Business process modelling of the pesticide life cycle: a service-oriented approach

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Abstract

Agri-food companies increasingly participate as networked enterprises in multi-dimensional, dynamic and knowledge-based networks. Information sharing increasingly becomes an important factor. Business processes should therefore be leading in designing and using of information systems. Flexible, standardized components, which allow setting up and quickly changing running business processes, are needed. A combined approach of Business Process Management (BPM) and Service-Oriented Architecture (SOA) is considered to be a very suitable to meet these requirements. This paper describes how BPM and SOA can be used for information modelling of farm management using the pesticide life cycle as a case study. Decisions on pesticide use are constrained by legal restrictions, social requirements and market conditions. Briefly, the basic principles of BPM and SOA are explained. This is applied to farm management and the pesticide life cycle in a series of aggregated models, using the formal business process modelling notation (BPMN). These models form the basis for further implementation of information systems. It is concluded that by using BPM and SOA, it is possible to make a model of the pesticide life cycle in farm management, covering the complete range of business processes in the chain. The models illustrate the use of standardized components that can be re-used in other contexts. Later on, they can be used as basis for setting up a complete architecture for total farm management. This should be further verified in other case studies and implementation of the model into real information systems based on web services.

Keywords: BPM, SOA, ICT, information sharing, agriculture

Introduction

The business environment of agri-food production is very dynamic, driven by various and changing needs of consumers and society. Production is becoming more demand-driven, has to be transparent and must meet quality and environmental standards. Several incidents in the last decades (e.g. foot and mouth disease, swine fever, dioxin scandals) have made food safety one of the major issues. Meeting these requirements gives actors in the supply chain a ‘licence to produce’. Adittionally, agricultural markets in Western Europe are under pressure because of high land and labour prices in combination with intensified competition due to globalisation. One main answer to this development is to innovate towards a more demand-driven and knowledge-based production, producing high-grade products. This requires application of ‘state-of-the-art’ knowledge and involvement of research and technology institutes in innovation. In such context, agri-food supply chains are not simple linear chains, but are characterized by multiple network dimensions: agri-food supply chain networks, further abbreviated as AFSCNs (Verdouw *et al.,* 2007). The driving factors require a high flexibility of processes and enterprises. The requirements of a license to produce, knowledge-based production and flexibility require in their turn appropriate communication between and control of all processes in the complete AFSCN. Appropriate information sharing and ICT play a crucial role in this. However, to organise this at the AFSCN level is a complex activity. There is a pitfall to focus to much at the technical level of software engineering and standardization of messages. Although technical implementation has to be done in the end, Wolfert *et al.* (2008) emphasize that the actual business processes should remain leading in information sharing. Getting organisational commitment and support at several levels of the organisations involved in the AFSCN is also very important. These two are very much related with each other, because one will only get commitment and support if improved information sharing also improves the business processes.

The objective of this paper is to explore and demonstrate how business processes should be leading in information integration is AFSCNs. A case study on pesticide information is used as study material be used for this purpose. We will briefly describe the concepts and methodologies of service-oriented architecture and business process management and – modeling that were used. Then the results of applying these concepts and methodologies to the pesticide case study are presented. Finally, the results are discussed and conclusions are drawn.

Material and methods

In this section, the pesticide case study and its context are briefly described. Then, the concepts and methodology of service-oriented architecture (SOA) and business process management (BPM) are described.

Pesticide case study

The case study that was used is part of a larger research and innovation program called KodA. KodA is a Dutch acronym for 'Kennis op de Akker', which can be best translated in English as: 'From knowledge to practice in the field of arable farming'. In KodA, about 60 arable farmers, their suppliers and processors (about 12 large companies), work together to improve quality and efficiency of arable crop production. This co-operation takes place in interactive learning networks in which predefined tasks for innovation are gradually implemented. KodA is a private-public project funded by the Ministry of Agriculture. ICT is seen as a key enabler to achieve the program's objectives. ICT enables the farmer to use and deploy knowledge, information and data efficiently. Development of integrated management support systems in which actual, state-of-the-art knowledge and farm-specific data are combined, is considered as a major condition for further development of sustainable practices (Wolfert *et al.,* 2005; Wolfert *et al.,* 2007).

