oueees-201506 Part 2: large-scale information systems

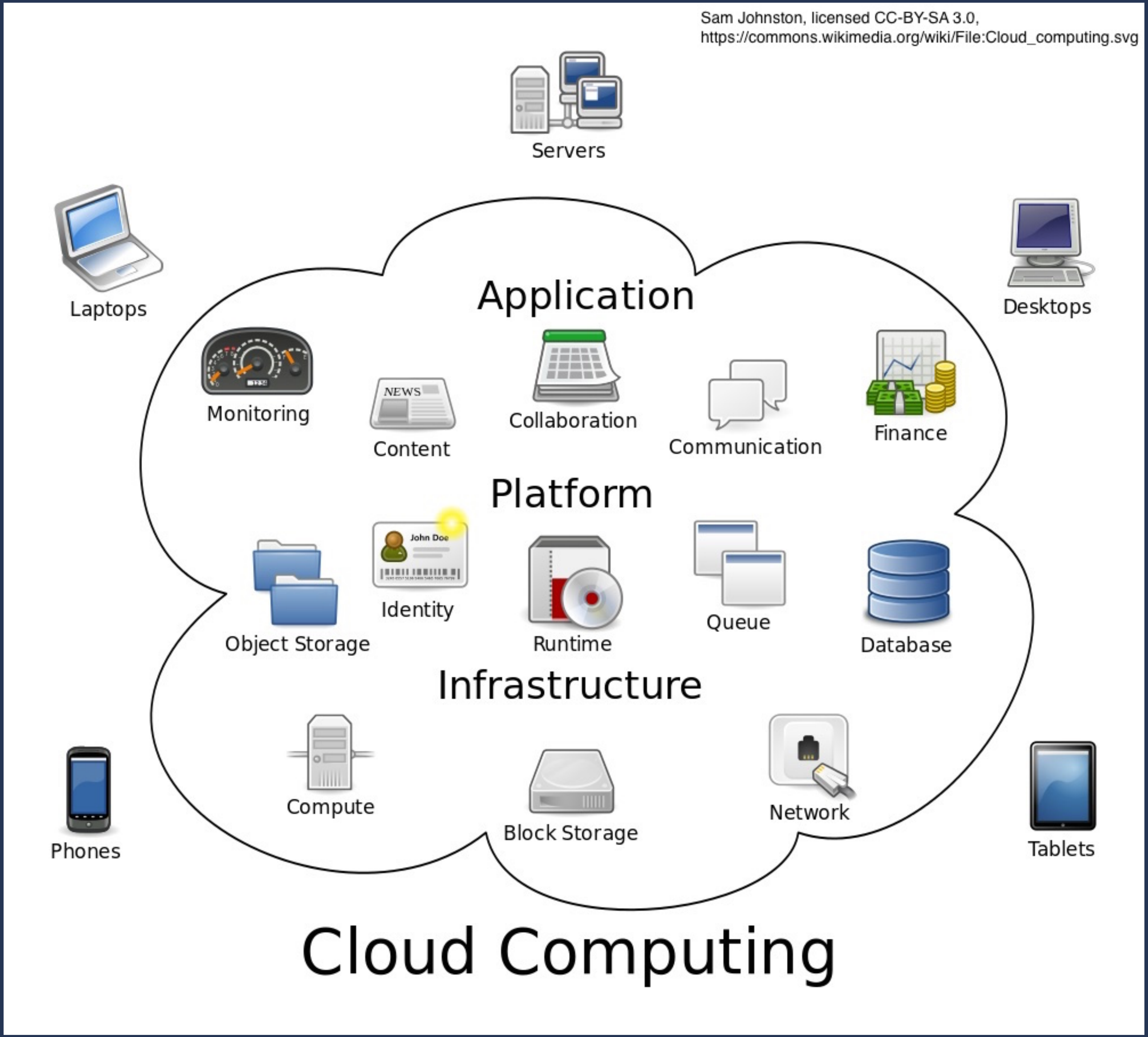
Kenji Rikitake

16-JUN-2015
School of Engineering Science
Osaka University
Toyonaka, Osaka, Japan
@jj1bdx

Lecture notes on GitHub

- https://github.com/jj1bdx/oueees-201505-public/
- Don't forget to *check out the issues*!

Cloud computing systems



Sam Johnston, licensed CC-BY-SA 3.0,
https://commons.wikimedia.org/wiki/File:Cloud_computing.svg

Cloud computing elements

- Servers and services on the Internet
- Endpoint terminals (smartphones, tablets, laptops, etc.) *outside* the cloud
- *Highly centralized systems depending on the Internet*

Inside the services

- A cluster of distributed systems
- Multiple computers *collaboratively* connected to do the same task
- *Highly decentralized* or even *distributed*

Forms of networks [1]

