Purpose and ambition

- to offer a sufficient number of graduate courses nationwide to allow graduate students at all participating nodes tp compose individual study programmes that will enable them to complete their graduate courses in 1-2 years.
- to provide graduate students with industrially relevant and scientifically challenging thesis topics, to be worked upon under competent supervision in stimulating academic and/or industrial environments.

Status

Courses
Four courses have been given during 97/98

- Software for Embedded Real-time Control Systems (KTH)
  web-based course, 1 week laborations etc. at KTH concentrated
- MODELLING and ANALYSIS of REAL-TIME SYSTEMS (UU)
  4 times 2-3 days of which half was given in Linköping and half was given in Uppsala
- Distributed Real-Time Systems (HIS)
  videoconference based distribution of weekly seminars
- Hardware/Software Codesign (LiTH)
  videoconference based distribution of weekly seminars

All courses had a mix of participants (graduate students from different universities, industry), but the general conclusion is that it is difficult to get well spread national participation in courses of this character (specialized, research oriented).

The best response was to the KTH course. This could have several causes - it was web-based and thereby easy to access and/or it was well-developed since before.

The UU course had several participants from both universities where the course was given, but few from elsewhere.

The videobased courses had participants from industry and the HIS course also had participants from other universities, but the national spread of participants was smaller.

Summerschool
In this perspective the summerschool organized by ARTES in august was a success - participants from all Sweden were there.

Conclusions to courses after 1 year

The goal that applies mostly is the first, even if the support from ARTES to develop and give local courses can contribute to achieving the second.

The following conclusions are close at hand even if the experiences cannot be said to support them conclusively.

- nationwide spread of a course requires significant effort
- it is not enough to just change the organization - to videoconferencing or intensive course
- easy access to the course is probably the one factor which is most important

Recommendation

If the purpose of having nationwide participation is to be achieved two lines of action are recommended:

- develop further the idea of summerschool - invited international well-known teachers, theme for the summerschool, give points for the participating graduate students.
- develop courses or course modules that are easily accessed - web distribution is the obvious choice. These courses should preferrably be at non-advanced level, with the purpose to give easy access to basic knowledge about RT systems.'
- focus course support to invited/special teachers with international standing.
- not excluding support for successful local courses

The modules should cover a well-defined domain and the prerequisites must be well stated. It is assumed that any graduate student has the knowledge corresponding to a student from the D-programme, without specializing in control or software engineering.

For LiTH this means (relevant courses):

Linear algebra, analysis, mechanics, discrete math and logic, basic programming, digital and computer technology, circuit theory, measurment technology, datastructures and algorithms, process programming, operating systems, numerical algorithms, statistics & probability theory, OO analysis and design, signal theory, combinatory optimization, AI, microcomputer design, automatic control, software development project.

Modules (suggestions)

The purpose with the modules are to give graduate students the possibility to achive basic competence in the real time systems area. The modules are necessary introductory. Advanced or more in depth courses must probably be given in traditional way.

A Module contains - a planned OH presentation with sound track via the web, a comprehensive planned track for the student to follow when reading the litterature, excercises available via the web, a detailed litterature plan.

The organization could be that ARTES enrolls a teacher to be available (jour) certain times for telephone or email conversation. Labs could be available via the web or possible to do at specific time periods.

Real-time Scheduling
Contents: Real Time scheduling theory - cyclic scheduling, RMS, priority ceiling etc. Schedulability analysis

Prerequisites: Traditional Operating system and process programming course

6 lectures á 45 min, excercises and 2 labs.

Execution time analysis
Contents: methods to estimate and measure execution time with emphasis on worst case execution time

Prerequisites: Compilers, operating systems

6 lectures á 45 min, excercises and 2 labs.

Real-Time Operating systems
Contents: Extention of undergraduate operating system course, focus on one/two RTOS.

Prerequisites: Operating systems, Real-Time scheduling

4 lectures á 45 min, 1 lab.

Real-Time Software Engineering
Contents: Orientational course. RT Software requirements, modelling and specification, one OO method like Schlaer Mellor or Rationals method, with specific emphasis on the specifics of real time software.

Requirements: OO analysis and design

4 lectures á 45 min, excercises

Control system design
Contents: Basic automatic control

Requirements: relevant math

6 lectures á 45 min, excercises.

Control software design
Contents: Discrete control, practical implementation considerations, development tools, detailed design of control software.

Requirements: Control system design, processprogramming, operating systems

4 lectures, project.

Real time signal processing
Contents: theory and techniques for typical control algorithms

Prerequisites:

Platforms for Real-Time systems
Contents: typical industrial architectures for real-time systems - avionics, tracking, engine control, measurement, hardware in the loop simulation, communication...

Prerequisites: basic computer technology

4 lectures, term paper.

Dependable computers
Contents: Basic reliability theory, realization in industrial systems

Prerequisites: Platforms for Real-Time systems

4 lectures, excercises, lab

Formal models
Contents: Automata, Petri Nets, Process algebra

Prerequisites: Basic discrete maths

6 lectures, excercises

Timing analysis and verification
Contents: Modelling and analysing timing properties focused to one paradigm

Prerequisites: Formal models

6 lectures, 2 labs

Real Time system specification, verification and validation
Contents: Functional specification, verification methods, testing functional and real time properties

Prerequisites: Formal models

6 lectures, excercises

Real Time communication
Contents: guaranteeing timing and function in networks

Prerequisites:

Distributed real time systems
Contents:

Real time programming languages
Contents:

Suggestion

- Interview several of the leading academic supporters of ARTES about their view on modules.
- Ask for offers immediately to develop two modules - in real time scheduling and analysis and one which is based upon the RIP-course from LTH.

Ownership, access and distribution

Unsolved issues