# The ebbits platform: leveraging on the Internet of Things to support meat traceability

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## ABSTRACT

The Internet of Things (IOT), the idea of having real-world objects communicating with each other, is changing the way for capturing, organizing and consuming information that comes from the real world, including the agricultural and farming environments. Even if the RFID is a feasible, proven, and cost-savvy technology for items identification, many other data sources or smart sensors could today be integrated to enrich product traceability features. Furthermore, there still is a gap in terms of traceability infrastructures: even if standards for identity exchange mechanism exist, few implementations are known. This paper will describe the "ebbits" event-driven service-oriented middleware, which aims to simplify the development of high value added smart-applications, fostering interoperability with ERP business systems and public authentication systems. The paper highlights the ebbits key architectural features in a concrete life-cycle tracing use-case, exploiting RFID tags and sensors to seamlessly collect data along the whole breeding, slaughtering and distribution chain, giving to farmers, retailers and consumers an integrated products history information.

**Keywords:** Internet of Things, ebbits, middleware, RFID, EPC, Identity, Europe.

## 1. INTRODUCTION AND STATE OF ART

The Internet of Things (IoT) is a concept in which the real world is made by a large populations of intelligent objects able to be seamlessly integrated in a virtual world of information. Today, wireless embedded technologies allow ubiquitous communications, pervasive computing and ambient intelligence, making the trend towards always-on devices possible.

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A lot of research and development towards the IoT are known, but the here presented vision provide also access to modify and add enriched information to people and to services simultaneously. Accordingly, such Internet of People, Things and Services (IoPTS) natively provides instruments and features to data integration, data fusion and context awareness, enabling to foster the Future Internet within different application domains. Among these domains, it is possible to cite industrial automation, logistics, intelligent transportation, assisted living; as an example, the food traceability scenario is presented in this paper.

The always higher worldwide interest in food safety and traceability is proved by the proliferation of laws and standards in this field (Frohberg et al., 2006). Equally prolific is the research on ICT systems for products life-cycle management, even if often characterized by a strong verticalization and leveraging mainly on RFID, like underlined in (Gandino et al., 2009). Many other agri-food research use RFID: (Laguna et al, 2012) introduces a system for milk production identification and tracing, (Zhao et al., 2009) proposes a RFID-enabled system for pork supply chain; (Trevarthen et al., 2008) provides an overall view of the components needed for an advanced dairy farm; in (Congguo et al., 2012) a whole pig breeding process is performed, in combination with services offered by an enterprise middleware. However, other traceability research propose an IoT-based approach: in (Zhongwei et al., 2012), the authors positively studied the possibility to apply this paradigm to the entire food supply chain, while (Fu Bing, 2012) pointed out the advantages obtained by introducing an intelligent system based on IoT to the fruit production. The presented work is exactly an application of the IoT middleware named “ebbits“ (ebbits, 2011), which provides a communication infrastructure that automatically and dynamically connects physical world sensors and devices, offering their capabilities as web services, easing the development of smart-applications, interoperable with business management and public authentication systems. The ebbits platform is introduced in Section 2, and its application to a meat traceability use-case is described in the Section 3.

## 2. THE EBBITS PROJECT

The ebbits project takes advantage from the results of previous FP6 project named “Hydra” (Eisenhauer et al., 2010), in particular on the middleware later called LinkSmart (LinkSmart, 2013). It combines a service-oriented architecture, peer to peer networking technologies and semantic Web Services, addressing the IoT issue. The ebbits project enriches the LinkSmart middleware by providing innovations like: Entity Virtualization - realized by specifying an addressing layer based on unique identifiers; Data and Event Management - providing a peer-to-peer (P2P) Event Management Architecture; Centralized and Distributed Intelligence – defining a standard data fusion framework and adopting ontology-based context models to promote self-awareness mechanisms; and many others. Thanks to these innovations, it is possible to decouple applications from specific physical resources (exposing physical devices, sub-systems and cloud facilities as services or a composition of them). Furthermore, ebbits aims to semantically resolve Internet of Things and to support interoperable end-to-end business applications. Other details about the complex ebbits architecture are available as public deliverables (ebbits, 2013).

