*Research Cluster*

# Ultra High-Speed Mobile Information and Communication (UMIC)

Fakultät für Elektrotechnik und Informationstechnik

RWTH AACHEN

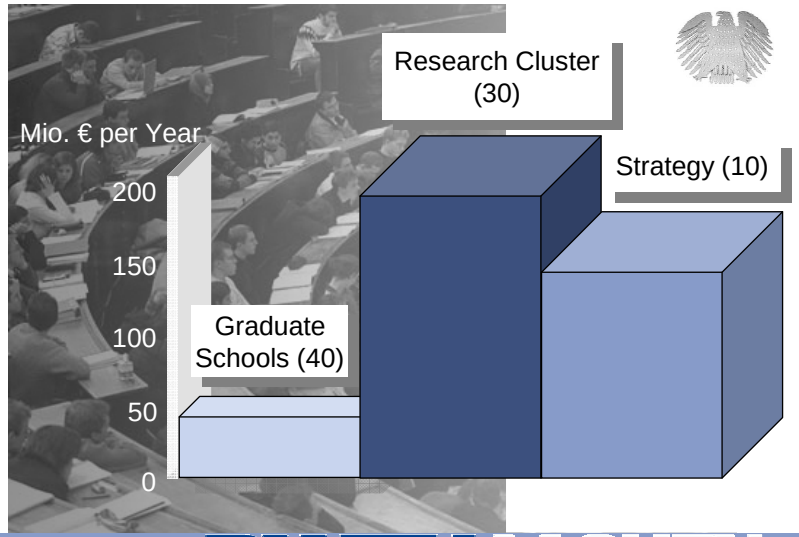
FACHGRUPPE INFORMATIK

# The „Excellence Initiative“

- **German government program**
  - 1,9 Bio. € total
  - Funding period: 5 years
    2 rounds, offset by 1 year:
    11/2006 – 10/2011 and 11/2007-10/20012

- **Structure : 3 Funding lines**
  - Graduate schools (funding: 1 Mio. € per year per topic)
  - Research cluster (funding: 6,5 Mio. € per year per cluster)
  - Strategy to develop top research
    (funding: 12.5 Mio € per year per University)

- **Thorough evaluation by renowned international researchers**



# The „Excellence Initiative“

- **RWTH Aachen**
  - 1 Graduate school
  - 2 Research cluster

- **Graduate school**
  - Aachen Institute for Advanced Studies in Computational Engineering Sciences

- **Research cluster**
  - Integrated Production Technology for High-Wage Countries
    Coordinator: Christian Brecher (WZL)
  - **Ultra high-speed Mobile Information and Communication (UMIC)**
    ⇨Computer Science, EE and IT Departments
    ⇨Coordinator: Gerd Ascheid (ISS)

# The „Excellence Initiative“

- **RWTH Aachen**
  - 1 Graduate school
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- **Graduate school**
  - Aachen Institute for Advanced Studies in Computational Engineering Sciences

- **Research cluster**

**Ultra high-speed Mobile Information and Communication (UMIC)**

Sole approved „cluster of excellence“ in the domain of information and communication technology

⇨Coordinator: Gerd Ascheid (ISS)

# Information and Communication

## at work

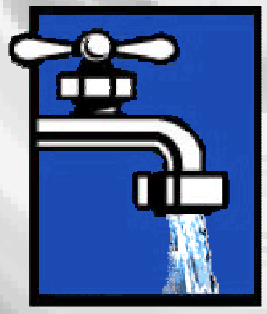
## and leisure

# Mobile Internet Access

## The Vision

**Ultra High-Speed Mobile Information and Communication *everywhere* at *low cost***

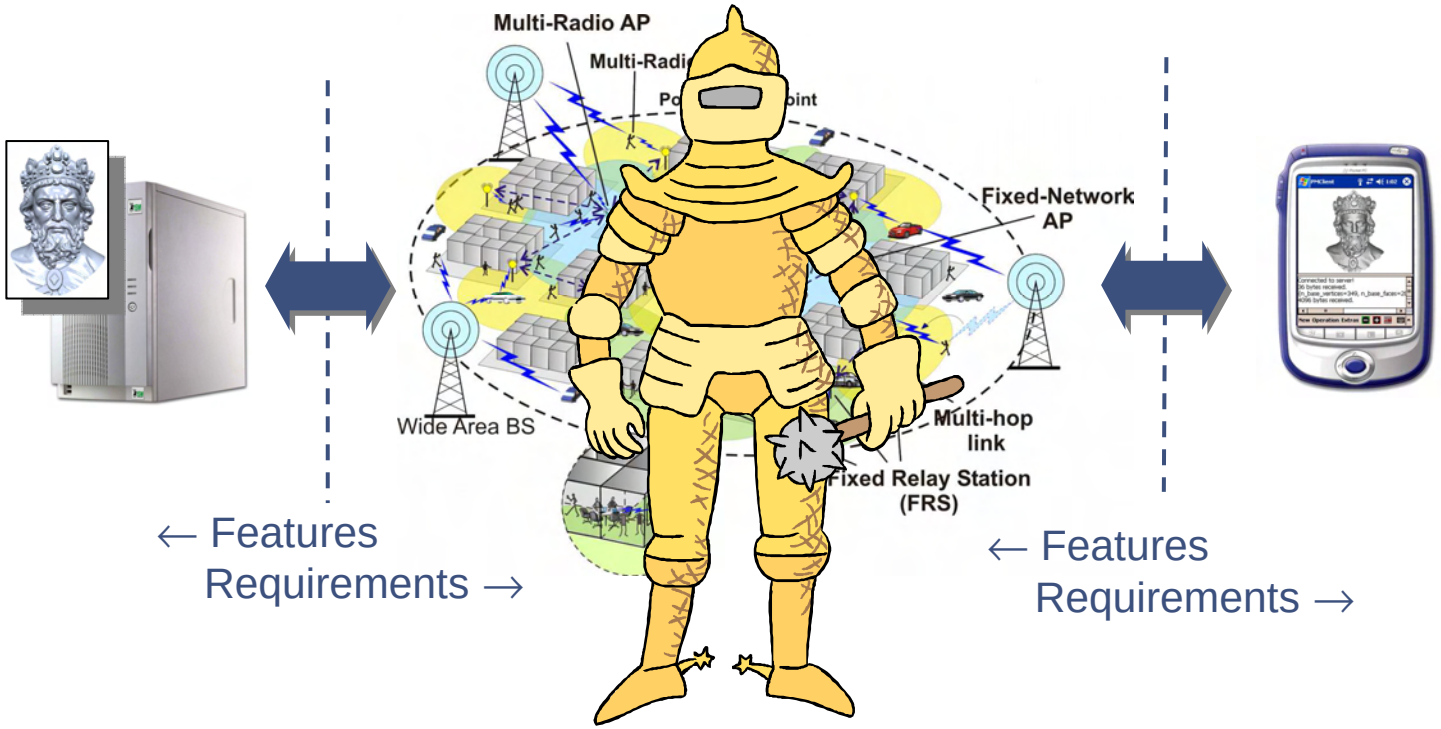
**UMTS Standard: 2 Mb/s**



**Reality today:**
**UMTS 0,1-0,3 Mb/s**
**GSM/GPRS 0,02 Mb/s**


- *I… …ocated places*
- *F… …rs*

# Cross-Disciplinary Research

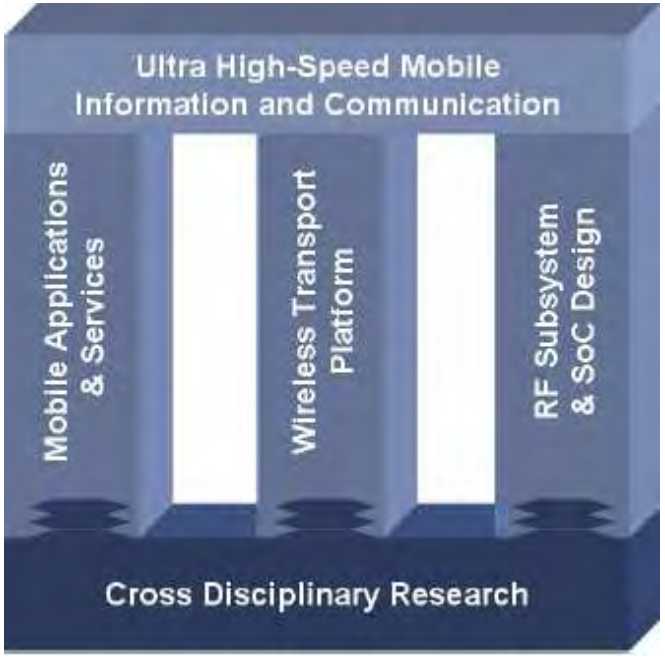



Application-agnostic specification leads to inefficient over-design

⇨ Match requirements and features!

