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SE 4.3 Technologies deployed to improve visibility and operational risk management within supply chains

SE4.3.1	**Overview of automated identification technologies – advantages and selection criteria**
SE4.3.2	Drivers for the deployment of RFID (technological and cost advancements)
SE4.3.3	Sensor technology combined RFID to monitor shipments and transport units
SE4.3.4	Practical examples and experiences of visibility systems deployments.

Summary

This sub study contains overview of technologies for automated identification, including bar codes, 2D codes, (passive and active) RFID and OCR technologies. Properties, technology comparison, as well as advantages and disadvantages are discussed. Identification technologies include barcodes and 2-D codes, OCR, RFID and location technologies such as RTLS, UWB and RFID location. Different technical aspects such as used frequencies, passive and active tags, readers and standardisation are discussed.

Overview of automated identification technologies – advantages and selection criteria

Contents

1. Objectives

This sub study contains overview of technologies for automated identification, including bar codes, 2D codes, (passive and active) RFID and OCR technologies. Properties, technology comparison, as well as advantages and disadvantages are discussed.

2. Target stakeholders

Technologies for improved visibility and risk management are of interest to all operative stakeholders in the supply chain:

- D2D Service Providers**,** which include ship operators, freight forwarders, logistics providers and Motorways of the Sea (MoS) operators
- Exporters & Importers (shippers)
- European ports, national port bodies and especially small-to-medium ports

Also related organisations have interest on the topic:
- Research organisations, Systems Developers and
- The large number of specialised companies that support the Maritime and Logistics industry; this includes bankers, financiers, designers, builders, providers of Single Window (SW), Port Community Systems (PCS) and Cargo Community Systems (CCS
- The European Commission and national transport ministries

3. Glossary terms

AutoID: Referring to an automated identification system. This includes technology such as bar coding and radio frequency tagging (RFID). (CSCMP: Terms and Glossary, March 2009).

Radio Frequency (RF or RFID): A form of wireless communications that lets users relay information via electromagnetic energy waves from a terminal to a base station, which is linked in turn to a host computer. The terminals can be place at a fixed station, mounted on a forklift truck, or carried in the worker's hand. The base station contains a transmitter and receiver for communication with the terminals. RF systems use either narrowband or spread-spectrum transmissions. Narrow-band data transmissions move along a single limited radio frequency, while spread-spectrum transmissions move across several different frequencies. When combined with a bar-code system for identifying inventory items, a radio-frequency system can relay data instantly, thus updating inventory records in so-called "real time (CSCMP: Terms and Glossary, March 2009).

Tags http://www.rfidjournal.com/article/glossary/

Active tag: An RFID tag that has a transmitter to send back information, rather than reflecting back a signal from the reader, as a passive tag does. Most active tags use a battery to transmit a signal to a reader. However, some tags can gather energy from other sources. Active tags can be read from 300 feet (100 meters) or more, but they're expensive (typically more than US$20 each). They're used for tracking expensive items over long ranges. For instance, the U.S. military uses active tags to track containers of supplies arriving in ports.

E-seal: A method of sealing a digital document in a manner similar to that used for electronic signatures. Electronic seals enable computers to authenticate that documents or electronic messages have not been altered, providing a level of security in digital communications.

EPC Generation 2: The standard ratified by EPCglobal for the air-interface protocol for the second generation of EPC technologies.

Memory: The amount of data that can be stored on the microchip in an RFID tag. It can range from 64 bits to 32 kilobytes or more on passive tags.

Passive tag: An RFID tag without its own power source and transmitter. When radio waves from the reader reach the chip's antenna, the energy is converted by the antenna into electricity that can power up the microchip in the tag. The tag is able to send back information stored on the chip. Today, simple passive tags cost from U.S. 20 cents to several dollars, depending on the amount of memory on the tag, packaging and other features.

Read range: The distance from which a reader can communicate with a tag. Active tags have a longer read range than passive tags because they use their own power source (usually a battery) to transmit signals to the reader. With passive tags, the read range is influenced by frequency, reader output power, antenna design, and method of powering up the tag. Low-frequency tags use inductive coupling, which requires the tag to be within a few feet of the reader.

Read-only: A term used to describe RFID tags that contain data that cannot be changed unless the microchip is reprogrammed electronically.

