A SWOT Analysis of EE

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H. Meyr

Institute for Integrated Signal Processing Systems
RWTH Aachen University

SWOT Analysis: A strategic management tool

Ch

Opportunity or Threat?

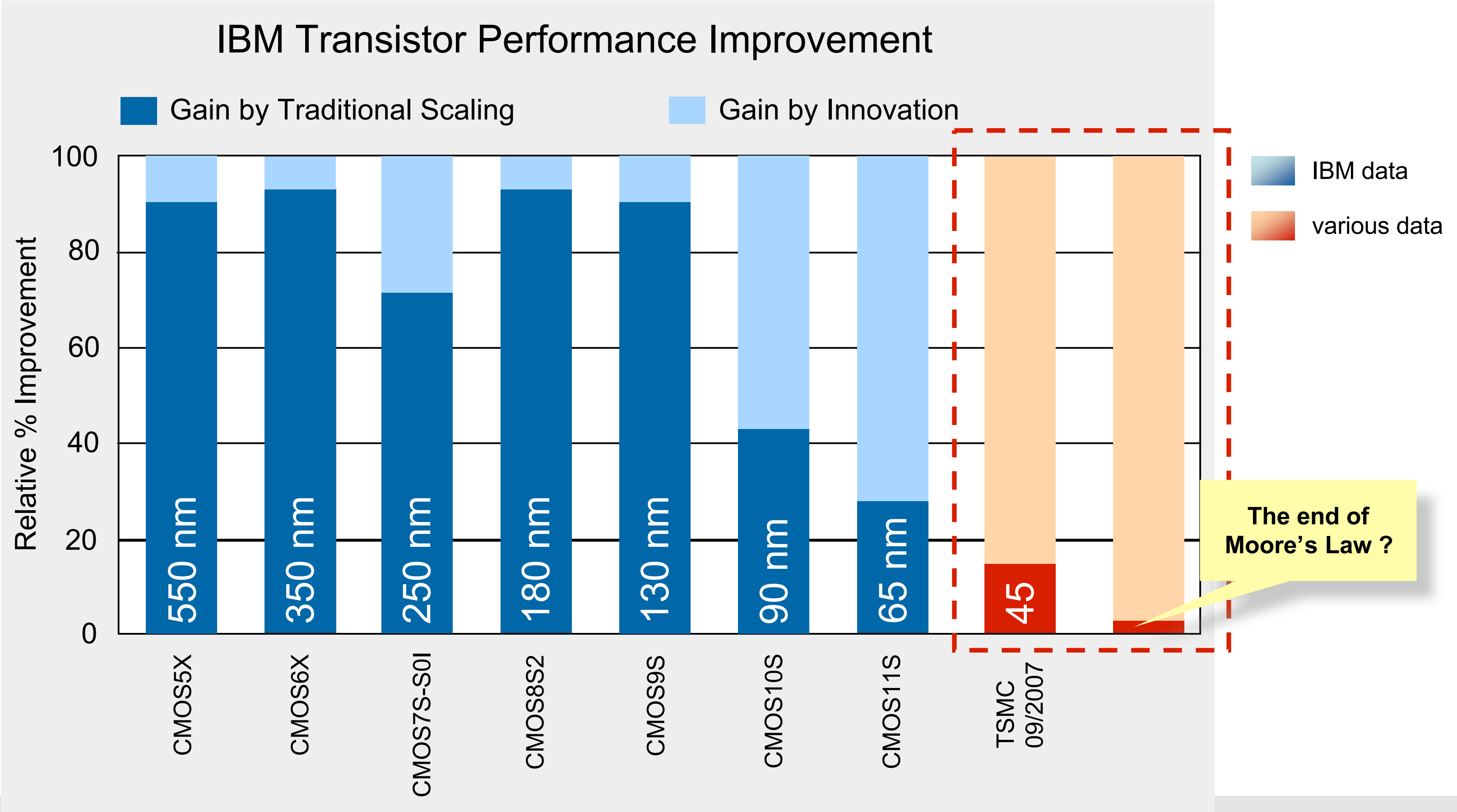
- The end of Moore´s law
- The explosion of SW content
- the advent of parallel computing
- The energy crisis

