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Integration of mobile machines into agricultural business processes using context-sensitive systems

An essential characteristic of agricultural business processes is the influence by unpredictable events. To control these processes in an IT point of view, it is necessary to develop a consistent structure for description and modular design of services and processes. Subsequently processes are modelled based on this structure. For execution of the processes a service-oriented architecture will be developed to facilitate an application in mobile machines. Essential is the ability of context-awareness and an adaptive behaviour by selecting appropriate sub-processes. New use-cases benefit from numerous generic modules evolving by modularization. With it a basis for the support of varied business processes in the agricultural domain is achieved.

Keywords
Business process, service-oriented architecture, context, network, self-organisation, service engineering

Abstract

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An important characteristic of agricultural business processes is the influence of unpredictable events. To control such processes in the IT sense a consistent structure has to be developed for the description and modular design of work and processes. Subsequently, processes can be modelled based on this structure. A work-oriented architecture is then developed for applying the processes, enabling application around self-propelled machines. Essential hereby is the ability to register emerging contexts (context-awareness) and achieve an adaptive (context-driven) mode of operation through selection of appropriate sub-processes. Through modularising, a large number of generic building blocks are produced which can be used for new applications thus creating a basis for supporting varied business processes in the agricultural domain.

Modularising and describing work and processes

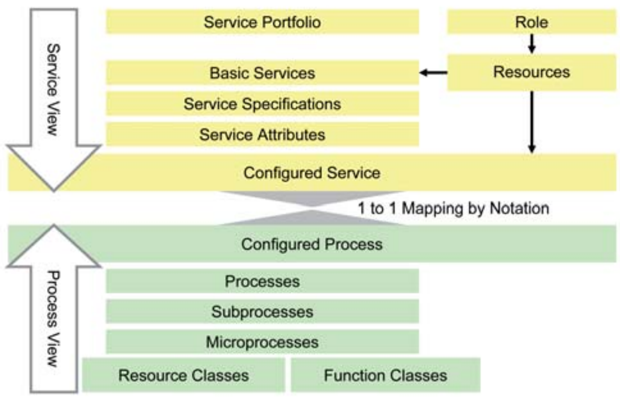
For recording and processing information it is necessary to precisely analyse and describe the relevant processes. In the project Robot to Business [1] the processes of forage harvesting were selected. Farm labour or inputs from third parties (agricultural contractor) can be broken-down into the components basic work (e.g. harvesting/chopping), specification of work done (e.g. according to area and/or time) and work aids (e.g. automatic information transfer into the field plan or automatic obstacle identification). Process building blocks are developed and placed for each work component for automatic transmission to the appropriate machines. If a harvester registers itself within the system the process building blocks are transmitted to, e.g., enable automatic entry in the field plan and identification of obstacles. The modulising of work and processes is presented in the master structure (**figure 1**).

Describing the process takes place with the help of the modelling notation BPMN [2] which gives clear presentation of the processes through flow diagrams. The modelling can be conducted by application experts with no deep knowledge of informatics required in the first step. In the next step the executable modelling notations need to be carried out by modelling experts in WS-BPEL [3]. The processes are constructed in modules so that they can be used in ever-new application contexts. Thus, e.g., the process of field identification is required for the field plan entry as well as for the obstacle warning.

Configuration of work

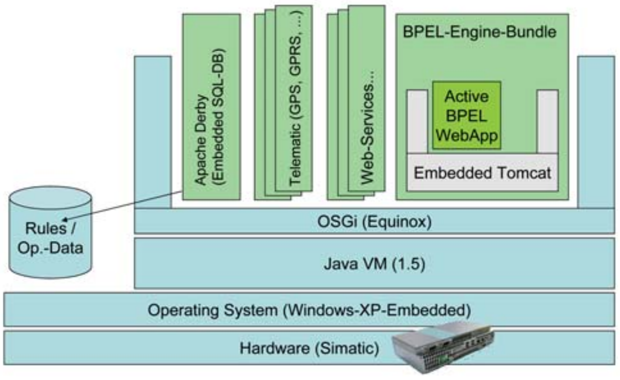
A configurator has been developed for the preparation of work inputs. As with a product configurator, this fits together the individual components according to rules, i.e. regulations and prohibitions on combination possibilities. This allows farmers or agricultural contractors to create a work directory similar to

Fig. 1



Master structure

Fig. 2



Architecture of mobile systems

a price list. For the configurated work process building blocks are laid which are then called-up by the machines.

Processing of context information

Contexts are central components of the system described here for automation of information processing. Unlike industrial situations where procedures are dependant to a lesser degree on external influences, structural applications do not give a direct answer. The advances in the labour procedure are influenced by contexts (e.g. field drivability, crop characteristics, availability of mobile communication, machinery working conditions) which require dynamic responses within the process. Thus to save local computer capacities and communication distances, the process of the field plan identification, e.g., is only begun when the machines are ready to start work – in the case of the silage harvesters when the header is lowered and the cutter drums activated. A context engine is applied for processing context information. This uses sensors to assess condition of aggregates and IT systems from which the interpreted (logical) contexts are applied for beginning the required process.

Procedural environment must offer suitable architecture

A suitable architecture has to be created for binding the machines in the processes and this has to meet a number of requirements:

- Application and process building blocks must be easily interchangeable in order to be able to support new work.
- Via established web technologies the machines applied in the process must be able to communicate with Backend systems and other machines.
- The systems must be compatible with various hardware systems (e.g. machine computer, Smartphone).
- Alternative communication technology must be able to be applied. E.g. if a W-LAN communication is not available it must be possible to apply GPRS instead.

