User-centric information modeling

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Abstract

Agriculture and farmers faces a great challenge in effectively manage information both internally and externally in order to improve the economic and operational efficiency of operations, reduce environmental impact and comply with various documentation requirements. In order to meet this challenge, the flow of information between decision processes must be analysed and modelled as a prerequisite for the subsequent design, construction and implementation of situated information systems.

This paper presents an attempt to use system engineering principles for the identification of decision processes and information flows within specific agricultural domains as a framework and guidance for the design of the physical information system.. The information flow configuration is centred around the farmer as the principal decision maker.

The new information management concepts and designs mean that farmers have to be ready to adopt new working habits and perhaps also undergo further training. Farmers can utilise different services more efficiently and they are able to outsource some of the tasks they had previously performed themselves. Farmers have better knowledge of their production processes and are able to evaluate the performance of the chosen technology. This should lead to better process control in farms. Farmers can also utilise the collected farm data to show the quality of farming *e.g.* traceability, to markets and administration. The system concept also allows the farmers to access and utilise better scientific research and technological developments by providing fresh real process data and the ability to update the systems according to the latest knowledge.

Keywords: system analysis, decision processes, information flows.

Introduction

Agriculture and farmers faces a great challenge in effectively manage information both internally and externally in order to improve the economic and operational efficiency of operations, reduce environmental impact and comply with various documentation requirements. In order to meet this challenge, the flow of information between decision processes must be analysed and modelled as a prerequisite for the subsequent design, construction and implementation of situated information systems.

The required information modelling can be fulfilled through concentrated efforts aimed at extracting domain knowledge and deriving information flows at various planning and process levels. This effort demand considerable research and development and that is specifically the case in terms of incorporating user preferences and requirements. The tendency to use a more user-centric approach in developing new technologies has gained considerable appeal (e.g. Akao & Mazur, 2003; Norros *et al.,* 2004). The development and design of innovative technologies, like dedicated information systems, has often lacked user acceptance when users or stakeholders are not sufficiently involved in the requirements elicitation and engineering (Kujala *et al.*, 2005). A user-centric approach assumes that the users' ideas and requirements reactions concerning the specific characteristics of the designed technology are integrated in the subsequent design.

This paper presents an attempt to use system engineering principles for the identification of decision processes and information flows within specific agricultural domains as a framework and guidance for the design of the physical information system. The information flow configuration is centred around the farmer as the principal decision maker indicating that the information flow is primarily seen in the view of the farmer and in terms of how he/she uses and produces information. Specifically, interface requirements and demands on time critical availability and amount of information are important aspects to be considered. The essential task of the information system is to be able to capture the Core-Task of the farming operation by developing a precise understanding of how the farmer experience the Core-Task and associated decision processes (Nurkka *et al.* 2007). The orientation of the farmer (concept of work) and the way of working (how the work is carried out) are important elements to include in the information model.

Information management in farming

Farming in general, which comprises many different production processes, can be compared with management of any process. The management duties include controlling and monitoring the farming process, collecting and analysing statistics on the process and using the collected information in decision-making and strategic planning. Challenges in management increase as the farmer needs to confront changes for which his experience provides limited guidance. These challenges include the introduction of new farming techniques, since the main aims of agricultural production to date are not only profitability in terms of economic efficiency, but also the maintenance of a healthy environment.

The focus of agricultural production is changing from quantity to quality and sustainability (Jensen *et al*., 2000). Precision Agriculture (PA) aims to achieve these goals. By generic definition, PA refers to agricultural techniques that increase the number of (correct) decisions per unit area of land per unit of time, with associated net benefits (McBratney *et al*., 2005). When practising PA, a farmer manages crop production inputs (seed, fertiliser, lime, pesticides, *etc*.) on a site-specific basis to increase profits and crop quality, but also to reduce waste and maintain environmental quality. In order to make precise decisions in different phases of the farming process, he/she therefore needs to analyse information from different vast and sporadically located information sources. Management of the information and decision-making is the core issue for the farmer in successful PA, not the data acquisition process. A range of Decision Support Systems (DSS) and Farm Management Information Systems (FMIS) are available to farmers, but the adoption of those systems and of PA has been disappointingly low (Rosskopf *et al*., 2003; McBratney *et al*., 2005; Parker, 2005). DSS and FMIS tools have a number of applications in farming, the most important being to support strategic and operational decisions and to enable better identification and shared analysis of problems (Loevinsohn *et al*., 2002) by permitting access to and manipulation of information.

