Leiden Embedded Research Center (LERC)

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LERC – Who we are

- Two senior staff members
  - Dr. Todor Stefanov (head)
  - Prof. Ed Deprettere

- Three PhD students

LERC – What we do

- Research on **Embedded Systems-on-Chip** (SoCs)
  - Methodologies, Techniques, Algorithms, and Tools for automated design of Embedded SoCs
  - Programing Techniques and Compilers for Embedded SoCs
  - Application models, system architecture models, and mapping models at various levels of abstraction

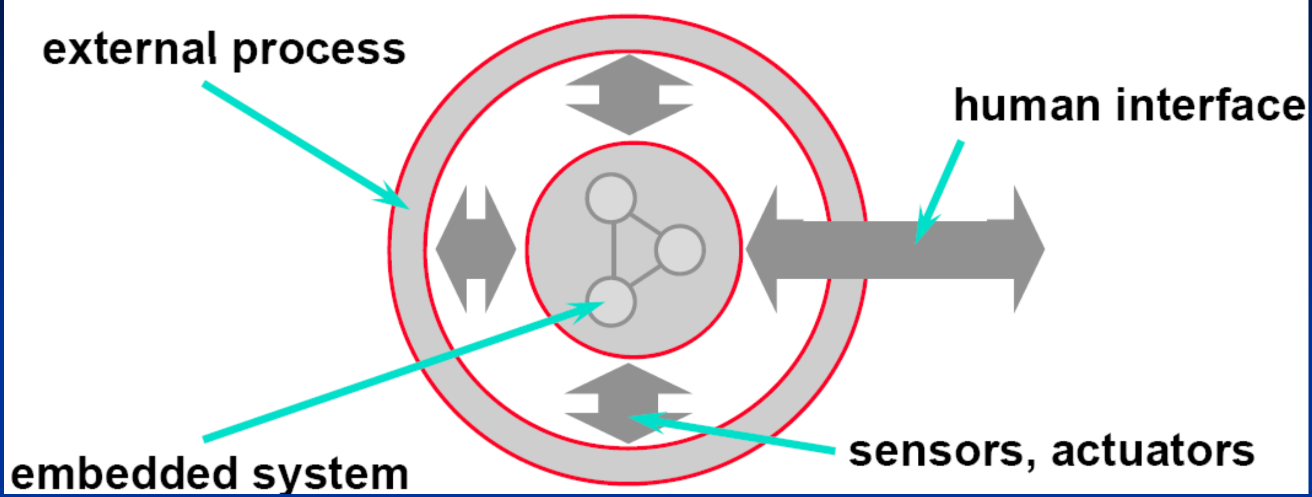
What is an Embedded System?

Embedded System = **Information processing system that is:**

- ***application domain*** **specific (*not* general purpose)**
- ***tightly coupled*** **to its *environment***
- ***embedded*** **into a larger product**

- examples of ***application domains*** - automotive electronics, avionics, multimedia, consumer electronics, etc.
- ***environment*** - type and properties of input/output information
- ***tightly coupled*** - the environment dictates what the system's response behavior must be

Embedded Systems



What they do

- **Sense** environment (input signals)
- **Process** input information
- **Respond** in real-time (output signals)

