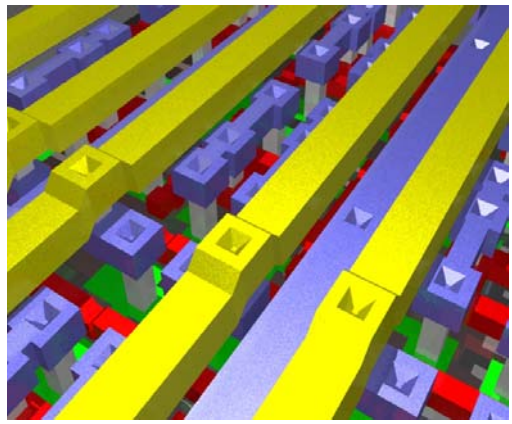
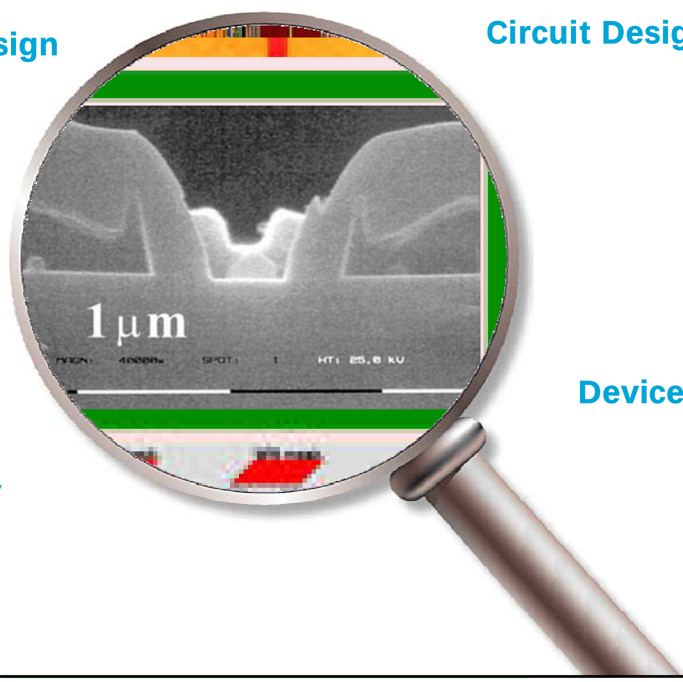
ET4293
Digital IC Design

N.P. (Nick) van der Meijs



System Design

Circuit Design



Devices

Process
Technology
Physics

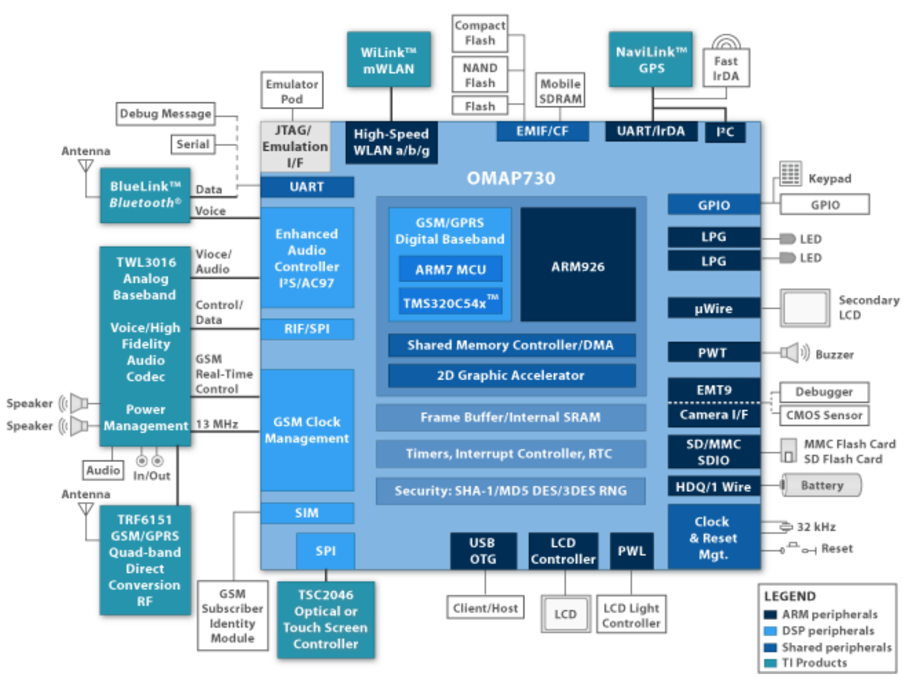
[Lina Sarro]

