UNIVERSITÄT PASSAU
Fakultät für Informatik und Mathematik

Gerold Hölzl, University of Passau

EMERGING ARCHITECTURES SEMINAR – INTRODUCTION OF TOPICS

Purpose of the Seminar

- To learn how to establish an understanding of a scientific topic based on one or several research publications
- To communicate this understanding to others in oral and in written form while adhering to time and space limits.
- To conduct a scientific discussion on the topic you presented and on topics presented by others.
- This presentation: brief (!) overview of seminar requirements and of the 20 available topics.
- See the seminar description (PDF document available in Stud.IP) for exact requirements and numerous hints.

Seminar Requirements & Deadlines

1. Assignment of topics at first Meeting (see StudIP)
2. An oral presentation of 20 minutes duration about your topic followed by a discussion.
   ➔ **Block seminar at the end of semester, dates TBD.**
3. A set of slides for your presentation.
   ➔ **Due one week before presentation by email.**
4. An 8-page (hard limit) written report on your topic.
   ➔ **Due on July 2nd 08:00. by email.**
5. Attendance at presentations by others and participation in discussion.

- Optional feedback on documents sent **one week in advance.**
- See PDF document for precise grading criteria.

Scientific Context

- Small embedded systems and ever higher density of transistors call for increased energy efficiency and smaller circuits.
- Computationally complex tasks such as machine learning call for accelerated processing.
- Big Data calls for new methods for data storage.
- This seminar covers emerging architectures that tackle these problems (among others).

Examples of Emerging Architectures Applications

- Neuromorphic Computing and Realtime Processing
  - Image Processing, Speech Recognition
- Self-adaptive Computing
  - Slower Component Aging, Voltage Scaling (Energy Saving)
- Blockchain
  - Cryptocurrencies, Decentralized Libraries
- Side Channel Attacks and Protection
  - Hardware Trojans, Cache Protection
- Bio-Computing
  - Biomedical Applications, Data Storage

Neuromorphic Computing

Neural Networks can perform complex tasks such as image and speech recognition and text analysis.

Problems occurring in these networks are:

- Large amounts of data need to be processed.
- Networks may take a long time for training.

New architectures emerge in order to solve these problems.

Realtime Processing

Sensors record data that needs to be processed in realtime:

- Video Object Tracking
- Image Processing (e.g. edge detection)
- Signal Filtering (e.g. lowpass/highpass filters)

Amount of data increases, new architectures needed to satisfy realtime requirement.

Topics on Neuromorphic Computing and Realtime Processing

No	Topic, study program, literature, prerequisites
1	**Image Processing with Stochastic Computing** (Bachelor) Literature: http://ieeexplore.ieee.org/abstract/document/6560729/ Prerequisites: stochastics +, image processing +, circuit design +
2	**Hardware-Software Co-design of Automatic Speech Recognition System** (Master) Literature: http://ieeexplore.ieee.org/abstract/document/4926174/ Prerequisites: computer architecture ++, circuit design ++
3	**FAWN: A Fast Array of wimpy Nodes** (Bachelor) Literature: https://dl.acm.org/citation.cfm?id=1629577 Prerequisites: network design ++
4	**Memristor Crossbar-Based Neuromorphic Computing System** (Master) Literature: http://ieeexplore.ieee.org/abstract/document/6709674/ Prerequisites: linear algebra ++, neural networks +

Topics on Neuromorphic Computing and Realtime Processing

No	Topic, study program, literature, prerequisites
5	**Nanoscale Devices and Circuits for Neuromorphic Computational Systems** (Bachelor) Literature: http://ieeexplore.ieee.org/abstract/document/6374663/ Prerequisites: circuit design ++, neural networks +

Self-Adaptive Computing

Systems are aware of, monitor and manage themselves.

- Dynamic Voltage Scaling
- Voltage-Reliability trade-offs
- Increased energy efficiency due to lowest possible operating voltage.
- Temporarily unneeded system parts can be switched off.