Intel RMS View 2015

- **User will need teraflops of computing power, terabits per second of communication bandwidth, and terabytes of storage to handle the information all around them**
- **Intel classifies the processing capabilities into three fundamental types**
  - Recognition
  - Mining
  - Synthesis
- **To support the multiple levels of concurrency and execution unit Intel is developing a "many core"chip architecture**

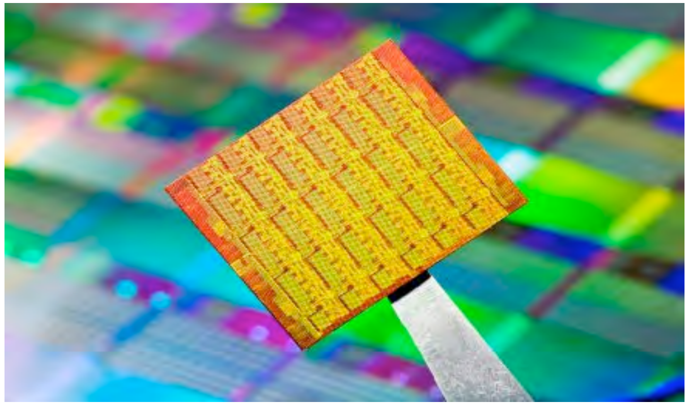
The Paradigm Shift: Innovation overtakes scaling

- Innovation now dominates performance gains between generations
- **This means** that “***scheduled invention***” is now the majority component in all technology gains



Source: Lisa Su /IBM: MPSoC’05 Conference 2005
Extensions based on various sources

Parallel computing



"Switching from sequential to modestly parallel computing will make programming much more difficult…….without a dramatic improvement in performance"

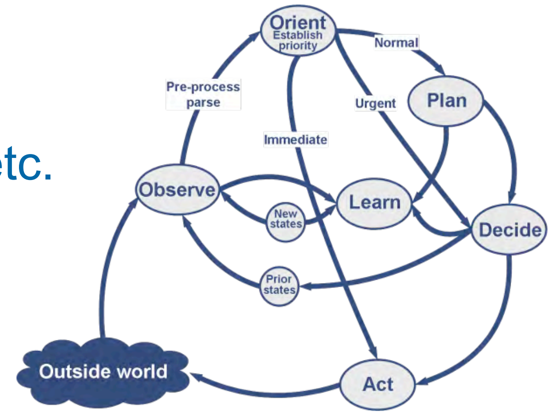
⇨ **We need to go to from multiple processors to many cores**

Source: Seven Questions and Seven Dwarfs for Parallel Computing, UC Berkeley Report, June 2006

Opportunities:

"Necessity is the mother of invention"

- **Cognitive Wireless Networks and Radios**



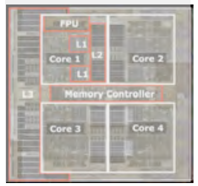
… must sense or be cognitive of the environment
- other user interference, multi-path, noise, etc.
- time-variations

… must be intelligent to analyze the situation and find the optimal communications protocol, frequency band, transmission mode, etc.

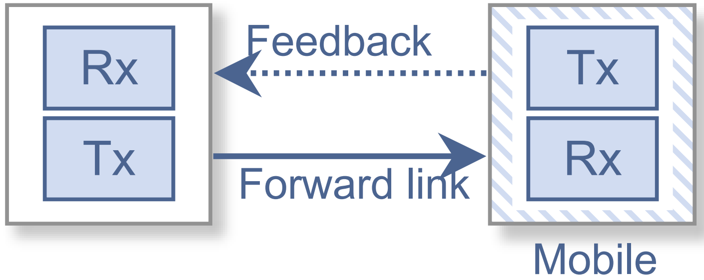
These radios “find the best protocol, frequency band, and transmission mode” leveraging the three driving forces
- **Semiconductor technology**
- **Machine Learning and Advanced Optimization**
- **Networked system thory**

Energy-efficiency :Communication systems

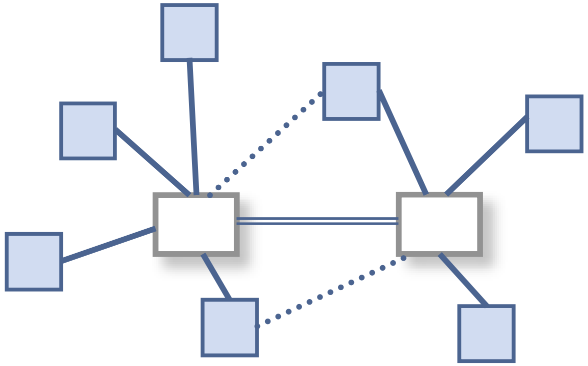
- **Implementation View**
  - Flexible energy-efficient platforms