In principle Backend and mobile systems should be able to be differentiated from one another. In Backend are located the configurator with its user interfaces and the configurated work components and the process register for further processing data received by the machines.

With the mobile systems is used INTEL x86 architecture with Windows XP embedded. Java-VM is applied as platform for all required applications. In an OSGi framework [4] applications are added in the form of bundles. Standardised interfaces are joined with the bundle concept which enable communication between individual programmes within the machine but also with other machines. Examples of bundles are the communications manager, the context engine or the web server. Installed in the web server is the BPEL engine that applies the previously modelled process and thereby serves the context engine or the communication server. The architecture of the mobile systems is presented in **figure 2**.

Example: automated entry into the field plan

The described system is able to conduct a large number of already configured work components and the linked modelled processes. The procedure is described below using the example of automated entries.

Firstly the work component „silage harvesting/chopping per hour configurated with automated field plan entry, automated invoice preparation and obstacle warning“. After harvesting work starts at a later point of time it registers with Backend, is recognised as harvester and takes delivery of the current processes, if they are not already present on the machine. As soon as the harvester is in the field and ready to start a field identification and, with that, ownership identification takes place. Furthermore, obstacle information for the field is prepared and displayed. During harvest, area covered, time involved and crop harvested information is recorded. When the harvester leaves the field, the data – as described in the process - is processed and sent to Backend. There the data is summarised according to the requirements of the farm management system (field plan, invoicing) and prepared for transfer. During the next connection between field plan and Backend the booking job is downloaded and, following a check by the user, imported into the system. In the same way the invoicing is processed. If during the processing a new obstacle is registered this is also entered and is available for use during subsequent work.

Conclusions

With the architecture presented here machines can be smoothly integrated in the business process with consideration of the context in each case. Extension to take in new services is simple because of the application of widely used web tools and interfaces. Through utilisation of sensor data and their intelligent further processing the farm business documentation can be automated to a great extent. Through this, application enables a reduction in data recording and creates a dependable database to help in business decisions.

Literature

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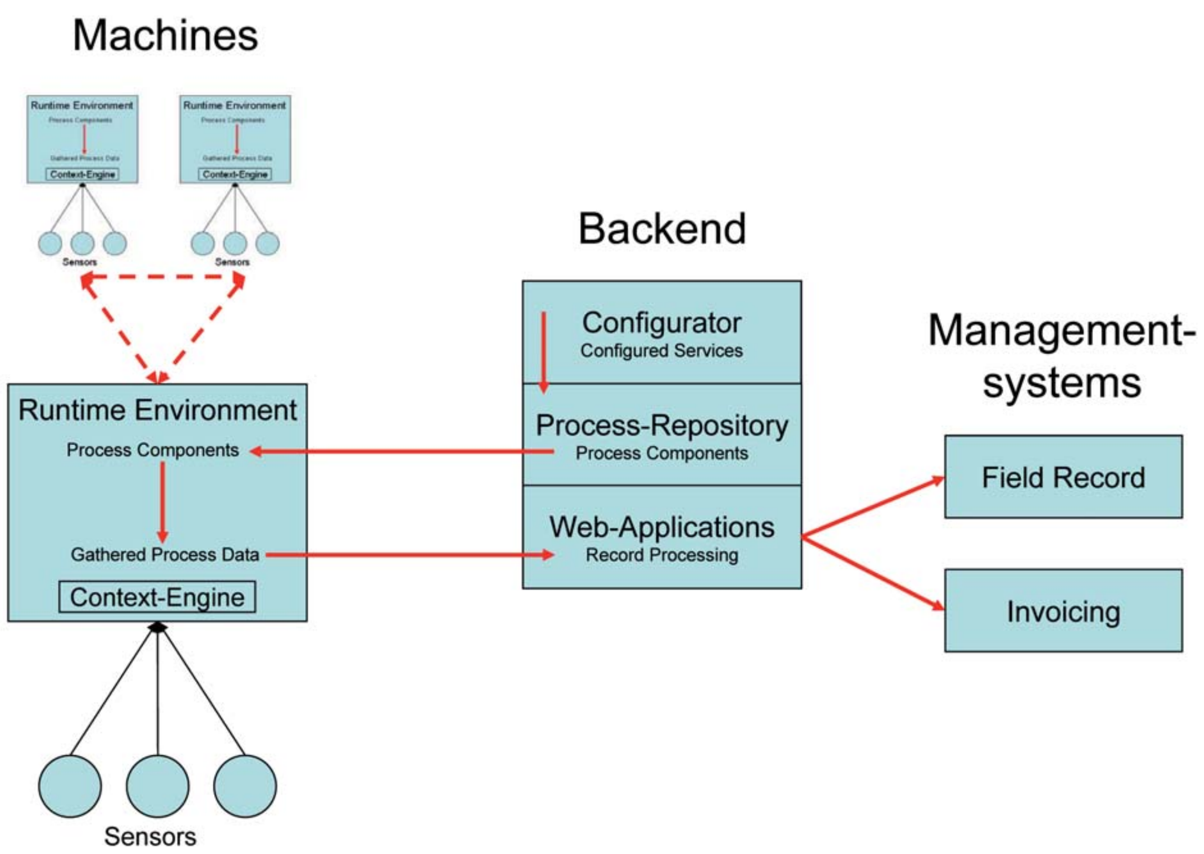
Fig. 3



Information processing