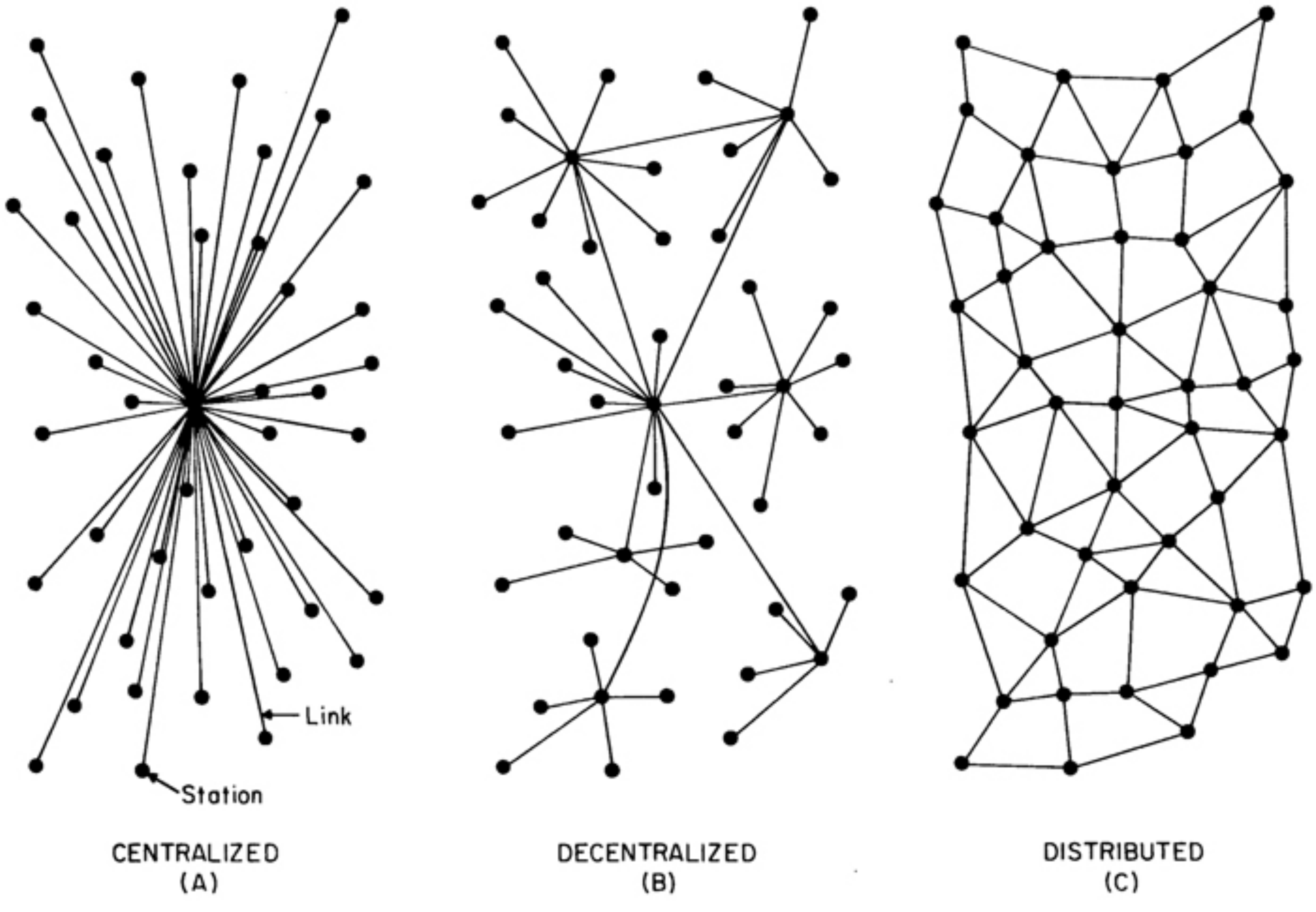
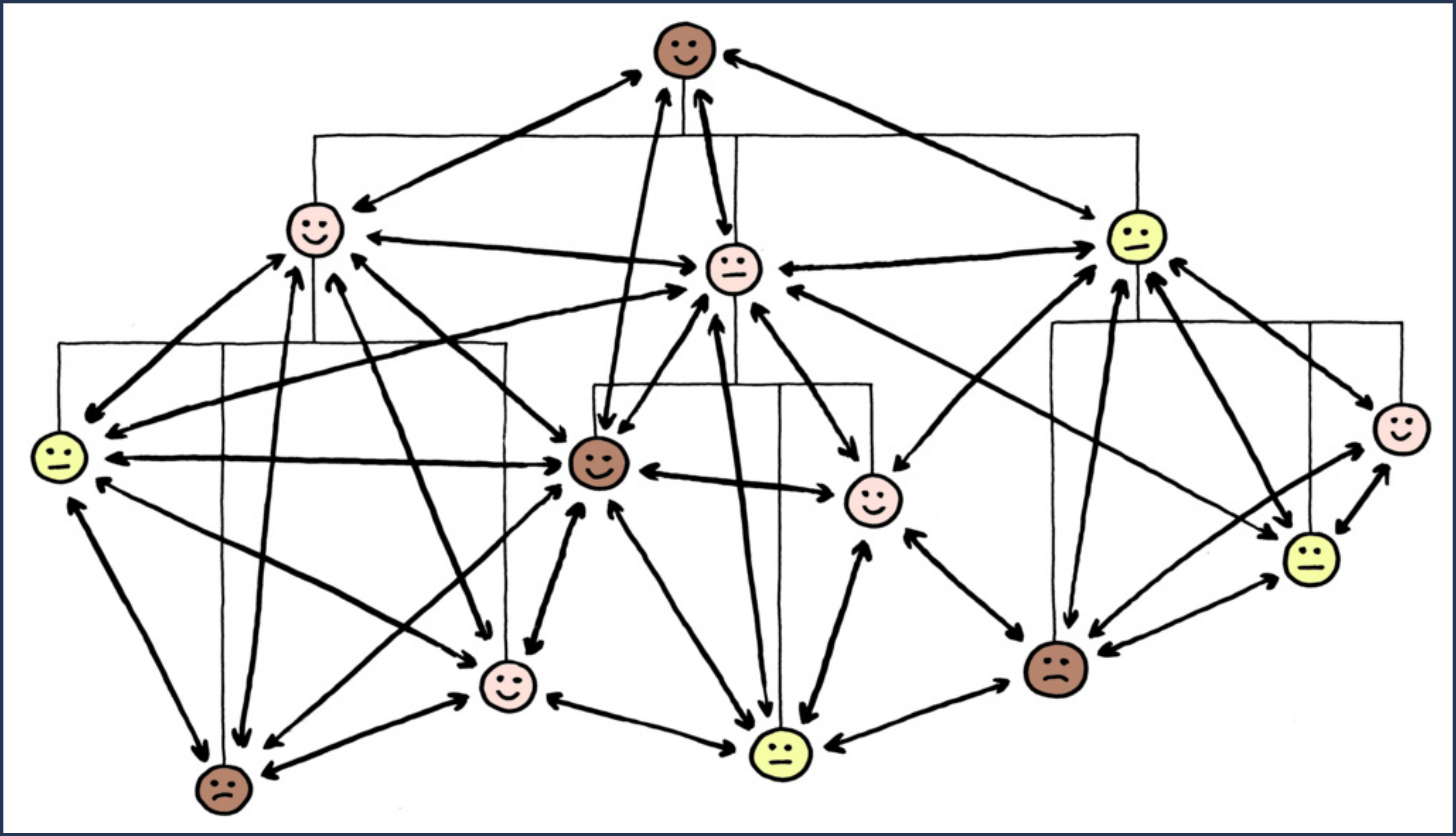


