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IC-project 1
Project Proposal 2014

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Contents

- This document presents the project which will be offered in the digital track of ETIN35
- Please get an idea of the different projects and contact the project supervisor for more information
- By March 19th you need to send an email to Joachim Rodrigues where you state:
  - 1st preference
  - 2nd preference
  - Project partner

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Projects

- Matrix inversion -Steffen
- Pre-coding and Interpolation - Hemanth
- Image Processing- Oskar
- Hardware based music identifier- Babak
- Pipelined FFT for channel estimation- Rakesh
- RISC processor- Michal

Overview

- In wireless communications, especially Massive-MIMO handling large matrices is necessary
  - High computational demands
  - Data shuffling
  - Memory
- Matrix inversion based on Gaussian eliminations NOT usable
  - Inefficient
  - Needs a lot of divisions

Task

- Perform matrix inversion on a random i.i.d. 4x4 complex matrix
  - Implement different algorithms in Matlab (and maybe C)
  - Evaluate algorithms according to
    - » Memory demand
    - » Number of operations
    - » Speed
    - » Accuracy (when using fixed point)
  - Choose an algorithm and motivate why you think it is best
  - Discuss your choice with me

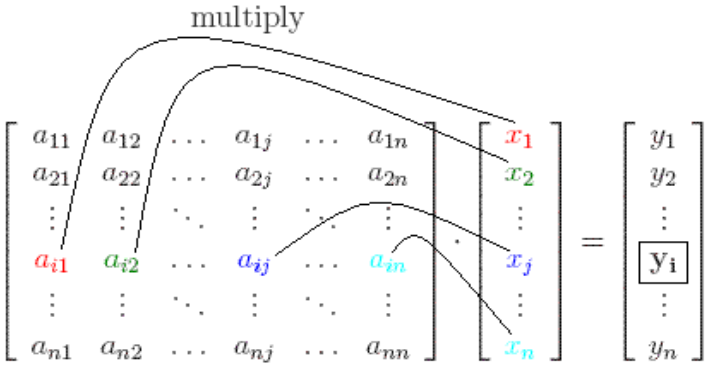
Task / Grading

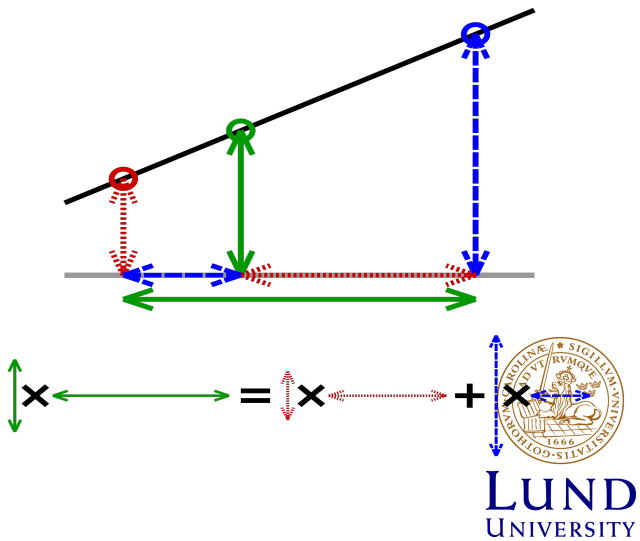
- Usable algorithms are among others
  - QR – decomposition
  - Cayley - Hamilton Theorem
  - Neumann Series Expansion
  - Block Inversion
- Implement the algorithm in VHDL and perform synthesis, place-and-route as well as power analysis
- Verify your design on an FPGA
- Grade will be either 4 or 5 depending on your implementation, report, how independent you work etc.
- Knowledge in Matlab is a prerequisite / Knowledge in C desirable

Pre-coding and Interpolation

- Hemanth Prabhu

- **In this project the students will design a pre-coder and Interpolation for large arrays.**
- **Basically requires a matrix-vector product and a linear interpolator.**
- **Student also need to build a behavioral model in catapultC.**
- **Students need to simulate BER w.r.t quantization effects, perform energy, area, latency trade-offs in hardware.**





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- **Grade 3 : Implement a flexible hardware to perform matrix-vector product, should be very generic. And also interpolate preferably linear (but open to more complex suggestions !!).**

- **Grade 4 : Implement model in CatapultC, look into systolic arrays, some design space exploration and scheduling.**