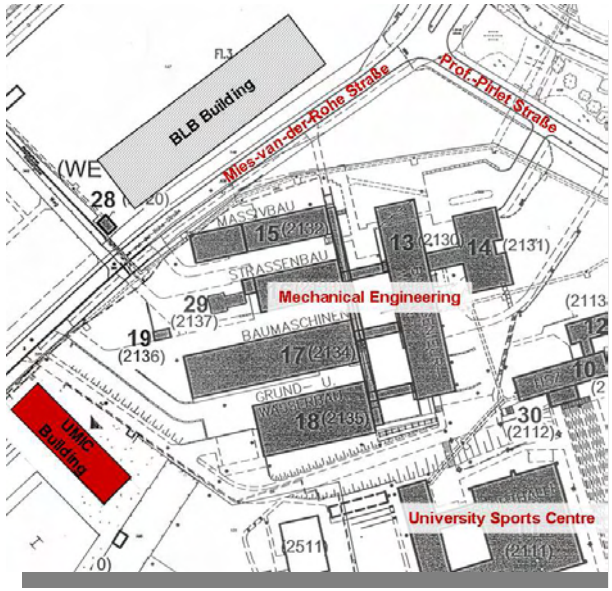
# Cluster Structure

- **Ultra high-speed mobile information and communication**
  - extremely challenging application demands
  - limitations of mobile communications and
  - technology capabilities and constraints
- **The design requires a tremendous leap**
  **⇨ needs collaborative research in**
  - Mobile Applications & Services
  - Wireless Transport Platform
  - Radio Frequency Subsystems & System-on-Chip (SoC) Design
  - Cross Disciplinary Methods & Tools



# UMIC Centre

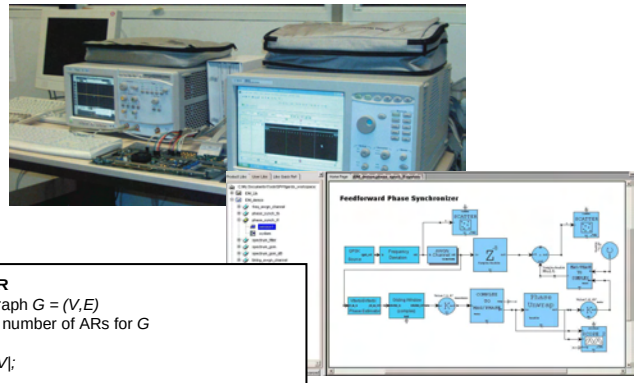
- **Establishing a Cross-Disciplinary Research Centre**
  - Jointly operated by
    - Computer Science Department and
    - Electrical Engineering and Information Technology
  - Augmenting research groups in participating chairs
    - **Research** space for cross-disciplinary research teams
    - **Development** space for prototype development and integration
    - **Demonstrator** space to showcase UMIC research results for academic and industry partners



# The UMIC Centre

## Prototyping activities in the UMIC Centre's Development and Demonstrator Spaces

- **Develop a test bed for**
  - key elements,
  - innovative components and
  - integration




```
algorithm MinAR
input: distance graph G = (V,E)
output: minimum number of ARs for G
begin
  if E = Ø return |V|;
  end if
  minAR = MatchingBasedAllocation(G);
  if matching-based allocation produced zero-cost solution
  then return minAR;
  end if
```

- **Prototyping activities**
  - Component prototype
  - Scaled component prototype (e.g. FPGA based platform)
  - In-door / out-door wireless communication test beds
  - "Demonstrable" simulation model(s)
  - Development and exploration tools

# The Research Areas

# The Research Areas

## A: Wireless Transport Platform

- New solutions for infrastructure, networks, radio links and terminals to get information and communication from/to mobile users

## B: Mobile Applications & Services

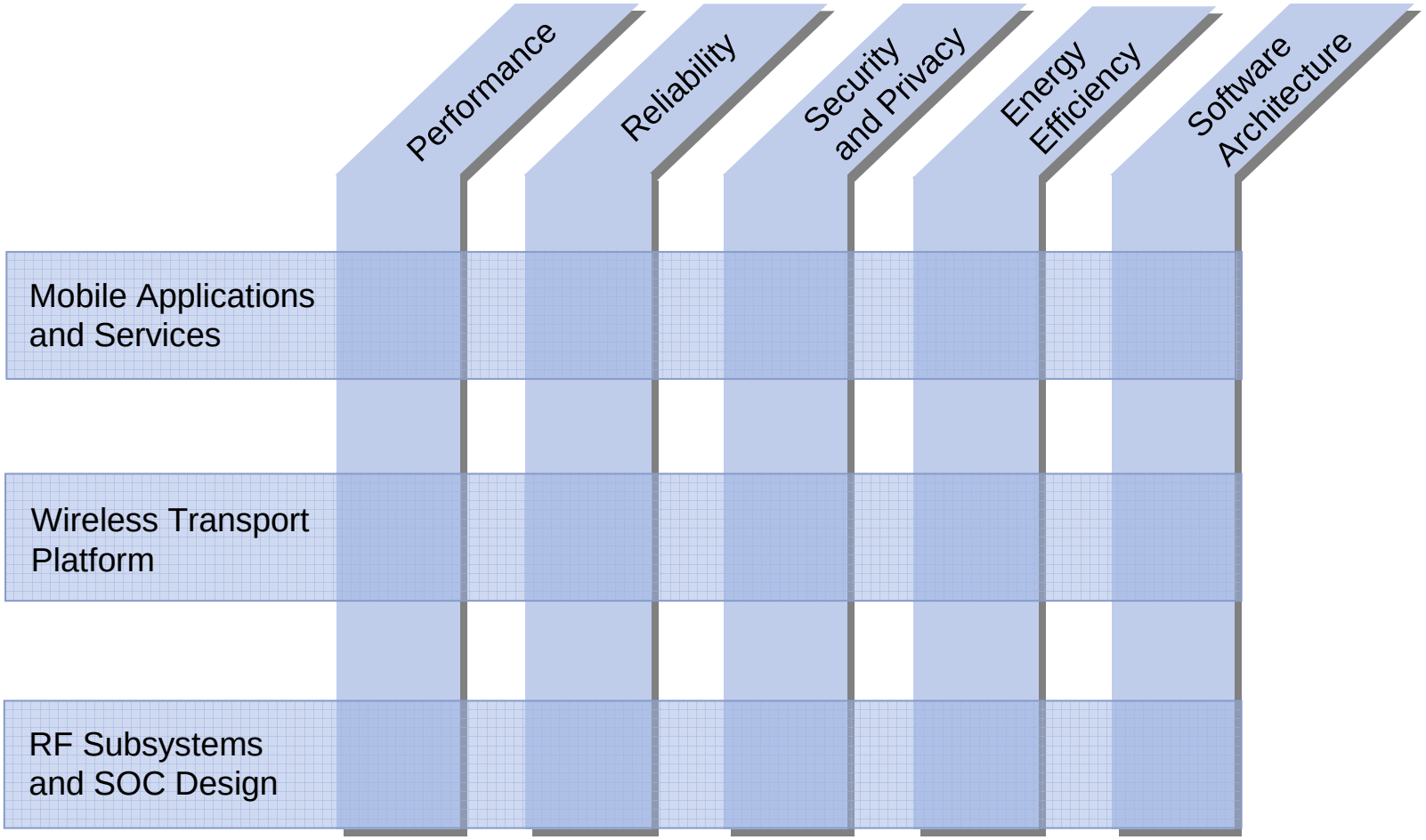
- Representative classes of applications and services
  - Common requirements of each class
  - Potential trade-offs to match requirements of mobile applications and services with wireless transport platform

