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The aXTool: a supportive tool in data exchange harmonization work for interoperability of information systems in agriculture

Sjaak Wolfert[1], Liisa Pesonen[2], Esther Mietzsch[3]
[1]LEI Wageningen UR, P.O. Box 35, 6700AA Wageningen, The Netherlands, sjaak.wolfert@wur.nl
[2]MTT Agrifood Research, Finland, liisa.pesonen@mtt.fi
[3]KTBL, Germany, e.mietzsch@ktbl.de

ABSTRACT

Agri-Food business requires access to increasingly accurate, detailed, and up-to-date information and data. Worldwide, agriculture lacks the coherence and coordination for exchanging these data. Many data are captured in existing information systems, but for developers of new services it is often difficult to use the data of these systems in order to make them interoperable. This paper describes a reference framework for interoperability that was developed in the agriXchange project. Use cases play a key role in interactive development of the framework. The framework's functions are introduced by a kind of a work flow process using reference information models. The aXTool supports the implementation of the framework in the agriXchange platform, which is supported by a web portal and community of practice. The aXTool systematically supports developers and other users to share and re-use knowledge and concrete components concerning data exchange in agriculture.

Keywords: data exchange, standardization, reference models, interfaces, use case

1. INTRODUCTION

In the face of a rapidly increasing global population and the subsequent rise in demand for foodstuffs, mounting pressure is being placed on the agricultural industry and associated supply and retail sectors. In order for growers, logistics companies and traders to cope with the exigencies of a globalized economy and growing world population, they require access to increasingly accurate, detailed, and up-to-date data and information.

At present, worldwide agriculture lacks the coordination and coherence for the exchange of this data to be executed smoothly, largely lacking standardized measures or gauges in place to be used as universal points of reference. Worldwide, there exist a large number of Farm Management Systems (FMSs), Decision Support Systems (DSSs) and many applications in between, all covering different aspects of farm management. These applications are usually proprietary solutions containing much implicit knowledge. For developers of solutions (typically software or hardware developers, modelers describing use cases, or so called business users like advisors, researchers, etc.) it is very difficult to find information about already existing solutions and to make them interacting with each other. This situation could be improved if existing

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knowledge is made more explicit and interfaces between different applications are clearly described. The EU-funded project agriXchange has attempted to initiate this improvement at an European level.
The overall objective of agriXchange was to coordinate and support the setting up of a sustainable network for developing a system for common data exchange in agriculture. This was achieved by addressing the following three objectives: 1) establish a platform 2) develop a reference framework for interoperability and 3) identify the main challenges for harmonizing data exchange in agriculture in the EU. This paper focuses on presenting the results of the Reference Framework development. The Reference Framework's functions have been introduced in the form of a work flow in terms of Reference Information models, using the novel aXTool, specially designed to incorporate the Reference Framework design into the existing agriXchange platform.

2. METHODOLOGY

The overall methodology in the agriXchange project followed the main steps of the method presented by Wolfert *et al.* (2010): 'Organizing information integration in agri-food—A method based on a service-oriented architecture and living lab approach'. A key characteristic of the method is a combination of overall development with incremental prototyping. It starts with an overall analysis and basic design of the core system, followed by iterative prototyping in use cases or pilots. It is schematically represented in Figure 1.

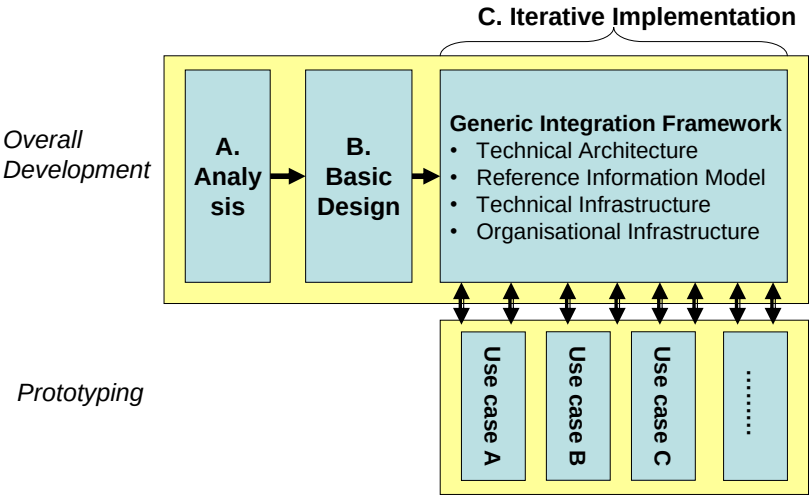

Figure 1 Method for organizing information integration combining sequential and iterative development (Wolfert *et al.*, 2010)

