Year 1 Review
Brussels, January 23rd, 2008

Transversal Activity

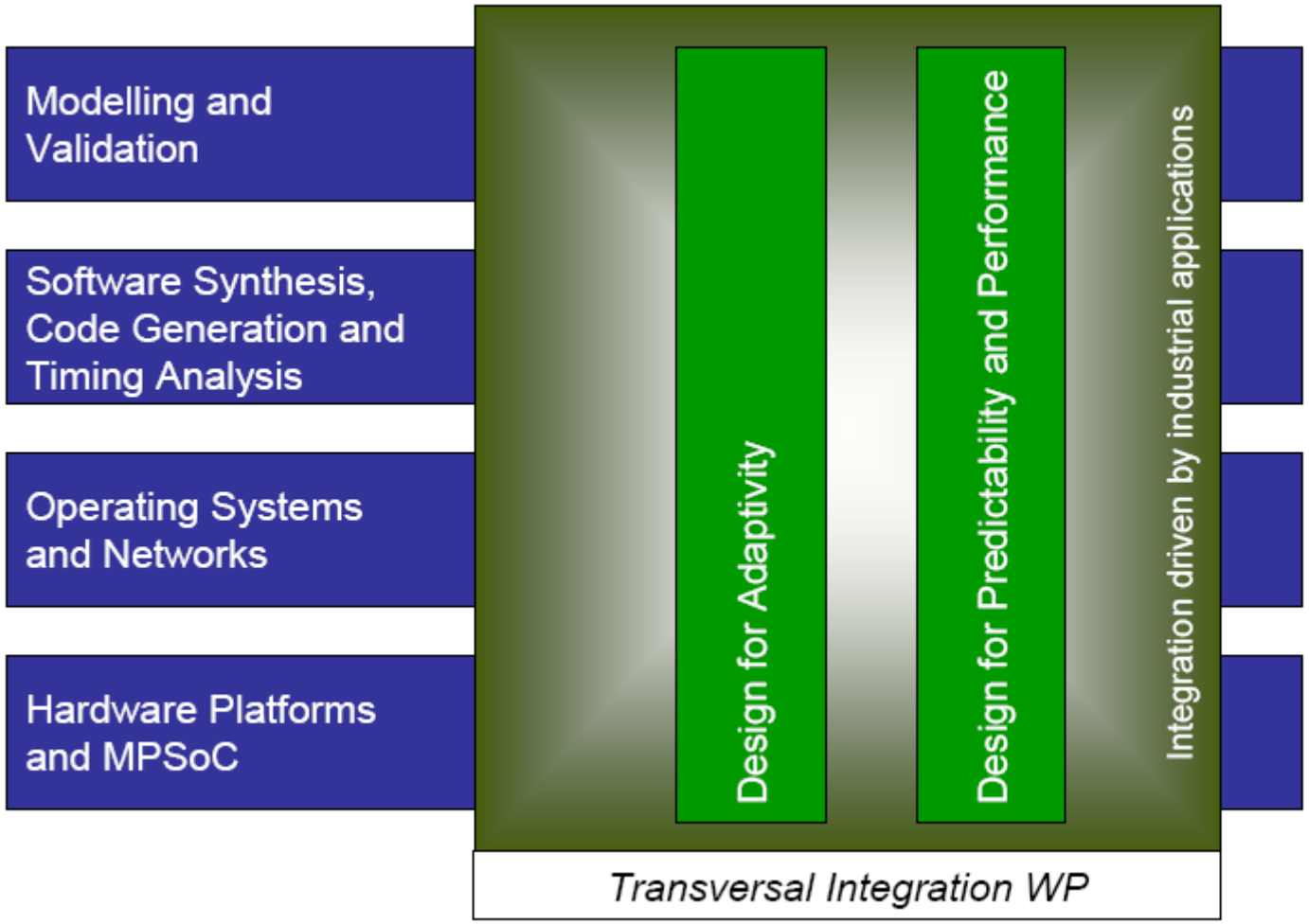
Achievements and Perspectives :

Integration Driven by Industrial Applications

Leaders: Alberto Sangiovanni Vincentelli (Parades)

Ed Brinksma (ESI)

Ambition…


Modelling and Validation
Software Synthesis, Code Generation and Timing Analysis
Operating Systems and Networks
Hardware Platforms and MPSoC
Design for Adaptivity
Design for Predictability and Performance
Integration driven by industrial applications
Transversal Integration WP

Main Trends in the Area

- High-tech industry is transforming into an ecosystem of system integrators and (1,2,3,...-tier) component suppliers
- To maintain quality and productivity such ecosystems must be managed as virtual vertically integrated industries
- This goal requires an explicit understanding of the relevant design flow(s) in an ecosystem, and ways to integrate methods and tools into such flows
- Research on design methods and tools that disregards design flows runs the risk of being industrially irrelevant

High-Level Objectives

- Goals:
  - to provide the “meta rules” for design flows according to which the design transformations are carried out and interfaces are built;
  - to provide an environment to the clusters to foster the integration their results into relevant design flows.
- Two approaches:
  - package design methods out of the thematic cluster results for relevant industrial segments;
  - identify main common features shared by different domains and work towards developing methods to address these topics.