## C: RF Subsystem and SoC Design

- Innovative hardware architectures leveraging opportunities and addressing challenges of future silicon technologies
- Design methods, tool concepts and programming for heterogeneous many-core systems-on-chip

# The Research Areas

## D: Cross Disciplinary Methods and Tools



# Research Area A:
# Wireless Transport Platform

**„High data rates to many mobile users at low cost“**

- **Approach: Smart, mobile, broadband, low-cost systems**

- **Key issues**
  - Cognitive radios and networks
  - Heterogeneous, high-density multi-hop radio network architectures
  - Communication theory and physical layer aspects

# The Platform Goal

**Smart, Mobile, Broadband, Low-cost Systems**

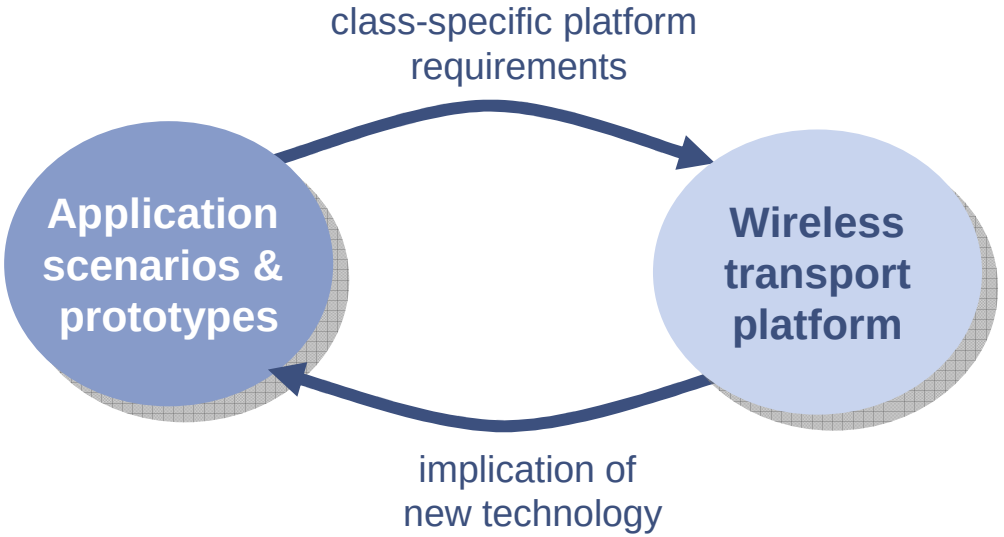
**that provide adaptive configuration and seamless connectivity, balancing between conflicting targets like data-rate, radio range and power consumption by continuous joint optimization.**

- **Smart**
  - Cognitive capability and adaptive performance optimisation
  - Plug-and-play deployment
- **Mobile**
  - Seamless access
  - Multi-homing
- **Broadband**
  - Maximum spectral and spatial efficiency (bit/s/Hz/$m^2$) at system level
  - x-Gb/s data rates for many users
- **Low-cost**
  - Minimum cost network elements, installation and maintenance
  - Nano-electronic based, fully integrated implementation

# Research Area B:
# Mobile Applications & Services

## „… leverage and challenge new communication platforms“

- **Approach**



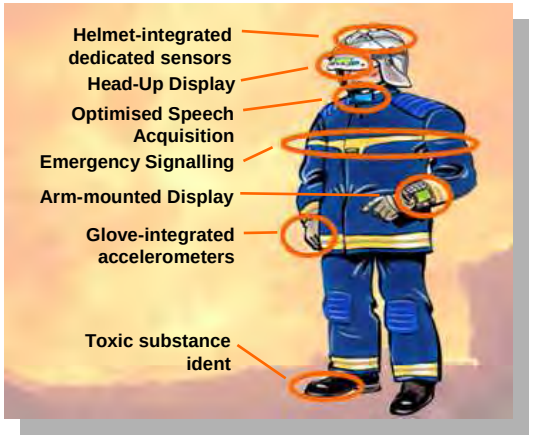

- **Key issues**
  - Mapping mobile web services on WTP with scalable automated service discovery
  - Context aware, adaptive peer-to-peer information management
  - High quality mobile multimedia

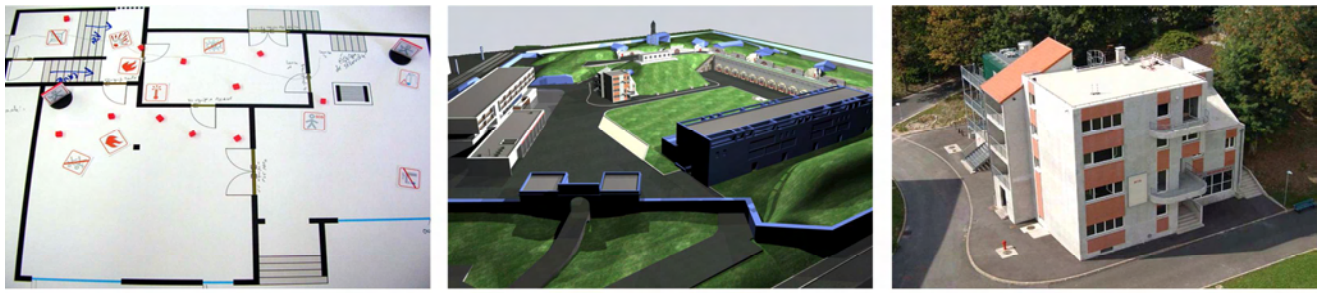
# Mobile P2P Context Management

- Automatic context management and modelling with many users in the P2P environment
- New algorithms and paradigms are required
- Novel usability aspects and development methods

## Mobile P2P information management:

- Example: Wearable computing in medical assistance networks
- Context-based data stream aggregation, mining, and information provisioning linked to textile and network engineering.



