Latest Advancements and Use Cases for Network Coding

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Code On / Steinwurf / Chocolate Cloud

Aim of the talk

- Future of network coding for future communication networks
- Some highlight for network coding for different applications
- Possible link to other existing IETF/IRTF

5G Lab Germany

5G LAB GERMANY

- 5G is next generation of mobile communication system
- Not only voice and multimedia support, but control and steering of the Internet of Things (IoT), which requires
  - Massive Low Latency down to 1 ms (Tactile Internet)
  - Security
  - Resilience
- Fusion of transport and storage
- Massive number of devices and low latency requirements results in more mesh architectures
- Network coding is key technology for transportation, storage, resilient software design, and many core platforms

Point-to-Point

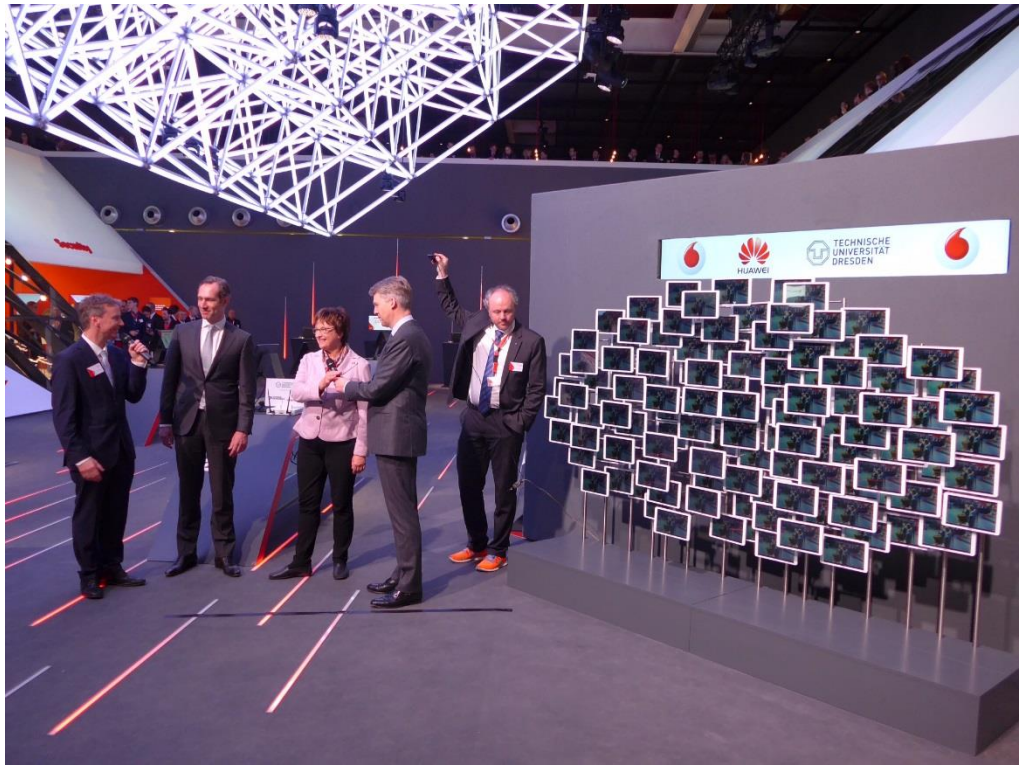
Advantage of p2p

- Sliding Window
- Tactile Internet
- Coded TCP (all variants)

Point-to-Multipoint

CeBit 2015

- Multicast live feed to 120 devices over WIFI (802.11)
- Use of the NORM protocol
- Kodo library
  - iOS
  - Android
  - Windows Mobile
- Interesting for controlling and steering devices. Delay is problem of legacy hardware not the coding.



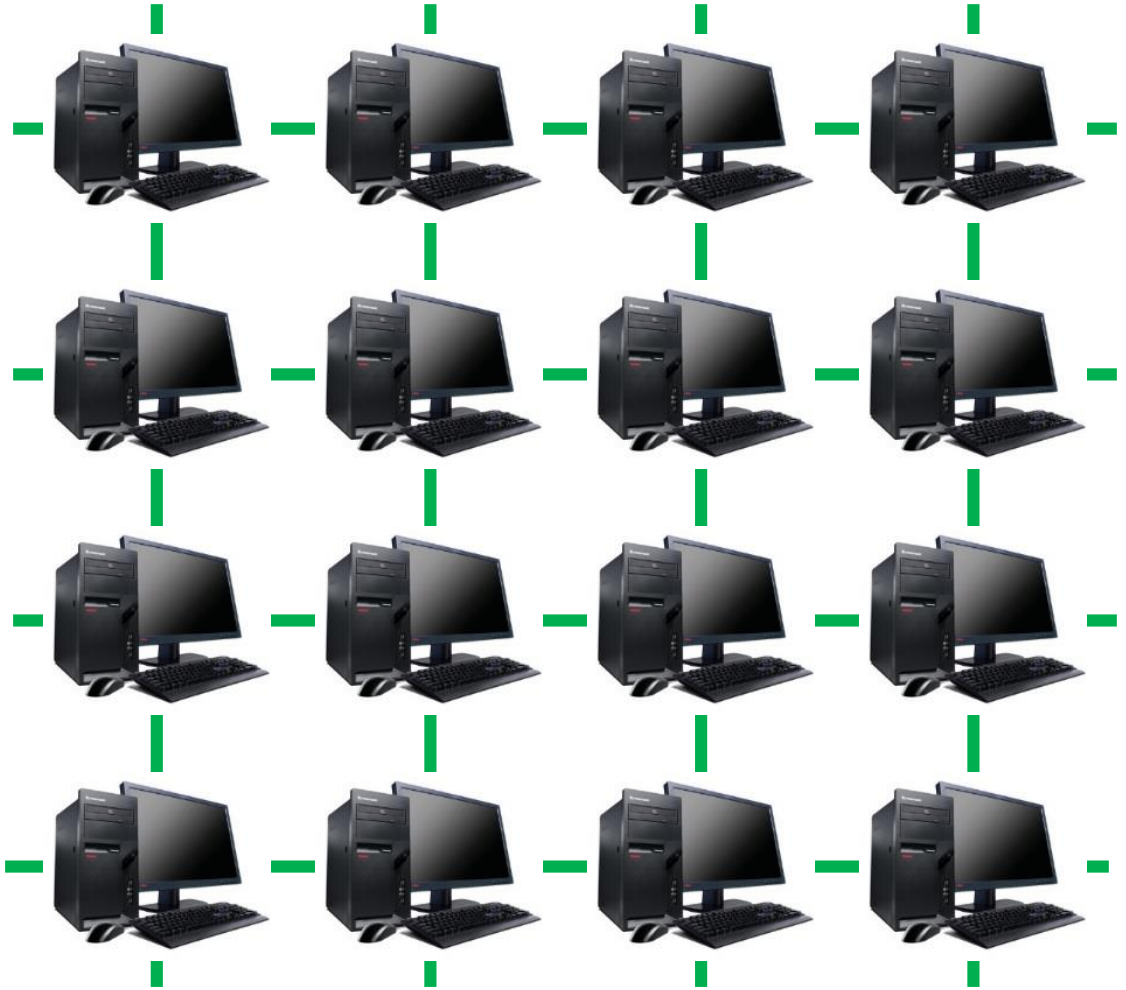
https://www.youtube.com/watch?v=WTFeTCeMFZ4