Cluster Participants

This activity is de facto open to all core partners in the consortium, who can use the specific budget for this activity to attend its technical meetings

Alberto Sangiovanni Vincentelli (PARADES - Italy), Ed Brinksma (ESI - Netherlands), UJF Filiale SAS "Floralis" (France), Univ. Joseph Fourier/VERIMAG (France), RWTH Aachen (Germany), Aalborg University (Denmark), University of Aveiro (Portugal), University of Bologna (Italy), TU Braunschweig (Germany), University of Cantabria (Spain), Commissariat à l'Energie Atomique (France), Denmark Technical University (Denmark), Dortmund University (Germany), Ecole Polytechnique Fédérale de Lausanne (Switzerland), ETH Zurich (Switzerland), IMEC (Belgium), Institut National de Recherche en Informatique et Automatique (France), University of Kaiserslautern (Germany), Royal Institute of Technology (Sweden), Linköping University (Sweden), University of Lund (Sweden), Mälardalen University (Sweden), OFFIS (Germany), University of Passau (Germany), Scuola Superiore Sant'Anna (Italy), Polytechnic Institute of Porto (Portugal), Saarland University (Germany), University of Salzburg (Austria),Uppsala University (Sweden), TU Vienna (Austria), University of York (UK).

Building Excellence

Aims:

- Involve industry in Artist Design to foster research interactions and discussions on trends and challenges
- Inform Clusters of industrial trends
- Integrate research teams working on different tools and design approaches so that the outcome is industrially relevant

Instruments:

- Meetings with interested partners and industry representatives at Conferences, Workshops and special Artist Design events
- Interactions at Artist Design Plenary Sessions

Overview of the Cluster's Activities

- Design flows for automotive and aerospace
  Leader: Alberto Sangiovanni Vincentelli (PARADES)
  - *interaction with COMBEST, ARTEMIS, US companies and research organizations…*
  - *outcome: meetings*
- Design flows for health and nomadic
  Leader: Ed Brinksma(ESI)
  - *interaction with GENESYS, ARTEMIS, …, NOKIA, Philips, NXP*
  - *outcome: meetings*
- Investigate other important application domains

  Leaders: ASV and EB
  - *identified Energy Efficient Buildings*

Overall Assessment

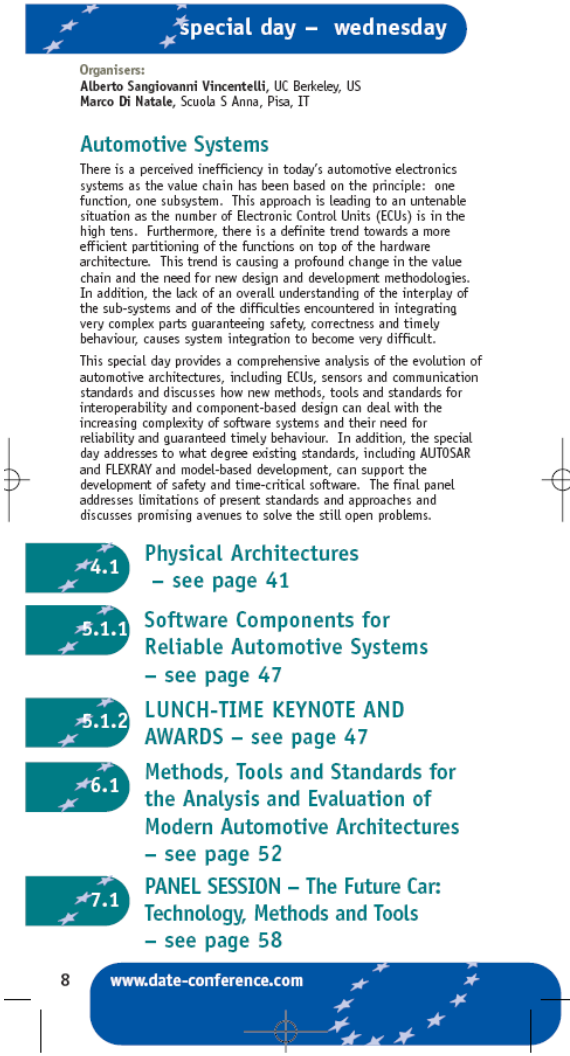
Achievements

- Vision confirmed by industrial participants
- Successful Automotive Special Day Organization at DATE 2008 (March 2008)
  - Three technical sessions, a key note speech and a panel
  - Most attended sessions
  - Special Issue of IEEE Transactions on CAD hosted by ASV
- Meeting at CPS Workshop organized by Tom Henzinger and ASV in Saint Louis with key US, Europe and Japan industrial players (GM, UTC, Boeing, Bosch, Daimler, Toyota...) (April 2008)
- Meeting in Rome to discuss driver selection, test cases and to plan for Year 2
  - Strong participation by European and US industry (Danfoss, Carmeq, Daimler, Philips, Oce', UTC, IAI,...

To be improved

- **Partner involvement in operations of the transversal activity**

Scientific Highlights



special day – wednesday

Organisers:
Alberto Sangiovanni Vincentelli, UC Berkeley, US
Marco Di Natale, Scuola S Anna, Pisa, IT

Automotive Systems

There is a perceived inefficiency in today's automotive electronics systems as the value chain has been based on the principle: one function, one subsystem. This approach is leading to an untenable situation as the number of Electronic Control Units (ECUs) is in the high tens. Furthermore, there is a definite trend towards a more efficient partitioning of the functions on top of the hardware architecture. This trend is causing a profound change in the value chain and the need for new design and development methodologies. In addition, the lack of an overall understanding of the interplay of the sub-systems and of the difficulties encountered in integrating very complex parts guaranteeing safety, correctness and timely behaviour, causes system integration to become very difficult.

This special day provides a comprehensive analysis of the evolution of automotive architectures, including ECUs, sensors and communication standards and discusses how new methods, tools and standards for interoperability and component-based design can deal with the increasing complexity of software systems and their need for reliability and guaranteed timely behaviour. In addition, the special day addresses to what degree existing standards, including AUTOSAR and FLEXRAY and model-based development, can support the development of safety and time-critical software. The final panel addresses limitations of present standards and approaches and discusses promising avenues to solve the still open problems.

