Course Purpose

• To have a platform to discuss the research developments of Mobile & Cloud Lab
• Introduce students to newest concepts and advances in the respective research fields
• To give students a feel of theses topics available from Mobile & Cloud Lab
• Preliminary platform for the students to understand their prospective Master/Bachelor theses better
• Help students in preparing proper technical reports
• Help students in making proper presentations
To pass the course

• Write a report on a chosen topic
  – At least 6 pages of ACM double column format
• Peer review the work of your colleagues
• Give an oral presentation on the topic
• Demonstrate their work
• Participate actively in all the seminars
Course grading

• We will have two intermediate presentations and a final presentation
• We will grade all three presentations, Peer Review and Final Report
  – We set 3 ratings: Good (+1), Neutral (0) and Bad (-1)
• To pass the course one should score >= 2 in total
• Intermediate and final Presentations are graded for Presentation, Progress and Punctuality
Course schedule

• Monday 14.15 - 16.00, Narva mnt 18 - 2047

• Schedule of the sessions

https://courses.cs.ut.ee/2020/mcsem/spring/
Related Courses

• **LTAT.06.009** Mobile Computing and Internet of Things (6 ECTS)
  – Fall 2020

• **LTAT.06.008** Cloud Computing (6 ECTS)
  – Tue. 14:15 – 16:00, Spring 2020
RESEARCH AT MOBILE & CLOUD LAB
Cloud Computing

• Computing as a utility
  – Utility services e.g. water, electricity, gas etc
  – Consumers pay based on their usage

• Cloud Computing characteristics
  – Illusion of infinite resources
  – No up-front cost
  – Fine-grained billing (e.g. hourly)

• Gartner: “Cloud computing is a style of computing where massively scalable IT-related capabilities are provided ‘as a service’ across the Internet to multiple external customers”
Cloud based Research

• Dynamic deployment of applications on multiple clouds
  – Standardization efforts from CloudML
    [REMICS EU FP7; Srirama et al, Cloud 2016; Viil and Srirama, JSC 2018]
  – TOSCA and extensions for serverless [RADON EU H2020]
• Auto-scaling & Resource provisioning
  – Taking advantage of cloud heterogeneity
  – Cloud cost models of fine-grained billing (e.g. hourly) [Srirama and Ostovar,
    CloudCom 2014; IJCC 2018]
• Adapting data analytics problems to cloud using MapReduce [Srirama et al, FGCS 2012]
• Alternative MapReduce implementations that are designed to handle iterative algorithms [Jakovits and Srirama, HPCS 2014]
  – E.g. Twister, HaLoop, Spark
A Manifesto for Future Generation Cloud Computing: Research Directions for the Next Decade

[Buyya and Srirama et al, ACM CSUR 2019]
Further Cloud related topics

• Resource management and scheduling in cloud
  – AI based cloud management
  – Game theory based management of supercomputing center resources

• Serverless computing
  – Function as a service
  – EU H2020 RADON (Rational decomposition and orchestration for serverless computing)
    • Creating a DevOps framework to create and manage microservices-based applications
    • Tools that facilitate in designing and orchestrating data pipeline applications that involve serverless entities
    • OASIS - Topology and Orchestration Specification for Cloud Applications specification

• Sustainability in clouds
  – Dynamic allocation and reallocation of resources
  – Models for green clouds

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Further Cloud related topics - continued

• Multi-Cloud and cloud interoperability solutions
  – TOSCA and implementations such as OpenTosca, xOpera and Cloudify
Big data analytics on cloud

• QoS guarantees of streaming data
  – Dynamic allocation and reallocation of resources

• Data pipelines on the cloud
  – AWS Data pipelines
  – Apache nifi
  – Auto-scaling the data pipelines in cloud

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Mobile Application development