In order to analyse the information flow on high-tech farms, both science-based and practice-based modelling of the core-task is needed in order to extract the requirements for facilitated decision-making. The human-centred design process aims to design a new information management concept that supports the farmer's core task. It is divided into two parts; research and design. The research part handles the problem at a general level, focusing on the core task of farming, the farmer's orientation to his/her work. The core task and associated information management are defined on both a scientific and practical basis. The science-based core-task model postulates the core task according to scientific and physical facts as a matrix where successive work processes form one dimension and the move from general to specific the other dimension. The practice-based core task is modelled after the farmer's understanding of his/her work.

The integrated information modelling phase changes the focus from general to specific, in this case from information management in farm production processes to information management in field task operations. In this phase results and demands from the research part are taken into account, data flow models of field task operations are created, available relevant technology for design is inventoried and specifications for a novel system concept are defined.

Integrated information modelling approach

In this phase, scientific information and practical information and experience are gathered together, and new ideas and technologies are brought in as material for a creative designing process. The work starts by defining a functional description of the needed system. Then, inventory of available technologies is made. Finally, specifications for a new concept for information management system in automated plant production are defined.

A detailed structuring and formalisation of physical entities and the information, which surrounds the planning and control of efficient mobile working units is a decisive prerequisite for the development of comprehensive and effective ICT-system for task management on the farm. The basic idea is to model all the activities and decisions, which take place in a targeted production section and combine this modelling with all the relevant data. The formal description includes **entity definition** (*in this case mobile work units*), a **process model** (*activities and decision processes*) and a **data model** (*data relating to the processes*). The defined processes in the process model and the entities and attributes in the data model provide the basis for developing compatible information systems – see Figure 1.

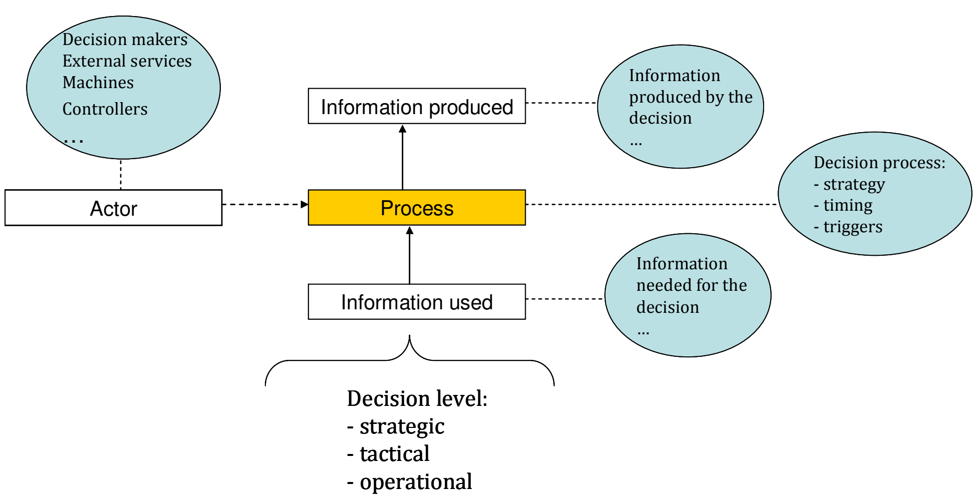

Figure 1. Employed information modelling approach

Information modelling of the core task of field work

In a new situation where a novel information management system concept is utilised, the description of the core task will change. As part of modelling the novel system concept, the information flow model for the case of fertilisation was run according to the new system concept and design. Figure 2 shows the scope of the information modelling the fertiliser case in terms of identified actors to be included in the system. These actors include external entities outside the farm, the farmer as the prime decision maker and the mobile unit entities involving in actual carrying out the planned tasks.