FIG. I — Centralized, Decentralized and Distributed Networks

[1] Carl S. Sterner, Resilience and Decentralization, http://www.carlsterner.com/research/2009_resilience_and_decentralization.shtml

Real world: hierarchy *and* decentralization [2]



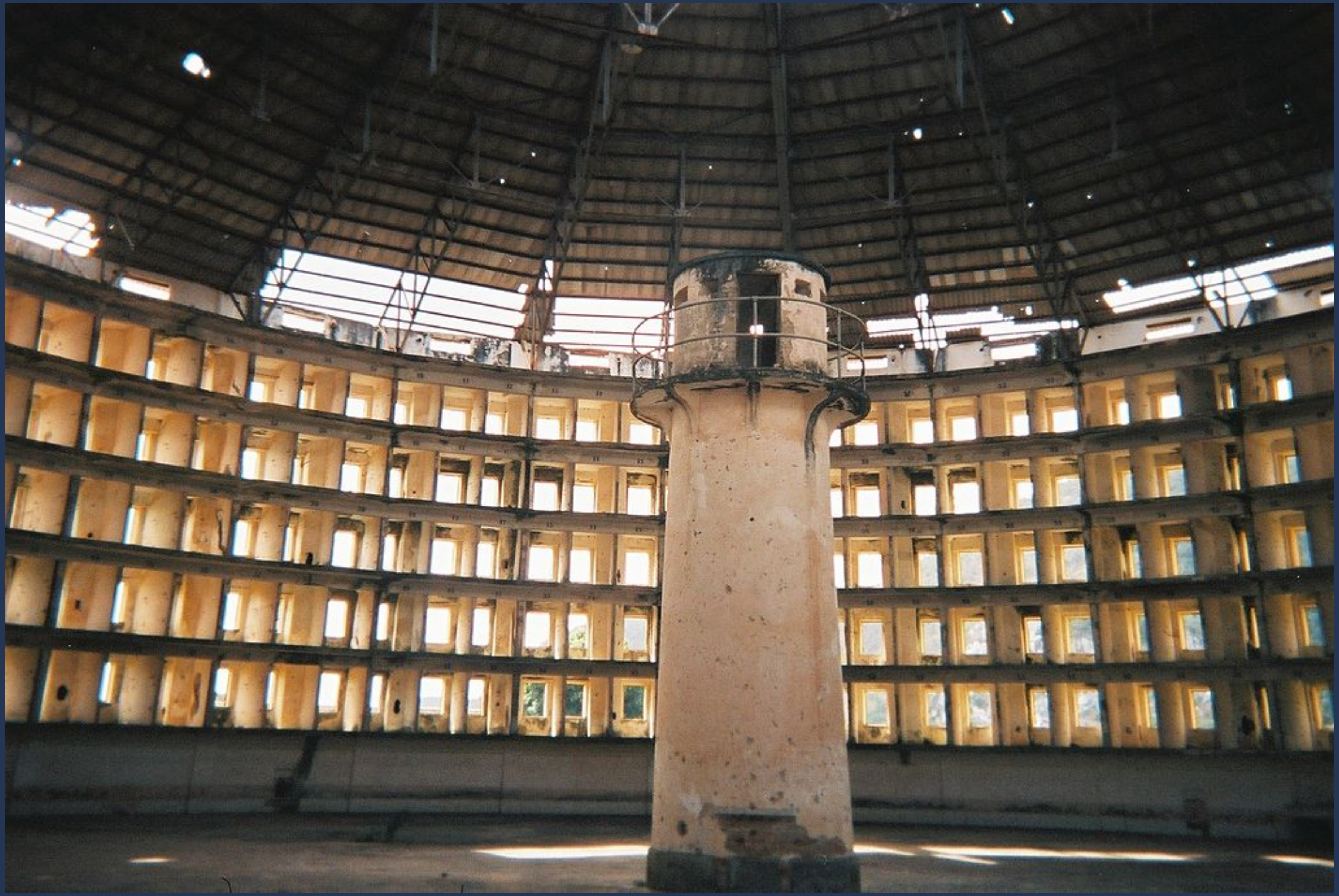
[2] By Jurgen Appelo, licensed CC BY 2.0, https://www.flickr.com/photos/jurgenappelo/5201869924/

Centralized social behavior accerelated by cloud computing

- Sharing *everything* - no privacy
- *Panopticon* [3] style of governance, filtering, *censorship, or autocracy*
- Complete *externalization* of resources, leading to *no personal control*

