Piattaforme Abilitanti Distribuite
- PAD -

Distributed Enabling Platforms

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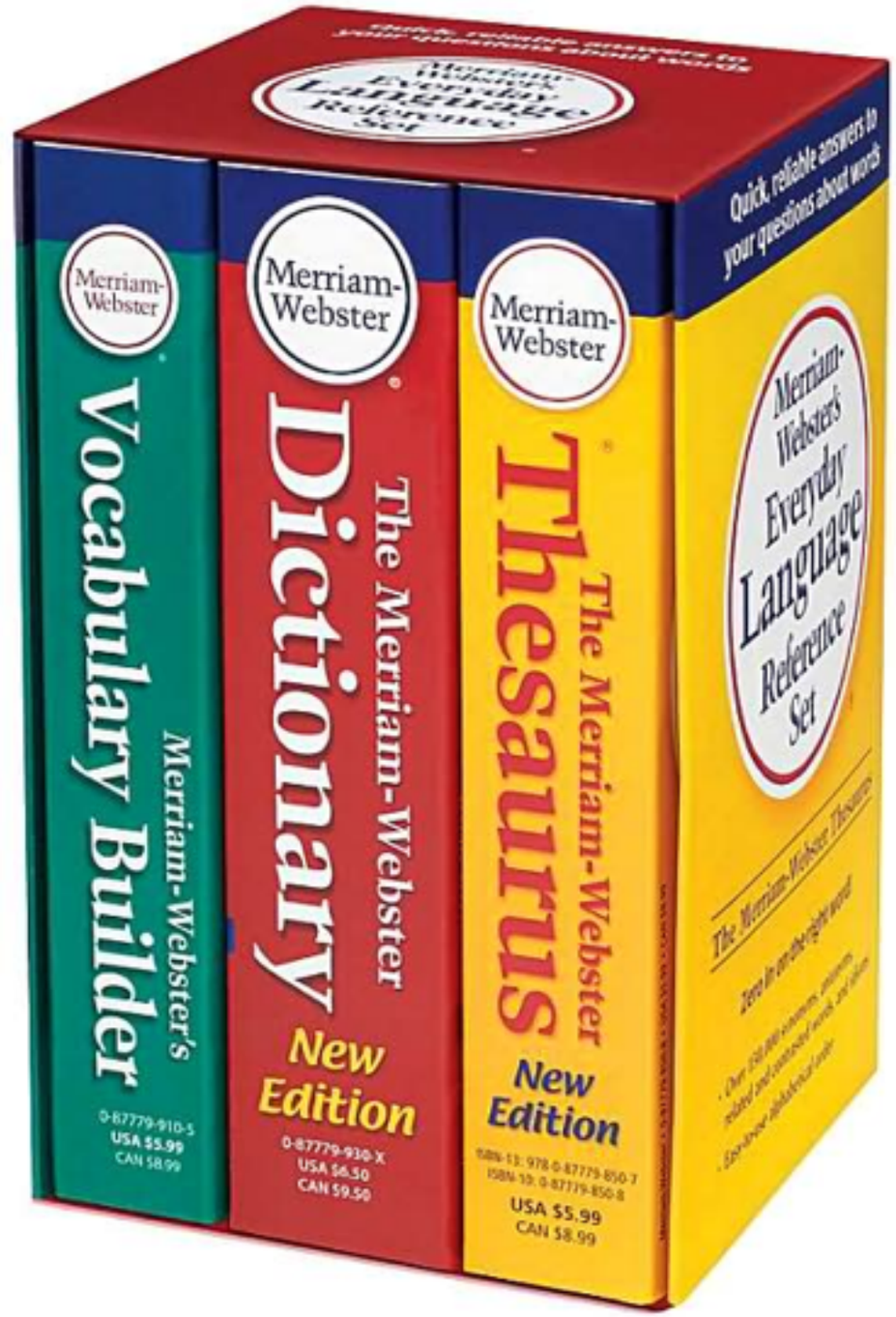
Today

Who?

What?

What is the meaning of words?

