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Enabling chain-wide transparency in meat supply chains based on the EPCIS global standard and cloud-based services

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ABSTRACT

Transparency in meat supply chains is necessary to guarantee the safety, quality and trust of consumers in meat products. However, transparency systems currently in place are often not adequate for sharing transparency data among food operators, providing consumers accurate transparency information, or enabling authorities to respond quickly and effectively in cases of food safety emergencies. Due to major meat crises and scandals the meat sector has in this respect attracted substantial attention. In this paper we identify regulatory, business, consumer and technological requirements for meat supply chain transparency systems and present a reference software architecture that will guide the realisation of these systems. The reference architecture is characterized by three main elements: the EPCIS standard for tracking and tracing, cloud-based realisation of transparency systems, and the provision of transparency systems as services by third-party transparency service providers (3pTSPs). Usage scenarios are presented to explain how the different types of meat supply chain actors can use transparency systems that are based on the architecture.

1. Introduction

Transparency in meat supply chains is necessary to guarantee the safety, quality and trust of consumers in meat products. Consumers' trust in meat products, production, origin and the actors[1] involved is crucial for the functioning and competitiveness of local, regional and global food markets (Brom, 2000; Schiefer, 2011). Particularly meat is a relatively sensitive product as highlighted by major crises and scandals such as the BSE (Bovine Spongiform Encephalopathy, commonly called mad cow disease) crisis (Collee and Bradley, 1997), the dioxin crisis (Verbeke, 2001) and the recent horse meat scandal (Premanandh, 2013). As a result a number of transparency measures are incorporated in food regulations such as the European regulation Reg. Nº 178/2002 (also referred to as the General Food Law – GFL) and the more recent regulation Reg. Nº 1169/2011.

Crucial aspects of transparency are tracking and tracing (traceability) and the ability to make consumers[2] aware of a wide range of quality attributes of their food. Traceability refers to the ability to *track* downstream the supply chain where a distinct batch or lot of product is (or is being processed) and to *trace* upstream the supply chain from where a distinct batch or lot came (van Dorp, 2004). In this article 'consumer awareness' refers to awareness of consumers about the diverse quality attributes of the meat products they buy, such as, nutritional value, place of origin or provenance, ingredients, specific quality attributes, and allergy risks.

Today's transparency systems rely largely on basic technologies, mainly, labelling and "paper trails" left by email, fax or EDI (Electronic Data Interchange) business interactions. Some large meat processing companies do have transparency systems in place as part of their enterprise system, however, the use of state-of-the-art enterprise transparency systems rarely extends entire meat supply chains (Trienekens et al., 2012).

Consumers rely almost exclusively on labels for information about meat products they buy from retailers. A label is a printed tag that is physically attached to the product and the information it carries can only be accessed if one can physically get hold of the product. The dependence on labels can be ascribed to the requirements of food regulations that mandate them as exclusive means of communication with consumers. Food regulations do not yet cover remote access to transparency information even though the Internet is a commonplace in today's society and

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[1] We use the terms *actor*, *company*, *food operator* and *business* interchangeably in this article.

[2] We use the term *consumer* to mean shoppers as well as consumers at home or elsewhere.

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consumers increasingly rely on it for information. A notable exception in this respect is the recent European food regulation, Reg. N° 1169/2011, that goes beyond labelling and towards rules that govern other means of access to food information, including the Internet (article 27, EC, 2011c).

Food regulations have also major influence on the way food operators collaborate and exchange information. In Europe, GFL prescribes the one-back/one-forward principle to meat transparency. According to this principle food operators are only required to identify and share information with their immediate suppliers (one-back) and immediate customers (one-forward) (EC, 2007, 2011a). This leads to a linear one-back/one-forward collaboration chain where transparency data is passed to retailers through successive links from farms and across the various intermediate actors (*i.e.* slaughterhouses and meat processing companies). This method is however not robust because, in practice, not all food operators implement state-of-the-art transparency systems and the benefits of gathering detailed transparency data by one actor are largely lost when subsequent actors are not able to pass on the data.

Realizing chain wide transparency – for either addressing food safety emergencies or enhancing consumer awareness – requires that each individual food operator implements a transparency system inside its production facilities, and that information flows smoothly among the individual transparency systems. Chain-wide transparency systems can thus be considered to consist of two complementary sub systems – internal and external transparency systems (Gandino et al., 2009; Moe, 1998). Realizing internal transparency requires food operators to establish the logical links between the identification code of a specific batch of output products they deliver to their customers to the identification codes of specific batches of input products (ingredients) they obtained from their suppliers and used in the making of the output products. Realizing external transparency requires pairs of trading food operators to establish the logical links between identification codes of products delivered by the one and received by the other.

