Multicast content distribution

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1

1

Quality of Experience

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QoE

ITU-T FG IPTV: Quality of Experience (QoE) refers to the overall acceptability of an application or service, as perceived subjectively by the user

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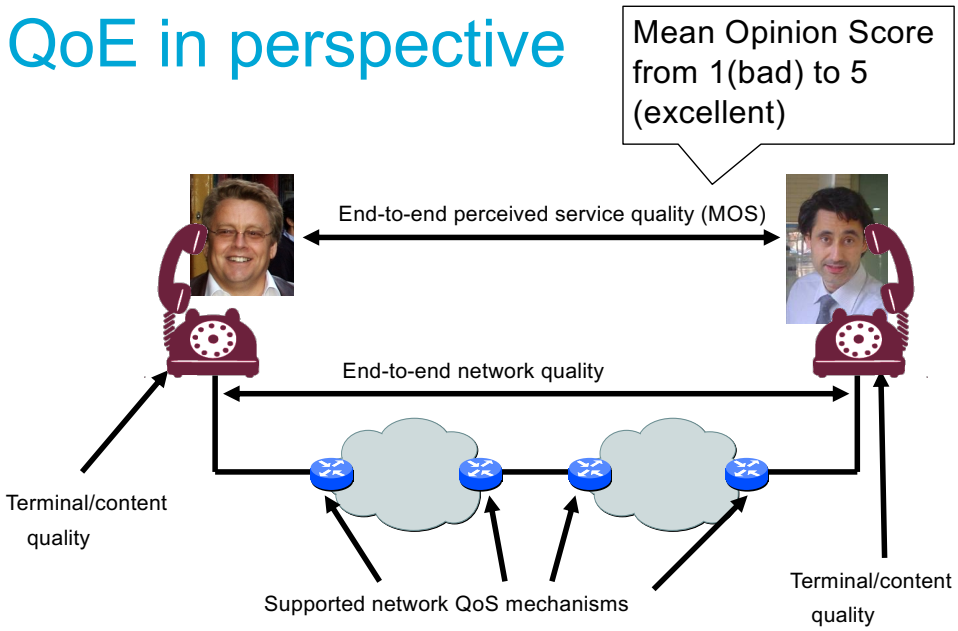
QoE in perspective



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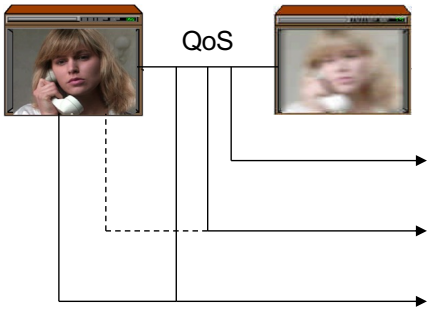
QoE measurement methodologies



- No-reference model
- Reduced-reference model
- Full-reference model

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No-reference E-model (speech)

$R = R_0 - I_s - I_d - I_e + A$

R_0: SNR

I_s: Speech signal

I_d: Delay

I_e: Equipment

A: Advantage

	A	B	C	D	E
1	**E-model according to updated Appendix/I G.113**				
2					
3	EchoLoss [dB]		codec	delay [ms]	loss
4	65		G.729	100	5.00%
5					
6					
7					
8	**MOS**				
9	**3.34**		**GSM quality**		
10					

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Full-reference models

- Full-reference speech: PESQ - ITU-T Rec. P.862
- Full-reference audio: PEAQ - ITU-R BS.1387
- Excerpts of reference and test signal are aligned and compared
- Tool:
  - Peaqb

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QoE & toxicity

abuse of game mechanics

flaming

antisocial behavior

griefing

cyberbullying

verbal abuse

Active Players	→	**quit playing**
Newcomers	→	**discouraged to join**
Community	→	**hostile environment**
Companies	→	**loss of $$$**

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Where does toxicity happen?

Toxicity is a major issue *especially* in MOBAs

MOBA: **M**ultiplayer **O**nline **B**attle **A**rena

Highly strategic and very competitive 5vs5 matches with a strong emphasis on cooperative team play

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How to detect it? [1]

- Analyze the content of text messages in MOBAs by Natural Language Processing (NLP)
- Ambiguity?

"you are noob" toxic? ✓

"sry, i am such noob - lol" toxic? ✗

Toxicity is not about saying bad words, it is about the context!

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[1] M. Märtens, S. Shen, A. Iosup, and F.A. Kuipers, "Toxicity Detection in Multiplayer Online Games," Proc. of NetGames, 2015.

10

10

n-grams

… get some brain u retards tech and blue …

unigram

get some brain u retards tech and blue

bigram

get some brain u retards tech and blue
get some brain u retards tech and blue

trigram

get some brain u retards tech and blue
get some brain u retards tech and blue
get some brain u retards tech and blue

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11

Multicast

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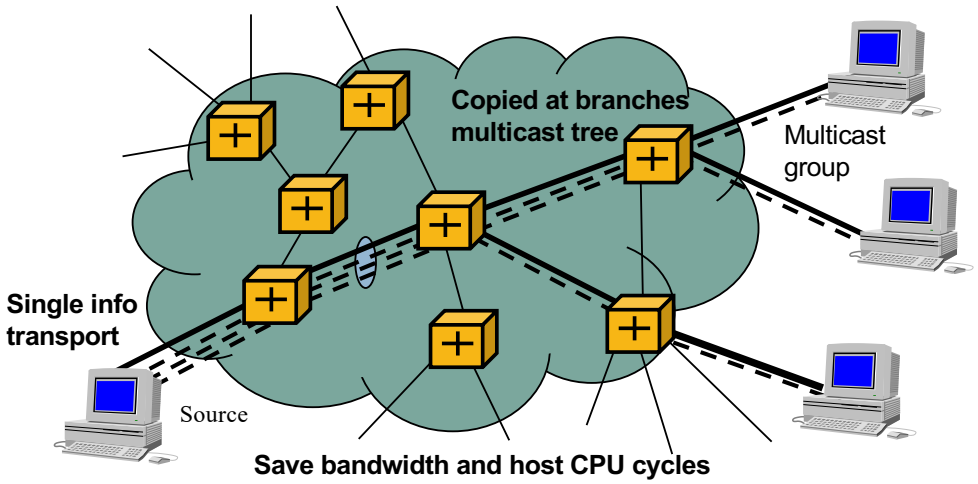
12

Multicast transmission



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13

Any-Source Multicast (ASM)

- Multicast applications:
  - Movie-distribution, Pay-TV
  - Software updates, multicast file transfer
  - Video conference
- Multicast is receiver based (scales well):
  - new group members attach to the closest branch of the multicast tree
- IP multicast model: Host group model and Multicast routing protocol
  - IPv4 + Internet Group Management Protocol (IGMP)
  - IPv6 integrates Multicast Listener Discovery (MLD)

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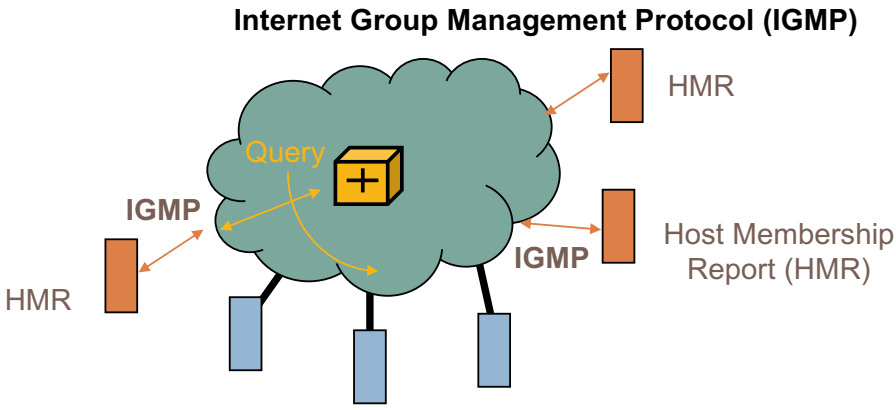
14