Wireless Mesh

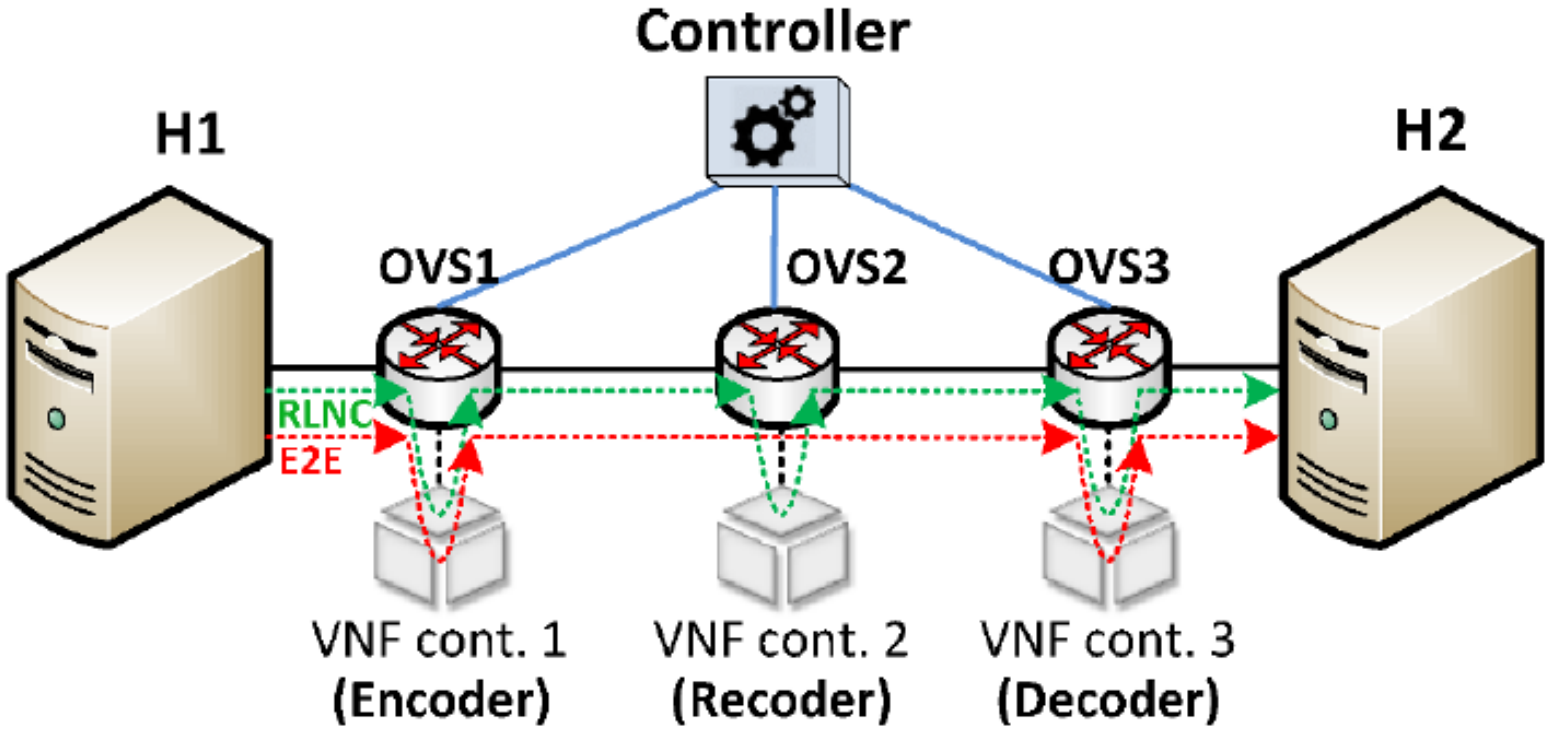
Foto: Torsten Proß, Jeibmann Photographik