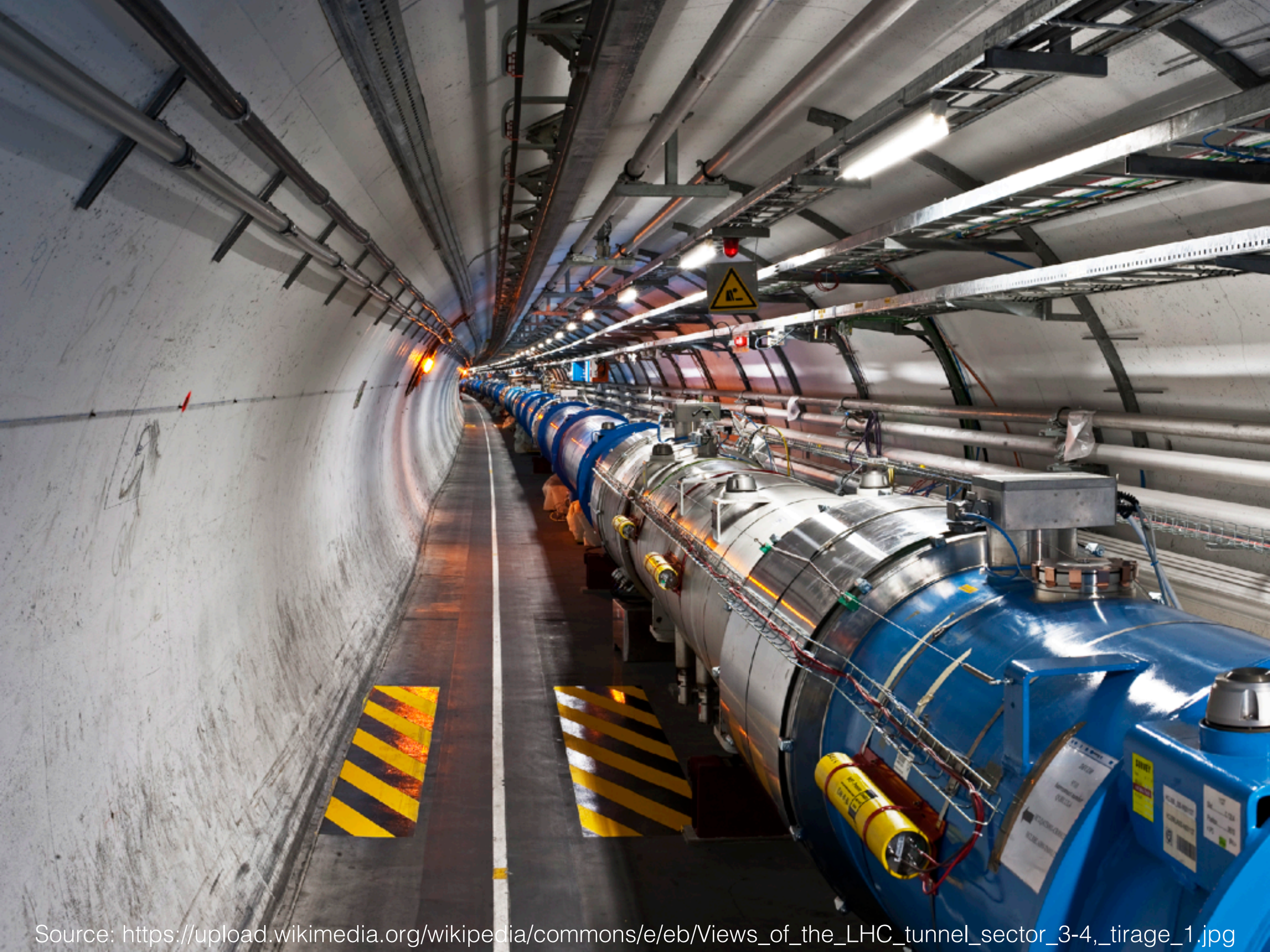
- Distributed…
  - relating to a **computer network** in which at least some of the processing is done by the **individual computers** and **information is shared** by and often stored at the computers
- Enabling…
  - to make possible, practical, or easy
- Platforms…
  - the computer architecture and equipment used for a particular purpose



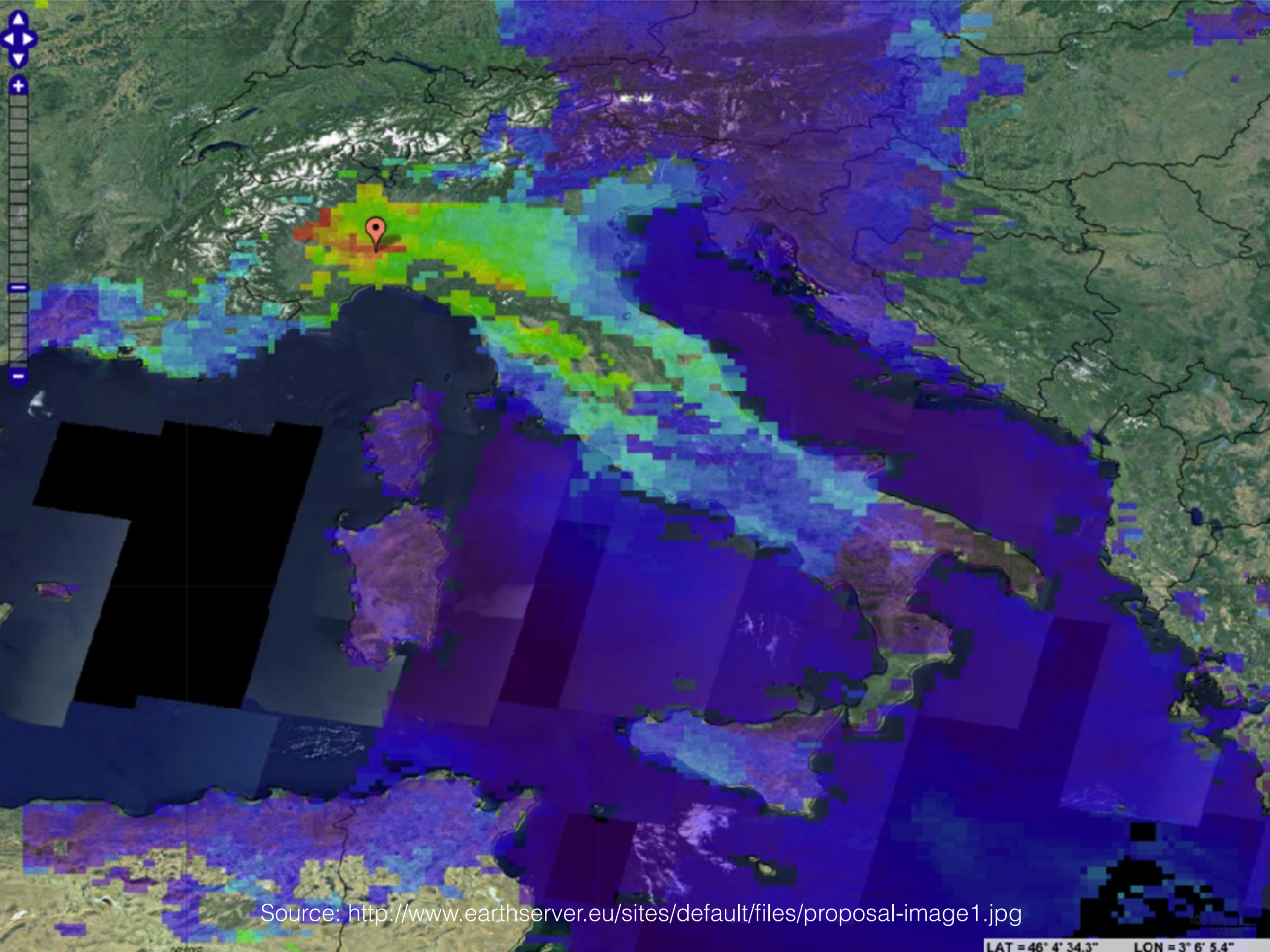
To do what?