• Mobile is the 7th mass media
  – 6.8 bn subscriptions / Global population of 7.2 bn
• Some popular application domains
  – Location-based services (LBS), mobile social networking, mobile commerce, etc.
• Multiple languages and platforms to choose from
  – Android, Apple iOS etc.
• Real time system development
  – Mobile Apps using sensors
  – Mobiles in biometry
The devices we use
Mobile Web & Cloud based research

- **Mobile Web Services**
  - Provisioning of services from the smart phones [Srirama et al, ICIW 2006]
  - Mobile web service discovery
- **Push notification mechanisms** [Warren et al, IEEE Pervasive 2014]
- **Mobile positioning**
  - Indoor and Outdoor
- **Mobile Cloud Computing**
  - To enrich the functionality of mobile applications
  - Task delegation and code offloading
Internet of Things (IoT)

- “The Internet of Things allows people and things to be connected *Anytime, Anyplace, with Anything and Anyone*, ideally using *Any path/network and Any service.*” [European Research Cluster on IoT]
- More connected devices than people
- Cisco believes the market size will be $19$ trillion by 2025

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2/10/2020

Source: Cisco IBSG, April 2011
Internet of Things – Challenges

- **Sensors**
  - How to provide energy efficient services?

- **Tags**
  - How do we communicate automatically?

- **Mobile Things**
  - How to interact with ‘things’ directly?

- **Appliances & Facilities**

[Chang et al, ICWS 2015]

[Chang et al, SCC 2015; Liyanage et al, MS 2015]
Cloud-based IoT

Remote Cloud-based processing

Connectivity nodes & Embedded processing

Sensing and smart devices
Research focus in IoT

• We have established IoT and Smart Solutions Lab with Telia company support

• Interesting topics
  – Discovery of IoT devices
  – Working with IoT based devices
  – Study of available IoT platforms
    • Amazon IoT
    • Open IoT
    • OpenHAB

• IoT-based smart cities
IoT Data Processing on Cloud

• Enormous amounts of unstructured data
  – In Zetabytes ($10^{21}$ bytes) by 2020 [TelecomEngine]
  – Has to be properly stored, analysed and interpreted and presented

• Big data acquisition and analytics
  – Is MapReduce sufficient?
    • MapReduce is not good for iterative algorithms [Srirama et al, FGCS 2012]
  – IoT mostly deals with streaming data
    • Message queues such as Apache Kafka can be used to buffer and feed the data into stream processing systems such as Apache Storm
    • Apache Spark streaming

• Edge analytics

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Issues with Cloud-centric IoT

- Latency issues for applications with sub-second response requirements
- Certain scenarios do not let the data move to cloud
- Fog computing [Chang et al, AINA 2017; Mass et al, SCC 2016]
  - Processing across all the layers, including network switches/routers
- Edge process management [Mass et al, IoTJ 2019]
Ongoing Research in Fog Computing

- Mobility, task offloading, discovery, scalability and containerisation
  
  [Soo et al, IJMCMC 2017]

- QoS & QoE-aware application placement across Fog topology
  
  [Mahmud et al, JPDC 2018, JPDC 2020; Adhikari et al, IEEE IoTJ 2020]

QoE – Quality of Experience

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Research Roadmap – IoT & Fog Computing

Distributed data processing on the Cloud
E.g. MapReduce, Spark

Distributed data processing across the Cloud and Fog layers
E.g. Personalized data, privacy etc.

Fog topology management and scheduling the tasks
E.g. tasks run across the fog topology such as stream data processing, smart streetlights etc.

Edge analytics
E.g. filter, error detection, consolidation etc.

Intelligent sensors
E.g. vehicular networks

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WE ALWAYS WELCOME NEW IDEAS!

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Seminar topics

• Listed at https://courses.cs.ut.ee/2020/mcsem/spring/Main/Topics

• Session 2 (17.02)
  – Second meeting to finalize the topics

• Selection of topics should finish by Wed., 19th Feb 2020
  – Email srirama@ut.ee, and your topic supervisor

• Session 3 (24.02) - Presentation by students about their topics
  – 5 min per person - Backed by slides
  – A page of abstract about the selected project
THANK YOU