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Towards a Design of a Generic Integration Framework for Agri-Food Supply Chain Networks

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ABSTRACT

Agri-Food Supply Chain Networks (AFSCNs) must increase production while reducing environmental impact. In these networks farms, as the main producing actor, adapt their production processes to meet these demands (e.g. by precision agriculture, precision livestock farming and precision horticulture). This leads to a more information-intensive agriculture that needs to be supported by state-of-the-art (software) tools. Currently, the available state-of-the-art tools, used for arable farming, cannot be integrated sufficiently, hindering adoption. Problems, related to integration and adoption, are identified and different projects are developing improved (software) tools that aim at enabling enterprise integration and business to business collaboration in AFSCNs. In these projects ad-hoc frameworks are used to develop these (software) tools. However, these frameworks are not aligned, which can result in (software) tools that are still not sufficiently integrated. This paper proposes to design a generic integration framework that can facilitate the design of project-specific frameworks in order to improve the integrating capabilities of state-of-the-art (software) tools. A structure of an integration framework is presented that is based on specific frameworks developed in three software development projects, which are selected as case studies. This structure can be used to design a generic integration framework. Such a generic framework supports the creation of specific frameworks.

Keywords: Arable farm enterprise integration, Business to Business collaboration, Design Oriented Research

1 INTRODUCTION

Over the years, the world-wide demand for food has grown due to an increase of the world population. Additionally, this food should be produced sustainably, in a production chain that is transparent and safe (Grunert, 2005, Seuring and Müller, 2008). At arable farm enterprises, advanced tools are required (e.g. connected information systems, decision support systems and devices) to produce such food. Additionally, to fulfil requirements related to profitable and sustainable food production, arable farm enterprises are adopting precision agriculture (PA). PA can increase production quality and quantity while reducing environmental impact (Pierce et al., 1999). It helps farm managers to adjust inputs to crops within a field according to spatial and temporal variability.

Although a high percentage of arable farm enterprises are aware of PA and possess (some) tools to practice it, the use of PA is not common (Reichardt and Jürgens, 2009). Problems of arable farm enterprises related to the limited use of PA have been investigated (Pedersen et al., 2004, McBratney et al., 2005, Lamb et al., 2008). This has shown that PA is a challenging management style and too few decision support tools support this. Arable farm enterprises also face problems in exchanging data and integrating the tools, which have a steep and time consuming learning curve to get used to and are incompatible with machines from different manufacturers (Reichardt and Jürgens, 2009). Solving these integration problems is expected to improve the use of PA because, as a group of potential PA users state, when PA proves to be unproblematic they will adopt it (Reichardt and Jürgens, 2009). As a first step towards a solution, these tool integrating problems have been identified with the help of a Reference Architecture of Agricultural Enterprises (RAAgE), described in detail in Kruize et al. (2013).

Over the years, solutions to solve (aspects) of integrating problems in Agri-Food Supply Chain Networks (AFSCN) have been developed in different projects organized by governmental, non-profit and commercial organizations. Examples are projects in which data standards are developed such as the AgroXML (http://www.agroxml.de), EDI-teelt (http://www.agroconnect.nl) and ISO-1783 (http://www.iso.org) . Furthermore, in the last four years, organizations started projects in which A*pplication Components* (software) with improved integrating capabilities are developed. Examples of such projects are the (partly) governmental funded Program on Precision Agriculture (http://www.pplnl.nl) in the Netherlands. European examples are the Smart Agri Food (http://www.smartagrifood.eu/) project, continued by the FI-space project. Additionally some commercial organizations started projects to develop state-of-the-art FMIS such as AgroSense (http://www.agrosense.eu), Crop-R (http://www.crop-r.com) and Agri-Esprit (http://www.agri-esprit.com).

Projects in which state-of-the-art FMIS are developed, should solve main integration bottlenecks, found in Kruize et al. (2013). Main integration bottlenecks are caused by FMISs, which can be modelled as *Application Collaboration Instantiations* and/or *Application Components*, which have partly overlapping and partly unique services and interfaces, have missing (standardized) data structures for data exchange and are unable to exchange data or have a shared data repository, see Figure 1.