The Host Group Model



Disadvantages: - multicast address allocation
- destination unawareness

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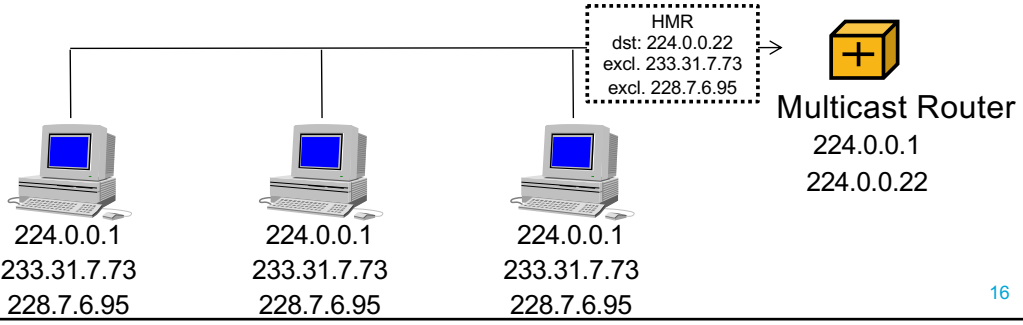
Internet Group Management Protocol (IGMP)

- Multicast router joins the "all multicast-capable routers" IP address (224.0.0.22, ff02::16)
- Hosts (receivers) join multicast groups
- Hosts send Membership Reports to router using the Multicast address (after randomized delay)
  - Membership Report: "exclude from G" to join group G



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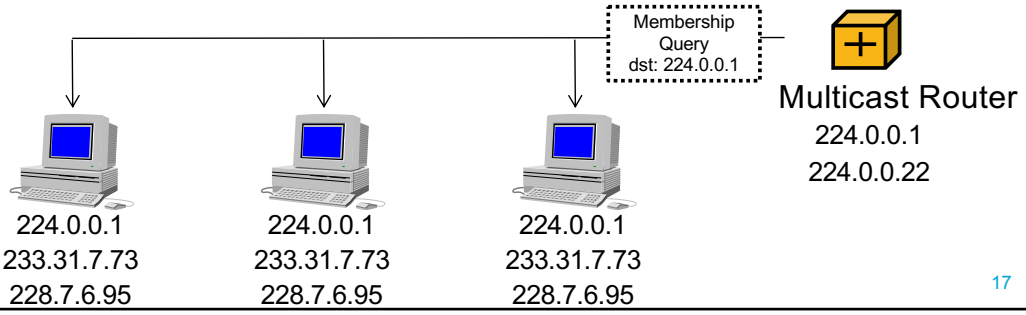
Internet Group Management Protocol (IGMP)

- Router periodically sends Membership Queries to obtain up-to-date information
- Can query "all systems" Multicast address (224.0.0.1, ff02::1)
  or query a specific group
- Hosts respond with Membership Report



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17

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Dense-Mode ASM

- Dense Mode (DVMRP, PIM-DM)
  - Reverse path forwarding (RPF):
    - When a multicast packet is received, denote source S and interface I
    - If *I belongs to the shortest path towards S*, forward to all interfaces except I, else refuse packet
  - RPF with pruning:
    - If there are no group members in a subtree, this subtree is cut off by sending a prune message to the previous hop router.

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Sparse-Mode ASM

- Sparse Mode (CBT, PIM-SM)
  - Build tree starting from a core (=center of multicast group); the recipients send 'join/leave' messages to the core
  - Source sends unicast message to core
  - Core sends message to all group members

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19

Disadvantages ASM

- Connection state scalability:
  - Entries for each multicast group
  - Huge multicast tables in backbone
- Source advertisement mechanism scalability:
  - Sparse Mode (CBT, PIM-SM): core node needs to be globally advertised
  - Dense Mode (DVMRP, PIM-DM): flood and prune mechanism

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20

Overlay networks

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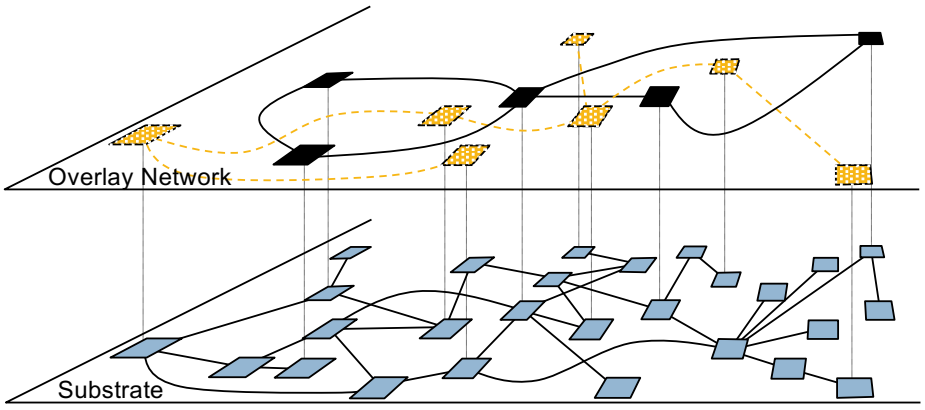
Overlay networks

Two overlay networks (black and red) on top of a same substrate



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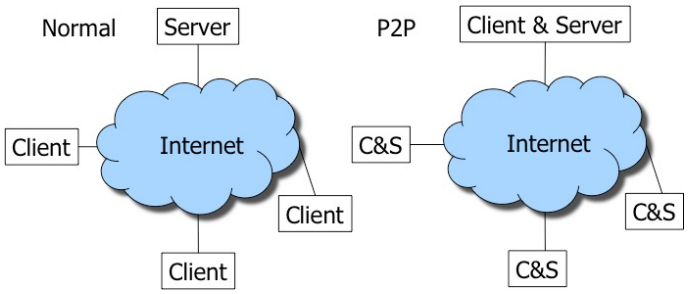
P2P network

- Distributed system consisting of interconnected nodes that are able to self-organize into an overlay network and adapt to changes
- Purpose: sharing resources (content, CPU, storage, …)
- Interaction between peers, instead of client-server model



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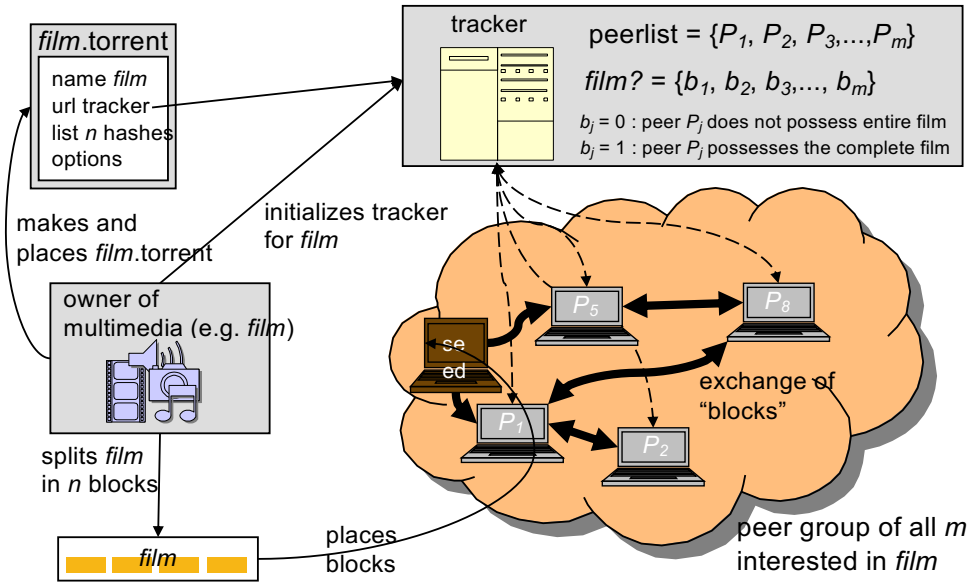
BitTorrent