Software Defined Networks

Physical SDN Testbed



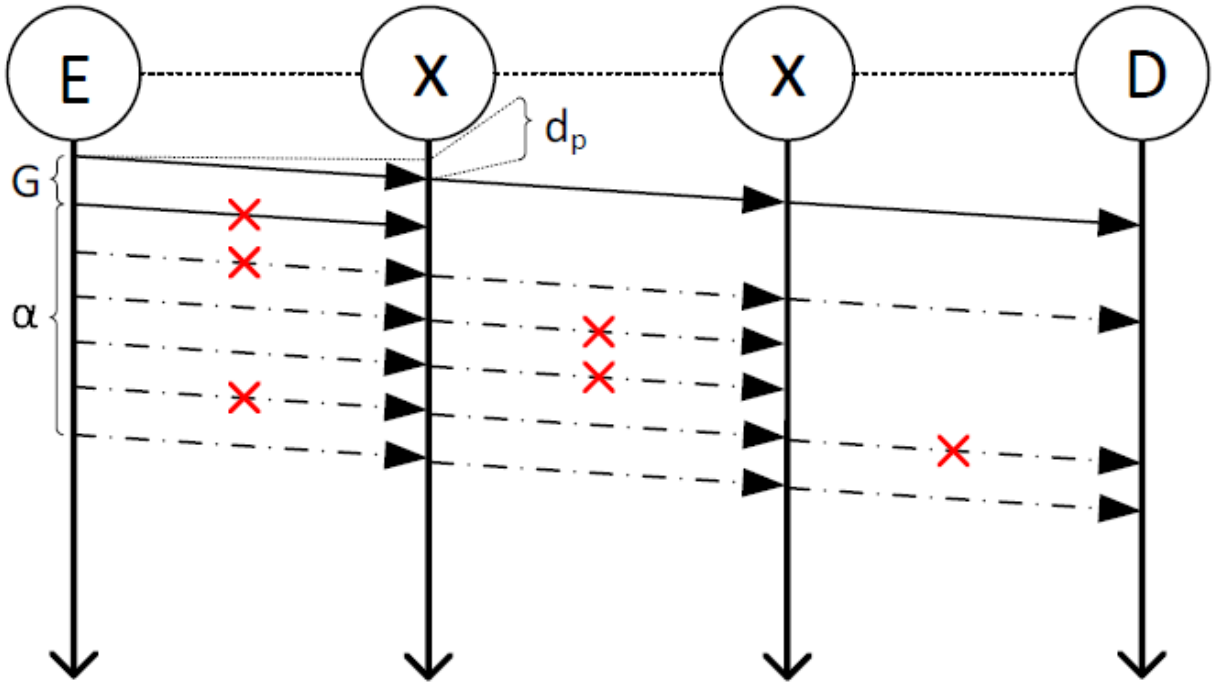
Virtual SDN testbed



Software Defined Networks

- End to End Coding Schemes: Store and Forward

$$P_{E2E} = \sum_{h=1}^{H} G \cdot \left(\frac{1}{(1-\epsilon)^h} \right) \qquad D_{E2E} = (G \cdot \left(\frac{1}{(1-\epsilon)^H} \right) + (H-1)) \cdot d_p$$