Read-write: A term used to describe an RFID tag that can store new information on its microchip. These tags are often used on reusable containers and other assets. When the contents of the container are changed, new information is written to the tag.

RFID tag: A microchip attached to an antenna that is packaged in a way that it can be applied to an object. The tag picks up signals from and sends signals to a reader. The tag contains a unique serial number, but may have other information, such as a customers'

account number. Tags come in many forms, such smart labels that can have a barcode printed on it, or the tag can simply be mounted inside a carton or embedded in plastic. RFID tags can be active, passive or semi-passive.

Semi-passive tag: Similar to active tags, but the battery is used to run the microchip's circuitry but not to broadcast a signal to the reader. Some semi-passive tags sleep until they are woken up by a signal from the reader, which conserves battery life. Semi-passive tags can cost a dollar or more. These tags are sometimes called battery-assisted tags.

Smart label: A generic term that usually refers to a bar code label that contains an RFID transponder. It's considered "smart" because it can store information, such as a unique serial number, and communicate with a reader.

Transponder: A radio transmitter-receiver that is activated when it receives a predetermined signal. RFID transponders come in many forms, including smart labels, simple tags, smart cards and keychain fobs. RFID tags are sometimes referred to as transponders.

RFID System http://www.rfidjournal.com/article/glossary/

Antenna: The tag antenna is the conductive element that enables the tag to send and receive data. Passive, low- (135 kHz) and high-frequency (13.56 MHz) tags usually have a coiled antenna that couples with the coiled antenna of the reader to form a magnetic field. UHF tag antennas can be a variety of shapes. Readers also have antennas which are used to emit radio waves. The RF energy from the reader antenna is "harvested" by the antenna and used to power up the microchip, which then changes the electrical load on the antenna to reflect back its own signals.

Anti-collision: A general term used to cover methods of preventing radio waves from one device from interfering with radio waves from another. Anti-collision algorithms are also used to read more than one tag in the same reader's field.

Compatibility: Two RFID systems are considered compatible if they use the same protocols, frequencies and voltage levels and are able to operate together within the same overall application (see interoperability).

Electronic pedigree: A secure file that stores data about each move a product makes through the supply chain. Pedigrees can help to reduce counterfeiting of drugs and other products. EPCglobal has ratified an e-pedigree standard for the industry.

Middleware: In the RFID world, this term is generally used to refer to software that resides on a server between readers and enterprise applications. The middleware is used to filter data and pass on only useful information to enterprise applications. Some middleware can also be used to manage readers on a network.

Reader: A device used to communicate with RFID tags. The reader has one or more antennas, which emit radio waves and receive signals back from the tag. The reader is also sometimes called an interrogator because it "interrogates" the tag.

4. Approach / methodology

This study bases on literature survey and pilot / implementation experiences at different projects.

5. Specific issues and topics to be addressed

5.1 Available technologies and their features

5.1.1 Identification technologies

AutoID is a basic element for implementing efficient positioning, identification and status & authenticity systems in the supply chains. The most important identification techniques for goods are barcode and RFID (Radio Frequency Identification). Barcode is currently the most widely used method, but RFID is better suitable for automated identification since it allows to handle larger reading distances, has the possibility to identify multiple items in a single reading, and can identify the target in motion.

Barcode and 2-D code

Barcodes are optical readable sequences of data, in which each character is coded as a combination of black and white lines. Barcode has been globally standardized and is widely used. Barcodes can be classified as linear barcodes, stacked, or 2D-codes. Barcodes are commonly used in the retail sector and have also spread to other sectors. Linear and stacked bar code readers use laser technology for reading. 2-D codes are read using imaging technology. Through the advent of cheap camera technology and increased processing capabilities of mobile phones, 2D-codes can now also be read with mobile phones at limited reading ranges. Applications are e.g. coding of a URL in 2D-code for easy web access.

Pros: Globally standardised and implemented (EAN), cheap labels and scanners.
Cons: Static (data cannot easily be changed or added), High labour costs, as labels often are scanned manually, low data capacity (not 2-D tags), visual contact required.