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Down- and uploading in BT

- Content is separated into pieces (“chunks”)
- Each piece is given a hash code for integrity
- Torrent file contains the hash codes of a file
- Distributed exchange process:
  - Selection strategy (which pieces first): rarest first
  - Fair mechanism between up- and downloading speed (tit-for-tat)

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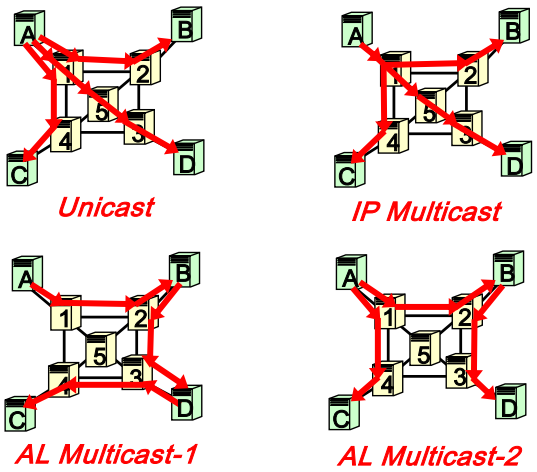
Application-Layer Multicast



End hosts perform the multicast function

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SDN multicast

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SDN Multicast

IP multicast

- Poor scalability
  - Multicast tables
  - Communication between routers
- Security issues
- Difficult failure recovery

SDN multicast

- Centralized view, so easy to:
  - Compute efficient multicast trees
  - Recover from failures (to some extent)
  - Add security

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Multicast in OpenFlow (OF)

- Requires outputting packet to multiple ports
- 2 methods:
  - Add multiple “Output” actions*
  - “All” group

** Not supported by all OF switches*

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Static Multicast (OF)

1. Compute optimal tree(s) connecting source and destinations
   - Shortest Path Tree
   - Steiner Tree
2. Install trees

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Dynamic Multicast (OF)

- Hosts can join, leave and create group at any time
- Construct trees on the fly
  - Add, remove, or edit flow entries where necessary

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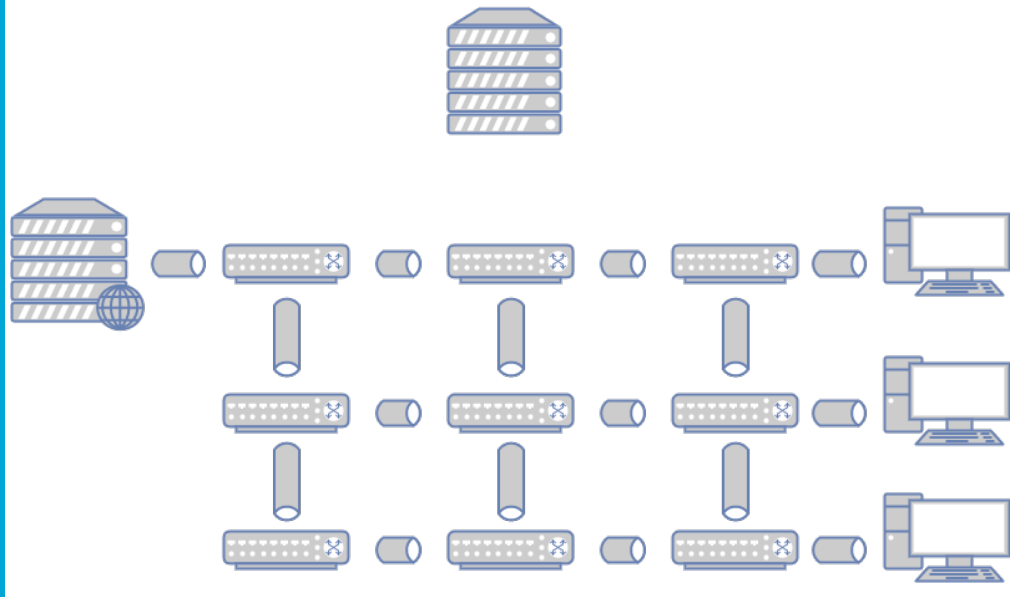
31



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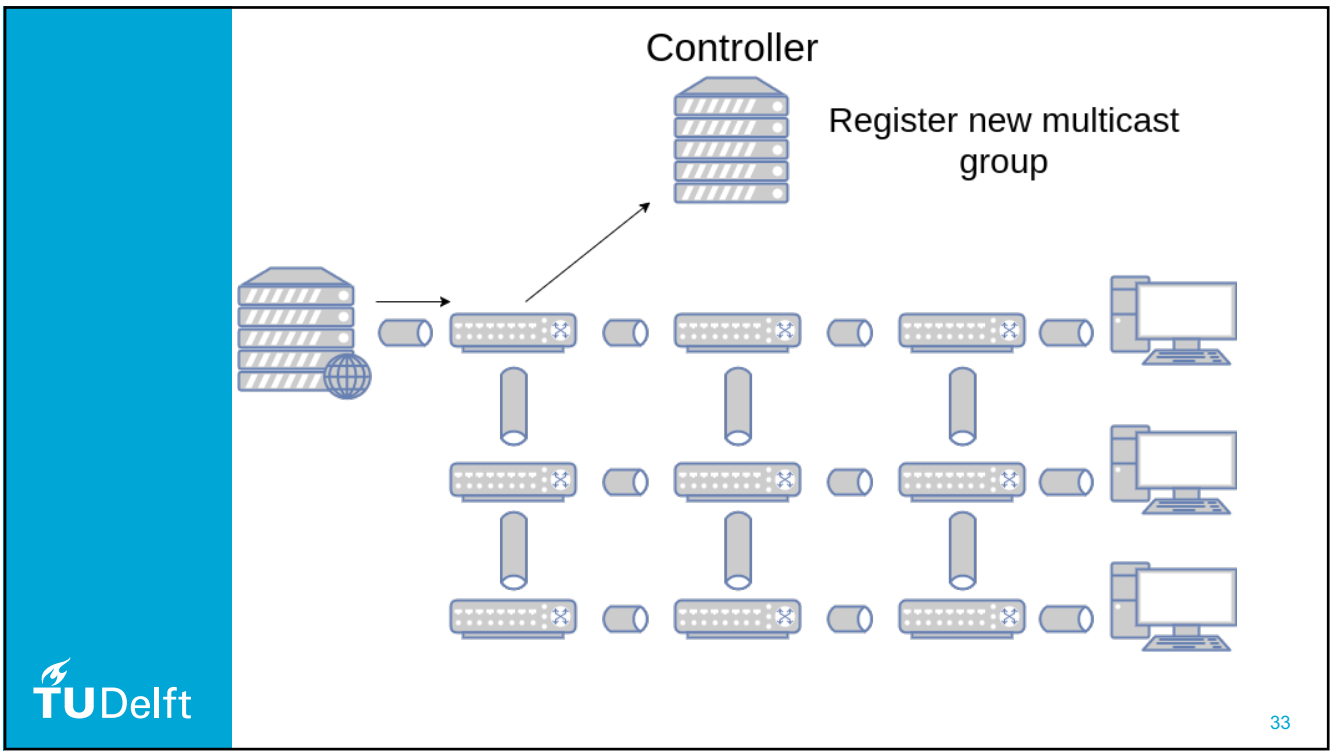
32