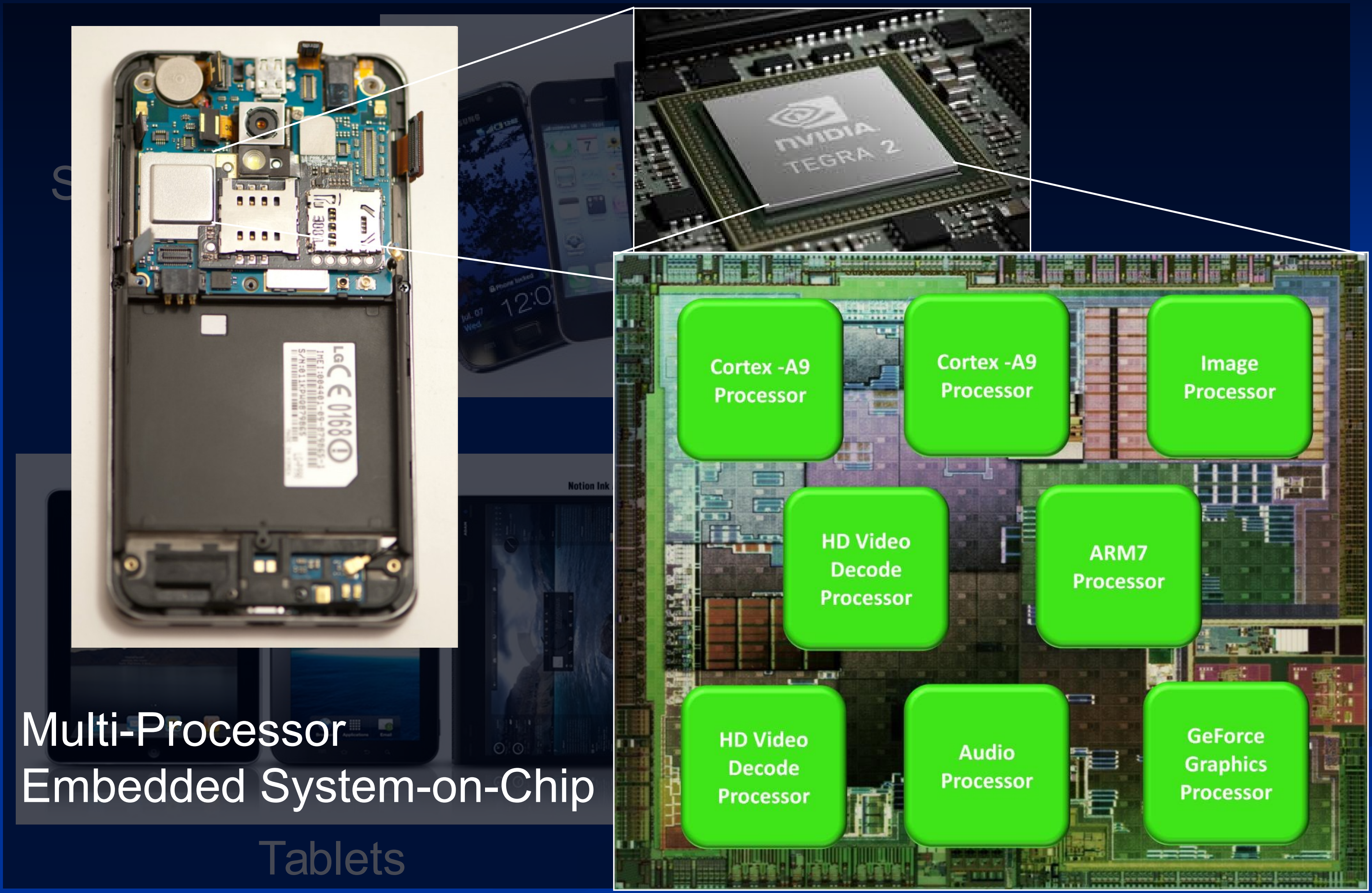
In Embedded Systems ***time matters***:

NOT in the sense that information processing should be always very fast

BUT in the sense that information processing should be:

determinate and *time predictable*

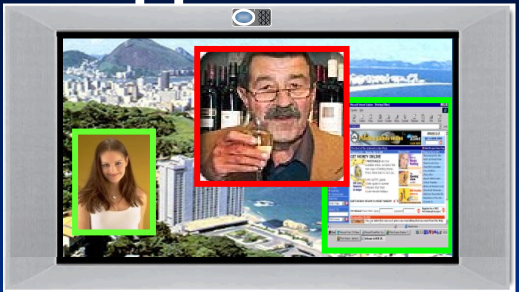
Embedded SoCs are Everywhere!



