OST
Eastern Switzerland
University of Applied Sciences

Blockchain (BlCh)

DS1 part 1

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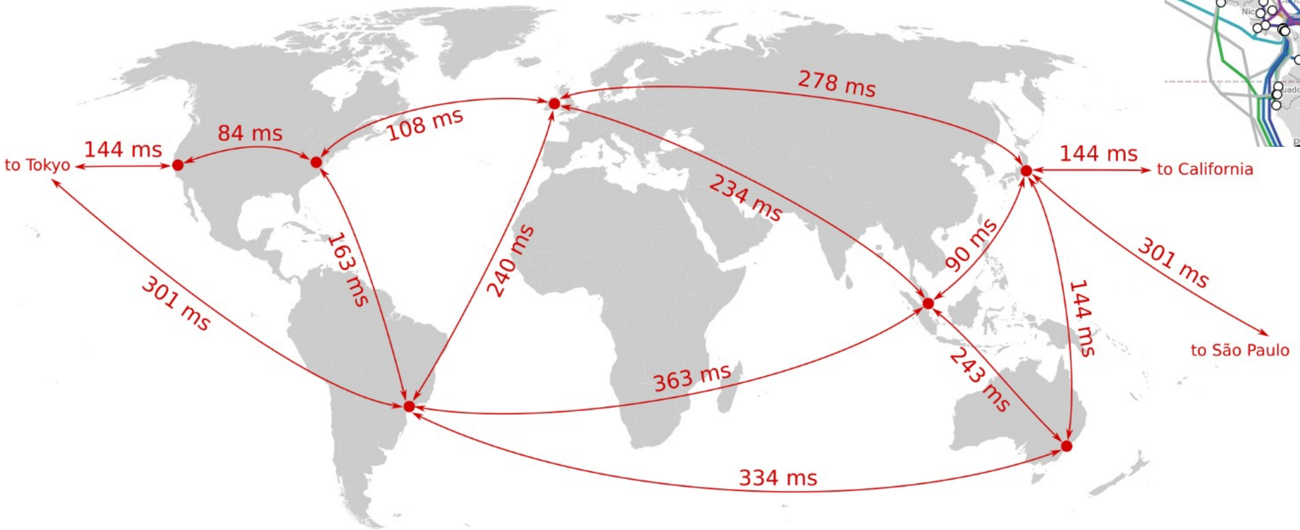
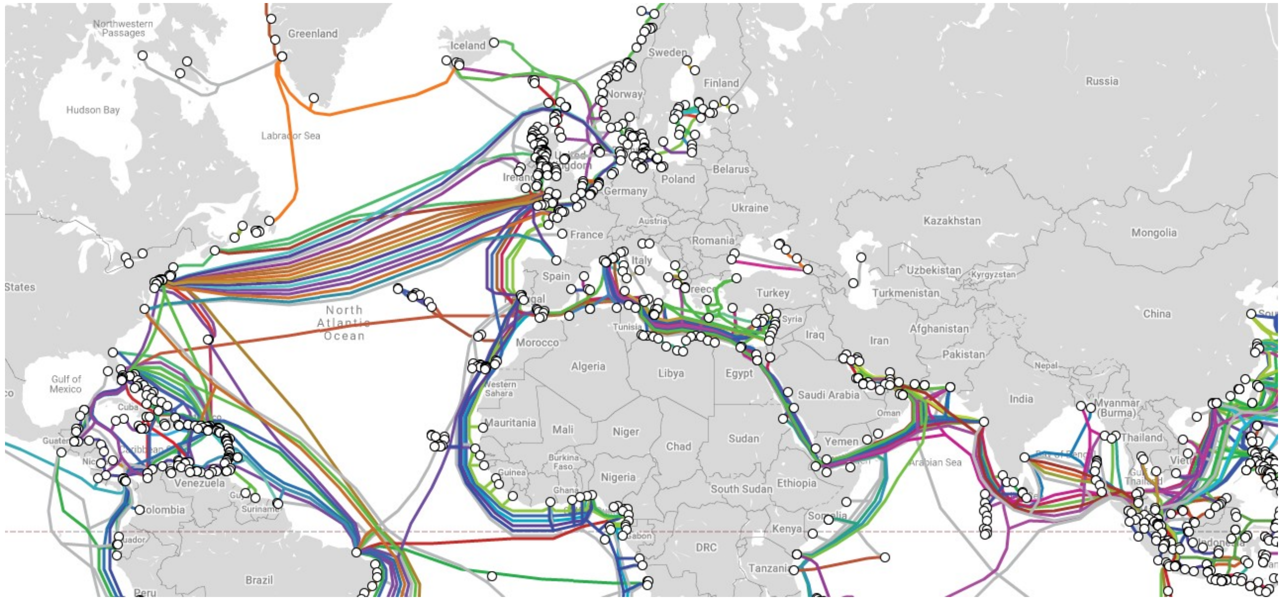
Lecture 1

