BRIDGE

Building Radio Frequency Identification Solutions for the Global Environment

FINAL REPORT 2006-2009

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European Commission
Information Society and Media

BRIDGE

SIXTH FRAMEWORK PROGRAMME

BRIDGE is an Integrated Project supported
by the European Commission's FP6 Programme

For more information, visit http://www.bridge-project.eu
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From the European Commission
Head of Unit for RFID, Gérald Santucci
BRIDGE Project Officer, Florent Frederix

Many ICT applications found a new life on the transition from analogue to digital. Some of them, such as the mobile phone, made the transition to the digital world fast. For other appliances, it took much longer, sometimes because the advantages of a transition were not obvious (e.g. digital television) or sometimes because the challenges to migrate to the digital world and to open up a whole new domain of applications were too huge. Radio Frequency Identification (RFID) has been for long in the last category.

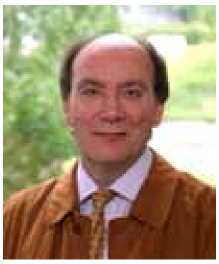
When it became clear that RFID would find its way to get on track and eventually create a new paradigm, the Internet of Things, the European Commission decided to allocate some research grants to support these developments. The BRIDGE project was the largest single RFID project receiving a grant from this research budget.

The BRIDGE consortium included academic partners in Cambridge (UK), Barcelona (Spain), Graz (Austria) and Zurich (Switzerland); technology partners in Tampere (Finland), Fudan (China), London (UK) and Viareggio (Italy); software partners in Walldorf (Germany), Malaga (Spain) and Uxbridge (UK); telecom partners in London (UK); GS1 standards organisations of most European countries and China; and an extensive list of users in retail trade, the pharmaceutical supply chain, and manufacturing. BRIDGE took on the challenge to harness their skills and experiences to drastically advancing the state of the art on RFID.

After three years of intensive work the list of achievements is remarkable:

- Low cost readers and smart shelves, building blocks for a practical deployment in the retail supply chain have been developed and prototyped for many sectors.
- Pilots have convincingly demonstrated the real benefits of the technology and will serve as best practices to educate prospective users.
- The BRIDGE discovery services activity met its ambition of building RFID-tagged object search functionality comparable to what search engines deliver today for content on the Internet. This BRIDGE investment in discovery services has been recognised by industry as the single largest effort of this kind in the world.
- Although early RFID applications made abstraction of security and data protection issues that can result from a mass deployment of the technology, BRIDGE dedicated work to these security issues. Without doubt this work will result in a new generation of RFID tags, readers and applications that can ensure a higher level of security and data protection than today's state of the art solutions.
- BRIDGE was present on stage at many European and international events to disseminate the knowledge it gained in the project and to create the momentum that should lead to a more competitive European industry in this new reborn RFID sector.

To conclude, BRIDGE's focus on research along with a growing international presence underscored its commitment to a longer-term focus at the time when RFID technology appeared to be an enabling technology for developing the Internet of Things and Internet of Services. Thanks to its groundbreaking work in moving a technology from a lab environment, out of the analogue age, to a mass market and into the digital world, maybe even the virtual world when objects find their identity on the Future Internet, BRIDGE has made a positive contribution to industry and society, primarily in Europe but also in a global perspective.



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From the BRIDGE Coordinator

It has been a privilege to work for more than three years with a dedicated team of close to 100 researchers and business executives from the 31 organisations member of the BRIDGE consortium.

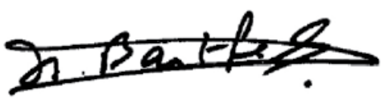
The journey started in May 2005, with the idea to develop a response to a call for projects issued by the European Commission. Following a complex evaluation and negotiation process, the BRIDGE project started officially in July 2006. Thirty-one organisations signed up to form the consortium that would implement the 150 pages business plan over the 3 years project life, representing a good balance between Universities, User companies, Solution Providers and Standard bodies. The overall budget of the project was evaluated at 13 million euros in terms of work efforts, investments and expenses. The European Commission committed to a maximum funding of 7,5 million euros, provided that the work plan was executed properly and the project deliverables met the quality requirements. The project progress was reviewed every 6 months by a panel of experts appointed by the Commission for this purpose. The periodic reviews were typically conducted through a 2-days meeting between the BRIDGE leadership and the independent experts.

During the course of the project, several patents were filed by participating organisations. A number of new hardware and software products based on innovative features developed by the research teams were commercialised. A start-up company was launched to promote a revolutionary concept of smart shelves embedding RFID readers and antennae. The project issued several important contributions to standard bodies in the areas of sensors, security and Discovery services. The business work packages identified the opportunities, established the business cases and performed trials and implementations in various sectors including anti-counterfeiting, pharmaceuticals, textile, manufacturing, re-usable assets, products in service and retail non-food items. A comprehensive set of education and demonstration material was produced. Many of the deliverables, documents, presentations, software tools, are publicly and freely available from the public web site. We strongly encourage anyone who has an interest in the RFID technology and its applications to make use of these valuable resources.

Our project was organised around fifteen work packages. I would like to thank particularly the work packages leaders who were responsible for the execution of the project plan in their areas. I would also like to thank the European Commission for having made this project possible. The formalism of the project structure and the reporting overheads are constraining but they are at the same time useful and probably indispensable to successfully run an ambitious project like BRIDGE.

The aim of this brochure is to provide an overview of the work that has been accomplished by the BRIDGE project. I wish you a pleasant reading and please do not hesitate to ask for more information or to consult our web site www.bridge-project.eu.

Henri Barthel
GS1 Director System Integrity, Technology and Partnerships, BRIDGE coordinator



BRIDGE

Building Radio Frequency Identification Solutions for the Global Environment

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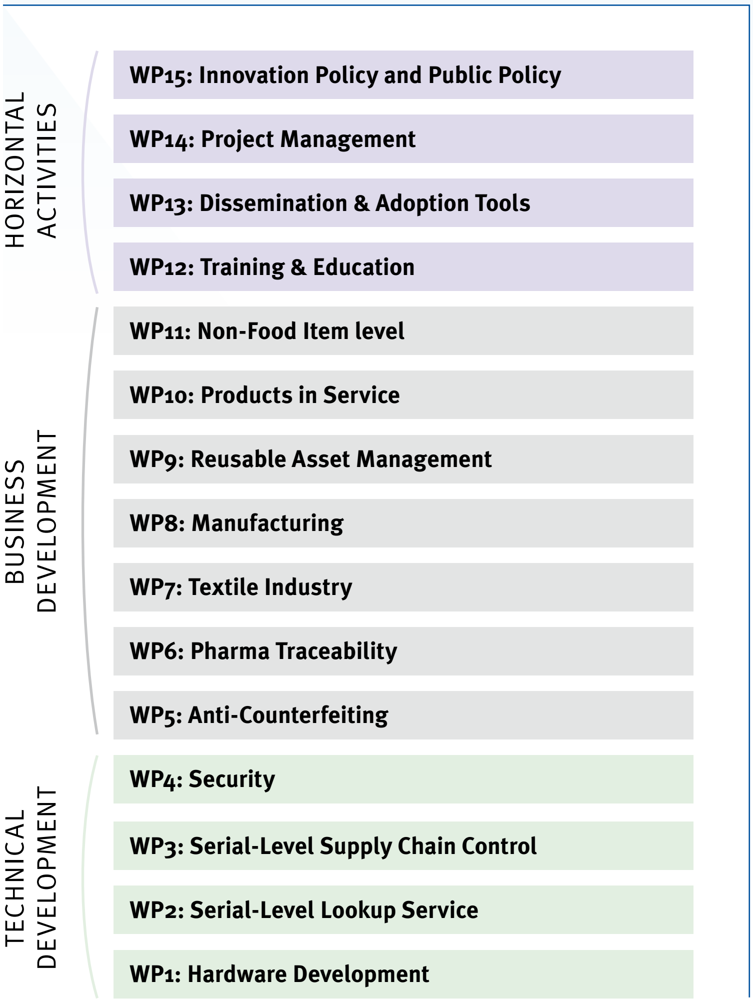
Executive Summary of the Project

BRIDGE (**B**uilding **R**adio Frequency **I**dentification Solutions for the **G**lobal **E**nvironment) was developed in response to the call for projects released in May 2005 by the European Union Information Society Technologies (IST) under the specific programme "Integrating and strengthening the European research area" in the Community sixth framework programme (FP6).

BRIDGE is a 3 year integrated project which started in July 2006 and ended in August 2009. Its consortium is composed of 31 partners, including 7 GS1 organisations, 5 universities, 11 solution providers and 8 user companies.

The objective of the BRIDGE project was to research, develop and implement tools to enable the deployment of RFID and EPCglobal Network applications. The project has developed easy-to-use technological solutions for the European business community, including Small & Medium sized Enterprises (SMEs), ensuring a basis for collaborative EPCglobal systems for efficient, effective and secure supply chains.



The project consisted of a series of business, technical development and horizontal activities. Seven Business Work Packages (WPs) were set up to identify the opportunities, establish the business cases and perform trials and implementations in various sectors including anti-counterfeiting, pharmaceuticals, textile, manufacturing, re-usable assets, products in service and retail non-food items. The project included an important research and development program in various aspects of RFID hardware, software, network and security. A series of horizontal activities provided training and dissemination services, enabling the adoption of the technology on a large scale in Europe for the sectors addressed by BRIDGE and beyond.

The chart on the left column shows the three main work areas, by Work Package group, in the BRIDGE project.

Technical Development

Four working groups concentrated on RFID Hardware, serial lookup services, serial supply chain control and Security.

Main achievements include:

- The **Hardware** team developed new RFID tags (more versatile, equipped with sensors, smaller and cheaper, more adaptable for metal and dielectric objects), new RFID readers and reader antennas (less expensive, more performing), new RFID systems prototyping some smart object environments.
- **The Serial Level Look-up Service work package** developed the requirement analysis and technical design documents for a Discovery Service, which has greatly contributed to the standards development on Discovery Services. This group also developed a software prototype implementing the original Discovery Service concept.
- **The Serial Level Supply Chain Control team** developed a tracing model based on track and trace probabilistic algorithms.
- **The Security team** issued a comprehensive security analysis documenting the requirements for enabling open and collaborative RFID-based business applications. They focused on security and privacy, RFID system security and integrity and network infrastructure security and developed several prototypes.

Business Development

The seven working groups looked at business developments in the use of RFID in a variety of sectors. Their work was organised following a common pattern:

Problem Statement

Requirements Analysis

Business Case

Pilot/Trial Infrastructure/Application

Base: EPCglobal Network

Most of the pilots conducted under the different application work packages started during the second year of the project and have been finalised in the third and final year. The impressive results, interesting outcomes, lessons learned and best practices include:

- **In anti-counterfeiting** – development of new services in the EPCglobal network to reduce the level of piracy of goods,
- **In pharmaceuticals** – increasing patient safety by improving traceability of pharmaceutical products as they move from the manufacturer to the hospital/ pharmacy,
- **In the textile industry** – better fulfilment of customers needs by increasing the flow and accuracy of information through the supply chain and in the store,
- **In food manufacturing processes** – reducing waste and stock holding and improving visibility and traceability of products and equipment, thereby improving food safety,
- **In re-useable assets** – improving information exchange and asset management between supply chain partners to reduce in losses and costs,
- **In products in-service** – developing systems and processes to increase the reliability of the upgrade, repair and replacement processes throughout the life of many products,
- **In the retail environment** – optimising processes in retail stores in order to increase service to the customer by using RFID on consumer sale units.

