COLLABORATIVE RESEARCH

A QUEST TO ALIGN ACADEMIC AND INDUSTRIAL RESEARCH OBJECTIVES

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ERICSSON RESEARCH

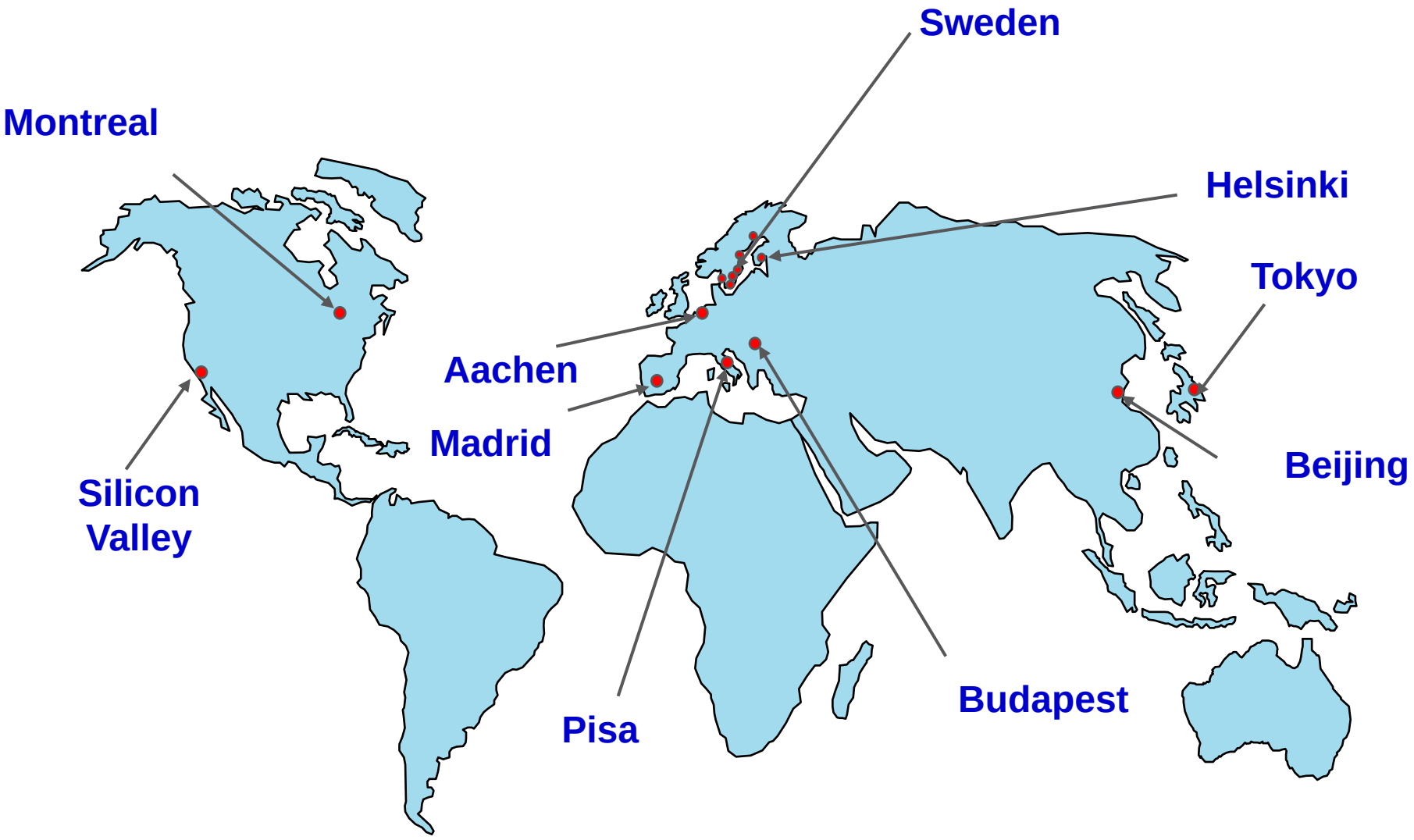
CONTENT

- Background
- Why collaborate
- Failure or success
- A case study: ACTORS and DREAM
- Conclusions

