Information Society Technologies

ARTIST2 – Year 1 Review

Grenoble, October 3rd-4th, 2005

Cluster

Control for Embedded Systems

Cluster leader : Karl-Erik Årzén (LUND)

Presentation of the Cluster - Activities

Cluster Overview – Karl-Erik Årzén

Cluster Integration Activities:

- Control for Real-Time Computing (**CREATE**) – Karl-Erik Årzén
- RT Techniques in Control System Implementation (**RTC**) – Alfons Crespo

NoE Integration Activities:

- Adaptive RT, HRT and Control (**HARTCON**) – Karl-Erik Årzén

Platform Activity:

- Design Tools for Embedded Control (**ECS-Tools**) – Martin Törngren

Presentation of the Cluster - Partners

Core partners:

- Lund University – Karl-Erik Årzén
  Areas: CREATE, RTC, ECS-TOOLS, HARTCON
  Activity leader for: CREATE, HARTCON
- KTH – Martin Törngren
  Areas: CREATE, RTC, ECS-TOOLS, HARTCON
  Activity leader for: ECS-TOOLS
- UPVLC – Alfons Crespo
  Areas: CREATE, RTC, ECS-TOOLS, HARTCON
  Activity leader for: RTC
- CTU – Zdenek Hanzalek
  Areas: RTC, ECS-TOOLS, HARTCON
- (ETHZ – Manfred Morari)
  Not participating for personal reasons

Affiliated international partners:

- Lui Sha – Univ of Illinois
  Areas: CREATE
- Tarek Abdelzaher – Univ of Virginia (Univ of Illinois)
  Areas: CREATE

Presentation of the Cluster

Affiliated industrial partners:

- dSpace (Joachim Stroop)
- ABB Automation Technology Products (Göran Arinder)
- Honeywell Prague Laboratory (Vladimir Havlena)
- Volvo Car Corporation (Jakob Axelsson)
- Volvo Technology Corporation (Magnus Hellring)
- Maquet Critical Care (Klas Engwall) -- New

Main role during year 1:

- Provide input to roadmaps and survey

Control in Artist2

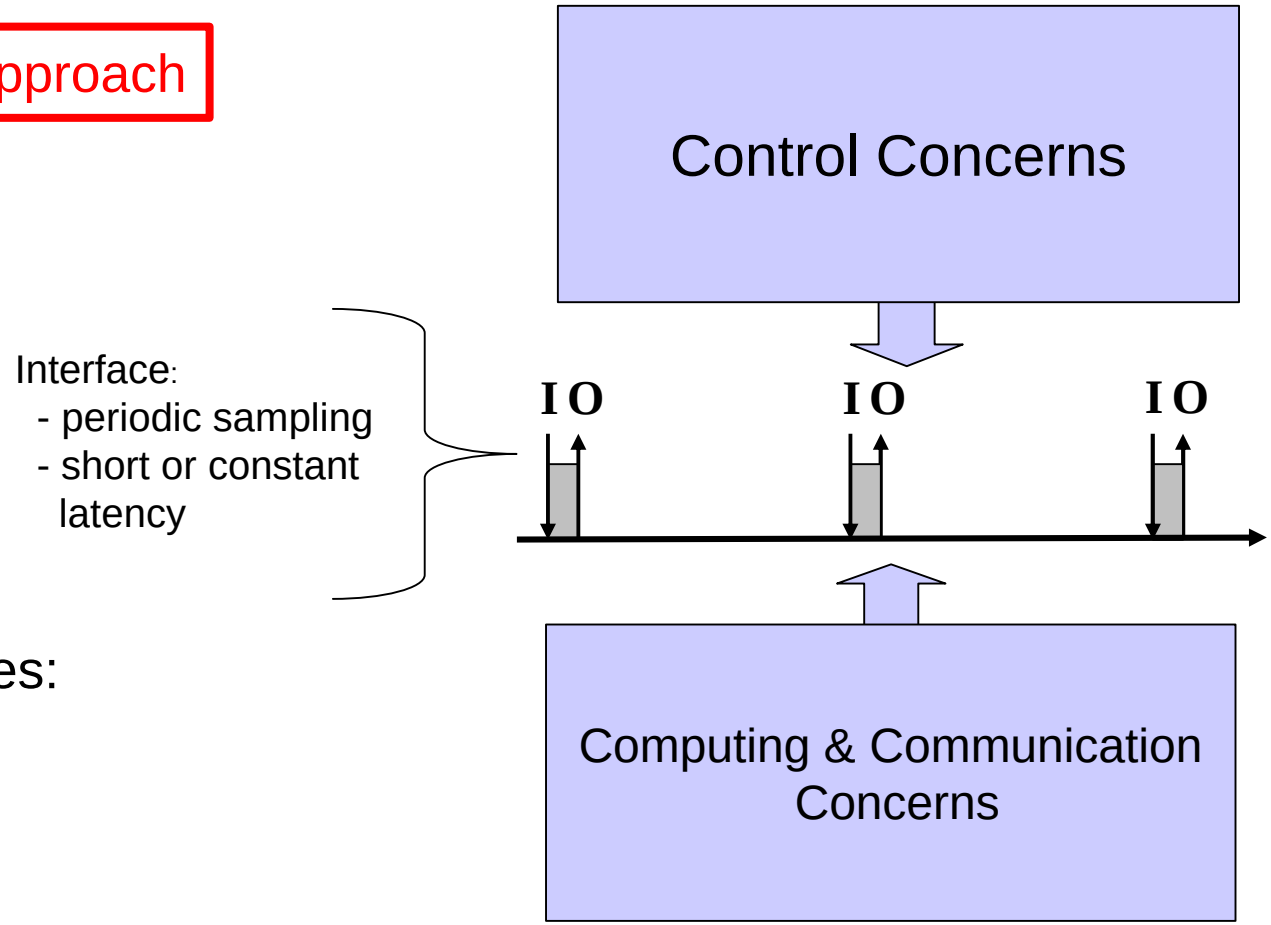
- Important application area for real-time embedded systems
  - Many embedded systems are control systems
  - Several of the computational models and scheduling models used in real-time systems are motivated by the concerns of control applications
- Embedded control systems have special characteristics and challenges:
  - Resource constraints
  - High level of autonomy
- Control is a basic technology for managing uncertainty that can be used to generate robustness and performance also in embedded systems

Industrial Relations

- Real-Time Techniques in Control System Implementation
  - Relevant for a wide range of industrial sectors
  - Our contacts primarily with
    - *Automotive*
    - *Automation & Robotics*
    - *Manufacturing*
    - *Medical Systems*
- Control for Real-Time Computing
  - Mainly relevant for consumer electronics and computing industry
  - Large potential also in other sectors

Activity: RT Techniques in Control System Implementation Separation vs Integration

Separation-Based Approach



- Several advantages:
  - simplicity
  - determinism
  - dependability
  - …..

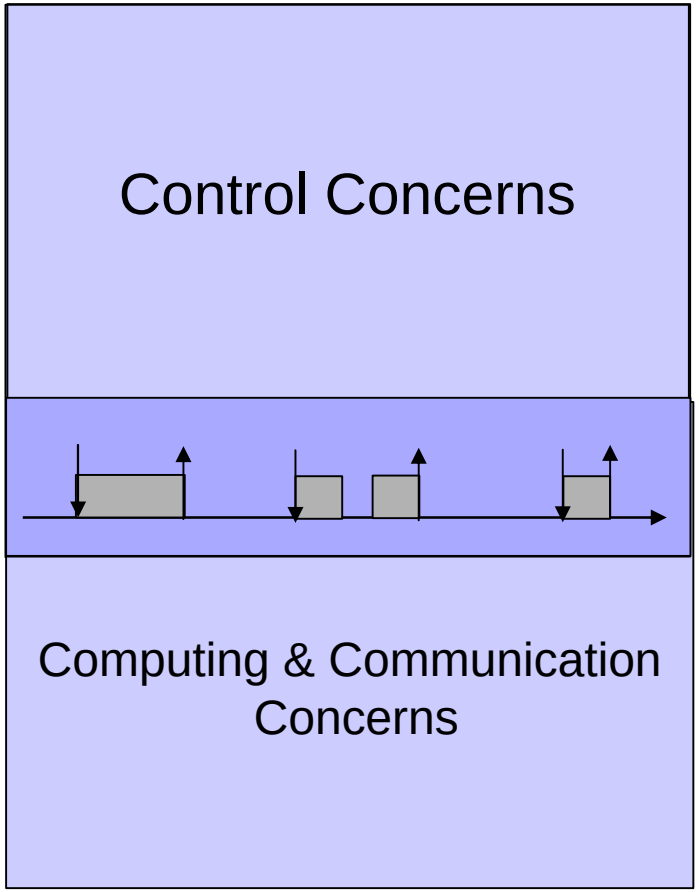
Activity: RT Techniques in Control System Implementation Separation vs Integration