Horizontal Activities

In the first year of the project, the four groups produced 6 concept animations (multimedia learning objects that illustrate the use of RFID/EPC and their applications) to support training requirements. An RFID market sizing study providing forecasts of the number of readers, tags and locations that would use RFID technology in 5, 10 and 15 years was released early 2007. In the second year of the project, a portable demo that shows how EPC/RFID works in real supply chain conditions was finalised and is now downloadable on the public website www.bridge-project.eu.

BRIDGE has also developed five high-level training courses covering basic to advanced level, has undertaken the translation in five languages of an awareness raising website on RFID www.discoverrfid.org and undertook vast analysis in regards to data protection issues.

To coordinate all these efforts and to make sure they are disseminated in a coherent way, the BRIDGE team established a reliable coordination system, including general assemblies and meetings from the project management and cooperation board. This has enabled the project partners to remain in contact with each other and has created a good synergy to develop common activities and interactions between work packages.

Dissemination of the results was guaranteed through the public website, bi-monthly newsletters, and a strong presence in the specialised media as well as at European and international events on communication and information technologies.

This project has provided a great opportunity for Europe to build on a standardised RFID technology for use in global supply chains. The BRIDGE project has clearly contributed to the development of new solutions for all businesses, both small to large. Improving skills and expertise on RFID technology and network information sharing is leading to enhanced competitiveness of European companies and to increased to customers and citizens.

For more information

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For complete information about the BRIDGE project, access to the articles and public deliverables visit the BRIDGE Project Website http://www.bridge-project.eu

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Hardware, Software, Network and Security

The technical work groups performed research and developments to advance the state-of-the-art of the technology. In a number of cases the results of this work was implemented by the business groups in their pilot implementations.

The Hardware work package developed solutions in the following areas: Sensor-enabled tags, Miniature tags, Metal and dielectric object tags, Low-cost readers, High read-rate antennas for readers and Ambient intelligent RFID systems.

Serial-Level Lookup Service and Serial-Level Supply Chain Control work packages developed software and network solutions to support the access to data and the management of information related to items.

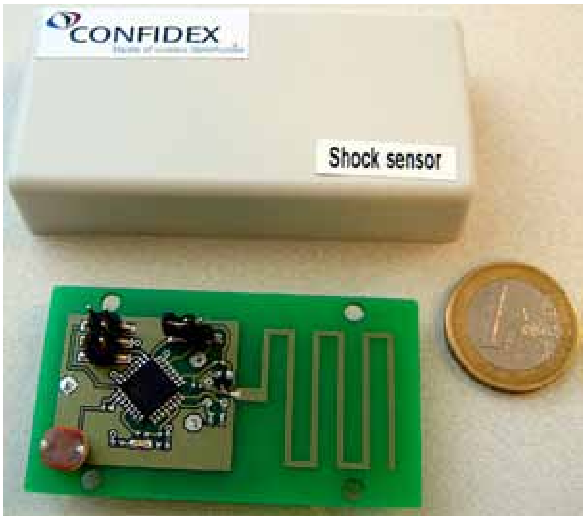
The Security work package analysed the requirements and developed solutions in areas such as RFID Tag Security, Anti-cloning RFID Tag, RFID Trusted Network, Network Confidentiality, Data Integrity for Preventing and Detecting False Information.

WP1: Hardware Development

WP1 has worked to advance the state of the art of RFID hardware. The goal was to develop:

- New RFID tags:
  - More versatile and equipped with sensors
  - Smaller and cheaper
  - More adaptable for metal and dielectric objects
- New RFID readers and reader antennas:
  - Less expensive
  - Better performance
- New RFID systems to prototype some smart object environments

In the field of **sensor-enabled tags**, first a benchmark study was performed investigating the different technologies, standards, and user requirements. This was compiled into a Sensor-enabled RFID Handbook that reduces the learning curve for any company seeking to develop this kind of tags. Later a design effort was started that resulted in a common platform, proposing operation modes, data management procedures, and protocol extensions to build modular sensor-enabled RFID tags. Finally, some multi-sensor tag prototypes were built based on the proposed common platform.



Prototype of a sensor-enabled tag, compatible with the EPC Gen2 protocol

In response to a high market demand for **smaller tags** several techniques where investigated for tag miniaturization, from fractal shapes to use of different materials. Finally, a tag with a very high read-range to size was designed, borrowing a concept from meta-materials research: the Split-Ring Resonator (SRR). Tags for **metal**

and dielectric material were designed using the same principle: isolation from the material but with a minimum thickness to keep the tags conformal to the shape of the tagged objects. This has been a very competitive field of research, in which industry has come up with high performance designs. The contribution of BRIDGE was a very thin design based on a double bow-tie resonator.

RFID-equipped metal shelf in its test environment

Two different research lines were started to design a **low-cost RFID reader**. On the one hand, the first prototypes in the industry based on specific RFID reader chipsets were designed and prototyped. The forecast was a factor of five cost reduction versus current market prices. On the other hand, an effort was started to reduce the price of the RFID chipset itself by designing it using common CMOS processes, rather than using a different process for the RF and the digital parts of the chip. This promises cost reductions of at least a factor of ten.

Research was also conducted to improve the **performance of the readers**. For this BRIDGE research concentrated on the reader antennas. First a novel design of a phased array antenna was tested, improving the read rates of static constellations of tags. It is well known that moving tags are easier to read since multi-path cancellation blind-spots tend to be static. When tags are static, the phased array reader antenna moves the beam slightly, and randomly, moving the multi-path blind spots, and thereby increasing the readability of large populations of static tags.

Next another difficult RFID problem was tackled: the **metallic shelf**. The smart-shelf concept, in which the shelf is aware of its contents, is an old RFID paradigm that has faced difficulties in practice since most shelves in use today are metallic and no reliable, robust, and economic way had been found to equip such shelves with RFID antennas. To address this a specific design based on slot antennas was prototyped and successfully tested in a live retail environment, producing 100% read rates over a full month of testing. In this test, multiplexing was used to reduce the total cost of equipping a supermarket with RFID antennas used on metal shelves.

Finally, more theoretical research was conducted with the goal of pushing the limit of how many tags a reader can read in a second. This number is limited by anti-collision protocols. Since all tags communicate with the reader using the same protocol, the reader can only communicate with one tag at a time, and needs to employ a multiple-access strategy, similar to those employed in other one-to-many networks to resolve collisions. The use of Blind Signal Separation (BSS) algorithm was shown to allow a single reader to communicate simultaneously with up to four tags. For this, readers would have to be equipped with at least four RF front-ends. Each of these receives a different mix of the signals from the four tags. The role of the BSS algorithm is to separate the response from each individual tag. Once this is done, the reader can also communicate back to the four tags simultaneously.

The third area of research demonstrated the use of RFID for **building smart-object systems**. First, the smart-shelf prototype was equipped with algorithms to use the RFID antennas to manage a stock of books in a store, locating them precisely on the shelf, sending out-of-stock alerts, and producing lists of misplaced items. Second, the smart-object paradigm was applied to the remote servicing of heavy equipment. For this a lab prototype of a washing machine was built, which made use of RFID readers and sensors to detect malfunction (over-heating, vibration, water leaks), misuse (wrong washing program for the clothes in the load), use of non-original spare parts, as well as sending warnings when specific parts needed servicing or replacement. A web-based platform was developed to remotely control all of these functions, demonstrating how RFID could dramatically improve the quality and efficiency of the management of a large and geographically disperse fleet of machines (washing machines, vending machines, vehicles, agricultural and mining equipment, etc.).

In summary, BRIDGE research has helped advance the state-of-the-art of RFID hardware with a set of prototypes ready for industrialization; promising concepts that require further research in the laboratory; and with some theoretical results. Some of these deliverables will be patented and some will be exploited commercially.

WP1 Leader: UPC

Partners: CAEN, UPM Raflatac, Confidex, Auto-ID Labs Fudan, Auto-ID Labs Cambridge, AT4 wireless and AIDA

WP2: Serial Level Look up Service

The Introduction of Discovery Services

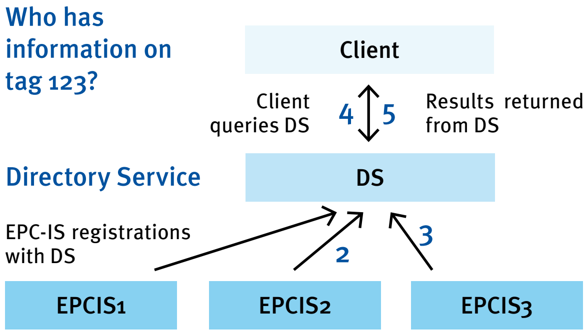
In the EPCglobal network context, data related to items identified with a serial number is typically stored locally by the different supply chain partners using EPCIS. WP2 designed a concept and prototype of a Discovery Service, a mechanism enabling discovery of sources of information related to specific items. The idea was to develop a "role" complementing existing functionalities on the EPCglobal architecture and specifically EPCIS and ONS. Such a tool would exploit the value of individual identifiers for track and trace purposes with a tremendous potential impact on supply chains and possibly in highly regulated sectors like food or pharmaceuticals where this information can improve consumer safety.

Furthermore, on a longer term basis, research on Discovery Services may have a great value for developing the Internet of Things, as networked nodes would need to announce themselves and discover others for sharing capabilities, resources and services. With this motivation, and the understanding that research work could not be driven by academic interest alone,
a group was formed with WP2. The group, led by AT4 wireless, included: the AIDA Centre, BT, Cambridge University, ETH, SAP, GS1 UK. The group looked at end user needs in different areas such as usability, performance, smooth integration to existing IT infrastructure and Return on Investment (ROI). Moreover, the group assumed that its work should be contributed to other research groups and hopefully would trigger or support early stages of discussions within standardization bodies.