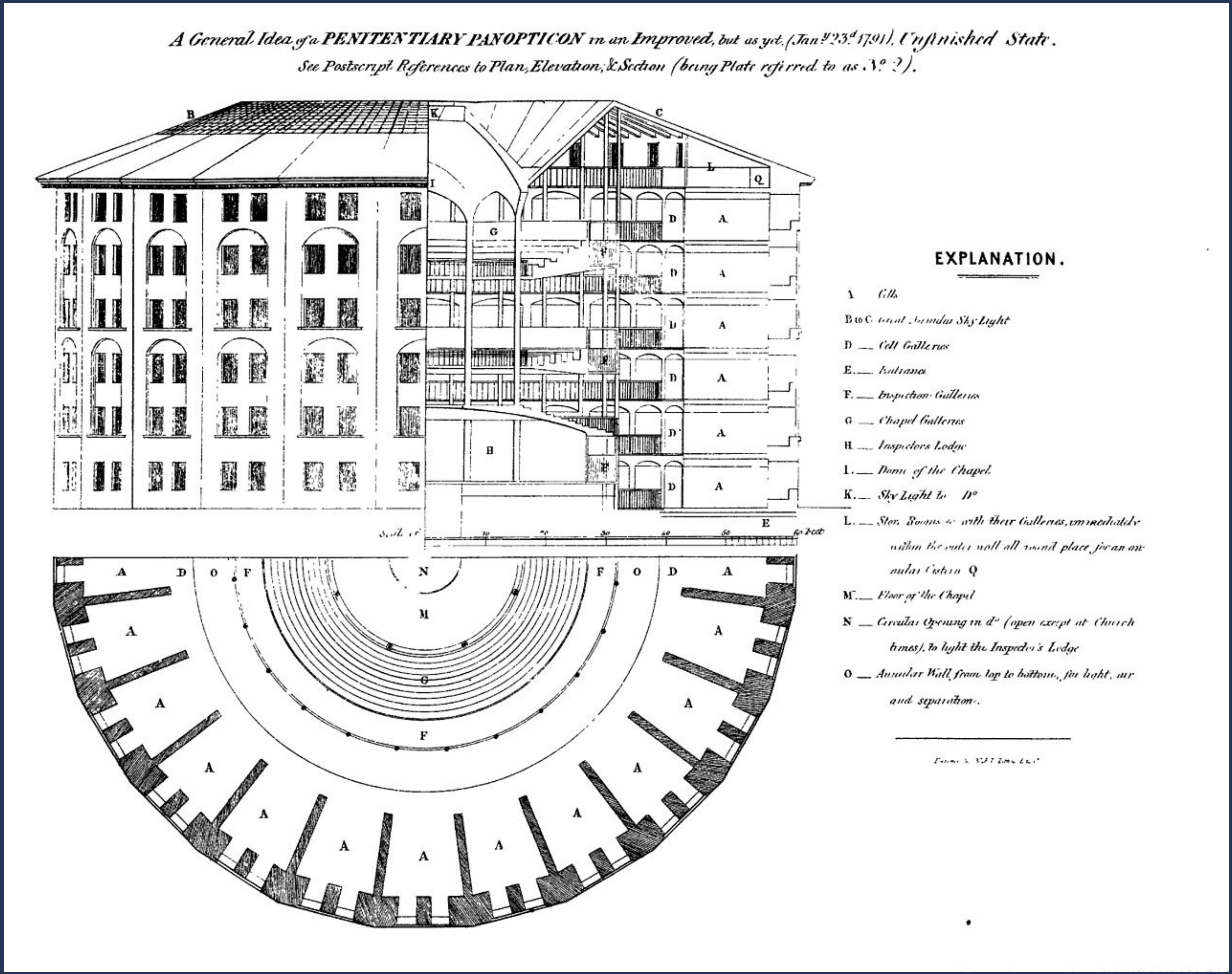
[3] n. a circular prison with cells arranged around a central well, from which prisoners could at all times be observed. (New Oxford American Dictionary, Apple OS X 10.10.3)

Precidio Modelo Prison [4]



[4] Friman, licensed CC BY-SA 3.0, https://en.wikipedia.org/wiki/Panopticon#/media/File:Presidio-modelo2.JPG

Panoption plan example (public domain)



A General Idea of a PENITENTIARY PANOPTICON in an Improved, but as yet (Jan^y 23^d 1791) Unfinished State.
See Postscript References to Plan, Elevation, & Section (being Plate referred to as N° 2).

EXPLANATION.

A Cells
B to C Great Annular Sky Light
D — Cell Galleries
E. — Entrance
F. — Inspection Galleries
G — Chapel Galleries
H — Inspectors Lodge
I. — Dome of the Chapel
K. — Sky Light to D°
L. — Store Rooms &c with their Galleries, immediately within the outer wall all round place for an annular Cistern Q
M. — Floor of the Chapel
N — Circular Opening in d° (open except at Church times), to light the Inspector's Lodge
O — Annular Wall from top to bottom, for light, air and separation.

INGSOC

The slogans: [5]

- War is peace
- Freedom is slavery
- Ignorance is strength
- Independent thinking = *thoughtcrime*

NOTE: this is a *fiction*!

[5] George Orwell, "Nineteen Eighty-Four", 1949.

Perpetual War
常在戦場

Why cloud computing has become so dystopian?