OCR

Image processing technology can be used for different applications related to detecting and identifying objects. For the identification of objects, licence plate recognition (LPR) is widely used in commercial Automatic Vehicle Identification systems, due to its profitability and good reliability, e.g. for tolling applications (e.g. London), parking hall access and identification of containers in harbour terminals. LPR does not make any

specific demands on the vehicles, except for the (human-readable) code in a standardised format. However, generally 100% readability is difficult to achieve, due to challenging illumination conditions and dirty or dented license plates may cause recognition errors. The recognition rate is usually optimised site by site by adjusting illumination properly and, in e.g. parking or access control applications, by exploiting authorised plate number list in recognition process. OCR-systems which are font-independent are less accurate than systems, which are based on specific fonts [turvath].

Other applications offered by image processing are the detection of the type of vehicle, estimation of used capacity (e.g. number of vehicles in parking lot), detection of exceptions, abnormal behaviour.

Pros: Cheaper than manual reading.
Cons: Not standardised; not 100% accurate (human backup required); relatively expensive.

Radio Frequency Identification (RFID)

RFID is a method for automatic identification of remote transponders called tags. RFID has also the possibility to change the information stored on the parcel or handling unit, does not require visual contact and is less susceptible to environmental conditions than other identification technologies. There is a wide range of RFID techniques: from small inductive tags for animal identification with a few centimetres reading range to active microwave or UHF active transponders with 100 meter reading range. Lack of widely industrially accepted standards and business models has delayed wide deployment of RFID techniques in supply chains between different actors.

Pros: Unique product ID; multiple tag readings simultaneously; reading of moving objects; no visual contact needed; large amounts of data can be stored; data can be added, changed, as well as locked and secured. Sensors can be added for increased functionality. Low labour costs for carrying out readings.

Cons: costs for tags (ongoing incremental cost per tag), technical problems in securing 100% reliability (not all tags are read). Several standards and low market penetration at the present.

RFID is described further in chapter 5.2

5.1.2 Location technologies

Location systems can be classified as independent and dependent systems. For an independent system, a device calculates its position based on the information coming from e.g. satellites or beacons. For dependent systems, the location information is calculated at a central server, based on the signals received by the different readers or beacons. Examples are positioning using the mobile telephone cellular network and WLAN-location.

The discussion of location technologies, such as satellite based positioning (Galileo, Glonass, GPS) and network based positioning (cellular network, WLAN) is not within the scope of this study. However, RFID-like systems are described.

RTLS (Real Time Location systems)

RTLS (Real Time Location System) is a technology, in which RFID-like transmitters are used for determining the real-time location. Within regular intervals are activated by radio signals which are received from the network of readers installed in the area. There are two types of systems on the market: systems which are based on the ISO 24730-standard and systems which are based on WLAN-infrastructure. The technology is used in e.g. hospitals and harbours to identify and track vehicles, containers and persons.

WLAN is also used for wide-area positioning of WLAN-enabled devices, by exploiting information on the location of the access points. This technique is used by Skyhook WPS (Wi-Fi Positioning System), extended in 2008 to XPS (hybrid positioning including WLAN, GPS and cellular tower triangulation). Skyhook has measured the location of millions of access points in urban areas in the U.S.A and Europe, and uses this information for WLAN enabled devices, such as laptops and WLAN phones (e.g. Apple iPhone).

UWB (Ultra Wideband)

UWB-technology use very short pulses which spread over a wide frequency range, and hence penetrates different materials well. Objects can be located with 30 cm accuracy. Due to possible disturbances in this wide frequency range, the allowed transmission power of UWB is limited. Initially, UWB is only limited to inside buildings.

Boeing is currently implementing a UWB based RTLS at the Kennedy Space Center in Florida to track tools, equipment and other assets. Currently about 3000 items will be tagged and tracked. The installation uses also vehicle-mount readers to track items that are driven to the launch pad.

New products are coming to the market, which combine UWB and RFID. Sandlinks' system consist of low cost system-on-a-chip active tags, which communicate with readers over UWB. Tags, which have integrated temperature sensor, can communicate with each other and hence achieve long read ranges (40 m indoor, 150 m outdoor) and provide 0.5 m location accuracy. Tag-to-tag communication enables different asset tracking processes, as alerting if a tag is removed from a group of tags.

RFID location

The startup company Mojix markets the STAR system which can read tags from 200 m, and cover an area 25 000 m^2 and pinpoints tags in 3D. Mojix differs from other systems by using separate components to power and read tags. Mojix eNode transmitters provide the signal power to excite tags, and cover a range up to 10 m. Once powered by an eNode, tags, which are EPC Gen 2 compatible, communicate their data which is received by a STAR receiver.