$a^n + b^n = c^n$,
$n, a, b, c \in N$,
$n > 2$
$\varphi(x) = \sum_{k \in z} u(k)\sqrt{2}\varphi(2x-k)$
$\hat{\varphi}(\xi) = \prod_{j=1}^{\infty} m_0(\xi/2^j)$
$\langle \psi_{j,k} - \psi_{l,m} \rangle = \delta_{j,l} - \delta_{k,m}$
$f(x) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} \hat{f}(\xi) e^{ix\xi} d\xi$
©Walt Disney Co.
Don Rosa

Solve large scale problems!



Source: https://upload.wikimedia.org/wikipedia/commons/e/eb/Views_of_the_LHC_tunnel_sector_3-4,_tirage_1.jpg



Source: http://www.earthserver.eu/sites/default/files/proposal-image1.jpg

Source: https://upload.wikimedia.org/wikipedia/commons/1/18/NASDAQ_studio.jpg

Source: https://upload.wikimedia.org/wikipedia/commons/1/19/Times_Square%2C_New_York_City_%28HDR%29.jpg

Source: https://upload.wikimedia.org/wikipedia/commons/2/24/Huge_crowd_turns_out_for_MTV_EXIT_concert_against_human_trafficking_and_exploitation.jpg

Some Numbers (I)

- 10,033 Tweets sent in 1 second
- 2,623 Instagram photos uploaded in 1 second
- 2,199 Tumblr posts in 1 second
- 1,862 Skype calls in 1 second
- 29,667 GB of Internet traffic in 1 second
- 50,512 Google searches in 1 second
- 107,401 YouTube videos viewed in 1 second
- 2,425,138 Emails sent in 1 second

source: http://www.internetlivestats.com

Some Numbers (II)

- 3.2 billions of Internet users
- 928 millions of Web sites
- 168 billions of email sent during the day
- 3.2 billions of google searches during the day
- 2.9 millions blog posts written during the day
- 640 millions of tweets sent during the day
- 6.8 billions of videos viewed on Youtube during the day
- 167 millions of Photos uploaded on Instagram during the day
- 1.5 billions of Facebook active users
- 1.5 billions of Google+ active users
- 328 millions of Twitter active users
- 120 millions of Skype calls during the day
- 40 thousands of Web sites hacked during the day
- 503 thousand of computers sold today
- 4 millions of smartphones sold today
- 772 thousands of tablets sold today
- 1.9 billions of GB (1.9 EB) Internet traffic today

source: http://www.internetlivestats.com

BIG DATA!

Google

Processes 20 PB a day (2008)
Crawls 20B web pages a day (2012)
Search index is 100+ PB (5/2014)
Bigtable serves 2+ EB, 600M QPS (5/2014)

JPMorganChase

150 PB on 50k+ servers
running 15k apps (6/2011)

YAHOO!

19 Hadoop clusters: 600
PB, 40k servers (9/2015)

ebay

Hadoop: 10K nodes, 150K
cores, 150 PB (4/2014)

300 PB data in Hive +
600 TB/day (4/2014)

facebook

amazon web services™

S3: 2T objects, 1.1M
request/second (4/2013)

How?

Famous predictions

1961

[...] computing may someday be organized as a public utility just as telephone system is a public utility [...] the computer utility could become the basis of a new and important industry [...]

John McCarthy (1927-2011)
Turing Award (1971)
Artificial Intelligence

1969

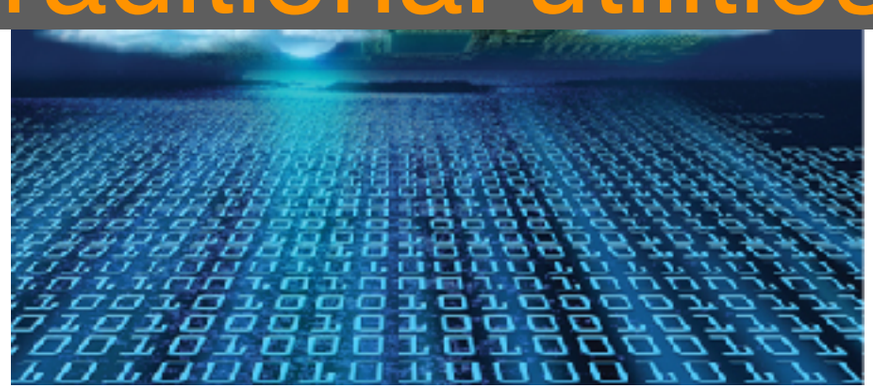
As of now, computer networks are still in their infancy, but as they group up and become sophisticated, we will probably see the spread of computer utilities which, like present electric and telephone utilities, will service individual homes and offices across the country.

