



Intro to Software as a Service (SaaS) and Cloud Computing

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Software as a Service: SaaS

- Traditional SW: binary code installed and runs wholly on client device
- SaaS delivers SW & data as service over Internet via thin program (e.g., browser) running on client device
 - Search, social networking, video
- Now also SaaS version of traditional SW
 - E.g., Microsoft Office 365, TurboTax Online



SaaS in 1996

One Person Can Immediately Affect Millions

Auction Web

[Menu] [\[Listings\]](#) [\[Buyers\]](#) [\[Sellers\]](#) [\[Search\]](#) [\[Contact/Help\]](#) [\[Site Map\]](#)

Welcome to today's online marketplace...
...the market that brings buyers and sellers together in an honest and open environment...
Welcome to eBay's AuctionWeb.

Welcome to our community. I'm glad you found us. AuctionWeb is dedicated to bringing together buyers and sellers in an honest and open marketplace. Here, thanks to our [auction format](#), merchandise will always fetch its market value. And there are plenty of great deals to be found!

[Take a look at the listings](#). There are always several hundred auctions underway, so you're bound to find something interesting.

If you don't find what you like, [take a look at our Personal Shopper](#). It can help you search all the listings. Or, it can keep an eye on new items as they are posted and let you know when something you want appears. If you want to let everyone know what you want, post something on our [wanted page](#).

welcome to eBay's AuctionWeb .

such as daily updates and the right to participate in our user feedback forum and the bulletin board.

Please [read on](#) about the AuctionWeb vision...

From the founder:
February 26, 1996

I launched eBay's AuctionWeb on Labor Day, 1995. Since then, this site has become more popular than I ever expected, and I began to realize that this was indeed a [grand experiment](#) in Internet commerce.

3
By creating an open market that encourages [honest](#) dealings, I hope to



Why SaaS?

1. No install worries about HW capability, OS
2. No worries about data loss (at remote site)
3. Easy for groups to interact with same data
4. If data is large or changed frequently,
simpler to keep 1 copy at central site
5. 1 copy of SW, controlled HW environment
=> no compatibility hassles for developers
6. 1 copy => simplifies upgrades for
developers *and* no user upgrade requests



SaaS Needs Infrastructure

1. Communication: allow customers to interact with service
2. Scalability: fluctuations in demand during + new services to add users rapidly
3. Dependability: service and communication continuously available 24x7



Your PC vs. Datacenter Computer Smackdown

Sun E-10000 “supermini” c.1996

Machine	Processor cores	RAM	Disk
E10000, 1996	64 x 250MHz	64 GB	20 TB
PC, 1996	1 x 250 MHz	32 MB	4 GB
Ratio	64:1	2000:1	5000:1
Datacenter computer, 2010	8 x 1 GHz	16 GB	2 TB
PC, 2010	2 x 3 GHz	4 GB	0.5 TB
Ratio	< 2:1	4:1	4:1



Modern datacenters use commodity computers.



“The Case for NOW (Networks of Workstations)”

- “Workstation price-performance is improving at 80% per year, while that of supercomputers is improving at only 20-30% per year.”

Why?

- “Instead of small computers for interactive use and larger computers for demanding applications, we propose using NOWs for ***all the needs of computer users.***”

Whoa.



- The first Web search engine whose design made possible the huge scale of today's search engines was invented at:
 - (a) Stanford
 - (b) Berkeley
 - (c) Yahoo!
 - (d) Google
 - (e) IBM



Why Cloud Computing?

