Mobile and Cloud Computing Seminar

MTAT.03.280

Spring 2017

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Mobile & Cloud Lab
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

• Thursday 14.15 - 16.00, Ülikooli 17 - 218

• Schedule of the sessions

https://courses.cs.ut.ee/2017/mcsem/spring
Related Courses

• **MTAT.08.027** Basics of Cloud Computing (3 ECTS)
  – Tue. 10.15 – 12.00, J. Liivi 2 - 402

• **MTAT.08.036** Large-scale Data Processing on the Cloud (3 ECTS)
  – Fall 2017

• **MTAT.03.266** Mobile Application Development Projects (3 ECTS)
  – Thu. 16.15 - 18.00, Ülikooli 17 - 218

• **MTAT.03.262** Mobile Application Development (3 ECTS)
  – Fall 2017
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

• We are one among the top 10 producers of cloud based research results [Heilig and Voß, TCC 2014]

• Migrating enterprise applications to the cloud
  – Optimal Resource Provisioning for Scaling Enterprise Applications on the Cloud
  – Based on LP mathematical model
CloudML

• Deployment description of cloud based applications [REMICS]
  – Developed to tame cloud heterogeneity
• DSL based on Java-based metamodel
  – Nodes, artefacts and bindings can be defined
• Different means to manipulate CloudML models
  – Programmatically via Java API
  – Declaratively, via serialized model (JSON)
• Models@Runtime
  – Dynamic deployment of CloudML based models
Scientific Computing on the Cloud (SciCloud)

• Scientific computing is usually associated with large scale computer modeling and simulation
  – Usually requires large amounts of computer resources

• Clouds promise virtually infinite resources
  – Probably good for HPC!!! Are they?

• Scientific Computing on the Cloud
  – Benefit from Cloud characteristics like elasticity, scalability and software maintenance
  – Cost-to-value of the experiments
SciCloud – continued

• Project established at University of Tartu in 2009 [Srirama et al, CCGrid 2010]

• Studied migrating and adapting scientific computing applications to the cloud
  – Migration of several benchmarks like NAS PB and domain specific applications [Srirama et al, SPJ 2011]
  – Adapt applications using MapReduce to successfully exploit the cloud’s commodity infrastructure [Srirama et al, FGCS 2012]
Communication pattern of Cluster vs Cloud

- Cloud has huge troubles with communication/transmission latencies
  - Virtualization technology is the culprit
- Performance Comparison of virtual machines and Linux containers (e.g. Docker)

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2/9/2017 Satish Srirama 14/31
Migrating Scientific Workflows to the Cloud

• Scientific Workflows have lately become a standard
  – Used for managing and representing complicated scientific computations

• Data and processes are brought together into a structured set of steps

• Each computation may contain thousands of tasks
  – Tasks are executed, in an order, on top of programs such as Pegasus or Kepler

• A lot of data is exchanged across these tasks/jobs
  – So migrating scientific workflows to cloud is a trouble !!!
Approach

• Problem: How to reduce the data exchange across tasks so that cloud can be exploited?

• Solution: Partitioning and scheduling scientific workflows
  – in such a way that it increases the intra-instance communication while reducing inter-instance communication
The Overall Migration Process

- Can we partition and schedule enterprise applications/workflows in this model and join our auto-scale models?
- Refactoring enterprise applications for the cloud

[Srirama & Viil, HPCC 2014]
Adapting Scientific Computing Application for Cloud Migration

• Research the utilization of cloud computing platforms for HPC

• Compare different Cloud computing frameworks for algorithms used in scientific computing
  – MapReduce
    • Replicate data and computation
  – MapReduce implementations
    • Hadoop
    • Twister
    • Spark
  – Bulk Synchronous Parallel (BSP)
    • Fault-tolerance (NEWT)
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, Windows Phone 7 etc.

• Real time system development
  – Mobile Apps using sensors
  – Mobiles in biometry
The devices we use
Mobile Web Services

- Provisioning of services from the smart phones
- Invocation of web services from smart phones
- Mobile web service discovery
- Addressing mobiles in 3G/4G networks
- Push notification mechanisms
- Mobile positioning
  - Indoor and Outdoor

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Mobile Cloud Computing

• One can do interesting things on mobiles directly
  – Today’s mobiles are far more capable
  – We can even provide services from smart phones
• However, some applications need to offload certain activities to servers
  – Processing sensor data
• Resource-intensive processing on the cloud
  – To enrich the functionality of mobile applications
Mobile Cloud Access Schemes

[Flores & Srirama, JSS 2014]

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Code offloading

• Decision making
  – When is it ideal to offload a task from mobile to cloud?
  – Fuzzy logic
  – Linear Programming

• We also think the decision making should be a continuous learning process
  – Machine learning
Adaptive Workflow Mediation Framework

• Task delegation is a reality!!!
  – Cloud providers also support different platforms
• Mobile Host allows invocation of services on smartphones
• So Peer-to-Peer (P2P) communication is possible
• Extended the Mobile Host to also support workflow execution [Chang et al, ICSOC 2012; MUM 2014]
  – To address challenges of discovery and quality of service (QoS) [Srirama et al, MW4SOC 2007]
  – Tasks can move between mobile and middleware

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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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IoT - Scenarios

- Environment Protection
- Smart Home

[Kip Compton]
[Perera et al, TETT 2014]

Internet of Things – Challenges

How to provide energy efficient services?

How do we communicate automatically?

How to interact with ‘things’ directly?

Sensors

Tags

Mobile Things

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 for the semester 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

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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

• How to ensure QoS aspects such as security of data?
  – Anonymization and Expiry of data?
    • Especially for the personal data

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Research Roadmap - IoT

Energy-Efficient and Cost-Efficient Connected Things

Reliable Adaptive Middleware

Big Data Acquisition & Analytics

Domain Specific Service Provisioning

- Smart Healthcare;
- Environmental Monitoring;
- Smart Cities etc.

- Elastic Cloud Processing;
- MapReduce & Apache Hadoop Ecosystem;
- Machine Learning;
- Stream Data Processing;
  - Service-Oriented Computing;
  - Process Management;
  - IoT Platforms & Fog Computing;
- Mobile Computing;
- Wireless Sensor & Actuator Networks;
Fog Computing

Public Cloud
- Distanced Computational & Storage Offloading

Private Cloud
- Near-field Computational Offloading (another form of MEC)

Cloudlet VM
- Proximity based Computational Offloading

MEC
- Collaborative Mobile Sensing

D2D
- Proximity-based Mobile Computing

OppNet
- Real-time Opportunistic Information Sharing

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WE ALWAYS WELCOME NEW IDEAS!
Seminar topics

• Listed at [https://courses.cs.ut.ee/2017/mcsem/spring/Main/Topics](https://courses.cs.ut.ee/2017/mcsem/spring/Main/Topics)
• Session 2 (16.02)
  – Second meeting to finalize the topics
• Selection of topics should finish by Mon., 19th Feb 2017
  – Email srirama@ut.ee, and your topic supervisor
• Session 3 (22.02) - Presentation by students about their topics
  – 5 min per person - Backed by slides
  – A page of abstract about the selected project