5.2 RFID tag development for different purposes including technology and memory features

5.2.1 RFID frequencies

RFID can use many different frequencies, including:

Low Frequency (LF)	125-134 kHz
High Frequency (HF)	13.56 MHz
Ultra High Frequency (UHF)	433 MHz, 860-960MHz
Microwave (active tags)	- 2.45 – 5.8GHz

The most important frequencies for logistics purposes are 13.56 MHz and UHF (860-960 MHz) and 433,92 MHz..

Figure 1 shows the different frequencies which can be used for RFID.

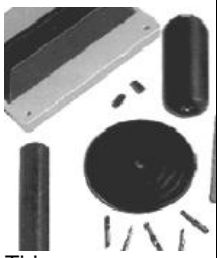
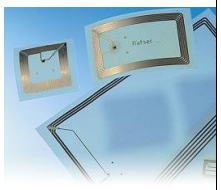
	Inductive 125 kHz, 134.2 kHz	Inductive smart card HF Vicinity, 13.56 MHz	Inductive label, HF proximity, 13.56 MHz	UHF smart label 865-870 MHz	UHF active tag 433 MHz, 868 MHz	Microwave active. 2.45 GHz, 5.8 GHz	Chipless tag
example tags	 Tiris	 Top-Tunniste	 UPM Raflatac	 UPM Raflatac -	 Identec ILR tag	 Amtech-tag	 Checkpoint tag
passive / active	Passive	passive	Passive	passive	active	active	passive
reading range	< 1 m	< 10 cm	< 1.5 m (gate reader)	3-6 m	4 - 500 m (IDENTEC)	8 - 20 m (up to 500m?)	
price (example)	0.5 - 20 €	< 1 €	0,25 €	0.3 €	20-50 €	20 - 50 €	< 0,10 €
Multiread/ Bulk read	No	no	Yes	Yes	normally	sometimes	
standardisa-tion	ISO 11784/5 ISO14223, ISO 18000-2	ISO 14443, NFC	ISO 15693, ISO 18000-3	ISO 18000-6, ePC	ISO 18000-7 (433 MHz)	ISO18000-4	No
Typical applications	Access control, animal ID, personal ID, Car anti theft,	Safe payment, access control, production	Library, clothes(store?), item level logistics	Logistics ID on pallet and parcel level	Container and Trailer ID in shipyards,	Vehicle access control, Toll collection , Real Time location systems, army	safe printing, tickets

Figure 1: *Technologies used in RFID*

RFID technology uses either inductive or electric linkage between tag and reader. The lower frequency systems (125 kHz and 13.56 MHz) use inductive technology, higher frequency systems (433 MHz) and up use mainly radio linkage. Higher frequency systems can use inductive linking for short range communication, e.g. for printing or for item identification, in which tags have to be uniquely identified.

Whereas the 13.56 MHz and 433,92 MHz frequency can be used globally, there is not a single UHF frequency which can be used globally: in the USA 915 MHz is used, in Europe 865-870 MHz. Also the allowed transmission power differs in the different areas: in the USA 4 W eirp, in Europe 2 W erp (about 3.2 W eirp).

5.2.2 Passive versus active RFID technologies

Basically, there are three different kinds of tags: passive, semipassive and active. Semipassive and active tags require inbuilt batteries while passive tags are able to function with no internal power source.

Passive tags

Passive tags use the energy of the reader signal for processing and replying. The most common technologies are 125 kHz, 13.56 MHz and UHF (865-870 MHz). Passive tags can come in different formats and shapes. The most popular form is the “smart label in which the tag is laminated between different layers of material. This allows e.g. to combine barcode and RFID tag in the same label. The achievable reading range is function of the used frequency, the power level, the size and shape of reader and tag antennas, and the used protocol. Secure applications, which require e.g. data encryption, require more processing power, which results in a lower reading range.

The "oldest" class is the 125–1,343 kHz inductive systems, which offer - dependent on the size of the antenna - small reading ranges. Typical applications are access control for persons at premises and public transport ticketing. The tags can be available in different formats. One of the major applications is animal identification: small glass transponders (the size of a grain of rice) are injected in animals. The reading range for this type of transponders is very small, only a few cm.

