Distributed Systems Intro

Logistics

- Course Policies
  - see web page...
  - http://www.cs.cmu.edu/~dga/15-440/S14
  - obligatory discussion of {late days, cheating, etc.}
- Waitlist!
- Maybe recitations this year - TBA
- Office hours will be on syllabus page soon
- Go work through the Tour of Go!

Waitlist

- Waitlist of unprecedented size. Keep coming to class, because we don't really know how it will work out.
- Registered: 106 + 19
- Waitlisted: 40 + **119** (!!!!!)
- The bad news: Not everyone will get in. We are *by law* limited to physical classroom size. This is not subject to negotiation.
- The plea: Not serious about the class? DROP SOON.
- The strategy:
    - Attend class! Sign the signup sheet.
    - If class is on immediate graduation path, *have your academic advisor email us*.
- Priority order for 440: SCS, CMU ugrads, others; 640: SCS MS, others

Course Goals

- Systems requirement:
    - Learn something about distributed systems in particular;
    - Learn general systems principles (modularity, layering, naming, security, ...)
    - Practice implementing real, larger systems; in teams; must run in nasty environment;
- One consequence: Must pass homeworks, exams, and projects independently as well as in total.

Course Format

- ~30 lectures
- Office hours: Practical issues for implementing projects; general questions and discussion
- 3 projects; 1 solo, 2 team + 2 mini-projects
    - Distributed (internet-wide) bitcoin miner
    - Building Tribbler (or something)
    - Choose-your-own with consistent replication or distributed commit/consensus

Book

- Link to Amazon purchase (new, used, rent) from syllabus page
- Several useful references on web page
- We'll be compiling notes (and these slides) for your use over the course of the semester; based on, but not identical to, prior 15-440 instance

About Projects

- Systems programming somewhat different from what you've done before
  - Low-level (C / Go)
  - Often designed to run indefinitely (error handling must be rock solid)
  - Must be secure - horrible environment
  - Concurrency
  - Interfaces specified by documented protocols
- Office Hours & "System Hacker's View of Software Engineering"
  - Practical techniques designed to save you time & pain
- WARNING: Almost 1/2 of students last year dropped during project 1 because they started too late!

Collaboration

- Working together important
  - Discuss course material
  - Work on problem debugging
- Parts *must* be your own work
  - Homeworks, midterm, final, solo proj
- Team projects: both students should understand entire project
- What we hate to say: we run cheat checkers...
- Partner problems: *address early*.

Late Work

- 10% penalty per day
- Can't be more than 2 days late
- Usual exceptions: documented medical, emergency, etc.
    - *Talk to us early if there's a problem!*
- Two "late points" to use - one day each (still can't be more than 2 days late)
- Regrade requests in writing to course admin

Why take this course?

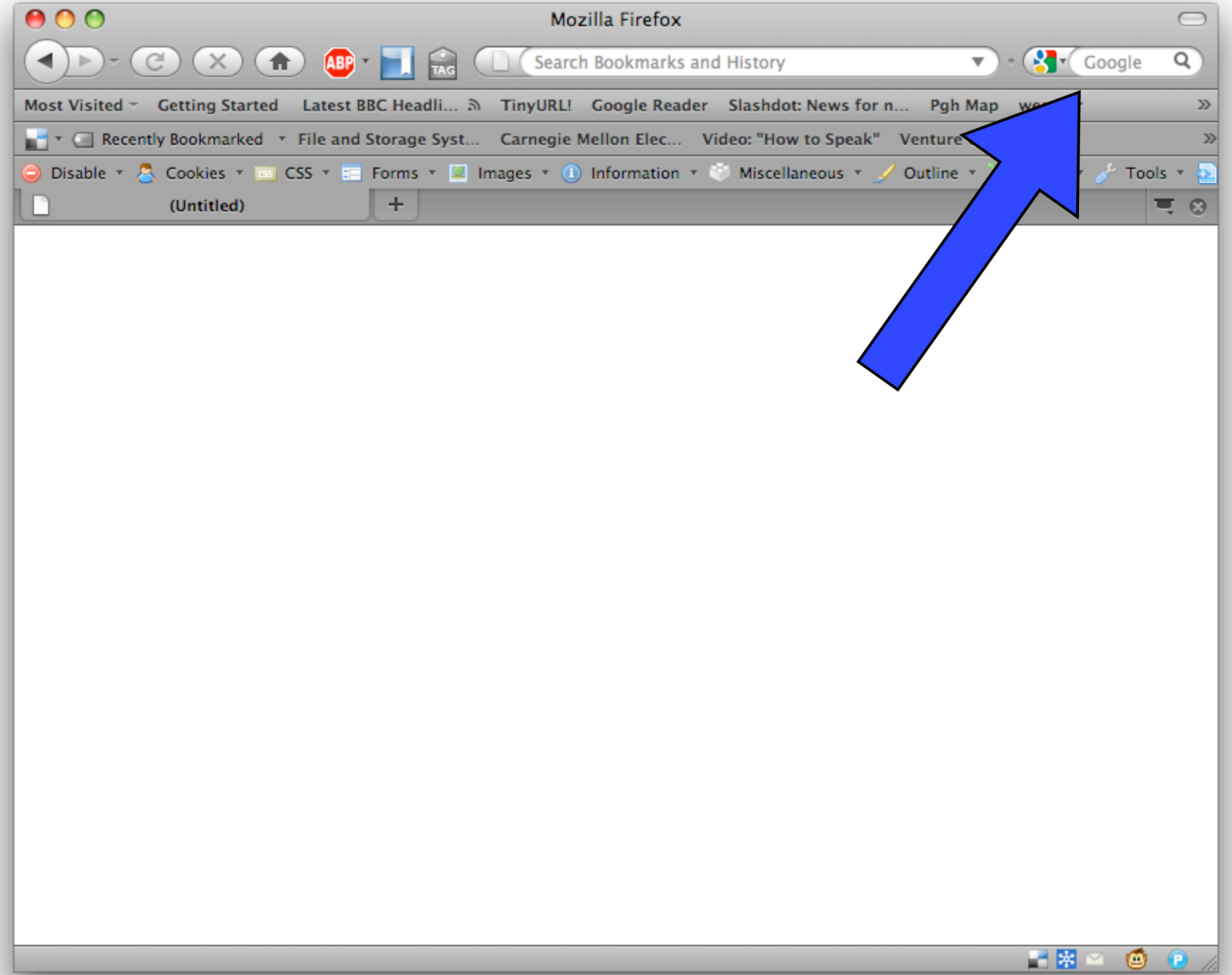
- Huge amounts of computing are now distributed...
  - A few years ago, Intel threw its hands up in the air: couldn't increase GHz much more without CPU temperatures reaching solar levels
  - But we can still stuff more transistors (Moore's Law)
  - Result: Multi-core and GPUs.
  - Result 2: Your computer has become a parallel/distributed system. In a decade, it may have 128 cores.
- Oh, yeah, and that whole Internet thing...
  - my phone syncs its calendar with google, which i can get on my desktop with a web browser, ...
    - (That phone has the computing power of a desktop from 10 years ago and communicates wirelessly at a rate 5x faster than the average american home could in 1999.)
  - Stunningly impressive capabilities now seem mundane. But *lots* of great stuff going on under the hood...
  - Most things are distributed, and more each day

