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From Syntactic Standards to Semantic Standards in the Agri-Food Logistics Domain

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ABSTRACT

This paper identifies gaps in standardization of agri-food logistics. Out of the European FP7 SmartAgriFood project a framework for classifying existing standards within the agri-food supply chain is introduced. Furthermore the characteristics to which a semantic standard should adhere are investigated. The standards classified as semantic out of the framework are assessed along these properties. The resulting conclusion is that the standards that are already present in the chain are more focused on syntax and lack semantic properties.

Keywords: Agri-food, standards, semantics, interoperability, logistics, the Netherlands

1. INTRODUCTION

In the agri-food supply chain, a multitude of information standards is present. However, these standards are all specific in terms of functionality and cannot be applied across the complete chain. For example, AgroXML and ISOBUS are widely accepted, but these standards do only cover activities at farm level. The problem that appears in this chain is therefore not the absence of standards, but the lack of standards that make the whole chain interoperable.

When focusing on agri-food logistics only, the known standards enable networked organizations in the agri-food supply chain to exchange information on food products that are shipped from producer to consumer. Such standards are used to identify both products and logistics units in order to facilitate the distribution of agri-food products, track and trace logistics items and enable the monitoring of product quality throughout the supply chain.

Most standards in this specific sector focus on syntactic definitions of the information that is shared, and only few touch upon the semantics. This paper identifies the gaps of standardization in agri-food logistics and proposes recommendations on improving the semantic aspects in this domain.

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2. FRAMEWORK FOR STANDARDIZATION OF AGRI-FOOD LOGISTIC

In the European FP7 SmartAgriFood project, a standardization overview has been undertaken that describes the various alternative standards in the agri-food logistics domain (SmartAgriFood, 2013a; SmartAgriFood, 2013b). A classification framework has been used that differentiates dimensions of agri-food logistics functionality and the levels of abstraction with regard to interoperability.

The first part of the framework, concerning business functions that exist in the agri-food supply chain, is the result of the identification of needs for standardization in this particular chain. SmartAgriFood (2013c) specifies the basic supply chains roles that are allocated to the various actors in the chain. These roles are Production, Outbound logistics, Inbound logistics, Logistics orchestration, Product development and Marketing & sales. As the research focuses on agri-food logistics, on the logistics flows from primary production (farm) to the market, not all roles within the supply chain are equally relevant. From the farm gate, where the primary produce is shipped, to the retail gate, where the agri-food products are received by the retailer, only the roles of outbound logistics, inbound logistics and logistics orchestration are important. For these three roles the following business functions can be specified, which serve as the first classification of standards:

Framework for standardization (horizontal classification)
Order processing (sales + purchase)
Sorting, picking, packaging, labeling
Transportation
Quality control
Storage
Planning, coordination
Monitoring

Figure 1: Framework for standardization – horizontal classification

For these business functions to be able to effectively work together, it is required that not only at one level interoperability is ensured, but that a coherent stack of agreements is present for all levels. If technical interoperability is fixed, but the meaning of the messages that are exchanged is not recorded and agreed upon, effective cooperation is not possible. In other words, also on the level of semantics and syntax must be strived for interoperability (Punter et al., 2011).
Based on these statements the choice is made to make a vertical classification to arrange the standards. The second part of the framework is therefore based on earlier work on interoperability frameworks (Van der Veer et al., 2008; Kubicek et al., 2009; European Committee for Standardization, 2010), resulting in a vertical classification with the

European Interoperability Framework for European Public Services as its basis (European Commission, 2004; European Commission, 2010).

Framework for standardization (vertical classification)		
Legal		Legal validity of data and data protection
Organizational		Organizational aspects of data exchange
Semantic		Meaning of data
	Document Definition (DD)	Structure of semantics and metadata
	Vocabulary (Voc)	Terminology within the structure
	Identification (ID)	Identification of data instances
Syntactic		Format of data
Technical		Technical aspects of data exchange

Figure 2: Framework for standardization – vertical classification

The horizontal classification is combined with the vertical classification to result in the following matrix that is the framework for standardization of agri-food logistics.

	Order processing (sales + purchase)	Sorting Picking Packaging Labeling	Transportation	Quality control	Storage	Planning Coordination Monitoring
Legal						
Organizational						
Semantic DD						
Voc						
ID						
Syntactic						
Technical						

Figure 3: Framework for standardization – complete framework

In total, 22 standards are classified using this framework, ranging from the generic GS1 family of identification standards to vocabulary standards such as AgroVoc and Lingual. The standards that are studied are: Agrovoc, Core Business Vocabulary, Daplos, EANCOM, eCert, Edibulb, EFSA, EPC, EPCIS, Florecom, GPC, GS1 Application Identifiers, GS1 ID standards, GS1 XML, ISO 21067, ISO 7563, LanguaL, PLU Codes, TBG3 standards, UNECE standards, UNSPSC and VBN Code.