Multi-Processor
Embedded System-on-Chip

Programming problem

Application



EASY to specify

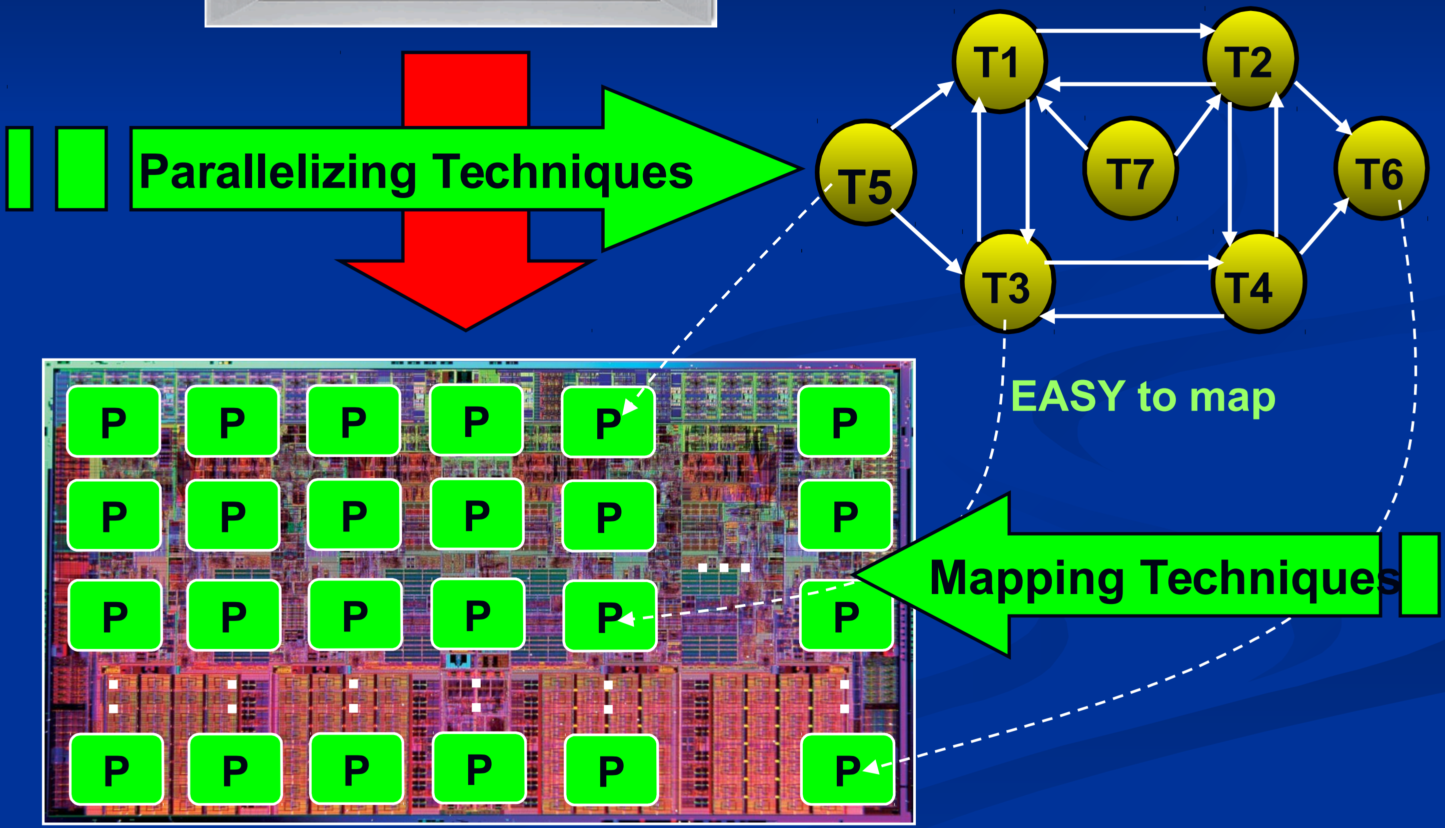
Sequential
Application Specification

```
for j = 1:1:N,
  [x(j)] = Comp1( );
end
for i = 1:1:K,
  [y(i)] = Comp2( );
end
for j = 1:1:N,
  for i = 1:1:K,
[y(i), x(j)] = Comp3(y(i),x(j));
  end
end
for i = 1:1:K,
  [Out(i)] = Comp4( y( i ) );
end
```

DIFFICULT to map

DIFFICULT to specify

Parallel
Application Specification



EASY to map

1000-Processor Embedded System-on-Chip

Directions for Bachelor projects

- Modeling, analysis, and optimizations of Embedded SoCs
  - Modeling using variety of Models of Computations
    - Process Networks, Dataflow graphs, etc.
  - Analytical or Simulation-based Analysis and Verification to check if SoC requirements are met:
    - Functional: consistency, deadlock-free, etc.
    - Non-functional: performance, power consumptions, cost, etc.
  - Single or Multi-objective Optimizations to:
    - Maximize SoC performance
    - Minimize/Maximize SoC resource utilization
    - …

Directions for Bachelor projects

- Program Code Analysis and Transformations
  - Automated parallelization of program code into tasks
  - Transformations of program code to increase/decrease parallelism (i.e. number of tasks)
- Mapping of program code onto Embedded Multi-processor SoCs
  - Efficient generation of task code for processors in C/C++
  - Efficient allocation of tasks code on processors
  - Efficient scheduling of multiple tasks on a processor
  - …

Directions for Bachelor projects

- In the projects you will gain experience with research and/or commercial tools and SW/HW platforms.
- Examples of research tools:
  - DAEDALUS (http://daedalus.liacs.nl), SDF3, …
- Example of commercial tools
  - Xilinx ISE and EDK, …
- Example of HW platforms
  - Xilinx FPGAs
  - Adapteva Parallella
  - …

Thank you