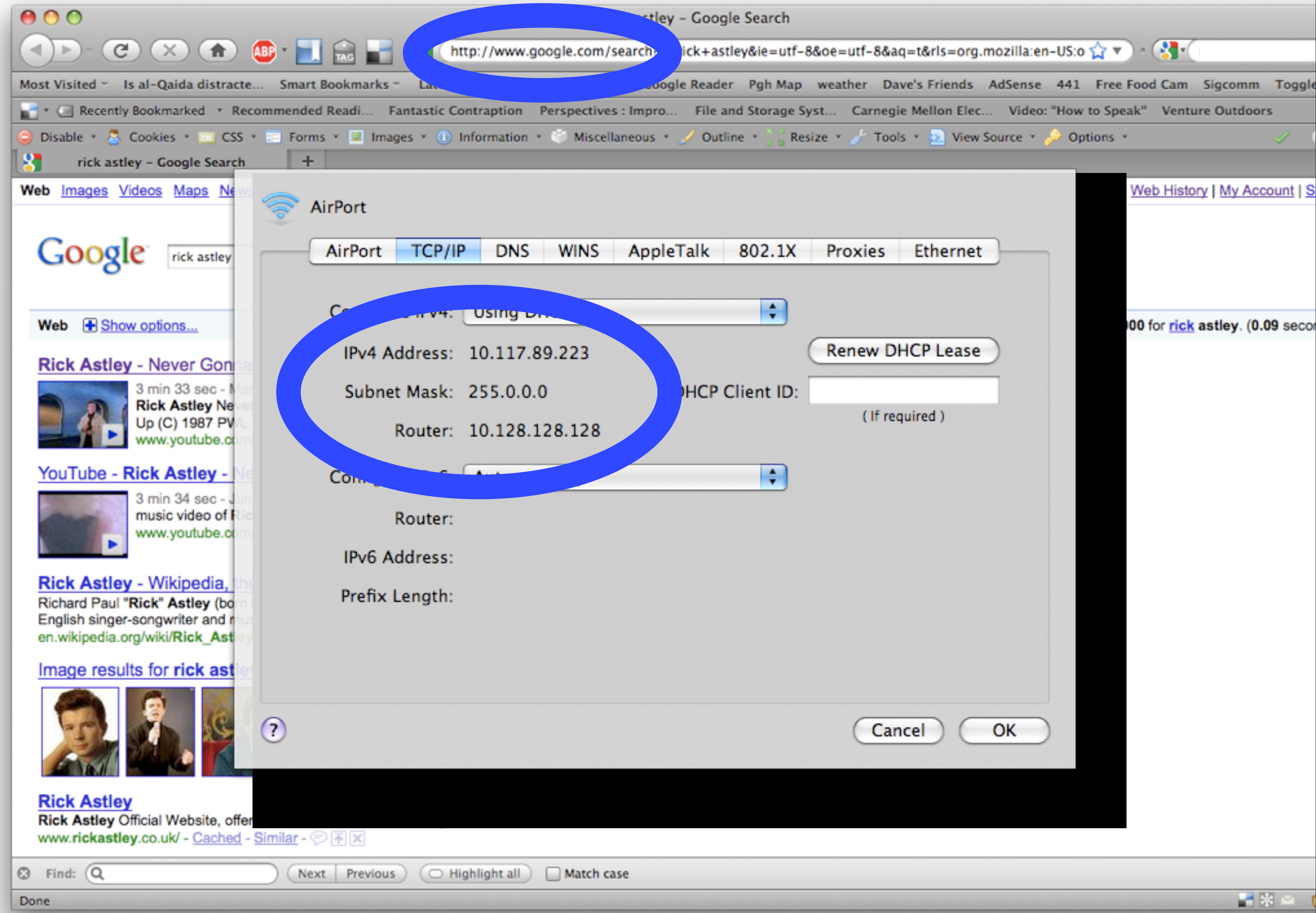
If you find yourself ...