Distributed Systems Motivation

- Why Distributed Systems
  - Scaling
  - Location
  - Fault-tolerance (bitflips, outages)



https://www.inkandswitch.com/local-first.html



Submarine Cable Map

Distributed Systems Categorization

“Controlled” Distributed Systems

- 1 responsible organization
- Low churn
- Examples:
  - Amazon DynamoDB
  - Client/server
- “Secure environment”
- High availability
- Can be homogeneous / heterogeneous

“Fully” Decentralized Systems

- N responsible organizations
- High churn
- Examples:
  - BitTorrent
  - Blockchain
- “Hostile environment”
- Unpredictable availability
- Is heterogeneous

Distributed Systems Categorization

“Controlled” Distributed Systems

- Mechanisms that work well:
  - Consistent hashing (DynamoDB, Cassandra)
  - Master nodes, central coordinator
- Network is under control or client/server → no NAT issues

“Fully” Decentralized Systems

- Mechanisms that work well:
  - Consistent hashing (DHTs)
  - Flooding/broadcasting - Bitcoin
- NAT and direct connectivity huge problem

Distributed Systems Categorization

“Controlled” Distributed Systems

- Consistency
  - Leader election (Zookeeper, Paxos, Raft)
- Replication principles
  - More replicas: higher availability, higher reliability, higher performance, better scalability, but: requires maintaining consistency in replicas
- Transparency principles apply

“Fully” Decentralized Systems

- Consistency
  - Weak consistency: DHTs
  - Nakamoto consensus (aka proof of work)
  - Proof of stake – Leader election, PBFT protocols
    Is Bitcoin eventually consistent?
    - Some argue no, some argue it has even stronger guarantees [link]
- Replication principles apply to fully decentralized systems as well
- Transparency principles apply [here, here, here]

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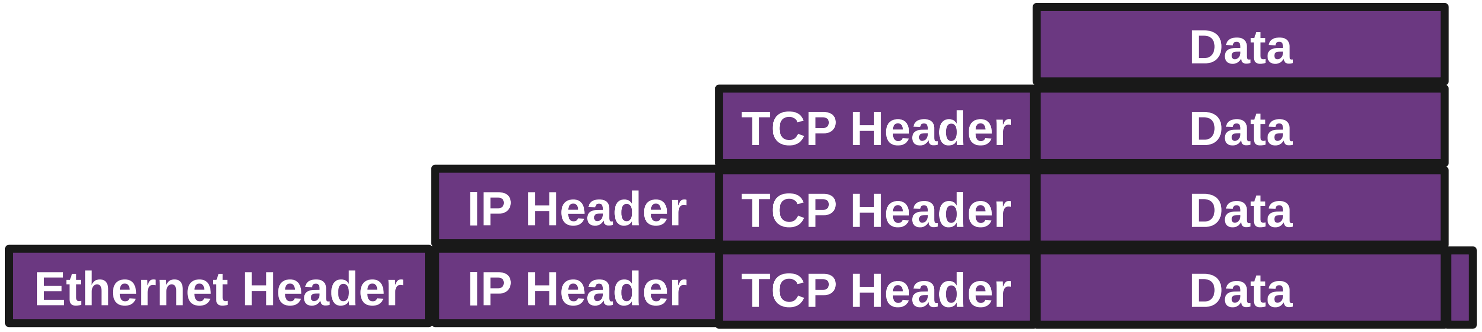
Lecture 2