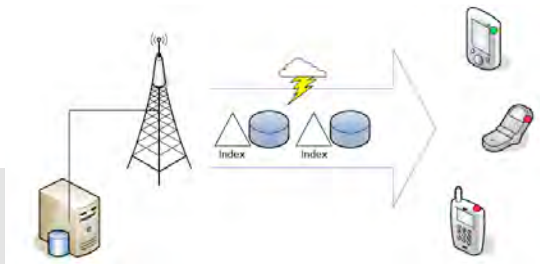
- **Link View**
  - Energy has two parts!
    - Transmit energy (Tx)
    - Processing energy (Rx)…



- **Network View**
  - Multiple cells vs. single links
  - Cross-layer optimisation



- **Application View (Quality of Service)**
  - Get the information to the user with minimum energy
  - Energy efficient data provisioning and dissemination



Mobile terminals

- Complexity grows stronger than battery capacity
- In the past CMOS technology has helped to close the gap
  → not true for deep sub-micron silicon technology

Infrastructure

- The energy bill has has become a significant (dominating) part of the operating expenses

- **Global Metric:**

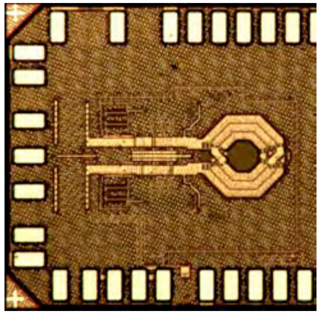
$$\frac{\text{pJoule}}{\text{Information Bit}} \qquad \frac{\text{Bits/sec/mm}^2}{\text{Information bit}} \Rightarrow$$

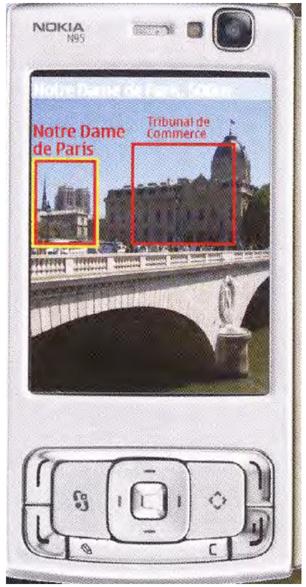
Minimize/maximize!

Problem statement

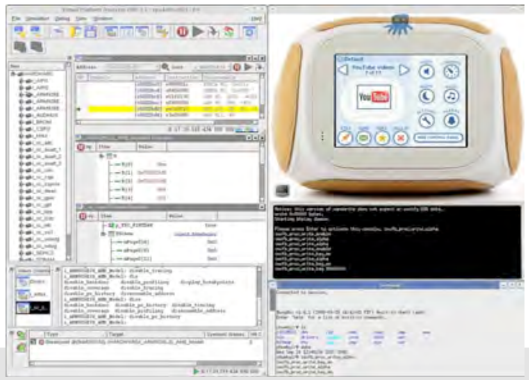
- **SoC design for future wireless multimedia terminals**

- **Optimization goals**
  - energy efficiency
  - flexibility
  - performance, cost
  - design productivity