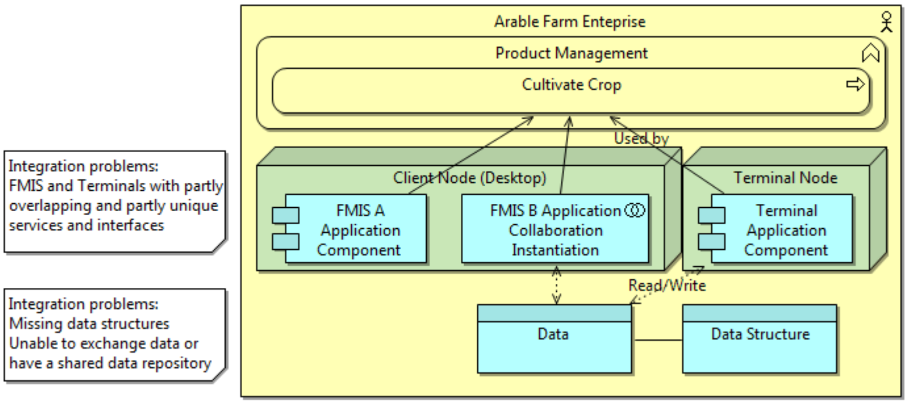

Figure 1: The cultivate crop farm business process of an arable supported by various FMIS based on RAAgE (Kruize et al., 2013). Integration problems are described in the notes.

In software development projects, project-specific frameworks are used to develop FMISs with improved integrating capabilities. However, these frameworks are not aligned, which can result in software that will not sufficiently solve main integration problems. Therefore, we propose to design a generic integration framework that can facilitate the design of project specific frameworks. This paper presents how we can work towards the design of such a framework by presenting its structure.

This framework structure can be used to design a generic integration framework that can be used in current or new software development projects, such as the European FIspace project, to create a project-specific framework that is aligned with other project-specific frameworks. This alignment of project-specific frameworks can facilitate the development of state-of-the-art tools that solve main integration problems experienced by arable farmers. These aligned project-specific frameworks can be used by stakeholders involved in business-, application- and/or data integration (e.g. developers, vendors, decision makers, farmers). Additionally, it can facilitate the discussion in application integration between different stakeholders involved in this matter.

2 METHOD

Designing the structure of a generic integration framework, that enables arable farm enterprise integration and business to business collaboration in AFSCN, is Design Oriented Research (DOR) according to Fällman (2004). The purpose of DOR is to create innovative artefacts that extend the boundaries of human and organizational capabilities (Hevner et al., 2004). There are four artefact types in information system research: constructs, models, methods and instantiations (March and Smith, 1995). *Constructs* forms the vocabulary of a domain. A *model* is a set of propositions or statements expressing relationships among constructs. A *method* is a set of steps used to perform a task. Methods are based on a set of underlying constructs and a representational model of the solution space. *Instantiations* are the realizations of artefacts in its environment. The generic design artefact presented in this paper is a set of artefact functions that is used as a structure for an integration framework. The integration framework itself, which includes constructs, methods and models to support arable farm enterprise integration and business to business collaboration in AFSCN, will be presented in a future paper.

In this DOR we created a structure of a generic integration framework based on case study research. Three software development projects were selected that focus on arable farm enterprise integration and business to business collaboration in AFSCN. These autonomous software development projects are selected as case studies because we have been involved in these projects, which provide us detailed knowledge. For each of these case studies we developed a project-specific framework description (see 3.1, 3.2 and 3.3). These project specific framework descriptions contain a list of artefacts that focus on arable farm enterprise integration and enable business to business collaboration in AFSCNs. The artefacts listed are described by name, artefact type, artefact function (i.e. a goal for which the artefact is used) and a reference to details of the artefact. Subsequently, these descriptions were discussed with the project leaders of each project-specific framework. Based on the identified functions of the project-specific framework artefacts we derived a set of generic integration artefact functions. To describe the project-specific framework descriptions we used architectural language ArchiMate 2.0 (ArchiMate 2.0., 2012).