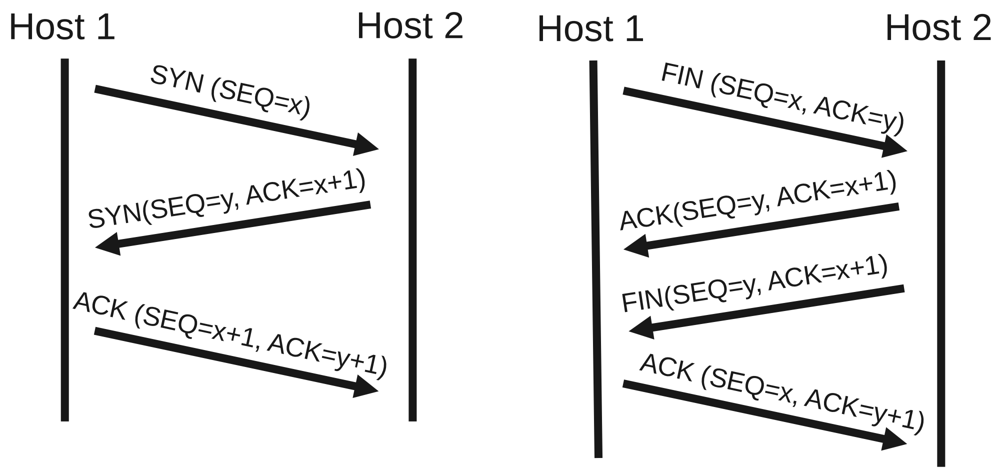
Networking: Layers

- Networking: Each vendor had its own proprietary solution - not compatible with another solution
  - IPX/SPX – 1983, AppleTalk 1985, DECnet 1975, XNS 1977
- Nowadays most vendors build compatible networks hardware/software from different vendors
  - Cisco, Dell, HP, Huawei, Juniper, Lenovo, Linksys, Netgear, MicroTik, Siemens, Ubiquiti, etc.
- Goal of layers: interoperability
  - 1984: ISO 7498 - The Basic Reference Model for Open Systems Interconnection



OSI model	"Internet model"
Application	Application
Presentation	
Session	
Transport	Transport
Network	Internet
Data link	Link
Pysical	

Layer 4 - TCP



- Connection establishment
  - SYN, SYN-ACK, ACK (three way)
  - Initiates TCP session: initial sequence number is ~ random
- Connection termination
  - FIN, ACK + FIN, ACK (three/four way)
  - 3-way handshake, when host 1 sends a FIN and host 2 replies with a FIN & ACK
- Sequences and ACKs
  - Identification each byte of data
  - Order of the bytes → reconstruction
  - Detecting lost data: RTO, DupACK:
- Retransmission timeout
  - If no ACK is received aftert timout (e.g. 2xRTT), resend.
- Duplicate cumulative acknowledgements, se lective ACK
  - ACKs for last consecutive packets
  - 3 times same ACK → retransmit missing packets (fast retransmit)