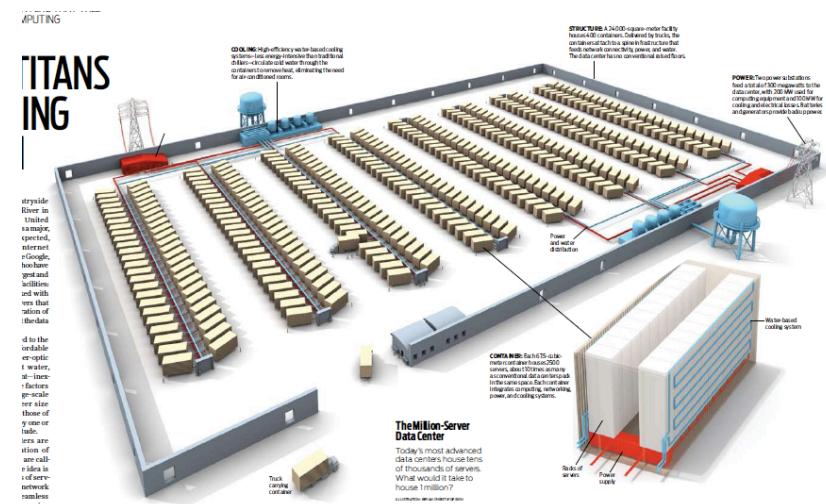
(Amazon Elastic Compute Cloud, 2008)

- What: **Pay-as-you-go** access to racked commodity servers
 - from **0.02/server-hour**, no minimum
 - 100 servers x 1h costs same as 1 server x 100h
- Eliminates financial barrier to deploy SaaS
 - FarmVille: 4 days = 1M players; 2 months = 10M; 9 months = 75M!
 - A cloud-based system is world's 42nd fastest supercomputer, at \$700/hr
 - IBM Watson would cost about \$290/hr



Datacenter is new “server”

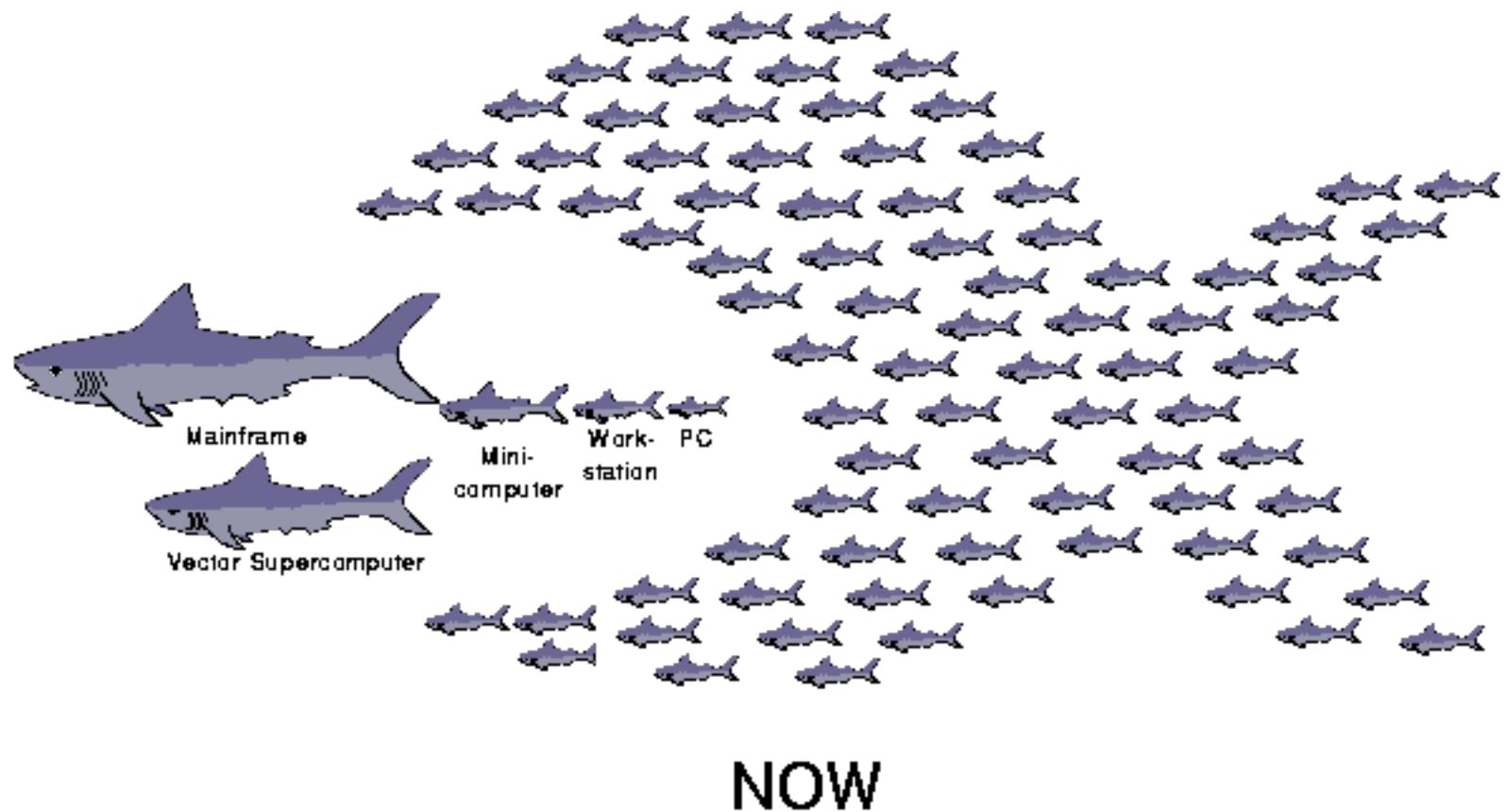
- **“Program”** => Web search, email, map/GIS, ...
- **“Computer”** => 1000's computers, storage, network
- **Warehouse-sized** facilities and workloads