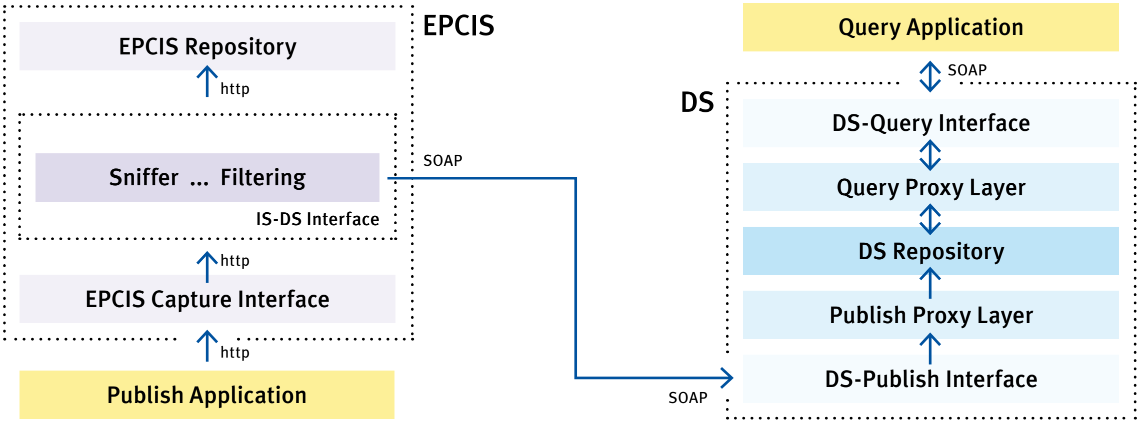
After the kick-off in July 2006, a survey with potential users was launched for a four month period. Results revealed that respondents were not confident with open supply chain models and expressed concern about sharing information without knowing exactly who would access that referral information via Discovery Services. These concerns became the main requirement for Discovery Services and led partners to decide to reduce as much as possible the amount of information stored in the service. Basic Discovery Service records would include only pointers to sources of information, enabling whoever uses this service to discover the source, but not releasing information and leaving this decision to the companies which would keep control of the information. This early concept of the service has evolved through the life of the project, also after receiving feedback from WP4, which assumed the development of a security framework for EPCglobal Network, including future Discovery Services.
When researching on high level design models, the security concerns supported the concept of a service that may act as a proxy, forwarding queries down to resources. However, aside from security another important requirement for the Discovery Service was the need to provide synchronous responses to queries, which is not the case for this model. Therefore, a synchronous model, the directory of resources, was selected as a first candidate for prototyping, using Web Services technology and LDAP (Lightweight Directory Access Protocol) as search engine and repository of referral information.

This prototype was developed and deployed, and today is in operation and accessible to BRIDGE members for trials, further development and integration with the security framework developed within the scope of WP4. In addition, the Discovery Service prototype source code is being distributed under Lesser General Public License (LGPL), in order to increase interest from the research community. Different organizations have shown interest in the Discovery Service, including BRIDGE members such as GS1 France, SAP, BT, Benedicta and Sony and also external parties like Afilias, GS1 Norway and even other EU projects like iSURF, led by Intel. For ease of use and demonstration purposes, a demo publishing application and query application were developed together with the open source software.

WP2 lasted for the first 18 month period of BRIDGE.



Directory of resources model



Discovery Service prototype components, integrated with Fosstrack EPCIS

Demo Applications for Discovery Service

However, WP2 partners have continued actively participating in other technical work packages, such WP3 and WP4, and also in business oriented work packages, which have shown some interest in Discovery Services, specifically WP9 and WP10.

At the end of 2007, some WP2 members contributed to the IETF ESDS (Extensible Supply chain Discovery Service) mailing list with work package conclusions and public deliverables. Also, since October 2007, WP2 members provide technical contributions and leadership within the EPCglobal Data Discovery Joint Requirements Group. In fact, University of Cambridge who also leads BRIDGE WP3 is taking a major role in both groups. Therefore, WP2 believes its work on BRIDGE will be inherited and extended toward developing this very important standard for the future Internet and information sharing among businesses.

WP 2 Leader: AT4 wireless

Partners: Auto-ID Labs Cambridge, ETH, BT, SAP, AIDA and GS1 UK

WP3: Serial Level Supply Chain Control

Progress on the track and trace analytics framework

BRIDGE WP3 was designed to be complementary to WP2. BRIDGE WP2 focused on the requirements, design and prototyping of Discovery Services, secure lightweight referral services that enable multiple information resources (such as web pages and EPC Information Service (EPCIS) repositories) across a supply chain to be found.

Although Discovery Services are a useful architecture component for enabling improved supply chain visibility, they are not fully fledged track and trace applications and essentially answer two very simply low-level query criteria, namely:

1) where can I find information about this EPC/RFID Tag
2) notify me of any additional future providers of information about this EPC/RFID Tag

BRIDGE WP3 leveraged the Discovery Services work of WP2 but bridged the gap to provide support for more business-friendly concerns about track & trace and supply chain control, while leveraging the benefits of being able to follow uniquely identified objects as they move through supply chains or product lifecycles, without requiring business users to know how to interact with EPCIS repositories or Discovery Services.

Members of WP2 and WP3 worked together on general requirements gathering for traceability, as well as the specific requirements for Discovery Services.

The first deliverable, D3.1, "Serial Level Inventory Tracking Model", described how to gather event information from across a supply chain, taking into account the need to follow changes of aggregation. The group then described how to use this event information with machine learning techniques such as Hidden Markov Models in order to learn the characteristic flow patterns, so that we can not only answer questions about where an individual object was last observed but also predict when and where an individual object is at the current time or future times, based on its previous observation history and the learned flow patterns. Using these probabilistic algorithms it is also possible to give a confidence level about whether an object is likely to reach a particular location by a specified time. This is clearly useful for being able to predict whether ordered supplies will arrive in time for a particular production schedule, as well as for monitoring that manufactured goods are likely to reach specific customers by particular deadlines – or whether there is any need to intervene.

D3.1 may appear as a rather abstract mathematical model for predicting flows of individual objects within supply chains. However, the decision was taken to develop a working software prototype of such a Track & Trace Analytics Framework, so that it could be available for use by the business application work packages, for monitoring their supply chains.

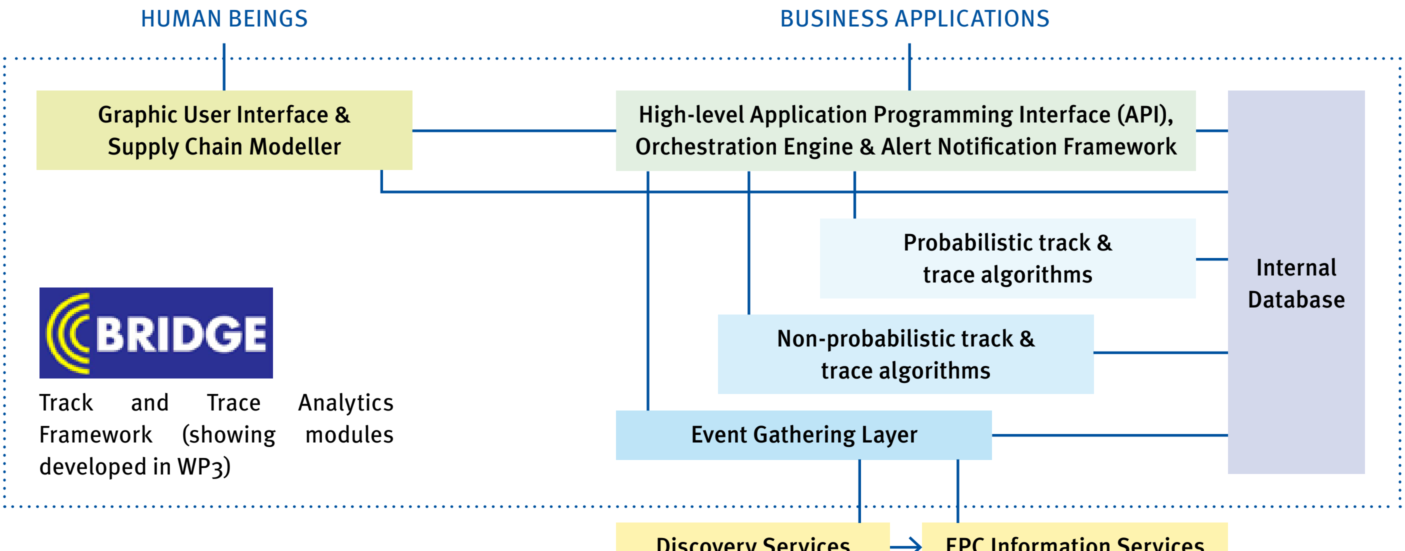
The Track & Trace Analytics Framework was designed as a number of modules that interface with each other.

At the lowest level of our architecture, an Event Gathering Layer is responsible for interfacing with the EPC Network architecture and specifically in making queries or registering standing queries to Discovery Services and EPCIS repositories in order to gather all the available event information about an individual object, even though the information is fragmented across the supply chain. Furthermore, the group recognised that as objects move across supply chains or throughout their product lifecycle (including the usage phase), there can be significant changes of aggregation, such as when raw materials and components are embedded within products, which in turn are aggregated into cases, pallets, totes and vehicles for distribution and storage. Conversely, in a number of sectors such as the food or chemical industries, large volumes of bulk product are manufactured and later broken down into smaller packages for use.

WP3 developed techniques for automatically following changes of aggregation, in order to ensure end-to-end tracking, even if it was necessary at times to switch to tracking a different identifier, such as the identifier of the pallet, vehicle or the identifiers of multiple products that were broken down from the original bulk product.

Having gathered the event information, it is necessary to build a model of the supply chain in order to make sense of the movements of the objects. A Supply Chain Modeller was developed, which was able to analyse the received event information and automatically construct graphs of nodes and transitions between those nodes. Further manual refinement of the models is also enabled through the provided graphical user interface.

Track and trace algorithms (both non-probabilistic and probabilistic) were developed in order to learn flow patterns, filter out false positives and false negatives and provide predictions and probability estimates about where an object is now, which path it is likely to have taken and where it is likely to be in the future.

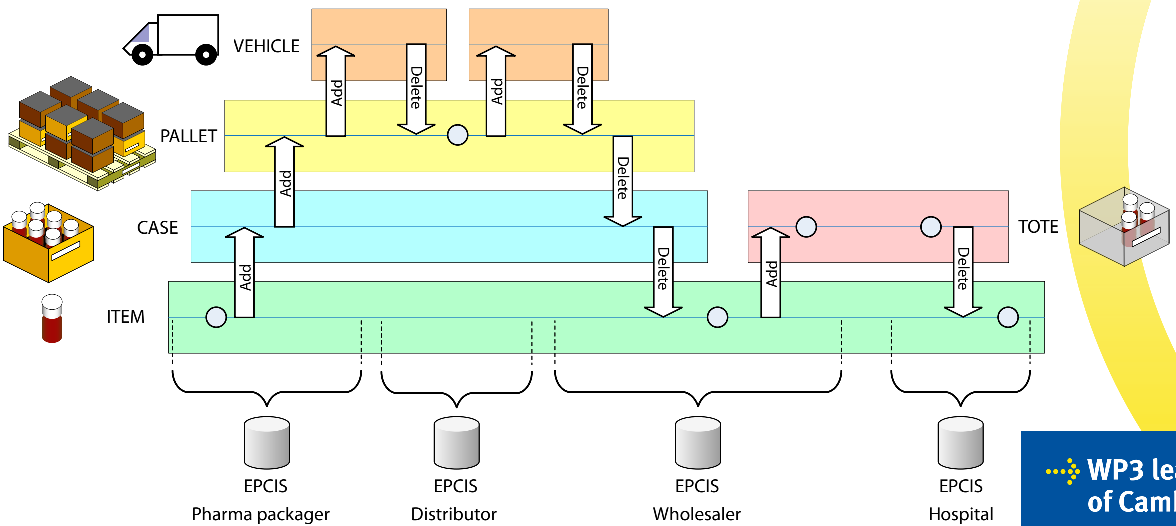


Conceptual diagram of Track & Trace Analytics Framework

Finally, the modules were integrated and tested using real-time event information from the automation lab in Cambridge, tracking the movement of autonomous shuttles moving around a conveyor track. The track & trace analytics framework was also used to analyse data from the WP6 pharmaceutical traceability pilot.