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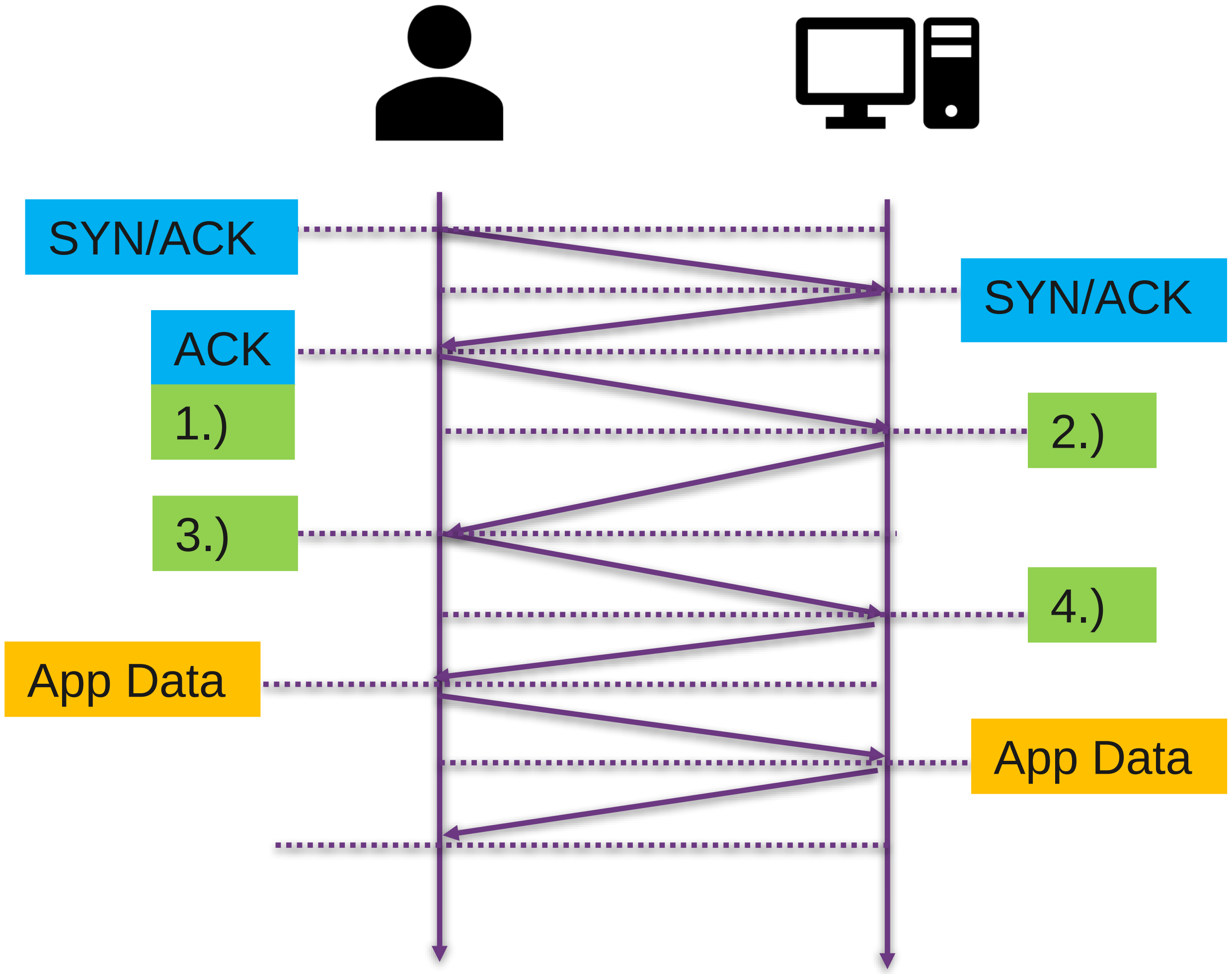
Layer 4 – TCP + TLS