photos: Sun Microsystems, CNET, & datacenterknowledge.com



UC Berkeley Networks Of Workstations (1994-1999)

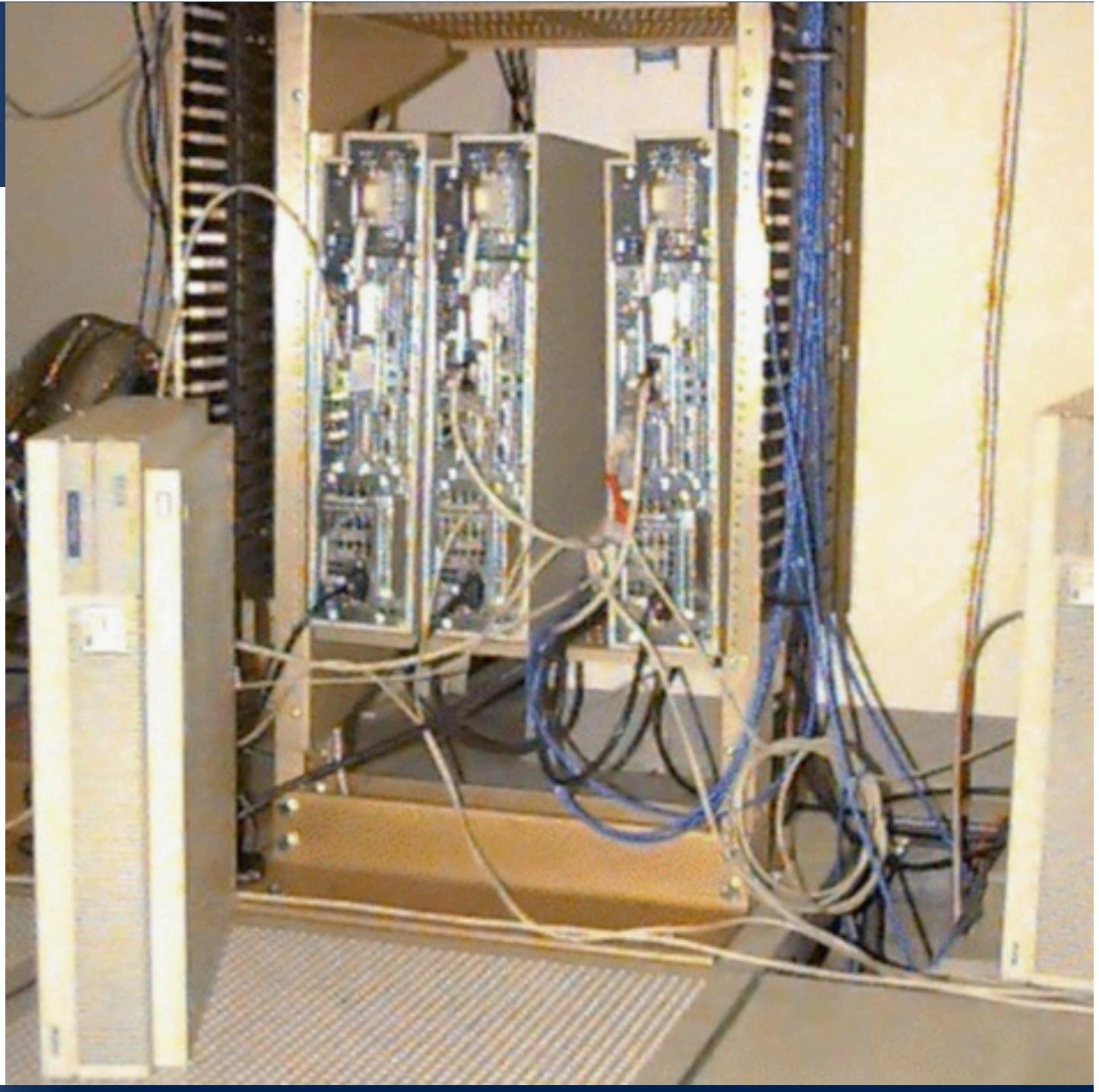




NOW-0

1994

Four
HP-735's

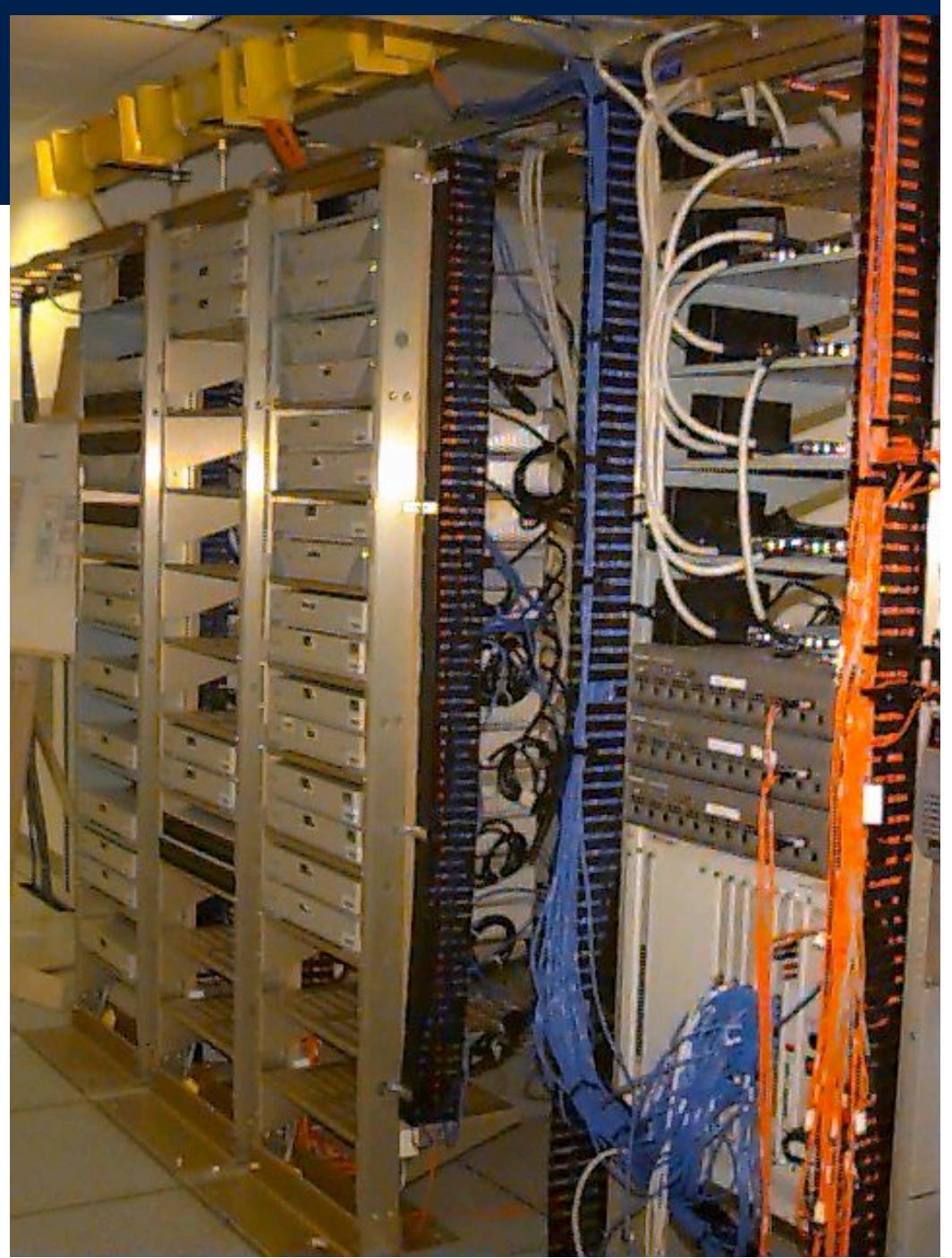




NOW-1

1995

32 Sun SPARC-
stations





NOW-2

1997

60 Sun SPARC-2





Challenge: how do you
program a NOW? How do you
keep it running as individual
machines fail?



Trivia Fact

- The first full Web browser running on a mobile device was developed by:
 - (a) Apple
 - (b) Stanford
 - (c) Berkeley
 - (d) Nokia
 - (e) Motorola



“Access Is the Killer App”

Project Daedalus, 1994-1999

- Faculty: Profs. Katz & Brewer
- Idea: Use the “cloud” for *services!*
 - First truly *scalable* search engine (Inktomi)
 - First mobile Web browser enabled by content transformation (TopGun)
 - *Vision: Anywhere, anytime access to data & services, supported by the “cloud”*





2007: Public Cloud Computing Arrives

- Amazon Elastic Compute Cloud (EC2)
- “Compute unit” rental: \$0.02-0.68/hr.
 - 1 CU \approx ~1 GHz x86 *core*
 - Virtual machine technology used to “slice up”
- No up-front cost, no contract, no minimum
- Billing rounded to nearest hour
 - pay-as-you-go storage also available
- “Computing as utility”—MULTICS, c.1969
- See abovetheclouds.cs.berkeley.edu

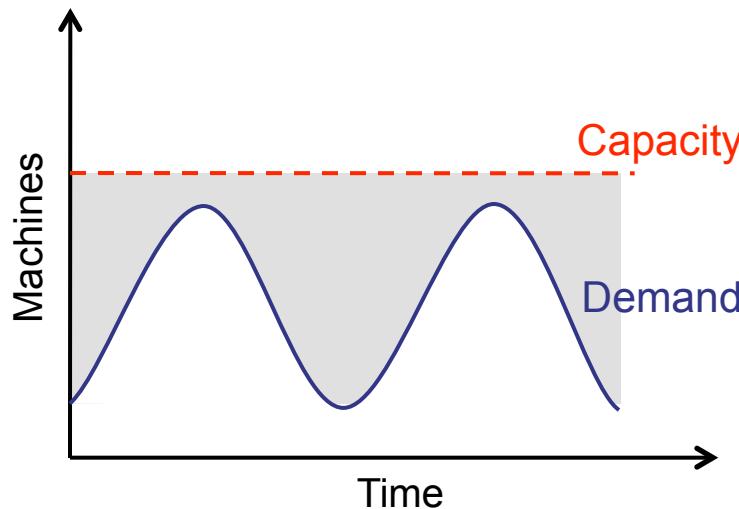


Why Now (not then)?