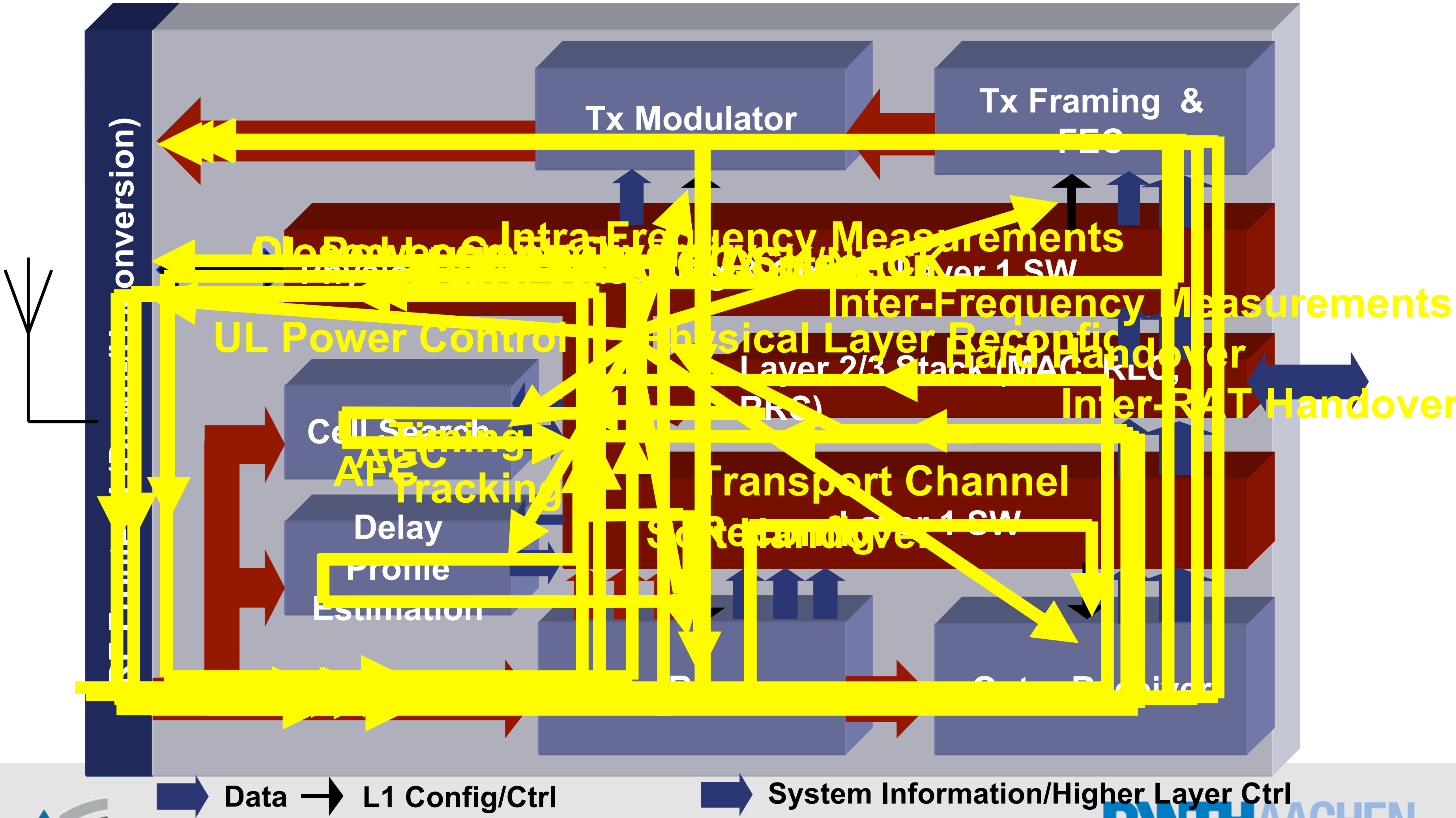


- **Major topics**
  - PHY and MAC layer processing
  - Algorithmic design
  - Digital SoC architectures
  - RF subsystem architectures
  - Design methodology and tools
  - Prototype design



Verification and validation (SW &HW)

Source: Dr. H. Dawid, Infineon



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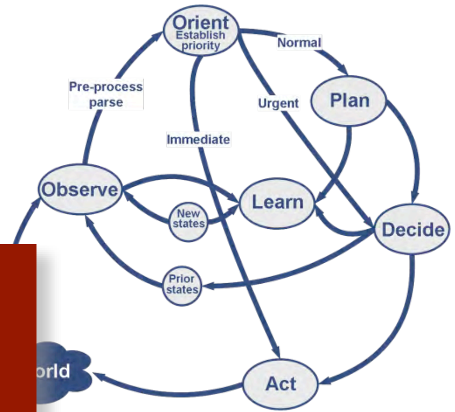


We need a "new system theory"

(Nothing is more practical than a good theory)

These [illegible], and transmission mode" leveraging the three driving forces
- **Semiconductor technology**
- **Machine learning and advanced optimization**
- **Networked system theory**

“Low hanging fruits have been picked”

Areas with largest economic growth potential

- **EE**
  - Power system and economics
    - Energy distribution

Are EE-skills useful or even necessary to solve the problems in these areas?