Practice

Reasons:

- incomplete separation
- lack of resources
- wrong assumptions
- technology incompatibility
  - *time vs event*
  - *static vs dynamic*
- *….*

Interaction:
- latencies and jitter
- numerics



Activity: RT Techniques in Control System Implementation Separation vs Integration

Integration-Based Approach

- Codesign of control, computing and communication
- Examples:
  - temporal robustness analysis techniques

    Is the interaction harmful?
  - implementation-aware control techniques

    What can be done from a control perspective?
  - control-aware computing and communication techniques

    What can be done from an implementation perspective?
- Design tools necessary – ECS-Tools Platform Activity
  - partners all develop codesign tools
  - e.g. TrueTime and Jitterbug from Lund
  - coordinate, integrate and promote

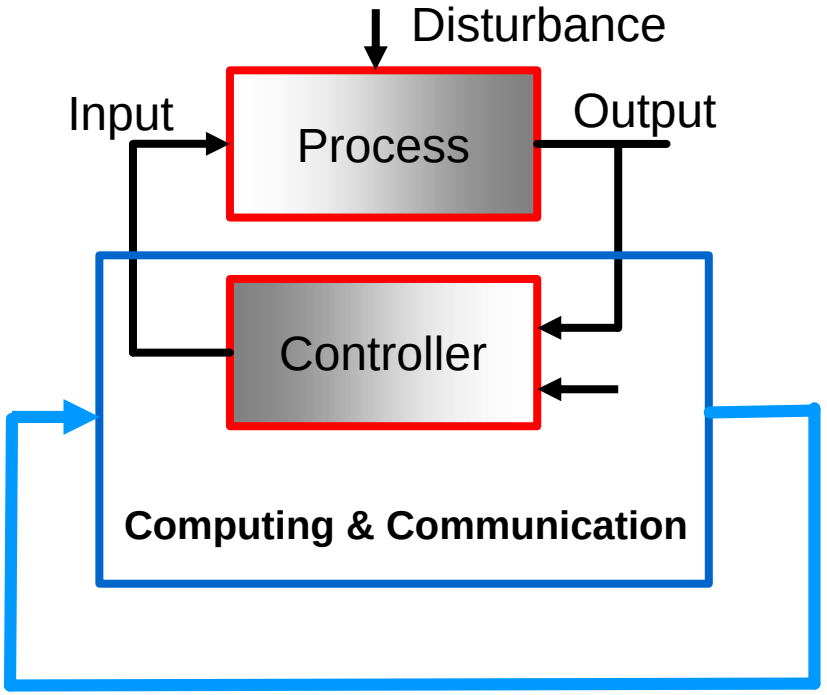
Activity: Control in Real-Time Computing