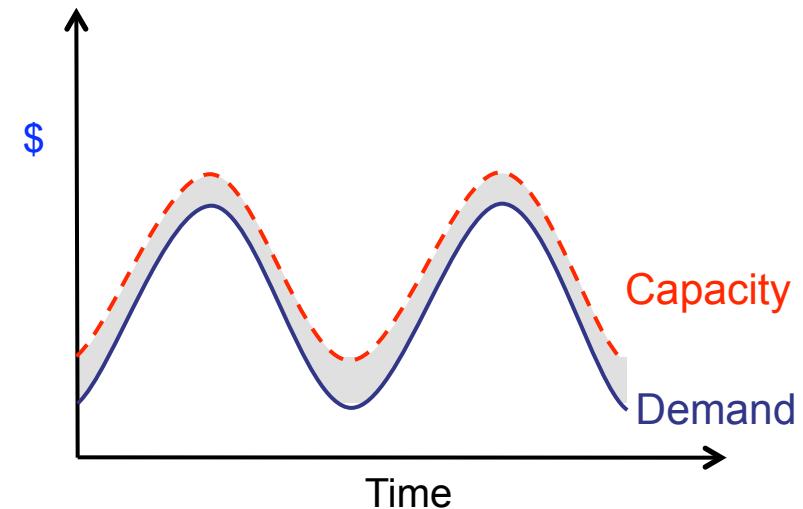
- The Web “**Space Race**”: Build-out of extremely large datacenters (10,000’s of **commodity** PCs)
- Driven by growth in demand (more users)
 - Discovered **economy of scale**: 5-7x cheaper than provisioning a medium-sized (100’s machines) facility
 - Infrastructure software: e.g., Google File System
 - Operational expertise
- More pervasive broadband Internet
- Dominance of Intel x86 architecture in servers
- Free & open source software availability
- *What's new:* risk transfer & cost associativity