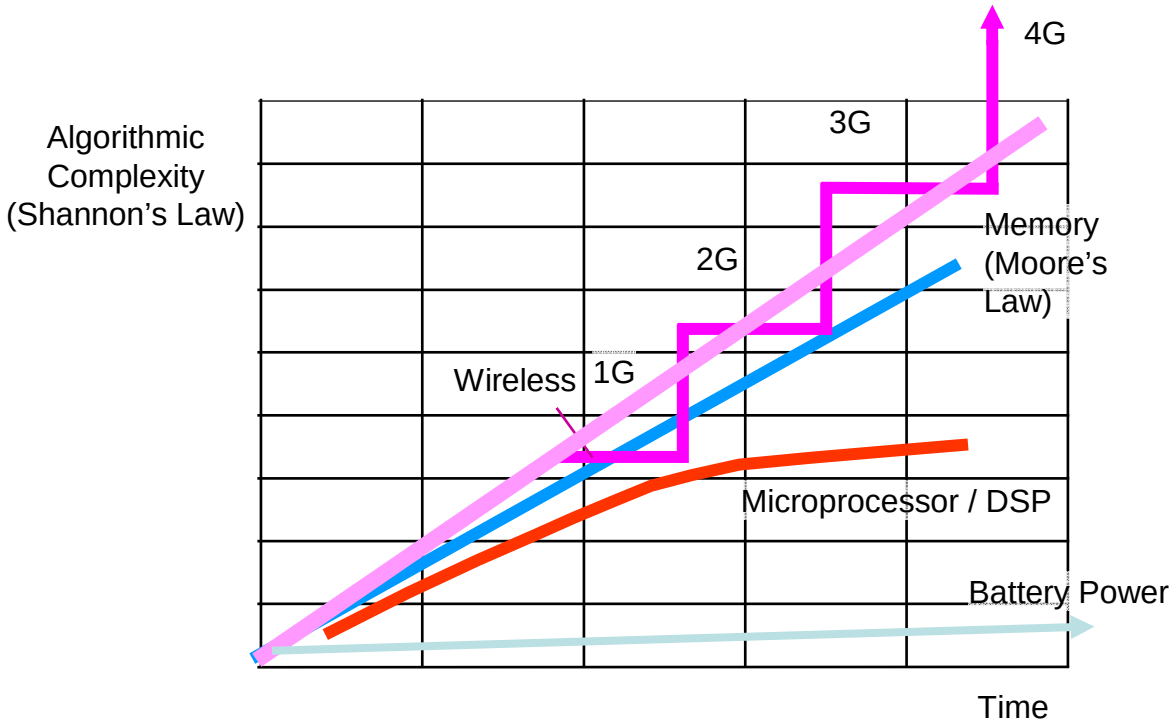
# Research Area C:
# RF Subsystem and SoC Design

## „Potentials and challenges of deep sub-micron based implementation”

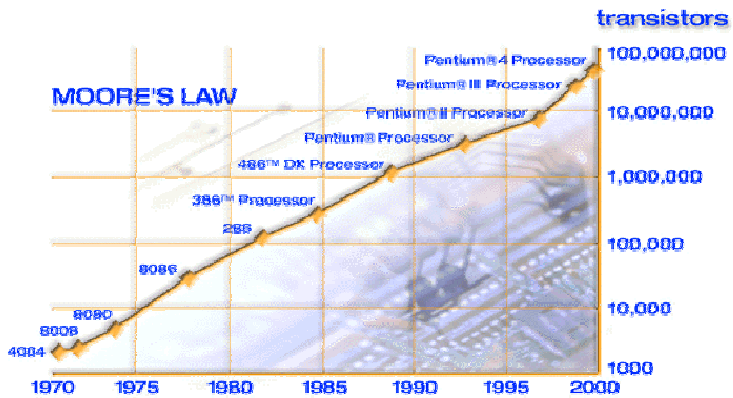
- **Approach**
  - Prototyping of critical components
  - Performance and cost modelling
  - Virtual prototyping
  - Design methodology and tool concepts

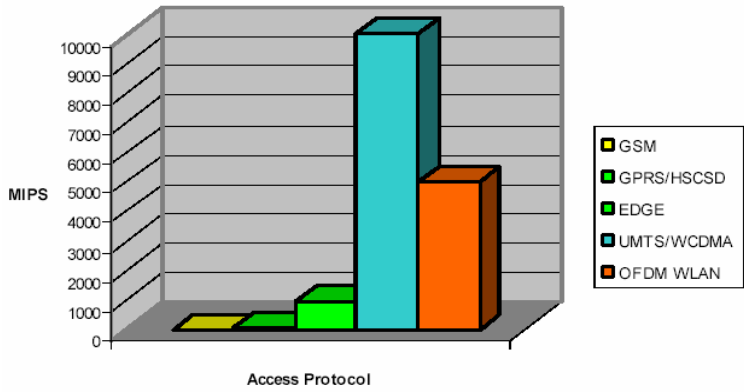
- **Key issues**
  - Flexible RF-subsystems
  - Multi-Processor-Systems-on-Chip:
    Processor and communication architectures
  - Deep sub-micron issues: fault tolerance and leakage
  - Methods, tools and programming