### 2.1 Entity management and EPCglobal compliancy

According to (Serbanati et al., 2011), in the IoT context, resources (as digital representation of physical entities) have the following fundamental property: "they are digital entities that are bi-univocally associated to the physical entity they represent. Each resource must have only one ID that identifies the represented object. The association between the resource and the physical entity must be established automatically". Considering this, the "ebbits" project introduces the concept of entities, which are static resources that can be monitored throughout their whole lifecycle and can be identified by static entity identifiers (EntityIDs). Anticipating what described in the Section 3, an example could be the creation of a link between cow breeder data plus transportation temperature with a specific cow (the entity). Key objective of ebbits entity management is to uniquely and persistently identify resources, store this information together with basic set of resource attributes and support lookup operations. Furthermore, it is necessary to address compatibility with already existing identification schemes, mainly vertical solution adopted within business processes. The most relevant is the EPCglobal architecture Framework (Traub et al., 2013). This framework standardizes the components and interfaces in systems using RFIDs in order to use them globally and across enterprises. RFID tags are being applied in ever more applications and are being used for traceability in many domains, but today is necessary to provide support to much more heterogeneous sources of information (environmental sensor, smartphones, GPS, etc.). For this reason, ebbits has taken into account already existing platforms and today provides support to EPC code representation. Indeed the EntityID can be seen as a compound representation of an entity consisting of the following parts: (i) world-wide unique identifier (generated by Entity Manager or taken over in case of EPC codes); (ii) local ID – it identifies the entity in the local domain of the resource provider; (iii) list of aliases –list of local IDs that identifies the same entity by different stakeholders; (iv) list of resources according to part-of relation with the original (identified) resource. The Entity Manager is the component implementing the entity management functionalities within the overall ebbits architecture and is composed of the following parts:

- Resource Directory - responsible for creating unique UUID as part of EntityID and registering newly created EntityIDs in the local database of the Entity Manager.
- Mapping&Relation Service - maintaining the alias relations between ebbits unique identity and different local IDs, as well as part-of relation between ebbits identities.
- Lookup Service – builds the communication infrastructure of Entity Managers according to the peer-to-peer architecture and offers ebbits-wide Lookup service.

### 2.2 The Physical World Adaptation Layer

The PWAL is an ebbits component, used to provide a common framework to support interactions with different "physical world" devices (including protocols and communication channels). It standardizes the connection with these devices by exposing their capabilities including services offered, events generated and available resources. This exposure is performed through the so-called PWAL drivers, which provide abstractions to device-specific technologies and interfaces. This approach ensures that devices can be seamlessly integrated with other IoT/ebbits components. The PWAL is not tightly coupled with LinkSmart since the interface between them is the ebbits IoT Layer. Within this layer is included the Device Discovery Manager (DDM) and the Device Proxy (DP). The DDM uses the LinkSmart device ontology to instantiate the Proxies (a device virtualization that communicates with the PWAL driver and provides a web service interface). The Context Manager, stores all information that is not included in the raw data of the device, and it is included in DP. This information could be measurement unit, reading frequency, error state, etc. The Context Manager in the Proxy provides and uses information found in higher levels Context Managers.

## 3. USE CASE: MEAT TRACEABILITY

The scenario taken into account is the product lifecycle management. The main idea is to use the ebbits platform as a distributed environment for animal/food product information sharing. These information are events, shared over ebbits in the form of XML (eXtensible Markup Language) files. Each XML is designed to contain information about all the steps taken by each product. When the cow is born the XML (which represents the animal identity) is created with the unique field “digiCOW”. Then the farm management system injects animal breeding information in each digiCOW (including dates, stable info, animal skate and all other pertinent information coming from national databases and sensors in the farm). Then the cow is moved to the slaughter. Here the same xml is associated with any bulk beef and each xml will have the same digiCOW, but a different “digiBulkBeef” (digiBB) entity. Any bulk beef will have its own entity but will always be attributable to a specific cow. The digiBB is also enriched with other relevant information (slaughter details, meat weight and quality). The same happens during other steps: during transportation, where product temperature information are included, and while selling products, where digiBB are splitted into many “digiProduct” entities (containing all useful product-specific data). From a single “digiProduct” is therefore possible to trace-back any valuable meat/cow details. Communication and data transfers are based on a loosely coupled event processing model where ebbits events are propagated along the product life cycle chain, triggering context dependent information and accumulating life cycle data. This infrastructure manages each step of the chain independently, indeed each sub-component only receive subscribed events, and publishes other events, which could be used by further subcomponents (Eugster et al., 2003). Accordingly, any independent systems/actors can be part of the ebbits traceability process by adhering to a set of ebbits services, components and standards. Data sources and services include both external databases and human actors (for data inputs or manual service/decision making) as well as various IoT devices such as RFID readers, temperature sensors or actuators. Therefore, adding a new component to the chain does not mean completely redesigning the overall architecture.