The objective of the pesticide case study was to design a business process model on pesticide application in arable farming within the total context of the AFSCN, but with the farm as a focal company. The main challenge of this is that application of pesticides at the operational level is depending on several decisions at the tactical and strategic level and they are influenced by external factors that can be classified into:

- market requirements (e.g. certificates for tracking and tracing, food safety, etc.);
- public concerns translated into governmental regulations, mainly connected with environmental issues.

Within the KodA program, farmers were also especially interested in how these objectives and constraints could be translated into precision agriculture concepts. The business process model was designed within a service-oriented architecture but no implementation into a real software application was made.

Service-oriented architecture and business process management and modelling
Service-oriented architecture (SOA) is a software architecture where functionality is grouped around business processes and packaged as interoperable services. The aim is a loose coupling of services with operating systems, programming languages and other technologies which underlie applications (Newcomer and Lomow, 2004). SOA separates functions into distinct units, or services (Bell, 2008), which are made accessible over a network in order that they can be combined and reused in the production of business applications (Erl, 2005). These services communicate with each other by passing data from one service to another, or by coordinating an activity between two or more services. Service providers publish web services in a service directory, service requestors search in this directory to find suitable services and bind to that service and use it based on information from the directory and standardized procedures (Leymann, 2003; Erl, 2005). In this way, SOA provides the appropriate technology that enables timely and flexible sharing of information demands. It is component-based by nature and widely acknowledged as the de facto standard for information integration. SOA enables definition of components with standardized interfaces, a central repository of published web services and standardized procedures for selection and implementation of components. Thus, SOA-based information systems decouple the process, application services, data sharing and technical infrastructure that is required to achieve flexibility(Wolfert *et al.,* 2008). Subsequently, SOA is chosen as backbone technology for the objective of the case study. A technical architecture based on SOA consists of three layers, which is illustrated in Figure 1. (Erl, 2005):

- *A business process management layer, coordinating the execution of business services*: this is a functional integration layer that groups services from the underlying business service layer into business processes. The process services are typically implemented through generic enactment engines, that execute workflows defined in languages like BPEL or BPML. Following the workflow specifications, the enactment engines invoke services in the next layer. Services in the process layer can be rapidly configured or reconfigured using business process management (BPM) tools.
- *A business services layer, delivering information services to the business processes*. The business services implement the information processing functions of the actual business processes. Business services may be either straightforward data registration or reporting services, or complex services based on extensive business logic. They may implement these functions directly, for instance applying the Business Rules Approach, or use application services that connect the business services to (legacy) information processing application systems.
- *A business application layer, executing the application logic and data storage*. Applications are wrapped in application services, offering a standard web service interface to the business services, thus enabling enterprise application integration (EAI).

In this paper, we mainly focus on the business process management (BPM) layer. A business process (BP) consists of a set of activities that are performed in coordination within the organizational and technical environment. BPM helps to investigate structural properties that use combination of abstraction and interesting observations of real-world's business processes. These observations are rather useful for detecting the structural deficiencies in real-world's business processes, with ability to provide a robust and scalable software system (Weske, 2007).
For BPM, a detailed exploration of business processes is needed. Such exploration is done with the aid of a model that makes every process visible to all concerned stakeholders e.g. manager,