4.1 Physical Architectures – see page 41

5.1.1 Software Components for Reliable Automotive Systems – see page 47

5.1.2 LUNCH-TIME KEYNOTE AND AWARDS – see page 47

6.1 Methods, Tools and Standards for the Analysis and Evaluation of Modern Automotive Architectures – see page 52

7.1 PANEL SESSION – The Future Car: Technology, Methods and Tools – see page 58

8 www.date-conference.com

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Information Society Technologies

Participants

Physical Architectures of Automotive Systems

- Pirelli (Associate)
- Accent (Associate)
- UC Berkeley (Associate)
- **Scuola di Sant'Anna**
- GM
- **PARADES**
- STM (Associate)

Panel

Daimler, BMW, Contiteves, Esterel, dSpace, **TU Vienna, PARADES**

Software Components for Reliable Automotive Systems

- **OFFIS**
- **TU Vienna**
- **PARADES**
- **Scuola di Sant'Anna**
- BMW

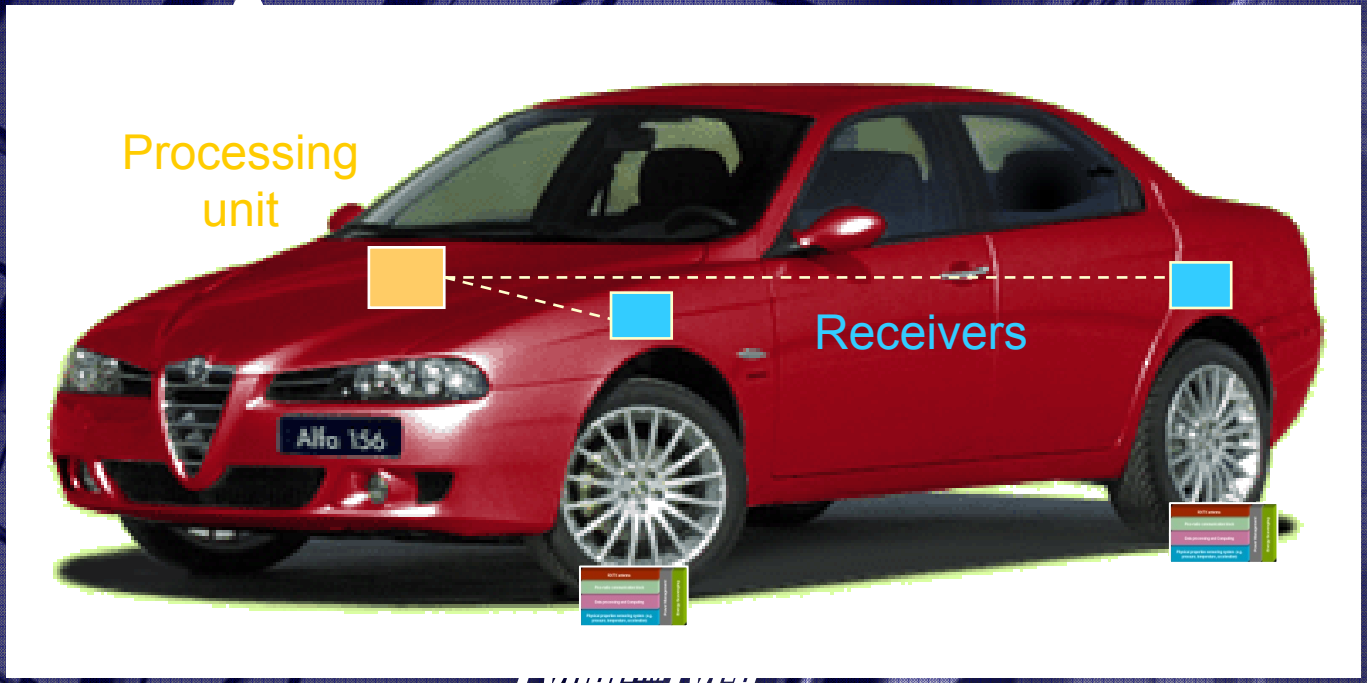
Methods, Tools and Standards

- **Saarland**
- **TU Braunschweig**
- **Scuola di Sant'Anna**
- **PARADES**
- VaST Systems

Intelligent Tyre System Block Diagram

Vehicle dynamics control system

User Applications



Cyber™ Tyre

Intelligent Tyre System Concept

Vehicle dynamics controller

Steering Angle
Speed
Torque
...