- **No Grade 5**

Image processing project:
Idea

Oskar Andersson

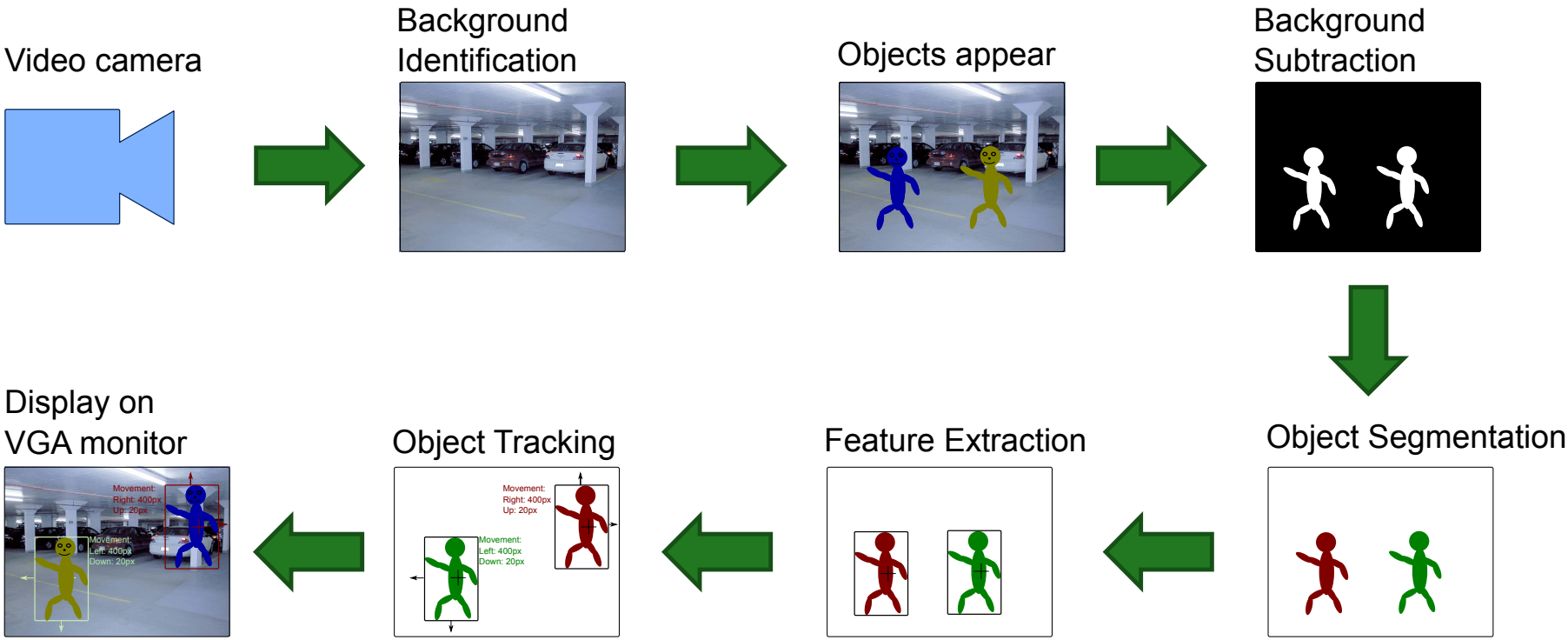

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Image processing project: Requirements