- Going From

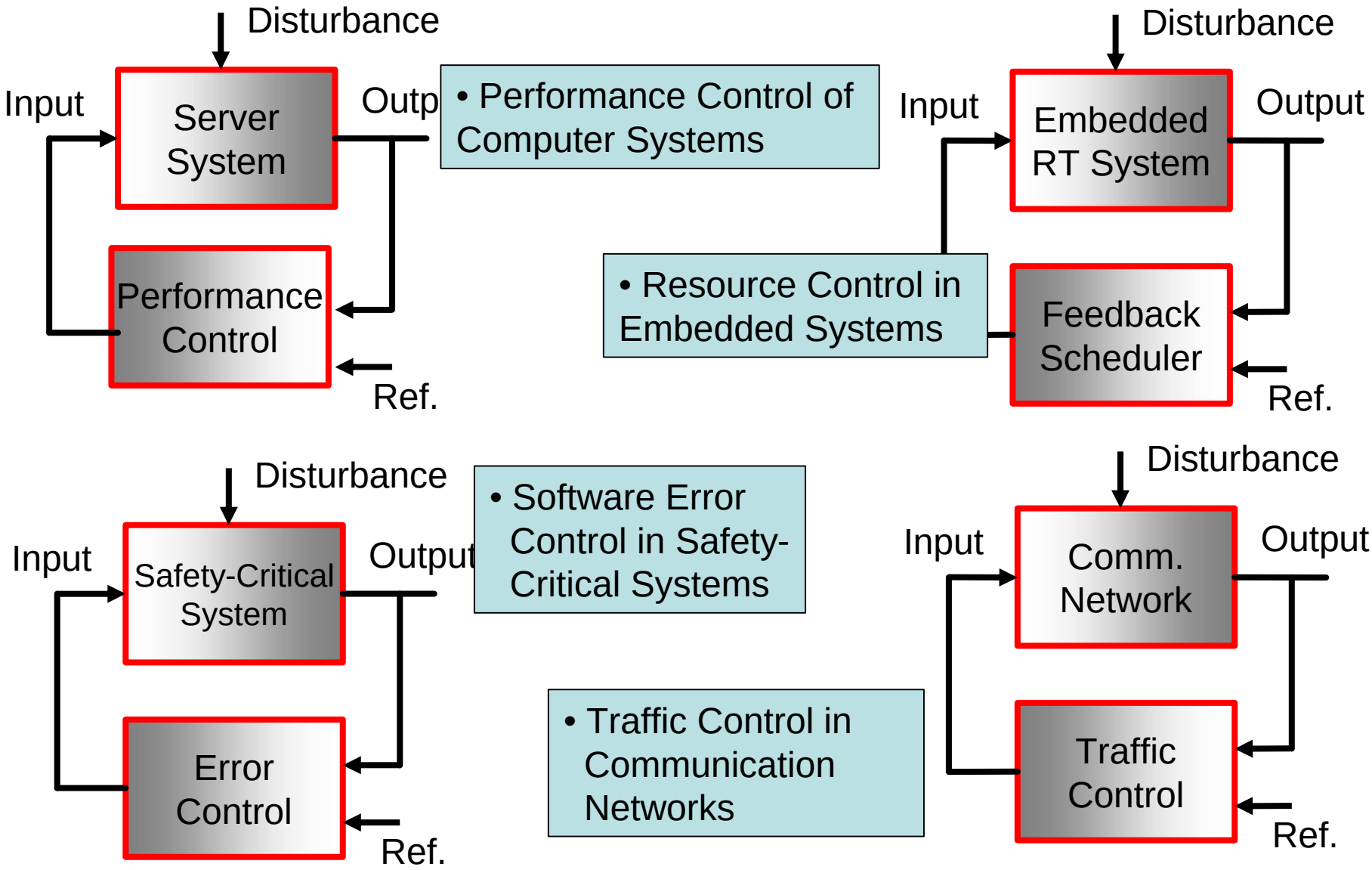
  Computing for Control

- To

  Control for Computing



Activity: Control for Computing



Connections to Other Clusters

- Hard Real-Time
  - computational models
- Adaptive Real-Time
  - flexible scheduling
  - adaptive resource management
- Modeling and Components
  - control components, formal modeling of control systems
- Testing and Verification
  - testing and verification of control systems
- Compilers and Timing Analysis
  - codesign tool issues

