

# CS5224: Cloud Computing

AY2019/20 – Semester 2



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# My Interests

**Research:** modelling (performance and simulation),  
parallel computing (cloud, edge)

**Teach:** Parallel Computing, Cloud Computing,  
Computer Systems Performance Analysis, ...

## Best Paper Awards

1. L. Birdsey, C. Szabo and Y.M. Teo, **Twitter Knows: Understanding the Emergence of Topics in Social Networks**, Proc of Winter Simulation Conference, IEEE Computer Society Press, US, Dec 6-9, 2015. **[WSC 2015 Best Paper Award]**
2. M. Mihailescu and Y.M. Teo, **Strategic-Proof Dynamic Resource Pricing of Multiple Resource Types on Federated Clouds**, Proc of 10th International Conference on Algorithms and Architectures for Parallel Processing, Busan, Korea, May 21-23, 2010. **[Best Paper Award]**
3. C. Szabo, Y.M. Teo and S. See, **A Time-based Formalism for the Validation of Semantic Composability**, Proc of the Winter Simulation Conference, pp 1411-1422, IEEE Computer Society Press, Austin, Texas, USA, December 13-16, 2009. **[ACM SIGSIM Best PhD Student Paper Award]**

# Research

## modelling

### performance

*time, energy & cost - multi-core, cluster, heterogeneous systems, cloud and edge computing*

1. **Design and Development of a Comprehensive IT Infrastructure for Data-intensive Applications and Analysis**, \$10m, NRF grant, Nov 2012 (5-yr)
2. **On Understanding Elastic Algorithms for Cloud Computing**, MoE exploratory grant, Mar 2016 (2-yr)
3. **Performance Analysis of Petascale Systems**, Sun Microsystems Research Award, \$400K, 2007 – 2013.

### simulation

*formalizing emergence, social interactions*

1. **National Cybersecurity R&D Lab**, \$8.5m, NRF grant, Nov 2015 (4-yr) [insider threats (*social interactions* and human behavior) and security vulnerabilities]
2. **Factoring Emergence in Simulation Modeling & Analysis**, MoE grant, Jul 2013 (3-yr)
3. **Modeling and Validation of Emergent Properties in Complex Systems**, MoE, Dec 2011 (3-yr)

# Cost of Computing

Computer prices, cost/MHz					
	1970	1984	1997	2007	2019
Cost (US\$)	4.6m	4K	1K	550	570
speed (MHz)	12.5	8.3	166	1600	4100
Cost/MHz	368K	482	6	0.34	0.14



IBM Mainframe  
Computer 1970

Dell Small  
Desktop  
3470

Amazon AWS (2019)  
\$0.01 to 0.27 per hour

# Cloud Computing



[course page](#)

# Learning Objectives

1. Explains and discusses fundamental aspects of cloud computing **concepts, models, technologies** and **applications**
2. Hands-on: IBM Cloud and Amazon Web Services with examples in developing applications using IaaS, PaaS and SaaS
3. Develop business case for cloud computing application

# Learning Objectives

1 Explains and discusses fundamental aspects of

- Class with varied knowledge – MComp, MSBA, graduate, undergraduate, ..
- Introductory module
- Teaching mode: lectures, programming assignments (IBM Cloud and Amazon AWS), group project (develop SaaS application that puts all you have learnt together)

computing

# What will we cover?

## **A. PRINCIPLES OF CLOUD COMPUTING**

L01: Introduction

L02: Concepts & Models

L03: Cloud Architecture

L04: IBM Cloud Services (PaaS, SaaS)

## **B. TECHNOLOGIES BEHIND CLOUD COMPUTING**

L05: Resource Hosting and Datacenter

L06: Virtualization & Multitenancy

## **C. APPLICATIONS & PROGRAMMING**

L07: Applications & Paradigms

L08: Amazon Web Services (IaaS, PaaS, SaaS, FaaS)