Deliverable 3.2 on the software prototype was completed at the end of 2008 and the remaining six months have mainly focused on completion of the remaining tasks, which examine how such a Track & Trace Analytics Framework can be applied to improve manufacturing processes and traceability, assist with the management of reusable assets (in particular, returnable transport items such as pallets, roll cages, trays, reusable plastic containers, beer kegs etc.) and how it can be further extended to support sensor-based condition monitoring as well as alerting and notification about operational problems within supply chains, such as monitoring of delays and shrinkage, probabilities of non-arrival of goods or supplies or detection of unusual or suspicious flow patterns. Based on the analysis within the deliverables D3.3, D3.4 and D3.6 of real-world practices, a number of additional high-level algorithms have been developed as a proposal for extension of the Track & Trace Analytics Framework developed in the deliverable 3.2.

In addition, in task 3.5, an alerting and notification framework has been designed, to support high-level alerting about operational problems within supply chains that are detected using the track and trace analytics framework.



The Event Gathering Layer can be used to automatically follow changes of aggregation, such as these changes observed in the WP6 pharmaceutical traceability pilot.

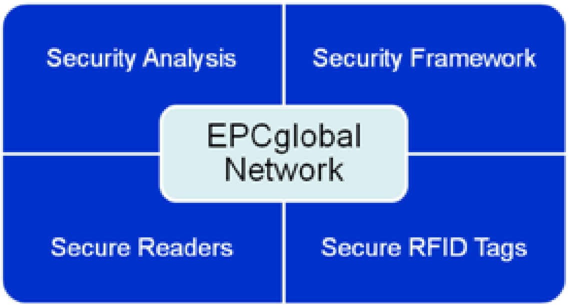
WP3 leader: University of Cambridge

Partners: BT, SAP, ETH Zurich and Bénédicta.

WP4: **Security**

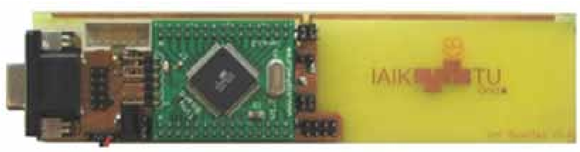
Securing Collaborative Supply Chain Networks

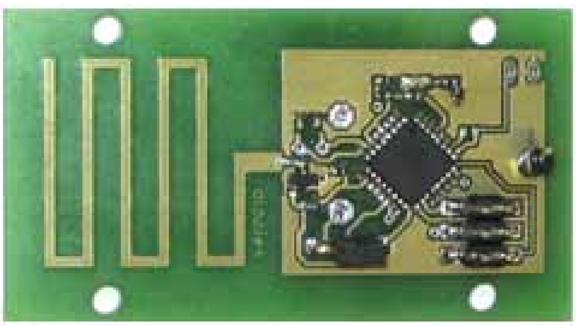
WP4 Security have operated technical research tasks on both hardware and software security and have performed requirements surveys, interviews and case studies, along with the publication and dissemination of our results and learnings to both ISO and EPCglobal standards activities.



Scope of the WP4 activities

The tag security research has concentrated on providing an asymmetric cryptographic capability of the tag that can be used to extend the ISO18000/EPC Gen 2 protocols to support a wide number of security operations for different scenarios. The work package has analysed different cryptography schemes to select one that requires low silicon area, has low power demands and fast computation. This enables the costs of the tag to be kept low and the performance maintained. The group also examined the potential to perform Side Channel Attacks (such as power analysis) to break such secure tags and recommended to tag developers to consider such attacks in their implementations.



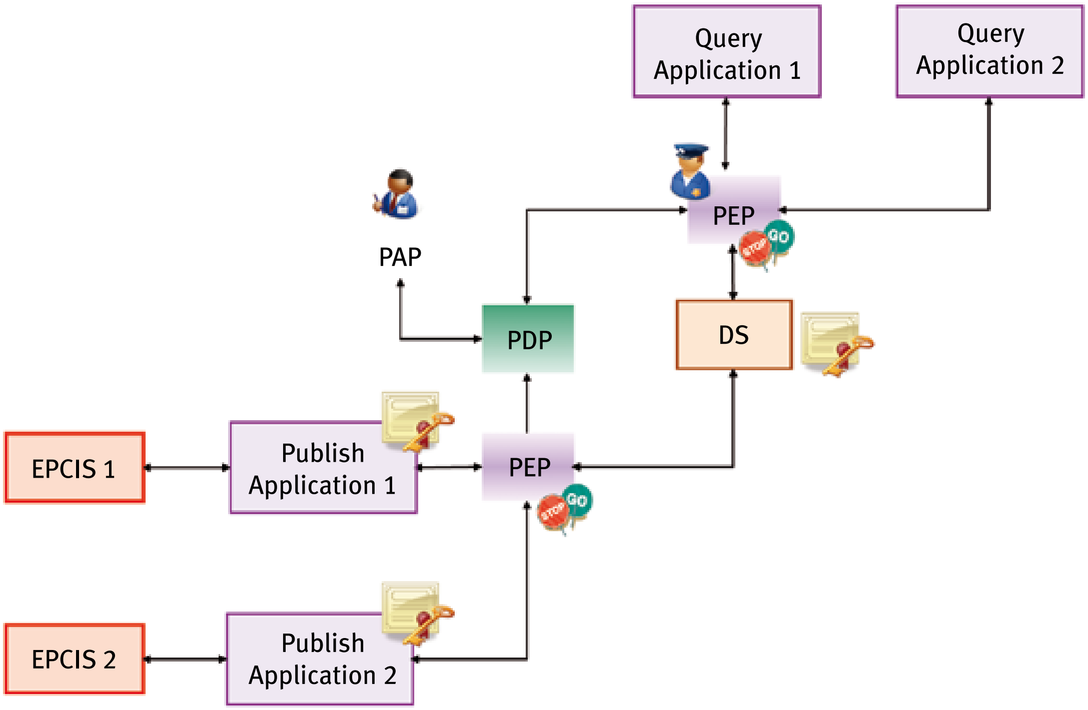


Examples of tags developed within WP4

Using the secure tag capabilities the group has implemented a number of security operations including pseudonym scheme and authentication commands. The authentication command has been implemented by two tag manufacturers, and the resulting anti-cloning tag has been demonstrated in an anti-counterfeiting demonstration with the addition of an authentication client, back end authentication server and EPCIS repository for results. WP4 has also produced a prototyping tag that allows researchers to experiment with new cryptographic capabilities and commands. Finally, the tag security research has worked with ISO to start a security working group to standardise the way that secure tags can advertise their capabilities.

The second hardware area involved the development of a Trusted Reader. This has involved developing a new reader control board incorporating a TPM (Trusted Platform Module), along with a software stack to secure the integrity of the operating system and allow multiple parties to instantiate secure local services on the reader. WP4 has shown how the Trusted Reader can offer many advantages to different tag authentication methods, and devised a scheme for controlling the distribution paths of goods using the Trusted Reader to check and authorise the shipment along supply chain paths.

In the area of software security the focus was networked services for inter-company operation of supply chains. A framework of components for access control and access control policies was developed and implemented in the Discovery Service prototyped in WP2. The group also looked at how critical business information can be leaked through raw RFID events and proposed methods to manage the information release. The problem of introducing previously unknown parties within the supply



Secure Discovery Service

Where access control is mainly about confidentiality, the group looked at the problem of information integrity, which is critical to inter-company operation. Each organisation has to be able to trust the data from its peers in order to be able to operate the joint processes. The economics of the problem of information sharing were examined. Technically the group demonstrated the use of visualisation to detect integrity problems (either in the information accuracy or in the process itself), along with the use of automated integrity rules checks.

chain and how this can be achieved using the Discovery Service or through other techniques was also considered. Where relevant the work package has shared information with the EPCglobal JRG on Data Discovery.

WP4 Leader: BT

Partners: Bénédicta, ETH, SAP, TUG, UPC, AT4 wireless, Auto-ID Labs Fudan, GS1 UK, UPM Raflatac, Confidex and CAEN.

2

Business Applications

The Business applications identified the business opportunities, analysed the requirements, established the business case, mapped the requirements with the available technologies and standards, and identified problem areas that should be researched. They performed pilots and implementation, evaluated the results and issued application guidelines for using the technology in their particular business context.

These pilots will serve as examples and inspiration in many industry sectors.

WP5: **Anti-counterfeiting**

Solutions to detect counterfeit products in the supply chain

Counterfeiting and product piracy constitute a serious and ever growing problem against legally run businesses and owners of intellectual property rights. Counterfeiting and piracy are not specific to any industry, but they affect a large number of sectors. They include the music, software, and luxury goods industries, and also pharmaceutical industry, automobile industry and fast moving consumer goods industry. According to the International Chamber of Commerce, "[...] counterfeiting and piracy are growing exponentially in terms of volume, sophistication, range of goods, and countries affected - this has significant negative economic and social impact for governments, consumers and businesses [...]."

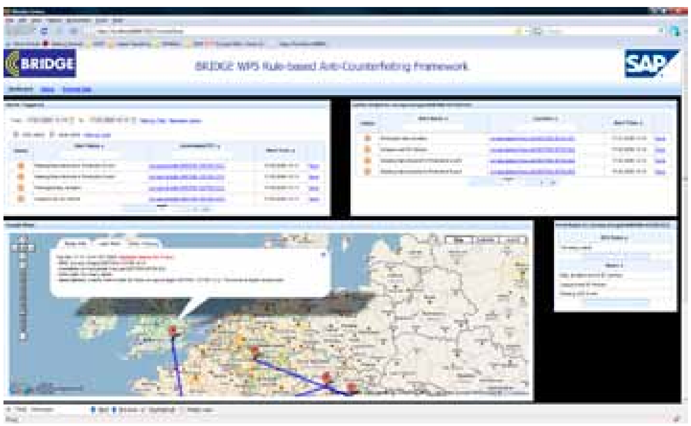
The potential of RFID and the EPCglobal network in enabling novel anti-counterfeiting and anti-fraud techniques is well recognized. Even though it seems that there will not be one silver bullet solution against illicit trade, industries and academia see mass-serialization among the most promising single countermeasures. There are two major reasons for using EPC network technology in anti-counterfeiting. First, RFID allows for new, automated and secure ways to efficiently authenticate physical items. Second, as many companies invest in networked RFID technology for various supply chain applications, the item-level data will be gathered in any case – so why not using it to detect counterfeit products?