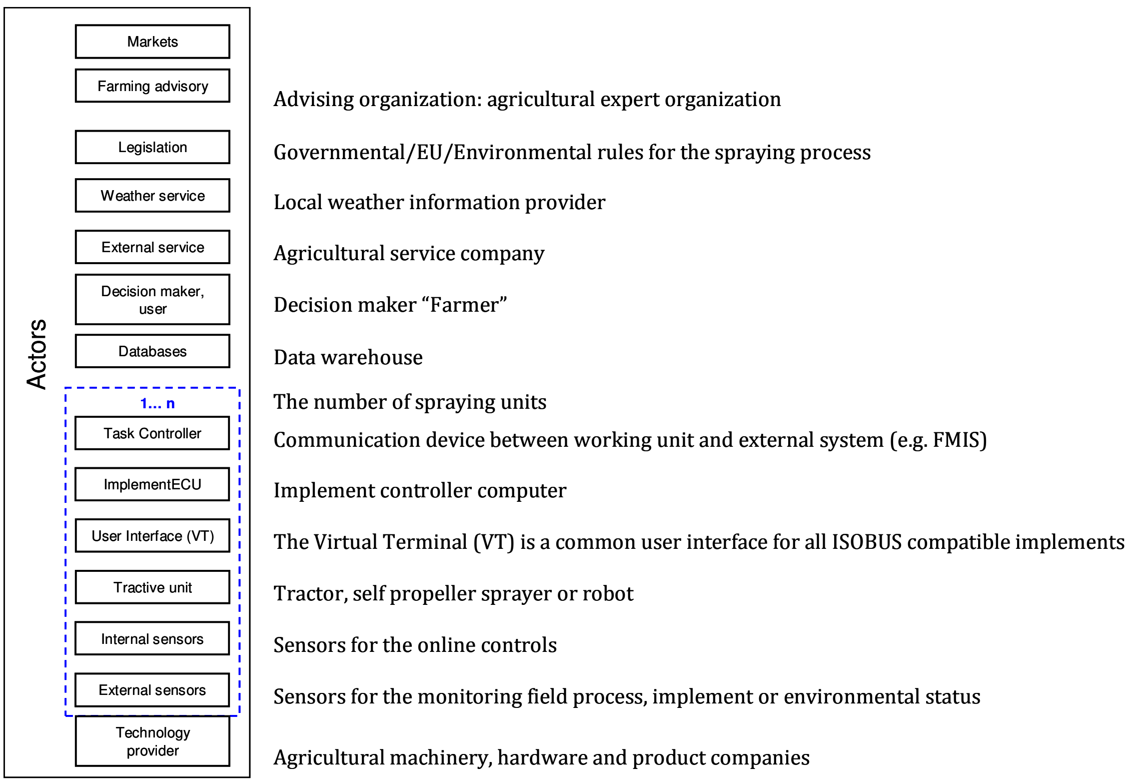

Figure 2. Identification of actors in the information system

The decomposition of information processes is based on the management functions ranging from strategical to operational planning, execution control and evaluation, and a number of underlying processes and sub-processes. Figure 3 gives an example of the information modelling for the tactical planning of a fertilising operation involving the seasonal planning.