L09: Examples: K-means Clustering & SaaS Video-Sharing

L10: Cloud Software Development

## **D. CLOUD MANAGEMENT**

L11: Pricing Models and Modeling TCO

## **E. SUMMARY & CONCLUSION**

L12: Summary and Open Issues



# Course Schedule & Webpage

- Lecture: Mon, 6.30-8.30pm+1, I3-AUD
- Tutor: Zhang Han (Com 2, #B1-01)
- Consultation:
  - Wed 2-3pm (Yong Meng)
  - Thu 1-3pm (Han)
- Webpage:
  - Luminus for course announcement
  - [www.comp.nus.edu.sg/~teoym/cs5224-20](http://www.comp.nus.edu.sg/~teoym/cs5224-20) for lecture slides, assignments, etc.



# Luminus Forum

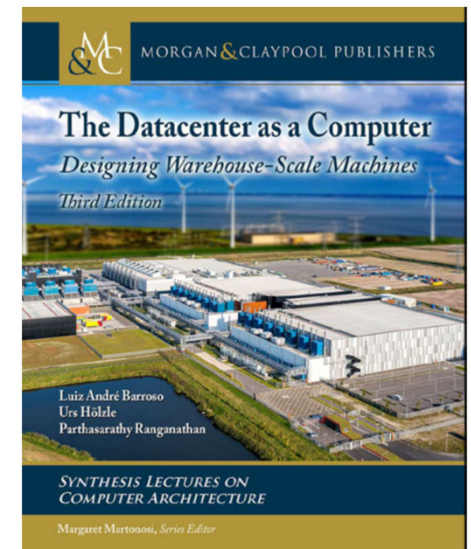
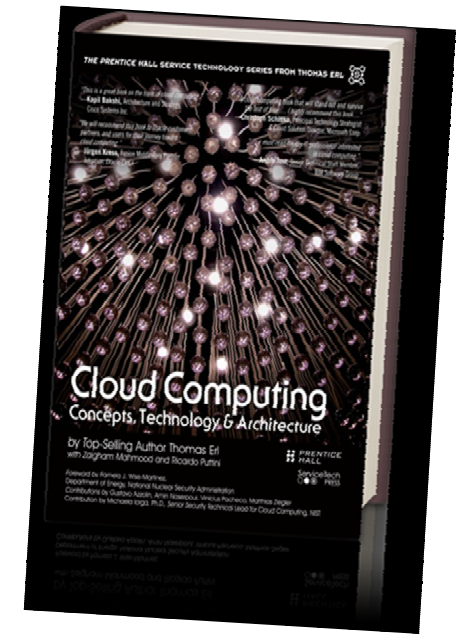
Additional avenue for discussion - using cloud services, assignments, project, etc

Please post to the respective forum pages:

1. IBM Cloud
2. Amazon Web Services
3. Assignments & Project

# Main Text

1. *Cloud Computing: Concepts, Technology & Architecture*, Thomas Erl, et al., Prentice-Hall, 2013, 2 copies at RBR in Central Library. [chapters 3, 4, 5, 11, 15 & 16]
2. *The Datacenter as a Computer – Designing Warehouse-Scale Machines*, 3<sup>rd</sup> Edition, Morgan & Claypool Publishers, 2019 (available online) [chapters 1, 2, 3, 4, 6]



# Module Assessment

## 100% CA

- Programming Assignment 1: IBM Cloud (individual): 10%
- Programming Assignment 2: AWS (individual): 10%
- Project (group): 30%
  
- Quiz (closed book): 20%
- Test (closed book): 30%

# Questions

## 1. programming

- objective: concepts + practice (service & deployment models, design & implement cloud applications, ...)
- learning by examples, focus on problem (not programming)
- programming: heavy-duty programming, more specific on this, amount of programming in business case .....
- jumpstart through self-learning hands-on: IBM Cloud (PaaS, SaaS) and Amazon EC2 (IaaS, PaaS, SaaS)
- project: form team (4) that leverage on the class with diverse knowledge and expertise
- **bottom-line: do not like programming, this may not be for you**

## 2. choices of cloud platforms

- why not Microsoft Azure, Google cloud, ....
- lack of cloud interoperability standards, etc