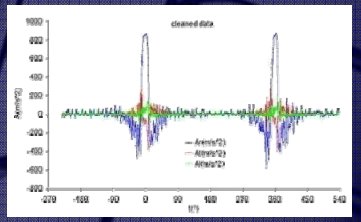
Kinematics pre-conditioner

Forces

Slips

Frictions

Cyber Tyre data



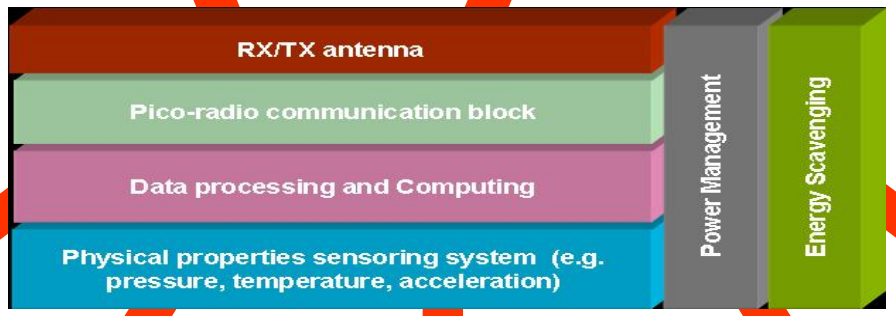
Cyber™Tyre Development Partners

Politecnico di Milano

Feature Extraction,
Kinematics pre-conditioner

Politecnico di Torino

Prototype Vehicle Integration,
Engineering Support



Fabrication

UMC

Ultra
low power
radio

assembly &
packaging
technologies

Valtronic
Technologies SA

Advanced new
communication
protocols

University of California,
Berkeley,
PARADES

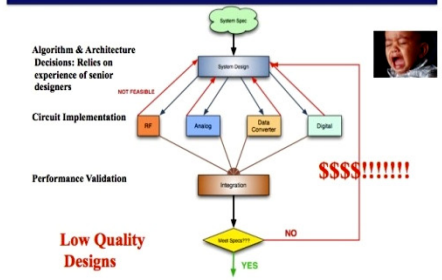
acquisition, processing &
advanced architectural technologies

STM
Accent S.p.A.
PARADES

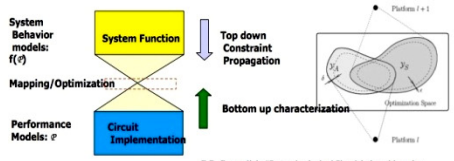
Breakthrough
energy supply & power management
technologies

Scuola S. Anna, Pisa
Encrea S.r.L.

Platform-Based Paradigm



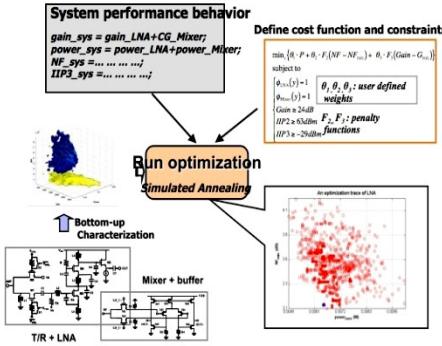
Traditional (Top-down Approach)



F. De Bernardinis, "System level mixed Signal design with analog platforms," PhD dissertation, UC Berkeley, Fall 2005.

- ✓ System level optimization
- ✓ IP reuse
- ✓ Design porting to advanced technologies
- ✓ Output guaranteed to be feasible
- ✓ Designer can focus on fundamental issues rather than iteration of simulation

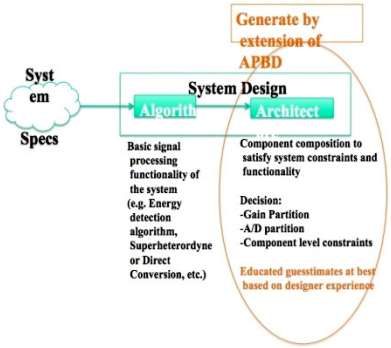
APBD (Meet-in-Middle) Approach

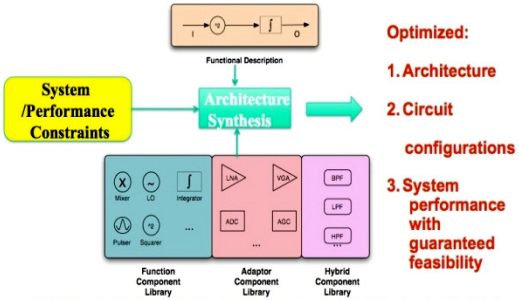


Front-end performance	Previous chip	Optimization
Band (GHz)	3.1-4.8	3.1-4.8
Gain (dB)	23.0-27.6	27.5-29.2
NF (dB)	5.0-6.9	4.36-5.05
IIP3 (dBm)	-22.0 - -19.6	>-22.5
P_{1dB} (dBm)	-34.3 - -31.8	>-34.6
Power (mW)	13.9	10.8
Technology	0.13µm	0.13µm

Total power savings: 22.3%

Architecture Synthesis (Work in Progress)



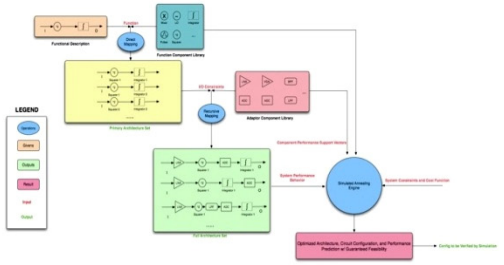


Optimized:

1. Architecture
2. Circuit configurations
3. System performance with guaranteed feasibility

Model Structure: C = (F, R, I, L) : (Function, Performance, Input Condition, Loading Condition)

Design Flow for AMS Architecture Synthesis

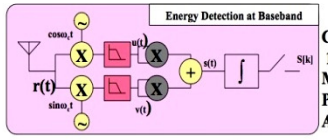


Design Driver: Intelligent Tires

Data Rate	Power Budget	Size	PER
1 Mbps (20Mchip/s)	< 1 mW (TX)	<1 cm^3 (TX)	<1%

Sensitivity < -79.99 dBm

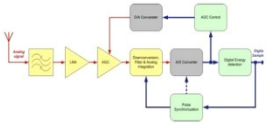
Freq: [6~8 GHz]



CER < 12%

Minimize: Power, Delay, Area…

???