3. DEFINING A SEMANTIC STANDARD

One of the key challenges in agri-food remains the lack of supply chain integration. Semantic technologies address this challenge in the agri-food sector. However, most standards investigated in the SmartAgriFood project contain some of the characteristics of a semantic standard, but lack other important properties. According to Klas and Schrefl (1995), the "overall goal of semantic data models is to capture more meaning of data by integrating relational concepts with more powerful abstraction concepts".

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Semantic technologies are specifically designed for data integration, and thus provide the fundamental glue for achieving this goal. They provide a set of ad hoc standards for data capture, for data publishing and for data consumption. They provide flexibility, rapid adaptation to new requirements, and greater functionalities (SmartAgriFood, 2013b). In order to assess a couple of standards currently applied in agri-food logistics on semantic properties, this paragraph focuses on summing the necessary characteristics for semantic interoperability in comparison with syntactic interoperability. The next paragraph applies this definition to a subset of standards from the list of 22.

Syntactic standards have existed for a long time. The most commonly used syntactic standard is by XML which fundamentally is a syntax for representing information. What a particular tag or entity means in XML is usually specified in the DTD, and all users of that particular XML variety must accept the same DTD. XML allows for infinite flexibility and variety in order to represent data but once a schema is chosen then it is set ins tone and there is no flexibility, nor any capacity to add further fields to the data schema. A similar situation is true of the GS1 GTIN system for barcodes. The standard is largely syntactic since it is the specific sequence of numbers which determine the interpretation. There is very little flexibility in adding further information. The semantics are fixed and can change only very slowly by a complex process of mutual agreement between many parties. The same can be said for EDI.

In general, semantic standards provide agreed upon definitions of the information exchanged, such that all actors have the same understanding of this information. Simpler semantic standards merely provide controlled vocabularies for the annotation or markup of data. Fully specified semantic models (i.e. formal ontologies) define all kinds of relationships between terms, provide a well-founded logic for classes and properties of terms, and consequently make possible the use of reasoners. These in turn allows the derivation of relationships that were not explicit, but rather were implicit in the knowledge representation design. An ontology or a semantic model is thus similar to a dictionary, taxonomy, or glossary, but with structure and formalism that enables computers to process its content (Lee, 2005).

Furthermore, rules can be defined to allow for precise business logic making relations between information elements and their values explicit or even define business document layout and business process sequences (Steinfield et al., 2007). Finally, semantically rich models can be put into RDF or OWL that makes it possible to publish and reuse them via the web. Subsequent figure displays the semantic web stack and the relationship between technologies mentioned here (Berners-Lee, 2000).

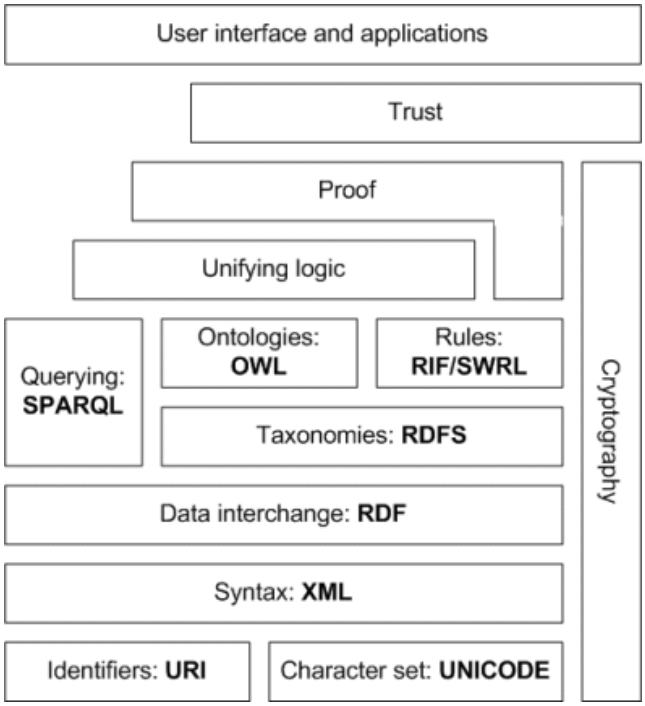

Figure 4: Semantic web stack (Wikipedia, 2013)

A prerequisite for using semantic standards such as the RDF/RDFS/OWL stack is the use of URIs (Uniform Resource Identifiers) and namespaces. They ensure on the one hand the absence of ambiguity (the meaning of an element is defined in the ontology in the namespace) and on the other hand immense flexibility because additional data can always be added using the URI either in that pre-existing namespace or another one. This means that data schemata are not fixed and thus are adaptable to the ever changing needs of (for example) the food and agriculture sector's continuous development of new products and new categories.