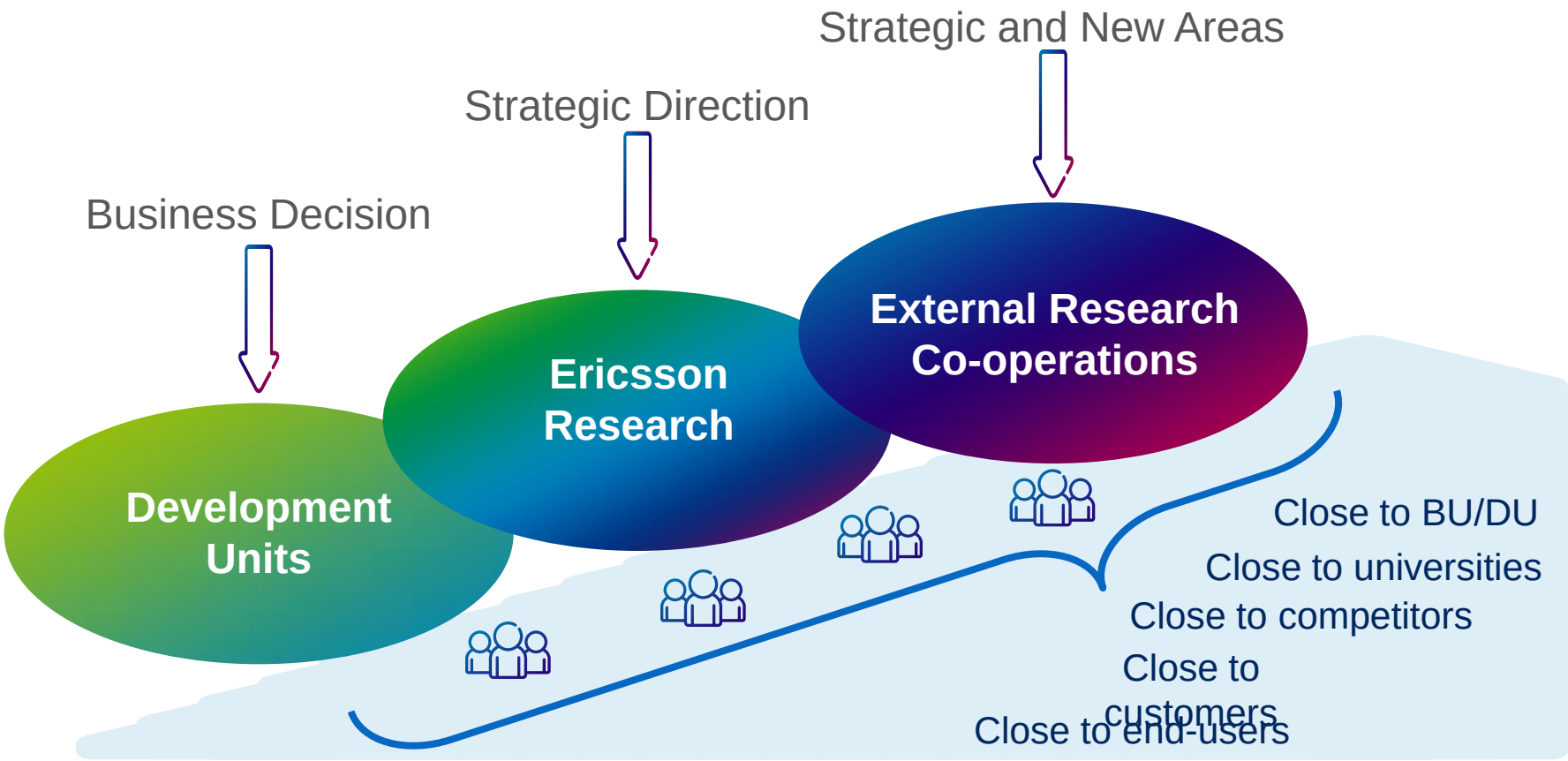
BACKGROUND

ERICSSON RESEARCH

A GLOBAL ORGANISATION



INNOVATION-FROM IDEA TO REALITY



ERICSSON RESEARCH - EIGHT AREAS

Security

EMF Safety and Sustainability

Wireless Access Network

Packet Technologies

Services and Software

Radio Access Technologies

Broadband Technologies

Multimedia Technologies

DEVICE SOFTWARE

- Belongs to RA Services and Software
- We are 12 people located in Lund
- Software Research
  - dataflow programming for multicore architectures
  - resource management
- Multimedia Research
  - 3D video
  - GPU utilization
  - augmented reality
- The end-user device is the main target for us
  - FOTA, Linux, signal processing (audio, image, video), web technologies, Bluetooth,…

DRIVERS FOR MOBILE DEVICES

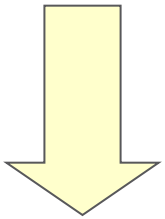
Imaging — speed, resolution, enhancements, quality, effects,…

Video processing — resolution, TV out, effects, enhancements, codecs,…

Graphics — games, display sizes, UI effects, GPU shaders,…

Flexibility — added functionality, deployment of services, PC-like experience,…

Bit rates — MIMO, HSPA, LTE, 4G, WiFi, UWB, multi-access terminals…



Memory bandwidth becomes a bottleneck
Mixed bag of hard and soft real-time requirements
Too much computational complexity…
Too much energy consumption…
Too much internal heating…

DEVICE CHALLENGES...

- Air interface and multi-access technologies
- The richer application environments
- Multimedia requirements

while

- **not** increasing the physical size
- **not** increasing the cost
- **not** overheating the device
- **not** complicate development

WHY COLLABORATE?

ACADEMIA'S OBJECTIVES (I)

- Publish papers
  - this is what researchers do…
- Understand real-world problems
  - do research in areas that have industrial relevance
  - find out what is important to the industry right now
  - strengthen its position concerning applied research
- Visibility
  - tell industry (and other academia) that we are here, we are good at this
  - attract talented students

ACADEMIA'S OBJECTIVES (II)

- Funding
  - alternative income source as governmental support decreases
  - partner with industry to increase likelihood of receiving research grants
- Commercialization of academic research
  - bring ideas, concepts, and research results into products
  - facilitate start-up companies around research ideas
- Technology transfer university ==> industry
  - perhaps the most important of all objectives

INDUSTRIAL OBJECTIVES (I)

- Seek competence within a particular field
  - can be a scarce resource within the company
  - use the sharp minds at the university, key persons
  - learning for the future
- Access to complementary research activities
  - not always available in-house
- More bang-per-buck
  - more people work for a given amount of money
  - several partners chip in
- Sharing cost and risk
  - make research projects possible that would not fly internally on their own

INDUSTRIAL OBJECTIVES (II)

- Add to overall company knowledge base
  - create new knowledge that other parts of the company can use to improve business
  - increase readiness to adapt to technology shifts
- Innovation
  - improving and extending company product portfolio
- Alignment with company strategy
  - where are we heading…
  - limited scope, we cannot address everything
- Production target
  - should be usable some day
  - relevant within a reasonable time frame (short- to mid-term)
- Find future sources of profit
  - can the collaboration lead to new disruptive technologies?
- Secure IPR
  - patents are really important