Leonard Kleinrock (1934)
Queueing Theory

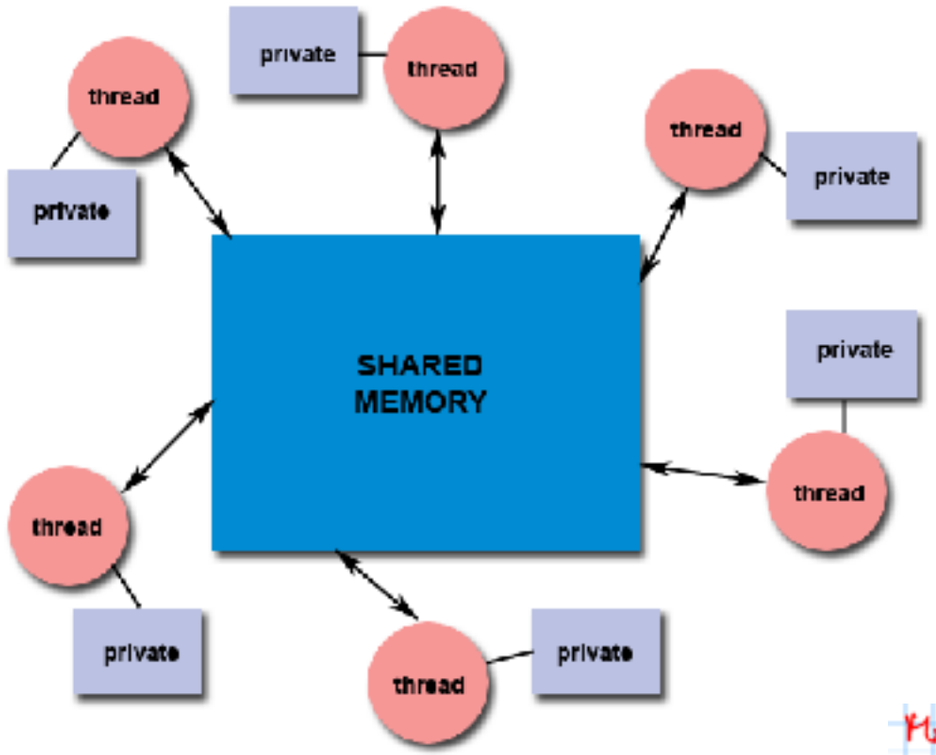
The 5th Utility

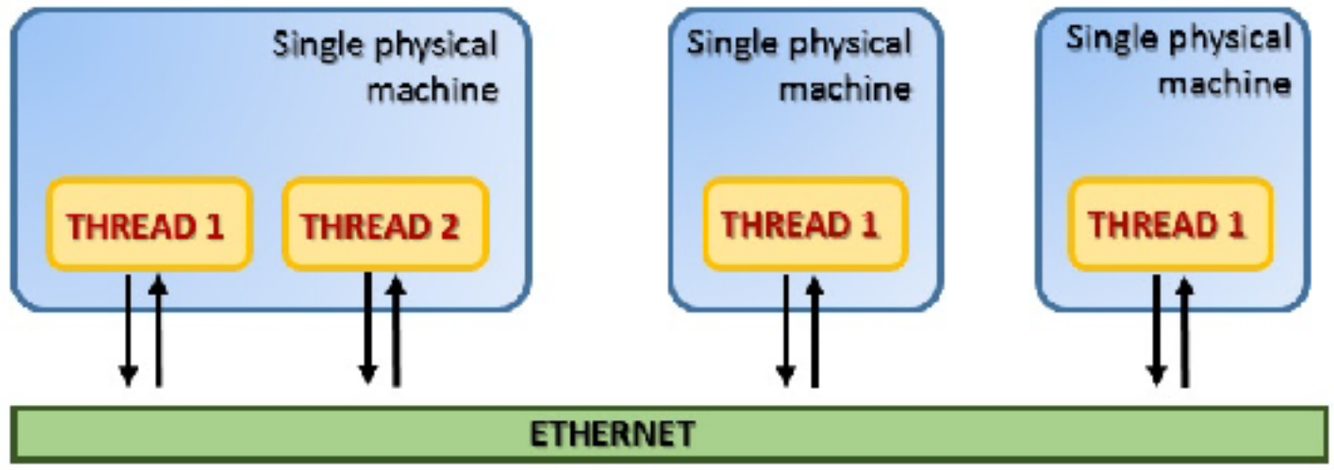
The 5th Utility

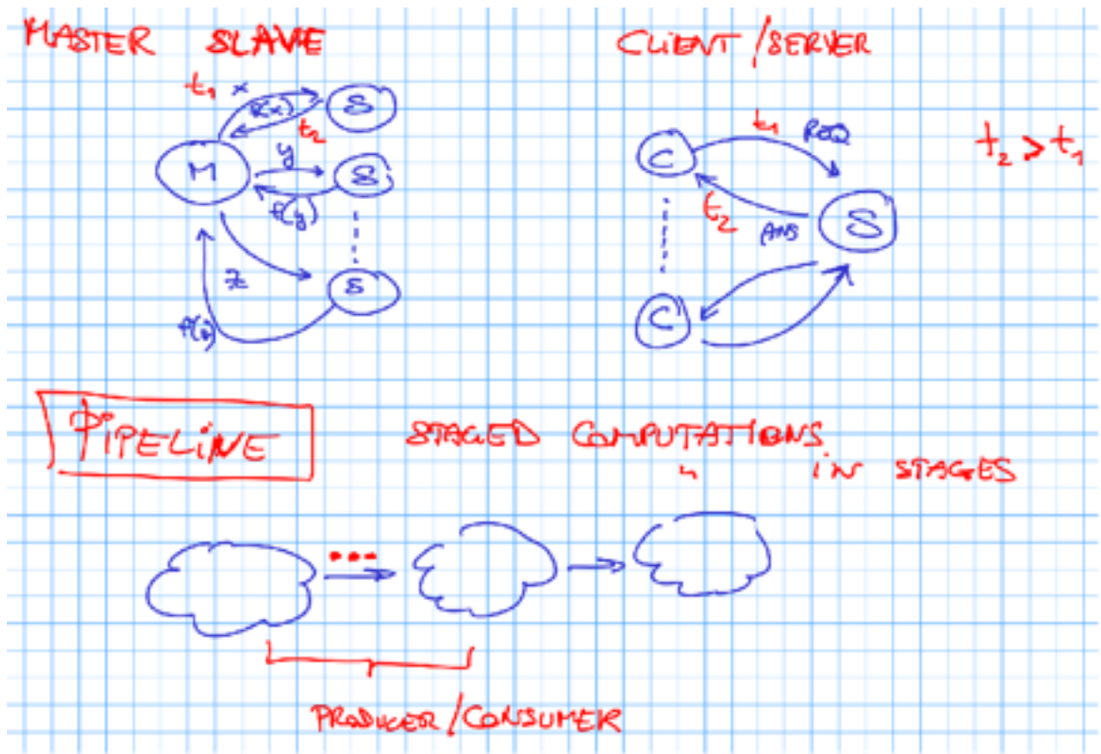
Computing is being transformed to a model consisting of services that are commoditized and delivered in a manner similar to traditional utilities



Tools you (should) know







Once upon a time...