To conclude, a standard can be assessed for its applicability for gaining semantic interoperability on the following four characteristics:

- Rules
- Ontologies
- Taxonomies
- Data interchange

4. APPLICATION OF DEFINITION TO STANDARDS

In order to apply the definition of semantic standardization to identify gaps of standardization in agri-food logistics, we have selected standards from the full range of standards classified in our framework that were labeled as semantic standards. These standards cover the following business functions:

	Order processing (sales + purchase)	Sorting Picking Packaging Labeling	Transportation	Quality control	Storage	Planning Coordination Monitoring
Agrovoc			v	v		
DAPLOS				v		
eCert				v		
Edibulb	v		v			
EFSA						v
eLab				v		
Florecom	v		v			
GS1 family		v	v		v	
Core Business Voc		v	v		v	
EPC		v	v		v	v
GPC	v	v	v		v	v
GS1 AI	v	v	v		v	v
GS1 ID	v	v	v		v	v
ISO 21067		v				
ISO 7563				v		
LanguaL		v				
PLU Codes		v				
TBG3 standards			v			
UNSPSC		v	v		v	v
VBN Code		v	v			

Figure 5: Standards scored on business function applicability

When we take a closer look at these standards based on the characteristics identified in the previous paragraph, the following scoring is the result:

	Data Interchange	Taxonomies	Ontologies	Rules
AgroVoc	v	v		
DAPLOS	v			
eCert	v			
Edibulb	v			
EFSA	v			
eLab	v			
Florecom	v			
GS1 family	v			
Core Business Voc	v	v		
EPC	v			
GPC	v	v		
GS1 AI	v			
GS1 ID	v			
ISO 21067	v	v		
ISO 7563	v	v		
LanguaL	v	v		
PLU Codes	v			
TBG3 standards	v			
UNSPSC	v	v		
VBN Code	v			

Figure 6: Standards scored on semantic properties

We find that standards that specify rich semantics in terms of ontologies and business rules and that apply across the full range of business functions in agri-food logistics, are currently lacking. Most are too specific in terms of functionality to be applied in other

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business functions or are at best an ill fit. Gaps in standardization thus exist along the chain, as not all business functions are covered. Secondly, there are gaps in content, no vocabularies exist for certain business functions. Also there are specific gaps in existing vocabularies (SmartAgriFood, 2013b).

The most obvious core to any set of standards may well be the GS1 family. It requires GS1 however to expand to cover the gaps in both content and functionality over time on the level of richer semantics.

5. CONCLUSIONS

Existing standards for agri-food logistics are very specific in terms of the logistic functionality they are able to support. Of particular importance given the high public profile and significance of tracking and tracing functionalities, current standards such as those from GS1 allow one to go from identifier to product information, but are unable to allow one to go from a set of product properties to a set of products. Semantic standards would enable this and would also support a wide range of business functions in agri-food logistics are currently non-existent. The current set of standards for agri-food logistics does not have some or all of the semantic properties. Existing standards that only address product identification (GS1 standards) should be enhanced with more complex semantic structures that enable the agri-food supply chain to be semantically queried on products and their status.

It is in the light of these perspectives that we provide the following recommendations. While a certain number of gaps need to be covered, the whole domain does not cry out for the creation of new standards. Rather what is needed is the decision to use one specific set of standards either through a policy decision from government/EC, or through common agreement among commercial actors. The latter is unlikely given the complex and heterogeneous nature of the agri-food sector. Repeated discussion within the SmartAgriFood consortium point to the need for regulation to impose data standards on the sector.

- Recommendation 1. Encourage regulators to impose data standards for the whole agri-food sector from farm to fork.

Given the time consuming nature of standards development, and the difficulty of achieving consensus, the obvious core to any regulatory imposed set of standards has to be the GS1 family. This does not mean others should be excluded but rather, over time, GS1 need to expand to cover the gaps in both content and functionality.

- Recommendation 2. Base the regulatory standards framework around GS1, but acknowledge the need for other standards to compliment it (i.e. Agrovoc).

The danger in all such regulatory interventions is that we end up with a sclerotic system unable to adapt rapidly enough to technological changes and developments in business

needs. Hence the importance of GS1 being an open extendible set of standards determined by its members. Equally, we would suggest, the applicability of semantic technologies here in providing a layer of interoperability with growing standards in other areas, and in providing technological infrastructure currently missing from GS1 should not be under-estimated.

- Recommendation 3. Compliment GS1 with other standards and vocabularies using the semantic technology stack to provide interoperability and extensibility.

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