Design Challenge

- **System Complexity**
  Dealing with the sheer size of the system
  - **> 10^8 components (transistors)**
  - **Compare boeing 747-400: $6x10^6$ components**
  - **>> 10 km of interconnect**
  - **Compare boeing 747-400: 274 km wiring, 8 km tubing**

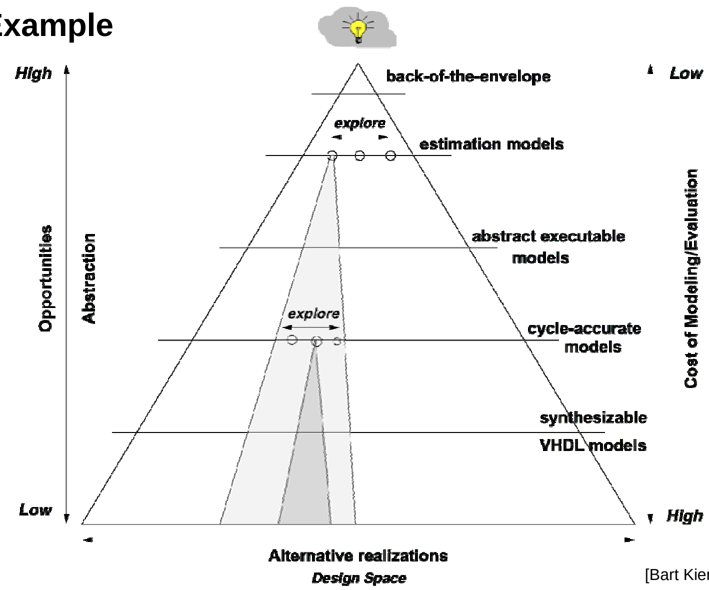
- **Silicon Complexity**
  Dealing with circuit and physical aspects
  - **Features < 0.0000001 m = 100nm**
  - **Actually far from ideal behavior**
    More like building spaghetti bridges then steel bridges
  - **Lots of unwanted parasitics**
  - **Manufacturing tolerances, …**

[http://www.boeing.com/commercial/747family/pf/pf_facts.html]



Dealing with System Complexity (1)

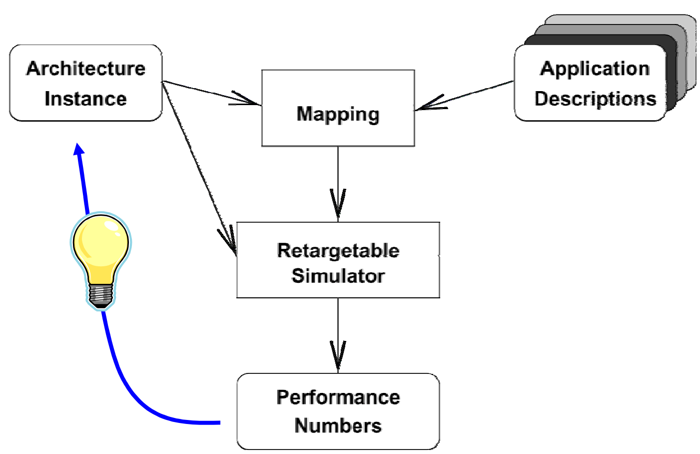
Example



[Bart Kienhuis]

Dealing with System Complexity (2)

Example



[Bart Kienhuis]

More System Complexity Concepts

- High-level architecture design
  - processors, busses, caches, cache sizes, instruction sets, IP blocks, …
- System on chip design
- Cycle-accurate simulation
- Network-on-chip, protocols,

Course Contents

- **System Complexity (Size of the system)**
  - This course does not deal with this aspect of VLSI design
  - But it can't overlook this issue either – many of the real issues relate to the interplay of system and silicon complexity
- **Silicon Complexity (circuit and physical)**
  - This course will focus on these aspects
  - Goal is to enable design of large systems

Contents (2)

- How to realize the full potential of advanced manufacturing technologies in realizing digital circuits and systems
- Show how circuit-level techniques help improve the overall design properties
- Show how properties from physical design create opportunities (and limitations)

Digital Electronics

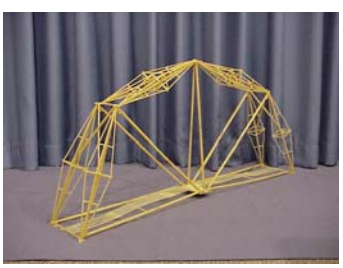
- Electronics
  - Behavior of electronic circuits from an electrical perspective
  - Not from an algorithmic perspective
- Digital
  - Not opamps, but logic gates (etc.)