# The Need for New Architectures

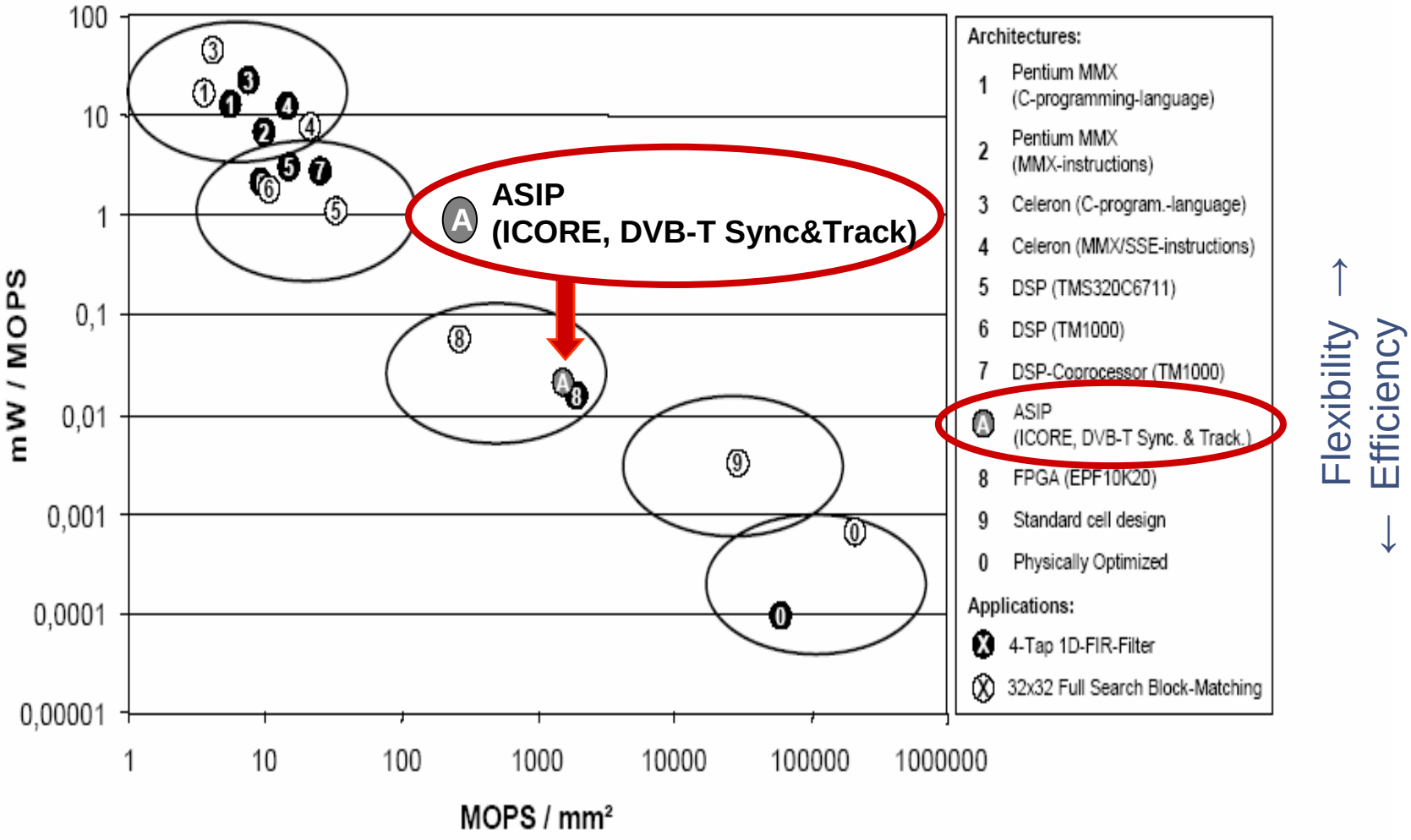



**Source: R.Subramanian. Berkeley Design Automation Inc**

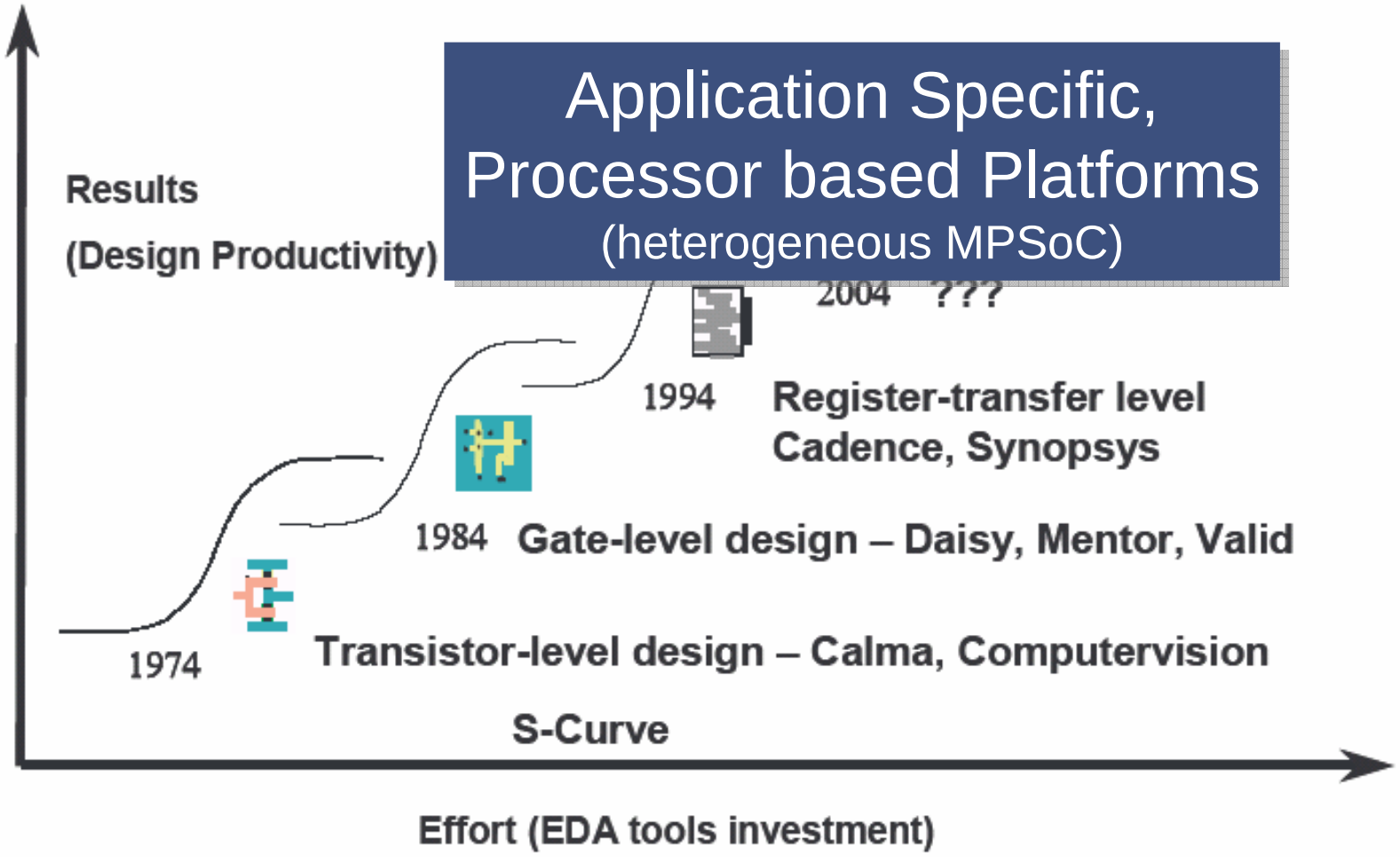


# Computational Efficiency vs. Flexibility



# Core Proposition



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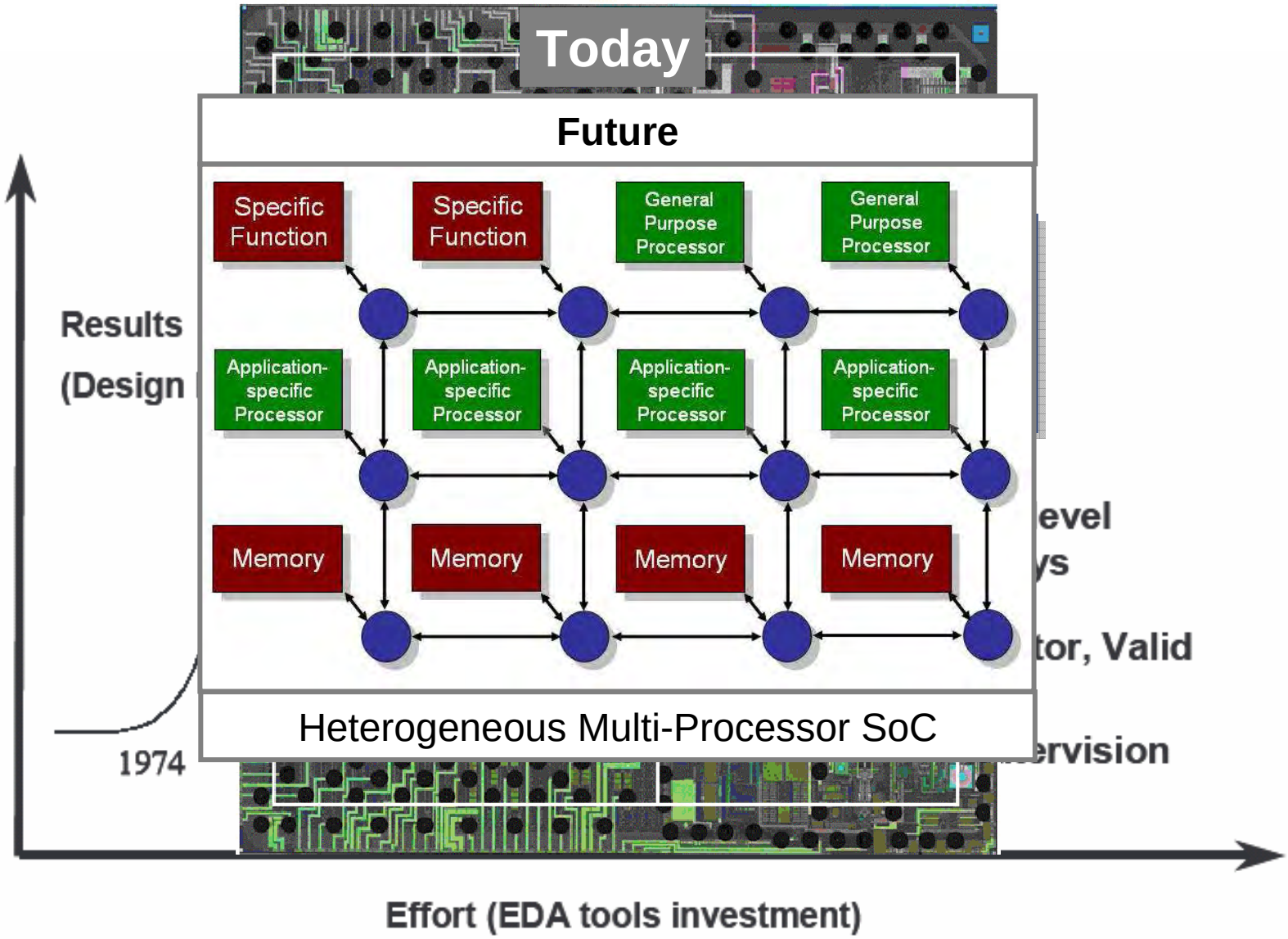

