CS 839: Design the Next-Generation Database
Lecture 1: Introduction

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Who am I?

Xiangyao Yu

- Pronounced like Shiang-Yao Yu.

Assistant Professor in Computer Science

PhD (in computer architecture) and postdoc (in databases) at MIT

Research interests:

- Transaction processing
- New hardware for databases
- Cloud databases
Today’s Agenda

What is this course about?

Course logistics

Class projects
A brief history of database systems
Single-Core, Disk-Based (1970s – 2000s)

- Data stored in HDD
- Main memory is a “cache”
- Timesharing across users
Distributed, Disk-Based (1980s – 2000s)

Shared-nothing architecture

Servers communicate over network

Can scale out to thousands of servers
Multicore, In-Memory (2000s – today)

Data stored in memory
- Memory is cheaper
- Memory capacity increases
What Is Next?

1. New processing units:
   - Multicore
   - GPU
   - FPGA
   - Accelerator

2. New memory/storage:
   - SSD
   - NVM
   - HBM

3. New network technology:
   - RDMA
   - SmartNIC

4. Cloud architecture:
   - Disaggregation
   - FaaS
What Is Next?

1. New processing units:
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Next-generation databases have new hardware and system architecture

3. New network technology
   - RDMA
   - SmartNIC

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   - FaaS
1. New Processing Units

Multicore

GPU

FPGA, accelerator
1. New Processing Units – Multicore CPU

Core count will continue increasing -> scalability challenges
1. New Processing Units – GPU

Graphics processing units (GPU) have massive parallelism but limited memory capacity.
1. New Processing Units – Accelerators

Accelerators are effective for compute bound applications.
2. New Memory/Storage

- Non-volatile memory (NVM)
- High Bandwidth Memory (HBM)
- Process in Memory (PIM) / Smart SSD
2. New Memory/Storage – NVM

INTEL® PERSISTENT MEMORY BASED ON 3D XPOINT™

- **DRAM**
  - Fast, Volatile, Expensive
- **NAND**
  - Slow, Persistent, Cheap

**3D XPOINT™**
- Fast, Persistent, High Density

**VALUE ACROSS A RANGE OF WORKLOADS**
- Big Data Analytics
- In-Memory Databases
- Cloud & VMs
- AI Training
- HPC

**INDUSTRY SUPPORT**
- Microsoft
- ORACLE
- SAP
- VMware

**LAUNCH ON TRACK**
- 2H'2018

Other names and brands may be claimed as the property of others.
High bandwidth memory (HBM) has much higher bandwidth than DRAM
2. New Memory/Storage – PIM/SmartSSD

Pushing computation closer to data -> reduces data movement
3. New Network Technology

Remote direct memory access (RDMA)

Smart NIC
Remote direct memory access (RDMA) networks reduce latency
3. New Network Technology – Smart NIC

Pushing computation into the network
4. Cloud Architecture

- Resource disaggregation
- Function-as-a-Service

Current Datacenter: Server-Centric

Future datacenter: Disaggregated?
4. Cloud Architecture – FaaS

<table>
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<th>PaaS (Platform as a Service)</th>
<th>FaaS (Function as a Service)</th>
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Managed by the customer: Green
Managed by the provider: Blue
Next-generation databases have new hardware and system architecture.

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Goals

If you work on databases:
   Take this course to learn future database systems/hardware

If you work on computer architecture:
   Take this course to get familiar with an important application

Otherwise:
   Take this course to learn both fields
Grading

- Paper review: 20%
- In-class discussion: 20%
- Project proposal: 15%
- Project final report: 30%
- Project presentation: 15%
Lecture Format

Syllabus:  
pages.cs.wisc.edu/~yxy/cs839-s20/

Reading: 1 paper per lecture (can skip 3 times)
Upload review to https://wisc-cs839-ngdb20.hotcrp.com before 9am

BONUS: review for optional papers

40 min: Instructor presents the paper
30 min: Group discussion, submit discussion summary
Group Discussion

Discuss the provided topics
• What if we relax assumption X?
• What if metric Y of the hardware improves?
• How does the technique extend to application Z?

Share conclusions with the class

Summarize your discussion and upload to https://wisc-cs839-ngdb20.hotcrp.com

Brainstorm ideas for the course project
Course Project

In groups of 2—4 students

Option 1: Research project towards top conference paper
Option 2: Survey for a particular area

A list of project ideas will be provided
Encouraged to propose your own ideas
Resources

CloudLab


Chamelecon

https://www.chameleoncloud.org

Email me if you need special hardware (e.g., GPU, NVM, RDMA, etc.)
Deadlines

Form groups: **Feb. 27**

Proposal due: **Mar. 10**

Paper submission: **Apr. 23**

Peer review: **Apr. 23 – Apr. 30**

Presentation: **Apr 28 & 30**

Camera ready: **May 4**
Before next lecture

[optional] Submit review for

What's Really New with NewSQL?