Oskar Andersson

- Grade 3:
  Object Segmentation + Feature Extraction + Display VGA

- Grade 4:
  Background Subtraction + Object tracking

- Grade 5:
  Complete system with Camera connected

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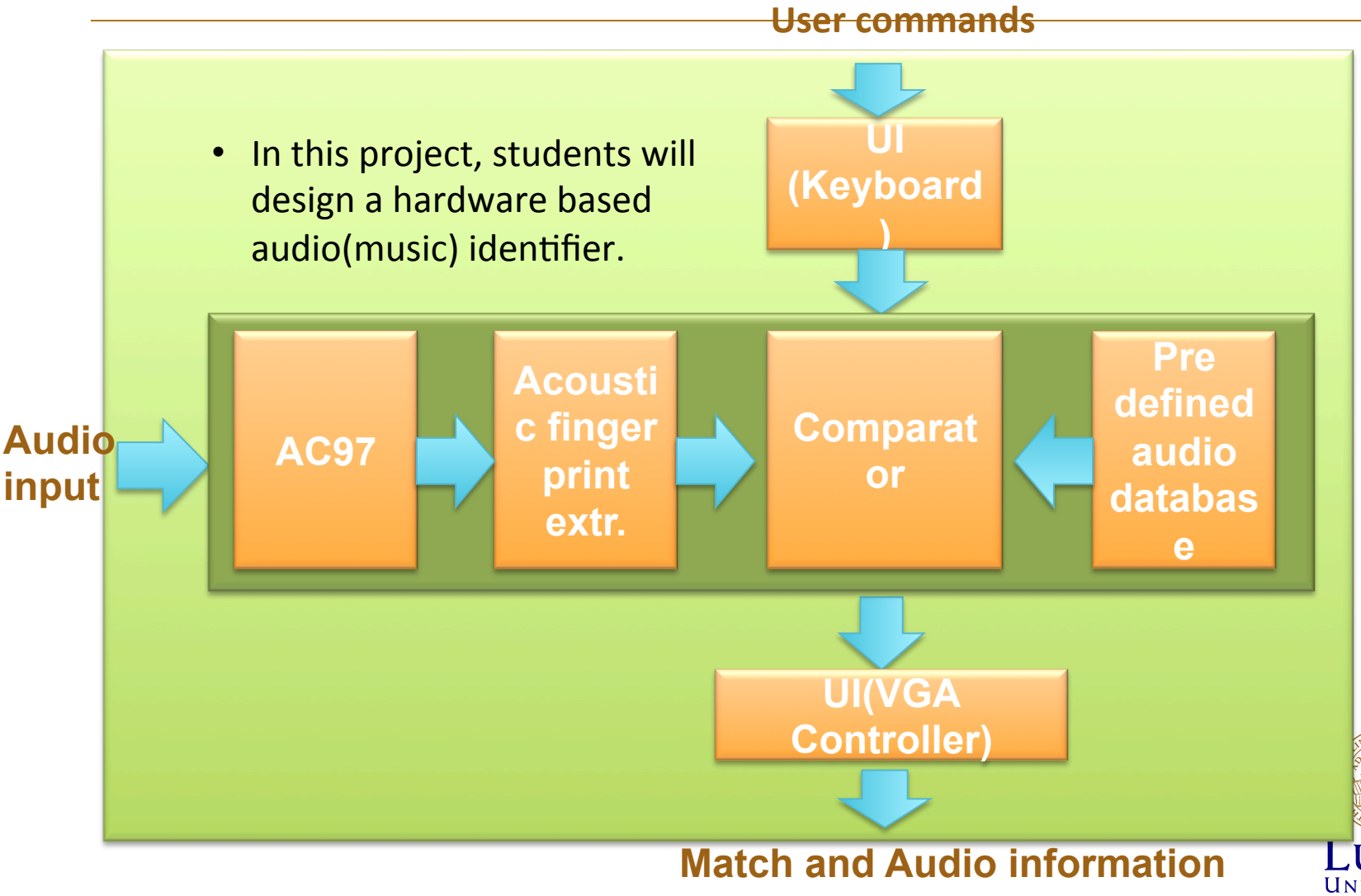
Hardware based music identifier (3/4/5)

- Babak Mohammadi



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Grading

- Grade: 3 *Mandatory:*
  - Implement an acoustic finger print extraction algorithm in HW and SW. The implementation should be able to identify the correct audios which were processed and stored in a database. A preliminary report including chosen algorithm, considered blocks, simulations and VHDL implementations should be handed in.
- Grade: 4 *Mandatory:* Tasks for grade 3 +
  - Handling anoisy input from microphone: the audio input is microphone and the audio (for example music) is played from an speaker. There are 2 persons talking in the background. The implementation should be able to recognize the original audio in the presence of noise.
  - VGA connection to a screen: showing the frequency domain visualization bars of input audio composed of 8 filters
  - PS2 connection to get the “Start listening” and “Cancel” commands from user
- Grade: 5 *Mandatory:* Tasks for grade 4 +
  - Speech recognition : The implementation should be able to recognize 2 selected words (like “hello” and “good bye” from 3 persons and be able to recognize the correct word from 2 persons. It should show the “not recognized” message for any other word.

