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

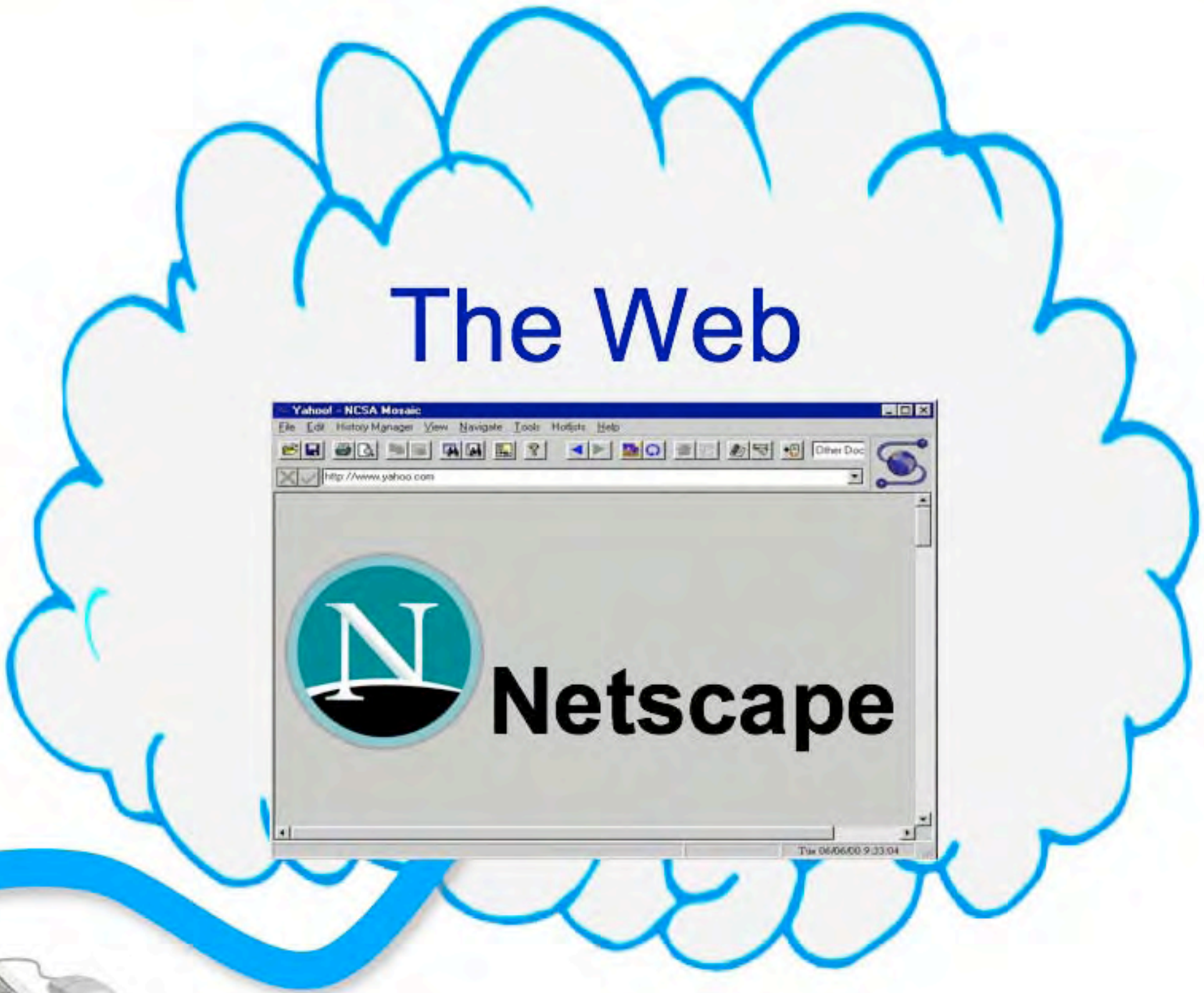
The Internet

Packet networking
Domain names
Protocols (TCP/IP)