13.56 MHz (also called "HF") is a global license-free frequency, which is used for applications requiring relatively small reading distance. Tags can be available as smart-labels: a loop antenna, connected to a small chip, is printed on an inlet. There are two types of 13.56 MHz RFID systems: "proximity", intended for logistic applications with higher reading ranges and little data exchange, "vicinity", intended for more secure and reliable technologies, e.g. smart card applications. "Proximity" is standardised by ISO 15693 and ISO 18000-3; "Vicinity" is standardised by ISO 14443, and example products are e.g. Philips Mifare.

The ISO 18000-3 technology supports currently two different technologies: Mode 1, which is the technology offered by the major manufacturers (Philips I.CODE, Tiris Tag-it) and Mode 2 (PJM technology), solely offered by Magellan Technologies. Mode 2 offers higher reading speeds than Mode 1, but due to its reliance on a single manufacturer, is not considered as option in other ISO application standards. Mode 3,

which provides a memory structure and applications compliant to EPC UHF interfaces, is under development. The maximum reading range (for Mode 1) is about 1.5 meter: as a rule of thumb, the size of the reader antenna is about the same size as the reading range. Large antennas are required to get large reading ranges, and they may be hence very costly.

UHF passive technology allows achieve higher read ranges: with standard tags reading ranges of 4-6 meter are possible. The performance of tags and readers has improved during the last years, and allows apply passive standard-based technology in applications which were previously addressed by proprietary active systems, such as access control. The technology allows to track multiple items at free flow (bulk reading) when passing through an industrial door at a distribution centre with up to 150 tags per second.

Tags can also use inductive coupling for near field communications, e.g. for printing or when unique identification (e.g. for item level identification) is needed. Much research has been put in the beginning of the millennium in this technology, and has led to industrially supported standardisation (EPC Gen 2, ISO 18000-6c), and is taken up by major retail chains, such as Metro and Wal-Mart. The frequency and allowed power are different in the U.S and Europe. In the U.S., where for specific applications higher power can be applied, passive tags can be used for secure long-distance applications, such as road use charging (e.g. Transcore eGo-system, which is in use in Puerto Rico).

Some products on the market which use a combination of different frequencies (e.g. iPico), e.g. a low frequency for wake-up of the tag and a higher frequency for reply.

For passive tags, UHF systems allow longer reader ranges and higher transmission speeds and lower costs, but cannot penetrate well through non-metal materials. The following table compares the two most important technologies for passive RFID: 13.56 MHz and UHF.

Table 1. *Comparison of HF and UHF frequencies (passive tags).*

Inductive (13.56 MHz)	**UHF (860-960 MHz)**
Reading range max 1,5-2 m (gate reader)	Reading range (in applications) about 4 m
Reads through non-conductive materials	Objects and fluids in the energy field decrease the range
Proximity of metal affects	Proximity of metal and fluids affects, but can be solved by special tag design
Standardised tags widely available	Tag antenna is normally optimised for the substrate to be applied to, and may have to be optimised towards the application
Global frequencies	Different frequencies and transmitting powers in Europe, USA and Japan
Size of antenna and reader are of the same magnitude (gate reader requires expensive antennas)	Reader antenna A4-size and cheap
Lower transmission speed (Mode 1)	High transmission speed

Chipless technology is a common name for a wide set of different technologies. Some of these technologies are already used, e.g. to secure documents, or for EAS (Electronic Article Surveillance) applications. By using the Surface Acoustic Wave (SAW)-technology, in which electro-magnetic waves are changed mechanically to surface waves through piezo-electric materials, reading ranges up to 10 meter for 2.45 GHz are possible, but tags are still very expensive.

Active tags

Active RFID technology has already been utilised more than 10 years in access control applications. The high price of the active tags and low standardisation level of these systems have limited their take-up. Tags which have a battery are either classified as active or semi-active, dependent if they use the energy of the battery only for amplifying the modulated reply to the reader, or if they completely rely on the battery for processing and sending the reply.