WP5 has developed anti-counterfeiting techniques for EPC/RFID-enabled supply chains. The solution concepts and prototypes are based on a thorough requirements analysis, and they leverage the visibility that the technology provides. Different solution approaches have been studied, developed and demonstrated, including: (i) Tag authentication based on unique transponder ID (TID) numbers; (ii) Synchronized secrets approach that detects if two different tags enter the supply chain with same ID numbers; (iii) Rule-Based Anti-Counterfeiting approach (see Figure on the right) that offers a flexible anti-counterfeiting toolkit which allows users to specify conditions that indicate evidence of counterfeits, and (iv) statistical track and trace analysis techniques to detect cloned tags automatically from RFID traces. All the studied and developed approaches represent different possible security measures that enable detection of counterfeit products in supply chains.

WP5 has also investigated the business cases of the studied solutions. When RFID technology is deployed not solely as an anti-counterfeiting technology but also for other purposes, as examined in BRIDGE, not all hardware and tagging costs need to be allocated as anti-counterfeiting costs. However, putting numbers on the benefit side of an anti-counterfeiting business case is extremely challenging. WP5 has investigated the value of security in anti-counterfeiting and provides an explanatory model for the benefit side of an anti-counterfeiting investment.

To support affected brand owner and manufacturing companies across industries, WP5 has also produced application guidelines and an implementation roadmap for EPC/RFID based anti-counterfeiting measures. These cover selection of the right security measures, selection of the right supply chain locations for the checks, and steering an anti-counterfeiting system deployment project.

All in all, the investigated techniques represent a paradigm shift in anti-counterfeiting. Today, technical countermeasures only treat the symptoms of counterfeiting and minimize apparent costs such as liabilities, but they do not make counterfeiting financially unattractive in an efficient way since only a few percent of products are ever authenticated, if even that. EPC/RFID-based anti-counterfeiting measures, on the other hand, can secure the whole supply chain against counterfeits and make product counterfeiting financially unattractive by significantly increasing the check rates.



BRIDGE Rule-Based Anti-Counterfeiting Framework

WP5 Leader: SAP

Partner: ETH

WP6: Pharma Traceability

Building a complete item level traceability system within the pharmaceutical supply chain

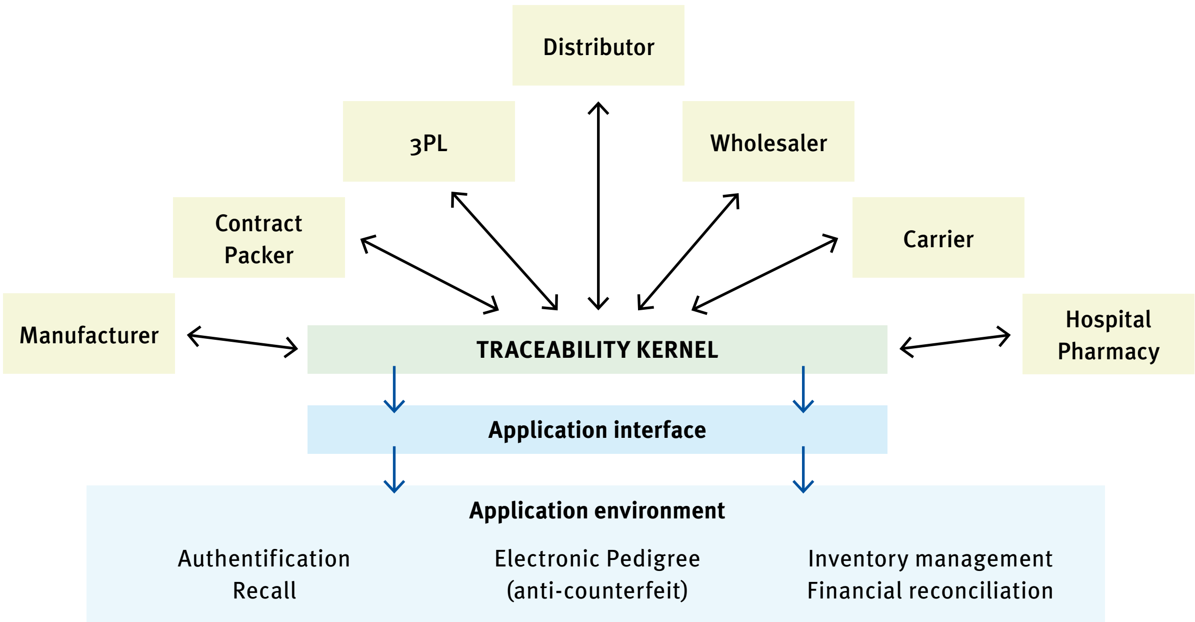
The Pharma Traceability Pilot has proved to be an exciting, innovative pilot on an international scale; no other project, to our knowledge, has designed, installed and successfully operated such a comprehensive system of track, trace and authentication within the 'real' pharmaceutical supply chain, anywhere in the world.

Work Package (WP6) has implemented and piloted a fully operational drug product tracking system using the EPCglobal network for supply-chain wide data collection as well as using GS1 DataMatrix symbology on all levels of product packaging – item, bundle, case, pallet and vehicle - for the first time. In addition, RFID tags were used at case and pallet level in hybrid labels (with printed bar codes). Some pallets were also fitted with active RFID tags to enable GPS tracking across national borders and shipping routes. Whilst this was an addition to the original project design, it added further innovation to the project. This use of interoperable RFID and printed bar code carriers should set an example to all of how such a practical system can function successfully in the real world.

The adoption of the four string data structure, as originally used in the Irish Haemophilia Trial of 2006, was very forward thinking. This structure is now being used by EFPIA as part of its European vision, in Turkey for its new reimbursement system and being considered by California and FDA in US. It may yet become the blueprint for the first globally accepted data structure used in the pharmaceutical industry at item level and beyond.

The serial number element that forms an integral part of the data structure is critical, simply because of its unique nature. The result is that every single pack of each product being tracked had a unique serial number associated with it. Using this and the process of aggregating the contents to unique serialised packaging, the team were able to provide full traceability of a single item from the packaging line, throughout the distribution supply chain to the precise delivery point at the hospital pharmacy as well as to every associated packaging type along the entire supply chain.

Full use was made of the GS1 and EPCIS systems including the GLN (Global Location Number) and GRAI (Global Returnable Asset Identifier) numbers for locations and physical assets and SSCC (Serial Shipping Container



Conceptual illustration of the Pilot's capability to support multiple business applications

Code) for logistic units deployed as part of this pilot. Linking these GS1 number formats to data carriers such as GS1 DataMatrix, GS1-128, and RFID tags and data structures has expanded the knowledge and use of how to integrate these 'tools' into a fully functioning solution.

The selection and use of a range of different printing technologies, substrates, line speeds, various types and sizes of container or pack added to the comprehensiveness of the project.

Choosing to work with both original pharmaceutical packers/manufacturers, as well as a contract packer, allowed the team to test the two most common routes into pharmaceutical supply chains. The choice of generic manufacturers, who in general operate at lower margins and higher line utilisation rather than branded product (so often used in pilots and trials), also added significantly to the worth of the project.

All of the product and event data was collected locally and then passed via the Internet to the respective EPCIS database for each of the nine user companies involved.

Where possible the WP6 team chose different methods of processing data for similar operations in order to compare their functionality and practical application; for example, the dual process for the receiving of the pallets. First, a manual scanning system linked to the Internet where the operator scanned the pallets using a bar code scanner was used and the data was then sent to the EPCIS system. Second, in a more automated operation where an RFID portal was used to read the pallet tags, the goods-in operator moved the pallet through the portal using a forklift truck, the data collected from this process being saved separately. The data collected from these operations was then compared to ensure that both were operating correctly.

Mobile technology to scan codes at various 'remote' locations was deployed which proved to be highly successful and added to the experience and learning from the practical use of complex code carriers such as GS1 DataMatrix where hardwired or other traditional solutions would have been difficult or impractical.

The Case label, bar coded and RFID tagged

The data collection model adopted by the Pilot was based on the recording of events against pre-published master (product) data. This provided the necessary flexibility to enable the support of a number of different applications – not only to enhance patient safety but also to improve supply chain efficiency: the ability to determine the whereabouts of products in the supply chain for speedy recall; the ability to integrate data into back-office applications such as inventory management for better stock utilisation with expiry date management and financial reconciliation (e.g. goods received data matched with supplier invoices); as well as the ability to identify non-authentic or non-authorised products.

In summary, whilst the Project experienced a number of delays and issues of a systems and operational nature during the course of the implementation and deployment, many valuable learnings and experiences were gained as a result. By successfully overcoming these obstacles, WP6 has demonstrated a practical, workable solution for mass serialisation for track and traceability of pharmaceuticals in the open supply chain.

Much more information is available on the Pharma Traceability Pilot from www.bridgewp6.eu

WP6 Leader: JJ Associates

Partners: Domino, GS1UK, Melior Solutions, Verisign Inc.

WP7: Textile Industry

European Textile Industry Business Applications

The focus of work package 7 was the textile supply chain. The objective was to examine the feasibility of EPC/RFID technology in the textile industry and to develop the adapted RFID technology for successful implementation. The entire project was conducted by analytical- and empirical-based studies to identify potential RFID opportunities in supply chain processes taking various factors into consideration.

The work package was developed through 5 steps and focused on the European textile market, the requirements of the technology, three different business cases, the pilots and a step by step implementation guide.

In each phase several experiences were made. Significant changes can be observed in consumer behaviour, distribution channels and retail structures. Due to increasing competition, price pressure and labour costs, companies are envisaging possibilities to save costs for example by implementing a new technology. By identifying the technical requirements, all these applications require different systems and set ups. Different hardware solutions are required, e.g. mobile devices vs. fixed gates, number of tags, antennas and printers.

The issue of different business cases for an SME supplier, a department store and a hypermarket were analyzed, and necessary aspects were clarified. Facts like company type, articles and labour costs were taken into account to determine the amount of investment, the amortisation time and the return on investment.

The screen display at the gardeur shop at Galeria Kaufhof

After developing and analysing these theoretical aspects, practical experiences were made within the pilot phase. Three partners participated in the empirical study phase.

The Galeria Kaufhof team was interested in the customer attitude towards customer oriented RFID applications. The gardeur shop in the Galeria Kaufhof store, Essen was equipped with smart shelves, smart dressing rooms and a smart mirror. Mirror, shelves and dressing rooms were equipped with displays to show RFID enabled product information to the customer.

All three applications were evaluated by a customer survey. Over a period of three weeks, more than 250 customers were interviewed (50% men/50% women). In general, customers accepted RFID applications and evaluated them as a big advantage regarding their personal shopping experience. Respectively, 56% and 49% of all respondents appreciated and accepted the smart shelf and the smart dressing room as an informative tool and a useful improvement for their selection of a product.