The Internet & E-Mail

The Internet & E-Mail

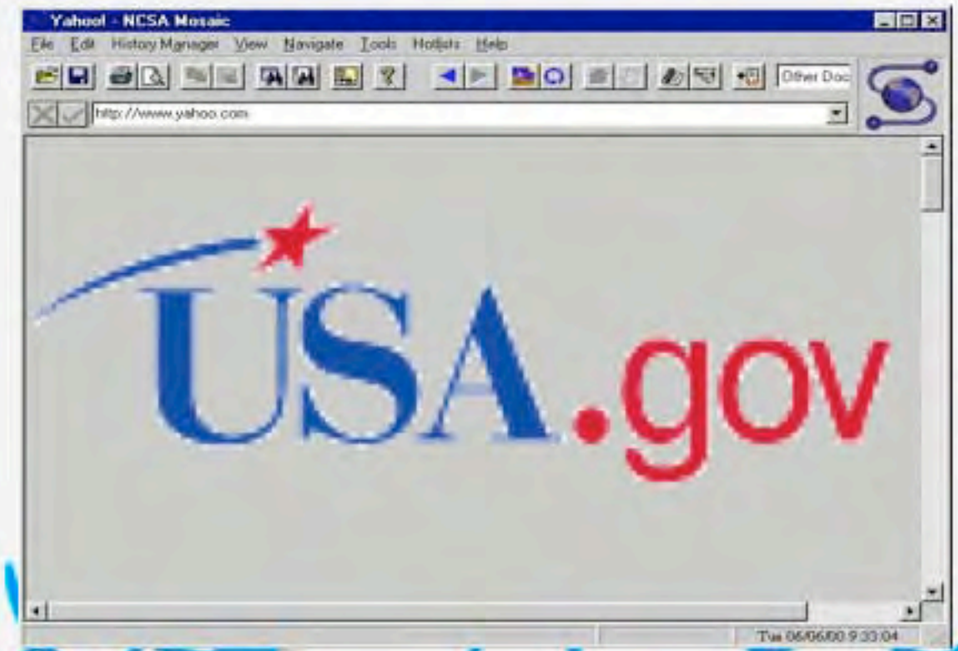
The Internet & E-Mail



The Internet & E-Mail

Browser: Universal Client

The Web



Browser: Universal Client

Browser: Universal Client

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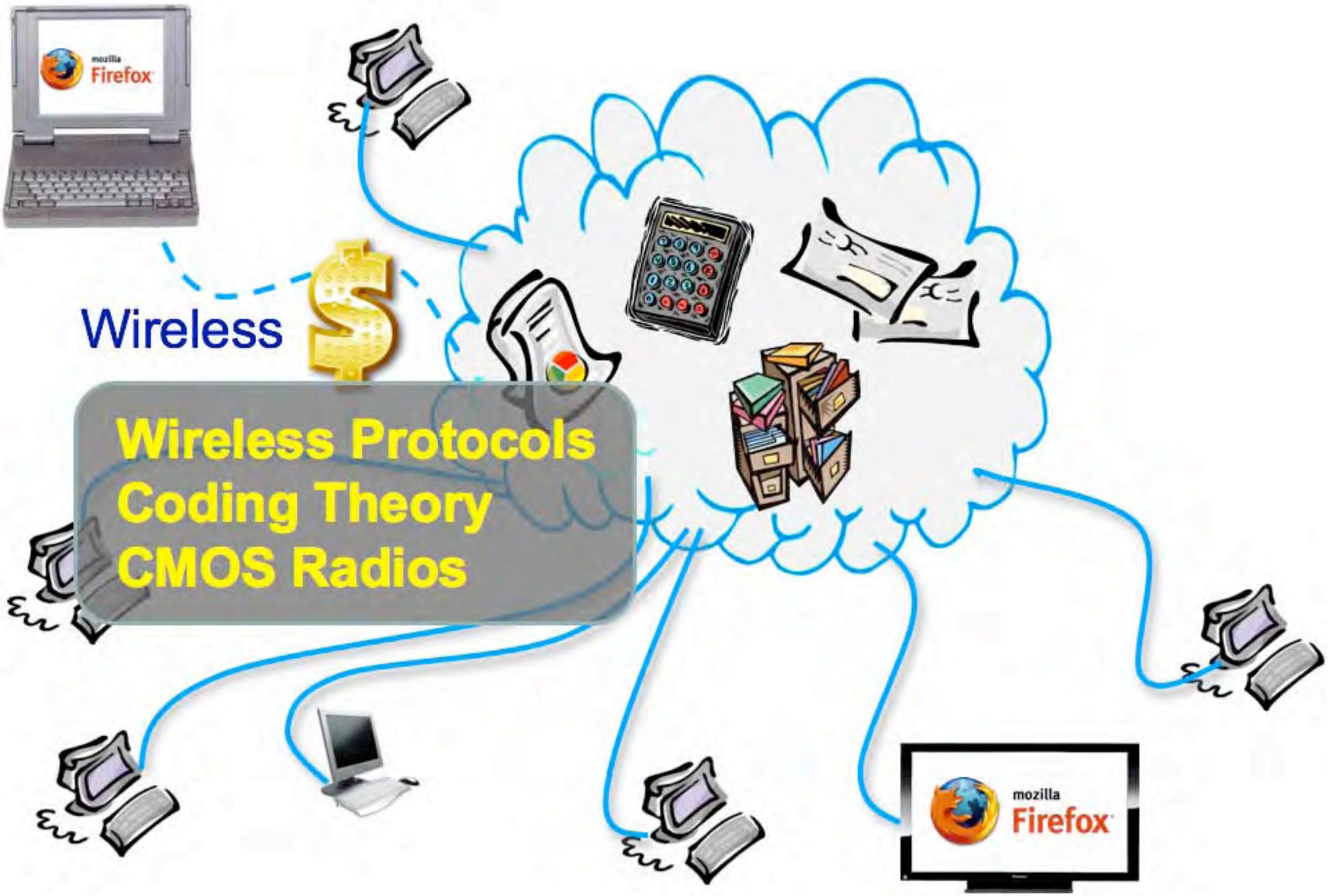
Browser: Universal Client