Cloud Economics 101

- Provisioning for peaks: wasteful, but necessary



“Statically provisioned”
data center



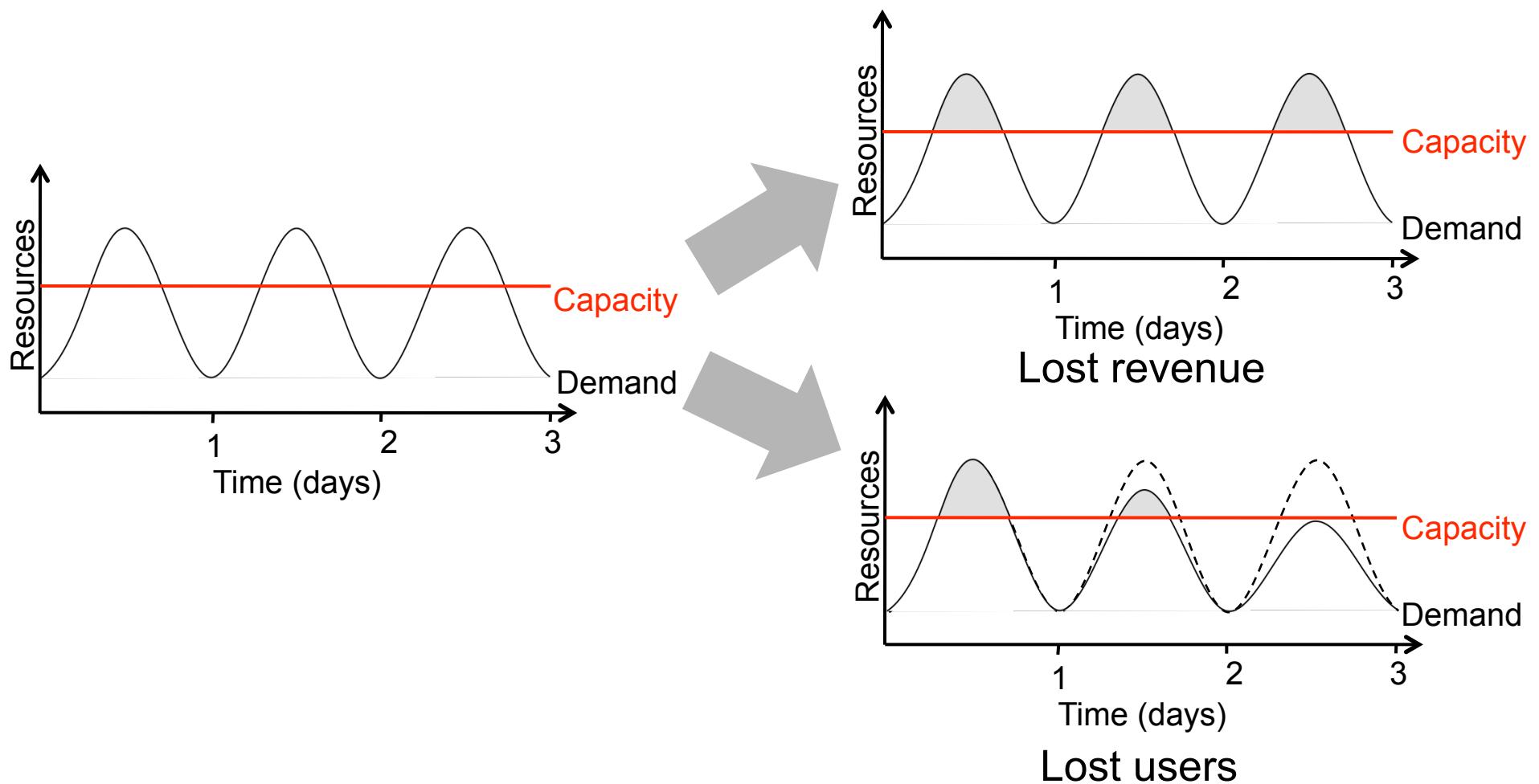
“Virtual” data center
in the cloud



Unused resources



Risk Transfer (or: who remembers Friendster?)





Cost Associativity

- 1,000 CPUs for 1 hour same price as 1 CPU for 1,000 hours
- Washington Post converted Hillary Clinton's travel documents to post on WWW
 - Conversion time: <1 day after released
 - Cost: less than \$200
- RAD Lab graduate students demonstrate improved MapReduce scheduling—on 1,000 servers