Controller
Register new multicast group
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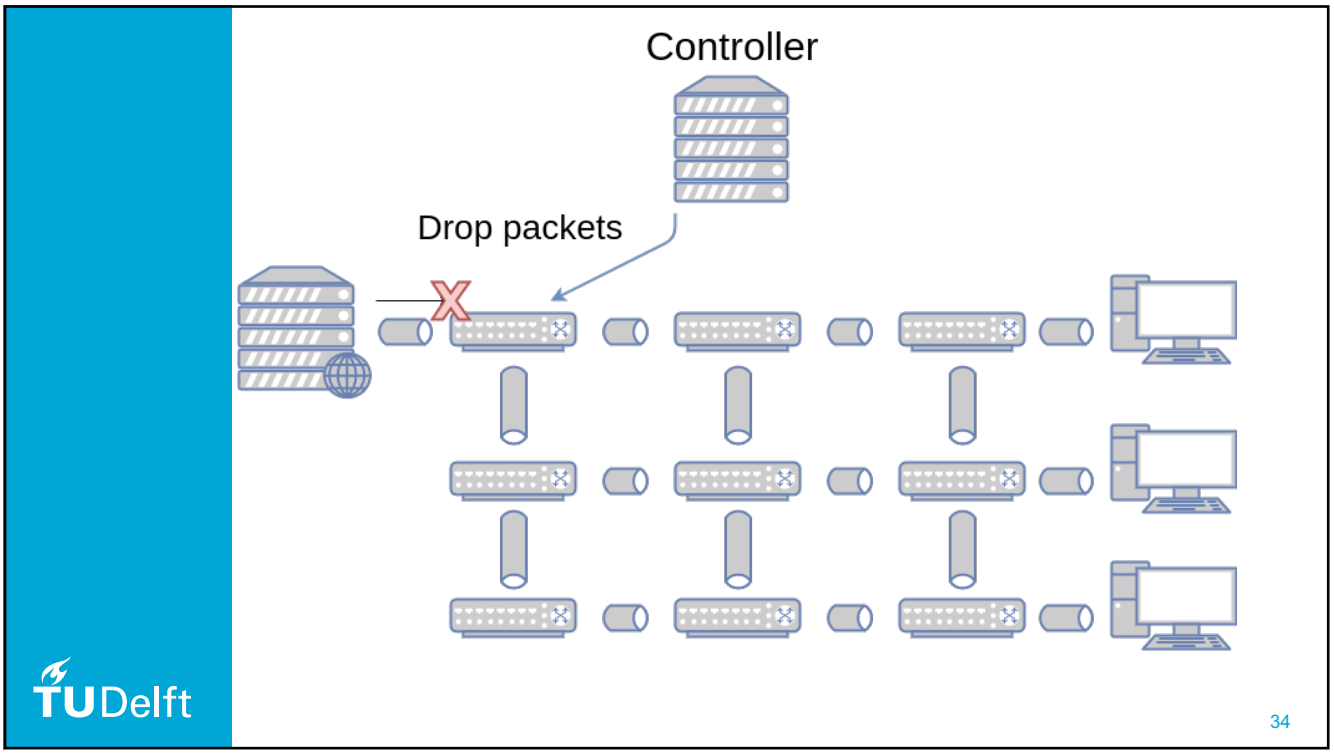
33


Controller
Drop packets
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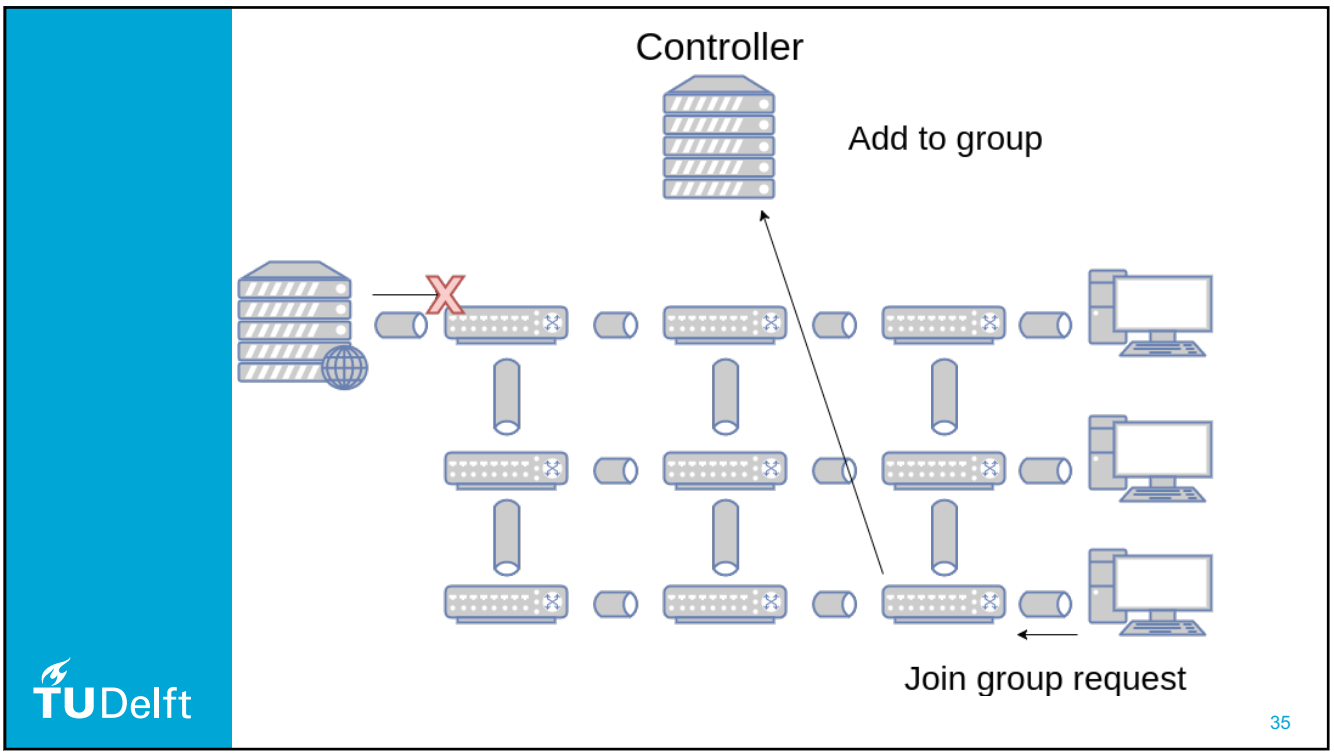
34