INDUSTRIAL OBJECTIVES (III)

- Visibility
  - high-tech companies do research
  - show others that we are here
  - attract talented students
- Recruitment base
  - make talented people interested in the company
  - very much dependant on company financial status…
- Networking
  - connect with external parties in the field
  - insight to latest research results in the field
- Synergy gains from different point-of-views
  - practical considerations within industry, conceptual generalizations within academia

DIFFERENT COLLABORATION TYPES

- Short term
  - thesis projects
  - summer workers
- Mid-term
  - researcher spend sabbatical year in the company
  - project employment
- Long term
  - research projects
  - industrial doctorands

FAILURE OR SUCCESS

POTENTIAL FAILURE REASONS (I)

- “We are about to submit a project application for call X on the really interesting problem area Y. Please, join our great team. BTW, the deadline is in two days, need an answer a.s.a.p.”
- “Give us a (real-world) problem and we will solve it for you”
- Research project proposal not well anchored within the company

POTENTIAL FAILURE REASONS (II)

- Difficulties in making long-time commitments for the company
  - lack of resources, varying workload
  - internal projects are prioritized
  - planning often done only for next 3 – 6 months period
  - company roadmaps, strategies, and programs changes over time
- Restrictive company policies regarding IPRs
  - negotiations may take really long time
  - agreement likely to obstruct cooperation with other companies
- Close cooperation may affect the academic freedom to do fundamental long-term and independent research
  - difference between contract research and strategic research

INTELLECTUAL PROPERTY RIGHTS

- Agree on how to handle information before starting the project
  - non disclosure agreements
  - what is considered to be confidential information
  - with whom can information be shared
- Terms and conditions regarding patents
  - ownership
  - acquiring rights
  - compensation
- Publishing at conferences and in journals
  - what can be published and when
  - an extra lead time is added for corporate reviewing purpose

SUCCESS FACTORS (I)

- Involve all parties in project planning
  - industry and academia together
- Securing resources
  - assign people and make sure they actually can work on the research project
  - a critical mass of researchers necessary on both sides
- Physical proximity stimulates joint work
  - formal and informal meetings
  - supervising of colleagues and subordinates
- Information must flow (relatively) freely between all parties
  - a thorough understanding of the intended use helps academia
  - how is things handled today, what problems are developers faced with
  - arrange workshops, seminars, and training to educate company staff

SUCCESS FACTORS (II)

- Regular follow-up meetings
  - technical discussions on weekly/bi-weekly basis
  - steering group 2-4 times a year
- Set concrete and realistic goals together
  - keep time schedules (reasonably) well
- Intermediate deliverables
  - one thesis coming within four years is not enough to sustain company interest
- Give-and-take
  - discuss problems
  - solutions goes both directions
- Active partners

THESIS PROJECTS

- Can be made as part of a collaboration
  - bridges the gap between long-time work done by doctoral students and short-time results that are desired by the industry
- Test ideas and concepts
  - affordable way of doing this without jeopardizing R&D project resources
  - focus on non-critical tasks
- Secure deliverables
  - helps keeping management attention and interest
- Prototyping and demonstrators
  - useful both internally and externally

DID WE SUCCEED?

- Success can be measured in many ways
  - published papers
  - patents
  - internal dissemination of know-how, results, and knowledge
  - use of results in products
- New products
  - did the research lead to additions or improvements to the company's existing product portfolio
- Incubators / spin-off companies
  - commercialization of disruptive technologies often better handled outside the mother company
- Uptake within R&D organization
  - are the results of use to developers

A CASE STUDY:

ACTORS AND DREAM

Adaptivity and
Con**T**rol
Of **R**esources in
embedded **S**ystems

2008.02 – 2011.02

DREAM

Dataflow applications and
REsource
m**A**nagement on
Multicore systems

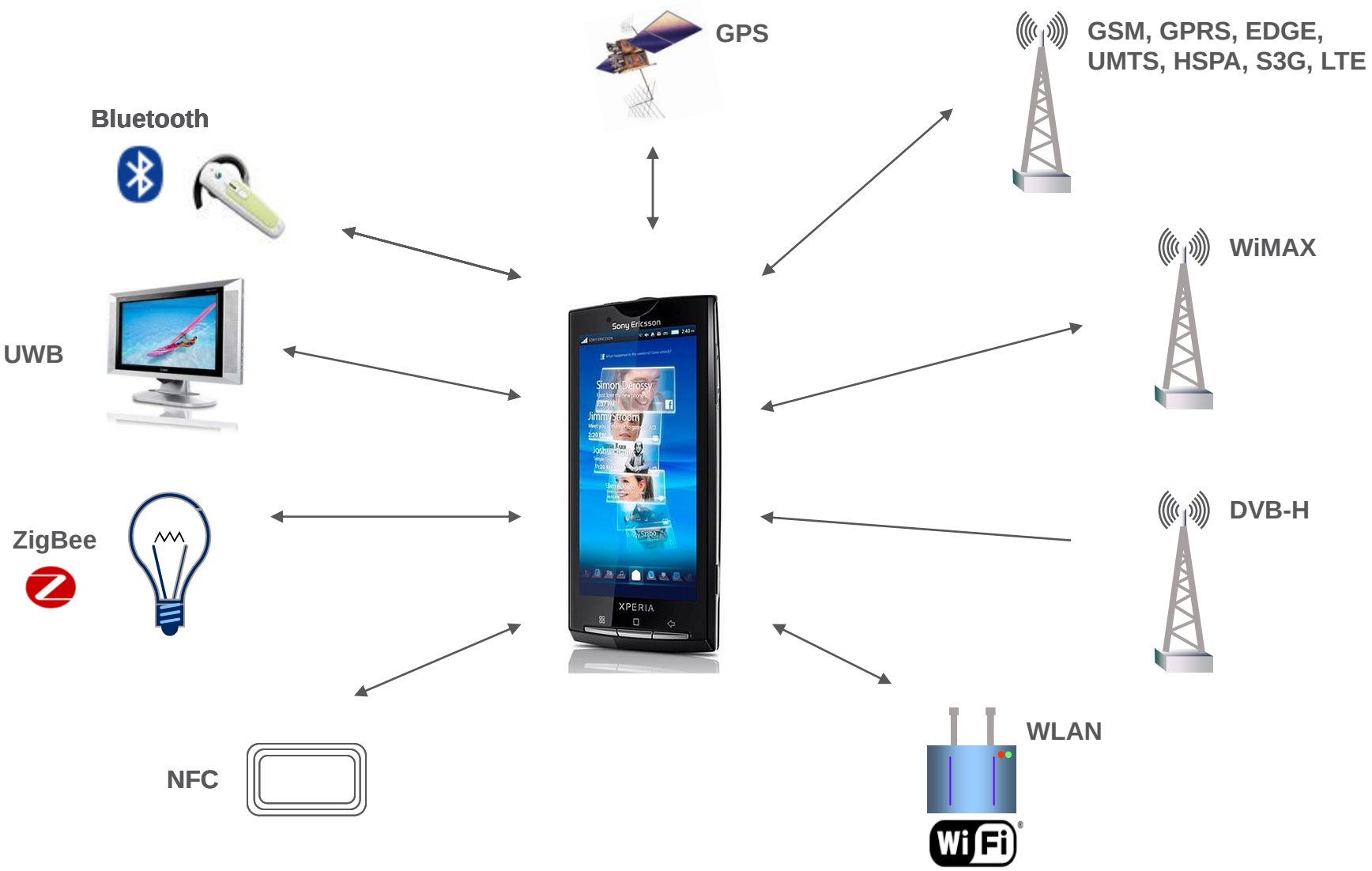
2009 – 2010

IN THE BEGINNING…

One app…

…and one access technology

...THEN SOMETHING HAPPENED TO ACCESS...



...AND APPLICATIONS

Modem

Phone

TV

MP3 player

Camera

Radio

Camcorder

Web browser

Gaming

Payment

Mapping

The New York Times

Saturday, May 8, 2004

Intel Halts Development of 2 New Microprocessors

By LAURIE J. FLYNN

SAN FRANCISCO, May 7 - Intel said on Friday that it was scrapping its development of two microprocessors, a move that is a shift in the company's business strategy.

Intel, the world's largest semiconductor manufacturer, said it canceled plans for Tejas, the code name for Intel's successor to the Pentium 4 chip, which is widely used in desktop personal computers. A second chip in development, code-named Jayhawk and intended for use in server computers, has also been canceled.

"We are reprioritizing and revamping our road map," said Laura Anderson, an Intel spokeswoman. Ms. Anderson said Intel, based in Santa Clara, Calif., had decided to focus its development efforts on "dual core" processors instead of single- core processors, like Tejas.

- This event marked a paradigm shift
- Increased clock frequency no longer provides a viable path to higher performance
- Several problems: *power density* is the toughest

SOFTWARE IS THE CHALLENGE

“The way the processor industry is going, is to add more and more cores, but nobody knows how to program those things.
I mean, two - yeah; four - not really; eight - forget it.”

Steve Jobs in NY Times Interview
Apple in Parallel: Turning the PC World Upside Down?, June 10, 2008

PARALLELIZATION

A fundamental observation:

› We need multiple threads to keep multiple cores busy!

› How to make a sequential program parallel?

THROUGHPUT SCALING

Question #1:

› If I have four cores, will my program run four times as fast?

Answer:

› No, not in general: that would require a ***perfect speedup***, which can't be achieved for all classes of problems

Question #2:

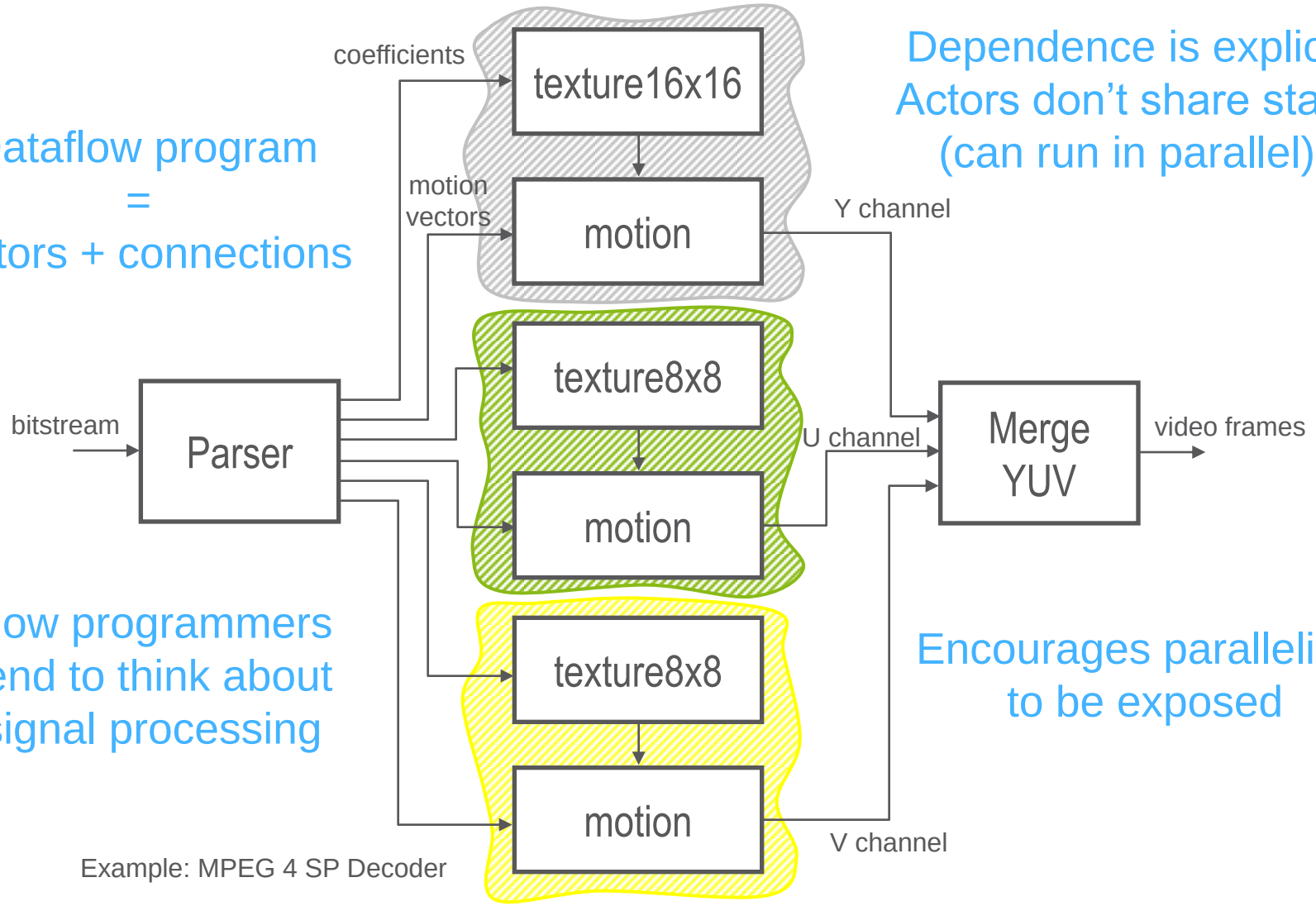
› If I have 64 cores, will my program…?

Answer:

› System bottlenecks and communication/synchronization overhead eventually limit throughput

DATAFLOW PROGRAMS

Dataflow program
=
actors + connections



Dependence is explicit
Actors don't share state
(can run in parallel)

