“More than the sum of its parts?” – Enhancing Optimisation for the Forest-based Value Chains by Integrating Process Specific Optimisation Solutions

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Introduction

FOCUS Project Overview I

- **FOCUS**: Advances in *Forestry Control and Automation Systems* in Europe
- SME-targeted collaborative research project funded by European Community (7th Framework Programme) with a duration of **30 months**.
- **Objectives**:
  - Advancing forestry control and automation
  - Combination of control, monitoring and planning
  - Making use of advanced sensor technologies
  - to support the management of the operations of the forest-based supply chain
- **Consortium**: 12 partners, 6 are SMEs (developers & users of technologies in forestry)
Introduction

FOCUS Project Overview II

- **FOCUS workplan** includes six WPs in three main stages:
  - Specification
  - Development
  - Assessment

- **FOCUS methodology**:
  - Rely on existing technological solutions of the participating SME’s and RTD’s and integration thereof (based on distinct Use Cases)
  - Enhanced with integrated sensor and RFID technology
  - Integration of other sources of freely available information (public data sets, satellite imagery, etc.)
Introduction

Motivation & Project Goals

i. **FOCUS** applicable to any supply chain within the realm of the forest-based production sector

ii. **FOCUS** aims to facilitate a bottom-up approach
   i. Integration of already existing solutions for different stages of a supply chain
   ii. To support optimal planning and control of the whole supply chain

iii. **FOCUS** integrates a Model Predictive Control (MCP) approach not present in current forest-based supply chain optimisation solutions.

iv. **FOCUS** makes use of spatial-temporal real-time sensor data and map metaphor to visualize (near) real-time situation
Forest-based Value Chains & Optimization thereof

- **Forest based value chains**
  - Description of adaptive ecosystem management perspective (managing under uncertainty, ...) (Heinimann, 2010)
  - Overview of Wood Flow Optimization in Forestry including an overview of the Forest Supply Chain (Rönnqvist, 2003)
  - Overview of Optimization for the Log Trucks in Austria including a thorough analysis of the problem at hand (Gronalt and Hirsch, 2007)

- **Optimization of Forest based value chains**
  - Optimizing log trucks (Weintraub et al., 1996; Flisberg, Lidén and Ronnqvist, 2007; Gronalt and Hirsch, 2007; Rönnqvist, 2003; ...)
  - System architectural approaches for forest supply chain management (Marques et al., 2010; Marques et al., 2012; Scholz et al., 2008)
Methodology for the Design of the FOCUS Architecture

Forest-based Value Chains & Optimization thereof

• Exploratory literature review

• Questionnaires and interviews to key actors in 4 pilot cases

• Systematization of the main findings into a FOCUS concept

• Workshop with IT experts on how to implement the FOCUS concept into FOCUS architecture

• Specification of FOCUS architecture components by IT experts

IFORS Barcelona, 13-18 July 2014
Forest supply chain represented as flow diagram:

- tanks = material stocked across the chain;
- in/out = material flow resulting from processes or disturbances
Preliminary Architecture

General Architecture and Components – Concept

Forest planning

Growing stock m³/ha/5-10yr
Yield and map intervention m³/ha/1-4yr
Management Unit to be harvested m³/ha/1-12 months
Trees to be harvested m³/ha/1-3 months

Harvesting

Harvest planning
Harvesting forwarding m³/hour/forwarder
Wood piled at roadside ton/pile/day

Logistics

Stock at mill ton/m²
1st transformation
Transportation ton/truck

Industrial processing

Sub-products ton/day
2nd transformation
Distribution and sales
finished products ton/day

PLANNING: set global and local setpoints (supply or demand driven)

Supervise stock levels and act accordingly

Distribution and sales

market

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Preliminary Architecture

General Architecture and Components I

• Core Components
  – Planning Component (Optimization)
    • Sets global and local setpoints with respect to the state of the supply chain
  – Controller: acts locally
    • Supervise the assigned supply chain section
    • Generate control „signals“ with respect to global and local setpoints
  – Sensors:
    • Gather data on the supply chain
    • Enhanced by spatial & temporal dimension
  – Service Bus:
    • „Glue“ between the architectural components
Preliminary Architecture