The Cloud: 1.6B Users

The Cloud: Everywhere

The Cloud: Everywhere



The Cloud: Everywhere

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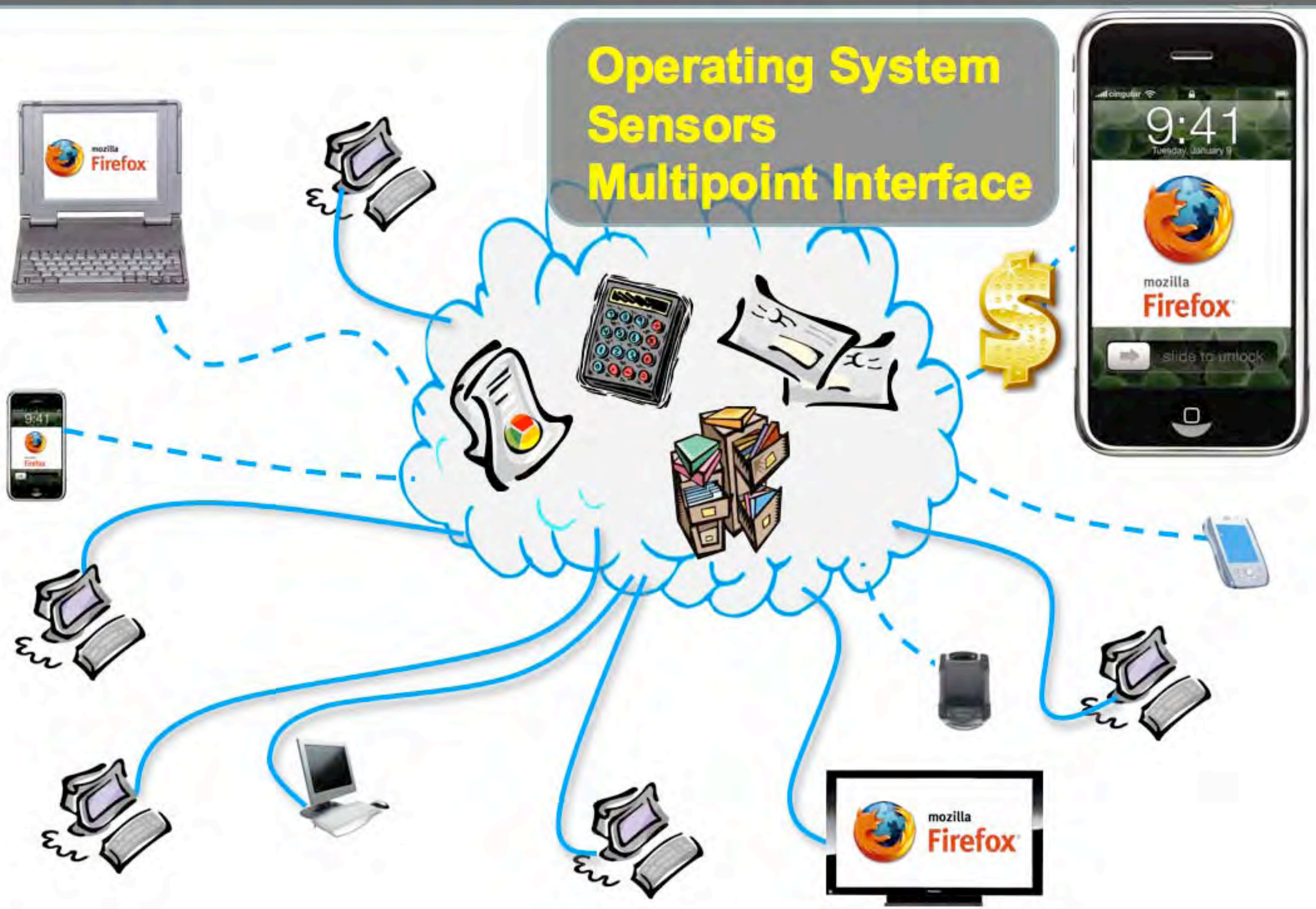
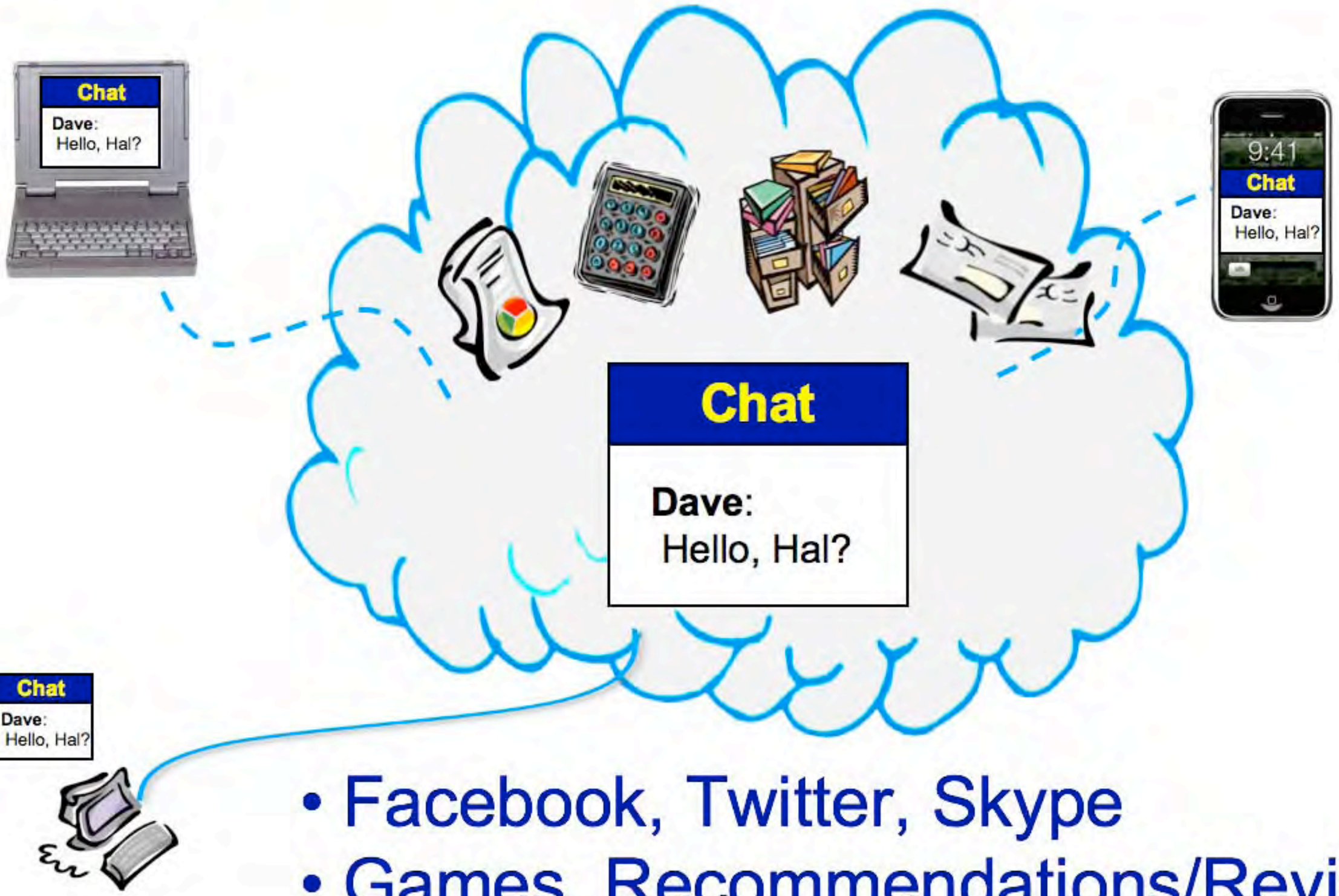
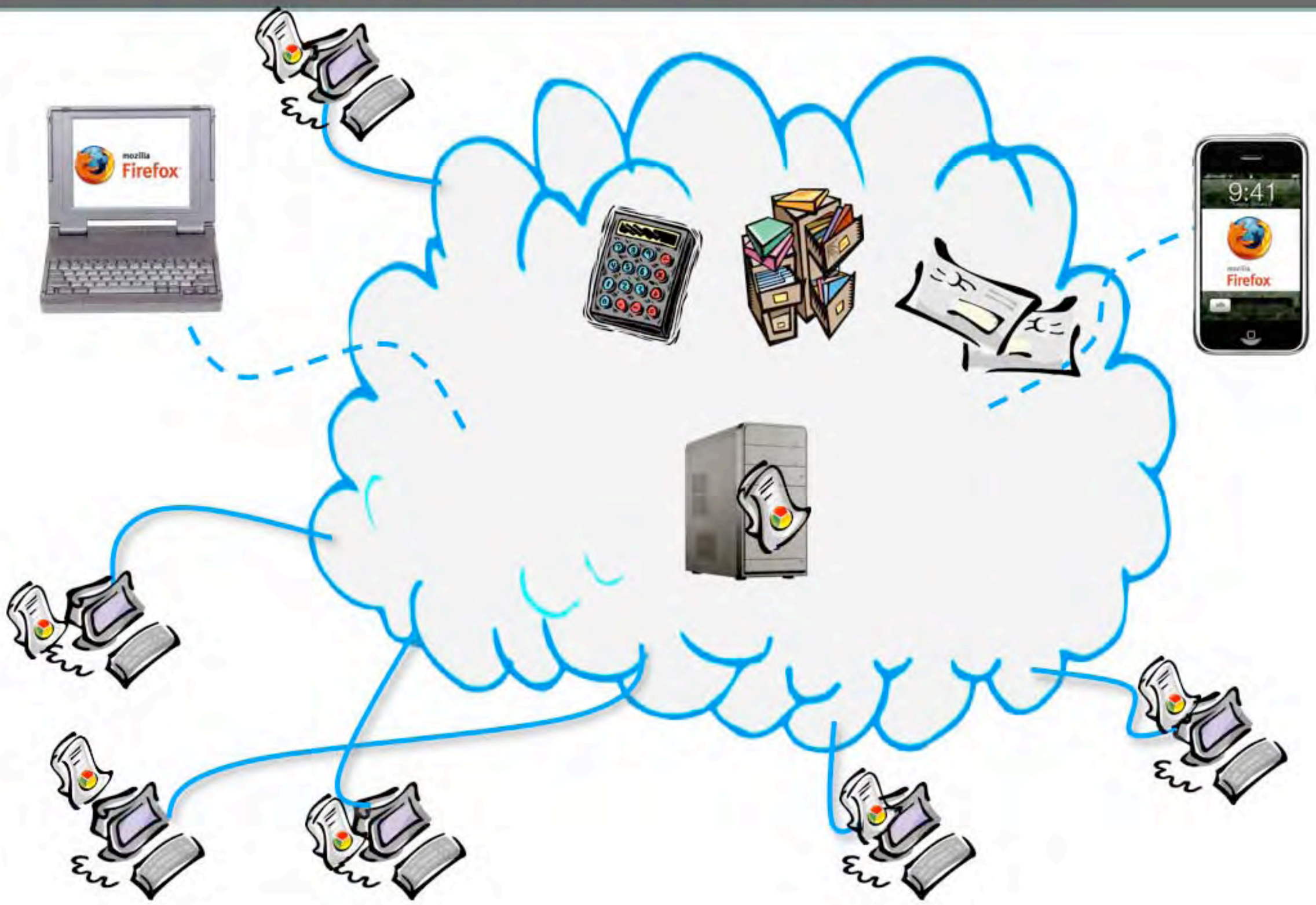