NoE Activity: Adaptive RT, HRT and Control

Year 1 activities

State of Integration in Europe

- **Control of Web server systems:**
  - dominated by US groups,
  - LUND the only active European group
- **Control-based resource allocation:**
  - Europe has several very strong groups.
  - ART cluster
  - LUND, UPVLC, and KTH strong in feedback scheduling of control systems and QoS approaches in control.
- **Control of Communications Network:**
  - Europe has several strong groups, incl KTH
  - Sensor networks – RUNES IP (LUND and KTH)
- **Real-Time Control Systems:**
  - The core partners are the best in Europe
- **Codesign Tools:**
  - Several European groups are working on tools for codesign of control and computing issues.
- **Hybrid Control:**
  - Strong integration through HYCON NoE
  - Strong links to HYCON NoE through KTH and Lund

Main aims for integration

1. Unite the best European groups and create a strong European research network on control for embedded systems.

2. Integrate this network with the other Artist2 clusters, thereby increasing the awareness of

   - the true computing and communication requirements of networked embedded control applications

   - how control techniques can be used in the design of embedded systems to achieve increased robustness and flexibility.

Year 1 activities
Achievements

- Achievements
  - Two Roadmaps + Survey on Codesign Tools
  - Lund Workshop on Control for Embedded Systems
    - *Thinktank*
    - *International partners + EU*
    - *Industrials*
      - Ericsson (co-sponsor)
      - ABB
    - *ART cluster*
    - *Strategic Research Agenda*
  - Valencia Graduate Course on Embedded Control
  - Several meetings and mobilities
  - Research
    - *69 publications*
- Joint work
  - roadmaps + tool survey
  - session
  - graduate courseware development
  - publications
    - *Handbook of Networked & Embedded Control*
    - *Journal of Real-Time Systems*
    - *….*

Year 1 activities

Interaction & Building Excellence

- Interaction between partners
  - Strong interaction within the context of roadmaps, workshops, courses, and mobility exchanges
  - Meetings held

    Five technical cluster meetings held
  - Mobilities

    Five PhD student exchanges

    11 senior researcher exchanges
- Building Excellence
  - the roadmapping activity
  - the Lund Workshop
  - numerous excellence spreading activities

Spreading Excellence Activities

So far:

- Valencia Graduate Course on Embedded Control
- RTC2005 – one day workshop at ECRTS 2005
- Invited session at IFAC World Congress
- Truetime tool tutorial at IFAC World Congress
- Summer school in connection with IFAC World Congress
- Embedded System Seminars for Swedish SMEs
- Special session on Model-Driven Engineering at Euromicro
- Key note at FORMATS'05

Planned:

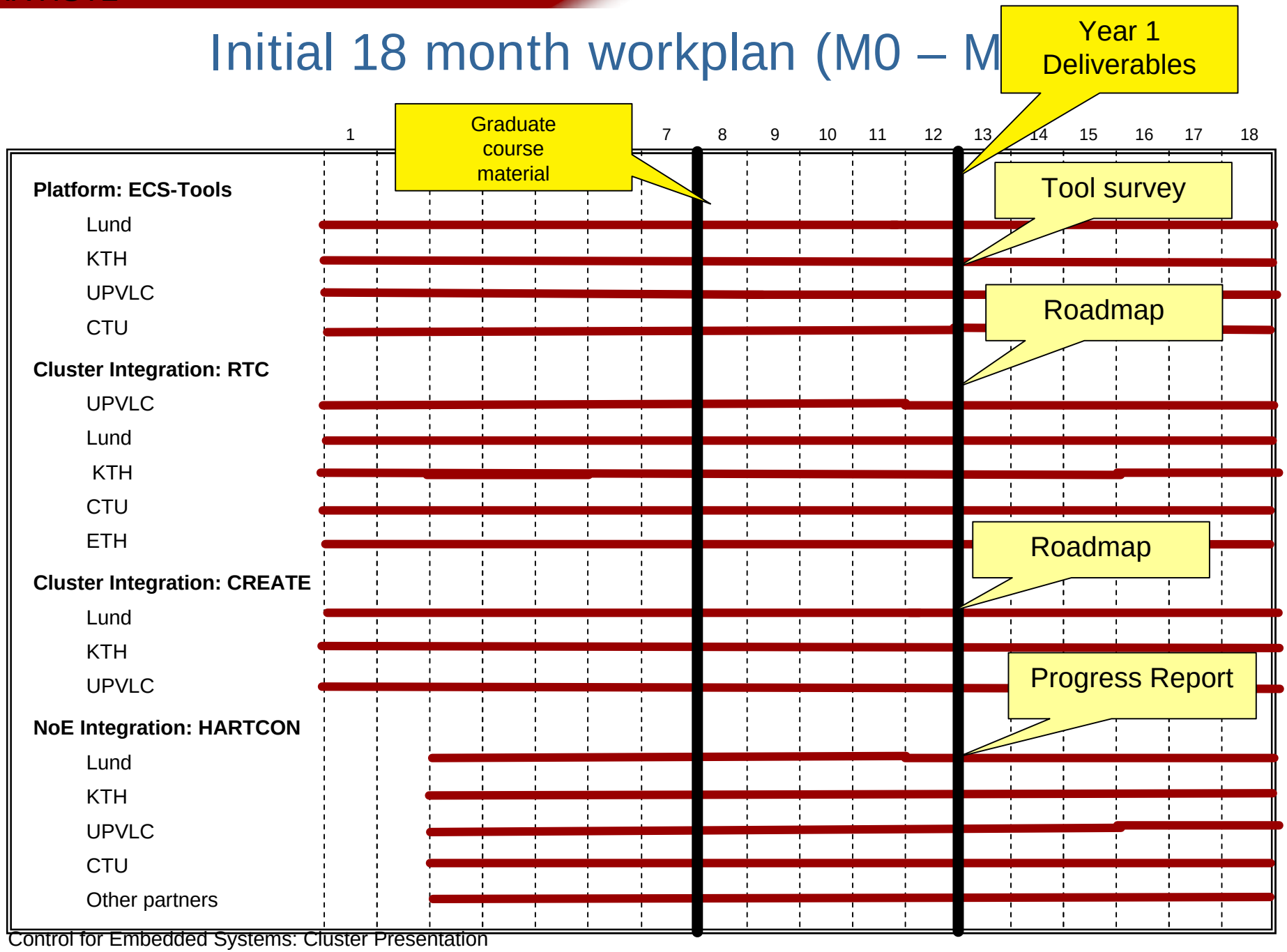
- Workshop/course at CDC-ECC in Sevilla, Dec 2005
- Invited session together with RUNES at CDC-ECC
- Next edition of Graduate course on Embedded Control, Prague, April 2006
- Joint Summer School with ART
- Follow-up to the Lund Workshop