### 3.1 Farm Data

This section presents a short description of the so called “seeder application”. The farm data can be originated from a local farm management system or from public database (containing basic information regarding individual animal such as date of birth, parents ID, medical treatment and production efficiency). The local farm management system is typically hosted on a PC located in the farm production facilities. It is used to manage daily operations such as feeding, to store information about movement of animals or other efficiency parameters. Based on example data from the two data sources, the ebbits demonstrative prototype application has taken into account the following data: Farm Country, Farm Name, Farm ID, Race, Animal ID, Date of birth, Parents ID, Production disorders (e.g. diseases), Medical treatments. In the real world, any further data could be used, accordingly to local regulations.

### 3.2 The cold chain

The so called the "cold chain" includes all the steps during which it is required to keep the products frozen and maintained at constant temperature (in any case below -18° C). The temperature maintenance involves all the processes from production to sale, including the critical transport phases. Such maintenance is necessary to avoid the thawing (even partial) followed by the refreezing processes: during refreezing a risky deterioration of food's organoleptic properties could happen and temperature oscillations can stimulate the proliferation of dangerous microorganisms. Cold chain interruptions shorten the product life and makes the expiration date invalid. Accordingly, to reduce thermal shocks intensity means to defend and preserve the quality of the food. The ebbits traceability prototype has taken into account also the transportation phase, as described in Figure 1, describing shipment from point A to the point B. In both the checkpoints, there is an UHF RFID gate.

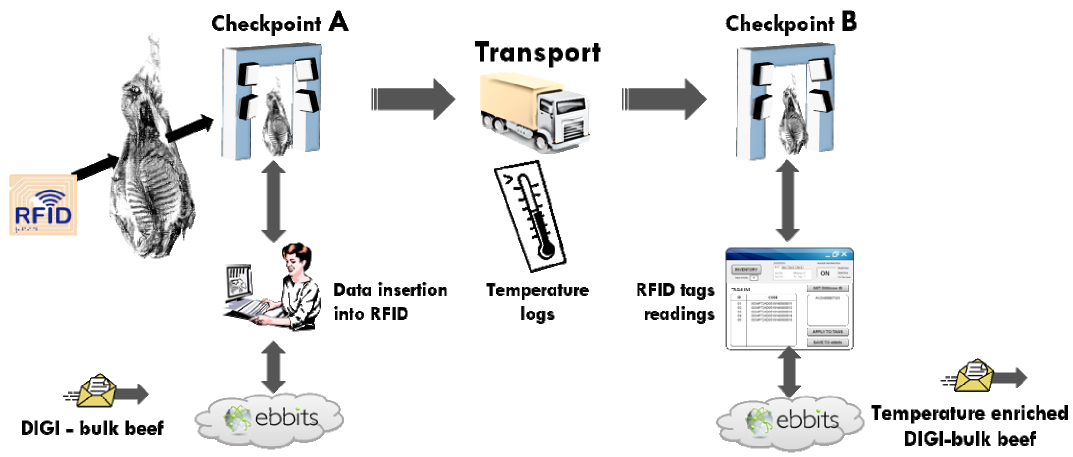


Figure 1 - transport from slaughter to reseller schema

In the dispatching phase (checkpoint A), slaughterhouse products and a digiBB identifier is going to be associated with each actual meat pass through UHF RFID transponders. This operation is carried out manually by an operator, which select tags available under the gate and digiBB events received to be inserted in the tag. Now each bulk beef have a tag contains only digiBB. Querying the platform with the digiBB it is possible to get the complete

XML containing the product history. During the transportation phase is necessary to measure and store temperature. The ebbits project takes into account two possible technologies to perform address this issue:

- Wireless Sensor Network (WSN) – a set of spatially distributed autonomous temperature sensor installed in the truck able to communicate with a portable PC (high sensing performances and flexibility, but invasive and expensive).
- UHF RFID Temperature Logger - semi-passive tag that allows temperature monitoring (poor configurability but easy usage plus low costs).

In the last step all the temperature logs will be associated with the single digiBB in order to enrich the traceability information associated with products. This operation is performed in a marshalling point (checkpoint B) while the products are received. Passing through the second RFID gate, the products are automatically recognized, as consequence, temperature information (manually or automatically downloaded from on-board PC or from temperature logger) are updated; furthermore, it is recorded as “delivered to point B”. Figure 2 shows the event message (the XML file) for one piece of meat, generated at both the checkpoints (in the simple example temperature are logged each four hour).