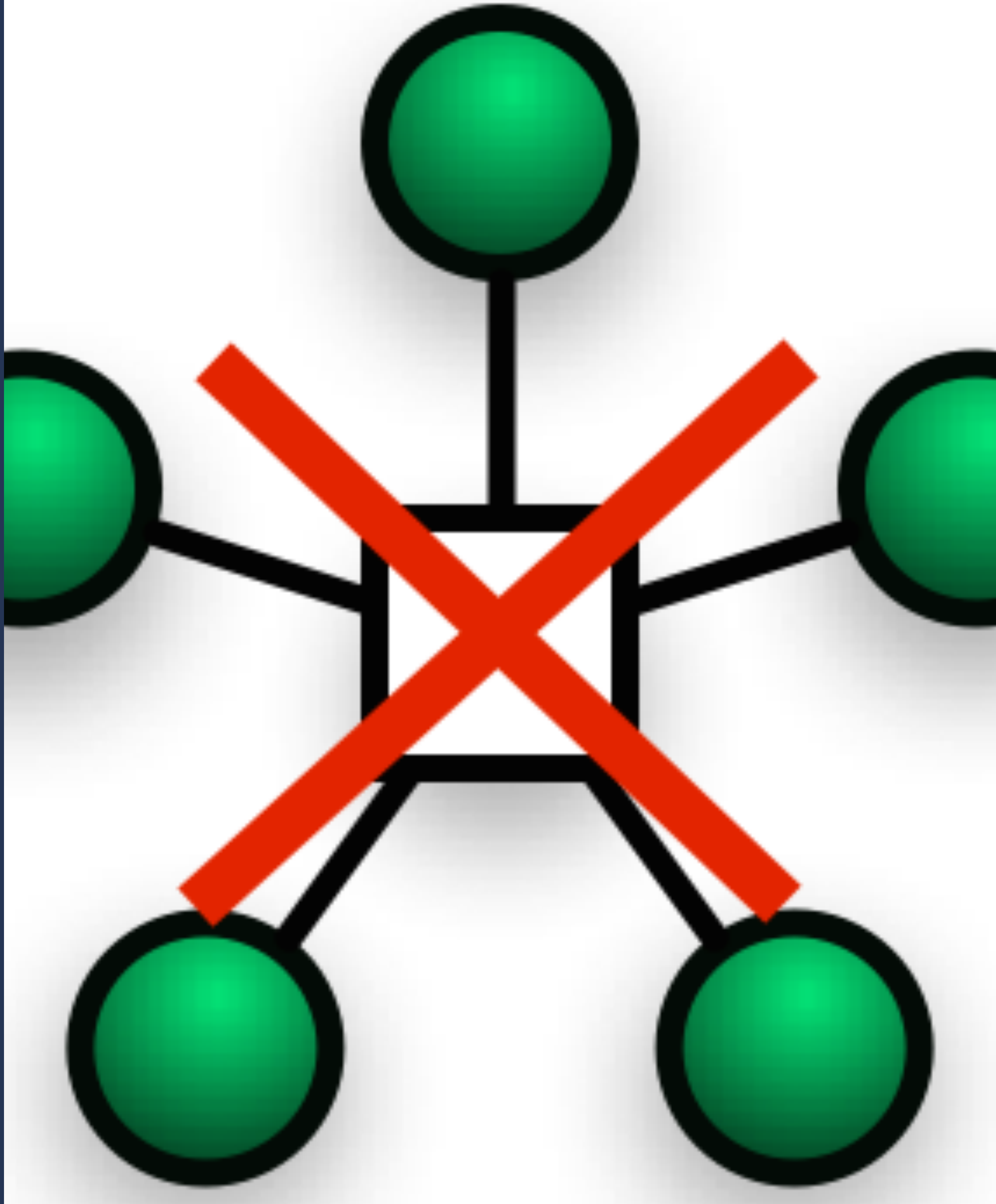
We have sold freedom for convenience

Convenience of centralized systems

- Ubiquitous/global accessibility
- Concentrated data for easy analysis
- Easy control of the information flow
- No extra cost for sharing
- No need to think about where the information locates

The inconvenient truth of centralized systems

What if the core/cloud fails?



Inconvenience of centralized systems

- Ubiquity or *no accessibility*
- When the core fails, no alternative
- When the core loses data, *no backup*
- The system performance is restricted by the capability of the core
- Endpoint systems will lost *all capabilities*

Centralized systems are *not* sustainable

Sustainable information systems: decentralized and distributed

Real-world challenges

- Natural disasters
- Device failures
- Human operation errors
- Political impediments
- Social resentments

Handling *failures*

- Redundancy: keeping backup units ready
- Fault tolerance: keeping systems running even the components fail
- Resilience by failing fast: early detection of failures and invocation of the recovery procedures

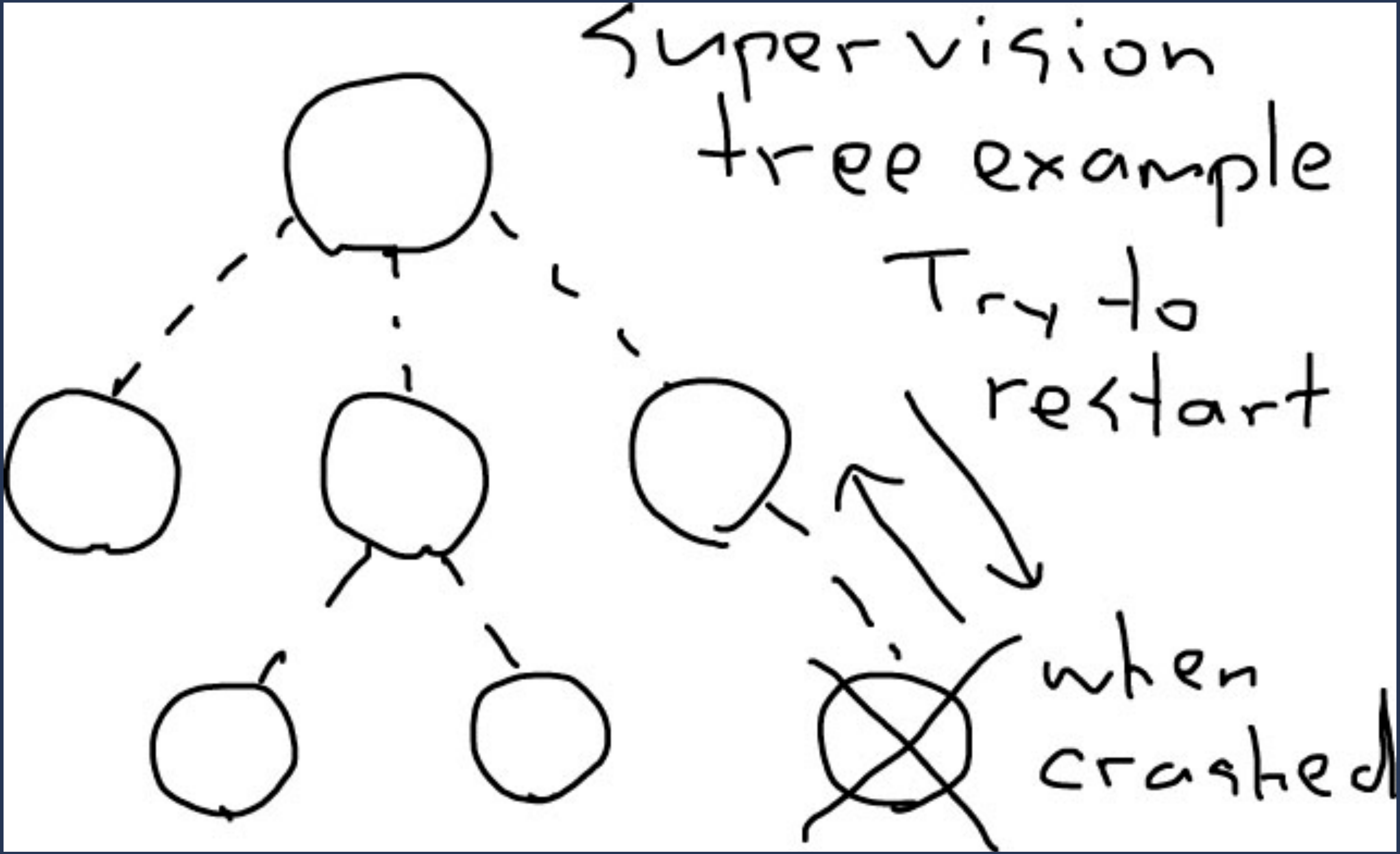
Why fault tolerance?