How programmers tend to think about signal processing

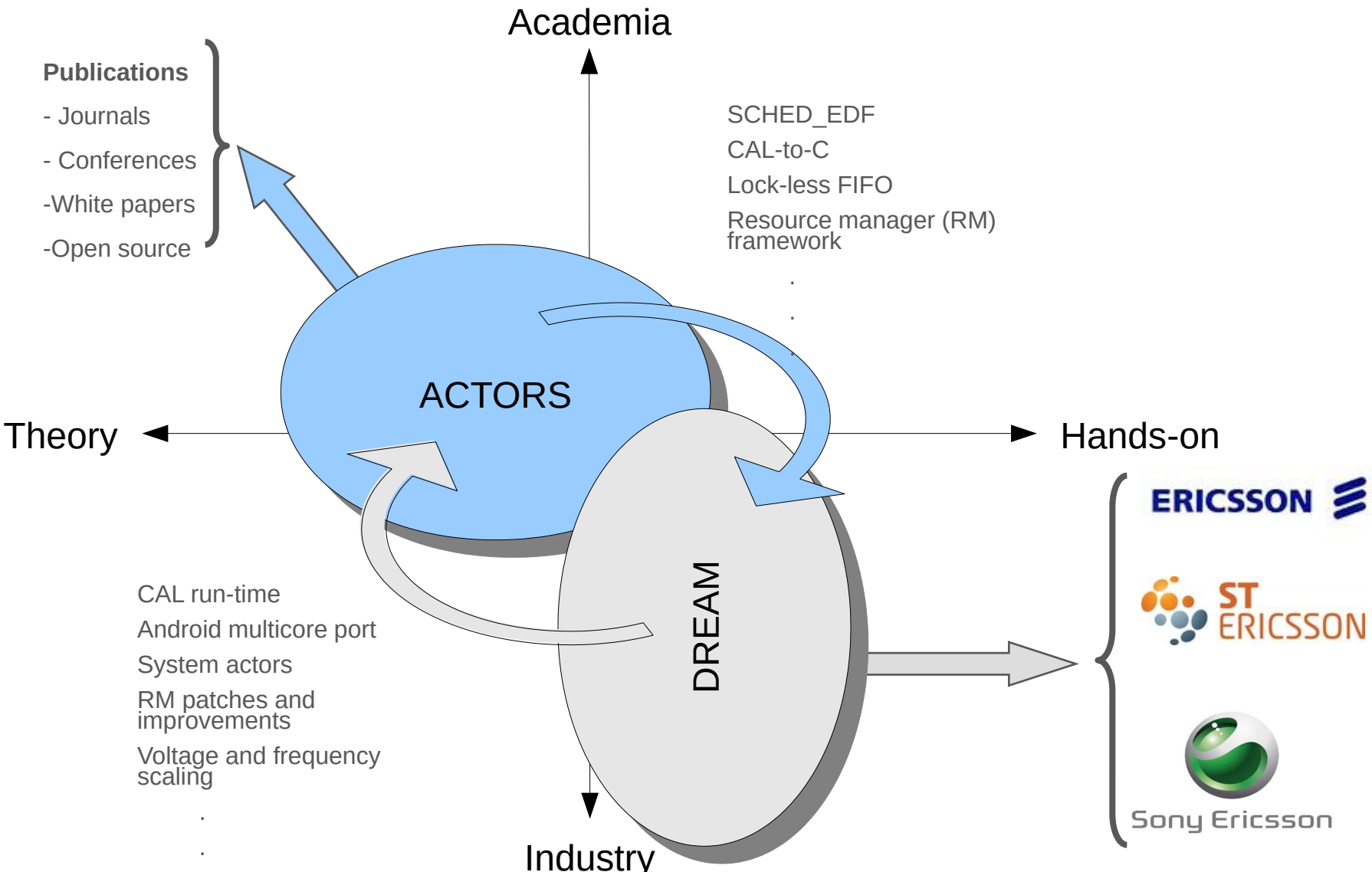
Encourages parallelism to be exposed

Example: MPEG 4 SP Decoder

ACTORS AND DREAM – THE VISION

- Shorten development time
  - High level description (CAL, dataflow)
  - Simplified resource configuration (RM, SCHED_EDF)
- Better HW utilization
  - Adaptive RM
  - Simplify multicore deployment
  - Scalability with number of cores
- Develop tools and methodologies
  - common for both embedded and “server” systems
- Reach acceptance through standardization and open source

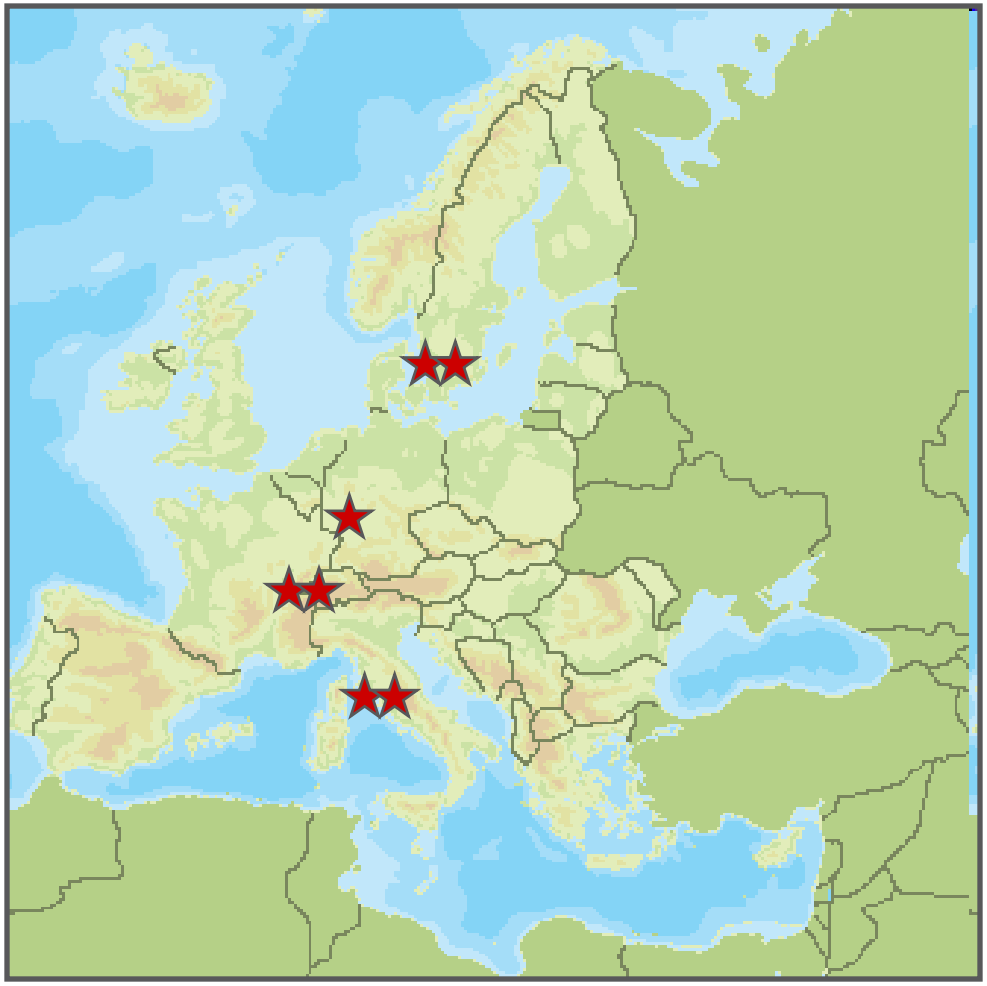
ACTORS AND DREAM – RELATION?



WHO ACTORS ARE AND WHERE

- Ericsson
- Lund University
- Technische Universität Kaiserslautern
- Scuola Superiore Sant'Anna
- Evidence
- Ecole Polytechnique Fédérale de Lausanne
- AKATech

Sweden, Germany, France, Italy, Austria, Switzerland, Brazil, Peru, US, Russia, China, (Egypt, Bangladesh).