Microcomputer

Minicomputer

Cluster

Mainframe

Cluster Computing

- A cluster is a type of parallel and distributed system, which consists of a collection of inter-connected stand-alone computers working together as a single integrated computing resource.

- Basic element is the node, a single or multiprocessor system with memory, I/O and OS
- Generally two or more nodes connected together
- In a single rack, or physically separated and connected via a LAN
- Appears as a single system to users and applications
- Specialized access, management and programming

...up to the Grid...

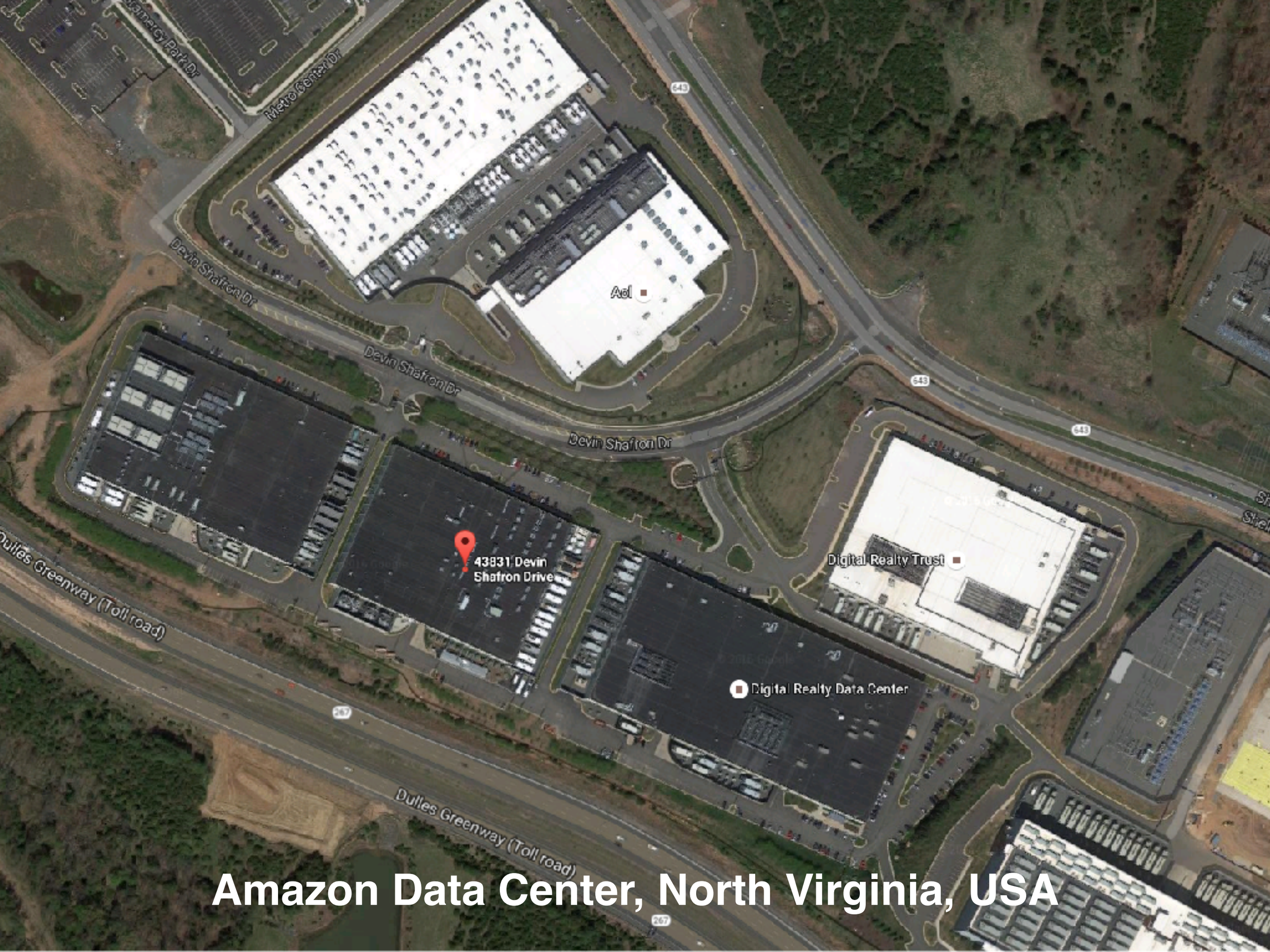
...up to the Cloud

...up to the Cloud

Google Data Center, The Dalles, Oregon

Facebook Data Center, Luleå, Sweden

Microsoft Data Center, Dublin, Ireland

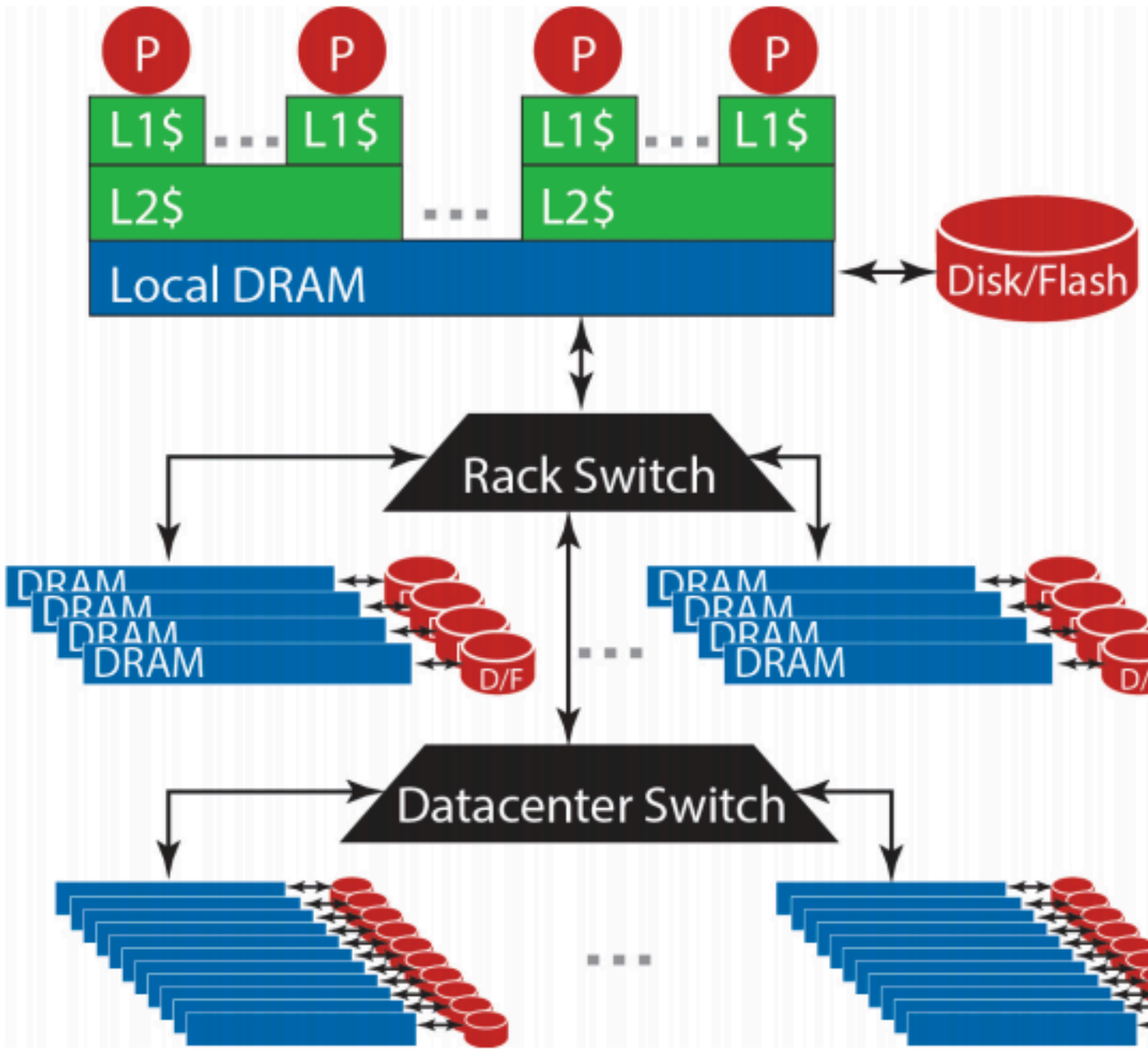


Amazon Data Center, North Virginia, USA

Datacenter Basic Components

Facebook

Datacenter Storage



One Server
DRAM: 16 GB, 100 ns, 20 GB/s
Disk: 2T B, 10 ms, 200 MB/s
Flash: 128 GB, 100 us, 1 GB/s

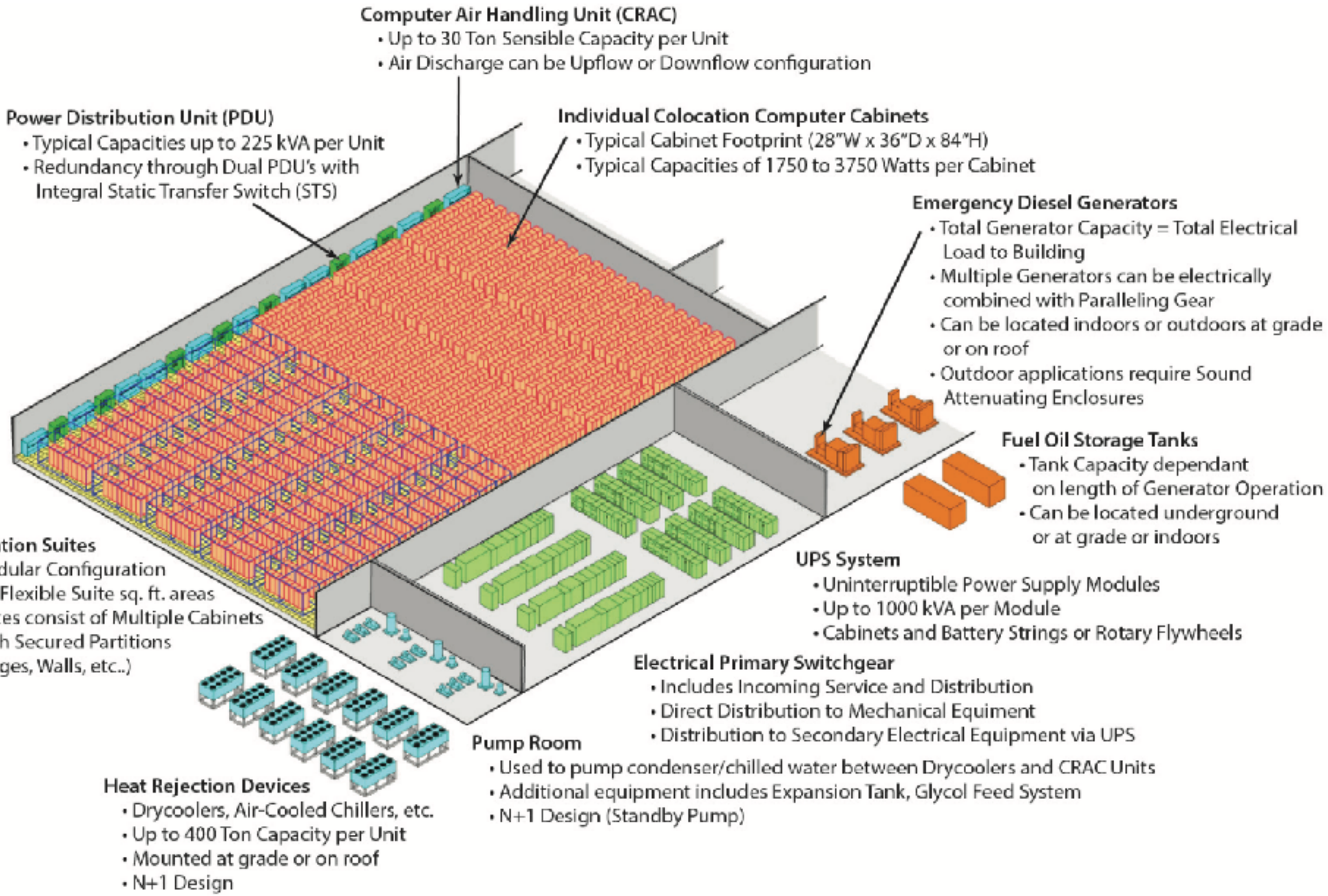
Local Rack (80 servers)
DRAM: 1 TB, 300 us, 100 MB/s
Disk: 160 TB, 11 ms, 100 MB/s
Flash: 20 TB, 400 us, 100 MB/s

