LCCC Workshop on Control of Computing Systems

December 5-7, 2011

Old Bishop's House, Lund

Organizers:

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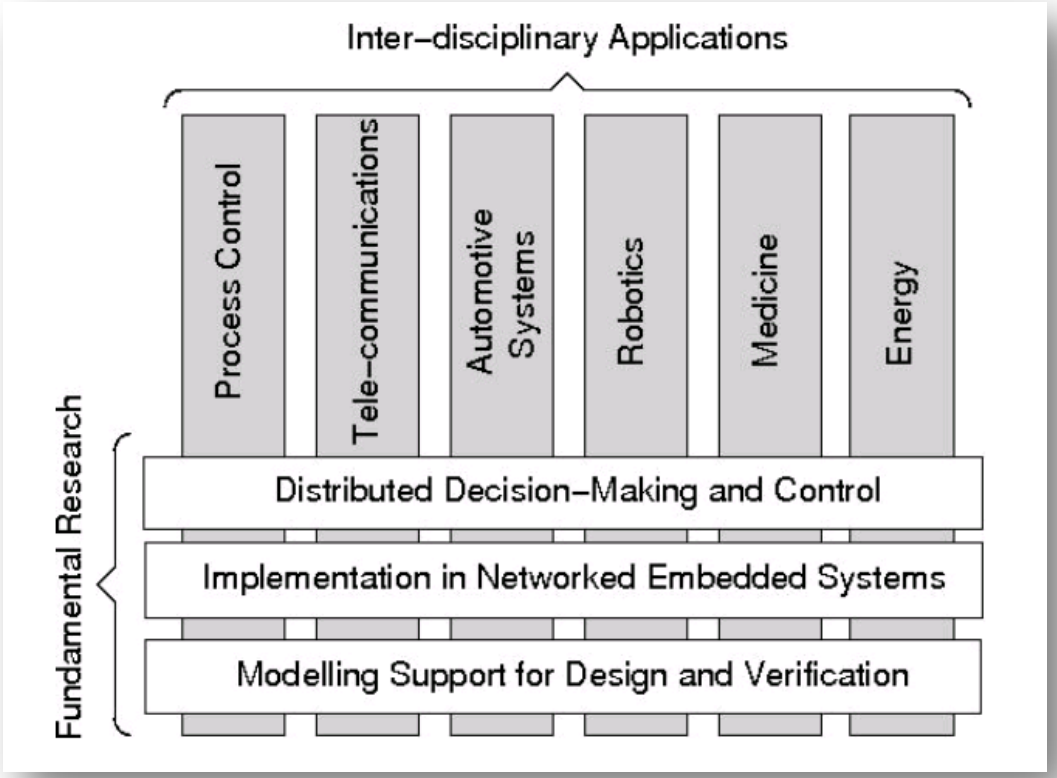
Tarek Abdelzaher, Anders Robertsson,
Maria Kihl

LUND INSTITUTE OF TECHNOLOGY
Lund University

LCCC – Lund Center for Control of Complex Engineering Systems

- Linneaus Grant: 2008 - 2017
- Coordinator: Prof Anders Rantzer



LCCC Workshops

- Multi-agent coordination and estimation
  - February 3-5, 2010
- Distributed decisions via games and price mechanisms
  - March 10-12, 2010
- Adaptation and learning in autonomous systems
  - April 21-23, 2010
- Distributed model predictive control and supply chains
  - May 19-21, 2010
- Dynamics, control and pricing in power systems
  - May 18-20, 2011
- **Control of computing systems**
  - **December 5-7, 2011**