Active tags use either 433.92 MHz, 868 MHz, 2.45 GHz or 5.8 GHz. The reading ranges depend on the frequency: 4-10 meter for the older 2.45 GHz technology, up till 500 m for 868 MHz technology (Identec Solutions). Standardisation actions have been performed for 433.92 MHz (ISO 18000-7) and 5.8 GHz. The 5.8 GHz technology is used for road traffic applications, such as road use charging (DSRC). Dependent on the country, the use of DSRC is restricted by regulation, so that only authorities can use it, or it may be possible to use it for value added services. For instance in Portugal, DSRC-devices are used in parking applications.

The ISO 18000-7 standard for 433.92 MHz is based on IPR from Savi Technologies, and has been licensed in 2007 to several other manufacturers. Standards on tracking of containers and electronic seals are based on this standard. The Dash7-consortium, consisting of the major ISO 18000-7 RFID-system manufacturers is promoting the

technology and works on promoting interoperability and reliability, and building applications on top of the standard, such as electronic seals and sensing and monitoring.

Semi-passive (or battery-assisted passive) tags are appearing on the market, e.g. from Intelleflex ja Power Paper. New developments are the use of paper-like batteries, which are flexible and can be used as normal smart labels. The achieved reading range is larger than passive tags and they allow to add more memory to the tags. Battery assisted tags also provide the possibility to add sensor information to the tag memory. Sensors can for instance measure temperature, moisture, shocks etc. (For more info on sensors se SE4.3.3) Battery assisted tags, which are compliant to the EPC Gen 2 protocols have come to the market (PowerID and Intelleflex).

5.2.3 Tag memory considerations

Tags can have either only read possibility (Read-Only), Read-Write or Write Once Read Many (WORM). For most tag types, the tag manufacturer writes a unique ID in the tag, which can serve as identification. Exception is the EPC Gen 2 protocol: the basic protocol only requires 32 bit for the tag ID, which corresponds to the tag type. Many Gen 2 tags have now unique 64 bit tag IDs.

HP has published that they are working on a Memory Spot large-memory tag. In the MinAmi project, 13.56 MHz NFC tags are being developed with mass memory. The prototype tag has been demonstrated in a museum application.

5.3 Reader development; fixed readers, mobile readers

Types of readers

RFID-readers consist of the reader electronics and antennas. The antenna can either be integrated in the reader or be external. Typically 4-8 external antennas can be attached to a reader (for UHF passive tags). Typical configurations are a gate, in which antennas are placed at both sides, handheld readers, and more recently also readers which can be integrated in forklifts. For handheld readers, the antenna can be directly integrated in the reader or available through a special handle. A central control unit is needed in order to synchronise all the tags and to use the available frequency spectrum optimally.

The form factors of readers have changed, and readers are available which can be plugged in the USB-port of computers (e.g. ThingMagic)

RFID technology is also being integrated in mobile phones. For the NFC technology, mobile phones are specifically targeted as readers. The NFC technology is based on ISO 14443-A, but allows bidirectional traffic (devices are both tags and readers). The main application for NFC is contactless payment. Due to the long value chain and security related issues, the standardisation of NFC has taken a long time, and NFC is currently still restricted to a few phones and isolated pilots. The technology has many possibilities for the development of user-friendly services, but needs a critical mass of supported phones and applications.

5.4 Standardisation work

RFID is widely used inside firms. But in order to be implemented in the global supply chains, RFID technologies such as radio frequencies, transmission protocols and data sets, need to be standardised so that they function across actors, different equipment etc. An overview of the different standards can be found in the GRIFS deliverable 1.3 (http://www.grifs-project.eu/db/sites/default/files/GRIFSD%201.3%20State%20of%20the%20Art%20Report.pdf).

5.4.1 GS1/EPCglobal

Large efforts have been made in standardisation of RFID systems in the UHF frequency range during the last years. Two major organisations are developing standards: ISO and EPCglobal. EPCglobal is a joint organisation of EAN and UCC.

EPCglobal has developed standards for the whole chain, from air interface protocol, data content, and exchange of information between business partners. Regarding to air interface, the specification of the EPC Gen 2 protocol was one of the first milestones and breakthroughs, allowing the production of interoperable RFID readers and tags.

Related to data content, EPCglobal has defined how different EAN-codes. sGTIN (Serial Global Trade Item) for product package, SSCC (Serial Shipping Container Code) for transport unit and GRAI (Global Returnable Asset Identifier), can be coded into an RFID tag.

EPCglobal has also provided specifications for the capture of data, and for the communication of information between partners. For data capture, ALE (Application Level Event) specifications provides a standard interface to filter the collected data from the tags, by communicating events about process, location and time.