Option 1. Digital Energy Detection

Option 2. Analog Energy Detection

Information Society Technologies

Implementing Synchronous Models on Loosely Time Triggered Architectures

Semantics preservation and performance results

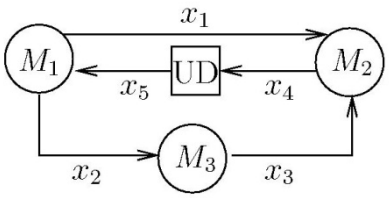
Stavros Tripakis, Claudio Pinello (Cadence)

Albert Benveniste, Alberto Sangiovanni-Vincentelli, Paul Caspi,
Marco Di Natale (GM and Sant'Anna)

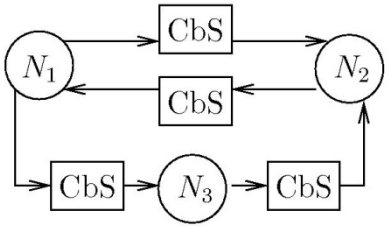
[IEEE TC '08]

Goals and setting

- We want to go from Sync to LTTA, semantics preserving
- Sync =
  - In general, synchronous languages
  - But we start with something simple:
    single-clock diagrams without causality cycles



- LTTA =
  - A platform that uses the CbS communication by sampling paradigm
  - Clocks are loosely synchronized (but for preservation we need not make any assumption on the clocks – except that they never stop)



- To make our life easier, we introduce one intermediate layer: FFP
  - FFP (finite FIFOs platform) is essentially a KPN with bounded FIFOs (not exactly, because blocking is replaced by skipping and we also block on full output queues)
  - FFP could also be used to map other models than Sync (future work)

Outcome

- Vision of virtual vertical integration confirmed
- Automotive domain mature for integration and transversal activity
- Frontier is at the cross road of different disciplines
- Distributed integrated fault tolerant architectures
- Role of fault-tolerant multi-core
- Zero-accident cars

CPS Meeting

Workshop: From Embedded Systems to Cyber-Physical Systems: a Review of the State-of-the-Art and Research Needs

Monday, April 21, 2008

CPS Meeting

9:00-11:30 Morning Session 1: What has been accomplished?

- 9:00 Jonathan Sprinkle University of Arizona, "CHESS: Building A Cyber- Physical Agenda on Solid Foundations"
- 9:20 Edward A. Lee University of California, Berkeley, "Making Time Essential in Computation"
- 9:40 Janos Sztipanovits Vanderbilt University "Cyber Physical Systems: New Challenges for Model-based Design
- 10:30 **Thomas Henzinger**, University of California, Berkeley and École Polytechnique Fédérale de Lausanne, "Designing Predictable and Robust Systems"
- 10:50 **Alberto Sangiovanni-Vincentelli**, University of California,Berkeley, and PARADES, Rome "Communication Infrastructure Synthesis and its Application to Cyber Physical Systems: The Intelligent Building case."
- 11:10 Sanjit A. Seshia, University of California, Berkeley "Teaching Embedded Systems to Berkeley Undergraduates"

11:30-12:00 Funding outlook: Views from the government

- 11:30 Helen Gill National Science, Foundation "Views from the HCSS Agencies"
- 11:40 **Philippe Reynaert**, DG INFSO Embedded Systems "Embedded Systems Research in Europe"

CPS Meeting

1:00-1:40 Afternoon Session 1: Evolving Industrial Road Map on CPS

- 1:00 Nady Boules General Motors. "Reinventing the Automobile: The Cyber-Physical Challenge“
- 1:20 Clas Jacobson United Technologies Corp., "Cyber Physical Systems – A Perspective from Building and Aerospace Systems"
- 1:40 David Corman Boeing , "CPS in Aerospace. Challenges and Opportunities"

2:00-2:40 Afternoon Session 2: European Research Activity

- 2:00 **Werner Damm** OFFIS . "Enabling innovations through embedded systems: the Artemis approach"
- 2:20 **Roberto Passerone** University of Trento . "Multiple viewpoint contracts in SPEEDS"

CPS Meeting

3:00-4:40 Cyber-Physical Systems Panel

Introduced by Jonathan Sprinkle (University of Arizona)

The panel includes:

- **Industry**: Clas Jacobson (United Technologies Corp), Nady Boules (General Motors)
- **Government**, Helen Gill, (National Science Foundation**), Philippe Reynaert** (DG INFSO Embedded Systems)
- **Academia**, George J. Pappas,(University of Pennsylvania), Bruce Krogh, (Carnegie Mellon University), **Alberto Sangiovanni Vincentelli** (University of California, Berkeley and PARADES, Rome), Janos Sztipanovits(Vanderbilt University)

4:45 Summary, Closing Remarks and Future Activities

- **Alberto Sangiovanni-Vincentelli**, University of California, Berkeley, and PARADES

Outcome

- Joint EU/US research program planning:
  - light/tight integration
  - Each side funds its own institutions or combined projects?
  - Industry participation
- CPS document/white paper for discussion
  - Looking for feedback
  - Is the document ready to be widely circulated?

Rome Meeting Nov. 12-13

10:20 Energy Efficient Buildings Presentation
Clas Jacobson, UTRC “Energy Efficient Buildings”.

11:10 Commissioning Systems in Buildings
R. Izadi-Zamanabadi, Danfoss “Commissioning Systems in Buildings”.

12:00 Healthcare Applications
P. America ESI/Philips Res./Philips Healthcare “Healthcare applications”.

13:00 Printing Applications
Ed Brinksma ESI “OCE’: a Printing applications”

15:15 Embedded Systems for Automotive
Michael Borth ESI (formerly with Daimler) “Embedded Systems for Automotive - the OEM perspective”.
Matthias Weber, Carmeq “Embedded Systems for Automotive: Challenges”.