- **Automotive**
  - Drives
  - Storage system
  - Navigation+multimedia+control
- **Mechanical engineering**

Cross-diciplin… esearch

Opportunity

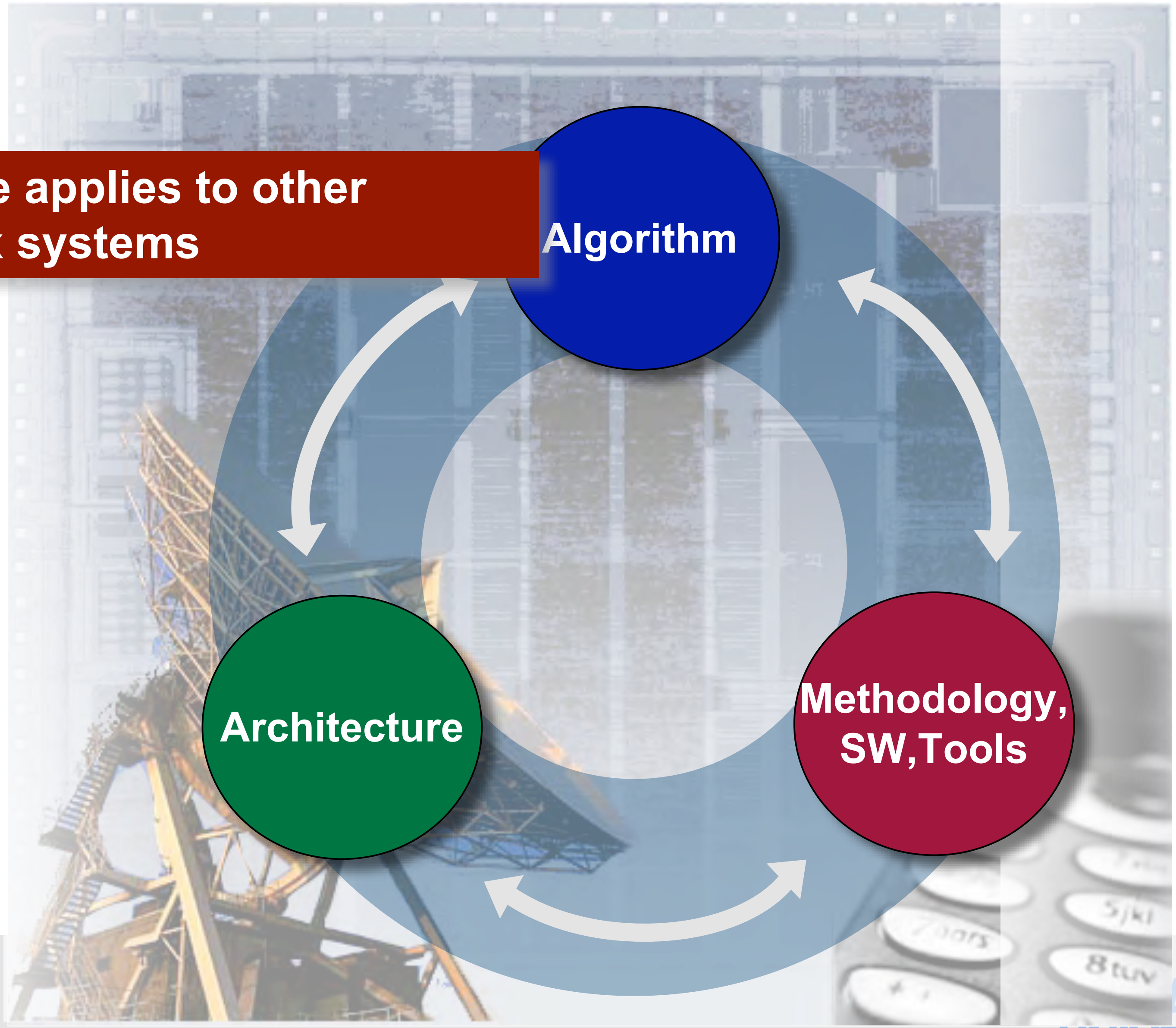
Definition of a complex system

- The whole is more than the sum of its parts
- The problem is too **heterogeneous** and too **complex** to be understood by an individual

Conclusion

- The solution of the problem ultimately requires the interaction of various disciplines