Controller
Add to group
X
Join group request
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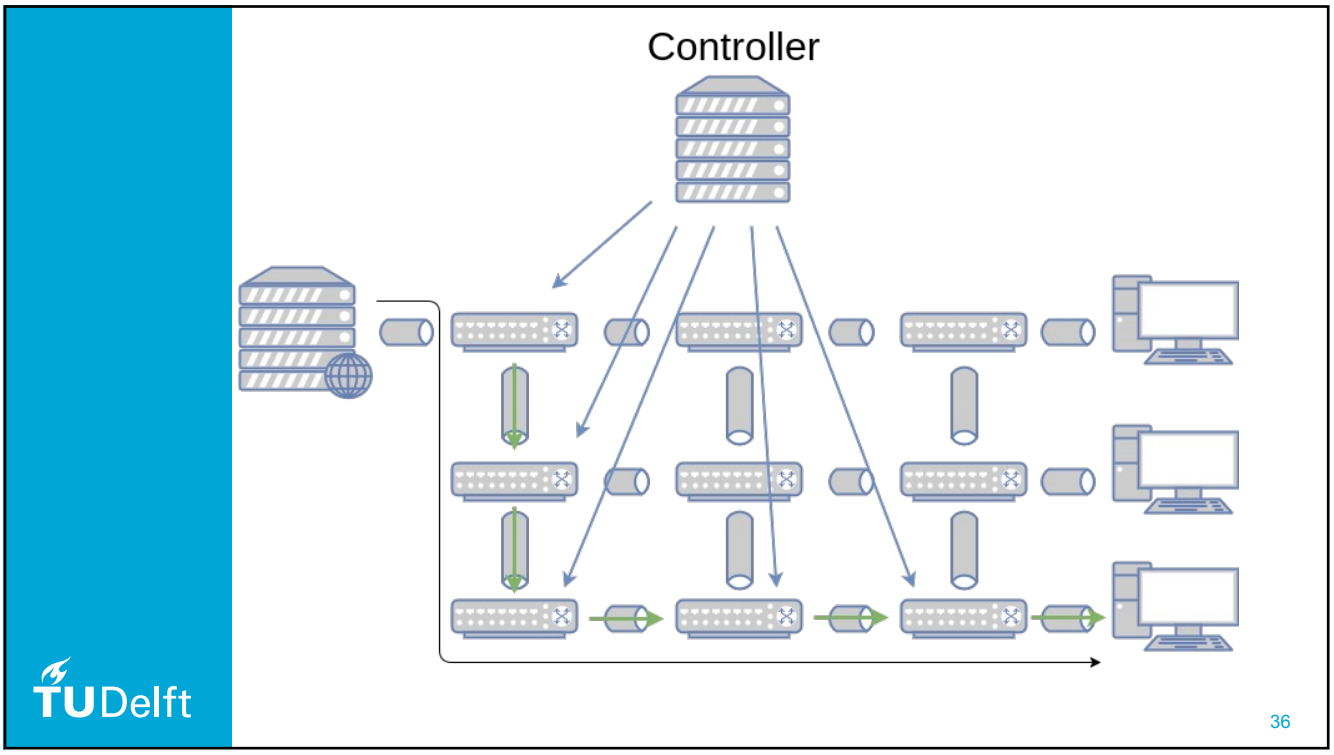
35

35


Controller
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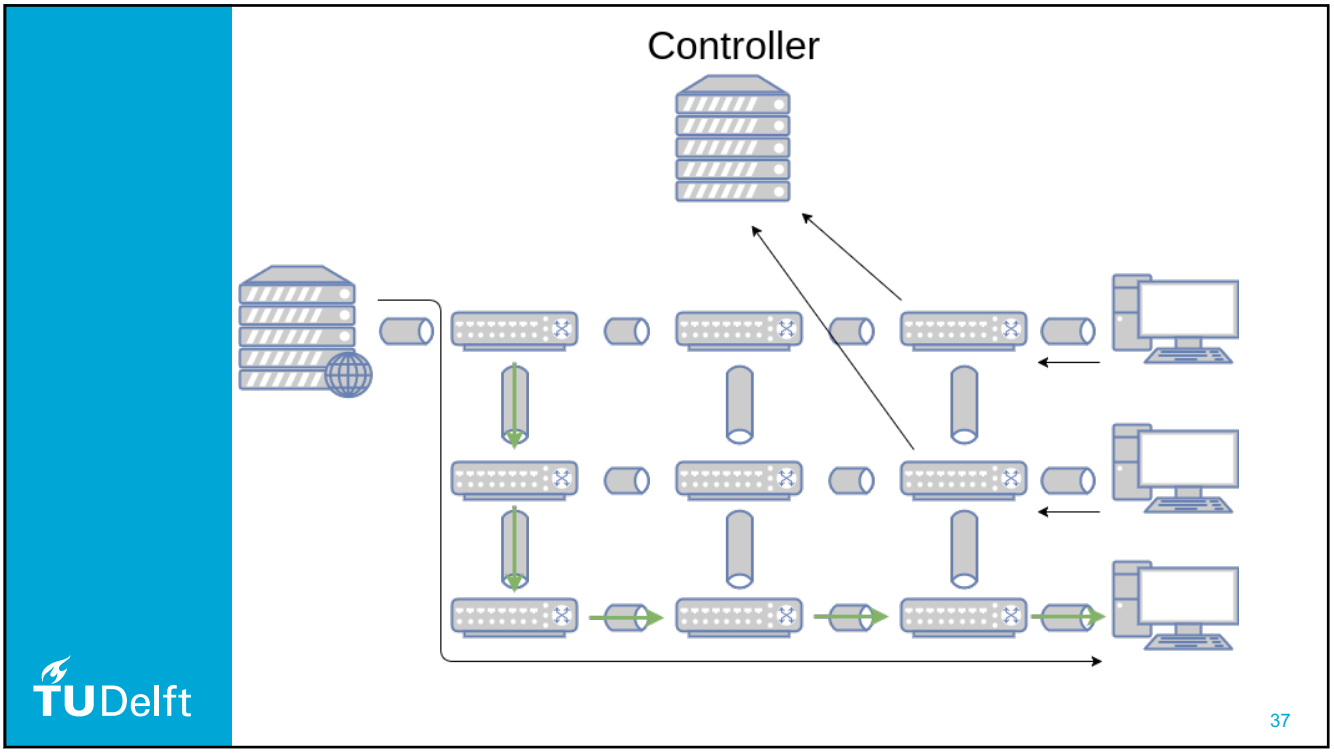
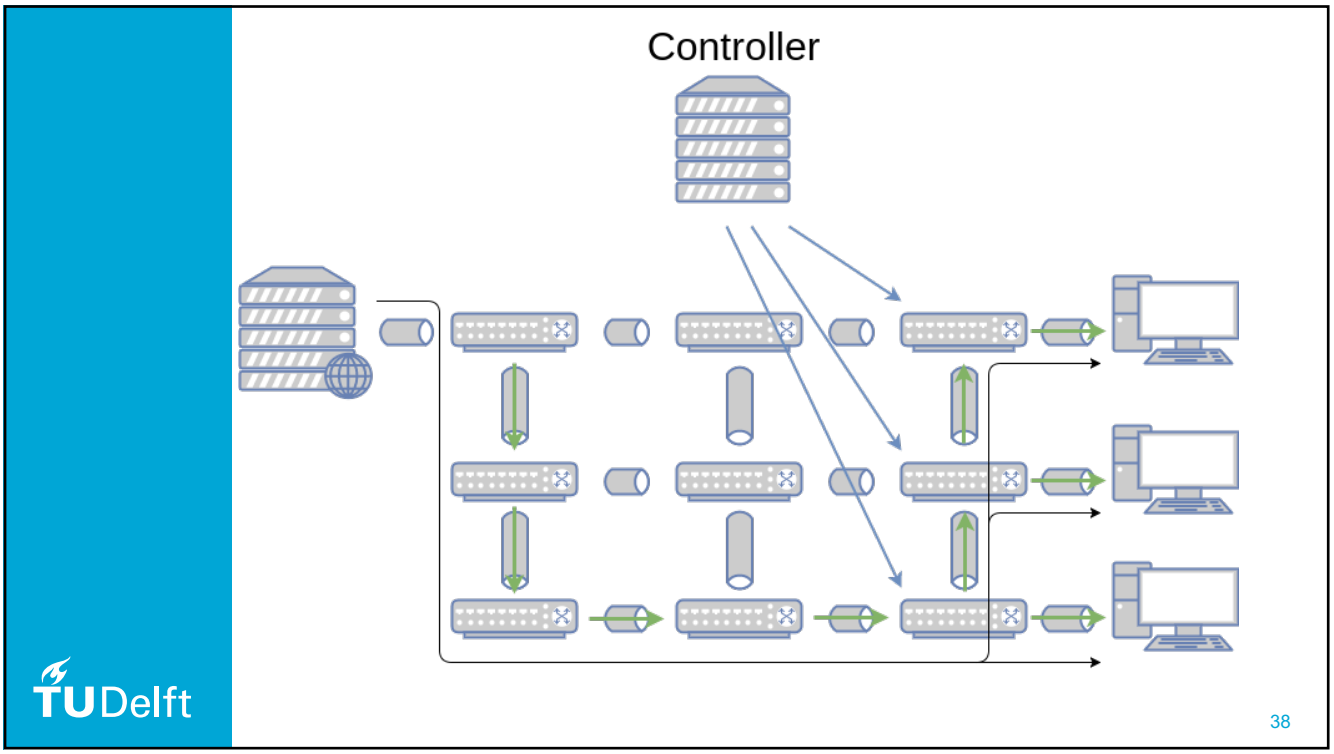