Long Term Objectives

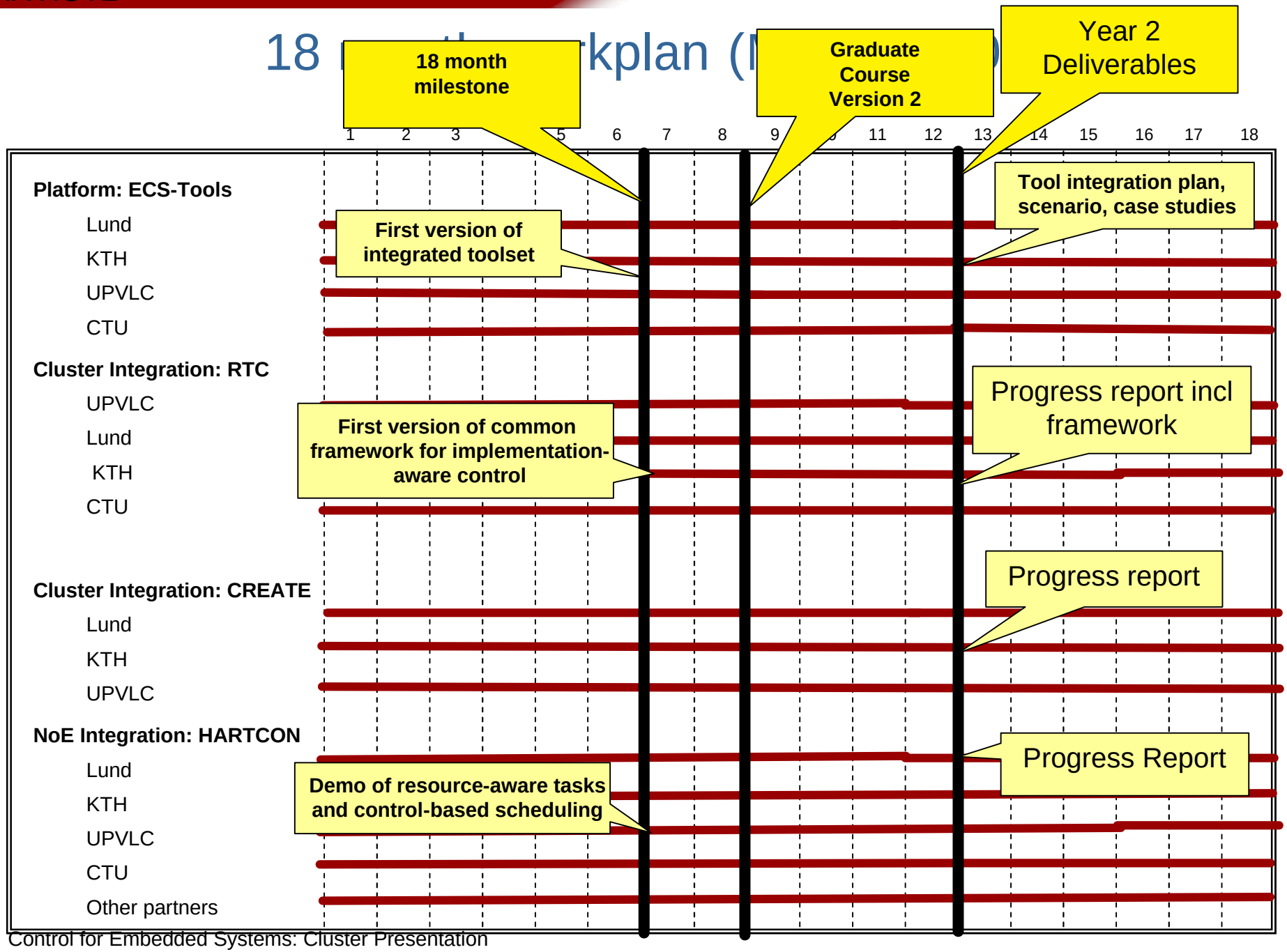
Development of methods, tools and theory that allow faster and more efficient development of networked embedded control systems that are safer, more flexible, more predictable, have higher degree of resource utilization, and better performance than what is possible today

Advance the state of the art in applying control methods for providing flexibility and robustness and manage uncertainty in embedded computing and communication systems.

Initial 18 month workplan (M0 – M



18 [illegible]kplan ([illegible])


18 month milestone
Graduate Course Version 2
Year 2 Deliverables
1 2 3 5 6 7 8 9 11 12 13 14 15 16 17 18
Platform: ECS-Tools
Lund
KTH
UPVLC
CTU
Cluster Integration: RTC
UPVLC
Lund
KTH
CTU
Cluster Integration: CREATE
Lund
KTH
UPVLC
NoE Integration: HARTCON
Lund
KTH
UPVLC
CTU
Other partners
First version of integrated toolset
Tool integration plan, scenario, case studies
First version of common framework for implementation-aware control
Progress report incl framework
Progress report
Progress Report
Demo of resource-aware tasks and control-based scheduling