- In hollywood....
  - ... rendering videos on clusters of 10s of 1000s of nodes?
  - Or getting terabytes of digital footage from on-location to post-processing?
- On wall street...
  - tanking our economy with powerful simulations running on large clusters of machines
  - For 11 years, the NYSE ran software from cornell systems folks to update trade data
- In biochem...
  - using protein folding models that require supercomputers to run
- In gaming...
  - Writing really bad distributed systems to enable MMOs to crash on a regular basis
- not to mention the obvious places

Enough advertising

- Let’s look at one real distributed system
- That’s drastically more complex than it might seem from the web browser...


Mozilla Firefox
Search Bookmarks and History
Google
Most Visited
Getting Started
Latest BBC Headli...
TinyURL!
Google Reader
Slashdot: News for n...
Pgh Map
Recently Bookmarked
File and Storage Syst...
Carnegie Mellon Elec...
Video: "How to Speak"
Venture
Disable
Cookies
CSS
Forms
Images
Information
Miscellaneous
Outline
Tools
(Untitled)



rick astley - Google Search

http://www.google.com/search?...ick+astley&ie=utf-8&oe=utf-8&aq=t&rls=org.mozilla:en-US:o

AirPort

AirPort | TCP/IP | DNS | WINS | AppleTalk | 802.1X | Proxies | Ethernet

Configure IPv4: Using DHCP

IPv4 Address: 10.117.89.223

Subnet Mask: 255.0.0.0

Router: 10.128.128.128

Renew DHCP Lease

DHCP Client ID:

(If required)

Configure IPv6: Automatically

Router:

IPv6 Address:

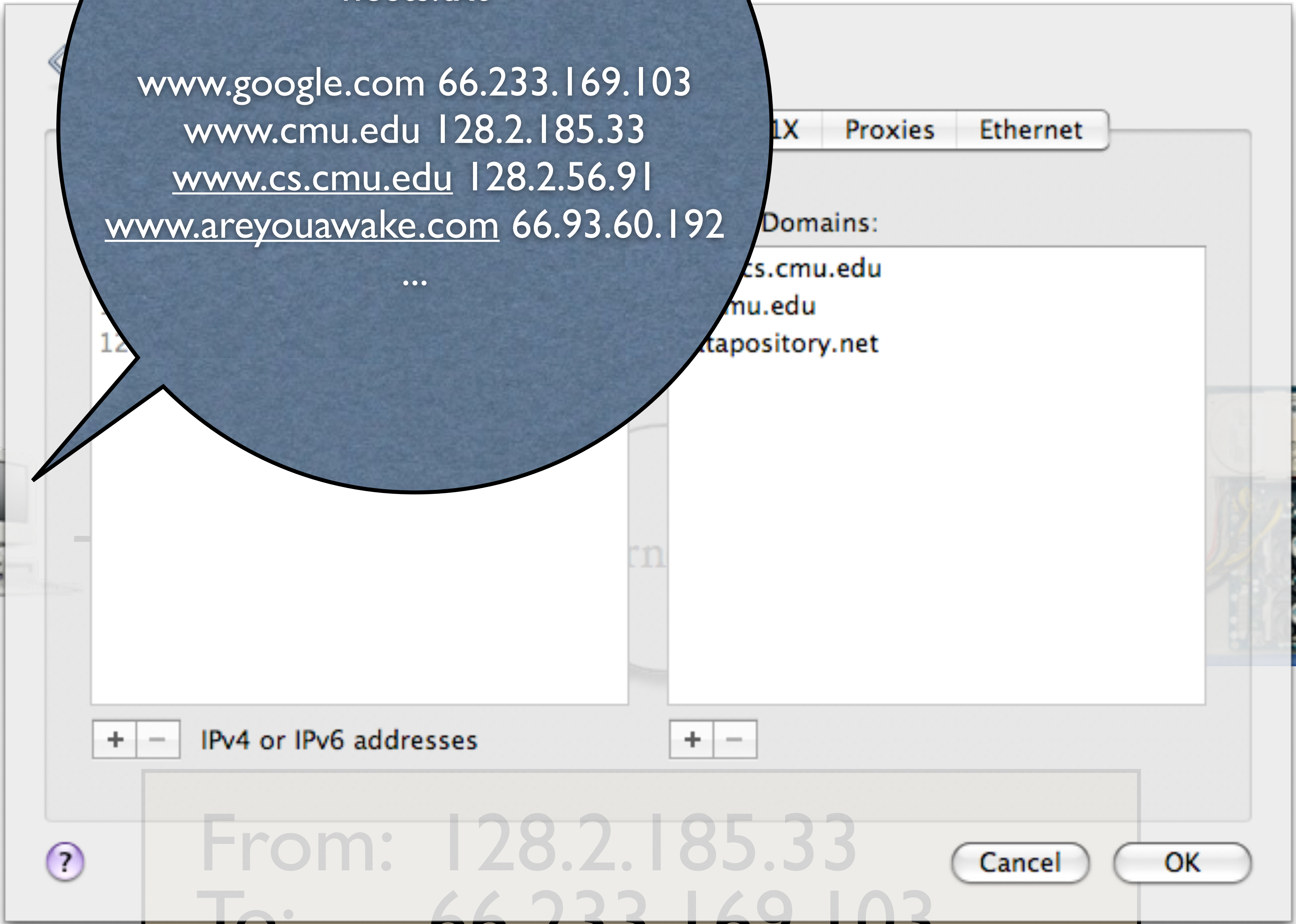
Prefix Length:

Cancel | OK

...ber IP...

hosts.txt

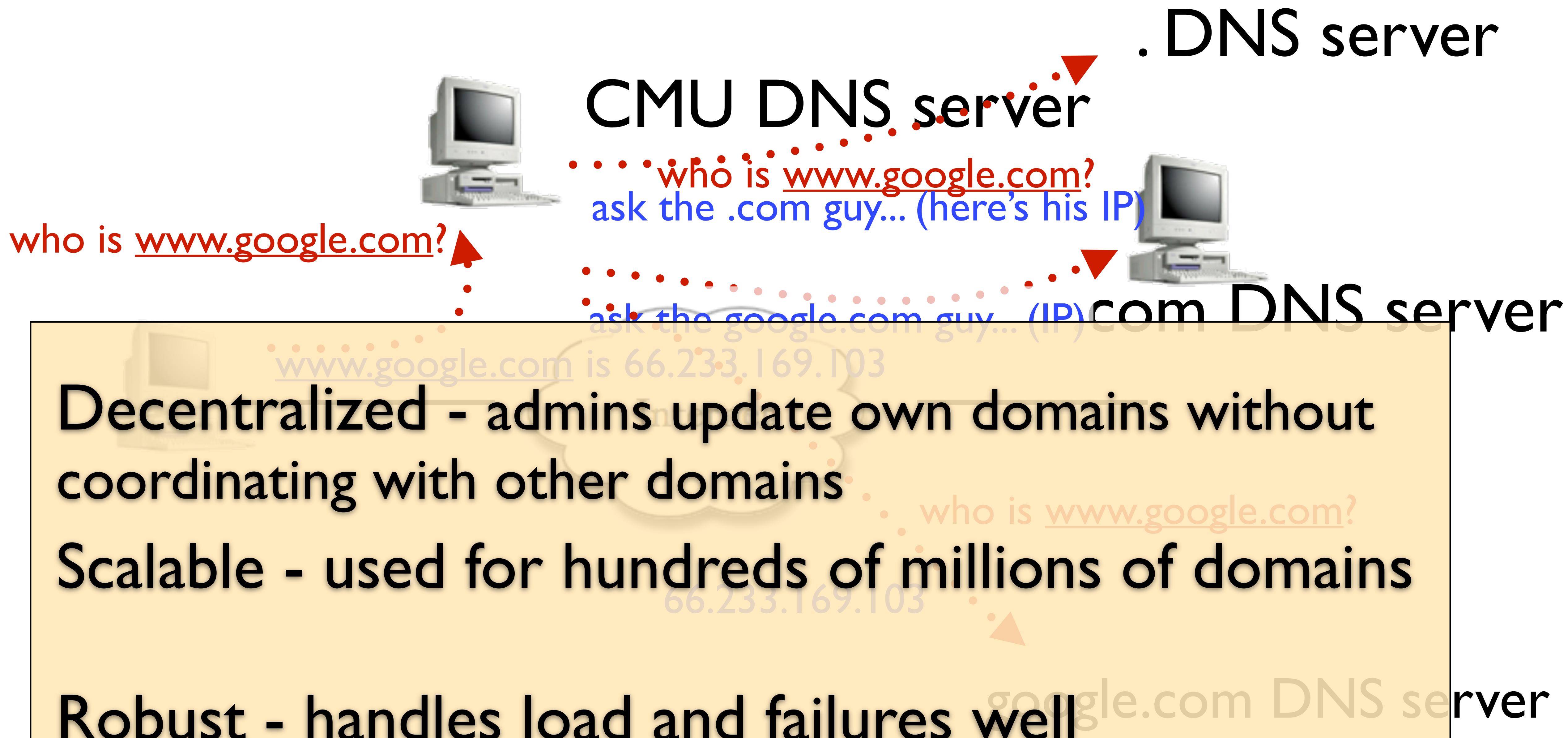
www.google.com 66.233.169.103
www.cmu.edu 128.2.185.33
www.cs.cmu.edu 128.2.56.91
www.areyouawake.com 66.93.60.192
...