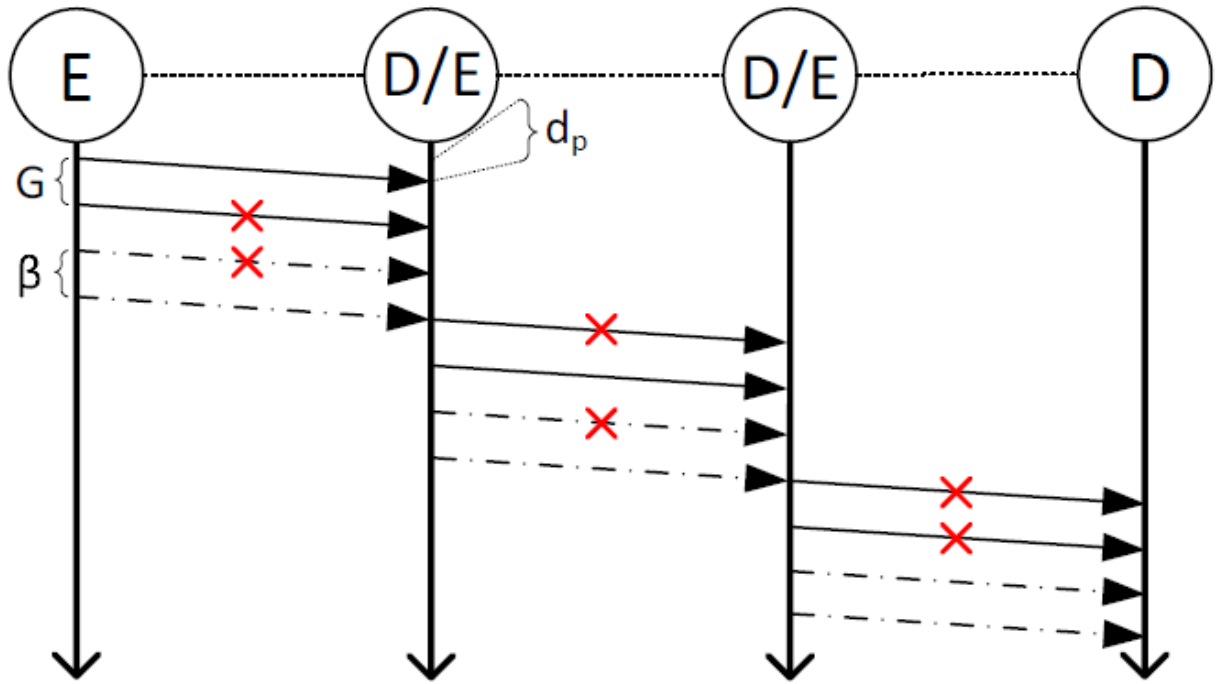


Software Defined Networks

- Hop by Hop Coding Scheme: Store and Forward

$$P_{HbH} = G \cdot H \cdot \left(\frac{1}{1-\epsilon}\right)$$

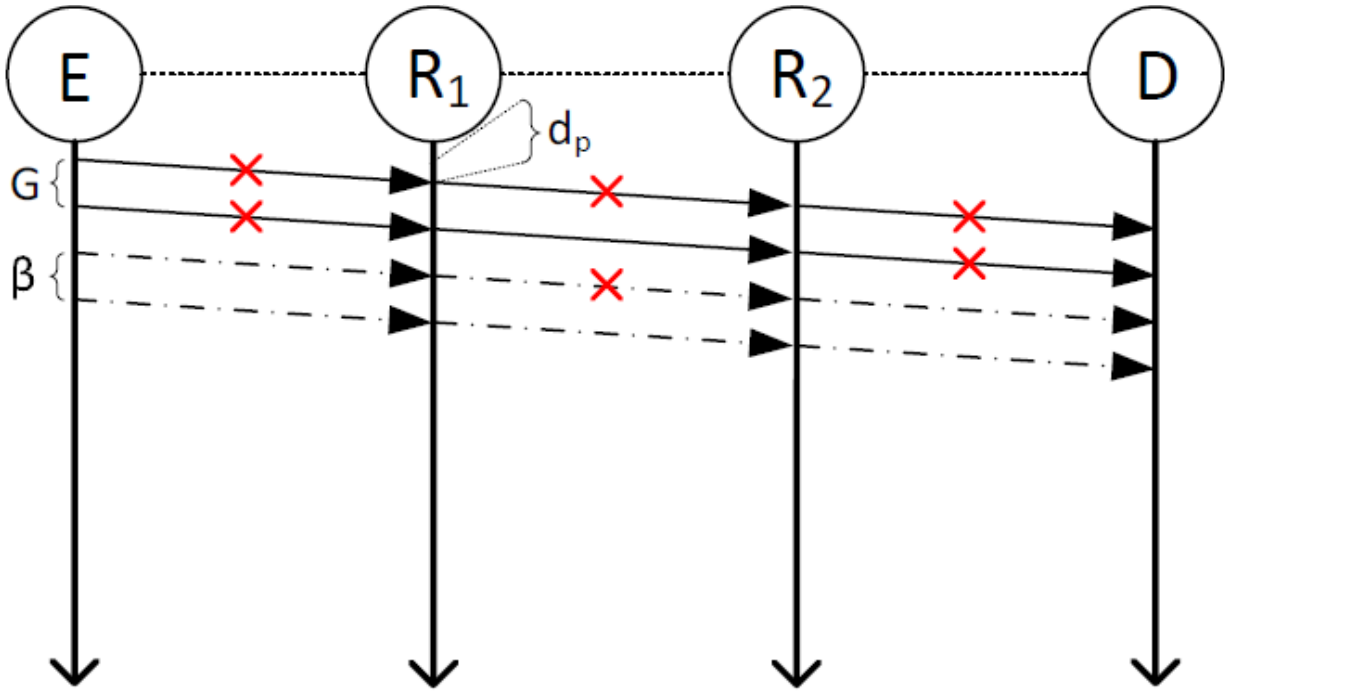
$$D_{HbH} = G \cdot \left(\frac{1}{1-\epsilon}\right) \cdot H \cdot d_p$$