The Cloud: Groups



- Facebook, Twitter, Skype
- Games, Recommendations/Reviews

The Cloud: Servers



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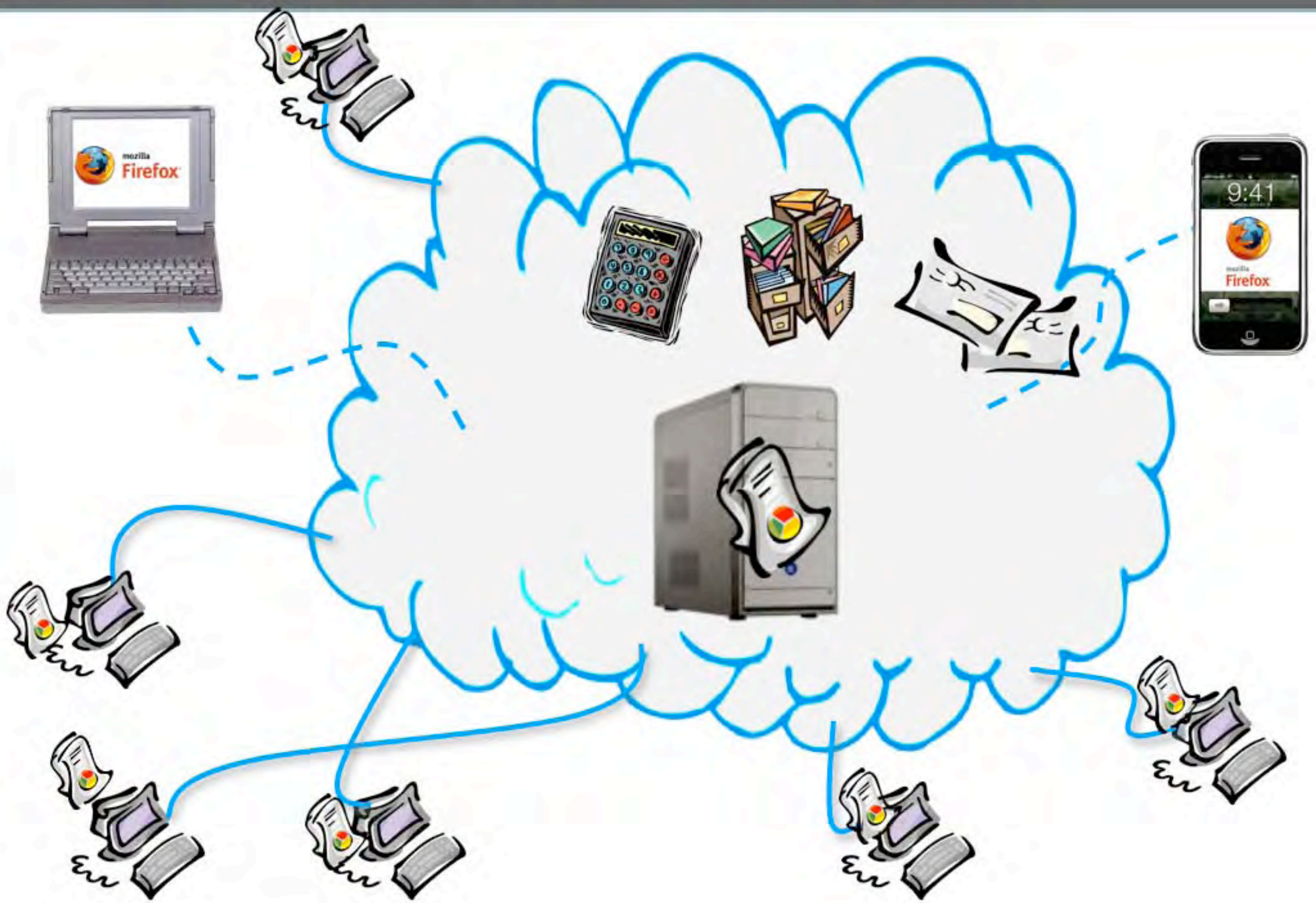