General Architecture and Components II

Overall Planning

Controller

Local Planning

Setpoints, constraints

Local Planning

Setpoints, constraints

Local Planning

Setpoints, constraints

…”

Controller

instructions

data

Controller

instructions

data

Controller

instructions

data
Preliminary Architecture

General Architecture and Components III

Planning

Controller

Setpoints, constraints

Recognize Deviation (now+future)

If deviation true

Suggest or Act within a given threshold

Alarm out of a given threshold

Supervising (with anticipation)

Automation

Replan

Data (Sensors)

Instructions for operations

models
Preliminary Architecture

General Architecture and Components IV – Sensor Webs

- Data collection with the **Sensor Web** and standardized **OGC Sensor Observation Services (SOS)**:
  - Collection of (any) measurement data in a standardized way
  - Storage of sensor data in a central database that provides sensor fusion services:
    - Query sensor data
    - Parallel sensor requests
    - Data harmonization
    - Providing of data in a standardized way (Web Feature Service, Web Mapping Service)
Preliminary Architecture

General Architecture and Components V

• Auxiliary Components
  – Service Bus
    • User Management
    • Access Control
    • Collaboration Engine
    • Service Discovery
  – FOCUS dashboard (mobile)
  – FOCUS dashboard (desktop)
  – FOCUS data store
    • Database engine storing data on the supply chain
Preliminary Architecture

General Architecture and Components VI - Dashboard

- ... is “an easy to read, often single page, real-time user interface, showing a (geo-) graphical presentation of the current status and historical trends of an organization’s key performance indicators to enable instantaneous and informed decisions to be made at a glance.” (adapted from Peter McFadden, CEO of ExcelDashboardWidgets)

Example of an emergency operations dashboard. (© ESRI, 2014)
Preliminary Architecture

General Architecture and Components VI - Dashboard

• ... is “an easy to read, often single page, real-time user interface, showing a (geo-) graphical presentation of the current status and historical trends of an organization’s key performance indicators to enable instantaneous and informed decisions to be made at a glance.” (adapted from Peter McFadden, CEO of ExcelDashboardWidgets)
FOCUS Pilot Use Cases:

- FOCUS Pilot Use Cases can be integrated in the overall FOCUS architecture by:
  - Plugging-in sensor data „streams“
  - Relying on existing or integrate a new controller for the Use Case
  - Integrating Data Storage that represents a model of the Universe of Discourse of the Use Case
  - The Service Bus serves as integration element for the components (serving high-order elements on a higher abstraction level!)
Preliminary Architecture

Architecture – Connection to Use Cases II

1. Plan
2. Setpoints
3. Sensor data gathering
4. Sensor data
5. Super
6. Request & delivery
7. Automate
8. Send instructions & visualize deviation

Forest planning DSS
Controller
Harvesting
Forest logistics

Sensor Data Store (spatial&temporal)

FOCUS data store

Controller...

Sensor data gathering components:
- Timber piles
- Machine sensor
- Sensor data
- ...
Conclusions and Future Work

• Conclusions and Wrap-up
  – Bottom-Up approach for Optimizing the Forest based Value Chain
  – Integration of Model Predictive Control approach to manage the Forest Value Chain
  – Integration of spatial-temporal Sensor Data to monitor the current status in (near) real-time
  – Making use of the map metaphor to visualize the current status

• Future Work
  – Workshop with IT experts on how to implement the FOCUS concept into FOCUS architecture
  – Specification of FOCUS architecture components by IT experts
  – Implementing Architecture and Integration of Use Cases
  – ...

References

- Strategic Research Agenda proposed by the Forest-based Sector Technology Platform, http://www.forestplatform.org/
Thanks to co-Authors, especially Alexandra, Christian & Jussi 😊

THANK YOU FOR YOUR ATTENTION!

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