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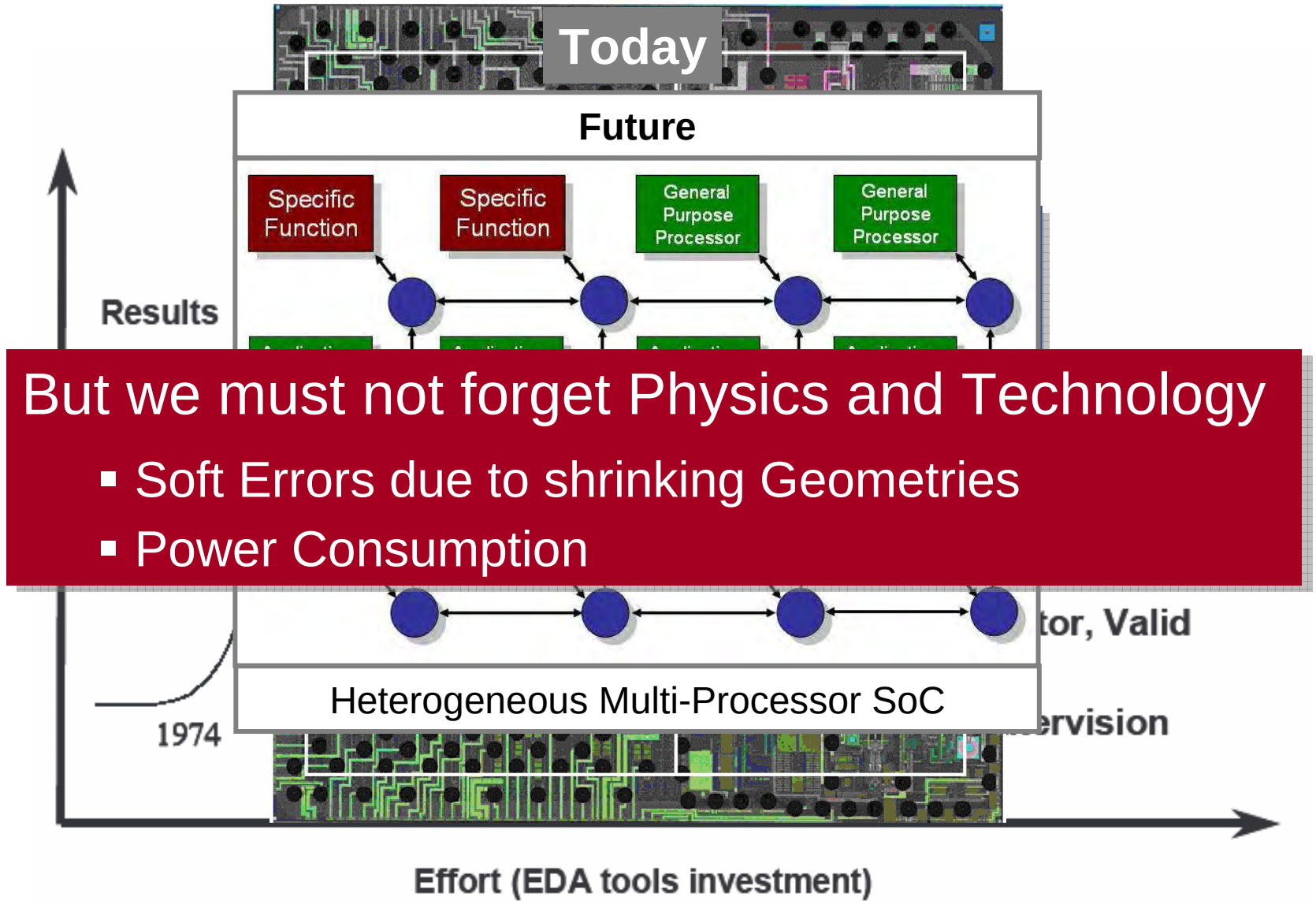
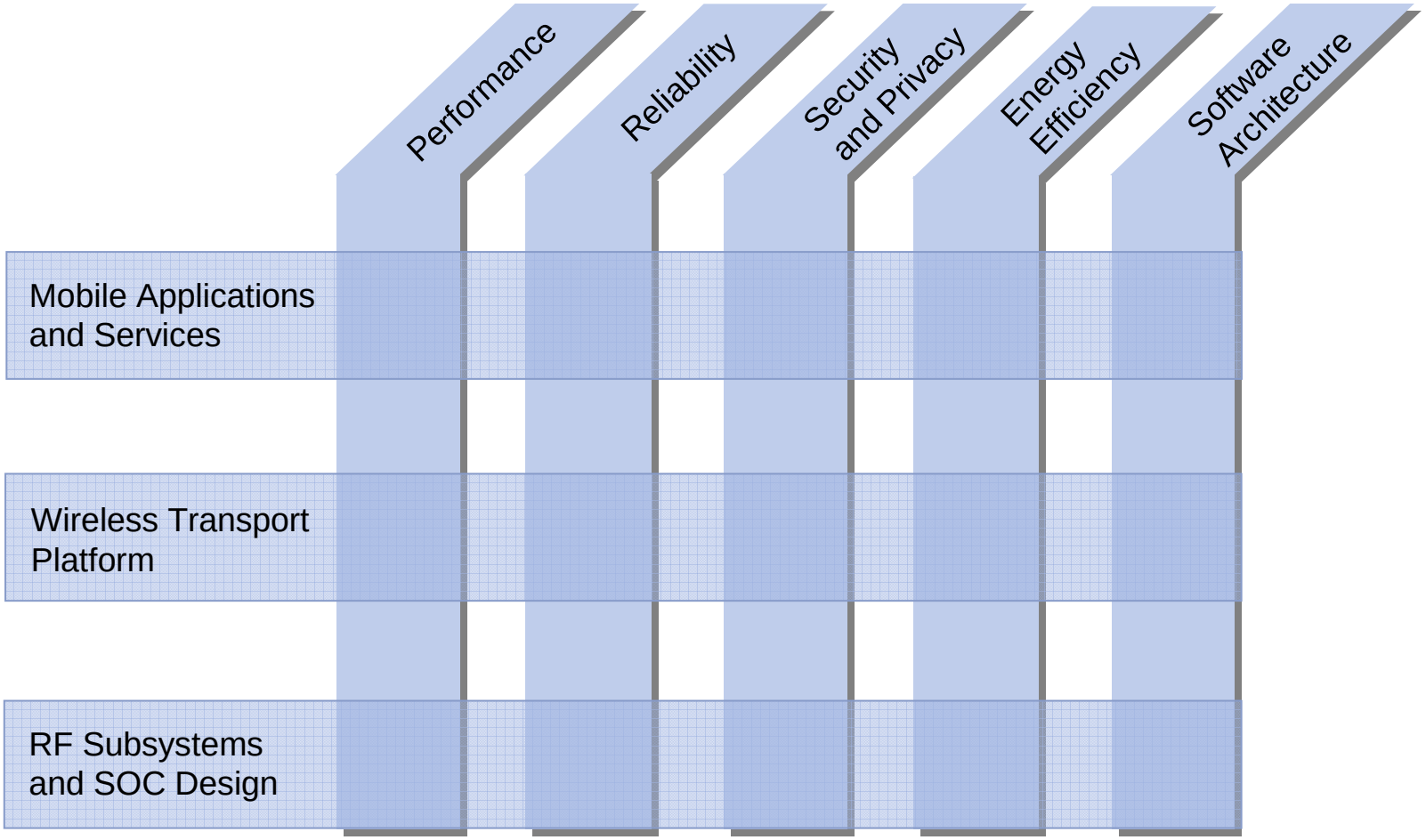