The Cloud: Servers

The Cloud: Clusters

The Cloud: Clusters

The Cloud: Clusters

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

The Cloud: Clusters

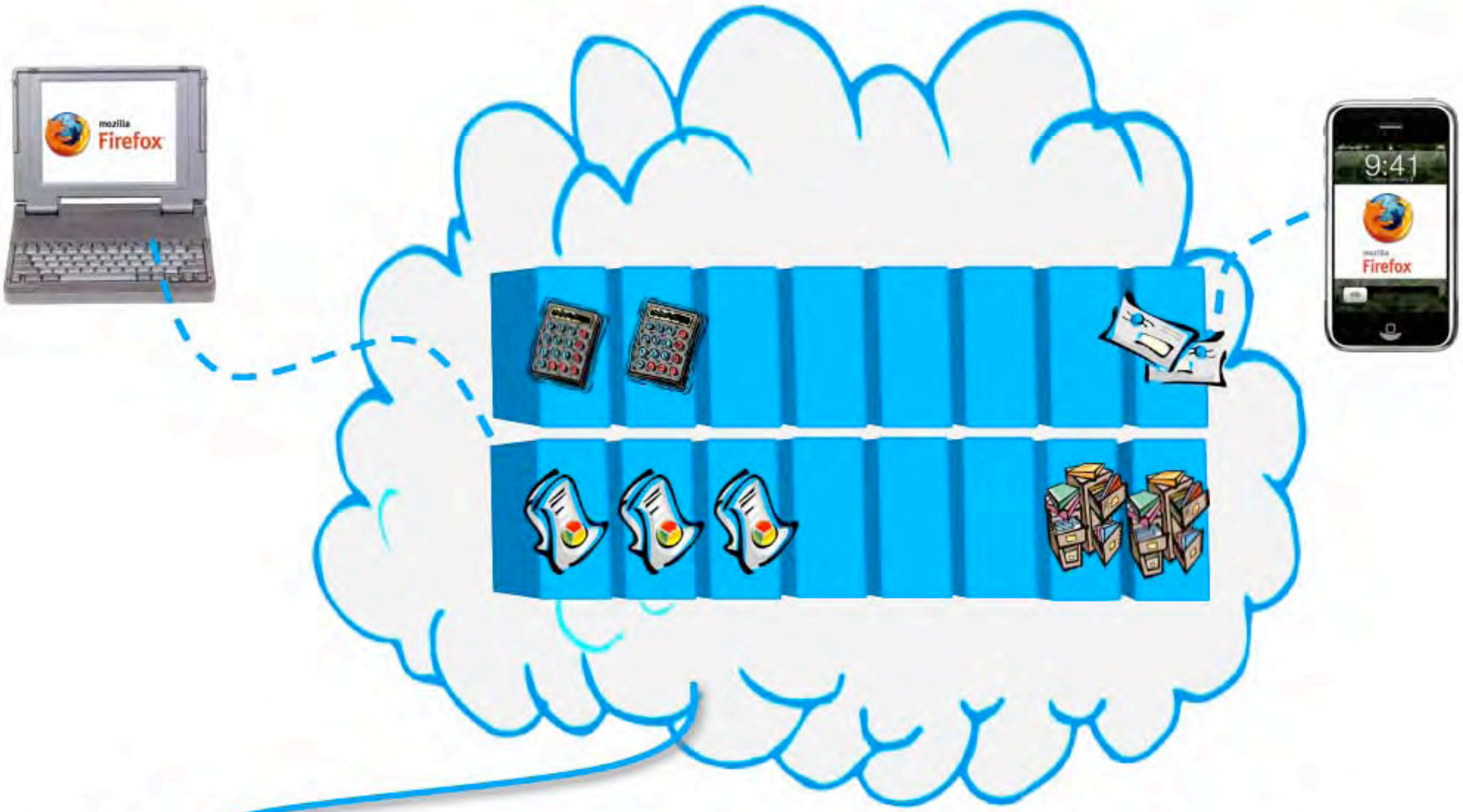
- Highly available
- Largest supercomputers

