Databases in the cloud, they will be different.

Gustavo Alonso
Systems Group
Department of Computer Science
ETH Zurich, Switzerland
Systems Group@ETH

www.systems.ethz.ch
What is the cloud?

Primarily a change in business model
- A shift from manufacturing to services
What is big data?

Primarily a change in business model

- A shift toward customization and personalization of “services”
What does it all mean?

• General purpose no longer the overall trend
• Many applications with enough value to justify customization
• Customization can be achieved by combining standard elements
• Customization supported by abundant surplus computing power
Specialization is the name of the game - also in the cloud
The role of hardware

• Oracle RAPID: High scale parallel data processor
• Microsoft Cypherbase: FPGA for encrypted database processing in the cloud
• Microsoft Catapult: FPGA acceleration for search tasks (page rank like algorithms)
• Intelligent storage systems: NetApp, Oracle, ...
• Intel HARP, IBM’s CAPI, ...
• HPC has been doing this for years ...
How will databases be different?
1. The Network
2. The Processing
3. The Processors
Multicore vs cluster

Barthels et al., SIGMOD’15
Scalability through more, smaller machines rather than through large, multi-socket machines = fast networks, RDMA
Short term (forget TCP)

Software Defined Networks

Optimized application level protocols for data centers
Proof?

Consensus in a Box, Istvan, Sidler, et al. NSDI’16
Long term (forget the computer)

If the network latency and the bandwidth significantly increase: **disaggregation**

HP “The machine” based on optical networks
1. The Network
2. The Processing
3. The Processors
Data movement is bad

It costs energy
It takes time
Bandwidth bottlenecks (I/O, network, cache hierarchies, etc.)

Solution:
use hardware to process data in place or as it flows
IBEX (Woods, VLDB’14; Istvan, SIGMOD’14)
A processor on the data path
A variety of operators

CPU bound operators on accelerators

• Skyline (FCCM’13)
• Complex Event Detection (PVLDB’11)
• Histogram calculation (SIGMOD’14)
• Aggregation (PVLDB’14)
• Simple statistics (PVLDB’09)
Sounds good?

Imagine the same at all levels:

- Smart storage
- On the network switch (SDN like)
- On the network card (smart NIC)
- On the PCI express bus
- On the memory bus (active memory)

Every element in the system
(a computer rack)
will be a processing component
1. The Network
2. The Processing
3. The Processors
The architecture of co-processing

- **GPU**
  - Parallelism
  - Floating point

- **CPU**
  - Memory bandwidth
  - Deep pipeline
  - Multithreading
A processor far, far away …

A co-processor (GPU, Xeon Phi, FPGA) on a PCI bus works only when:

• Load is computationally bound
• Load remains computationally bound on the co-processor
• The data movement cost is less than the performance gain in the co-processor vs the CPU

Relational operators are often memory bound …
Heterogeneous multicore

INTEL HARP Program

DISCLAIMER: this is pre-production hardware and software, and may not reflect the performance of production or future systems.
User Defined ... Hardware

User Defined Functions extend the functionality of a database

Imagine the same but in hardware (extending performance or functionality)

Perform operations on relational data that no database has ever done before: Skylines, Monte-Carlo, pattern matching, clustering, complex text search, advanced statistics, learning, ...
The End
The agenda ahead of us

• Very interesting times
  • Many opportunities driven by hardware
  • Plenty of use cases justifying specialization

• Many challenges
  • Hardware changes affect the whole stack
  • How to program heterogeneous architectures

• Think beyond one machine
  • Racks, clusters, data centers
  • Pay attention to developments in computer architecture and networking