The Magic of the Cloud: Supercomputers for Everyone, Everywhere

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Personal Computer
Many Applications

Office Applications

Math & Science

Databases & Storage
The Internet & E-Mail

The Internet

Packet networking
Domain names
Protocols (TCP/IP)
The Internet & E-Mail

The Internet

E-mail readers
E-mail servers
The Internet & E-Mail

The Web

Mosaic
The Internet & E-Mail

The Web

Netscape
The Internet & E-Mail
Browser: Universal Client

The Web

Hotmail
Gmail
Yahoo! Mail
Browser: Universal Client

The Cloud

Databases
High Performance Computing
The Cloud: 1.6B Users
The Cloud: Everywhere

Wireless
The Cloud: Everywhere

Wireless

Wireless Protocols
Coding Theory
CMOS Radios
The Cloud: Everywhere
The Cloud: Everywhere

Operating System
Sensors
Multipoint Interface
The Cloud: Groups

- Facebook, Twitter, Skype
- Games, Recommendations/Reviews
The Cloud: Servers
The Cloud: Servers
The Cloud: Clusters
The Cloud: Clusters

Cluster Computing
Scalable Search Engines
The Cloud: Clusters

- Scalability: > 10B pages/day
- Cost effective (commodity servers)
The Cloud: Clusters

- Highly available
- Largest supercomputers
The Cloud: Clusters
The Cloud: Virtual Machines

- Makes servers interchangeable
The Cloud: Virtual Machines

- Makes servers interchangeable
- Supports all the applications
The Cloud: Elasticity

Nearly infinite capacity as needed
The Cloud: Scale

1700 CPUs, 3400GB
The Cloud: Scale

125,000 CPUs
250,000 GB
Some Opportunities
Software Engineering

Cloud is much too dynamic!
- Doesn’t need to perfect 1\textsuperscript{st} time
  - New version every day
  - Test versions on random users
- “Agile” rapid processes win

Accelerates innovation:
- Low capital, rent capacity on demand
- Build a new site by yourself in one day
  - And it will scale as needed!

Need to rethink Software Engineering
Energy

The Cloud uses tremendous energy
  – Already 0.5% of global carbon footprint
  – And fastest growing segment

... but easier to optimize
  – Move cloud near power sources
  – Co-design power & cooling
  – Redesign servers, processors, networks, ...

Energy can be a Big Win
Security & Privacy

The Cloud stores all your Data
- And what you do online
- And enables deep analysis & correlation
- ... forever into the future

Research can make a difference:
- How to detect/prevent/track leaks?
- How to enforce deletion?
- What rights should you have?

Great Risk & Great Opportunity
Enabling the Future

Supercomputers for everyone, all the time

... but need rural broadband access

Rethink most of life:

- Health Care: new capabilities meets privacy
- Education: supercomputer for every student
- Science: a revolution in science
  - Grand scale simulation, e.g. climate modeling
- Productivity: US leads the Cloud Revolution

$ A Historic Shift in is Progress $