The Cloud: Clusters

The Cloud: Virtual Machines

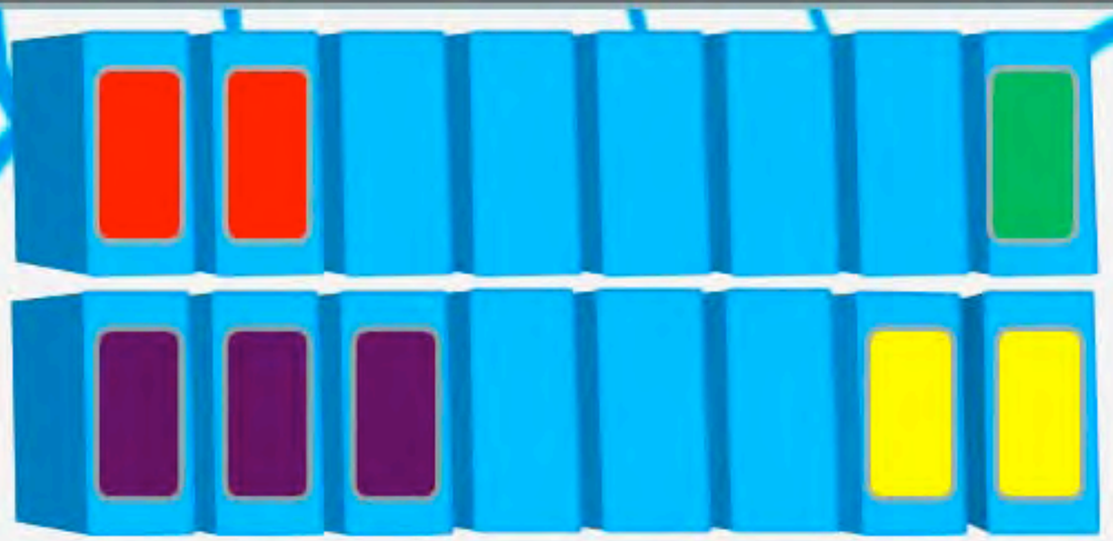
- Makes servers interchangeable

The Cloud: Virtual Machines

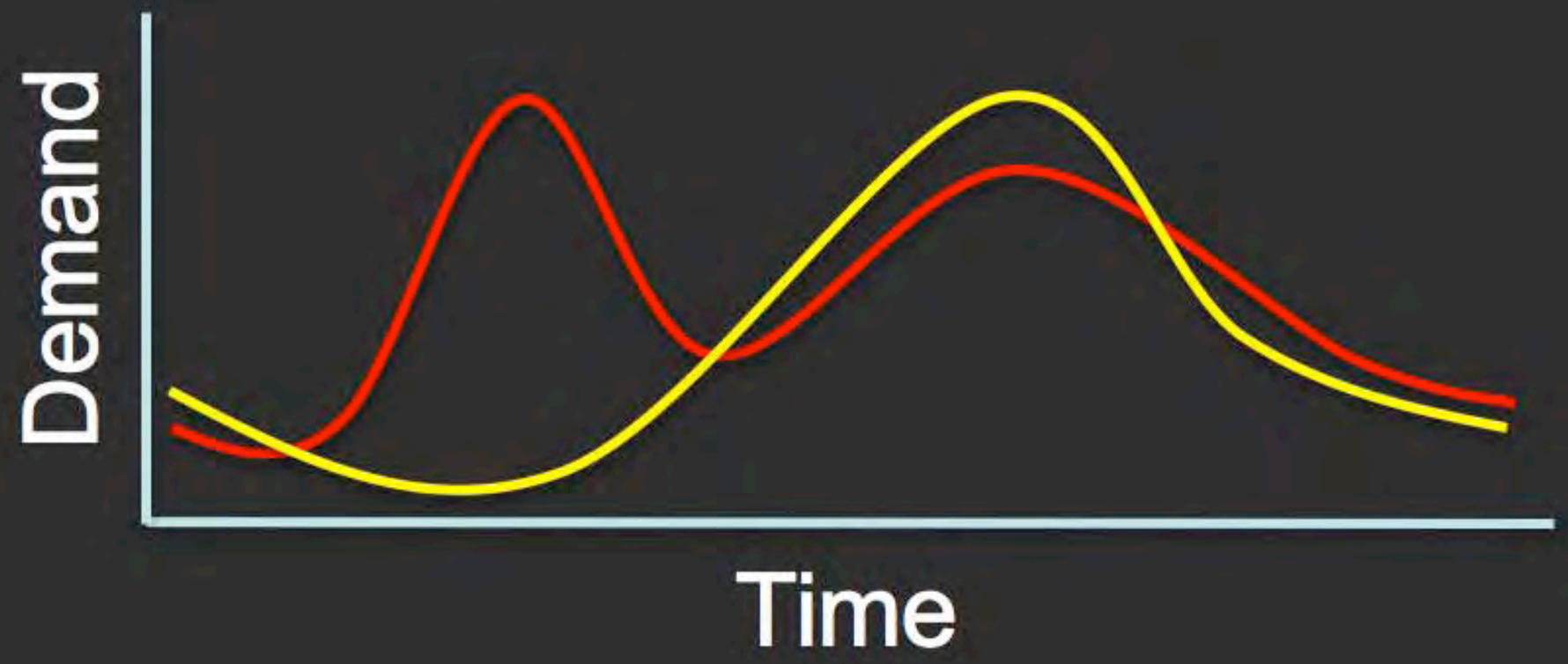


- Makes servers interchangeable
- Supports all the applications

The Cloud: Elasticity