Adaptivity & Control of Resources in Embedded Systems

ACTORS HIGHLIGHTS

- Multicore - “Design for scalable parallelism“
  - Tools available and working
  - On SourceForge (BSD license)
  - Language now MPEG/ISO standard (CAL)
- Resource Management
  - Linux framework (will be available under BSD)
  - Runs on Android and ongoing integration with ST-E
- Linux Scheduler
  - Developed a deadline based scheduler (GPL license)
  - Released and under consideration by the Linux kernel developers

ACTORS DISSEMINATION

- Post on SCHED_EDF – all-time high at Ericsson Labs
- Many publications and several open work shops
- Positive feedback from EU review – “genuine collaboration” project
- Source Forge hosted project site
  - Compilers, run-times, simulators, example code
- Ericsson internal evaluation of results
  - compiler, scheduler, resource manager

ACTORS PUBLICATIONS (I)

Journals

1. E. Bini, M. Di Natale, G. Buttazzo: “Sensitivity Analysis for Fixed-Priority Real-Time Systems”, Real-Time Systems Journal, August 2008 2. A. Cervin, K-E Årzén: “TrueTime: Simulation tool for performance analysis of real-time embedded systems”, Book chapter in CRC Press Book “Model-Based Design of Heterogeneous Embedded Systems”, Taylor and Francis Group, Boca Raton, London, New York, 2008 3. S. B. Bhattacharyya, G. Brebner, J. Eker, J. Janneck, M. Mattavelli, C. von Platen, M. Raulet: “OpenDF - A Dataflow Toolset for Reconfigurable Hardware and Multicore Systems”, Special issue of the ACM SIGARCH Computer Architecture News (CAN) , 2009.
4. E. Bini, G. Buttazzo: “The space of EDF deadlines: the exact region and a convex approximation”, Real-Time Systems Journal, January 2009.
5. M. Bertogna, N. Fisher, S. Baruah: “Resource holding times: Computation and Optimization”, Real-Time Systems Journal, January 2009.
6. S. B. Bhattacharyya, J. Eker, J. Janneck, C Lucarz, M. Mattavelli & M. Raulët, “Overview of the MPEG Reconfigurable Video Coding Framework”. Special issue of Journal of Signal Processing Systems, 2009, Springer, 7. Christophe Lucarz, Jonathan Piat, Marco Mattavelli: “Automatic synthesis of parsers and validation of bitstreams within the MPEG Reconfigurable Video Coding Framework”, Special issue of Journal of Signal Processing Systems, 2009, Springer.
8. Hussein K Aman-Allah, Karim M Maarouf, Ehab A Hanna, Ihab M Amer, Marco Mattavelli: “CAL Dataflow Components For an MPEG RVC AVC Baseline Encoder”, Special issue of Journal of Signal Processing Systems, 2009, Springer.
9. Christophe Lucarz, Marco Mattavelli, Julien Dubois: “A platform for the development and the validation of HW IP components starting from reference software specifications”, EURASIP Journal on Embedded Systems, 2009.
10. R. Mosqueron, J. Dubois, M. Mattavelli, D. Mauvilet: “Smart camera based on embedded HW/SW co-processor”, EURASIP Journal on Embedded Systems, 2009.
11. Jani Boutellier, Christophe Lucarz, Sebastien, Lafond, Victor Martin Gomez, Marco Mattavelli: “Quasi-static scheduling of CAL actor networks for Reconfigurable Video Coding”, Special issue of Journal of Signal Processing Systems, 2009, Springer.
12. M. Bertogna, N. Fisher, S. Baruah: “Resource-sharing servers for Open Environments”, IEEE Transactions on Industrial Informatics, August, 2009.
13. I. Amer, Ch. Lucarz, G. Roquier, M. Mattavelli, M. Raulet: “Reconfigurable Video Coding: the Video Coding Standard for Multi-core Platforms”, IEEE Signal Processing Magazine, Special issue on Multicore Platforms, November 2009.
14. A. Carlsson, J. Eker, T. Olsson, C. Von Platen: “Scalable Parallelism using Dataflow Programming in Multimedia and Radio Applications”, Ericsson Review (to be published)

Conference publications

1. C. von Platen, J. Eker: “Efficent Realization of a CAL Video Decoder on a Mobile Terminal”, SiPS 2008, IEEE Workshop on Signal Processing Systems, October 8-10, 2008,Washington, D.C. Metro Area, USA 2. G. Franchino, T. Facchinetti, G. Buttazzo: “Time Properties of the Bust Protocol Under the NPA Budget Allocation Scheme”, DATE 2008, Proceedings of the Conference on Design, Automation and Test in Europe 3. J. Boutellier, V. Sadhanala, Ch. Lucarz, Ph. Brisk, M. Mattavelli: “Scheduling of Dataflow Models within the Reconfigurable Video Coding Framework”, SiPS 2008, IEEE Workshop on Signal Processing Systems, October 8-10, 2008,Washington, D.C. Metro Area, USA.
4. J. Li, D. Ding, Ch. Lucarz, S. Keller, M. Mattavelli: “Efficient data flow Variable Length Decoding Implementation for the MPEG Reconfiguranle Video Coding Framework”, SiPS 2008, IEEE Workshop on Signal Processing Systems, October 8-10, 2008,Washington, D.C. Metro Area, USA.
5. D. Ding, L. Yu, Ch. Lucarz, M. Mattavelli: “Video Decoder Reconfigurations and AVS Extensions in the New MPEG Reconfigurable Video Coding Framework “, SiPS 2008, IEEE Workshop on Signal Processing Systems, October 8-10, 2008,Washington, D.C. Metro Area, USA.
6. C. Scordino: “Documentation of the current Linux scheduler.”, Linux kernel documentation part of 2.6.27 release 7. M. Raulët, J. Piat, Ch. Lucarz, M Mattavelli: “Validation of bitstream syntax and synthesis of parsers in the MPEG Reconfigurable Video Coding Framework”, SiPS 2008, IEEE Workshop on Signal Processing Systems, October 8-10, 2008, Washington, D.C. Metro Area, USA.
8. Ch. Lucarz, M. Mattavelli: “Dataflow/Actor-Oriented language for the design of complex signal processing systems”, Conference on Design and Architectures for Signal and Image Processing (DASIP), 2008, Brussels, Belgium.
9. R. Mosqueron, M. Mattavelli: “Dataflow design of a co-processor architecture for image processing, Conference on Design and Architectures for Signal and Image Processing (DASIP), 2008, Brussels, Belgium.
10. S. Bhattacharyya, G. Brebner, J. Eker, J. Janneck, M. Mattaveli: “How to Make Stream Processing More Mainstream”, Workshop on Streaming Systems: From Web and Enterprise to Multicore in conjunction with the 41st Annual IEEE/ACM International Symposium on Microarchitecture (MICRO), November, 2009, Lake Como, Italy.
11. S. Bhattacharyya, G. Brebner, J. Eker, J. Janneck, M. Mattavelli: “OpenDF - A Dataflow Toolset for Reconfigurable Hardware and Multicore Systems”, MCC 2008, the First Swedish Workshop on Multi-Core Computing, November, 2008, Karlskrona, Sweden.
12. S. Baruah, E. Bini: “Partitioned scheduling of sporadic task systems: an ILP-based approach”, Conference on Design and Architectures for Signal and Image Processing (DASIP), 2008, Brussels.