3 CASE STUDY-SPECIFIC FRAMEWORK DESCRIPTIONS

This section presents the case study-specific framework descriptions.

3.1 AgroSense

The AgroSense project is a software development project in which an Open Source and modular FMIS is developed. Different organisations can collaborate in this project. The AgroSense modular FMIS can be modelled as an A*pplication Collaboration Instantiation* composing of one or more *Application Components.* Both the AgroSense *Application Collaboration Instantiation* as the AgroSense *Application Components* are developed using the java NetBeans rich client platform. The AgroSense *Application Collaboration Instantiation* is deployed on a *Client Node* such as a laptop or farm computer using an extension of the NetBeans module configurator. An additional *Application Component* can be deployed on a *Cloud Node* or *Cloud/Proxy Node* to connect multiple AgroSense *Application Collaboration Instantiations* and have continuous availability of data to other *Application Components* outside the farm premises. Currently, there are a collection of AgroSense *Application Components* available offering a variety of planning and (geo-)services that can be used by the arable farmer. These AgroSense *Application Components* can have interfaces with other AgroSense *Application Components* or with external *Application Components* using a network (e.g. by web services). Other actors can collaborate in the AgroSense project by developing AgroSense *Application Components* or by offering an *Application Interface* (e.g. web-services) that can be accessed, with a certain contract, by AgroSense *Application Components*. The artefacts enabling enterprise integration and business to business collaboration used or developed in the AgroSense project are presented in Table 1.

Table 1: Artefacts enabling enterprise integration or business to business collaboration developed in the AgroSense project.

Name	Artefact type	Artefact function	Reference
AgroSense Architecture	Model	Instantiation description	Website about development[1]
AgroSense NetBeans module configurator	Instantiation	Instantiation configuration	AgroSense website[2]
AgroSense Modular Application components	Instantiation	Farm business process support	AgroSense website[2]
AgroSense Wiki	Constructs,	Modular Application Component development	Website about development[1]
	Instantiation	Manage knowledge repository	
AgroSense Guides	Method	Modular Application Component development	Website about development[1]
AgroSense FAQ	Method	Modular Application Component development	Website about development[1]
AgroSense Business model	Model	Framework continuation	

[1]https://java.net/projects/agrosense
[2]www.agrosense.eu

3.2 Crop-R

Crop-R is an online platform offering GIS-based crop-recording applications on the web, smartphones and tablets. The Crop-R web application can be modelled as an *Application Collaboration Instantiation*. The Crop-R *Application Collaboration Instantiation* is developed in HTML-5, composing different *Application Components*. The Crop-R *Application Collaboration Instantiation* is deployed on a *Cloud Server*. Currently, Crop-R offers different predefined Crop-R *Application Collaboration Instantiations* as a free or paid service. These Crop-R *Application Collaboration Instantiations* are offering a variety of crop registration and (geo-)services to arable farmers. In the project, different collaborations with actors are established. First, other actors can collaborate with the Crop-R project by offering an *Application Interface* (e.g. a web service) that can be accessed by a Crop-R *Application Component*. Second, actors such as accountancy agencies and crop processors can receive data from Crop-R using a custom or generic Application Programming Interface (API). Third, a synchronisation interface is implemented allowing collaboration between Crop-R and a specific FMIS (Dacom). Fourth, *Application Components* owned and developed by different actors can be integrated using OAuth authentication. The artefacts enabling enterprise integration and business-to-business collaboration used or developed in the Crop-R project are presented in Table 2.

Table 2: Artefacts enabling enterprise integration or business to business collaboration developed in the Crop-R project.