EPCIS (EPC Information Services) is a specification for the exchange of information between trade partners. Each company has its own EPCIS to manage and store the information related to EPC-tagged products. EPCIS data can be divided into the following categories: product data (description, lot number, expiration date), quantity information (availability), transaction events (e.g. last monitored occurrence). EPCIS Discovery services are used to find where information is stored: in the EPCglobal network, information is managed by each relevant partner. EPCIS Discovery service returns a link to the EPCIS services where data is stored.

Several tools are available on the market, e.g. Fosstrak (www.fosstrak.com), an open source RFID software platform that implements the EPC Network specifications. It is intended to support application developers and integrators by providing core software components for track and trace applications.

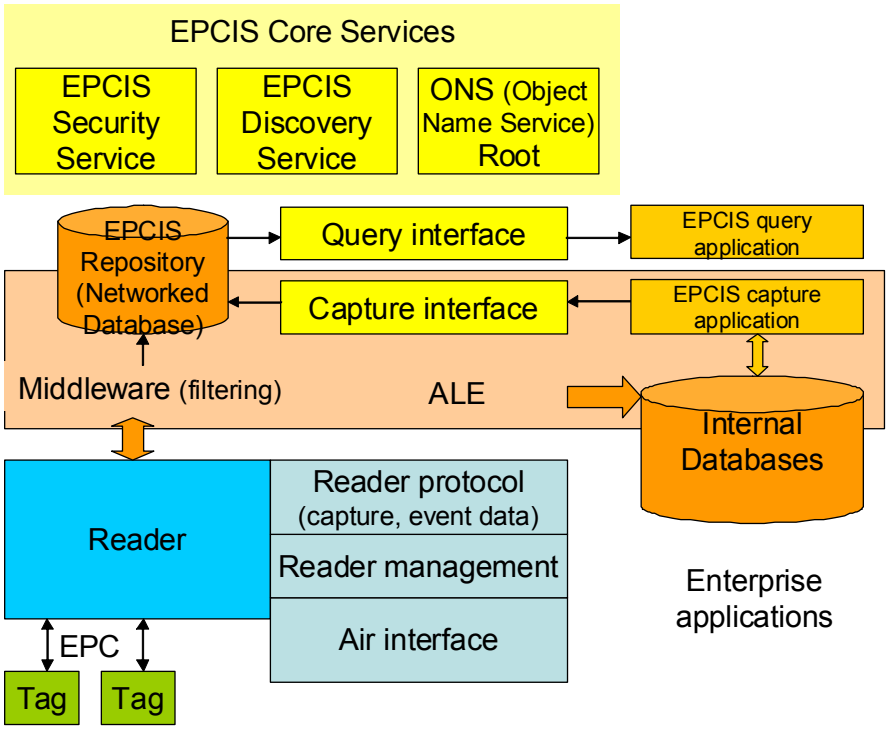


Figure 2 EPCIS services

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5.4.2 ISO

In the ISO approach, all information is written to the tag, and no interchange over the network is needed. ISO has developed standards for the air interface (ISO 18000 set of standards), data and device management (ISO 24791), commands and responses (ISO/IEC 15961) and data encoding and decoding (ISO/IEC 15962). The ISO standards take the work of EPCglobal into account, but are alos intended to provide additional functionality for RFID tags and applications, which are not directly relevant to EPCglobal.

In the UHF range, the most important for logistics operations, the 18000-6 standard has been developed, which allows for two different air interface protocols (18000-6A and -6B). After the standard was approved in 2004, the EPC Gen 2 was published, and the EPC Gen 2 air interface protocol was merged into the standard as ISO 18000-6. One main difference between the A- and B- protocols and the C-protocol is the way in which the tag memory is structured. Since UHF is not the optimal solution for all problems, there is a need to have a uniform structure of the tag memory independent of the memory. For this reason, there is currently work on incorporating EPC Gen 2 features for 13.56 MHz, which will result in the ISO 18000-3 Mode 3 protocol.

ISO/TC 122/104/JWG is also working on application standards for the different levels (vehicle, container, transport unit, product package and product) in the transport chain. At the different levels, different types of tags are used. For instance, for containers active microwave tags are used, for lower levels (product package - transport units)

UHF-passive tags are recommended, but HF-tags can be used with trading partners' agreement. The standards are currently still under development (see figure 2).