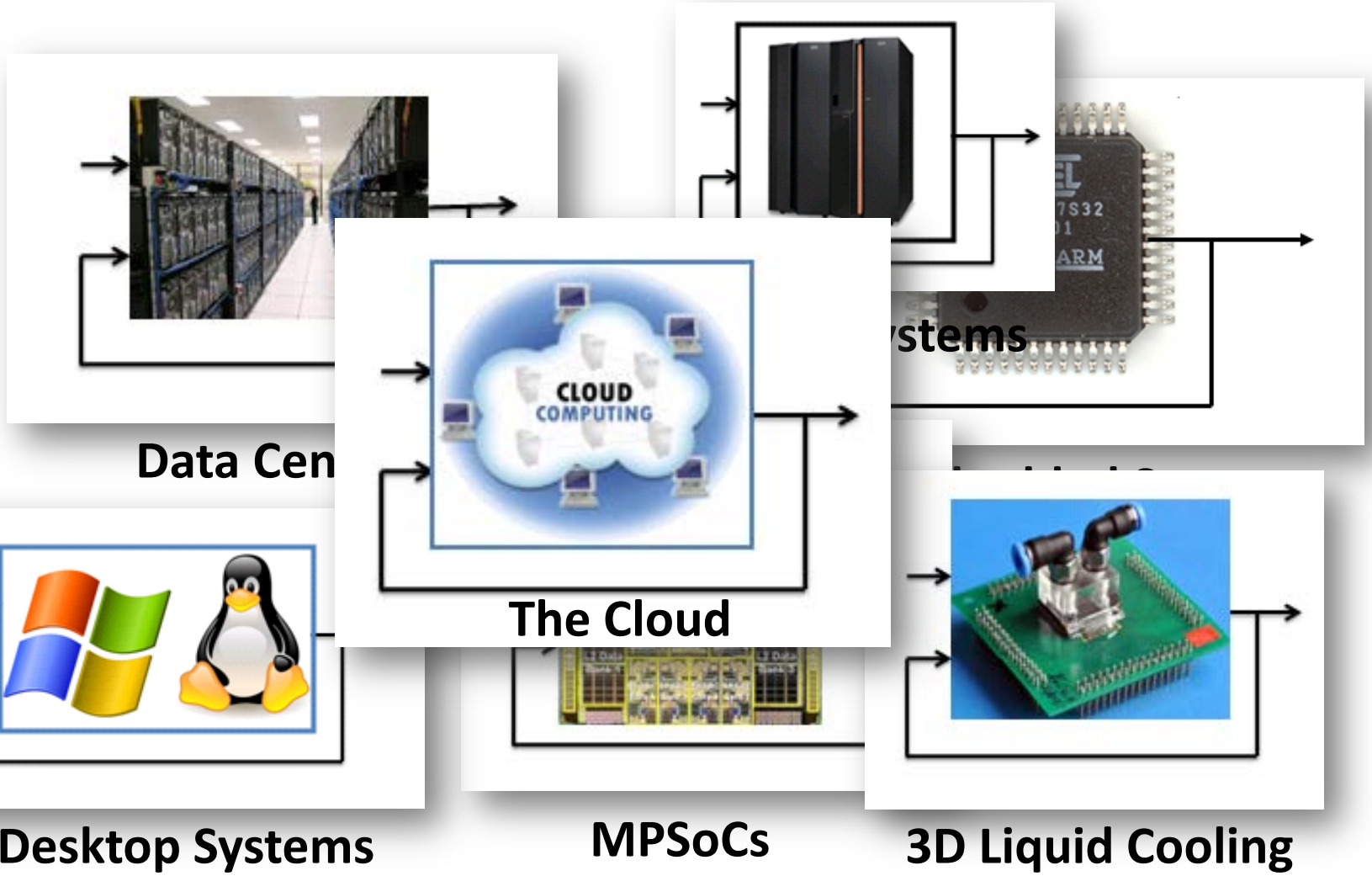
Invited world-leading researchers from Control, Computer Science, Economics, Communication, Mathematics, . . .

Old Bishop's House

- Built 1842 for the university
  - Physics, Chemistry, Zoology
- Later the bishop's home
- Returned to the university in 1994
  - Meetings
  - University art collection

Control of Computing Systems

- Applications of control and optimization to computing and communication systems
- Cyber-Physical Systems (CPS)?



Workshop Structure

- Monday:
  - Data/web servers
  - Data centers
  - Cloud
- Tuesday
  - Cloud
  - Networks
  - Computers
- Wednesday:
  - Embedded Systems
  - Computer Control
  - Non-conventional sampling and control

Why?