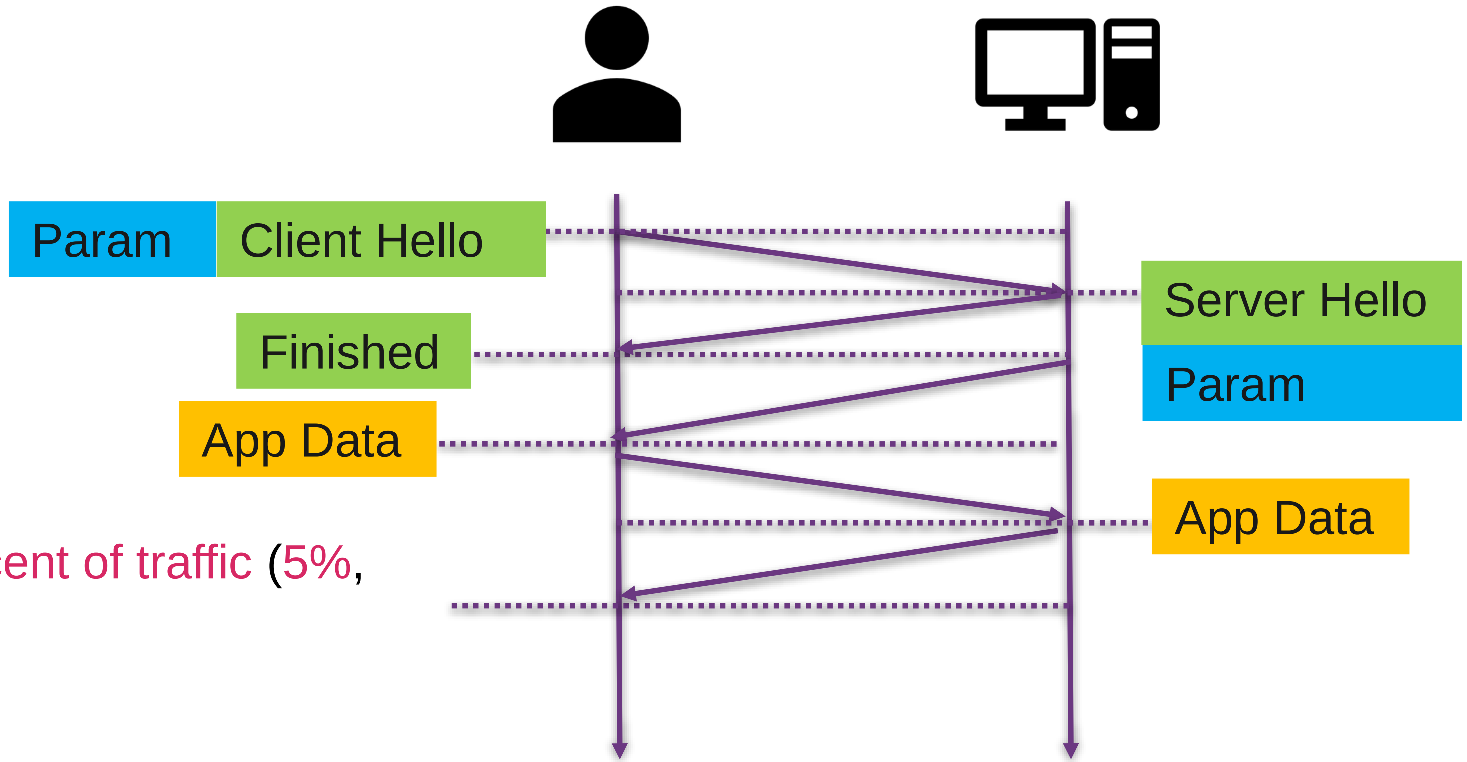
- Security: Transport Layer Security (TLS)
  1. "client hello" lists cryptographic information, TLS version, ciphers/keys
  2. "server hello" chosen cipher, the session ID, random bytes, digital certificate (checked by client), optional: "client certificate request"
  3. Key exchange using random bytes, now server and client can calc secret key
  4. "finished" message, encrypted with the secret key
- 3 RTT until first byte



https://www.ibm.com/support/knowledgecenter/en/SSFKSJ_8.0.0/com.ibm.mq.sec.doc/q009930_.htm