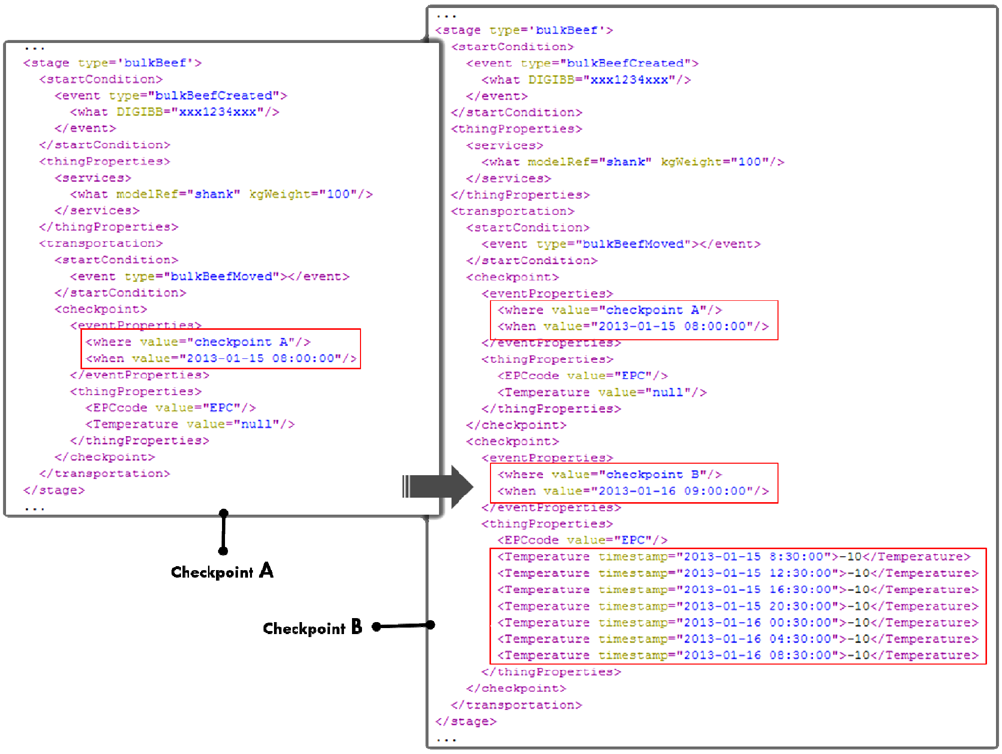


Figure 2 – xml event generated at the checkpoints A and B

The RFID system presented shall be read as IoT devices generating information. In order to interact with those devices it was necessary to develop a custom PWAL driver. Consequently it was chosen to achieve compliancy with the Low Level Reader Protocol LLRP (EPCglobal, 2013), an EPC Global standard which specifies the network interface between readers and controlling software/hardware. The choice of LLRP protocol is due to the need, at infrastructure level, to interact with heterogeneous traceability data sources in the most standard and general purpose way.

### 3.3 End-user application

For demonstration purposes, the ebbits project took care of the interaction of the traceability system with the end-users (the consumer), giving them access to the platform through a custom mobile App, in order to retrieve detailed product history information. Primary functionalities taken into account are scanning labels from meat packages and using scanned information to retrieve additional metadata from globally available services. Labelling can leverages on RFID/NFC tags or simply QR codes. Mock-up screenshots of the application are represented in Figure 3.