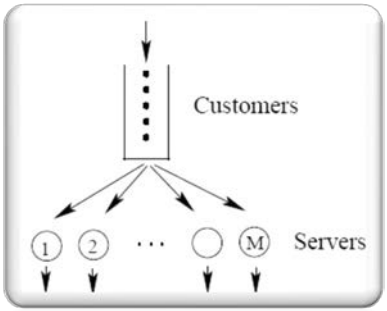
- Green Computing
  - Data centers
  - Communication networks
  - Battery-driven systems
- Problems with static worst-case design approaches:
  - Heterogeneous platforms
  - Multi-core/multi-thread with shared caches
  - Instead: self-organization and auto-tuning

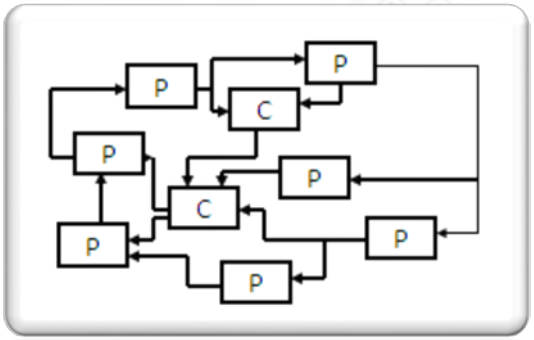
Theoretical Foundations

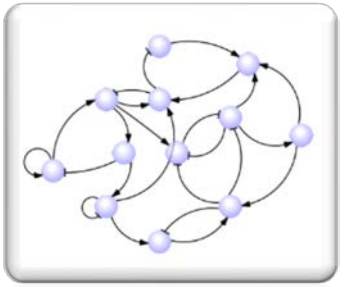
- Control theory
- Scheduling theory
  - Real-Time Scheduling
  - Job-Shop Scheduling
- Queuing theory
- Mathematics
  - (Distributed) Optimization
  - Network dynamics
  - ….
- ……

$$\begin{aligned} \frac{dx}{dt} &= Ax(t) + Bu(t) \\ y(t) &= Cx(t) + Du(t) \end{aligned}$$

$$\text{“}\tau_i = (T_i, D_i, C_i)\text{”}$$







What do we control?

- Performance Control

Utilization control

Throughput control

Latency control

Deadline misses control

- Resource Control
  - Power / Temperature
  - As control objective or as constraint