The analysis has resulted in a detailed description of the current situation on data exchange in agriculture in the EU27 and Switzerland (Holster *et al.*, 2011). The basic design is an initial version of the Generic Integration Framework that is further developed by implementing use cases in the iterative implementation phase. In agriXchange, the development of the technical and organizational infrastructure has

mainly resulted in the agriXchange platform which is basically a web portal and community of practice (Martini and Mietzsch, 2012). The Reference Framework and corresponding aXTool are the result of designing the technical architecture and reference information model. This was done by modelling three use cases in different areas while a fourth use case was used for verification. The modelling process was initialized by the partners in the project and further developed iteratively through three international workshops and various other meetings that involved many stakeholders. The agriXchange platform was used the support this, so also in that way many stakeholders helped to improve the use case descriptions and therewith the Reference Framework. The technical architecture was based on a service-oriented approach (SOA) consisting of three layers: business process management, business services and application services. The business process management layer was described by several reference information models using Business Process Modelling Notation (BPMN) as a modelling language (OMG, 2009). The reference information models are supported by the aXRIM: the agriXchange Reference Information Model. The business services layer mainly concerns the Interfaces that describe data exchange between process nodes. The application service layer concerns the actual connection with existing applications, but this was outside the scope of the project.

3. RESULTS

This section first describes how use cases were used to analyse interoperability problems and to make the basic design of the reference framework. Then the role of reference information models are described, which has resulted in aXRIM, the agriXchange reference information model. Finally, the aXTool that systematically guides the implementation of the framework is described.

3.1 The agriXchange use cases

Use cases are the key approach in designing complex software systems, as the use case description gives a pinpointed understanding of the problem and its context. In general, use cases which are typical for the domain of the project are analysed and the design of the software solution is based on these results. In the agriXchange project, use cases have been utilized to investigate the interoperability and data exchange problems in the agri-food sector as a foundation for the development of the basic design of the reference framework (Lokers *et al.*, 2011). Three typical use cases were investigated in detail: 'Updating of LPIS (Land Parcel Identification System)', a process needed in the management of EU subsidies in arable farming, 'GeoFertilizer', generating advice for the variable rate fertilizer application and 'Animal Registration', data exchange when an animal is moving from one country to another one.

The target group is typically the one of software or hardware developers, modellers describing use cases, or so called business users like advisors, researchers, companies, etc., seeking information about already existing solutions. The developer's scope of interest focuses usually on a narrow interest area, while business user's scope of interest concerns wider themes capturing several solutions, e.g. use cases handling several data exchange interfaces and standards, etc. Wide scope use case descriptions serve

development and optimizing of farming, food logistics and trading systems capturing several sub-systems, actors and stakeholders. Narrow scope interfaces focus on single data exchange interfaces and actors and processes around them; the level of information details is higher including technical details, standards and other implementation instructions.
To fulfil the needs of these two scopes, the 'wide scope' use case description covers a whole range of domain-specific procedures fulfilling the user needs, e.g. fertilizing procedure from planning to execution, consisting of a chain of processes, actors and data exchange transactions. From a business point of view, this level of use cases is interesting for actors in the SOA business service layer. The 'narrow scope' interface description serves as a metadata model of the interface, where the context of the data transaction of that specific interface is described shortly. In the process of analysing the use cases, the following template for description was developed (* refers to the narrow scope description):

- Name of the use case *
- Short description*
- Relevance for European agri-sector
- Relevant countries or regions
- Relevant parties
- Relevant "conditions" *
    - Standards used in the use case
    - Dictionaries
    - Regulations and legislation
    - Technologies
- Definition of use case variants
- Description of the information exchange processes and exchanged data; data dictionaries and their interconnection *
- Known issues and bottlenecks for harmonization
- Proposed recommendations and solutions for harmonization

This structure was integrated into the existing agriXchange platform (www.agriXchange.eu), which also serves to enable discussions among the stakeholders and to present the results of the project. You can find several detailed examples of use case descriptions at the platform.