Northland – an Austrian manufacturer of outdoor clothing wanted to find out to what extent an RFID inventory process was more effective than a manual inventory. They identified very good results both in terms of time saving and accuracy of the inventory: The pilot showed a reading rate of nearly 99% and an increase of speed by 20 times.

Gardeur, an SME manufacturer of men's clothing wanted to get a better understanding of consumer behaviour by tagging labels hanging on clothes. gardeur benefited from more detailed visibility of their flow of merchandise on the sales floor and used this information for planning purposes.

All three pilots – regardless of the structure or size of the company – showed positive results which is highly motivating in terms of further implementation of RFID applications. Nevertheless, each company has to investigate their own processes to figure out their potential and to check if RFID is the right technology for their objectives.

WP7 Leader: GS1 Germany

Partners: GS1 Spain, Kaufhof, Carrefour, gardeur, Northland, UPC, AIDA

WP8: Manufacturing Process

Key Achievements and Innovation

The BRIDGE project manufacturing work package aimed at developing tools and methodologies to help organisations give effective decisions on RFID implementation. Implementing RFID within a manufacturing plant requires extensive analysis and experimentation. Resulting from this observation, problem and requirements analysis, business case and pilot preparation guides for the manufacturing industry, using case studies from our application partners Nestle UK and the Spanish cooperative COVAP were developed. The WP8 team devised an exemplary systematic approach to investigate how and where RFID can be used, how priority areas can be detected, how a business case can be developed and value drivers be identified; and finally, how requirements relating to hardware, software, human factors can be drawn, and planned. The work package was led by the University of Cambridge, with SAP, BT and AT4 wireless offering invaluable guidance on technology set up and integration.

State of the art in literature shows either overly complex analytical models or overly qualitative benefit claims often from RFID consultancy companies. Furthermore, existing modes of analysis are often supply chain focused. As a result manufacturers are in need of reliable decision support methodologies that enable cost effective and time effective expedited testing of alternative solutions. Within this respect WP8 reviewed current trends in decision making and simulating RFID implementations, and made the case for simulation as a decision support mechanism in RFID implementation. In support of the point of using the lean manufacturing analogy, practitioners could find as-is and to-be manufacturing waste to be an effective means of analysing the impact of RFID in their operations. Consequently, a simulation model was proposed where input parameters consist of physical and information flows of the manufacturing process under consideration and output consists of waste reduction what-if analysis. The simulation approach was tested with two industrial case studies: Nestle UK Intermediate Bulk Container Management (IBC), and COVAP Iberian Ham Manufacturing (Figure 1). Both of these processes showed potential in achieving a leaner mode of operations through reduction of different waste types.

A major goal and focus of WP8 was the development of a successful manufacturing pilot. Together with COVAP and AT4 wireless the goal of creating and running a ham traceability application in just 6 months was achieved. The Iberian ham product is a delicatessen, manufactured through a highly handcrafted process. COVAP aimed at increasing item level traceability at each stage of the manufacturing process, automating inventory counts and manual information

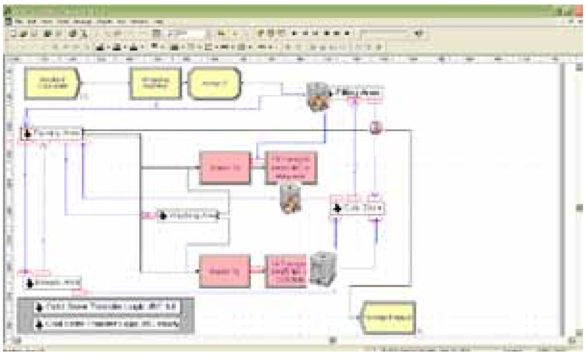


Figure 1: Simulation of RFID based manufacturing waste reduction

records. Due to challenging process conditions such as flaming, washing, and greasing, a carefully designed tag encapsulation was needed. After extensive testing with various set ups UHF Gen2 tags were used at three fixed and two mobile read points to ensure the highest read rates. The first mobile read point is used for product classification according to animal feed, weight, origin, and Ph levels; whereas, the second mobile read point (shown in Figure 2 a) is used for batch scans when products move between different cellars that simulate seasonal conditions.

COVAP developed the Ham traceability application to interface read events with its information system (Figure 2 b), and aims to explore the use of EPCIS and further extend the pilot into its supply chain. After the three years when manufacturing process lead time is complete, COVAP is intrigued to examine the correlation of various product and process data such as feeding and weight; as well as, maturation times in different cellar conditions, with the end product quality. It is envisaged that in addition to a leaner operating environment, and increased traceability, the RFID set up will also enable process innovation through the gathering of statistical data.

Figure 2a: Tests at the COVAP ham manufacturing plant

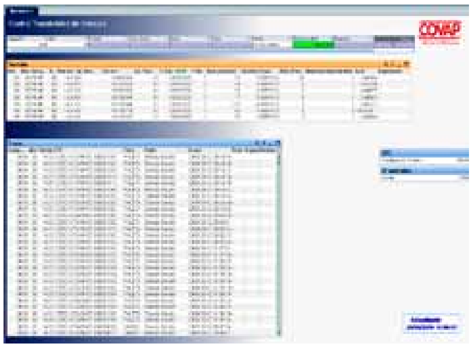


Figure 2b: COVAP ham traceability application

WP8 Leader: Auto-ID Labs Cambridge

Partners: Nestlé UK, COVAP, SAP, BT, AT4 wireless

WP9: Reusable Transport Items

Improving Asset Management with RFID

The scope of the work package 9 Reusable Asset Management was to improve reusable asset management in the supply chain by using solutions based on GS1 and EPCglobal Standards.

As a first step, the WP9 group analyzed the market needs. The analysis showed that currently there is no common commitment among supply chain participants to guarantee efficient asset control. Only some companies committed, therefore the improvement of asset control is difficult, especially in the case of open loop systems.

This situation leads to problems such as, number of asset lost (about 10% per year), oversized asset pools, non-transparency on rental costs, non-identification of problems starters (damage, unauthorized reuse or loss), number of disputes and tensions between business partners, inefficiency in logistic processes, inefficiency and substantial number of counterfeit assets (often with pallets). In the end, companies need to improve their asset flow visibility in order to improve Asset Management and tackle the difficulties listed.

RFID pallets at Carrefour warehouse delivered from the pool operator LPR

As a second step, the WP9 group defined how GS1 and EPCglobal standards based solutions can improve asset management by improving visibility. It was decided to use:

- The Global Returnable Asset Identifier (i.e. GRAI) to identify uniquely the returnable assets
- RFID tags and readers for automated identification of assets at each step of the logistic process
- EDI messages and EPCIS Events to exchange relevant data concerning asset flow with partners

The third step of the work consisted of launching a trial in order to test the solutions in a real-world context. The aim of the Carrefour pilot was to track and trace empty pallets and their shipment (the goods) from a warehouse to a store and vice-versa. It started in June 2008 and ended at the beginning of November 2008 which resulted in the exchange of a total of 5264 RFID pallets. Each pallet was tagged with two tags encoded with the same GRAI and was identified at each step of the logistic flow.

After the trial, the fourth step consisted of matching the pilot results with the business cases and requirements in order to validate the expected benefits and propose a set of recommendations of GS1 and EPCglobal standards for asset management improvement.

Many business opportunities such as, increase of number of rotations per pallet, the identification of locations where problems occur, improvement of process productivity and efficiency or optimization of partners account management have been confirmed during the pilot. Moreover, the results also showed that it is possible to track and trace goods by tracking and tracing pallets if an aggregation between the SSCC(s) and the GRAI is efficiently managed in the database and shared with authorized trading partners.

The experimentation in a real context during the pilot phase also allowed to propose a set of technical requirements concerning tag selection, tag encoding, tag placement, reader configuration, and of course

Information System infrastructure for companies who want to improve their asset management using RFID and EPCglobal standards. As a result, learnings concerning tag fitment and tag content permitted the WP9 group to help EPCglobal develop a guideline that defines the minimum specifications for the integration of EPC/ RFID tags on pallets:

- The minimum of two RFID tags per pallet ensures a minimum process security. GS1 128 barcode are not mandatory but instead are optional.
- Wooden pallets should have one RFID tag on the longer side and one tag on the shorter side of the pallet
- Plastic pallets should have one RFID tag in the corner and another RFID tag in the opposite corner of the pallet
- 96 bits is a minimum of the EPC memory bank for each tag. The tags fixed onto a pallet have only to encode the same GRAI-96 bits (one and its duplication). SSCC or other data are not mandatory but instead are optional and could be registered into the additional memory of the tag (if available).

Finally, the last task of the WP9 group concerned the dissemination of the work done since the beginning of the project. Based on WP9 conclusion, four documents have been compiled to help companies improve their reusable asset management by implementing GS1 EPCglobal based solutions:

- A Technical Guideline to help solution providers understand the market needs and develop efficient solutions
- An Application Guideline to help end users to implement the technology
- A Financial tool to help companies evaluate the costs/ benefits of the solution
- A training tool kit to help companies plan training session on RFID asset management

Conclusion:

In providing better visibility on asset flow, GS1 and EPCglobal based solutions offer Asset Management specialists, such as pool operators and pool providers, the opportunity to:

- Adjust their pool size according to the actual demand and at the same time improve reactivity to customer demand
- Improve their processes such as asset delivery, collection and reconditioning

RFID portal deployed during the pilot at Carrefour warehouse

- Improve their capacity to fight against asset damages, counterfeiting or unauthorized reuses
- Improve pricing competitiveness (rental, repair, transportation, etc.)
- Invoice customers with better transparency and fairness
- Propose new services to their customers. For example, provide them with a means to track and to trace goods by tracking and tracing the asset on which they are loaded.

For other trading partners in the supply chain such as manufacturers, retailers, carriers and logistics providers; these solutions provide the opportunity to:

- Improve asset accountability
- Reduce asset over stock
- Optimize exchanges with partners (delivery and collection of empties)
- Reduce number of disputes
- Reduce costs (rental, reconditioning, dispute, etc.)
- Address the Supply Chain Management in doing Asset Management (track and trace the goods by tracking and tracing the assets)

WP9 Leader: GS1 France

Partners: GS1 Germany, Carrefour, Bénédicta

WP10: Products in Service

Identifying benefits of EPC beyond the point of sale

WP10 (Products in Service) has focused on the consumer electronics sector, investigating many benefits of unique serialisation, not only within the supply chain logistics up to the retail store, but also looking at after-sales processes such as warranty management.

The Sony pilot extends across the supply chain from a factory in Barcelona, where Bravia TV sets are manufactured, through a distribution centre in Tilburg, to the Sony Style retail store in Berlin, then onwards to Sony's network of authorised repair centres.

Much of the initial work was concerned with upgrading manual data capturing processes to fully automatic processes, to improve the efficiency of operations. An example is paperless warranty management, through which it is possible to determine the date when a specific product was purchased by the customer - and to determine whether or not the product is eligible for repair under warranty, even if the customer can no longer find the original printed receipt or returns the product to a store or service centre other than the store where they originally purchased the product.