16:40 Avionics Systems
Clas Jacobson, UTRC “Avionics Subsystem Suppliers and Helicopters”.
M. Winokur, IAI, “Avionics challenges

Participants

Name	Company
Alberto Sangiovanni(ASV)	Parades S.c.a.r.l.
Ed Brinksma	ESI
Alberto Ferrari (AF)	Parades S.c.a.r.l.
Leonardo Mangeruca (LM)	Parades S.c.a.r.l.
Massimo Baleani (MB)	Parades S.c.a.r.l.
Marco Carloni (MC)	Parades S.c.a.r.l.
Christos Sofronis (CS)	Parades S.c.a.r.l.
Alessandro Catasta (AC)	Parades S.c.a.r.l.
Orlando Ferrante (OF)	Parades S.c.a.r.l.
Gianluca Codella (GC)	Parades S.c.a.r.l.
Alessandro Mignogna (AM)	Parades S.c.a.r.l.
Alessandro Ulisse (AU)	Parades S.c.a.r.l.
Clas Jacobson (CJ)	**UTRC**
Roberto Passerone (RP)	University of Trento
Bernhard Josko (BJ)	OFFIS
Michael Borth (MB)	ESI
Peter Marvedel (PM)	TU Dortmund

Name	Company
Matthias Weber (MW)	**Carmeq GmbH**
Pierre America (PA)	**Philips Research/ESI**
Jörn Migge (JM)	**RealTime-at-Work**
Philippe Mils (PM)	**Thales**
Simon Schliecker (SS)	TU Braunschweig
Michael Gonzalez Harbour (MGH)	Universidad de Cantabria
Raimund Kirner (RK)	Vienna University of Technology
Stylianos Mamagkakis (SM)	IMEC
Davide Brunelli (DB)	University of Bologna
Wang Yi (WY)	Uppsala University
Jan Madsen (JM)	Technical University of Denmark
Luca Benini (LB)	University of Bologna
Roozbeh Izadi-Zamanabadi (RIZ)	**Danfoss A/S**
Peter Puschner (PP)	Technische Universität Wien
Michael Winokur (MWK)	**Israeli Aerospace Industries**

Outcome

- Combine Automotive and Avionics given the similarities and given the overall vision of the Transversal Activity
- Continue explore Health Care applications
- Energy Efficient Buildings as a key area to invest on
- Two to three separate meetings for Artist Design partners/industry, one per design area at meetings such as DATE, CPS and ESW
- One plenary session to understand similarities and differences at Artist Design plenary meeting
- Push community to participate actively
- White papers on specific areas of interest

Building Energy Demand Challenge

The buildings industry
- employs 8 million people,
- contributes to 10% of the U.S. GDP
- construction cost $1 trillion per year.

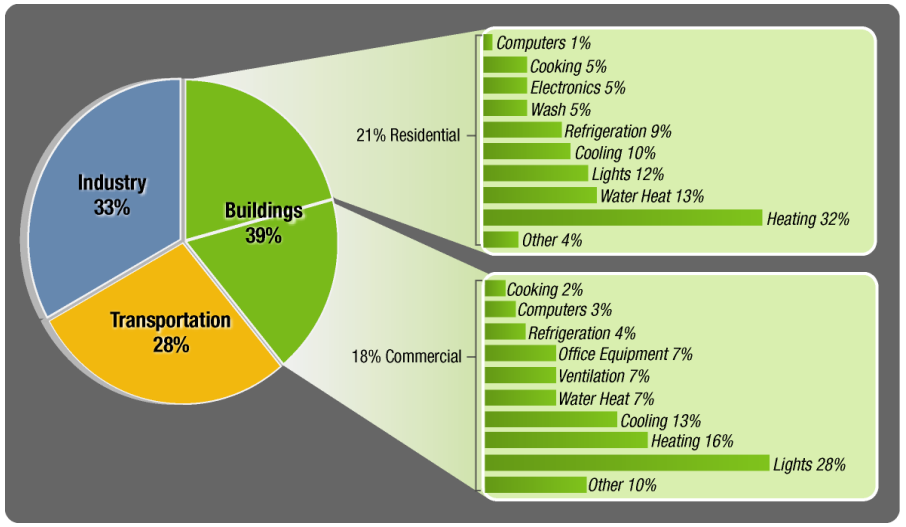
U.S. Buildings consume
- 39% of total U.S. energy
- 71% of U.S. electricity
- 54% of U.S. natural gas

U. S. Buildings produce 48% of Carbon emissions

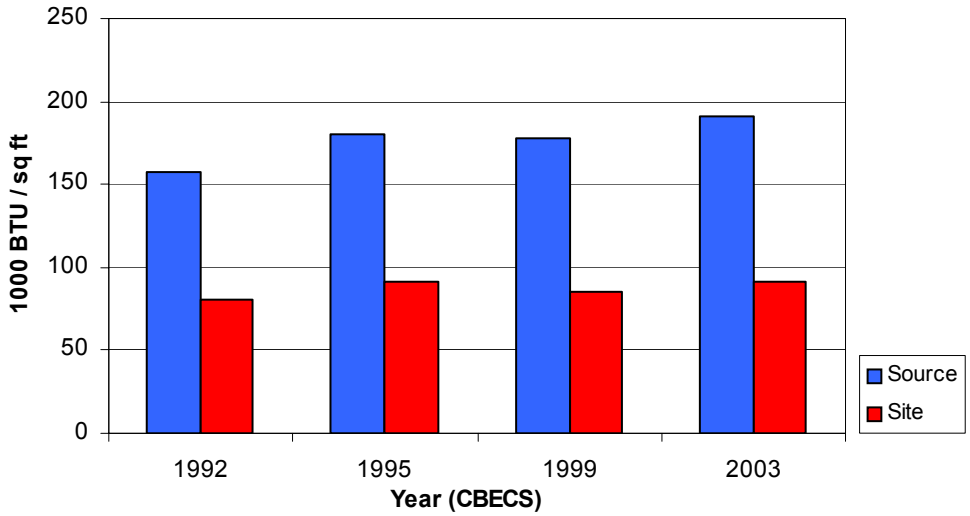
U.S. Commercial Buildings annual energy bill: $120 billion (2004)