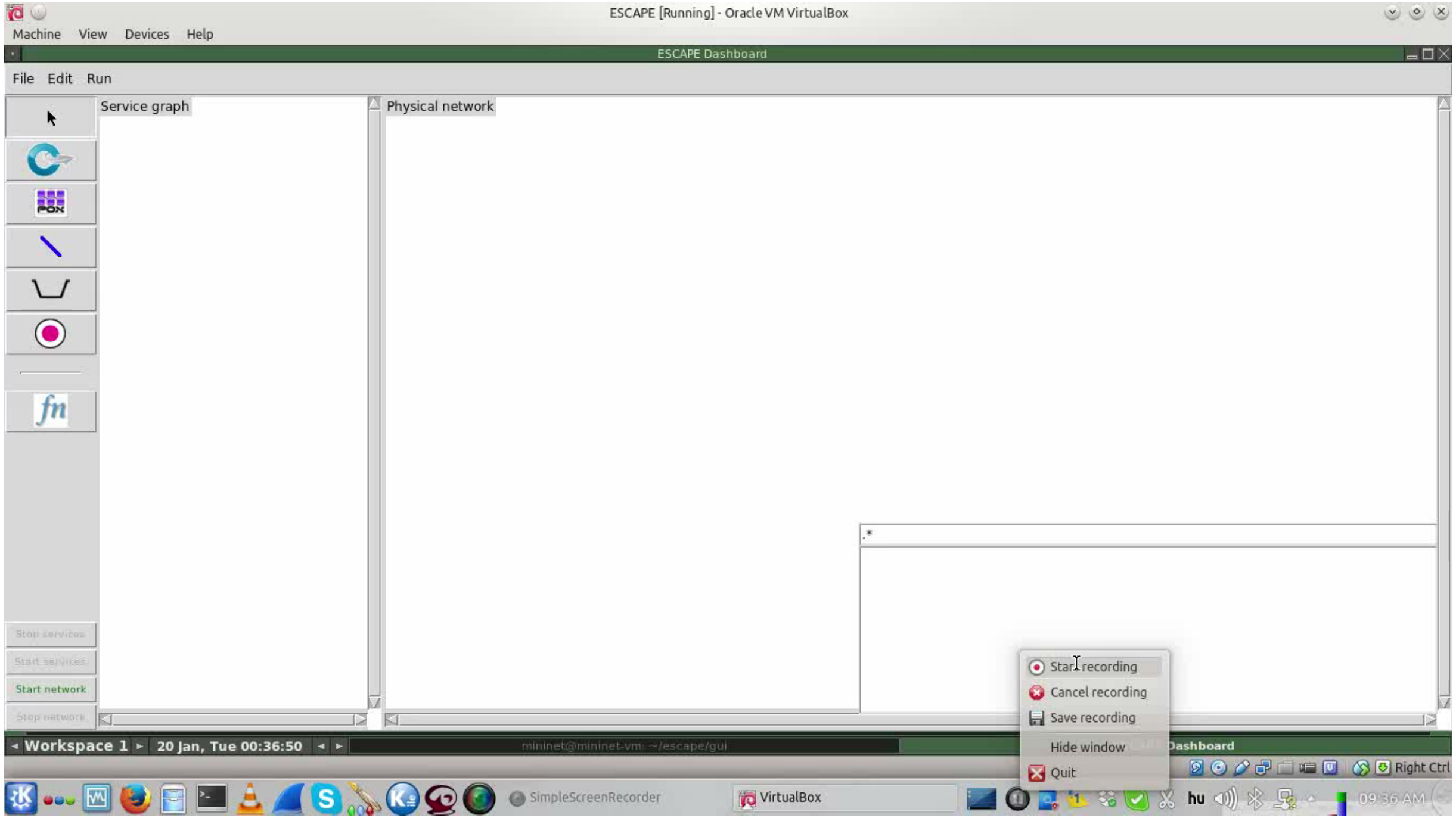


Software Defined Networks

- Network Coding Scheme: Compute and Forward

$$P_{RLNC} = G \cdot H \cdot \left(\frac{1}{1-\epsilon}\right) \qquad D_{RLNC} = (G \cdot \left(\frac{1}{1-\epsilon}\right) + (H-1)) \cdot d_p$$

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Machine View Devices Help
ESCAPE Dashboard
File Edit Run
Service graph
Physical network
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Stop services
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Start network
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Start recording
Cancel recording
Save recording
Hide window
Quit
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mininet@mininet-vm: ~/escape/gui
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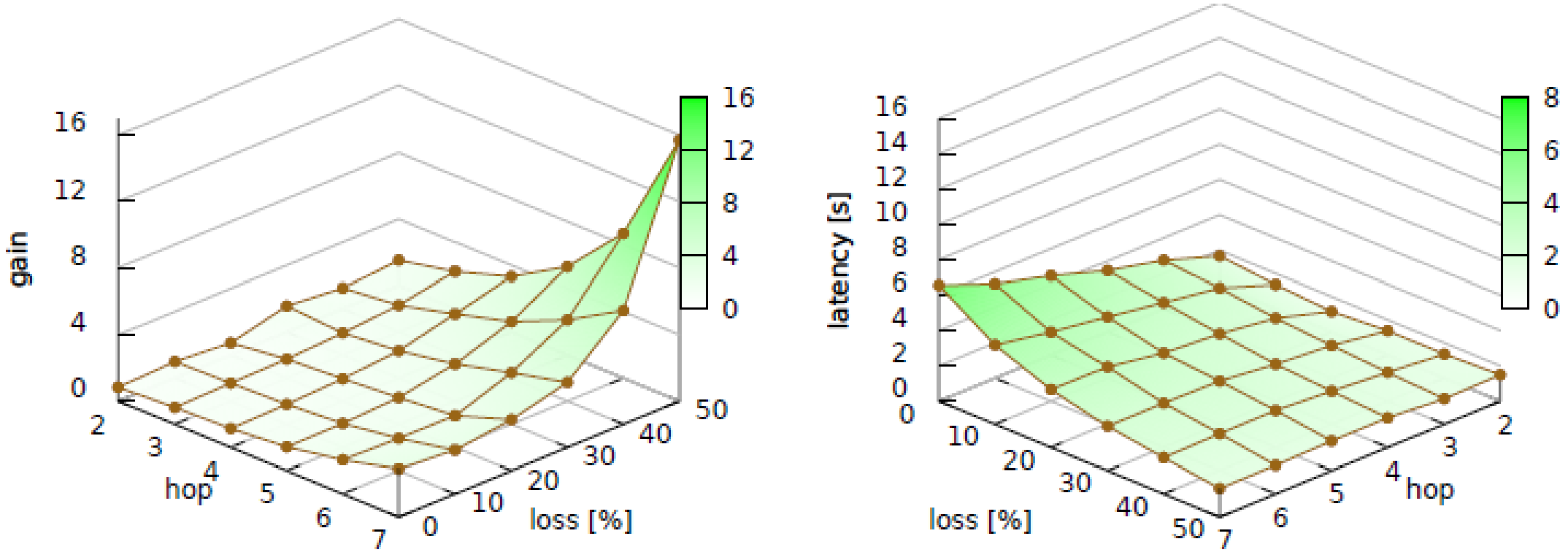
Software Defined Networks

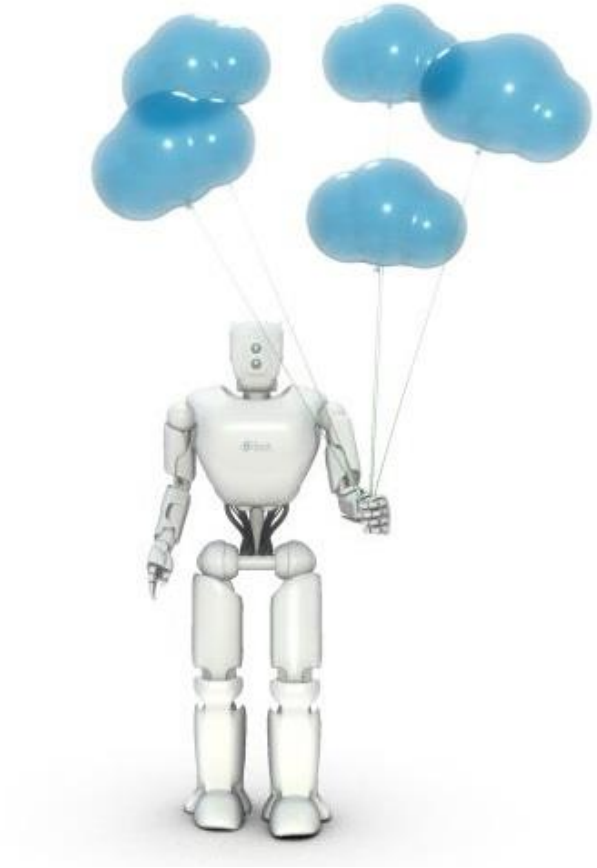
- Latency gain of e2e vs RLNC (left) and hbh vs RLNC(right)