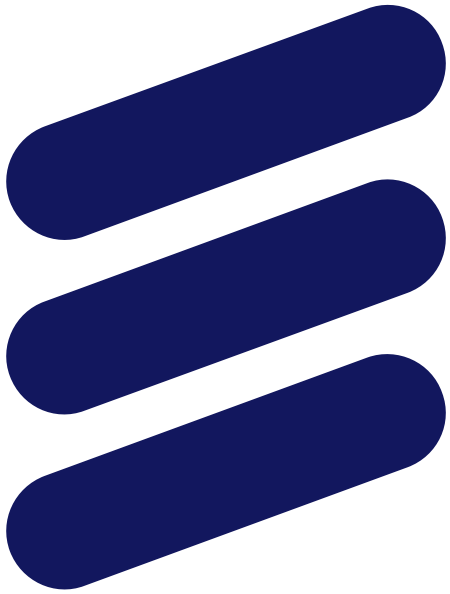
ACTORS PUBLICATIONS (II)

Conference publications (cont.)

- 13. E. Bini, “Minimizing end-to-end response time in transactions”, Workshop on Compositional Theory and Technology for Real-Time Embedded Systems, November 30th 2008, Barcelona, Spain.
- 14. D. Faggioli, M. Trimarchi, F. Checconi, M. Bertogna, A. Mancina: “Implementing a Partitioned Earliest Deadline First Algorithm in Linux”, 24th Annual ACM Symposium on Applied Computing, March, 2009, Honolulu, Hawaii, USA.
- 15. M. Bertogna, F. Checconi, D. Faggioli :“Non-Preemptive Access to Shared Resources in Hierarchical Real-Time Systems”, CRTS 2008, 1st Workshop on Compositional Theory and Technology for Real-Time Embedded Systems, November 30, 2008, Barcelona, Spain.
- 16. E. Bini, G. Buttazzo, M. Bertogna: “The Multi Supply Function Abstraction for Multiprocessors”, RTCSA 09, IEEE International Conference on Embedded and Real-Time Computing Systems and Applications, August 24 to 26, 2009, Beijing, China.
- 17. D. Ding, L. Yu, Ch. Lucarz, M. Mattavelli: “A Hybrid Decoder Configuration of MPEG-4 and AVS in Reconfigurable Video Coding Framework”, Proceeding of ISCAS 2009, May 2009, Taipei,, Taiwan.
- 18. G. Roquier, Ch. Lucarz, M. Mattavelli, M. Wipliez: “An integrated environment for HW/SW co-design based on a CAL specification and HW/SW code generators”, Proceeding of ISCAS 2009, May 2009, Taipei, Taiwan.
- 19. J. Boutellier, Ch. Lucarz, V.M Gomez, M. Mattavelli: “Multiprocessor Scheduling of Dataflow Models Within the Reconfigurable Video Coding Framework”, DASIP 2009, Conference on Design and Architectures for Signal and Image Processing, September 22 - 24, 2009, Sophia Antipolis, France.
- 20. R. Thavot, R. Mosqueron, J. Dubois, M. Mattavelli: “Hardware Synthesis of Complex Standard Interfaces Using CAL Dataflow Descriptions”, DASIP 2009, Conference on Design and Architectures for Signal and Image Processing, September 22 - 24, 2009, Sophia Antipolis, France.
- 21. D. Faggioli, M. Trimarchi, F. Checconi, C. Scordini: “An EDF scheduling class for the Linux kernel”, 11th Real-Time Linux Workshop, September 2009, Dresden, Germany.
- 22. A. Carlsson, J. Eker, T. Olsson, C. Von Platen: ”A Reconfigurable OFDM Inner Receiver Implemented in the CAL Dataflow Language”, ISCAS 2010, The 2010 IEEE International Symposium on Circuits and Systems, to be held in Paris, France from 30 May - 2 June, 2010.
- 23. V. Romero, K-E. Årzén, S. Schorr, R. Guerra, G. Fohler, J. Eker, H. Gustafsson: ”Adaptive Resource Management for Mobile Terminals – The ACTORS Approach”, WARM 2010 Workshop on Adaptive Resource Management, April, 2010, Stockholm, Sweden.

CONCLUSIONS

- A successful collaboration does not come for free…
- Involve the industrial partner already when planning a proposal (academia)
- Secure internal resources from day one (industry)
- Set up a steering group to align goals on higher level
- Frequent meetings on technical level
- Active involvement from both sides necessary



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