Commercial Building Energy Intensities are increasing
- Electrical Energy consumption *doubled* in last 18 years
- 25% growth projection through 2030

Energy Breakdown by Sector



U.S. Commercial Building Energy Intensity



Sources: *High Performance Commercial Buildings: A Technology Roadmap*, U.S. DOE., US GBC, DOE EIA CBECS Database, Table C2A and 5B.

Integration-Enabled High Performance Buildings

The whole is more than the parts and cannot be "unbundled"

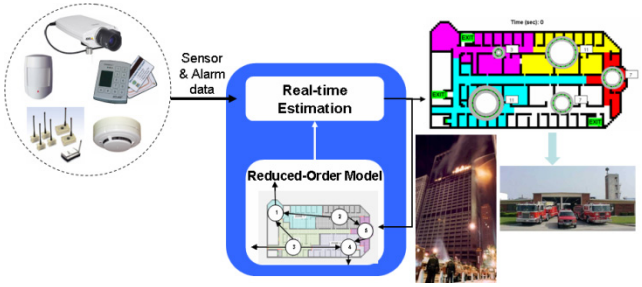
Network-Enabled Information & Decision Support

Model-based Controls to Shape Dynamics

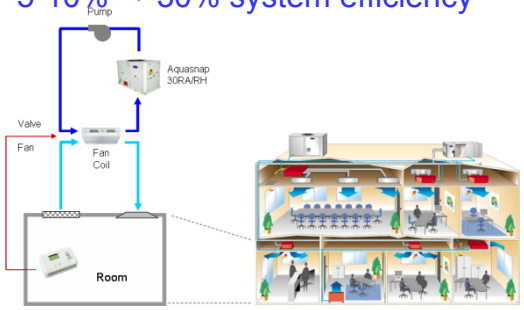
Model-based Systems Engineering

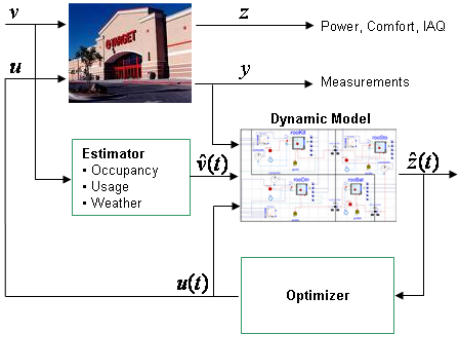
Product Margins and Customer Value

30% response time reduction,
40% evacuation time reduction



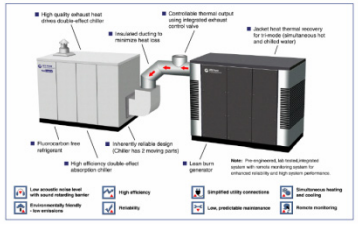
5-10% → 30% system efficiency

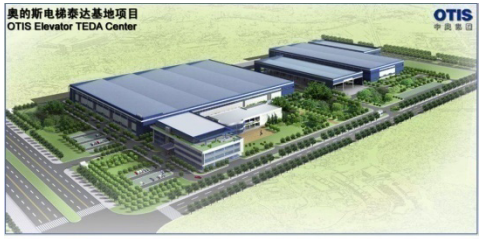




15% peak demand reduction

30% → 90% system efficiency





2-3% → 25% site energy reduction

2000-2005

Controls and IT

Thermodynamics | Fluid Mechanics | People Movement

hours — *Decreasing Response Time Scale* → seconds

thousands — *Complexity (number of equations)* → millions

Information Society Technologies

Key Points

- Market pressures on increasing performance for buildings
  - *Energy efficiency: need to go to Net Zero Energy;*
  - *Security: need to improve false-alarm rates dramatically.*
- Current best practices for high-performance buildings
  - *Functional integration for increased efficiency.*
- Barriers for dramatically improved high-performance buildings
  - *Complexity, heterogeneity and emergent behavior of networked systems.*