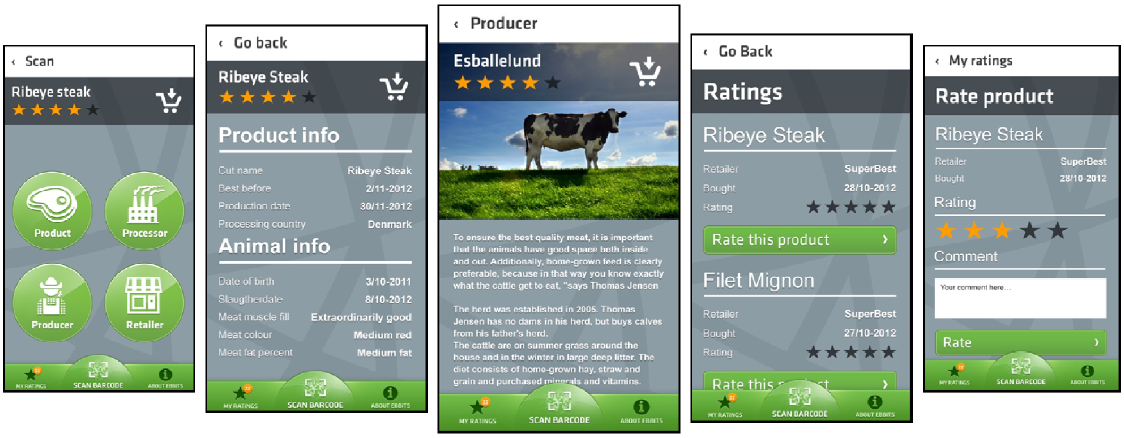


Figure 3 – ebbits end-user traceability application

## 4. CONCLUSION

This paper described the ebbits event-driven service-oriented middleware, highlighting its key architectural features in a traceability use-case: the effective beef meat life-cycle tracing, exploiting different RFID tags and sensors to seamlessly collect valuable information and delivery the same to potential users. The paper emphasized the potential impact of the ebbits platform that takes middleware solutions for the entire meat production chains, aiming at demonstrating both real-time data management and usage of repositories with historic traceability information. The presented platform can also be deployed in different domains, characterized by different processes and objectives.

## 5. ACKNOWLEDGEMENTS

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## 6. REFERENCES

(Congguo et al., 2012) Congguo M., Yazhou L., Genwang Y., Jianxiang J. “The monitoring and information management system of pig breeding Process based on Internet of Things”. Fifth International Conference on Information and Computing Science, 2012.

(ebbits, 2013) FP7 ebbits project site. Online available: www.ebbits-project.eu, 2013

(Eisenhauer et al., 2010) Eisenhauer M., Rosengren P., Antolin P. "Hydra: A development platform for integrating wireless devices and sensors into ambient intelligence systems." The Internet of Things. Springer New York, 2010.

(EPCglobal, 2013) LLRP. Online available: www.gs1.org/gsmp/kc/epcglobal/llrp, 2013

(Eugster et al., 2003) Eugster P. T., Felber P. A., Guerraoui R., Kermarrec A. M. “The many faces of publish/subscribe”. ACM Computing Surveys (CSUR), 2003

(Frohberg et al., 2006) Frohberg K., Grote K. and Winter E. “EU Food Safety Standards, Traceability and Other Regulations: A Growing Trade Barrier to Developing Countries’ Exports?”. International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

(Fu Bing, 2012) Fu Bing. “Research on the Agriculture Intelligent System Based on IOT”. Image Analysis and Signal Processing (IASP), 2012.

(Gandino et al., 2009) Gandino, F., Montrucchio B., Rebaudengo M., Sanchez E. R. “On Improving Automation by Integrating RFID in the Traceability Management of the Agri-Food Sector”. IEEE Trans. Ind. Electron., vol. 56, no. 7, pp.2357 -2365, 2009.

(Laguna et al., 2012) Laguna C., Higuera A. G., Zangroniz Cantabrana R., De Las Morenas J. ”Comprehensive traceability system of milk samples using RFID”. Smart Objects, Systems and Technologies (SmartSysTech), Conference Proceedings, 2012.

(LinkSmart, 2013) LinkSmart project wiki site. Online Available: http://sourceforge.net/projects/linksmart, 2013.

(Serbanati et al., 2011) Serbanati A., Medaglia C.M., Ceipidor U.B. “Building Blocks of the Internet of Things: State of the Art and Beyond”. In Cristina Turcu (Eds), Deploying RFID - Challenges, Solutions, and Open Issues (pp. 251-366), 2011.

(Traub et al., 2013) K. Traub, F. Armenio, H. Barthel, P. Dietrich, J. Duker, C. Floerkemeier, J. Garret, M. Harrison, B. Hogan, J. Mitsugi, J. Preishuber-Pfluegl, O. Ryaboy, S. Sarma, K. Suen, J. Williams. “The GS1 EPCglobal Architecture Framework Version 1.5”, 2013.

(Trevarthen et al., 2008) A. Trevarthen, K. Michae. “The RFID-Enabled Dairy Farm: Towards Total Farm Management”. Seventh International Conference on Mobile Business (ICMB), 2008.

(Zhao et al., 2009) Zhao D.A., C.F. Teng, X.W. Wang. “Design of Traceability System for Pork Safety Production Based on RFID”. Second International Conference on Intelligent computation Technology and Automation, pp. 562-563, 2009.

(Zhongwei et al., 2012) Zhongwei Z., Zhongyi Z. “Application of Internet of things in agriculture products supply chain management”. Int. Conf. on Control Engineering and Communication Technology, 2012.