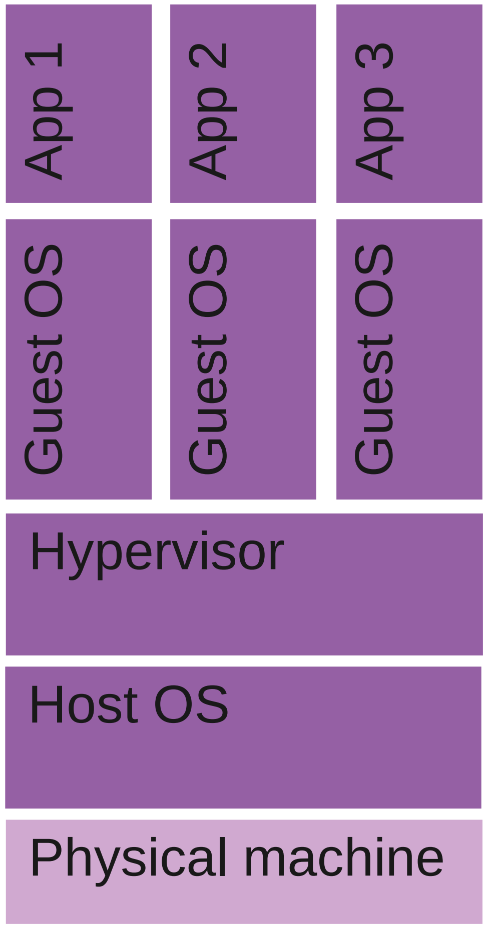
QUIC

- QUIC: 1RTT (chrome example)
  - For known connections: 0RTT
  - Built in security
  - “between 2.6 per cent and 9.1 per cent of traffic (5%, 9%)”
    - Facebook
    - Cloudflare
  - Can I use
- Example Australia: TTFB from 987ms to 329ms

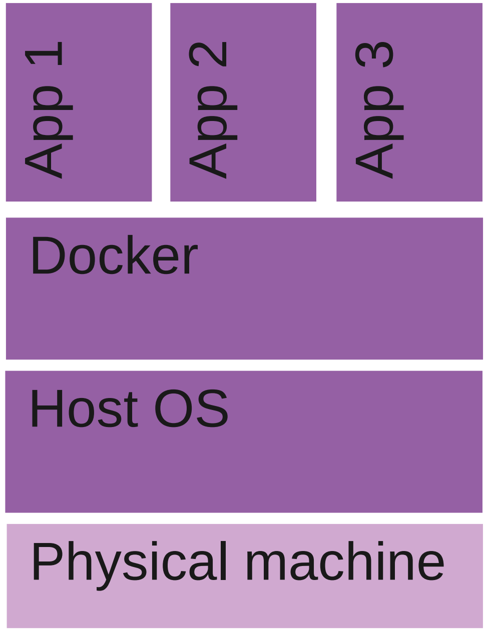


Lecture 3

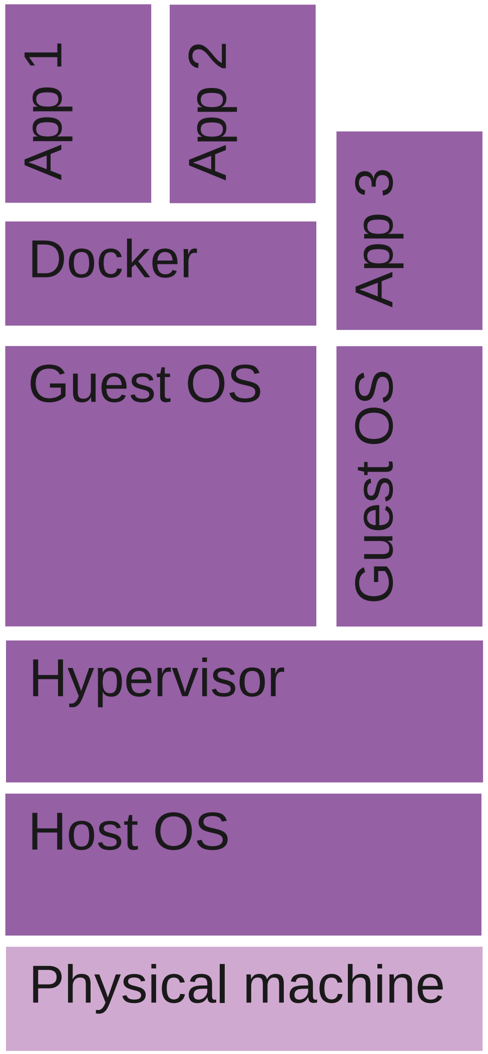
Virtualization



- Virtual machines



- Container



- Both

Virtualization Comparison

Container

+ Reduced IT management resources

+ Reduced size of snapshots 2MB vs 45MB

+ Quicker spinning up apps

+ / - Available memory is shared

+ / - Process-based isolation (share same kernel)