But we must not forget Physics and Technology

- Soft Errors due to shrinking Geometries
- Power Consumption

# Research Area D:
# Cross-Disciplinary Methods and Tools

## „Innovative methods and tools for cross layer issues “



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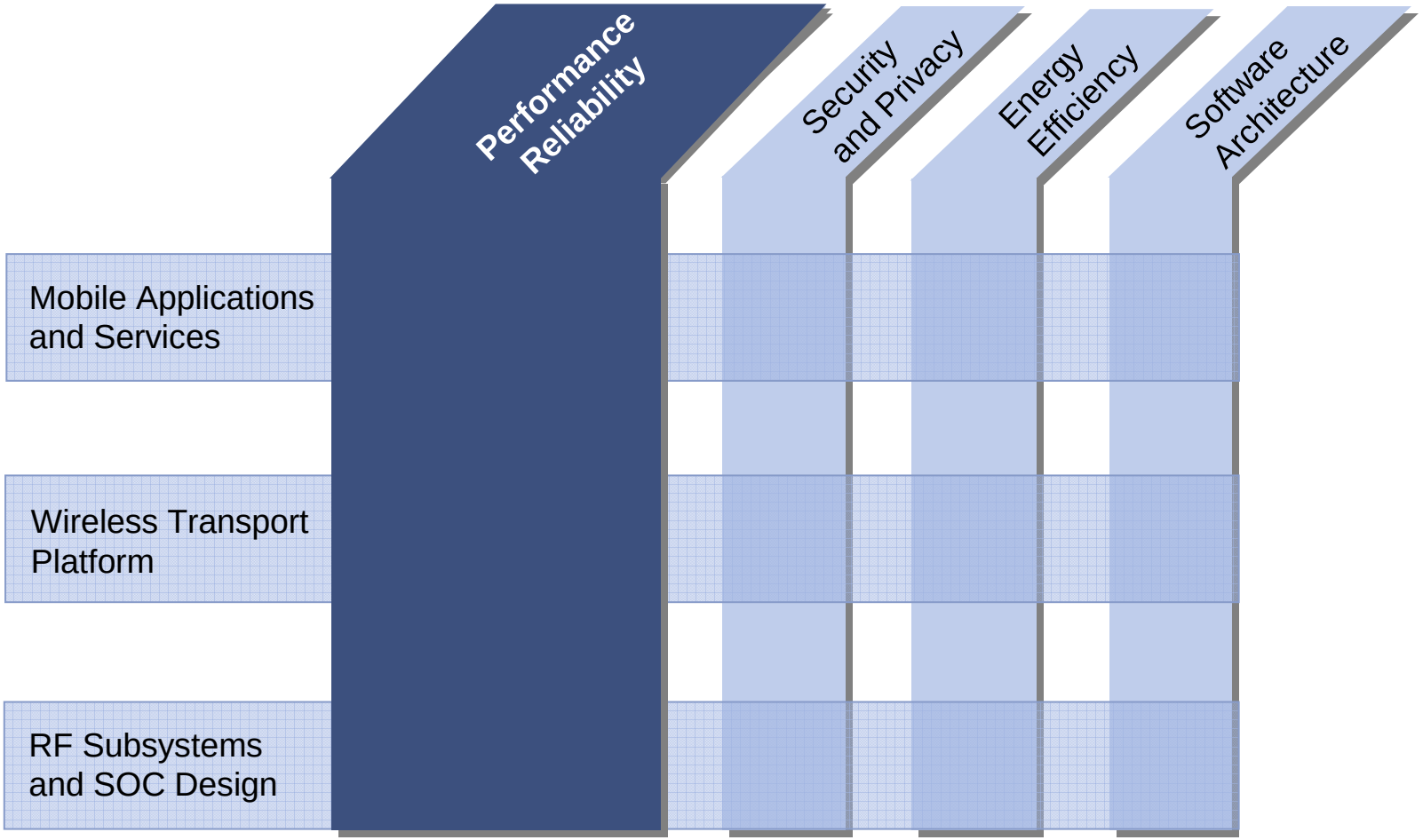
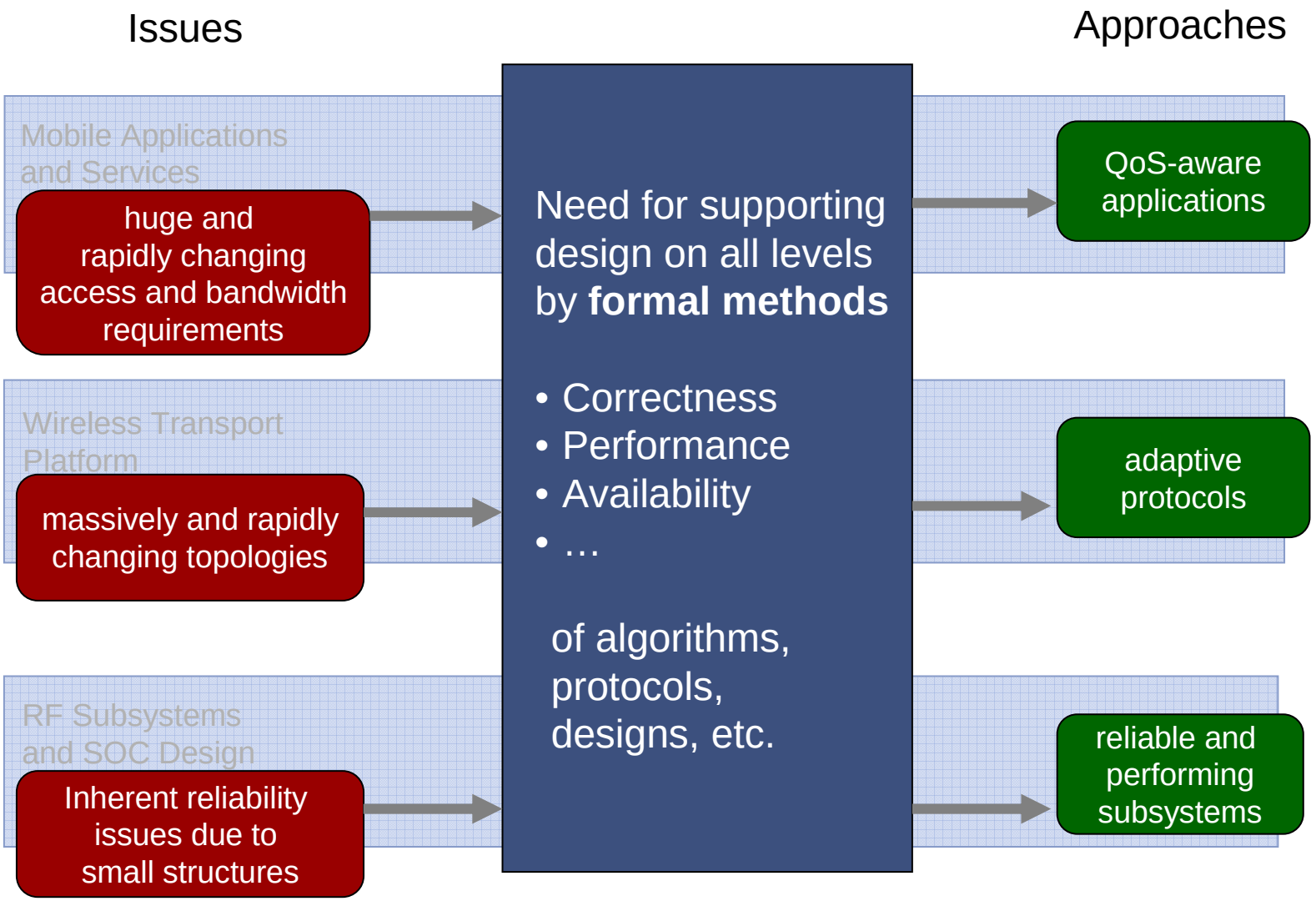


# Reliability and Performance



# Reliability and Performance

**Performance** oriented design and analysis methods

**Reliability** oriented design and analysis methods

Need for supporting design on all levels by **formal methods**

- Correctness
- Performance
- Availability
- …

of algorithms, protocols, designs, etc.