For food operators to engage in an efficient and effective information exchange their internal transparency systems should be based on electronic record keeping and the information exchanged should conform to standards. The need to share traceability data across a wide range of industries led the GS1, a global consortium of businesses, to develop the EPCIS (Electronic Product Code Information Services) standard (GS1 EPCglobal, 2014b). The standard specifies how traceability data are captured digitally and defines standard data types and interfaces for exchanging them. The information exchanged is about individual or a class of product items that are uniquely identified globally by an identification code called EPC (Electronic Product Code).

Chain-wide transparency systems can be realized using a linear, centralized or distributed model of collaboration (Bhatt et al., 2012; Folinas et al., 2006; GS1, 2010; Meuwissen et al., 2003). An example of the *linear model* of collaboration is the one-back/one-forward approach. In the *centralized approach*, such as national bovine animal registration systems in Europe (EC, 2000, 2004), a shared transparency system is created where transparency data is collected and from which it is accessed. In the *distributed approach* food operators maintain own transparency systems that are interconnected into a network. One approach to realize a distributed model of collaboration is to adopt the EPCIS standard (Shanahan et al., 2009; Thakur et al., 2011).

Recent experiences in practice as well as research literature indicate that, besides the one-back/one-forward method, both the centralized and the distributed scenarios are viable forms of collaboration for realizing chain-wide transparency systems (Bowling et al., 2008; Hartley, 2013; Myhre et al., 2009; Shanahan et al., 2009). However, besides the national (centralized) bovine animal registration systems and few experimental distributed (EPCIS-based) systems we are unable to determine a widespread use of these two approaches. The centralized approach is simple to implement but requires either trust among supply chain actors or regulatory mandate. In addition the centralized approach requires a trusted third-party that manages the centralized system to which all food operators will have to publish transparency data. Distributed systems, on the other hand, require that each food operator maintains state-of-the-art transparency system following global standards (such as the EPCIS standard). But, state-of-the-art systems are costly and in most cases beyond the means of small businesses.

In recent years, the cloud computing paradigm is enabling standard software packages to be available as a service following the SaaS (Software as a Service) business model. This new business model makes state-of-the-art software affordable and accessible on-demand over the Internet. The European Future Internet Public–Private Partnership (FI–PPP) programme (FI-PPP, 2013) aims to accelerate the adoption of this new Internet-centric technologies in Europe by providing the building blocks required to realize the technologies.

In this paper we argue for such a cloud- and standards-based approach for realizing chain-wide transparency systems. We further argue that these systems have to accommodate both centralized and distributed forms of information sharing and collaboration. We present a reference architecture that shows how this can be achieved.

The paper is organized as follows. In Section 2, we describe the methodology followed. In Section 3, we discuss the current state of transparency systems in meat supply chains with the help of an illustrative example. In Section 4, we formulate a number of requirements for the reference architecture. In Section 5, we present the reference architecture based on the requirements outlined in Section 4. Finally we make concluding remarks in Section 6.

2. Research approach

The work presented in this paper is design-oriented research conducted in the context of two research projects: Smart Agri-Food (SAF) (SAF, 2013) and its follow-up FIspace (FIspace, 2013). Both projects are part of the European FI-PPP programme. In this programme a new integrated IT infrastructure is being developed and tested in three phases. At the core of FI-PPP is the FI-Ware project (FI-Ware, 2013b) that develops a core platform consisting of a set of IT Generic Enablers (GEs). Around the FI-Ware project are a number of use case projects, in which requirements are gathered and the resulting platform tested (Brewster et al., 2012). SAF and FIspace are two of such use case projects. This paper is based on a pilot study within SAF and FIspace in which the architecture is designed.

The design process is done in three steps. First, we analysed the current state of meat supply chain transparency. The analysis is based on a beef supply chain in Germany (hereafter referred simply as *the supply chain*), which we consider to be representative of major meat supply chains in Europe. To gain insight two focus group workshops were conducted in November and December of 2011 involving representatives of relevant organisations, food operators, retailers, and members of the FIspace research team. We also visited a large slaughterhouse (hereafter simply referred to as *the slaughterhouse*) that is part of the beef supply chain of our pilot study. The organisations involved in the workshops include GS1, Orgainvent, EHI, Global G.A.P., QS, the slaughterhouse and two supermarket chains in Germany. GS1 is a global not-for-profit organisation that is responsible for developing global standards to improve the efficiency and transparency of supply chains; Orgainvent is an organisation responsible for standardizing meat labelling in Germany; EHI is a scientific institute of the German retail industry; Global G.A.P is a global organisation that promotes