3.2 aXRIM: the agriXchange Reference Information Model

Use case descriptions provide information needed to get understanding about the Generic Information Framework of the use case system, as depicted in the Figure 1. To define information flows in the use case, an information model is constructed. The information model complements the section 'Description of the information exchange processes and exchanged data; data dictionaries and their interconnection' in the wide scope use case description. Since the focus is on the inter-enterprise data exchange, the information models of the use cases concentrate on the information content of the

exchanged data between the different actors and their processes. Information modelling interlinks both the wide and the narrow scope and utilizes two modelling techniques: 1) Business Process Modelling Notation showing the processes and collaboration between different participants (actors) in a graphical form (wide scope; see Figure 2) and 2) lists of definitions and information content of the messages between the actors in a table form (narrow scope). These data exchange interfaces have two message flow arrows described: send and receive. The information is divided into three parts; *ID* of the message arrow, *description* of the message and *information content* of the message.

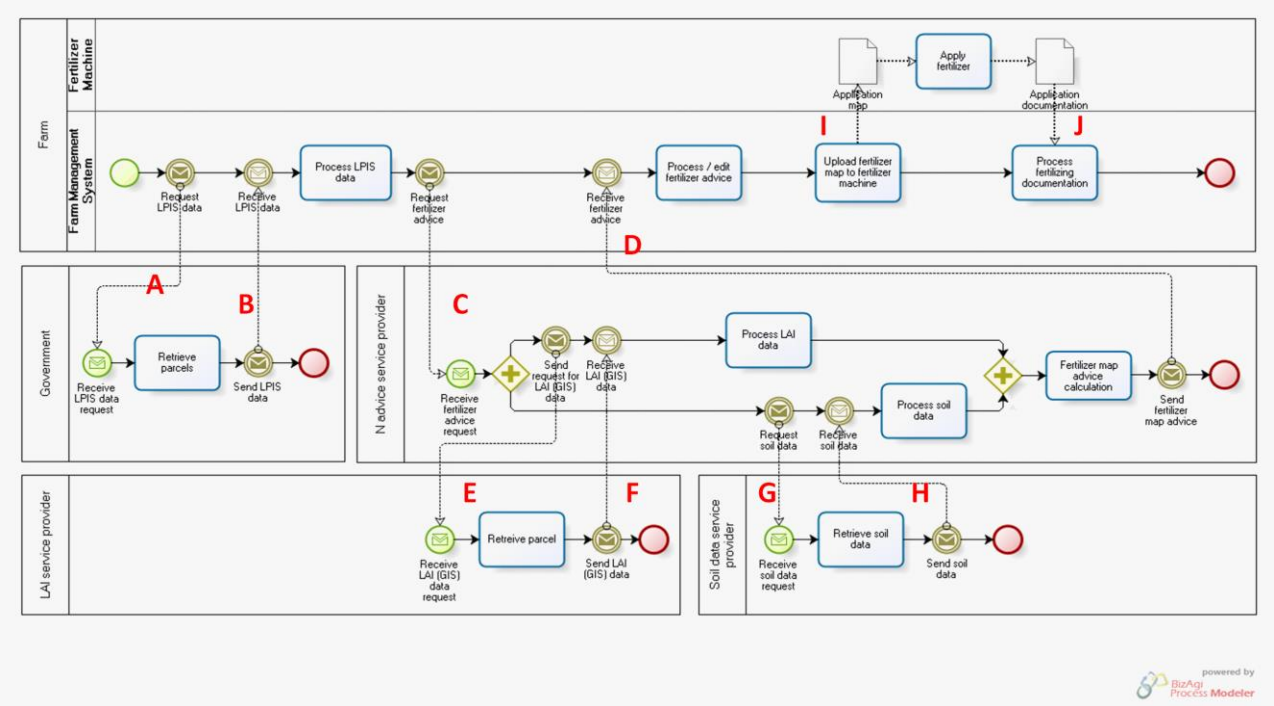

Figure 2 A BPMN diagram representing the GeoFertilizer use case. The red capital letters indicate IDs of data exchange between two actors in the use case.