Principle applies to other complex systems



Cross-Disciplinary Research : Necessary conditions

- **People (“the human nature”)**
- **Identify an attractive goal and define a “win-win” situation for the participating disciplines**
- **Management structure**
  - Administration
  - Leadership
- **Joint lab**

Cross disciplinary research: approaches

- **Centralized with no teaching duties**
  - Santa Fe institute
  - Princeton institute of advanced study
- **Centralized with graduate teaching**
  - Max Planck institutes
  - IMEC
  - Berkeley wireless research center (BWRC)
  - ParLab UC Berkeley
  - RWTH Aachen UMIC
  - ETH Zürich: IIS (Prof.Fichtner) and institute for communications (Prof.Boelcskei)
- **Distributed**
  - TU Dresden: Cool silicon
  - Nano-tera in Switzerland

People

- **Classification of EE professors**
  - Type1: Classical academic. Devotes most of his energy and enthusiasm to research and teaching. Works preferably alone. Inspiring and true leader for his students. Often a prima donna
  - Type 2: Administrator , in its worst form a committee professor. In Germanyknown as “Gremienprofessor”.
  - Type 3: Manager, runs a large research cluster. In its best form a leader. Has good credentials from his active days as type 1 professor. Very rare species.

- **Universities are not well suited for of large cross-disciplinary projects**
  - Building and managing a cross-disciplinary team is the most difficult task
    - Difficulty in defining a “win-win” situation
    - Management has no authority to enforce penalty/reward system
    - Professors are notoriously difficult to handle (see classification in previous slide
    - Leadership and administration most likely separate

Weakness

Threats

De-focusing in research

- **Focusing in research**
  - On technically interesting but economically unimportant niche markets
  - On mathematically interesting but mature fields with no impact on applications (e.g., we know much about point to point transmission)
  - “Exporting” and applying methodologies to other fields (example: information theory to genetics) without a fundamental understanding of this field .
  - “Importing” is much more successful (e.g. random processes to communication theory)

- **…instead of working on hard problems which need solutions and which require the core competency of EE**

De-focusing in teaching

- **Teaching**
  - Avoid fashionable “cross-disciplinary” curricula such as, e.g. “Power systems and economics” (Wirtschaftsingenieur). This produces graduates with superficial knowledge of both engineering and economics incapable of solving real world problems in practice
  - …. Teach instead the fundamentals of electrical engineering with a strong mathematical background. Let the student specialize later on

Education :Centers of gravitiy of electrical engineering

- Teach fundamentals in the three gravity centers (courses, basic lab) thus providing the “base vectors” of knowledge
- Provide “problem solving skills” by hands-on experience in project work (part of on-going research of PhD students). This will teach the students how to combine the “base vectors” to form a subspace
- Teach basics of project management etc, but not a watered down version of an MBA

The role of globalization & standardization

- The role of outsourcing of R&D has to be critically assessed since this is a one time saving only.
- Low salaries in India are past for top R&D. Management of various development centers matched to the skills of the respective culture is a key factor.
- In the long run it will be difficult to have successful academic research in a country without an industrial base to employ the students later on.
- The communications industry is based on standards. This is a curse and a blessing at the same time for innovation

Research in technology

- Top research in technology is extremely expensive . Most EE department will have difficulty to maintain this research. Most likely technology will be done in collaboration with large research institutions (like Fraunhofer, KFA Jülich in Germany)