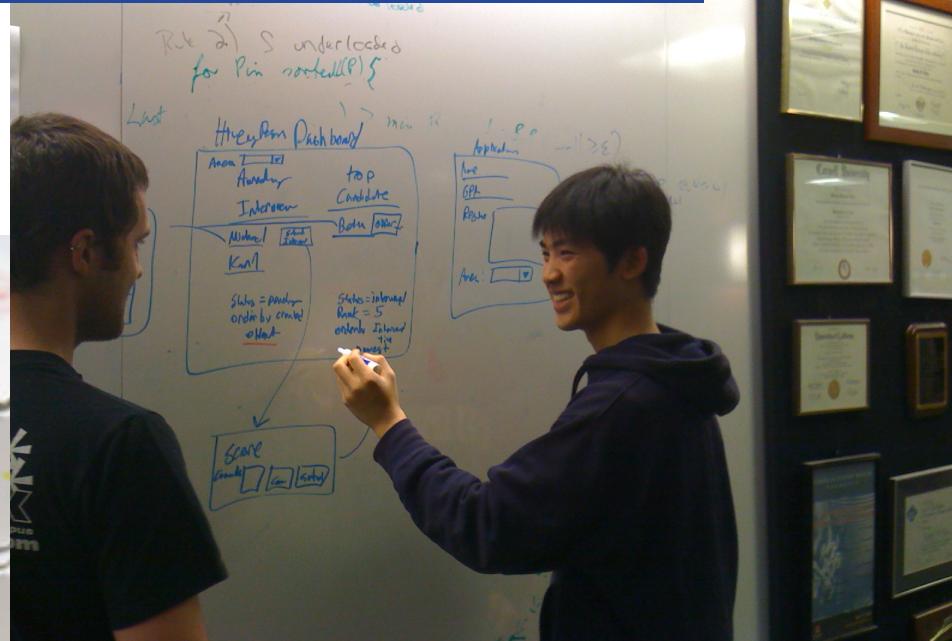


What cool things can we do with the cloud in academia?



2005-2010: RAD Lab and Karl's Long Weekend

COMR★IDES



Presidents' Day
Weekend, Feb 21-13
Final demo on Feb 24



CS 169: cloud supports SW *development* too!

- Develop your app
- Keep track of your code
- Test your app on different browsers
- Deploy it to the world



Total UCB computer resources: **zero**



2012: Cloud Computing and a MOOC*

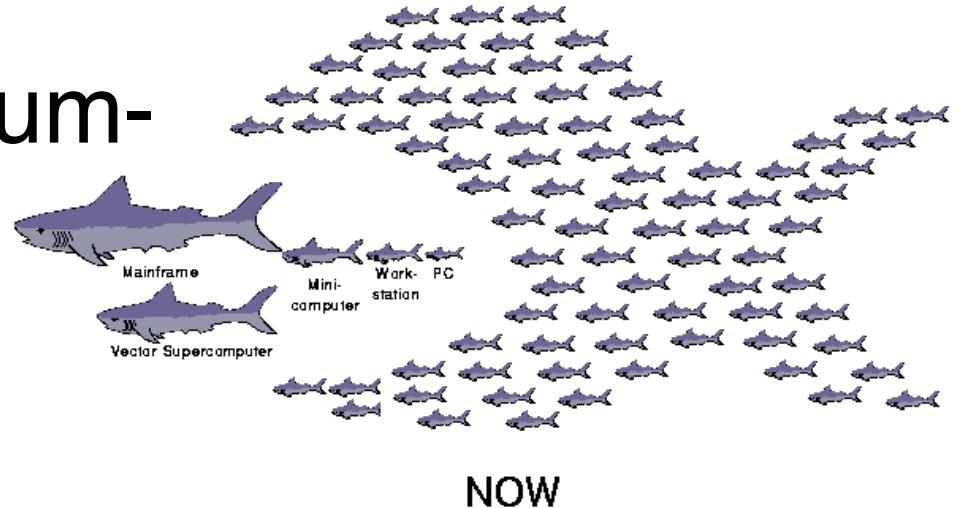
- saas-class.org: first 5 weeks of CS 169
- 25,000 students learning SaaS programming!
- Cloud computing for autograding
 - What happens when 25,000 students submit a programming HW on the same day...?

* massive open online class



Going back to NOW...

- 2000: using medium-sized clusters for Internet services
=> several PhD's
- 2010: CS169 students do it in 6-8 weeks and deploy on cloud computing
 - *Everything* delivered as SaaS now...
- 2020: ?





2011: Future=Mobile+Cloud





Summary

- Cloud computing *democratizes access* to large-scale computing resources
 - Pay-as-you-go => low risk, low entry cost
- *Accelerates “SaaS-ification”*
 - Economic benefits of delivering software as a service now available to anyone
- Allows students, academia to have even greater impact on industry
- Open up research/innovation opportunities



Thank you!