37



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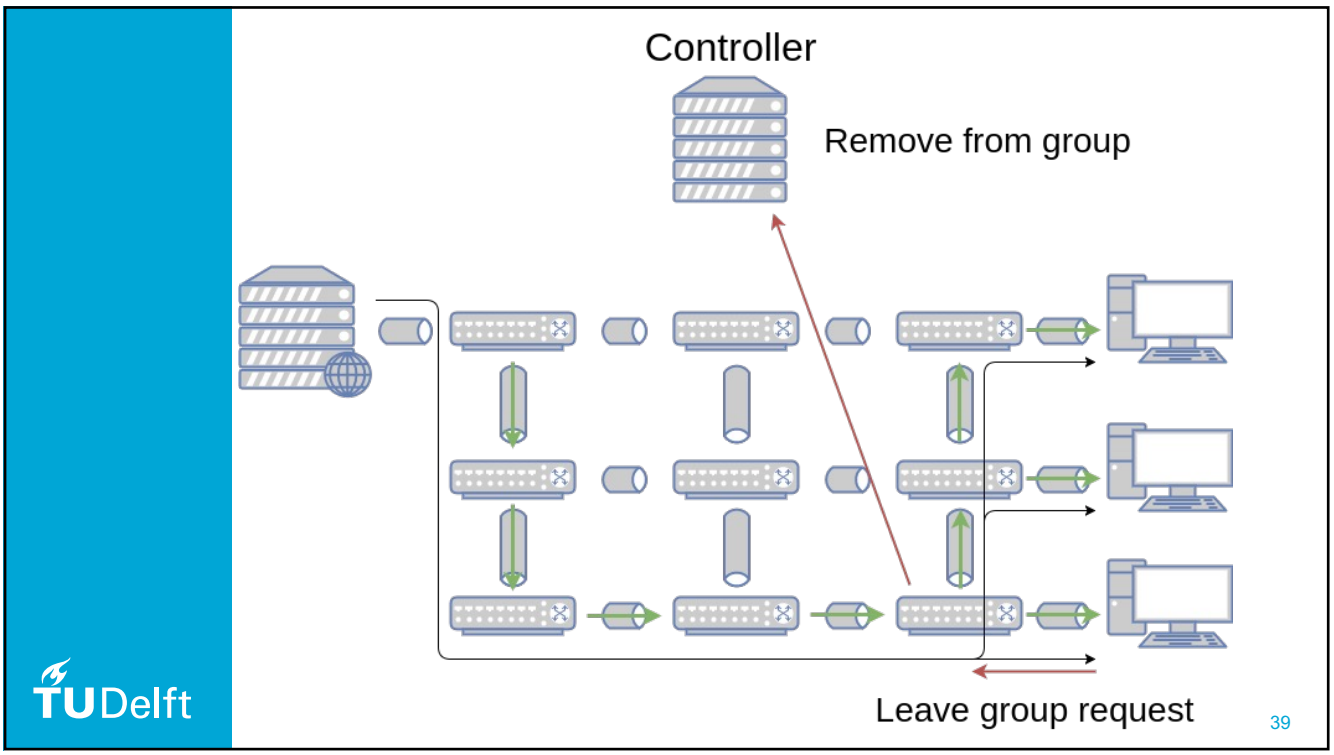
Controller
Remove from group
Leave group request
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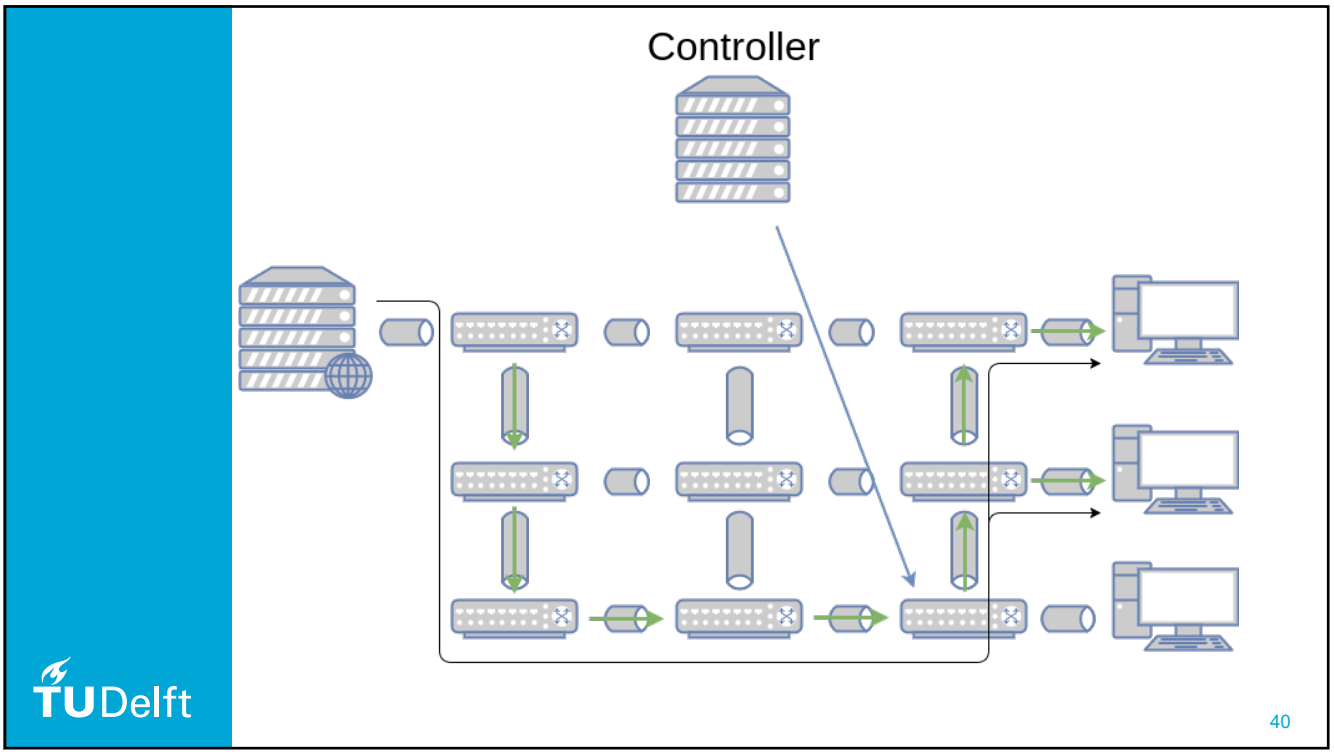
39

