools should integrate moreover its "product ID" also its "origin ID" and its "destination ID". Each IA in the value chain can profit these data to give more flexibility to its business model.

More practical standards could facilitate information formats with generalized use by diverse AIs, in order to achieve compatible software tools and file transfers.

Affordable access networks are possible giving the new legal agreements from the providers´ sector about next generation networks (NGN), where networks operators can generate creative offers to new industrial customers not necessarily early-adopters minded, giving flexible and customized options for specialized demands.

Information-based logistic services could find a new niche market for creative service providers, able to collaborate with the IAs grouped in a particular "value chain". Given the abovementioned model, an example could be an ISP providing services of hosting and housing for DDBs, CDBs and ERP tools in a particular AIL application.

In Fig.11 is depicted a network architecture for the proposed model, according to the requirements of Software Oriented Applications (SOA):

## 5. The need to deploy RFID reading infrastructures in seaports

### 5.1 Active RFID as a key enabler

Finding a data capture technology that would reliably identify trucks in the harsh marine environment was a key aspect of Port Authorities, (Fig.12). Especially, needed a way to "marry" containers and trucks in its management system, i.e. to track which inbound and outbound boxes were paired with which street trucks as they entered, transited and exited the terminal. (Identec, 2010).

In most ports, a high percentage of containers arrive and depart by truck, including many short-haul, time-sensitive moves. Truck drivers may visit the terminal several times a day

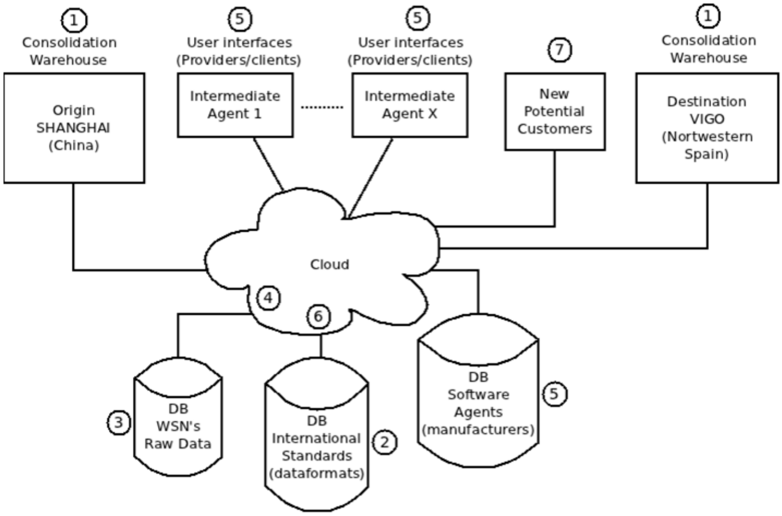


Fig. 11. SOA's testbed for SCM in AIL based on the new network model

Fig. 12. Reading infrastructures OCR/RFID in Georgia Port Authority. Courtesy of Identec.

and need to be in and out as quickly as possible to meet shipper schedules. So planning for the future meant handlingan increasing volume of trucks without compromising service levels.

License plate recognition software was considered, but discounted due to lack of consistency in license plate position and misreads due to dirty or damaged plates. Instead, radio frequency identification (RFID) technology won the day for its ability to uniquely identify assets in the most challenging conditions.

To capture key data and manage business processes, plus middleware to integrate data into central terminal management applications, use RFID, GPS & Wireless Sensor Solutions:

- Optical character recognition (OCR) to identify containers and chassis passing through the gates
- A position detection system (PDS) to locate containers and equipment in the yard

- RFID to track trucks moving through the gates and around the terminal
- A wireless local area network for data transmission

RFID solution to provide real-time visibility into truck inventory and enable data capture at the required hand-off points:

- Inbound and outbound gate moves for street trucks
- Container transfer between yard cranes and street trucks
- Container transfer between vehicles and mobile container handling equipment (CHEs)

### 5.2 Gate benefits

Combined with OCR for container ID, the introduction of RFID in Ports enable to move staff away from the direct gate area, alleviate the administrative burden of manual data processing and allow trucks to move faster through the system. RFID technology also supports to Ports Authorities (PA) web access system, a related efficiency measure introduced by the port for trucking companies to preadvise container pick-ups and drop-offs before arriving at the terminal.