Cluster (30 racks)
DRAM: 30 TB, 500 us, 10 MB/s
Disk: 4.80 PB, 12 ms, 10 MB/s
Flash: 600 TB, 600 us, 10 MB/s

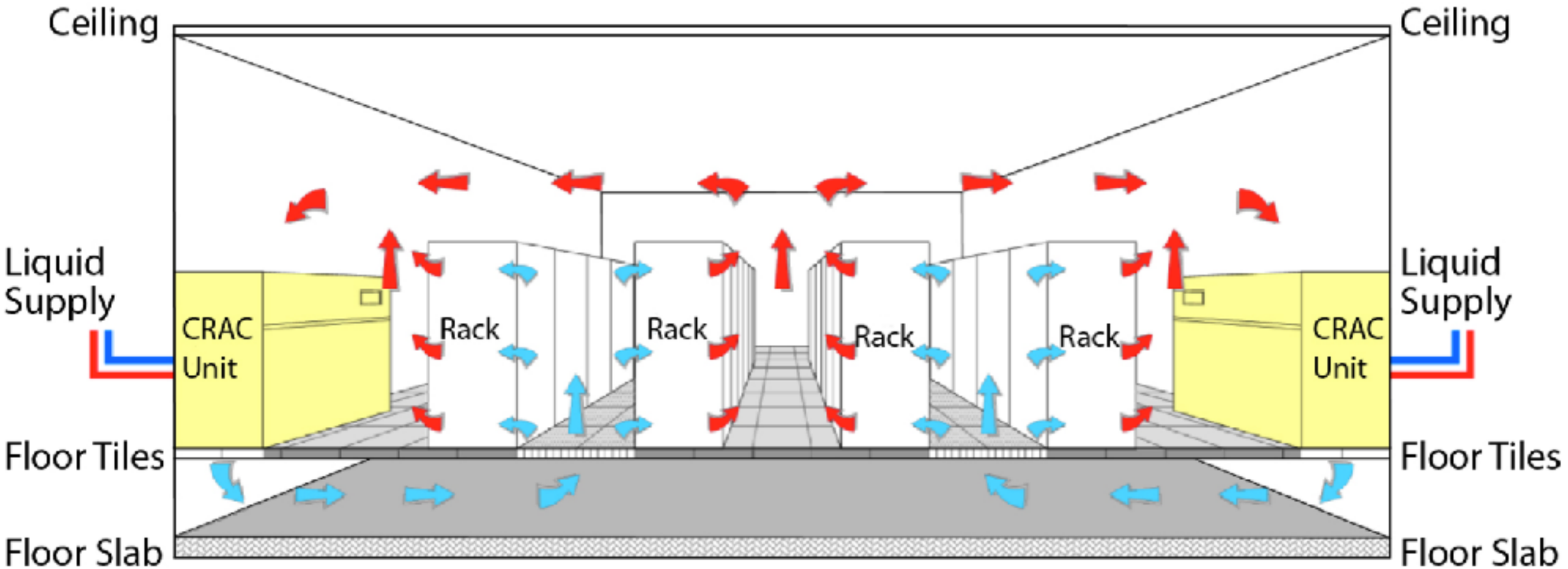
Datacenter Tiers

- **Datacenters have strict standards for reliability and availability**
  - Tier 1: 99.671% Availability: 28 hours of downtime/year
    - a single path for power distribution, UPS, and cooling distribution, without redundant components.
  - Tier 2: 99.741% Availability: 22 hours of downtime/year
    - redundant components to this design, improving availability.
  - Tier 3: 99.982% Availability: 1.5 hours of downtime/year
    - one active and one alternate distribution path for utilities.
  - Tier 4: 99.995% Availability: 26 minutes of downtime/year
    - two simultaneously active power and cooling distribution paths, redundant components in each path, and are supposed to tolerate any single equipment failure without impacting the load.