- Hard disk MTBF ~= 1 million hours
- 1000 hard disks running 24 hours x 365 days = 8.76 million hours
- If you're running a system with 1000 hard disks, *nine* out of 1000 will fail in a year
- Recovery of a disk content takes often *a day*
- You can't stop a system for *a day*, can you?

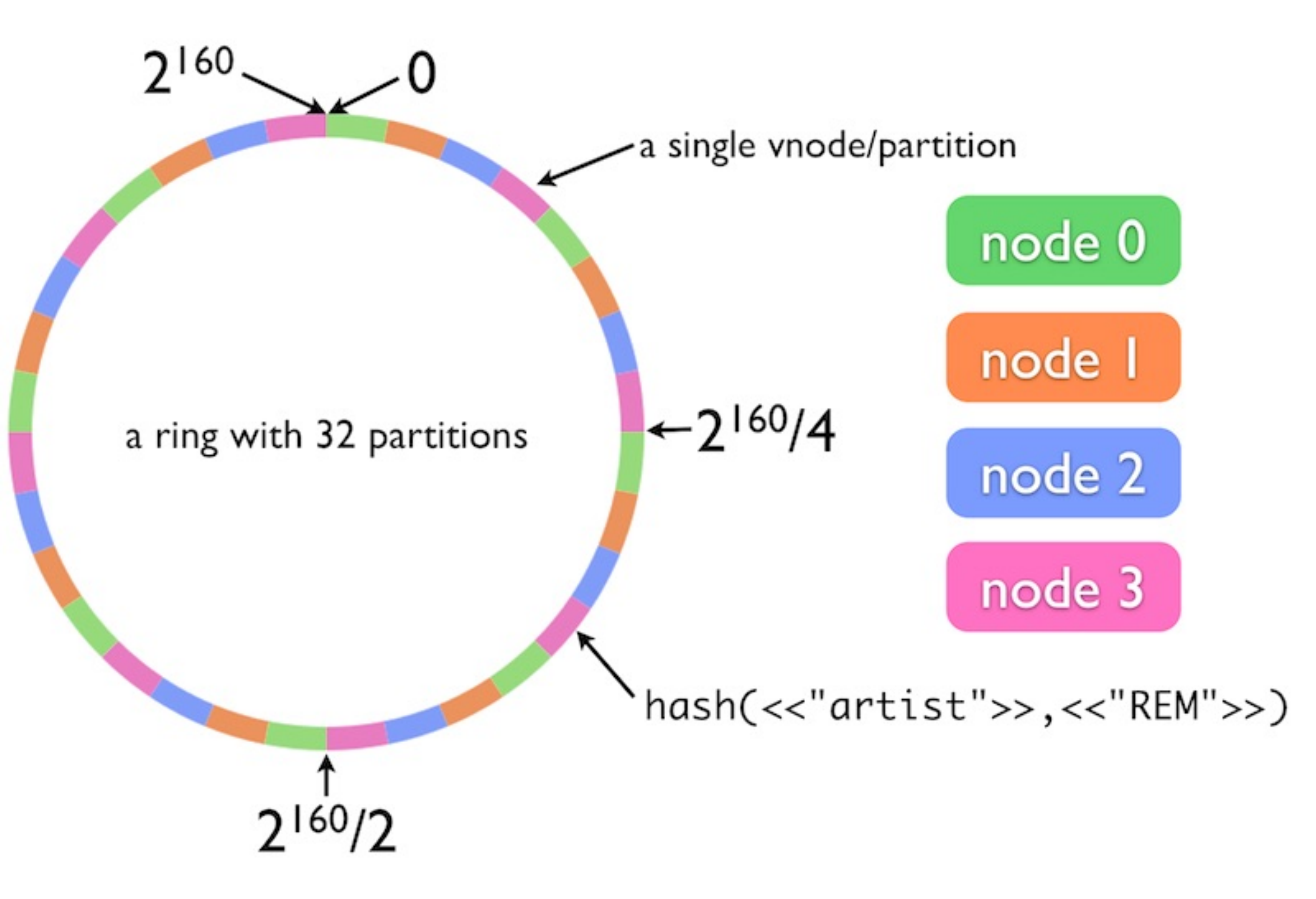
Requirement to keep the systems fault tolerant

- Redundancy: two or more resources for each unit of processing
- Supervising the failure of the units by an independent supervisor
- Rollback capability: undo the incomplete operations and retry

Supervisor



Consistent hashing of Basho Technologies' Riak database [6]



[6] (Note: Rikitake was a Basho Technologies employee during February to September 2013.) http://docs.basho.com/riak/latest/theory/concepts/Clusters/