Use case: complex application setup, with container less complex configuration

Providers: ECS, Kubernetes Engine, Docker on Azure (or Kubernetes)

Virtual Machine

+ App can access all OS resources

+ Live migrations

+ / - Pre allocates memory

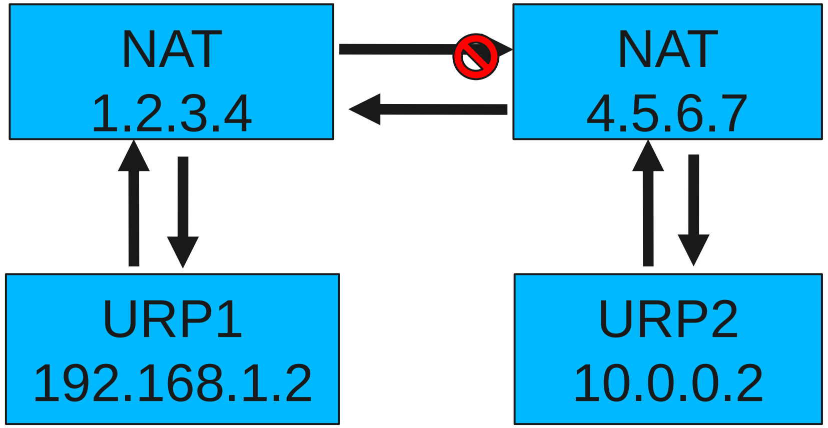
+ / - Full isolation

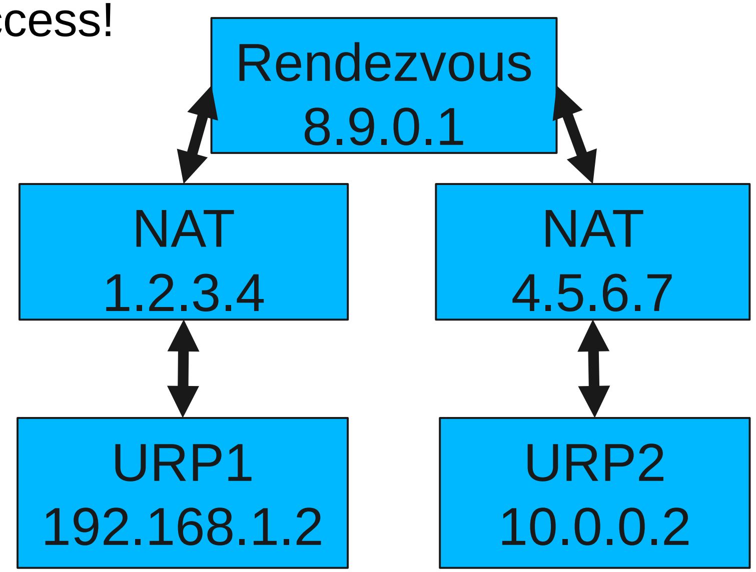
Use case: better hardware utilization / resource sharing

EC2, Virtual Machines, Compute Engine, Droplets

Connectivity, Security, and Robustness

- Hole punching
  - URP1 got 4.5.6.7:5000, URP2 got 1.2.3.4:4000
  - Unreachable peer 1 request to NAT 4.5.6.7, will fail – no mapping, however, unreachable peer 1 creates mapping with that request
  - Unreachable peer 2 sends request to unreachable peer 1 (1.2.3.4:4000) success!





Mapping for NAT 1.2.3.4 (Unreachable peer 1)			
192.168.1.2:4000	4.5.6.7:5000	4.5.6.7:5000	1.2.3.4:4000

Mapping for NAT 4.5.6.7 (Unreachable peer 2)			
10.0.0.2:5000	1.2.3.4:4000	1.2.3.4:4000	4.5.6.7:5000

Questions?

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