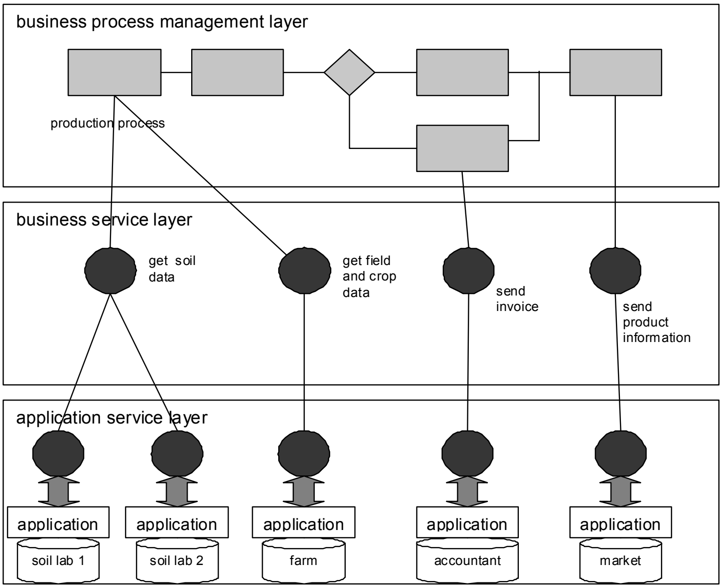

Figure 1. Three-layered SOA architecture with some illustrative examples of components from the arable farming sector.

business analyst, software developer, etc. Such process model looks at entire organizations over a long-term period. Most important diagrams for modelling are:

- *Actor models*: depict the structure of the involved actors, the basic roles and main interactions;
- *Business control models*: specify the main functions for business process planning and monitoring (excluding interactions), at different time horizons, i.e. strategic, tactical and operational level of control. Business control models must provide a complete overview of business functions, including product development, sales and contracting, procurement, and production.
- *Business process models*: visualize the sets of interrelated activities usually supported by information systems (Kock *et al.,* in press). In a SOA approach, the activities of business process models define the supported web services, while the sequence of activities defines service orchestration, i.e. the routing of event data amongst multiple services. SOA-compliant modelling tools support definition of business process models in the graphical modelling notation (BPMN), and translate these models to business process execution language (BPEL). These are XML-based standards for specification of business processes that can be executed as web services.
- *Data models*: specify data and relationhips between data which are necessary for executing and managing processes. Broadly used methods to model data are ERD and different UML structure diagrams. These diagrams can be elaborated into EDI- and XML-based standard messages. In a SOA approach, the emphasis is on definition of standard messages, usually by adopting international standards, especially UN-CEFACT, often without graphical data models. Relationships between data are incorporated in service orchestration (part of process models) and business rules.

The models were designed and verified by desk study and interviews with different stakeholders. We used the Cordys platform, which is an integrated software suite that supports business process modelling and SOA.

Results

Figure 2 shows the actor model with the basic roles and interactions. The farm is part of a supply chain, but also other actors are involved so that a network can be distinguished.
The farm plays a central role in the network: it is the main point where products, and how they are produced, is influenced most. Pesticide application takes place at the farm, but information also comes from the supplier and other actors such as the government or advisory services. Information on pesticides is shared through the whole chain network.
If we zoom in one level deeper, we arrive at the level of the business control model, which is illustrated in Figure 3. In the centre, it shows three layers of processes: support processes, production process and managerial processes. At the left and right the direct actors of the farm are shown.
The production process is, and particularly the cultivation process, the main process that is related to pesticide application. However, Figure 3 shows that it always has to be placed within a certain context with many relationships.
The next level is modelled in a whole architecture of interrelated business process models. This was worked out in an MSc-thesis (Matocha, 2008). In this paper we have limited space and will just present a few illustrative business process models.
In Figure 4, the formal conditions are checked whether a certain pesticide is permitted by governmental regulations and subsequently if the pesticide is perhaps restricted by a certain customer (e.g. by some certification scheme).
Pesticide application is part of a more complex decision, resulting from tactical crop rotation and protection plans. An operational decision is influenced by factors such as weather, soil conditions and by personal and resource schedules. This is modelled in the 'pesticide application scheduler' which is illustrated in Figure 5.