Fault tolerance of Riak

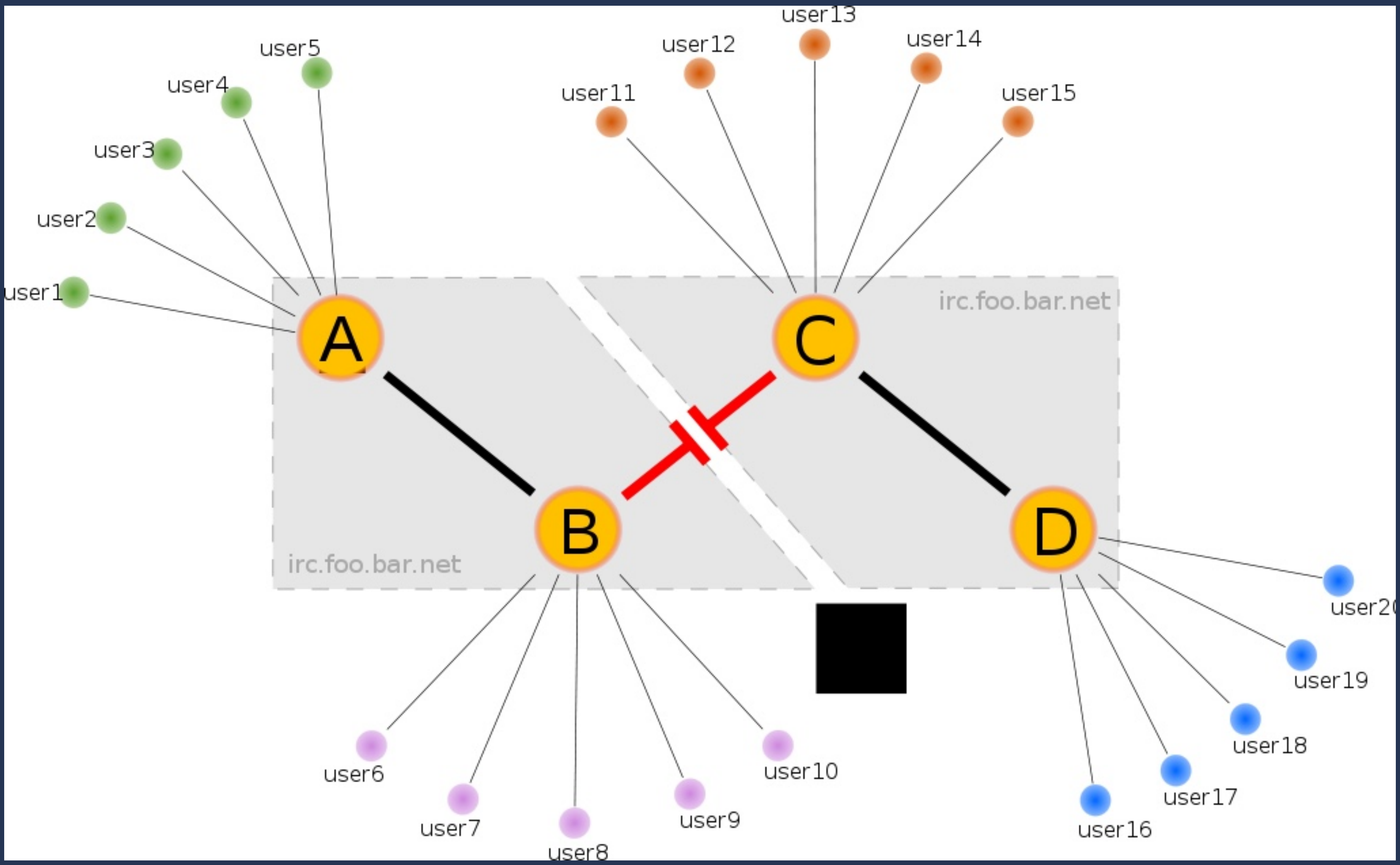
- Multiple copies for each data bucket
- Data evenly distributed to each cluster member node, more resilient to failures
- Even if a node fails, the other nodes respond with the valid data
- Recovery replication will happen after the node recovery
- All *automated*