From: 128.2.185.33
To: 66.233.169.103

<packet contents>

Domain Name System

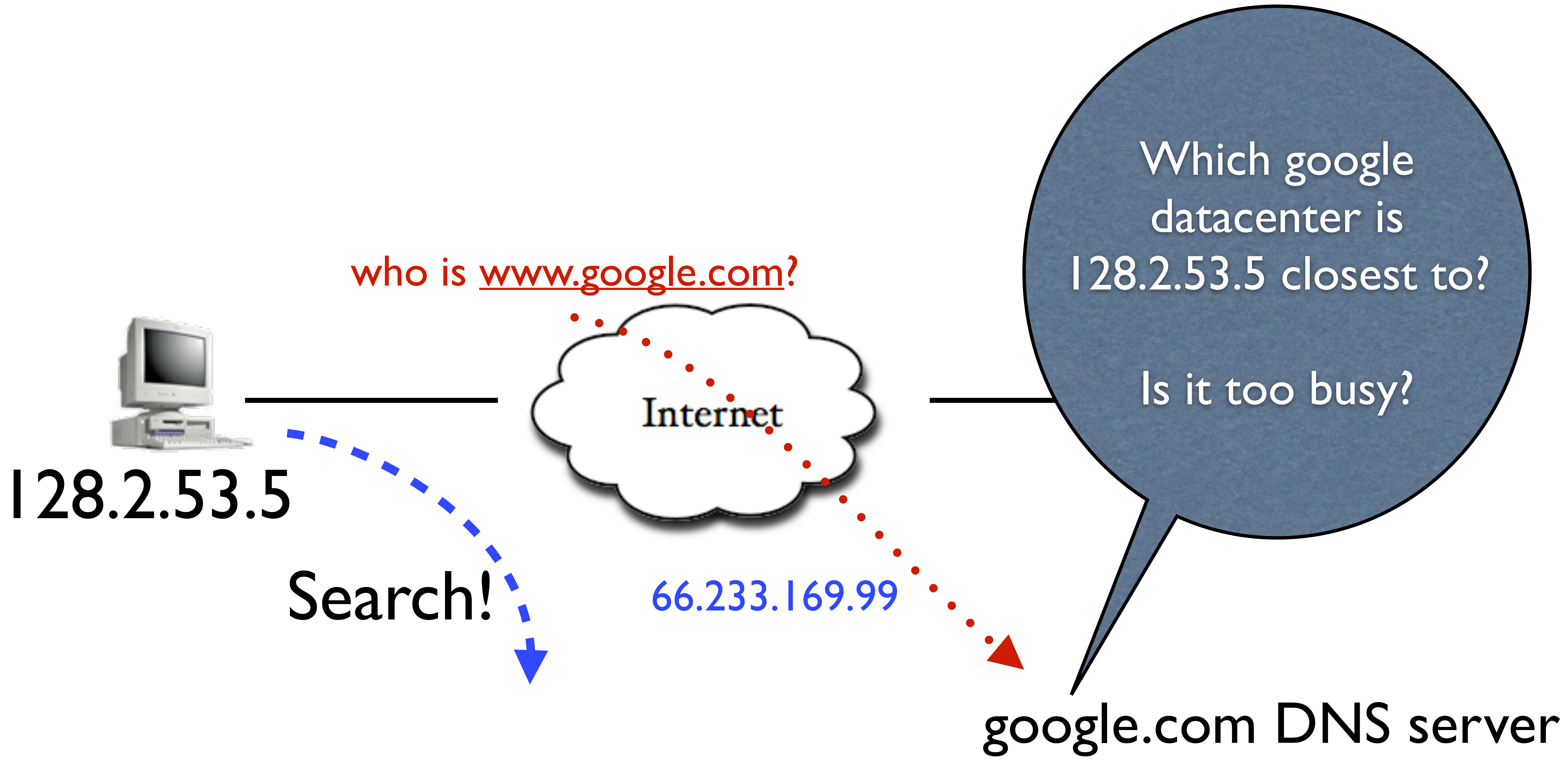


Decentralized - admins update own domains without coordinating with other domains

Scalable - used for hundreds of millions of domains

Robust - handles load and failures well

But there's more...