When harmonizing data exchange, the focus is on the system interfaces (narrow scope) between the actors and their processes. System interface descriptions are often applicable to other use cases, sometimes even cross-sectoral applications. To support sharing these generic elements in an organized manner, the agriXchange Reference Information Model (aXRIM) was created. The aXRIM consists of structured classes of key factors that are relevant to data transfer actions in the agri-food sector. The main classes are Process, Actors, Communication protocol and Data. Each class contains a list of attributes which portrays their typical sub-classes. The basic structure of the aXRIM is kept as simple as possible to keep the model flexible and extendable in the further development of the Reference Framework. The aXRIM supports the interface provider to describe the communication problem in a structured classified manner, so that the shared information is easily searchable afterwards.

3.3 aXTool: a supportive tool in data exchange in agriculture for harmonization work for interoperability

The main requirement of the Reference Framework is to support efficient information sharing among the agriXchange community to enhance harmonizing of data exchange in agriculture. Creating awareness of existing solutions and on-going development work, and allowing introduction of new or improved solutions are the core subjects in harmonizing work of the agriXchange community, supporting the phases A, B and C (see Figure 1). The design of the Reference Framework for harmonizing data exchange in agriculture can be presented as a diagram as shown in Figure 3, showing the core parts of the framework. The design includes concepts of four main user-assisting functions: 1) searching for existing solutions interlinked with any open (standardized) interface, 2) contributing (to) existing solutions, 3) discussion and 4) evaluation of solutions and ranking them. The agriXchange Reference Framework design is constructed to support both the wide and the narrow scope use case descriptions and their interactions.

The elements of aXRIM assist in connecting the descriptions of the shared data exchange interfaces with the relevant grouping of a conceptual technical architecture, generic reference information model, technical communication infrastructure and the institutional embedding (organization), the elements of the generic integrative framework (see Figure 1). The information can be used as search entry in the aXTool to restrict the number of possible solutions connected to the context-relevant ones.

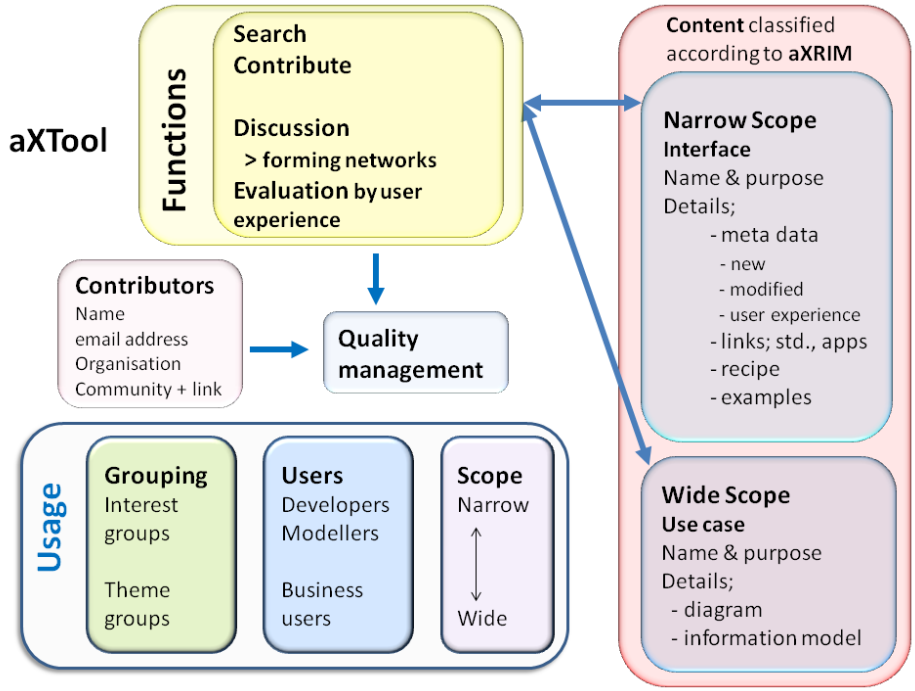

Figure 3 Diagram illustrating the agriXchange Reference Framework, and its implementation as aXTool.