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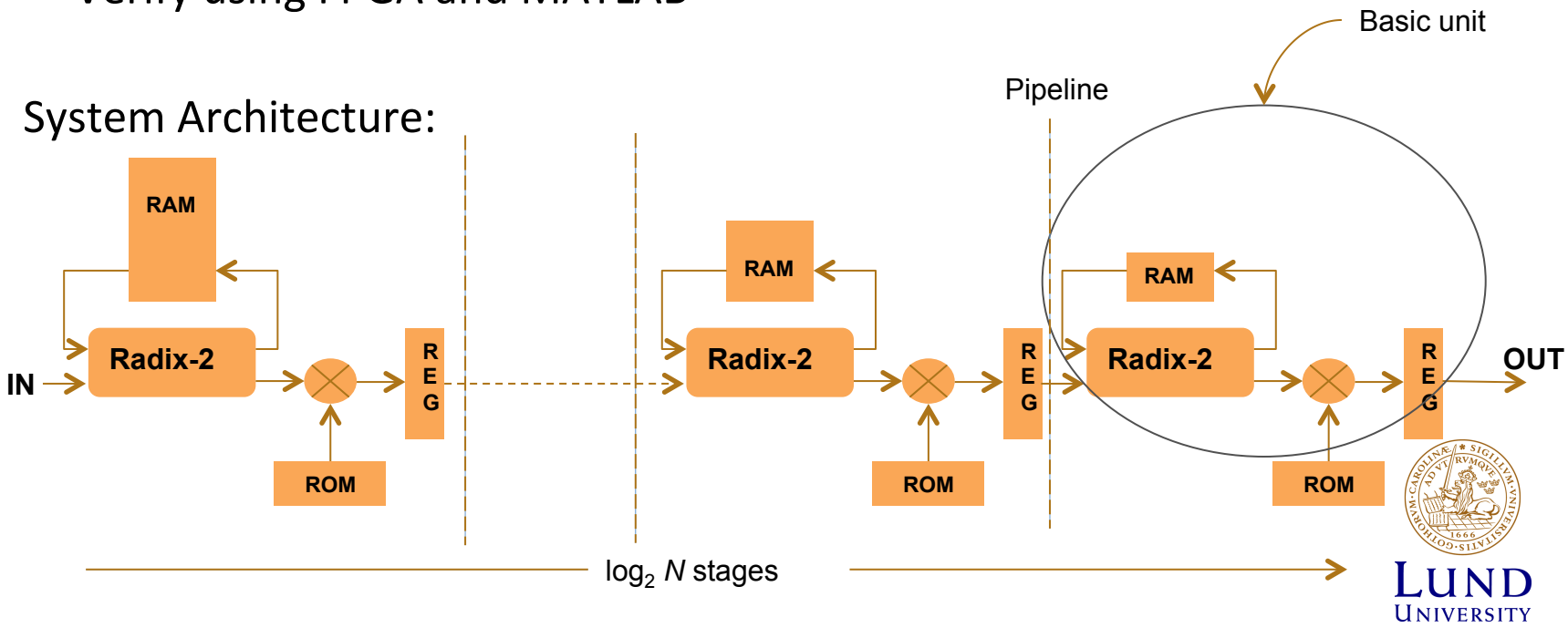
Pipelined FFT for channel estimation

- Rakesh Gangarajaiah

- Goal:
  - Design a flexible pipelined *N* point FFT for LTE channel estimation
  - Use Windowing to reduce spectral leakage
  - Enable configurability to perform partial channel estimation
  - Verify using FPGA and MATLAB

- System Architecture:



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Pipelined FFT for channel estimation

- Rakesh Gangarajaiah

- Grade 4 : Implement the pipelined FFT for 2048 points
  - Decimation in Frequency structure
  - With control for enabling other implementations such as 1024 or 128 points through clock/power gating

- Grade 5: Implement windowing to reduce spectral leakage
  - Overlap add method to remove windowing effects after FFT
    - Other techniques to remove windowing can be used
  - Implement control for producing variable number of estimates at predefined resolution.

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Mini-MIPS project-

Michal Stala

- 32-bit RISC with a subset of MIPS instructions.
- Grading:
  - Grade 4: Fully verified pipelined Mini-MIPS.
  - Grade 5: I/O console, or extended instruction set, or memory hierarchy.
- Prerequisite course:
  - EITF35 Introduction to Structured VLSI Design
  - EITF20 Computer Architecture

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Mandatory tasks

Michal Stala

- Task 1: behavior modeling
- Task 2: synthesizable pipelined implementation
- Task 3: P&R in 130 nm CMOS
- Task 4: Verification in FPGA