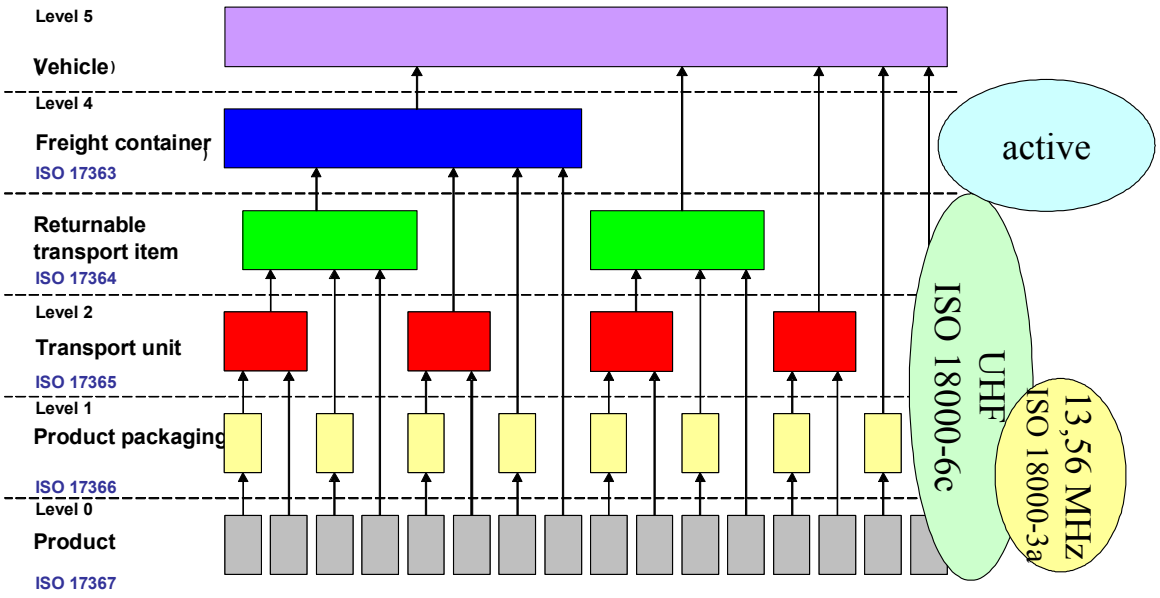

Figure 3: *Different identification levels in the logistics chain*

In the draft application standards, there are two different possibilities for providing a unique number to the asset: for retail items by using the EPC coding system; for non-retail items by the ISO/IEC 15459 International Unique Identification (IUI). The unique number consists in both cases of a Company Identifier, which is assigned by a Registration Authority (for EPC-codes GS1), and a serial number, assigned by the company.

In addition to these levels, there is the shipment, which can consist of different transport units (coded with SSCC). For this purpose GS1 is developing the Global Shipment Identification Number (GSIN) standard for RFID, which will be used to identify logistics transport units and will serve as the Unique Consignment Reference (UCR) for the shipment.

5.5 Intermodal units in multimodal chains

According to the ISO standards a container should have 3 different tags:
http://www.autoid.org/presentations/presentations.htm

- Container ID Tag - ISO 10891 (nee ISO 10374.2)
- Electronic Seal -ISO 18185
- Supply Chain Tag - ISO 17363

Sea containers will be identified with Extended Conveyance Asset Tags (XCATs), which is a passive RFID standard that EPCglobal is developing. Sea containers will also be outfitted with Gen2 passive RFID tags that will serve as security seals, and active tags will be tested for identifying pallets.
http://www.rfidupdate.com/articles/index.php?id=1708

6. Conclusions

RFID technology has developed rapidly during the last years. Also the standardisation is far enough. UHF/RFID technology is a radio technology. Information on automated identification has increased. Also technology performance has increased. The constraints and boundaries of RFID technology are well known. New devices which base on EPC Gen2 standards are more effective and reliable compared to earlier equipment. RFID's deployment still requires more industry cooperation on supply chain and branch levels as the deployment on operator level is challenging.

RFIF is a technology for future. Passive technology fits well on pallet level identification. On unit level there is also active systems in use.

7. References

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