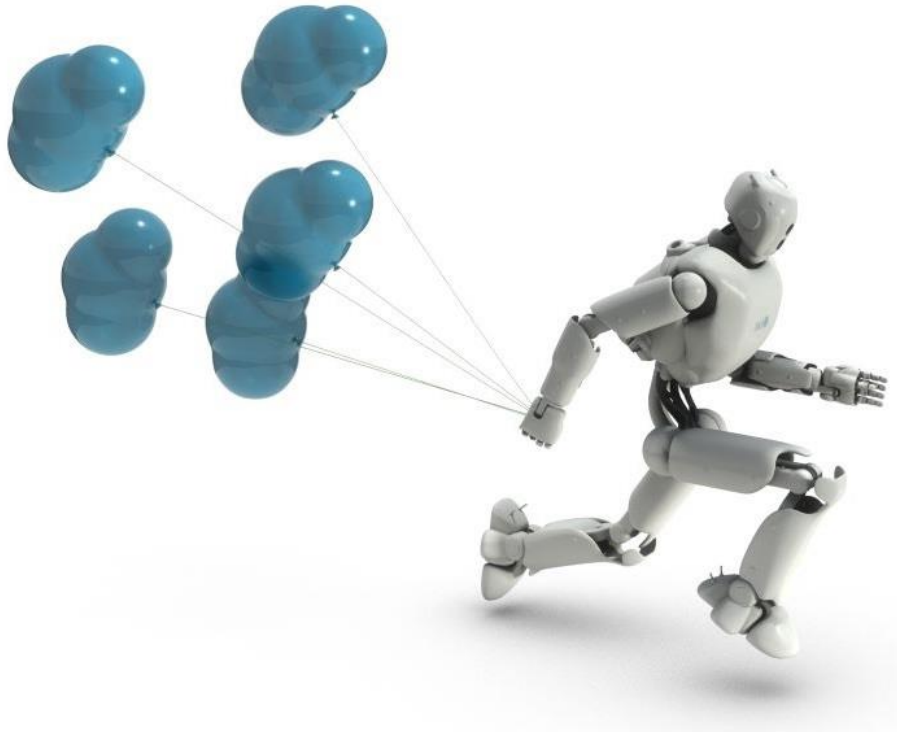
Storage

Cloud Evolution

Single/Static

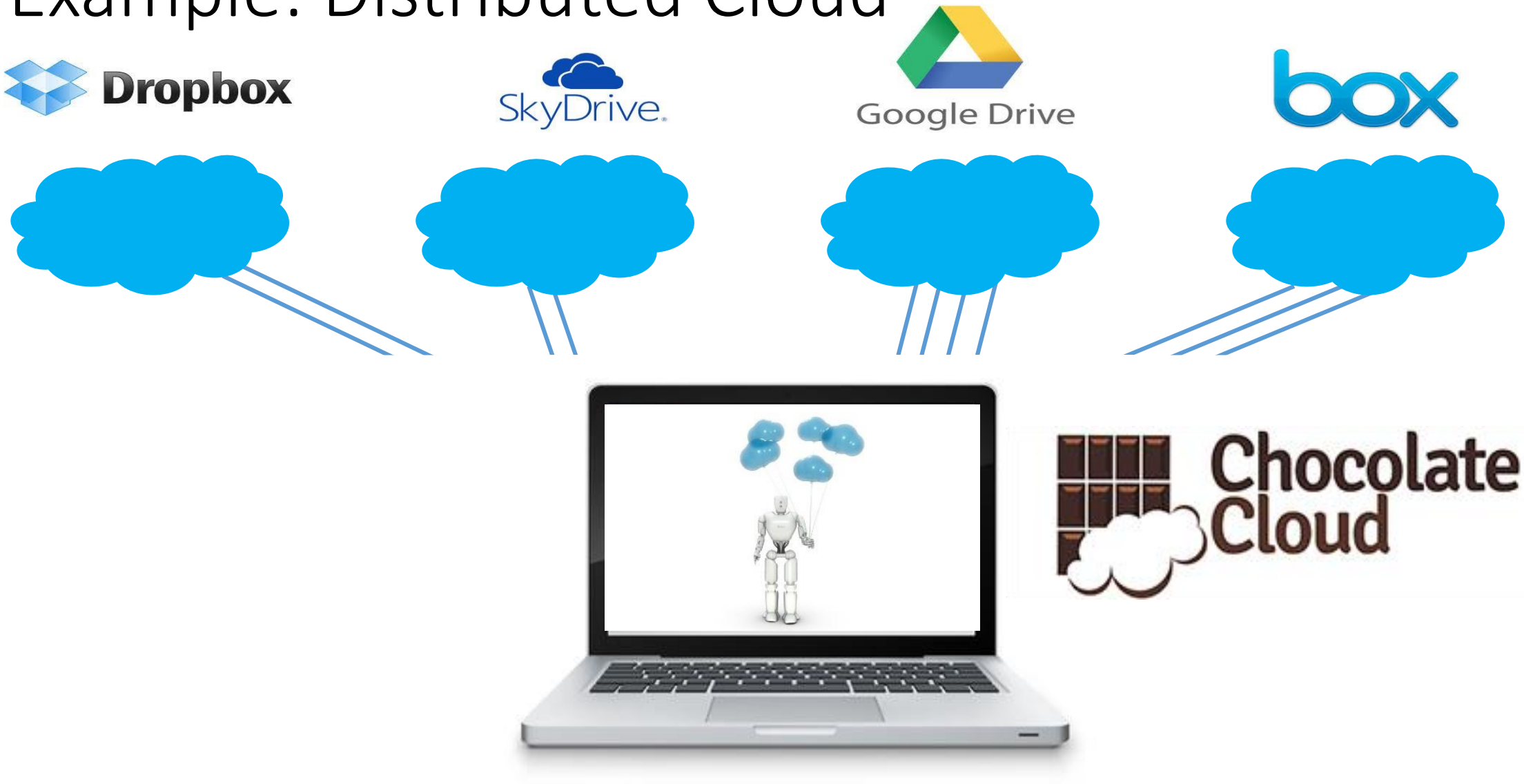


Distributed/Static

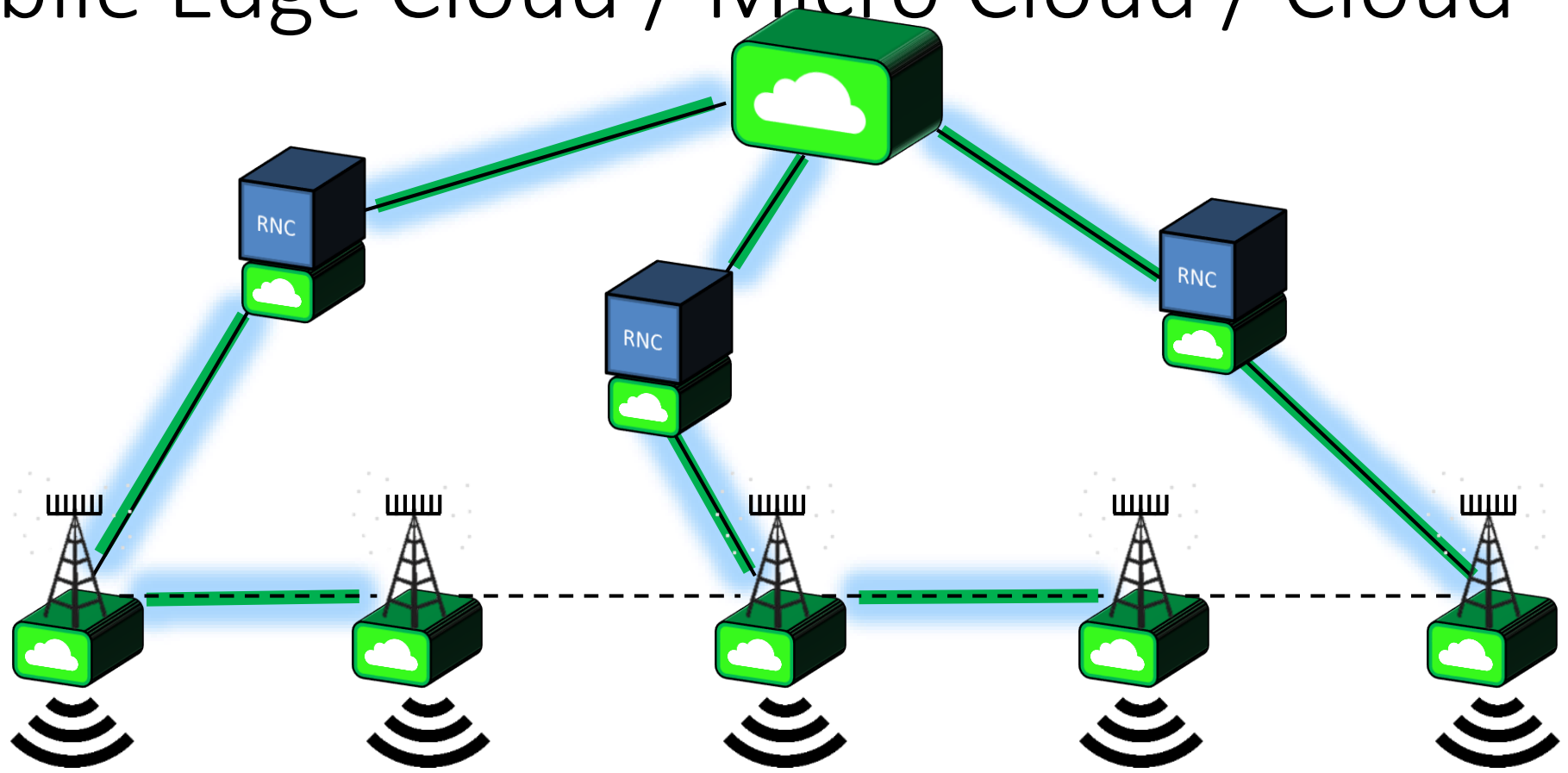


Distributed/Agile

Example: Distributed Cloud



Mobile Edge Cloud / Micro Cloud / Cloud

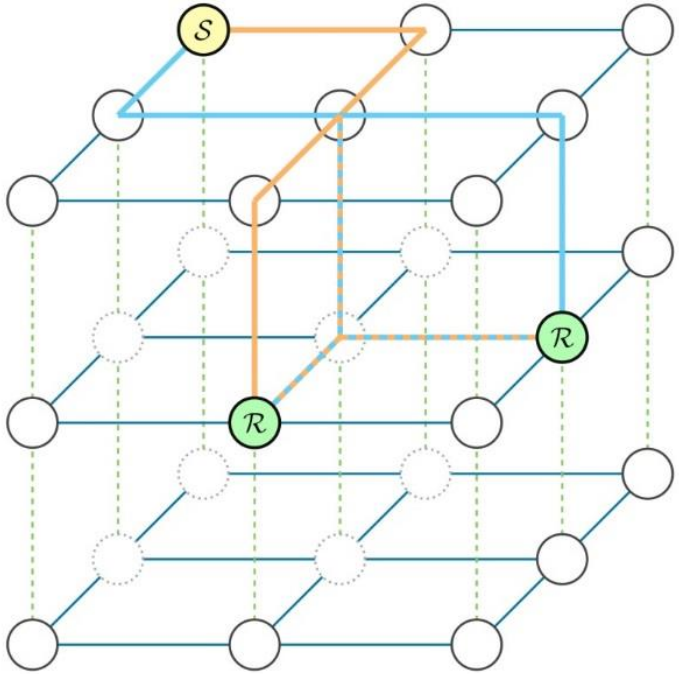


Security and Integrity

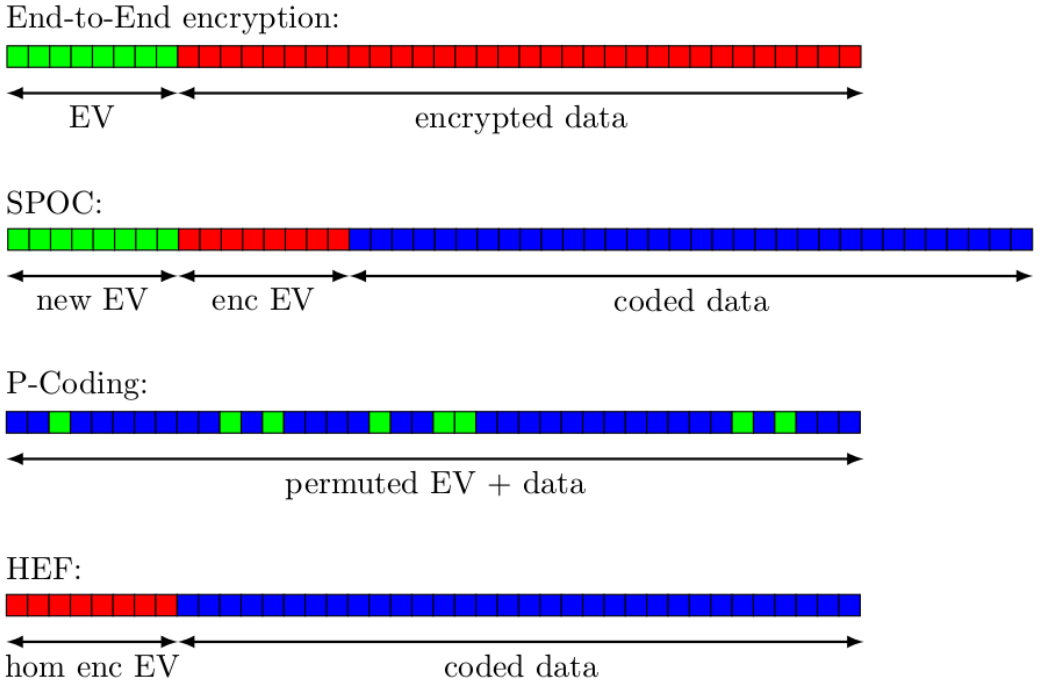
NC & Security: Confidentiality

Threat

- Relay nodes get partial or (if they can decode) full knowledge of the messages