Deployment of Discovery Services from WP2

More recently, WP10 has been the first BRIDGE business application work package to deploy the Discovery Service prototype that was developed in BRIDGE WP2 by AT4 wireless and AIDA. This deployment allows each organisation in WP10 pilot to create a record within the Discovery Service for each product instance for which it holds some information, typically within the EPCIS repository of that organisation. Within the supply chain, this typically occurs when each product instance is created by the manufacturer and then upon arrival at each subsequent site or organisation through the supply chain (including any post-sale arrivals at service centres or dedicated repair centres). Nevertheless, each of those organisations may hold several detailed events and other information about the specific product instance within their EPCIS repositories and other systems.

Although the number of organisations involved in the current WP10 pilot is relatively small, the deployment of Discovery Services allows first hand experience with EPC data sharing concepts in terms of usability, technical performance and functionalities. It also paves the way for a larger roll-out, since it provides an important scalability mechanism for extending to include a wider range of products as well as additional factories, distribution centres, retail stores, service centres and repair centres that are associated with them.

Alignment with EPCglobal standards

Like the pharmaceutical traceability pilot (BRIDGE WP6), the Sony pilot has also experimented with the use of RFID in addition to optical data carriers such as barcodes and DataMatrix symbols. RFID tags are typically only attached to the packaging during supply chain logistics, whereas optical identifiers such as barcode and DataMatrix are used to uniquely identify each product instance, avoiding any privacy issues. Associations between identifiers (including associations resulting from changes of aggregation and containment) are recorded via the EPCIS interface provided by the RedBite system installed at each site. For almost all products, Sony already allocated serial numbers. Together with their solution provider, Sony have made use of the EPC Tag Data Translation standard and the open source TDT implementation from Fosstrak in order to construct serialised SGTIN EPC identifiers from their EAN-13 barcode identifiers and serial numbers.

The use of Auto-ID technologies such as RFID and EPC enables easier data capture at key points in the supply chain e.g. on arrival and departure at each site. Automated data capturing and the ability to identify several objects simultaneously without the line of sight enable companies to increase the visibility of product flows whilst at the same time reducing the effort for manual object identification. The underlying assumption however is that the read rates are always at 100%, which is not the case in a real world situation. The Sony pilot installation and the developed applications demonstrate how to introduce RFID into an operational environment and how to handle read rate issues in order to reap the benefits of increased productivity and visibility.

Goods detected by antennae pillar

All in one solution developed for the WP10 pilot. This pillar contains antennae, reader, middleware and EPCIS repository.

Analysis and usage of data captured using Auto-ID technology

Because each product instance can be uniquely identified, each can have its own life history with details about its creation, distribution, usage and any maintenance/repair activities, including details about parts or components that were replaced during its service life. At the level of an individual product, this has the potential to help make informed decisions during repair or servicing, as well as for extracting maximum residual value at the end of life, especially if some particularly valuable components were only installed recently. Furthermore, when this information can be collected across a 'fleet' of products of the same type, it is possible to do data mining to analyse for any systematic performance issues across a particular product line or production batch - and to be able to take more effective and responsive remedial action. The availability of more granular information in searchable electronic format can ultimately provide better decision support tools for streamlining repair and maintenance processes.

The improved visibility enabled through the use of Discovery Services and track and trace techniques enables manufacturers such as Sony to make more selective phased product recalls to remove any dangerous or defective products from the supply chain, even before they reach the retail stores. In addition, there is the potential to send more targeted advisory notices if there are any issues with the products in the inventory of particular stores or distribution centres.

Through experimental pilots, BRIDGE WP10 has been investigating and demonstrating how deployment of RFID and the EPC Network architecture can yield benefits not only within the supply chain but beyond the point of sale.

WP10 Leader: Auto-ID Labs Cambridge

Partners: Sony, BT, Carrefour

WP11: Item Level Tagging for Non-Food Products

The implementation of RFID can take many paths. The research undertaken by WP11 has been conducted around the retail sector and the use of the RFID technology at one of the most ambitious levels: products sold to consumers. In order to evaluate the usage of the technology in operational contexts, four sub-projects have been organised to include a set of product families that were selected based on three important parameters: the complexity of product management from a business point of view, the influence of the technology on the performance, and the price of the product sold. The four sub-projects included two pilots within the culture category, an apparel pilot, and a book pilot.

The same five step methodology (as detailed below) was used during the four different sub-projects. The first task was to review current business processes for selected products. The second was to study the RFID usage and to define the target scenarios for pilots. The third task was to build the business case. The fourth was to implement and to run the experiment into the live environment; the fifth task was to report on the lessons learned during the trial. Taking into account these factors, the work package has carried out four demonstrations in three countries in order to verify the capabilities of RFID.

Culture category

In the first pilot, CDs, DVDs, video games and accessories have been marked to compare the current business processes versus the RFID ones. New RFID processes like receiving, inventory/cycle counting and the reverse logistics have been significantly improved, and they have served as the baseline for other pilots. Overall improvement of time varies from 57% to 85% for each activity.

This pilot has taken place in France and used the HF technology, mainly because of the regulatory constraints at that time.

Built upon the positive returns of the first pilot, the second pilot has been conducted with the same product families but using UHF/EPC technology. The pilot incorporated collaboration with suppliers; thereby, being more integrated with existing IT applications.
Unfortunately the new retained solution showed disappointing performance. A detailed analysis of this pilot explains the root causes of issues. Later on, the project team redesigned the implementation based on the earlier learnings and fine tuned it so that the pilot demonstrated a good solution. In particular using mixed tags (combination of far field and near field UHF) helped achieve these results. It has to be noted that the concentration of products on the sales area affects the communication performance between the RFID reader and the tags on the products (several thousand tags in our situation).

Textile category

The textile sub-project was planned in two steps. The first part focused on the retailer business processes at the store and the warehouse. In addition, the distribution center (DC) of one international textile supplier was involved. The tagging took place at the manufacturer DC and the retailer warehouse. Each item was marked with one RFID detachable paper label.

In the second step the manufacturer factories were also involved. In particular it has been demonstrated that

source tagging can be deployed in the textile supply chain. The implementation of RFID into existing processes requires minimal adaptation; therefore, it is a key enabler for large rollout.

In addition, the feedback from participants who interacted with the implementation was very good. The workers on the sales area believe the RFID solution is a real improvement of their working conditions, especially with regards to counting inventory for stock controls. This improvement has been measured and requires between 80% and 94% less time for inventory management tasks than the traditional situation.

This work occurred in Belgium, France and China using UHF/EPC technology.

Book category

The fourth sub-project focused on books. One of the goals was to reuse the infrastructure of the textile sub-project. In particular the mobile prototype designed during the textile phase was adapted for inventory management. In practice the density of metallic shelves has a high effect on the performance. From the four antennas on the RFID trolley, one was adapted to ease human handling and to ensure optimal functioning.

The reverse logistics were also improved by the RFID process. Overall figures show an improved productivity between 74% and 92%, depending on the work.

In addition a collaboration with UPC and Keonn was set up to evaluate the intelligent shelves solution derived from the WP1 activity in the retail stores. The solution gives a quasi real time inventory and product shelf location.

These shelves potentially support the creation of an enhanced relationship with the customer through improved availability based on advanced interactivity.

Since the RFID process adaptation effort is low, the potential of industry rollout is high. The costs of the infrastructure and its management are still important variables in decision-making.

WP11 Leader: Carrefour

Partners: Auto-ID Labs Cambridge, GS1 France, GS1 Germany

3 Horizontal activities

The project included a comprehensive set of training activities aiming to educate a large number of parties on RFID and EPC technologies but also on the specific results of the project itself.

The dissemination and adoption tools activities delivered conceptual animations, a portable demonstration, and studies on the economic impact and on the consumer impact of the technology as well as a web portal and a cycle of conferences.

The deliverables were widely disseminated throughout Europe and internationally.

WP12: **Training & Education**

Educating people on the RFID/EPC technology

Training is a key enabler for the adoption of the EPC / RFID technology on a large scale in Europe for the sectors addressed by BRIDGE and beyond.

Training activities within the BRIDGE project have been carried out within the training work package (WP12) framework. This WP was led by GS1 and its constituent country based member organisations that have long been involved in creating training materials, supply chain best practices and seminars, workshops and conferences in local language for SMEs.

WP12 started its work by performing a Training Requirements Analysis.

Training requirements were gathered by interviewing BRIDGE participants, EPCglobal experts, academics, corporate members of EPCglobal and consumer and business groups. Based on the identified Training needs, a matrix was developed indicating which topics would be of interest for which target audience and what would be the preferred delivery mechanism(s).

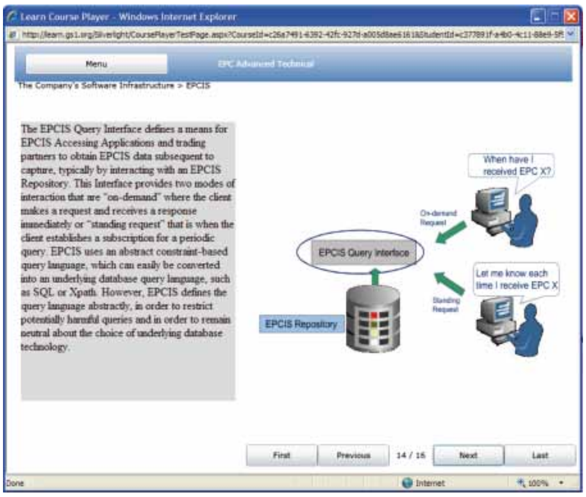
This analysis also showed that special efforts had to be made to ensure training on EPC/RFID actually reaches SMEs e.g. by ensuring training for SMEs are provided locally or electronically, to limit travel expenses; and whenever possible, in local languages, as English-only sessions can be a true barrier.

A Suite of 5 Training Courses

However, the main goal of WP12 was not to perform an analysis but to provide a blended learning solution on EPC / RFID combining classroom material, Webinars, e-Learning and other training delivery mechanisms, to the active and future users of this technology.

Based on the Training Requirements Analysis, GS1 and its WP12 partner, the Auto-ID Lab at the University of Cambridge, have developed five training courses on EPC/RFID that are publicly available in both classroom and eLearning formats.

The suite of courses starts with an introduction that explains the basics of EPC and RFID from business, technical and implementation perspectives. This basic



Slide on EPCIS taken from the eLearning course advanced technical aspects of EPC/RFID

course is followed by the 3 advanced courses covering the business, technical and implementation aspects of EPC / RFID in more detail.

The fifth and final course is targeted at senior managers and demonstrates how EPC / RFID impacts the different business processes of the supply chain as defined in the Supply Chain Operations Reference (SCOR) model.

All courses have been developed by a multi-disciplinary faculty of experts using a strong training course development methodology based on the widely accepted ADDIE model. This ensured a high quality initial version of the training material. To further improve the quality, all courses have been tested live and reviewed thoroughly by additional experts from GS1, EPCglobal, academics and business companies over a 3 months period.