Datacenter Power Systems



Datacenter Cooling



Google Cooling System

Latency Numbers Every Programmer Should Know

Latency Comparison Numbers

L1 cache reference	0.5	ns		
Branch mispredict	5	ns		
L2 cache reference	7	ns		14x L1 cache
Mutex lock/unlock	25	ns		
Main memory reference	100	ns		20x L2 cache, 200x L1 cache
Read 4K randomly from memory	1,000	ns	0.001 ms	
Compress 1K bytes with Zippy	3,000	ns		
Send 1K bytes over 1 Gbps network	10,000	ns	0.01 ms	
Read 4K randomly from SSD*	150,000	ns	0.15 ms	
Read 1 MB sequentially from memory	250,000	ns	0.25 ms	
Round trip within same datacenter	500,000	ns	0.5 ms	
Read 1 MB sequentially from SSD*	1,000,000	ns	1 ms	4X memory
Disk seek	10,000,000	ns	10 ms	20x datacenter roundtrip
Read 1 MB sequentially from disk	20,000,000	ns	20 ms	80x memory, 20X SSD
Send packet CA->Netherlands->CA	150,000,000	ns	150 ms	

Source: Jeff Dean and Peter Norvig (Google), with some additions

https://gist.github.com/hellerbarde/2843375

For all scale analogies, consider 1 CPU cycle = 1 second

(In reality, 1 CPU cycle = 0.3 nanoseconds)

ONE CPU CYCLE
= .3NS, WHICH = 1 SEC,
OR IS EQUAL TO

Clapping your hands

L1 CACHE ACCESS
= .9NS, WHICH = 3 SEC,
OR IS EQUAL TO

Blowing your nose

L2 CACHE ACCESS
= 2.8NS, WHICH = 9 SEC,
OR IS EQUAL TO

Bill Gates earning $2,250

L3 CACHE ACCESS
= 12.9NS, WHICH = 43 SEC,
OR IS EQUAL TO

COMPLETING AN AVERAGE MARIO BROS.
Level 1-1 speed run
(THE WORLD RECORD IS ABOUT 21 SECONDS)

MUTEX LOCK/UNLOCK
= 17 NS, WHICH = 58 SEC,
OR IS EQUAL TO

Washing your dishes

MAIN MEMORY ACCESS
= 100 NS, WHICH = 6 MIN,
OR IS EQUAL TO

LISTENING TO QUEEN'S
"Bohemian Rhapsody"

COMPRESS 1KB WITH ZIPPY
= 2µS, WHICH = 2 HOURS,
OR IS EQUAL TO

Watching a movie

READ 1M BYTES SEQUENTIALLY FROM MEMORY
= 9µS, WHICH = 9 HOURS,
OR IS EQUAL TO

COMPLETING A STANDARD
US workday

SSD RANDOM READ
= 16 µS, WHICH = 14 HOURS,
OR IS EQUAL TO

TAKING A FLIGHT FROM
New York to Beijing

SOLID-STATE DISK I/O
= 50-150 µS, WHICH = 2-6 DAYS,
OR IS EQUAL TO

WAITING FOR A STANDARD GROUND-SHIPPED
US domestic package

READ 1M BYTES SEQUENTIALLY FROM SSD
= 200 µS, WHICH = 8 DAYS,
OR IS EQUAL TO

IF THERE WERE 8 DAYS IN A WEEK,
IT WOULD NOT BE ENOUGH TIME FOR
The Beatles
TO SHOW THEY CARE

ROUND TRIP IN THE SAME DATACENTER
= 500 µS, WHICH = 19 DAYS,
OR IS EQUAL TO

Free climbing
EL CAPITAN'S DAWN WALL
IN YOSEMITE NATIONAL PARK

READ 1M BYTES SEQUENTIALLY FROM A SPINNING DISK
= 2MS, WHICH = 70 DAYS,
OR IS EQUAL TO

PLANTING + HARVESTING A
zucchini

DISK SEEK
= 4MS, WHICH = 5 MONTHS,
OR IS EQUAL TO

TRAINING FOR YOUR
first marathon
IF YOU'VE NEVER DONE ONE + YOU'RE
AT AN AVERAGE FITNESS LEVEL

ROTATIONAL DISK I/O
= 1-10MS, WHICH = 1-12 MONTHS,
OR IS EQUAL TO

WAITING UNTIL THE NEXT SEASON OF
Game of Thrones

INTERNET: SF TO NYC
= 71MS, WHICH = 7 YEARS,
OR IS EQUAL TO

ATTENDING + GRADUATING
Hogwarts
IF YOU'RE A WITCH OR WIZARD

OS VIRTUALIZATION REBOOT
= 4 S, WHICH = 423 YEARS,
OR IS EQUAL TO

423 YEARS AGO,
Shakespeare
WROTE RICHARD III

SCSI COMMAND TIME-OUT
= 30 S, WHICH = 3,000 YEARS,
OR IS EQUAL TO

3,000 YEARS AGO, PEOPLE STARTED
wearing pants

HARDWARE VIRTUALIZATION REBOOT
= 40 S, WHICH = 4,000 YEARS,
OR IS EQUAL TO

4,000 YEARS AGO, THE PHARAOHS STILL
ruled Egypt

PHYSICAL SYSTEM REBOOT
= 5 MINUTES, WHICH = 32,000 YEARS,
OR IS EQUAL TO

32,000 YEARS AGO, THE AREA THAT IS THE
Sahara desert was well-watered

Source: DZone

Where? & When?

Course Organization

- Agreement on room and timetable
  - Currently: Mon 16 – 18 (room L1), Fri 9 – 11 (room C1)
  - Depending on availability
- Highly interactive lectures
- Laboratory
  - Java programming skills required
  - Bring your own laptop (don’t forget plugs!)
- Slides and references available online
  - Updated in real time on the course wiki
- Final examination: project + oral session
  - To be agreed with teacher

Syllabus & Lectures

https://github.com/tonellotto/pad2017