C4C Project - Research Highlights

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C4C Project

Project. Control for Coordination of Distributed Systems (C4C)

• Financial Support of the European Commission Program EU.ICT, Objective ICT-2007.3.7 Networked Embedded and Control Systems (Project 223844)
• Life time project: 1 May 2008 - 1 May 2011. To be extended to 1 September 2011.
• Research focus: Control of distributed systems. Case studies and theory development.
• C4C Consortium: 4 industrial firms and 8 academic partners.
  Research institutes: CWI, CER;
  Universities: TUD, TUE, UCY, UGE, UPO, UVR;
  Companies: PSA Antwerp, Ocean Scan (Porto), Océ Technologies (Venlo), Trinité Automation (Uithoorn).
WP5. AGVs on container terminal
Operation with Straddle Carriers
Operation with Yard Stackers and AGVs
Yard Stackers and AGVs schematic overview
AGVs on container terminal

**Setting**
Container terminal PSA Antwerp (formerly Hesse-Noord Natie).
Motivation. Automate transportation of containers.

**Problem**
Control of the automatic transportation of containers.
Control objectives:
(1) Automatic operation of AGVs on the yard.
(2) Optimizing productivity levels of container terminals.

**Results**
WP4. Control of road networks

Research objectives

Design of a hierarchical control and communication network for control of road networks.

Setting

- Control and signalling system on the motorway network of The Netherlands.
- Existing network (built since 1975) planned to be upgraded.
- Hierarchical structure necessary.
  Hierarchical levels: sections, link, ring, network, etc.
Control road networks - Amsterdam network
Control road networks - DRIP
Control road networks - Control room
Control road networks

Problem
Hierarchical control of road networks.

Traffic control centers in The Netherlands

- Traffic control network North-Holland (Amsterdam).
- Control measures: coordinated ramp metering, incident detection, dynamic speed control, routing advice, variable message signs. 25,000 sensors, data processing, control algorithms.

Research issues of vehicles interacting with environment

- Hierarchical control at various levels. Coordination scenarios.
- Integration of data from different sources for control.
Some results

- The Scenario Coordination Module (SCM): successfully installation of a network control system, based on a hierarchical model in the Amsterdam area.
- Standardization: first draft between four parties to standardize interaction between traffic control units, both local and coordinating.
- Platoon Based Traffic Modeling: applied to traffic state estimation and network control for urban networks.
- BlueTrack: cheap Bluetooth based monitoring device has been developed.
WP6. Complex Machines

Image Processing

Paper sheet micropositioning

Subnode processor card

Mainnode

Image circuitry
Printing Process

Image formation and transfer to sheet

- Complex process
- High quality and performance requirements
  - Quality / maintenance procedures
  - Energy saving
  - Highest possible throughput
- Distributed control
  *Interaction may result in suboptimal behavior*
Objectives

Conventional design

• Domain engineers informally specifies requirements.
• Software engineers write and debug control code.

Supervisory control synthesis

• Generate code, based on synthesis algorithms, instead of writing code by hand.
• Shift the focus of software engineers from writing and debugging code to modeling plant and control requirements.
• Improve communication between software and domain engineers, since both can think in terms of behavior.
• Shorten the design-validate-redefine loop.
• Use the formal, behavioral models for, simulation based, controller validation.
Results

Case facts

• 15 automata (2–17 states).
• 50 requirement specifications.
• Supervisor: software in C code.

State-based supervisory control synthesis

• Shorter and more intuitive formal specifications, jointly developed by software and domain engineers.
• Reduced development time.
Other case studies - Overview

Other case studies

1. Autonomous Underwater Vehicles (AUVs).
   Coordination control for formation flying.
   Joint search for chemical pollutants.
   When to communicate?

2. Uninhabited Aerial Vehicles (UAVs).
   Moving sensors.
   Search, detection, computation, communication.
Forms of control of distributed systems

1. Distributed control.

2. Distributed control with communication.
   Examples. AUVs, UAVs, AGVs.
   Nearest neighbor control.

3. Coordination control.
   Examples. AUVs formation flying. High-speed printers.
   Coordinator orchestrating two or more subsystems.

4. Hierarchical control.
   Examples. Road networks. Complex machines. AGV control.
   Modeling, prediction, control design.

Research program for 2, 3, and 4 above.
Concluding remarks

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http://www.c4c-project.eu/

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The End!