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To illustrate the use of the aXTool, the use case 'GeoFertilizer' serves as an example. The short description says: 'A farmer requires a fertilizer advice that optimizes the variable rate fertilizer application to the local conditions of his fields/crops.' The use case identifies a number of relevant standards such as ISOBUS and agroXML. Information model items (see Figure 2) are e.g. '**C** Request of fertilizer advise from FMIS to Advisory service' and '**E** Request of LAI GIS data of the field parcel from Advisory service to LAI service'. The use case is also linked to several interface descriptions, e.g. 'Fertilization advice reply' and 'Parcel boundary request'. The known issues are the identification of current developments on European and national level, the compliance with standards such as ISOBUS, UN/Cefact and OGC and the harmonization of relevant code lists.

Each use case description is linked to social media, where participants can refer to entries in the aXTool, enhancing its visibility to the public. The agriXchange platform itself has a high rank in search engines for a number of agricultural terms. Within the aXTool, items are linked with each other. The aXRIM allows for a guided search for each of its terms, facilitating the search for related interface descriptions. Additionally, a keyword search on all contents is possible.

Comments can be added to each item, displaying the stakeholder's experience. The number of comments on each item can be used as an indicator of its relevance.

All contributions of contents for the aXTool can only be made by community members attached to a recognized stakeholder (research institution, company etc.) working in the area or agricultural data exchange. However, comments can be made by each registered user. All contents can be traced back to the author. Until now, most content has been provided by the agriXchange project team.

The use case 'European Bovine Identification and Traceability within one European country.' was used for evaluation of the tool. A user, not involved in the development of the aXTool, entered the data. The result of this evaluation was that the tool is suitable for the sharing of knowledge on existing solutions in agricultural data exchange.

4. CONCLUSIONS AND OUTLOOK

The agriXchange reference framework provides a structured aid for developing interoperable system solutions in agriculture. It mainly focuses on message interfaces between different processes, in particular for wide scope use cases in which usually several stakeholders are involved. Users are provided with a rich knowledge base of existing use cases, including interface messages and references to standards, so that this knowledge and complete components can be easily re-used. This is further leveraged by the aXTool that supports this process by guiding the developer step-by-step through a process, supported by intelligent search functions. Every new use case adds new knowledge to the reference framework so that the knowledge base becomes increasingly richer. The aXTool currently contains 9 use cases, 24 interface descriptions and 20 descriptions of relevant standards. This will be further leveraged when the agriXchange community grows. So far, the people that were really working on the use cases and reference framework were limited to the project consortium and a small circle around it.

However, the agriXchange LinkedIn group (http://www.linkedin.com/groups/agriXchange-3807971) consists to date of more than 800 users from all over the world who are somehow interested in agricultural data exchange, which shows a large potential for further exploitation. Ultimately the agriXchange platform, including the aXTool should be sustained by the community itself with a minimum of paid maintenance. For that purpose, the existing knowledge base should be further increased. Partly, we already succeeded in that because there are already more use cases than originally planned in the project. An additional feasibility study indicated that use by other projects is the most promising pathway to enhance and sustain the platform. The ICT-agri ERANET project has already shown interest in the aXTool. Another potential candidate is the Future Internet project SmartAgriFood, which contains 6 pilots from which use cases for data exchange could be derived. Ultimately, the platform and aXTool should be supported and maintained by standardization organizations from the agricultural sector worldwide. During the project there was some interaction and interest from these organizations, but it has not yet resulted in concrete follow-ups. Yet, the need for smooth information- and data exchange through interoperable information systems will remain and even become more pressing. It is therefore expected that the basis that was laid in this work will somehow find its way to further adoption.

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