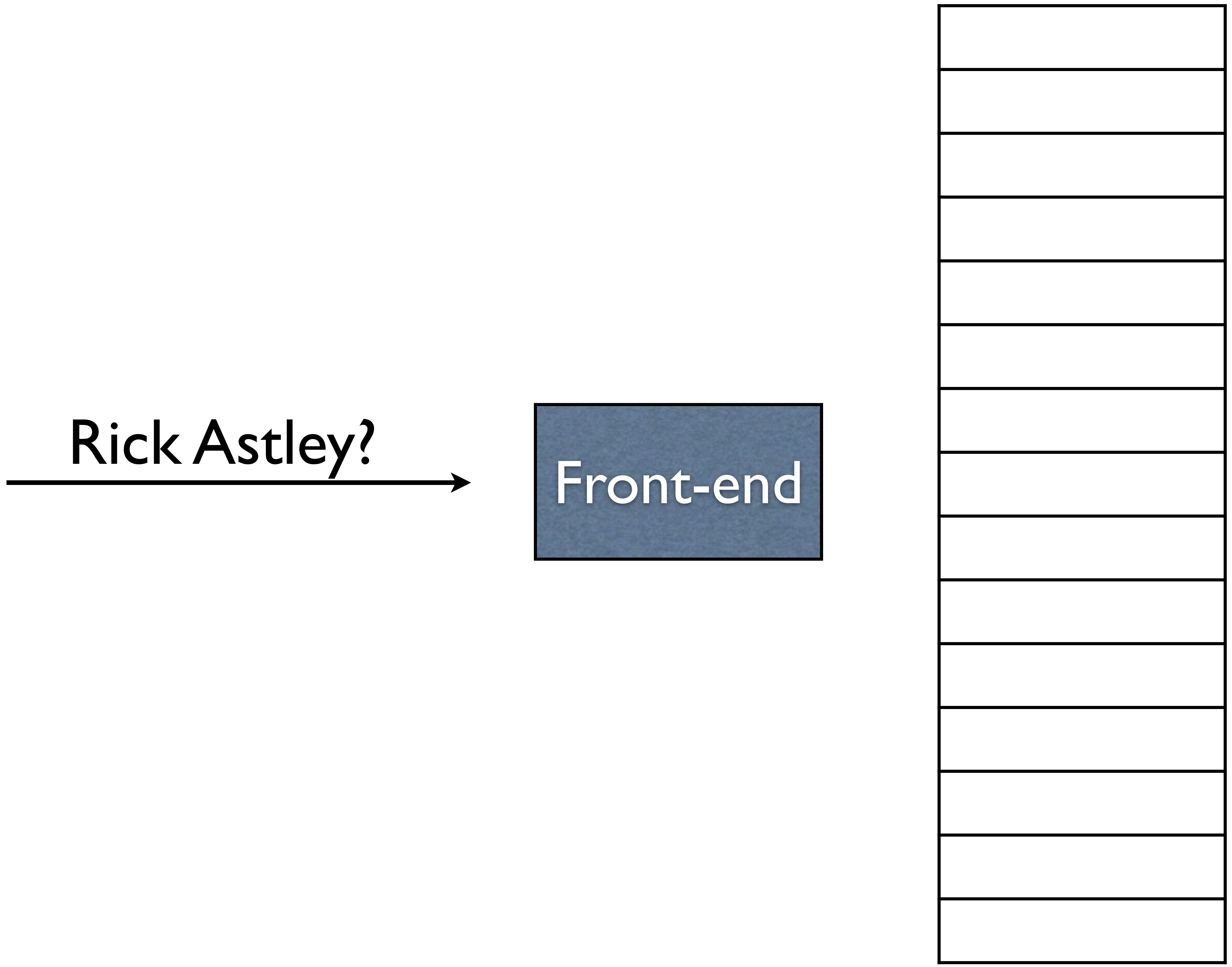


A Google Datacenter

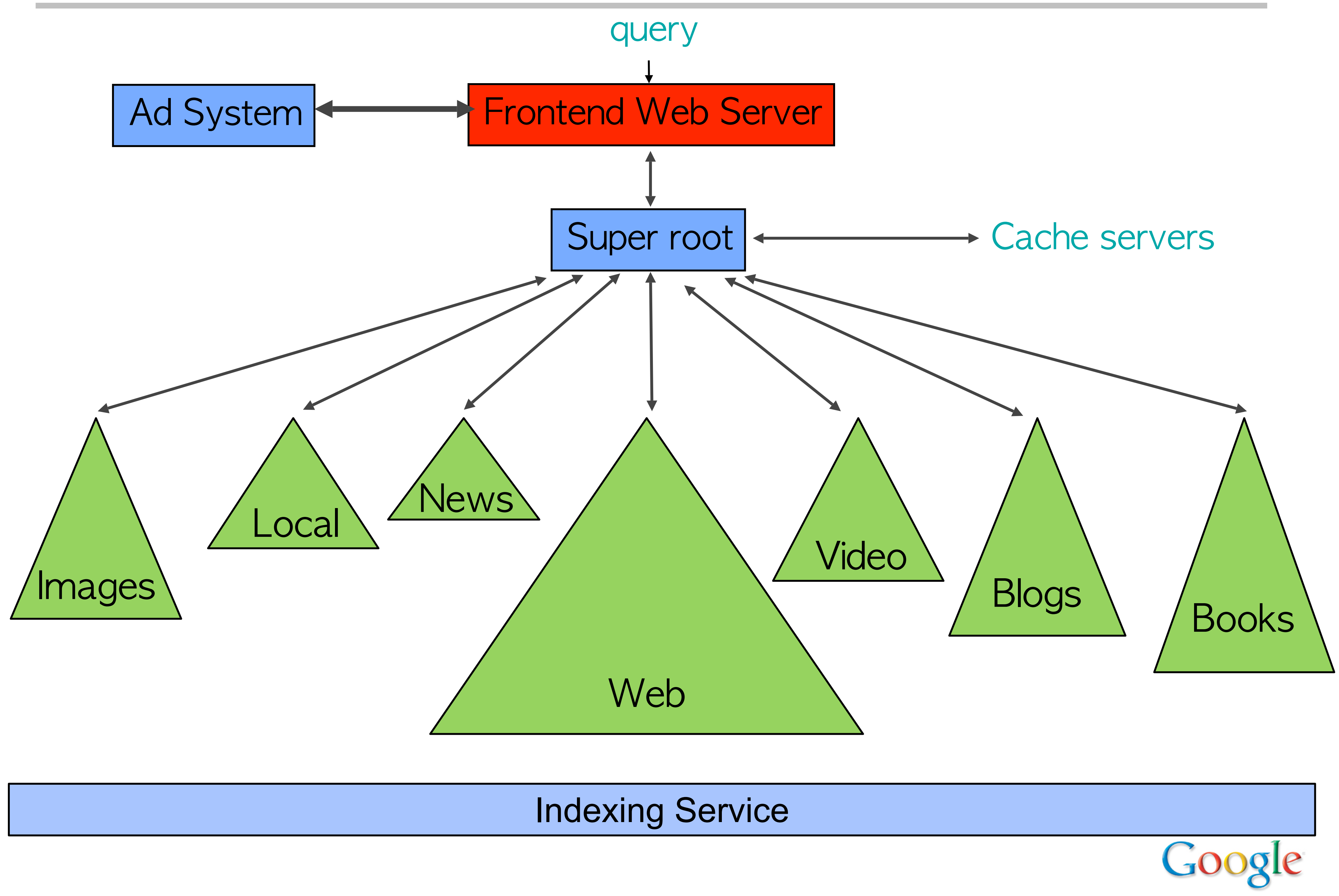
How big? Perhaps one million+ machines

but it's not that bad...

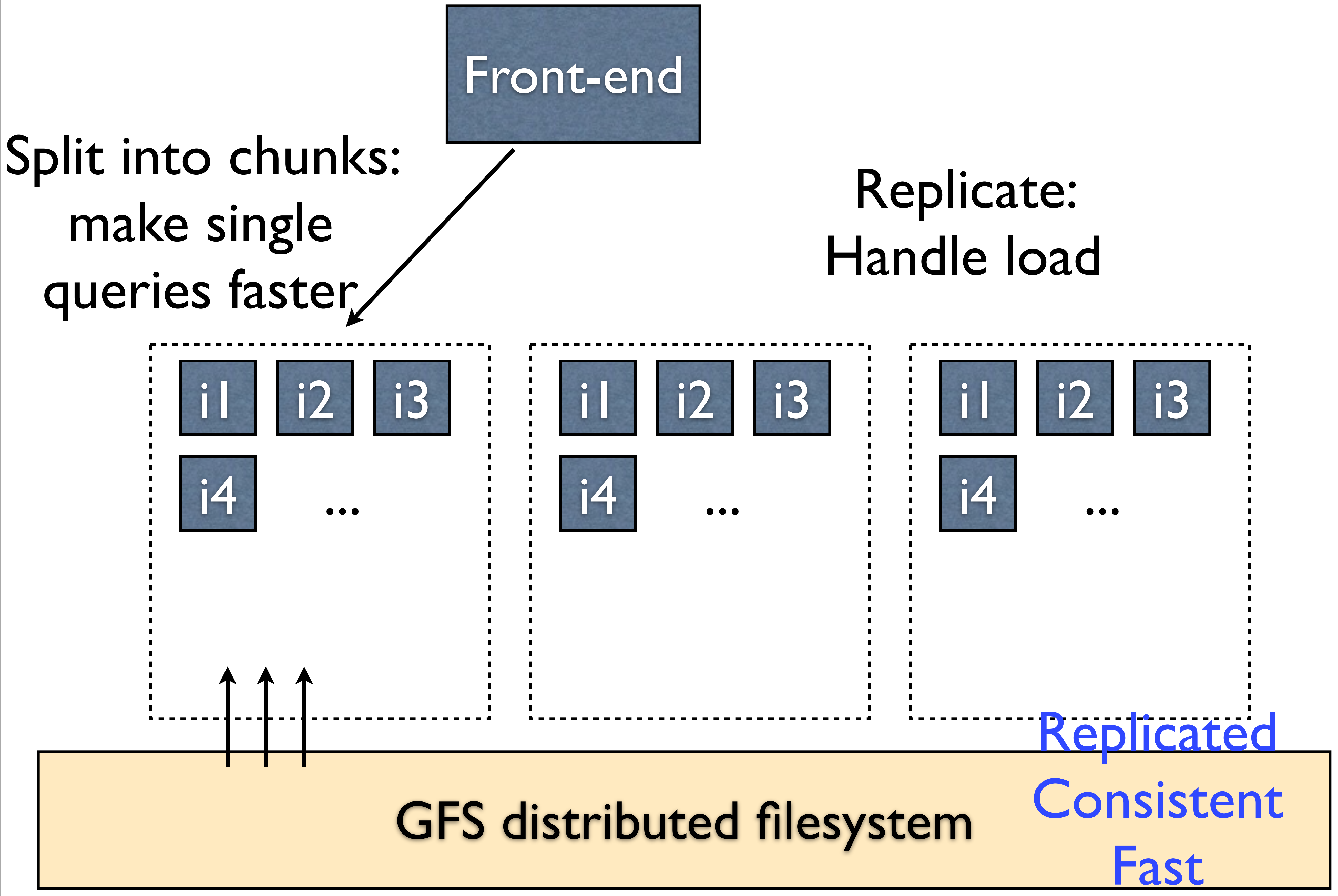
usually don't use more than **20,000** machines to accomplish a single task. [2009, probably out of date]


Rick Astley?
Front-end

2007: Universal Search



slide from Jeff Dean, Google


Front-end
Split into chunks: make single queries faster
Replicate: Handle load
i1
i2
i3
i4
...
i1
i2
i3
i4
...
i1
i2
i3
i4
...
GFS distributed filesystem
Replicated
Consistent
Fast

How do you index the web?