Solutions

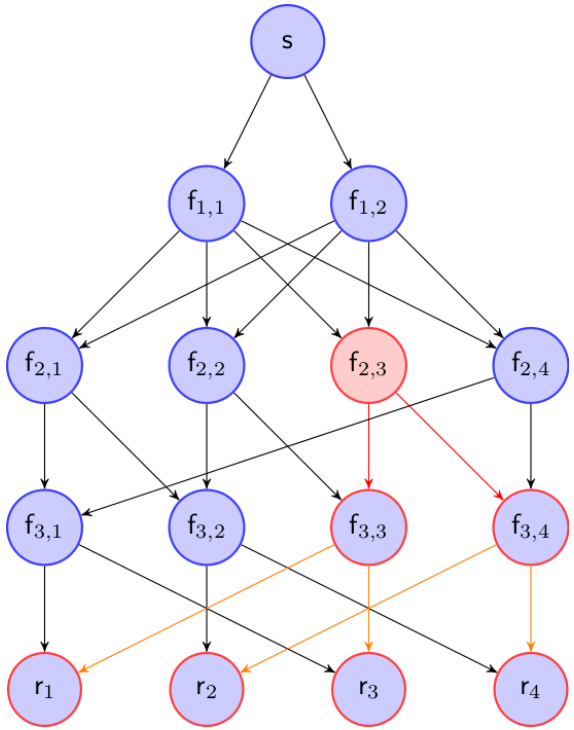


- Lightweight alternatives to full end-to-end encryption

NC & Security: Integrity (Prevention of Pollution Attacks)

Threat

- Injection of bogus messages pollute all subsequent messages (upto failure of the system)



Solutions

Coding approach:

- Add redundancy into packets
- Receiver can correct errors
- Pro: No costs for intermediate nodes
- Con: not that powerful; only applicable to known attacker strength

Crypto approach:

- Add homomorphic crypto (hashes, signatures, MACs,…) to packets
- Intermediate nodes are able to check validity and can recode packets
- Pro: No pollution of the network; very adaptive
- Con: Need for expensive computations at intermediate nodes

Mapping to other IETF/IRTF Initiatives

Collaboration potential

- SDNRG
- ICN
- NFVRG
- RTCWEB
- MANET
- MPTCP
- Congestion control (several groups)

- And what can we do in our group?