Digital vs Analog

- Fundamentally, all circuits are analog, they are just ‘overdriven’ to achieve digital behavior
- ‘Digital’ is just an abstraction
  - Way of looking at circuits and signals
- Understanding range of validity of digital abstraction is essential
- Deep-submicron evokes many unwanted ‘analog’ effects:
  - Crosstalk, delay, overshoot, reflection, supply noise, substrate noise, …

Scaling

- All features become smaller and smaller
- Smaller means faster but also less ideal
- Deep-submicron design becomes more like building spaghetti bridges then steel bridges



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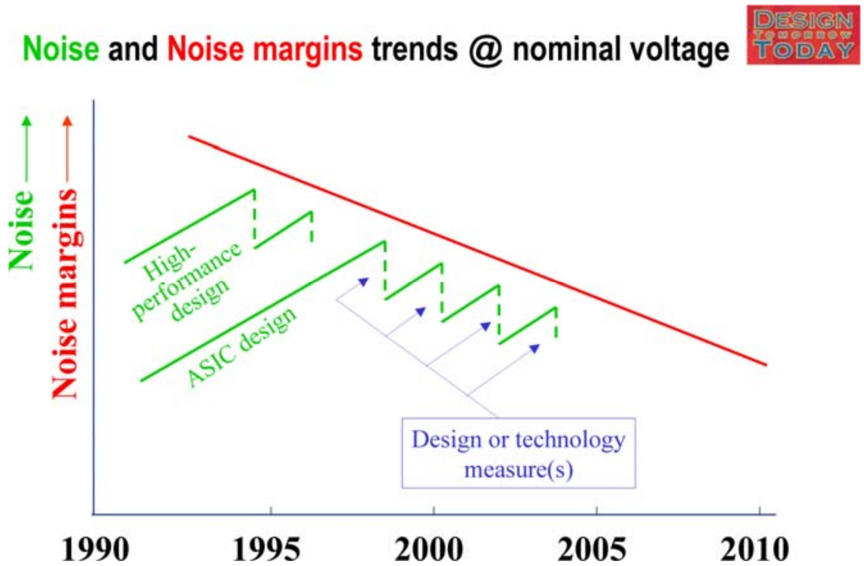
Example: Voltage Scaling



[Slide: Harry Veendrick, NXP]

Why 'Electronic' insight for VLSI

- **Someone needs to design and implement libraries**
- **Creating a model of a (standard) cell and modules requires deep understanding**
- **Library-based design and standard abstractions partially avoided for very high performance designs**
- **Deep scaling defeats many standard practices and abstractions**
  - **New design issues arise**
- **Troubleshooting requires in-depth knowledge of all issues involved**

Prerequisites

- Circuit Theory
  - Resistor, capacitor, voltage, current, kirchoff laws, power, …
- Digital circuits
  - Boolean logic, logic gates, flip-flops, state-machines, clocking, …
- Part 1 of the Rabaey book is helpful
  - MOS devices, technology, …
  - Summary in first lectures

Instructor

Instructor	**Dr. ir. N.P. (Nick) van der Meijs (HB 17.300)** ☎ **86258** 💻 **nick@cas.et.tudelft.nl**
TA	**Qin Tang (HB 17.140) Q.Tang@tudelft.nl** **available: 15:30-17:30 Tuesday and Friday**
Secretary	**Laura Bruns (HB 17.230)** ☎ **81372** 💻 **lbruns@cas.et.tudelft.nl**
Section	**Circuits and Systems** **http://ens.ewi.tudelft.nl/**
Department	**Microelectronics & Computer Engineering** **http://me.its.tudelft.nl**

Course Material

Book:

Jan M. Rabaey - Digital Integrated Circuits, A Design Perspective, 2nd ed, Prentice Hall, 2003 (via ETV)

Web site:

http://cas.et.tudelft.nl/~nick/courses/digic

Bi-directional link with blackboard

Announcements, etc.

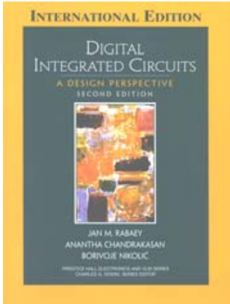
Blackboard Discussion Forum (!)

Syllabus:

website

Slides / Presentation Material:

Website – published after lecture



Agenda

- Lectures on Monday 3rd + 4th, and Wednesday 7th + 8th, room D
- Handout/web exercises, to be discussed during lecture
- Lab exercises / Design project
  - Competition: bonus points to be gained for best designs
  - Includes report and presentation
  - Cadence design system
  - Details will follow
- Written exam April 2
- Mark determined for 50% by exam, 50% by design project

Reading

- **Next Lecture – Chapter 2**
- **For today's lecture – Chapter 3**
- **Background – Chapter 1**