Data center cooling

Smartphones

Laptops

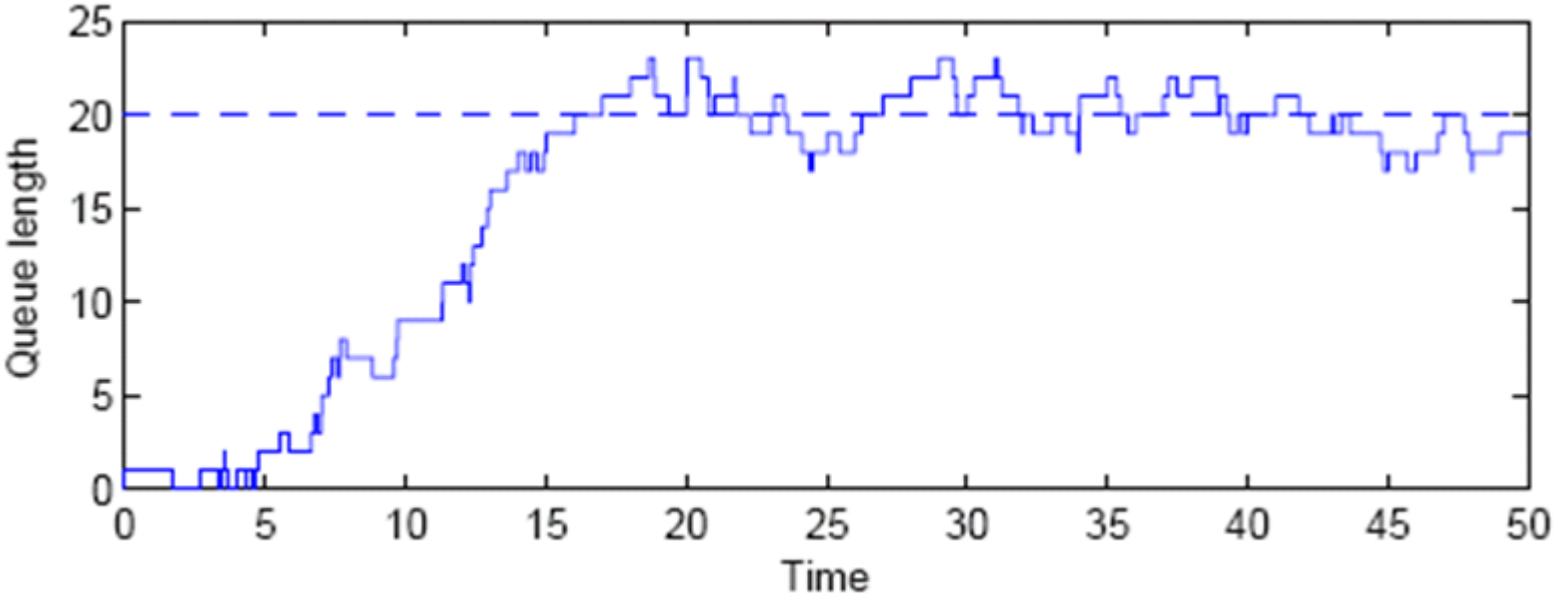
Hot spots in MPSoCs

Examples of control signals

- Change the amount of load/traffic on the system:
  - Admission control / Re-routing
  - Rate adaptation
  - Content adaptation
  - Any-time algorithms
  - …..
- Change the processing capacity:
  - Physical or virtual (VMs/reservations/partitions/bandwidth servers)
  - Turn on or off:
    - DPM of servers/cores
    - VMs
  - Change speed:
    - DVFS
    - Change the speed of VMs
  - …..

Examples of Models

- Computing Systems are discrete-event dynamic systems (DEDS)
- Power and temperature → Continuous-time dynamics



Liquid Flow Models (queues = tanks)

Non-Conventional Sampling and Control

- The discrete-event nature of computing systems makes approaches based on non-conventional sampling and sampling interesting
  - Events:
    - arrival or departure of jobs
    - discrete actions (on/off, DPM modes, DVFS speed, …)
- Approaches:
  - Event-based Control
  - Self-triggering Control
  - …….

Schedule

Monday

- 9:00-10:15
- 10:45-12:1
- 12:15-13:3
- 13:30-14:0
- 14:00-14:3
- 14:30-15:3
- 16:00-17:00 Session 4

Tuesday

- ession 1
- Session 2
- Lunch
- Group meeting
- Discussion 2
- Session 3
- Session 4
- 18:10 Bus leaves
- 19:00 Dinner, Svaneholm Castle

Schedule

Wednesday

- 8:45-10:15 Session 1
- 10:45-12:15 Session 2
- 12:15-13:30 Lunch
- 13:30-14:00 Group meeting
- 14:00-14:30 Discussion 3
- 14:30-15:00 Session 3
- 15:30-16:30 Session 4
- 16:30 Closing

Working Groups

Group 1:

- **Topics:**
  - What are the main challenges in control of data centers?
  - Are the models and assumptions used in academia the right one from an industrial perspective?
- **Chair:** Tarek Abdelzaher
- **Participants:** Kihl, Robertsson, Håkansson, Liu, Sinopoli, Wang, Wahlberg, Diao + others
- **Discussion:** Monday 13:30
- **Presentation of discussions**: Monday 14:00

Working Groups

Grupp 2:

- **Topics:**
  - -What are the main challenges in control of computing systems?
  - - Are the models and assumptions used in academia the right one from an industrial perspective?
- **Chair:** Jeff Kephart
- **Participants:** Stadler, Elmroth, Zhu, Eker, Johansson, Karlsson, Maggio, Rutten + others
- **Discussion:** Tuesday 13:30
- **Presentation of discussions:** Tuesday 14:00

Working Groups

Group 3:

- **Topics:**
  - -What are the main challenges in control of embedded systems?
  - - Are the models and assumptions used in academia the right one from an industrial perspective?
- **Chair:** Luca Benini
- **Participants:** Palopoli, Fohler, Cervin, Årzén, Wittenmark, Peng, Ushio, Lemmon, Bini, + others
- **Discussion:** Wednesday 13:30
- **Presentation of discussions:** Wednesday 14:00

Book Project??

- If you are interested
- A subset of the topics of the workshop
- Collection of papers
- Not so many books available on this topic
- Please indicate your interest to me during the workshop