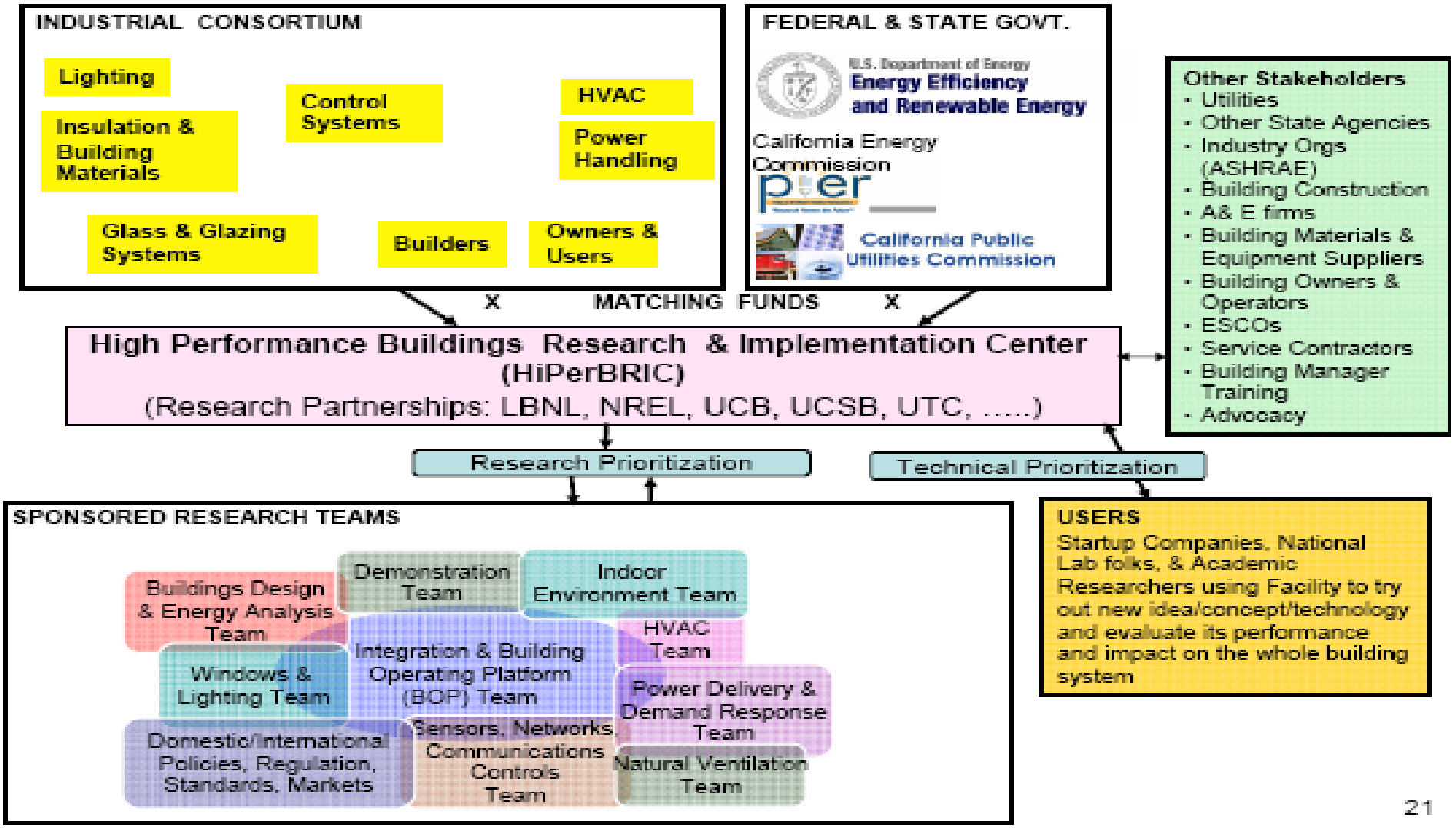
R&D needs in Systems Technology:

1... Design processes that address complexity explicitly;
2... Modeling and analysis that is focused on dynamics;
3... Explicit representation and management of uncertainty;
4... Design methodologies for networked embedded systems;
5... Supply and demand side energy demonstrations.

High Performance Buildings Research & Implementation Center (HiPerBRIC)

National Labs - Industrial Consortium - Academia Partnership

HIPerBRIC Structure



Confirmation Hearing of DOE Secretary (S.Chu)

- **STEVEN CHU**: Well, Senator, thank you for that opportunity. I think uh, let's start with buildings. I think the energy in the United States, buildings consume 40 percent of the energy used in the United States today. Roughly half and half between residential and commercial buildings. It's also my understanding, not only my understanding, but **Berkeley has been talking and working with companies like United Technologies. We think that new commercial buildings can be built in a cost-effective way to actually reduce the use of energy in those buildings by 80 percent and with investments that would pay for itself in ten years. We are very gung ho on developing these ideas and to prove to the construction community that this is in fact not just fluff but it's real**.
- **He refers to the HIPERBRIC Project to be included in Artist Design and Combest partner**

KeyNotes

- **List of KeyNotes and Talks to be found in Report**

Plans for Y2

- Focus on
  - Avionics/Automotive
  - Energy Efficient Buildings
- Organize meetings at specific conferences (DATE, CPS Week, EMS week) of each of the two lines
- Organize plenary session at Artist Design Plenary
- Favour US-Europe collaboration
- **Encourage integration of Clusters and other Transversals along industrial flows**

Semantical preservation results

- Sync -> FFP:
  - Every Sync model can be implemented on an FFP with:
    - 1 buffer for non-unit-delay links, 2 buffers for UD links (non-tight bound). Increasing number of buffers still preserves semantics.
    - At least m+1 buffers for every loop, where m is number of unit-delays in that loop (tight)
  - If Sync is strongly-connected:
    - by appropriately sizing the buffers, we can safely use non-blocking FFP writes
    - e.g. If all links have at least m buffers, where m is the min of the total number of unit-delays in the loop, over all loops containing this link, then:
    - “Blocking” write not needed in FFP (need only test that all input buffers are non-empty)
- We preserve streams

Semantical preservation results

- FFP -> LTTA:
  - Every FFP FIFO of size k can be implemented with k+1 CbS channels.
    - Currently “isFull” is implemented by back-pressure (“echo” messages): conservative.
    - We could also do “predictive” (less conservative) by exploiting some of the bounds in the “performance” section:
      - Using these bounds we may know that the reader must have fired, even though we have not received an up-to-date echo yet
  - If we never call “isFull” on the FIFO (non-blocking write) then we can do it with k CbS channels.
- We preserve streams
- What is the amount of progress? Do we keep skipping all the time?