The Training Requirement Analysis and the final version of these training courses are publicly available at http://www.bridge-project.eu/index.php/public-deliverables/en/

WP12 Leader: GS1

Partners: Auto-ID Labs Cambridge

WP13: Dissemination & Adoption Tools

Raising awareness on EPC/RFID technology and its applications and benefits

In order to promote the adoption of EPC/RFID in Europe, a number of adoption tools have been developed by WP13. These adoption tools will enable any interested organisation to inform and educate their stakeholders (consumers, industries, SMEs, solution providers, non-profit organizations, etc.), not only on the findings and results of the various BRIDGE work packages, but also on the impacts and benefits of EPC/RFID in general.

Six Concept Animations

The first deliverable was a set of 6 concept animations. These concept animations are multi-media learning objects i.e. Macromedia Flash that can be reused for various purposes (e-learning courses, presentations, etc.). As a result of research conducted in other Work Packages, animations have been developed to clearly present key applications of the technology e.g. patient

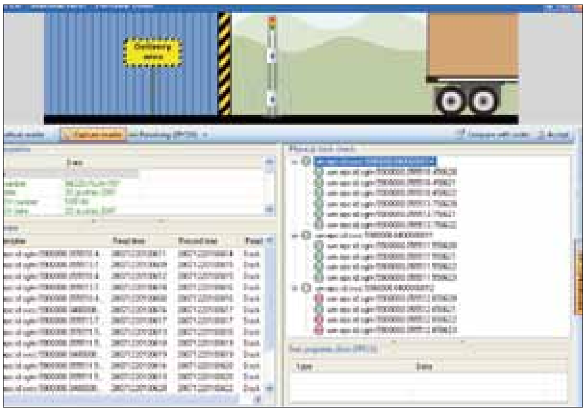
Screen of the Shipping & Delivery concept animation.

safety, Reusable Transport Items management, shipping & delivery or improving repairs.

Portable Demonstration

The next step for WP13 was to produce ***a Portable Demonstration***, i.e. a software tool showing how the EPC network works in real supply chain conditions.

This tool mainly serves presentation and educational purposes and can be installed on one or several computers to simulate the kind of information each trading partner would see on their screen while goods are transferred from one trading partner to another.



Screen of the Portable Demonstration.

Impact Reports

WP13 has also produced ***2 reports*** that help better understand the economical and social impacts of different rates of adoption of EPC/RFID in Europe.

The first report is a market sizing study that forecasts the market for passive RFID in Europe for the next fifteen years and shows that RFID is developing very differently from the way most people envisioned a few years ago.

The second report explains the reasons and evaluates the impact that RFID technology will have on the economy, especially in Europe.

Conference Package

Considering that conferences and seminars are a very important channel for sharing knowledge and experience on EPC/RFID, WP13 has developed ***a conference package*** that consists of brochures, white papers, reports, and

Discover RFID Website

discoverRFID website in Russian language

demonstration setup and presentation material. This material can be freely reused by organisations interested in developing an EPC/RFID related event or for those wishing to find out more about the findings of the BRIDGE project.

Finally, as the role of consumer acceptance of such new technology and appreciation of its benefits in ensuring its success is crucial, WP13 has contributed to the development of the www.discoverRFID.org ***website and its translations in 5 additional major European languages.***

The website developed by EPCglobal is oriented towards consumers to enable them to understand what is behind RFID and EPC and how the technology helps companies, institutions and organisations make their life easier and safer.

BRIDGE Website

WP13 also developed and maintains ***the BRIDGE collaborative website*** http://www.bridge-project.eu where all the deliverables mentioned above are publicly available.

WP13 Leader: GS1

Partners: GS1 Poland, GS1 China, ETH

WP14: Project Management

Working together and disseminating project results

To coordinate the work and efforts of the project's partners and to ensure results were disseminated in a coherent way, consistent project coordination was put in place, including regular general assemblies and project management and cooperation board meetings. This internal communication enabled project partners to remain in contact and created a good synergy to develop common activities and interaction between work packages.

Project results were disseminated through a public website, bi-monthly newsletters, and a strong presence in specialised media as well as at European and international events on communication and information technologies.

The website http://www.bridge-project.eu has proven to be the most important tool in terms of external communication.

The main objectives of the website were to:

- Present the project and partners
- Publish the public deliverables
- Publish other information around the project such as newsletters, press releases, articles etc
- Inform on RFID related events and projects (links)

Over a period of 2 years, the site received more than 10,000 visits.

In order for the results to be accessible after the project has been concluded, the website will remain open for at least 5 years. This will ensure visitors still have the opportunity to download public deliverables and other documents and also to contact us with questions.

The team also created brochures and posters to illustrate the results of the project and ensure an attractive presence at specialised events. The project office supported consortium partners by providing templates, presentations, and promotion material when necessary. Partner presentations were also collected for use and promotion on the project website. Over the past three years, BRIDGE has been directly involved in the organisation of several events including the EU RFID Forum held on 13-14 March 2007, the Internet of Things 2008 event organised in Zurich in March 2008 and the RFIDsec2008 and RFIDsec2009 events.

Newsletters were produced every two months by the project office including input from the different work packages. Each newsletter included detailed articles on the latest project results as well as any new project announcements and interesting news on the subject of RFID technology in Europe.

In total, 14 Newsletters were published during the course of the project. Newsletters are still downloadable via the BRIDGE website.

Finally, the BRIDGE Project office regularly organised Webinars to present specific aspects of the project/ work packages. These webinars were open to the public from November 2007 and enabled better interaction between project partners and interested parties.

Significant media coverage was received during the project, in particular articles in RFID specialised media, such as the RFID Journal.

WP14 Leader: GS1

Partners: GS1 UK

WP15: **Public Policy & Innovation**

BRIDGE in the context of European innovation and public policy discussions

This work package was added to the project to analyse and provide updates on the innovation and public policy aspects of the European Union activities, as well as within the activities of the BRIDGE project.

The first objective addressed innovative aspects of the technology. Progress of the European Union activities on innovation and the way the institutions promote and encourage innovation was tracked. A key focus was to analyse BRIDGE work packages and highlight the innovative aspects of the work within the project. Examples are diverse, from the prototypes developed to the pilots conducted. Both the technical work packages and the business applications work packages have demonstrated very innovative aspects in their work and outcome. A yearly report was provided to present this.

The second objective was to provide a yearly update on public policy issues handled by the European Commission and related to RFID technology. To achieve this, the team closely monitored the work of the EPCglobal Public Policy Steering Committee European Working Group and attended the major events organised by the European Commission and the different Presidencies of the European Union on RFID and the Internet of Things throughout the course of the project. WP15 also participated actively to the CERP-IoT Cluster (Cluster of European Research Projects on the Internet of Things) together with other RFID and Internet of Things projects (see next page).

Public policy activity highlights were, among others, the development of the definition and concept of the Internet of Things that arose around the same time as the project's initiation, or the EU/US Lighthouse Project which was launched in 2008 and which represents a groundbreaking collaboration between the US authorities and the European Union to encourage pilots on an international level and promote the social benefits of the technology.
The most important public policy issue however, was the debate around privacy and data protection issues related to the RFID technology, concluding with the publication of a recommendation on "the implementation of privacy and data protection principles in applications supported by radio-frequency identification" in May 2009.

This discussion at the European level led the European Commission and the reviewer's panel to request the BRIDGE team to undertake a special analysis of their own activities in the frame of the current policy debate on data protection and privacy matters related to the RFID technology. The team developed a survey to analyse its own pilots and explored to what extend they were preserving the consumer's privacy and data protection rights during the application. Through a set of very precise questions to pilot leaders, to describe the application, the kind of data collected and the collection means, the conclusion could be drawn that none of the pilots were collecting personal data or harming the data protection or privacy principles. In particular, the pilots interacting directly with consumers made a great effort to develop enough information material to inform the consumer about the technology and to explain in detail what kind of data was collected.

The work undertaken in this last work package has certainly been very valuable to contribute to the public policy debate on a European, and even international level.

WP15 Leader: GS1

Partners: GS1 UK, Auto-ID Labs Cambridge, UPC, Auto-ID Labs Fudan, ETH

The Cluster of European Research Projects on the Internet of Things (CERP-IoT)

BRIDGE is one of the founding members of the "Cluster of European RFID Projects" which was launched in January 2007 to promote the exchange of information between the EU funded RFID projects in Europe.

In 2008, the Cluster was renamed CERP-IoT (Cluster of European Research Projects on the Internet of Things) and was given the wider scope of the Internet of Things to include such concepts as IoT Architecture, Security and Privacy, Coding, Naming, Spectrum, harmonized global RFID and IoT standardisation.

The Cluster is bringing EU-funded projects together to define and promote a common vision of the Internet of Things.

The main objectives of the cluster are to:

- Facilitate networking of different RFID and IoT projects in Europe
- Coordinate research activities in IoT including RFID
- Leverage expertise, talents, and resources and maximise impact
- Establish synergies between projects
- A Network to bring EU Projects Together

Achievements of the Cluster so far:

- Sustainable collaboration of EU funded projects on Internet of Things issues (Regular meetings of the cluster)
- Working Paper on RFID research needs (2007), available at http://www.rfid-in-action.eu/cerp-iot
- Contribution to the EU RFID Expert Group (EU REG)
- Participation in important RFID and IoT events
- Members of the cluster involved in numerous RFID and IoT EU activities (calls for proposals, action plans, thematic network etc.)

The CERP-IoT will focus on the following tasks in the coming months:

- Publication of an updated strategic research roadmap
- Publication of a CERP-IoT Cluster book
- Active contribution in the next high level events and conferences
- Identification of specific areas of cooperation
- Reinforcement of network synergies with the EU
- Thematic Network "RACE Network RFID", CASAGRAS and GRIFS

"The Cluster aims at developing a solid ground for the future Internet of Things through the networking of European research efforts."

Patrick Guillemin, CERP-IoT coordinator, ETSI

"The cluster is part of Europe's ambition to shape a future Internet of Things for its businesses and citizens."

Peter Friess, CERP-IoT EC Secretary, Directorate General Information Society and Media, European Commission

BRIDGE Partners

The partners engaged in the BRIDGE consortium represented a good balance between GS1 organisations, Universities, Users and Solution Providers. The Partners included large corporations as well as small and medium size companies. GS1 Global Office was the project coordinator.

GS1 Organisations
Global Office (coordinator) – France – United Kingdom – Germany – Spain – Poland – China

Universities
Cambridge – ETH Zurich – Fudan – UPC Barcelona – TUG Graz

Users
Carrefour – Bénédicta – Kaufhof – Gardeur – Nestlé UK – Sony – Northland – COVAP

Solution Providers
BT – SAP – AIDA – CAEN – Confidex – AT4 wireless – UPM Raflatac – Verisign UK – Melior – Domino – JJ Associates

Users

Solution Providers

Universities

GS1 organisations

BRIDGE is an Integrated Project supported by the European Commission's FP6 Programme

For more information, visit http://www.bridge-project.eu
Or contact us at info@bridge-project.eu