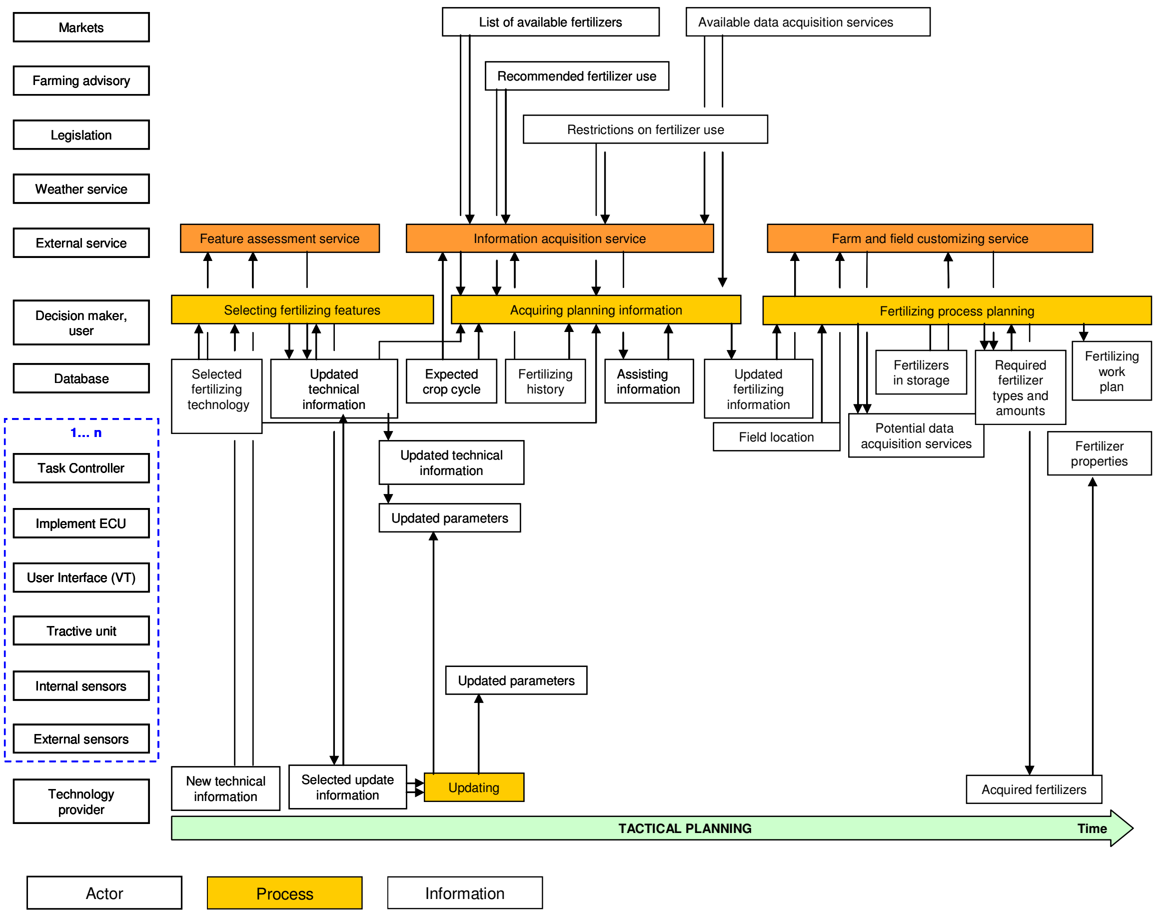

Figure 3. Information flow model for execution of field fertilisation operations. The elements include actors (physical entities), processes (information users and producers) and information (information flow)

Based on the identified information flows associated with the management functions and controlling of the spraying operation, the data entities and attributes inherent in the information flows is identified. Table 1 shows selected data entities for the execution phase in Figure 3.

Table 1: Selected data entities for the execution phase

Entity	Definition	Attributes/data
Field information	Description of needed field information	- field ID - location - area - crop type
Actual crop condition	Current status of the growth	- field ID - current growth status - type of observation
Selected TASK-file	The selected TASK-file for execution	- field ID - type of setting (fertliser 1… n, nominal dosage, mixture rates, driving speed, documented parameters, variable rate application (VRA) map) - control settings value for the specified types of settings

Conclusions

New information management concepts and designs mean that farmers have to be ready to adopt new working habits and perhaps also undergo further training. Farmers can utilise different services more efficiently and they are able to outsource some of the tasks they had previously performed themselves. Farmers have better knowledge of their production processes and are able to evaluate the performance of the chosen technology. This should lead to better process control in farms. Farmers can also utilise the collected farm data to show the quality of farming *e.g.* traceability, to markets and administration. The system concept also allows the farmers to access and utilise better scientific research and technological developments by providing fresh real process data and the ability to update the systems according to the latest knowledge. The results are in accordance with the policy recommendations to *implementation strategies* proposed by Ahlqvist *et.al* (2007) in the summary report "Nordic ICT Foresight: Futures of the ICT environments and applications on the Nordic level".

Important enhancement includes:

- Recording and storing of implement status/work documentation into farm database. This also means increased usage of numerical / formative data.
- Farm database has a central role in both human and machine decision making.
- Active use of external services increases.
- Increased use of automation.
- Smart assisting system features to support work are common, used information management technology shifts towards knowledge management technology

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