Name	Artefact type	Artefact function	Reference
Crop-R Architecture	Model	Instantiation description	
Crop-R	Instantiation	Farm business process support	http://www.crop-r.com/
Description of Crop-R Interfaces	Model	Modular Application Component development	
Software Development Kit	Method Instantiation	Modular Application Component Development	Under development

3.3 SmartAgriFood

In the context of the SmartAgriFood (SAF) Project a Farm Management System (FMS) architecture has been designed and implemented (Kaloxylos et al, 2012). The FMS developed in SAF is an *Application Collaboration Instantiation* that can accommodate *Application Components*. The SAF FMS can enable interoperation between different *Application Components*. In this way it can function as a marketplace of services and applications offered and developed by different providers. This SAF *Application Collaboration Instantiation* is comparable with the AgroSense *Application Collaboration Instantiation*. The FMS architecture consists of two main parts i.e., the FMS deployed on a *Cloud Node* and the FMS deployed on the *Client* or other *Node* within the farm premises (e.g. *Cloud Proxy Node*). The FMS deployed on a *Cloud Node* contains a services' repository to enable services developers to upload their services for users to discover and use them. The FMS deployed on a *Node* within the farm premises contains different *Application Components* such as a "FMS Controller" and "Management Functions".

The implemented proof of concept is equipped with a number of generic software tools called Generic Enablers (GEs) that are developed in the context of the FIWARE project (FIWARE Mediawiki, 2012). The purpose of these tools is to provide to software developers the means to develop in a fast and reliable way cloud services for the future Internet. Apart from the GEs, various technologies (e.g., Java, HTML, CSS, JavaScript, JQuery, C/C++, AJAX, ALLOY UI, Jersey, Mule, etc.) have been used. The artefacts enabling the operation of the FMS and especially those related to business to business collaboration through the realization of the marketplace are presented in
Table 3.

Table 3: Artefacts enabling enterprise integration or business to business collaboration used or developed in the Smart Agri Food project.

Name	Artefact type	Artefact function	Reference
FMS Architecture	Model	Instantiation description	A. Kaloxylos et al, 2012
Cloud FMS configurator	Instantiation	Instantiation configuration	D200.3 Final Report on http://smartagrifood.eu/
Local FMS	Instantiation	Farm business	D200.3 Final Report on

instance	process support	http://smartagrifood.eu/

4 GENERIC STRUCTURE OF AN INTEGRATION FRAMEWORK

In information system research there are different types of artefacts: constructs, methods, models and instantiations (March and Smith, 1995). These different artefacts have dependency relations and can have a certain function (i.e. a goal for which the artefact is used).

The project-specific framework artefacts, enabling (arable farm) enterprise integration and business to business collaboration in AFSCNs, are listed in the tables 1 till 3. Based on these identified functions of the project specific framework artefacts, we compose a set of generic integration artefact functions. The generic integration framework should include artefacts that support:

- *the framework knowledge repository*
- *describing framework instantiations*
- *Modular Application Component development*
- *configuring Modular Application Components into an Application Collaboration instantiation*
- *farm business processes*
- *framework continuation*

This list of artefact functions can be seen as a structure for a generic integration framework. This structure can be used to create additional (generic) artefacts that can enable alignment between the project specific frameworks.

5 Discussions

This paper aims to deduce a list of artefact functions to provide a structure for a generic integration framework. The artefact functions are identified by analysing artefacts of existing project specific frameworks and their functions. Based on these project specific artefact functions, structure elements are defined for a generic integration framework. These structure elements (list of artefacts functions) can be used in future research to develop a generic integration framework. A generic integration framework will aim to support projects in developing new specific integration framework that are aligned and can be used in parallel. We expect that alignment of project specific frameworks will contribute to arable farm enterprise integration and business to business collaboration in AFSCNs because software developed in these projects can have better integrating capabilities.

In this research a limited number of case studies are used to find artefact functions to provide a structure for a generic integration framework, which does not guarantee that our set of artefact functions is complete. In future research more case studies could be used to check if these project-specific integration frameworks fit into this generic structure. Moreover, based on this structure a generic integration framework should be developed including additional (generic) artefacts that enable alignment between the project specific frameworks. This generic framework should be tested by developing project-specific integration frameworks and use these to develop farm enterprise-specific software that is fully integrated.

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