Other key gains include the elimination of truck queues outside the terminal gates, with productivity benefits both for the port and truckers, reduced highway congestion and less pollution from idling trucks.

### 5.3 Yard benefits

Once empty and laden street trucks enter the yard, the RFID system helps manage the container hand-off process between trucks and yard cranes. As with the gate, use of RFID in the yard help PA to improve operational safety and productivity and provided real-time intelligence on truck and container inventory location.

Working conditions and efficiencies for the operators are also improved. They no longer have to look down at containers some 70-80ft below to manually read container ID numbers, while automated job promotion eliminates the need to scroll through a list of assignments on the cab data terminal in order to find the right task.

### 5.4 Commercial a security benefits

Ports can provide data feeds as required. A broad range of terminal operational data supporting security processes and logistics operational processes by use RFID active tags with commercial and security benefits as:

- Brand protection
- Reduce pilferage, damage
- Positioned for “green lane” (reduced inspections)
- Audit trails for isolation, recovery and learning (“inspected already” –quicker re-starts)

## 6. Conclusions and future work

The evolution of international transport of goods is closely linked to technological developments such as RFID technologies, and the adoption of standards, whether of technologies as WSN, either of content from the initial EDI to the current based on ISO-18000c.

Some challenges should be overcome in order to enhance the productivity of the business involved in SCM domain. These challenges could be faced by the ICT market providing software tools (ERPs) better integrated in the business models.

First of all, is necessary to consider some important aspects such as the support for international transport for automotive parts (AIL) between suppliers to automotive constructors, where some SCM challenges have been detected in the "best effort" practices actually made, to say the least. Second, consider a wide insight over the state-of-the-art of relevant international standards in the field of AIL provided from several institutions like: ODETTE, AIAG, European Union, IEEE, ISO, IEC and others.

Also propose from the ICT market giving new information codes for RFID tags, better sensors deployment (WSNs) in the access network (RSUs), freight containers and vehicles (OBUs). Build a model based upon an open network structure in order to provide the basic rationale for potential users, network operators and service providers, in order to have a clear framework where new offers (infrastructure networks and ICT services) could be better integrated in existing business software tools.

Will be convenient studying infrastructures identification ICT already deployed in the most advanced ports and benefits from the standpoint of SCM and security.

Limitations of this developments:

1. Administrative complexity. Multiple administrations with different regulations and competences.
2. Limitations in current software tools don't provide the necessary standards
3. Incompatible technology platforms from different vendors

Future work:

One testbed could be implemented following these seven main points:

1. Involving the two extreme main places in international logistic traffic scenario.
2. Selection of suitable information standards, in order to achieve compatible software tools and file transfers through the "cloud", over the unified data formats.
3. Involving network operators and ISP providers for giving suitable WSNs in a few points on the logistic chain, in order to maintain the model affordability whether by budgetary reasons or low-complexity purposes.
4. Involving hosting and housing service providers for implementing DBs in selected places "on-route" for producer/consumers of unified data formats, from the moving identified products.
5. Involving a bunch of Intermediate Agents (IAs) with compatible ERPs, user interfaces and AIL applications.
6. Developing a whole "case study" over the implemented testbed between two end points of the supply chain for selected moving products, in order to get valuable experiences and software tools refinements until to give a real SOA´s application.
7. Further enhancements of flexible and customized software options able to be integrated in current business software tools, for new potential industrial customers.