39


Controller
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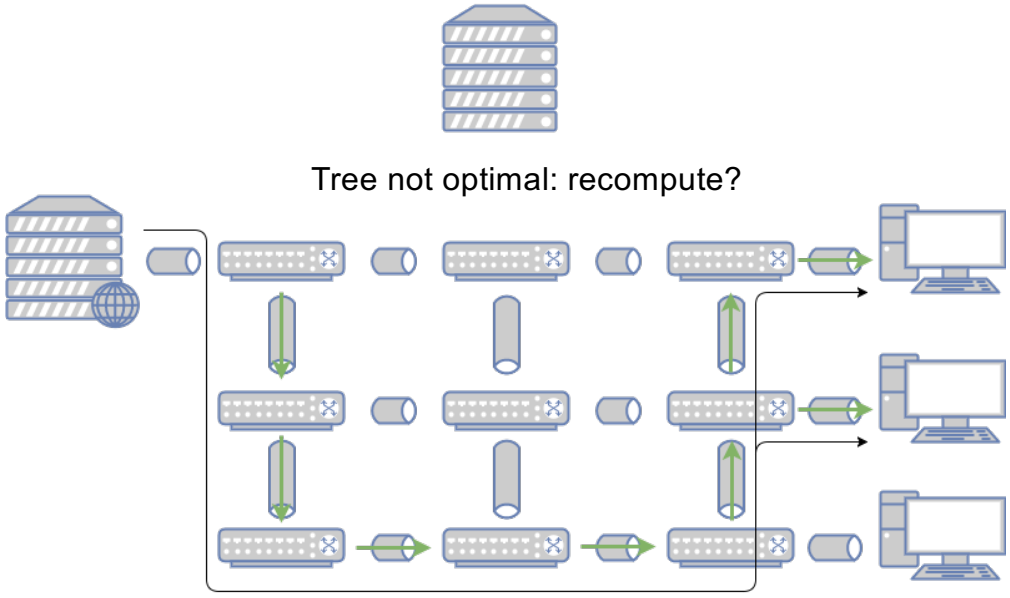
40

40

Controller



Tree not optimal: recompute?

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41

Content-centric networking

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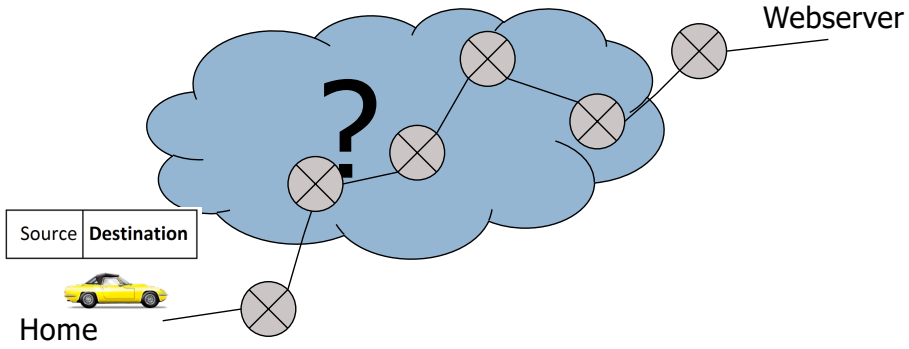
[N. van Adrichem and F.A. Kuipers, “NDNFlow: Software-Defined Named Data Networking,” Proc. of IEEE NetSoft 2015.]

42

42

The Internet today



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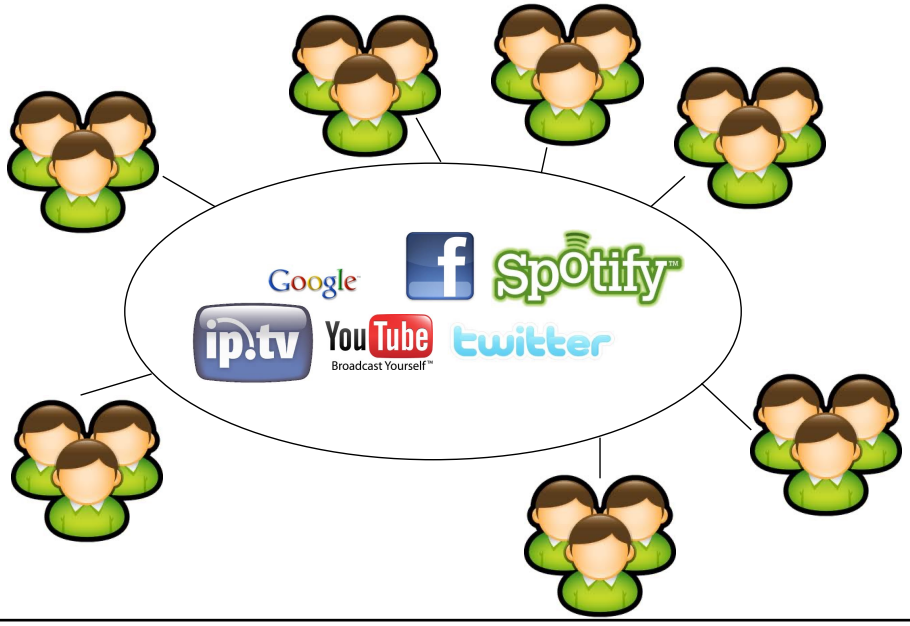
The Internet's use



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Content distribution networks

- Load balancers
- Localisation by
  - source IP: GeoDNS
  - anycast IP addresses
- Synchronization between nodes

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Explicit connections

http://www.tudelft.nl

DNS(www.tudelft.nl) -> IP:131.180.77.102

TCP(131.180.77.102:80) -> 3-way handshake

HTTP(GET "/")

Explicit connection disables direct optimization for Content Distribution and DDoS prevention

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IP and CCN protocol stack

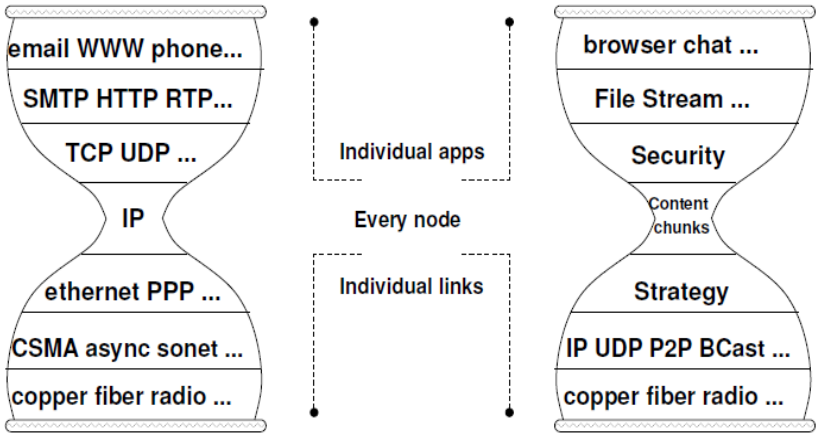

figure: Van Jacobson (2009)