The inconvenient truth of distributed systems

Consistency: hard or impossible to maintain

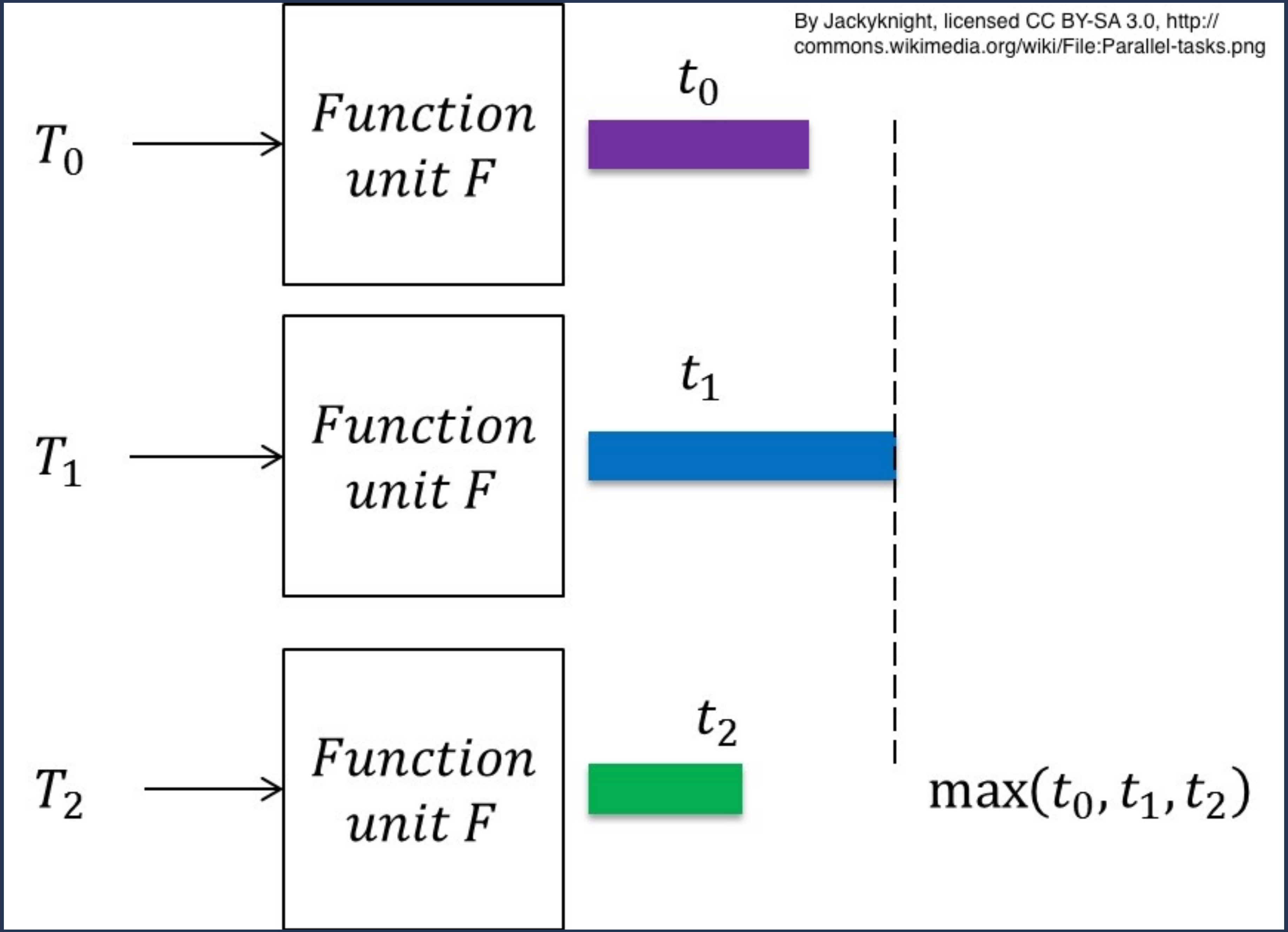
Net split

Recovery from net split is complex



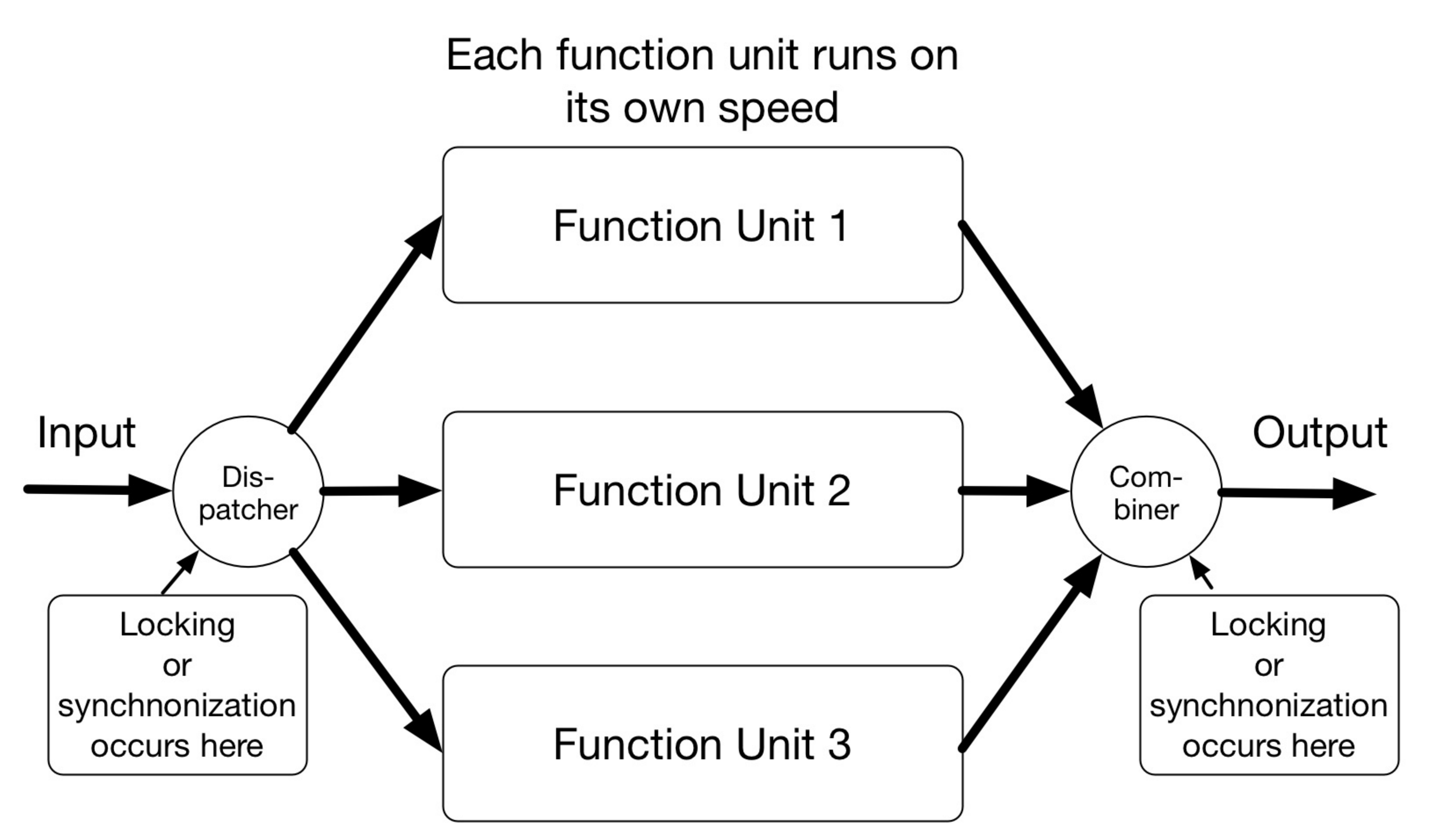
Concurrency: every system is running on its own; synchronization needed

Synchronization



By Jackyknight, licensed CC BY-SA 3.0, http://commons.wikimedia.org/wiki/File:Parallel-tasks.png

Locking


Each function unit runs on its own speed
Function Unit 1
Function Unit 2
Function Unit 3
Input
Dis-patcher
Output
Com-biner
Locking or synchonization occurs here
Locking or synchonization occurs here

How precise the locking or synchronization timing should be?

- *It depends on the application*
- Bank transaction: strict
- Shopping cart: not necessarily strict
- Domain Name System: loose

Current trend: less locking, more inconsistency allowance

Questions

- How much is the cost of synchronization?
- Why do we need concurrent systems? Stability? Performance?
- What have we traded in for obtaining the *convenient cloud computing systems*? Can we take them back?