**computational learning**

**evolutionary game theory**

**continuous-discrete systems analysis**

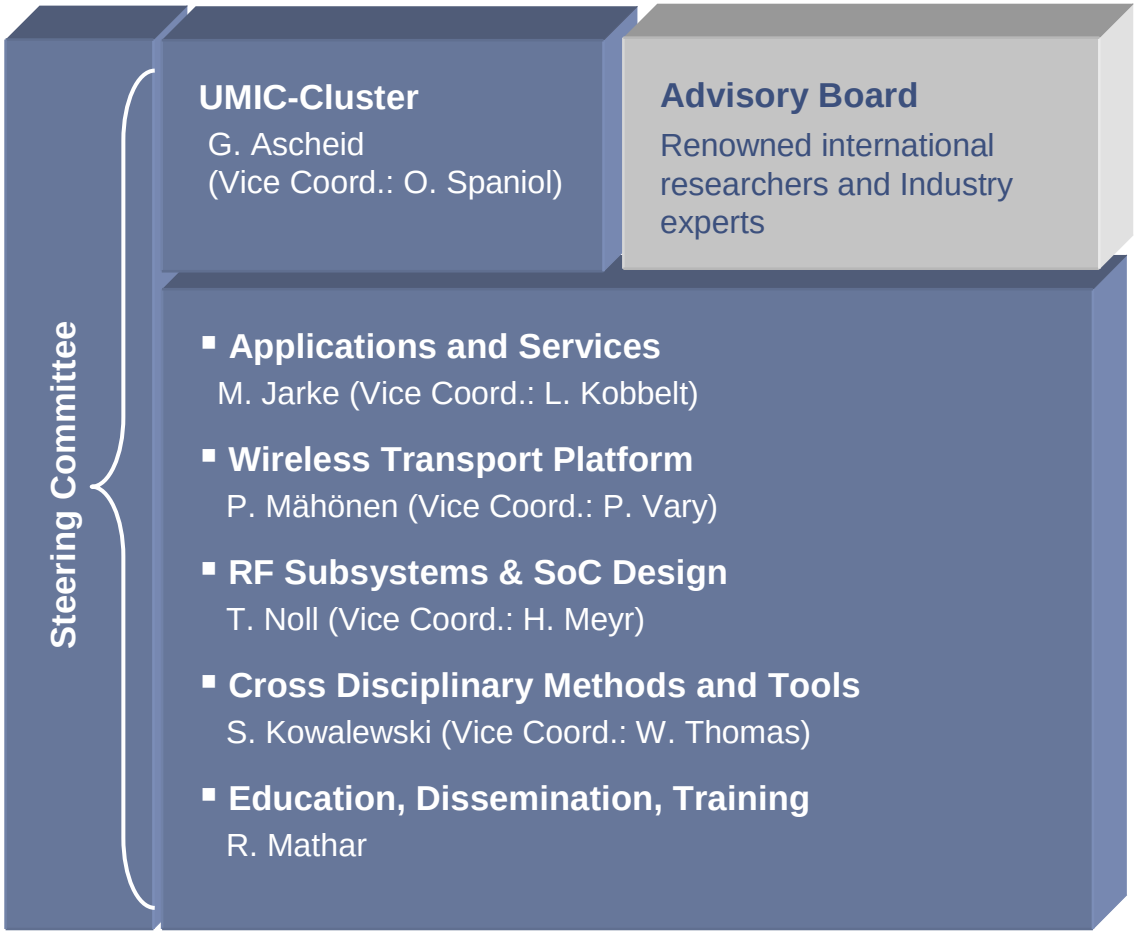
**verification of dynamically changing systems**

**probabilistic verification**

**evaluation of architectures**

# Organization

# Quality Focussed Cluster Management




The **UMIC Steering Committee** is responsible for the cluster research programme management like, e.g., project approval and review.

# Principal Investigators

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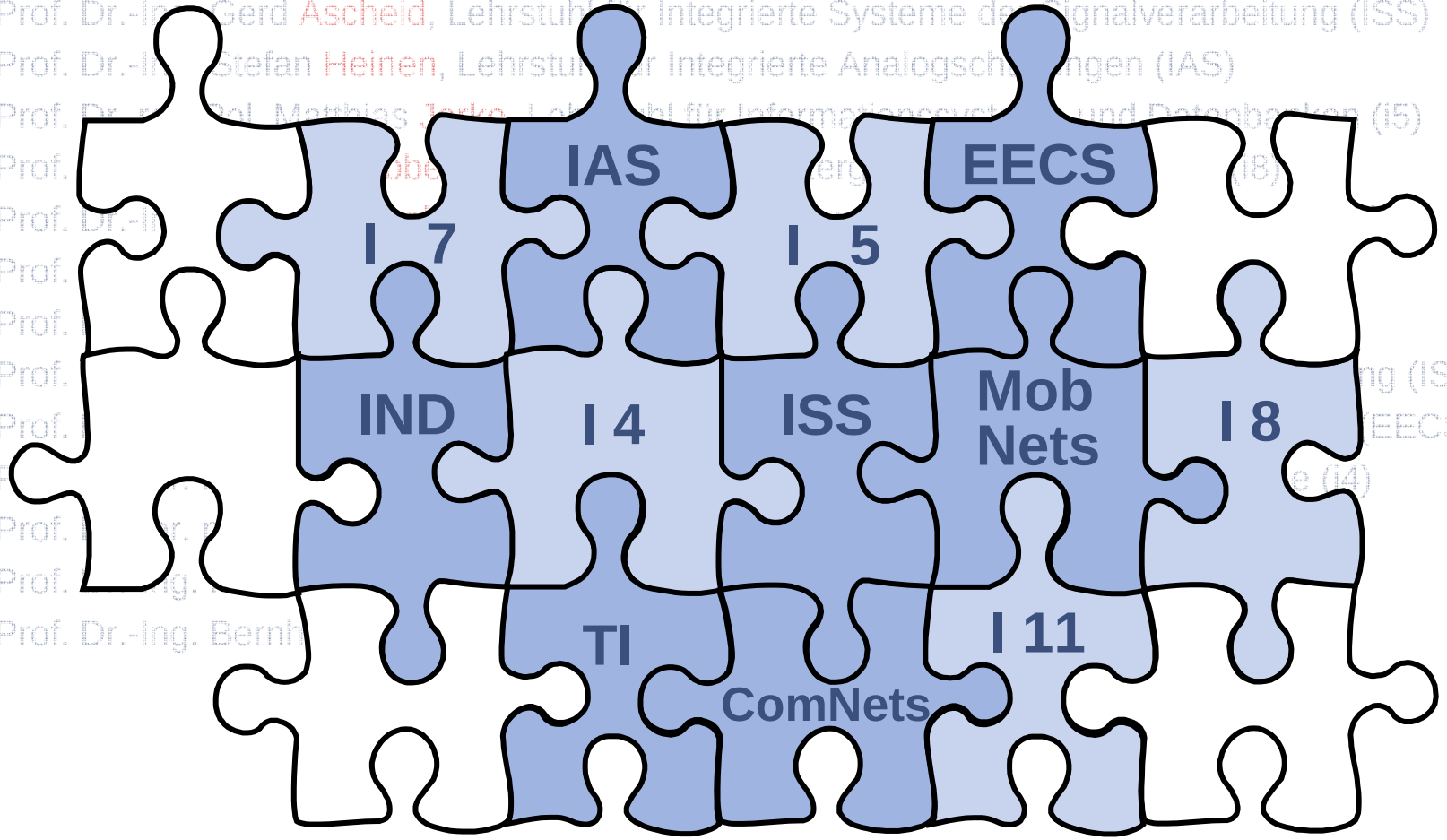
# Principal Investigators

## Design and Implementation

RF Subsystems, MPSoC, nm-CMOS-Implementation, Tools



# Contact and Information

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