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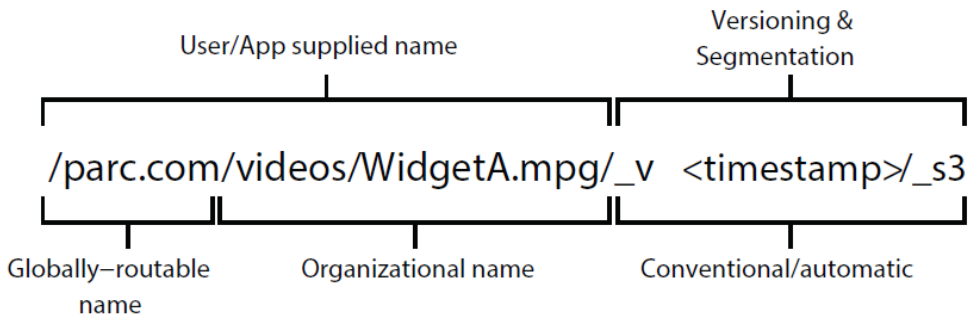
47

Content names



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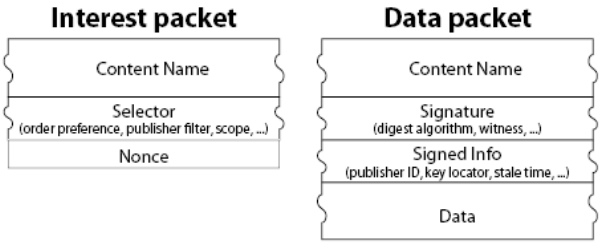
48

48

CCN packets



There are two CCN packet types: *interest* (similar to http "get") and *data* (similar to http response)

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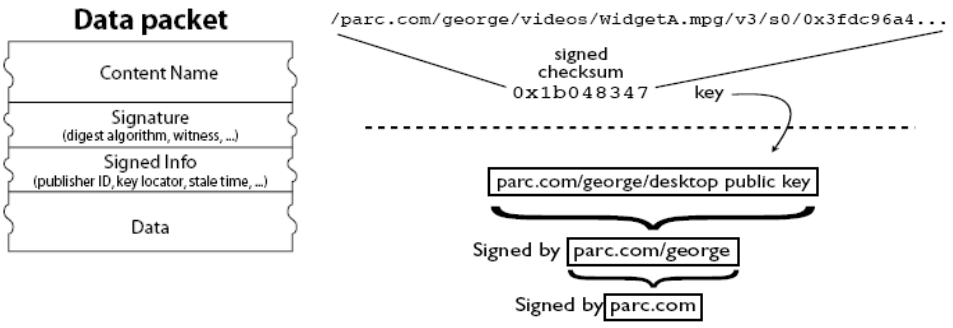
Content-Based Security

Data packet is authenticated with a digital signature



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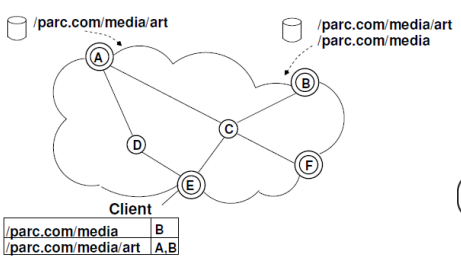
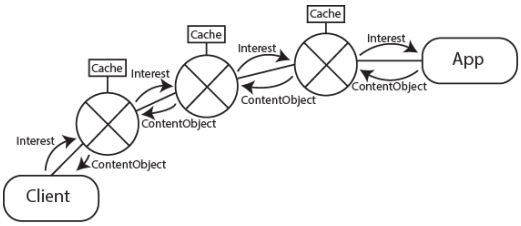
CCN routing

- Route-and-cache by name
- Layer 3 request for information (Interests)
- Rely on next hop to either
  - Deliver ContentObject (from cache)
  - Send out Interest to a node closer to the information



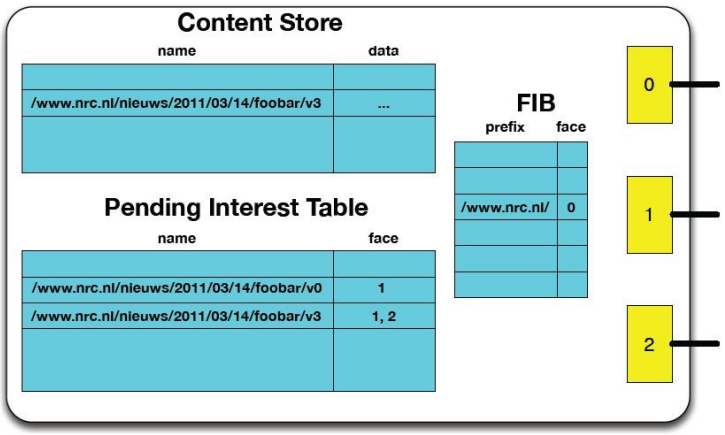


V. Jacobson, D. K. Smetters, J. Thornton, M. F. Plass, N. Briggs, and R. Braynard, "Networking Named Content," *CoNEXT*, 2009.

51

51

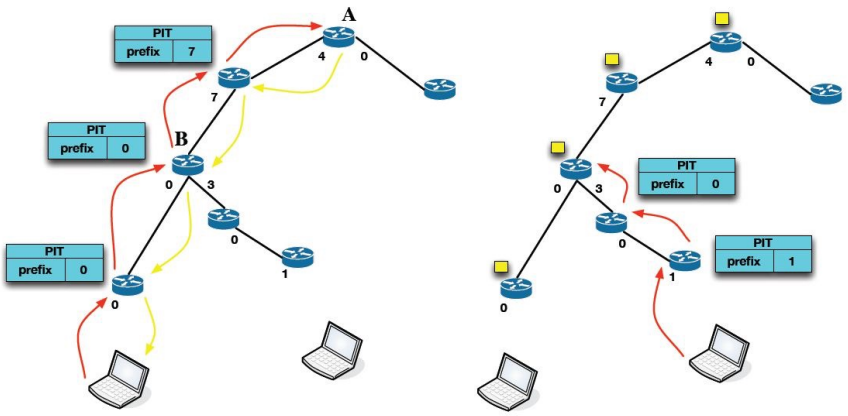
CCNx Principles - Architecture



52

52

CCNx Principles - Traffic



(a) 1^{st} request (b) 2^{nd} request

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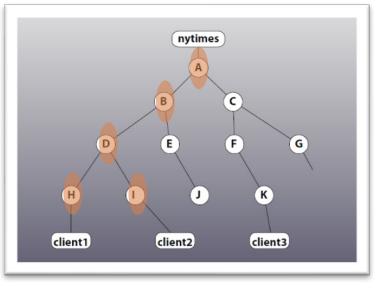
Advantages



- Content goes only where there's interest
- It takes at most one trip across any link
- Average latency is minimized
- Total bandwidth is minimized
- There's no routing or control traffic associated with the replicas

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New problems

- Cache eviction/replacement policies
- Longer evaluation times of packet header
- New forms of DDoS
  - PIT attacks
- Increase of global routing table (~200 mln)

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N.L.M. van Adrichem and F.A. Kuipers, "Globally Accessible Names in Named Data Networking," Proc. of the 2nd IEEE INFOCOM Workshop on Emerging Design Choices in Name-Oriented Networking (NOMEN 2013), Turin, Italy, April 19, 2013.