1. Get a copy of the web.
2. Build an index.
3. Profit.

There are over 1 trillion unique URLs

Billions of unique web pages

Hundreds of millions of websites

30?? terabytes of text

=

- *Crawling* -- download those web pages
- *Indexing* -- harness 10s of thousands of machines to do it
- *Profiting* -- we leave that to you.

- *“Data-Intensive Computing”*

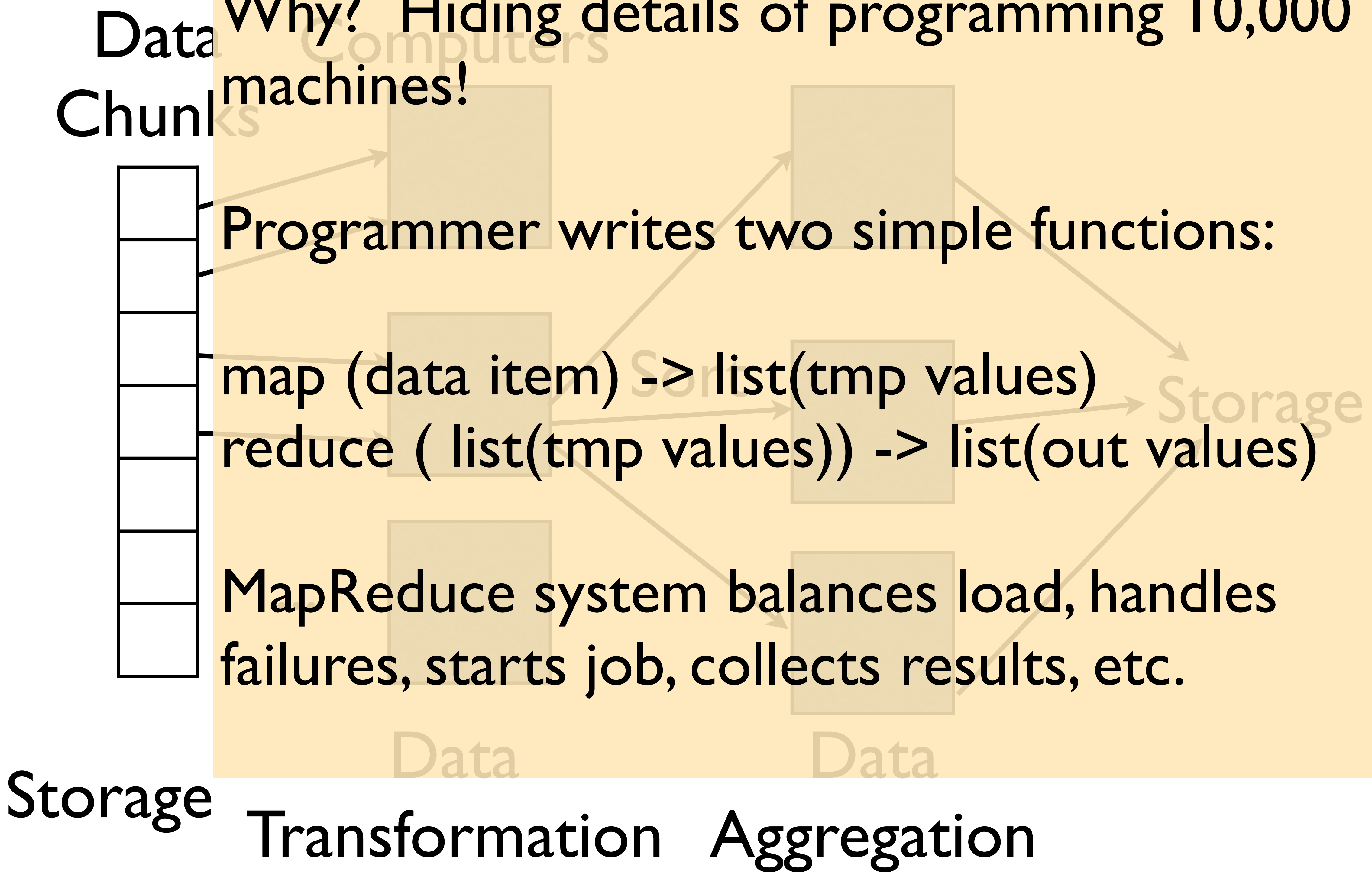
MapReduce / Hadoop

Why? Hiding details of programming 10,000 machines!

Programmer writes two simple functions:

map (data item) -> list(tmp values)
reduce (list(tmp values)) -> list(out values)

MapReduce system balances load, handles failures, starts job, collects results, etc.



All that...

- Hundreds of DNS servers
- Protocols on protocols on protocols
- Distributed network of Internet routers to get packets around the globe
- Hundreds of thousands of servers
- ... to find one bad video in under 1/2 second