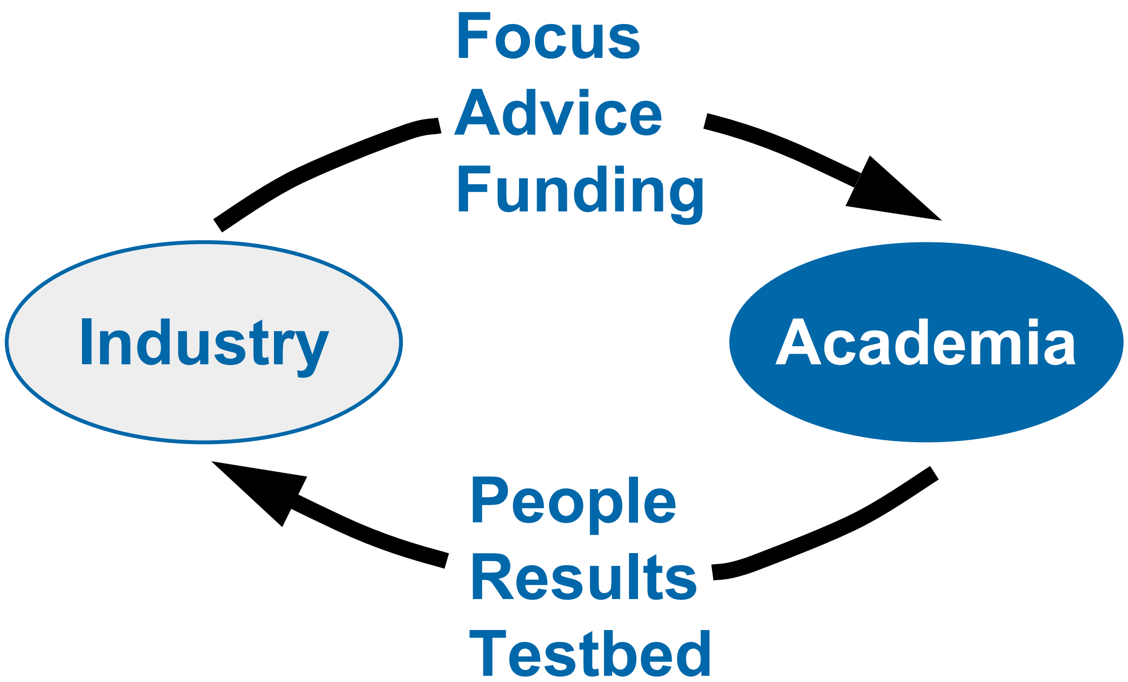
Strength

Expertise in modeling systems

- **Definition "model":**
  - Idealized representation of a system. Completeness and accuracy are determined by the question to be answered, the knowledge and the modeling environment
- **Principles of modeling:**
  - A real world system encompasses many orders of magnitude of time scales
  - We use
    - Abstraction: neglecting details
    - Hierarchy: Hiding of details

    to obtain answers of the system behavior
  - Verify or falsify your model by experiment
- **Example:**
    - PHY layer of a communication system: from transistor level to channel variations
    - Kalman filter

University-industry cooperation



About Ph.D education

- **Traditional Goal**
  - Contribution to the foundation of Knowledge

- **Today**
  - Develop competency in solving complex problems
  - Take risk. Explore new avenues. ("pushing the envelope")
  - Learn to work in a team
  - Sell results
    - publications
    - technology transfer

In Germany a PhD is seen as a top qualification for an industrial career

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Summary

The Future of Electrical Engineering – A View from a Cellular Handset Platform Designer

Source: Dr. H. Dawid, Infineon

- Mobile Communications, the Internet and ubiquitous computing have already changed our life more than anything else in the recent 20 years. This process is continuing at fast pace.
  - **Spectrum efficiency** and seamless mobility are of central importance for mobile networks
  - **Energy efficiency** is of central importance for mobile terminals (performance, cost & reliability go without saying)

System Design

Communications
Information Theory
System Theory
Signal Processing
Mobile Radio Networks
SW Engineering
Real-time Systems
Operating Systems
Compilers
Parallel & Distributed Computing

Semiconductor Technology
VLSI Architecture
RF Technology
RF Microelectronics
Analogue Electronics
Digital Electronics
Computer Science
Computer Architecture
Antenna Technology
Embedded Systems & Software

The whole is more than the sum of it´s parts → **interdisciplinary research is required**

Challenge **and** Opportunity for Electrical Engineering

There are huge challenges ahead like

Cognitive Radio **Cooperative/Coordinated Communications** **Intelligent Networks**

Universities should form research clusters, work together with the industry, contribute actively to standardization activities and actually build prototype systems as proof of concept

The future has just begun. Come and shape it!

Summary

- EE skills are indispensible to solve the most important problems society is facing
- Let us look for “solutions for problems” rather than looking for “problems for a solution”
- Focus rather than diversify

“Vision without action is a daydream.
Action without vision is a nightmare”

Japanese proverb

Thank You

Delivering the right message

- **Students numbers are strongly increasing in**
  - Mechanical engineering
- **Student numbers are declining in**
  - Computer science (strongly)
  - Electrical engineering….with the exception of power engineering
- **What went wrong?**
  - Do we communicate the wrong message?
  - Or do we experience a “pig cycle” based on negative industry news?
  - What else?