## 7. Glossary

| | |
|---|---|
| AIAG: | The Automotive Industry Action Group (AIAG) is a not-for-profit association of companies involved in the automotive industry in America |
| CALM: | Continuous Air-interface, Long and Medium Range |
| CRM: | Customer relationship management, is a widely implemented strategy for managing a company's interactions with customers, clients and sales prospects |
| EDI: | EDI stands for Electronic data Interchange and is the umbrella term for industry standards for the electronic exchange of business documents |
| EPC: | The Electronic Product Code (EPC) is designed as a universal identifier that provides a unique identity for every physical object anywhere in the world, for all time |
| FTP: | File Transfer Protocol (FTP) is a standard network protocol used to transfer files from one host to another host over a TCP-based network, such as the Internet |
| ISM: | The industrial, scientific and medical (ISM) radio bands are radio bands (portions of the radio spectrum) reserved internationally for the use of radio frequency (RF) energy for industrial, scientific and medical purposes other than communications |
| KANBAN: | Kanban is not an inventory control system. Rather, it is a scheduling system that tells you what to produce, when to produce it, and how much to produce |
| MAF: | Advanced warehouse consolidation, deconsolidation and security, for service to auto assembly plants |
| ODETTE: | Odette International is an organization, formed by the automotive industry for the automotive industry in Europe |
| RFID: | Radio Frequency Identification is a technology for the contact-free identification of objects of any type by means of radio waves |
| SCM: | Supply Chain Management, logistics process between suppliers and customers; also multilevel, i.e., the chain of all suppliers up to the completion of the end product |
| SMTP: | Is an Internet standard for electronic mail (e-mail) transmission across Internet Protocol (IP) networks |
| TIER 1: | A Tier 1 supplier would be a company who makes products specifically for one of the original equipment manufacturers (OEMs) |
| WAVE: | Wireless Access for a Vehicular Environment |
| WSN: | A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to *monitor* physical or environmental conditions, such as temperature, sound , vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location |
| XML: | Extensible Markup Language (XML) is a set of rules for encoding documents in machine-readable form |

## 8. Table of standards referenced in this chapter (Odette, 2010)

| Standard | Title |
|---|---|
| ETSI TR 102 436 V1.2.1 | Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) intended for operation in the band 865 MHz to 868 MHz. Guidelines for the installation and commissioning of Radio Frequency Identification (RFID) equipment at UHF |
| EPCglobal | EPC global Tag Data Standards Version 1.4 |
| IEEE 802.15.4 | Specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). It is maintained by the IEEE 802.15 working group |
| ISO/IEC 15418 | Information technology --EAN/UCC Application Identifiers and Fact Data Identifiers and Maintenance |
| ISO/IEC 15961 | Information technology --Radio frequency identification (RFID) for itemmanagement --Data protocol: application interface |
| ISO/IEC 15962 | Information technology --Radio frequency identification (RFID) for itemmanagement --Data protocol: data encoding rules and logical memory functions |
| ISO/IEC 18000-6 | Information technology --Radio frequency identification for item management -Part 6: Parameters for air interface communications at 860 MHz to 960 MHz |
| ISO/IEC 18000-7 | Defines the air interface for radio-frequency identification (RFID) devices operating as an active RF Tag in the 433 MHz band used in item management applications |
| ISO/IEC 18046 | Information technology --Automatic identification and data capture techniques --Radio frequency identification device performance test methods |
| ISO/IEC 18047-6 | Information technology --Radio frequency identification device conformance test methods --Part 6: Test methods for air interface communications at 860 MHz to960 MHz |
| ISO/IEC 8859-1 | Information technology --8-bit single-byte coded graphic character sets --Part 1:Latin alphabet No. 1 |
| ISO/IEC 17367 | Supply Chains Applications of RFID -Product tagging |
| ISO/IEC 15434 | Syntax for high-capacity ADC media |
| ISO/IEC TR24729 | Implementation Guidelines |
| ANSI MH10.8.2: 2006 | Data Application Identifier Standard |
| Odette | Labels (OTL1, OTL3 and GTL) |
| Odette | RFID in supply chain container management |

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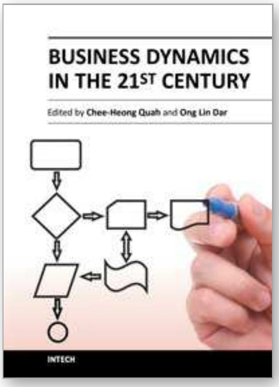


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