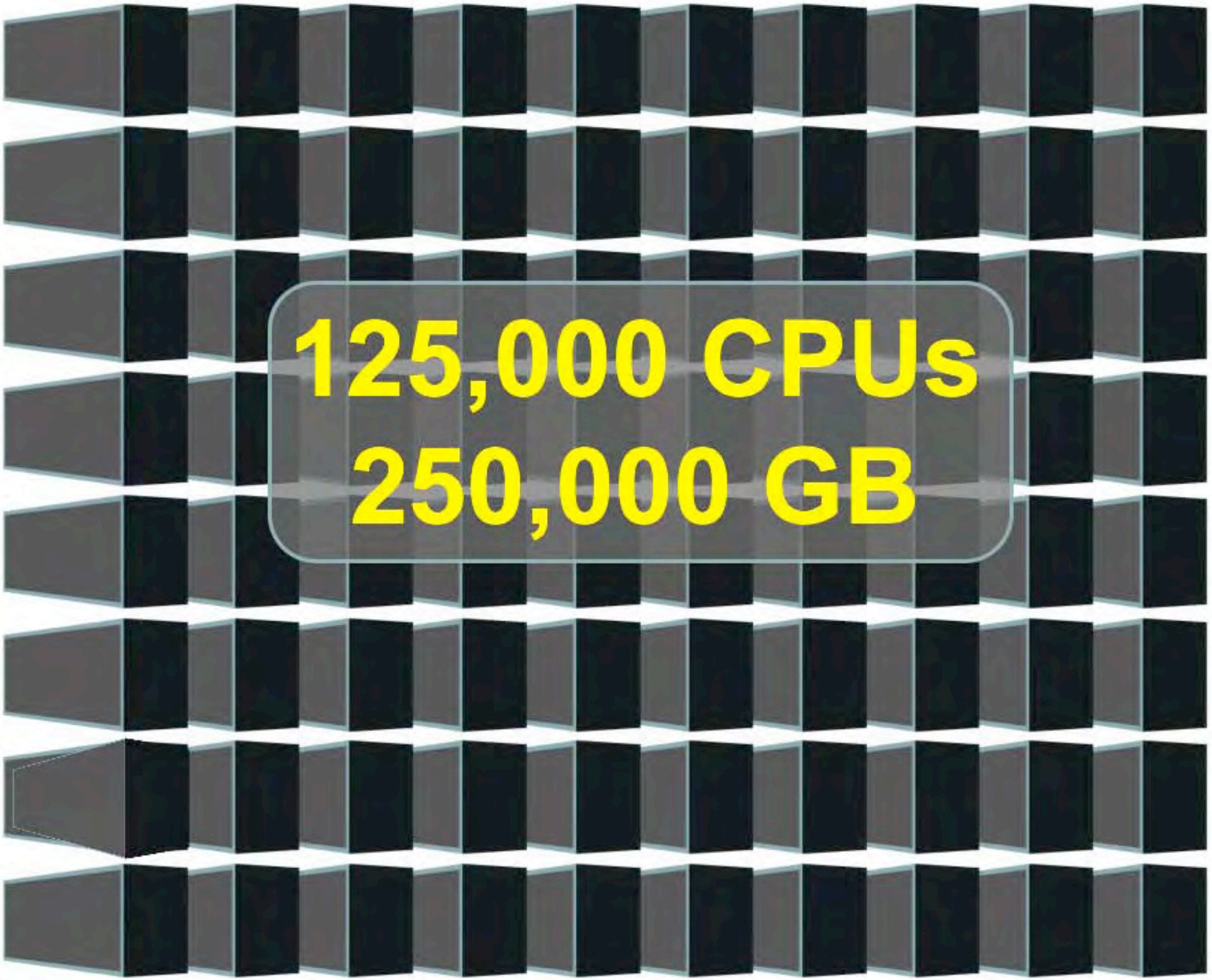
Nearly infinite capacity as needed



The Cloud: Scale

1700 CPUs, 3400GB

The Cloud: Scale



Some Opportunities

Software Engineering

Cloud is much too dynamic!

- Doesn't need to perfect 1st 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