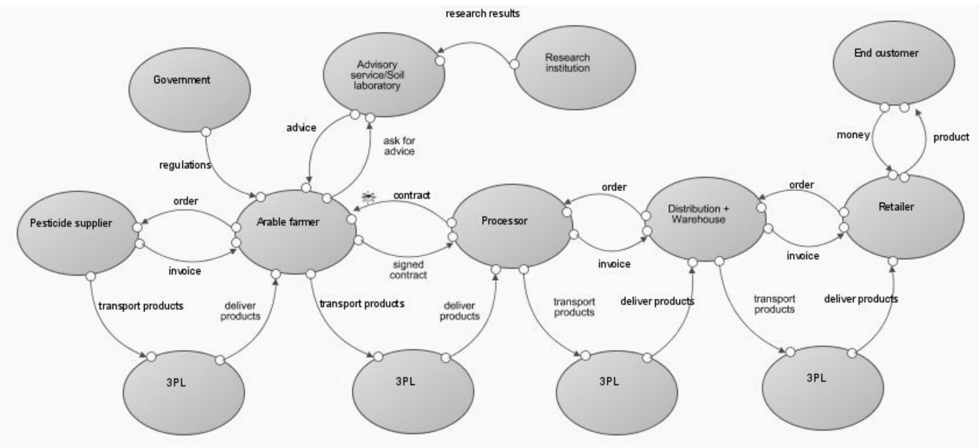

Figure 2. Actor model for the pesticide case of the AFSCN with the farm as a focal company.

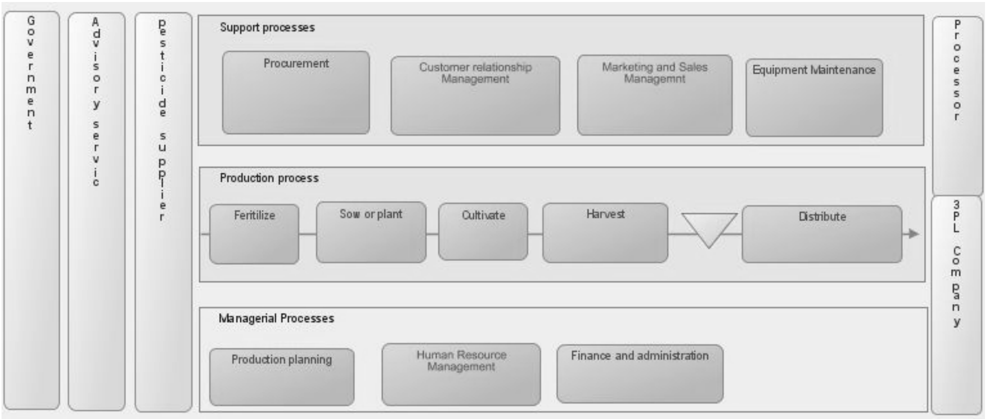

Figure 3. Business control model from the farm's perspective.

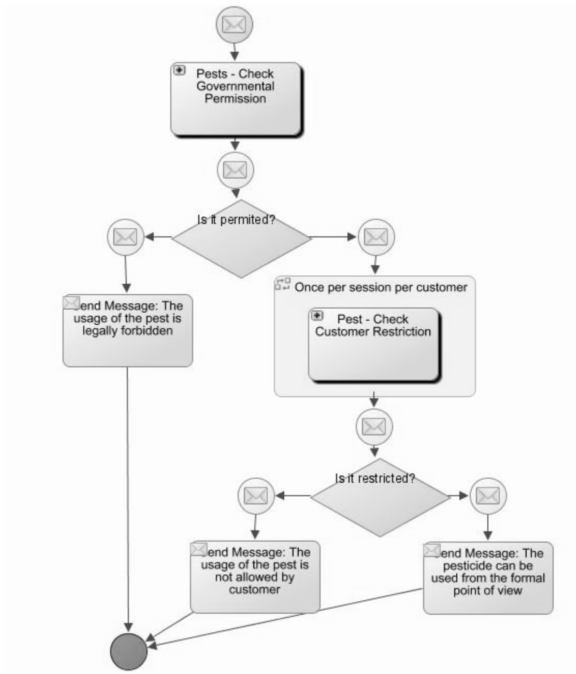

Figure 4. Checking of formal conditions. A ' +' sign in the upper left corner of a processes means that this process is modelled into more detail in sub processes. An envelope indicates a certain data message that is sent.

The crop protection plan is prepared at the beginning of each season, containing the yearly crop protection activities. Based on this plan, the concrete decision about the pesticides application is scheduled as presented in the future pesticide application planner (Figure 6).