Topics on Self-Adaptive Computing

No	Topic, study program, literature, prerequisites
6	**SAMR: A Self-Adaptive MapReduce Scheduling Algorithm** (Bachelor) Literature: http://ieeexplore.ieee.org/abstract/document/5578538/ Prerequisites: data processing ++
7	**A Self-Adaptive System Architecture to Address Transistor Aging** (Bachelor) Literature: https://dl.acm.org/citation.cfm?id=1874641 Prerequisites: computer engineering ++
8	**A Self-Adaptive Heterogeneous Multi-core Architecture for Embedded Real-time Video Object Tracking** (Master) Literature: https://link.springer.com/article/10.1007/s11554-011-0212-y Prerequisites: image (video) processing ++

Blockchains

A Method to manage large, decentralized networks with untrustworthy and potentially malicious members.

Many open questions, e.g.:

- How to handle scaling problems (e.g. Bitcoin blocksize)?
- How to deal with attacks from a subnetwork of malicious members?

Topics on Self-adaptive Computing

No	Topic, study program, literature, prerequisites
9	**The Quest for a Scalable Blockchain Fabric** (Bachelor) Literature: https://link.springer.com/chapter/10.1007/978-3-319-39028-4_9 Prerequisites: distributed systems ++
10	**Subversive Miner Strategies and Block Withholding Attacks in Bitcoin** (Master) Literature: https://arxiv.org/abs/1402.1718 Prerequisites: distributed systems ++
11	**Security and Performance of Proof of Work Blockchains** (Master) Literature: https://dl.acm.org/citation.cfm?id=2978341 Prerequisites: distributed systems ++, calculus +

Topics on Self-adaptive Computing

No	Topic, study program, literature, prerequisites
12	**Bitcoin-NG: A Scalable Blockchain Protocol** (Bachelor) Literature:https://www.usenix.org/system/files/conference/nsdi16/nsdi16-paper-eyal.pdf Prerequisites: distributed systems ++

Side Channel Attacks

Information about the system can leak through physical effects, e.g.:

- Temperature changes
- Energy consumption

Trojans that measure these effects can be placed during manufacturing.

Topics on Side Channel Attacks

No	Topic, study program, literature, prerequisites
13	**New Cache Designs for Thwarting Software Cache-based Side Channel Attacks** (Bachelor) Literature: https://dl.acm.org/citation.cfm?id=1250723 Prerequisites: computer architecture ++
14	**MUTE-AES: Preventing Side Channel Attacks on AES** (Bachelor) Literature: https://dl.acm.org/citation.cfm?id=1509605 Prerequisites: cryptography ++, circuit design +
15	**A High Resolution, Low Noise L3 Cache Side-Channel Attack** (Bachelor) Literature:https://www.usenix.org/system/files/conference/usenixsecurity14/sec14-paper-yarom.pdf Prerequisites: computer architecture ++

Topics on Side Channel Attacks

No	Topic, study program, literature, prerequisites
16	**Stealthy Dopant-Level Hardware Trojans** (Master) Literature: https://link.springer.com/chapter/10.1007/978-3-642-40349-1_12 Prerequisites: computer engineering ++, circuit design ++
17	**Trojan Side-Channels** (Bachelor) Literature: https://link.springer.com/content/pdf/10.1007/978-3-642-04138-9.pdf#page=396 Prerequisites: computer architecture ++, circuit design +

Bio-Computing

- DNA is an extremely dense Data storage method with a lifetime higher than classical storage mediums.
- Logical operations can also be performed with DNA.
- Proposed uses mostly in Biomedical devices.

Topics on Bio-Computing

No	Topic, study program, literature, prerequisites
18	**DENA: A Configurable Microarchitecture and Design Flow for Biomedical DNA-Based Logic Design** (Bachelor) Literature: http://ieeexplore.ieee.org/abstract/document/7956302/ Prerequisites: computer engineering ++
19	**Design of a DNA-based arithmetic and logic unit** (Master) Literature:http://digital-library.theiet.org/content/journals/10.1049/iet-nbt.2014.0056 Prerequisites: computer engineering ++, circuit design +
20	**Digital biosensors with built-in logic for biomedical applications** (Bachelor) Literature: https://link.springer.com/article/10.1007/s00216-010-3746-0 Prerequisites: computer engineering ++