The crop protection plan is a result of the crop production plan at the tactical decision level. The crop production plan is a result from several decisions influenced by legal conditions, physical

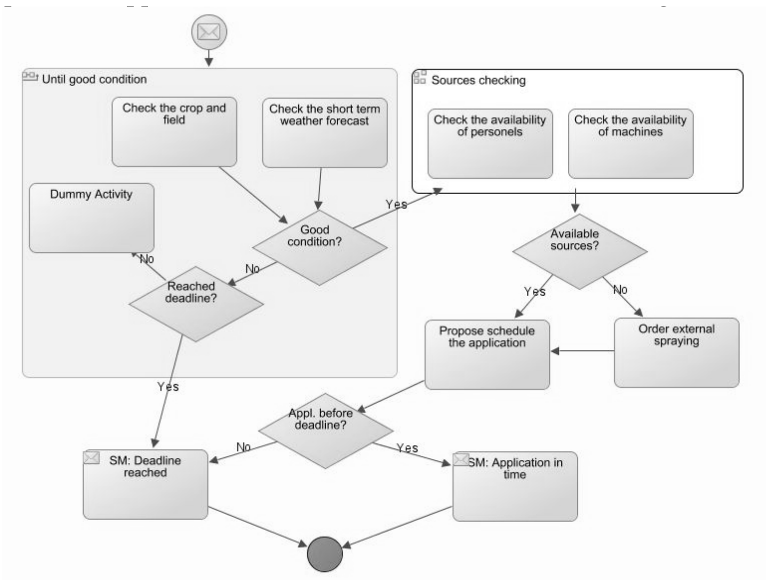

Figure 5. Pesticide application scheduler.

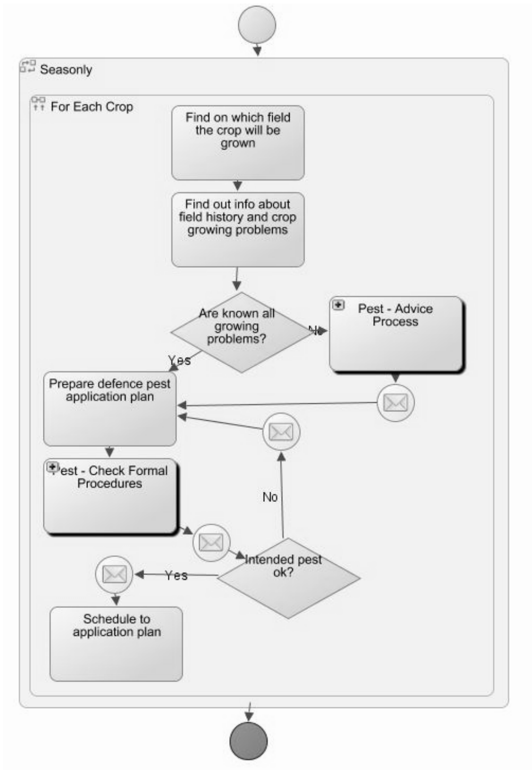

Figure 6. Future pesticide application planner.

constraints and market considerations. It will also be linked with the strategic management level at which the long term direction of the farm is defined.
The next level would be the data model level in which the messages are further defined in XML messages that communicate with or are part of different information systems. However, this was beyond the scope of this study.

Discussion and conclusions

The results in this paper showed how business process management and -modelling enables designing an architecture, which is a sound basis for developing information systems for AFSCNs, because:

- it takes all relevant stakeholders within the network into account at the level of the actual process, where decisions have to be made; this will support the 'license to produce';
- modelling the business processes puts decision-making in front of ICT, which makes it more clear what knowledge is needed to make good decisions;
- it was illustrated how business process models consist of several reusable components and sub processes, which will increase the flexibility of information systems in a dynamic environment.

In this way, the information systems, and messages that are sent between them, will follow the business process and thus improve the communication and control. The models illustrate the use of standardized components that can be re-used in other contexts. Later on, they can be used as basis for setting up a complete architecture for total farm management.
The business process models were derived from practice, but should be further validated by stakeholders and information system users. The concepts should be tested further by implementing the models into real information systems.

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