Mobile video delivery using ICN

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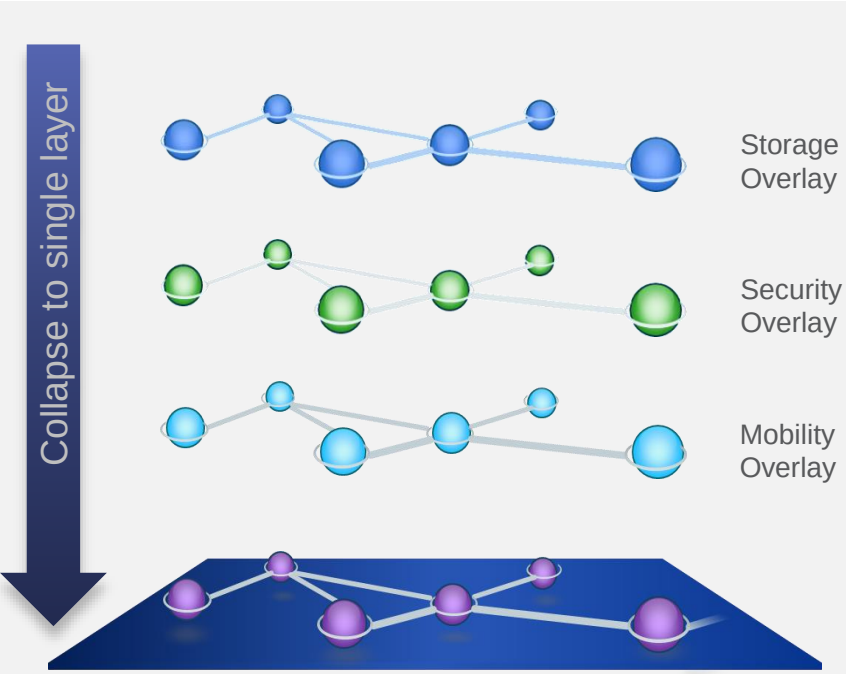
Information Centric Networking
Providing a New Foundation



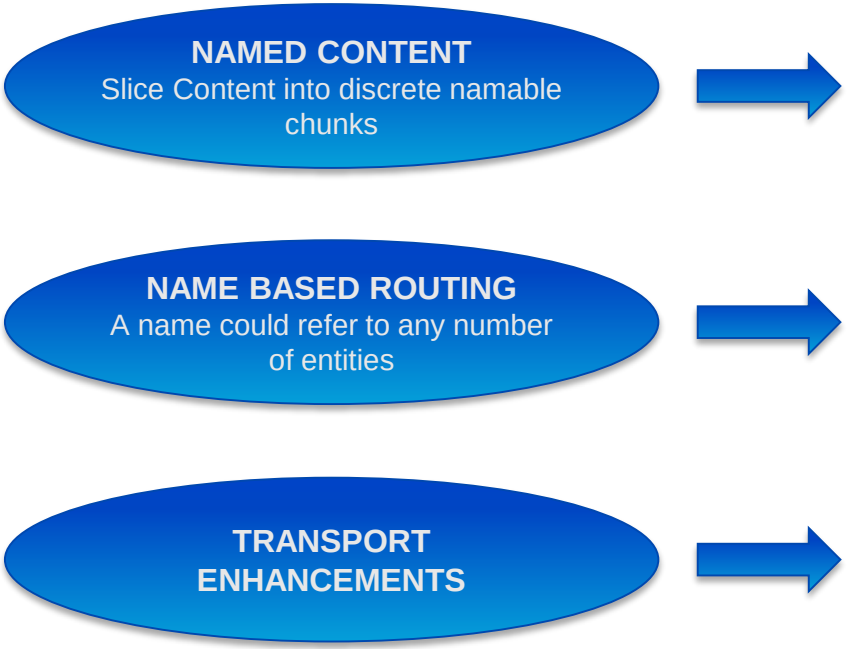
Transform the Overlaid IP Transport Network
To an Integrated Mobile, Secured, Distributed Storage Network

Deliver services using a new communication model that addresses modern Internet usage *&* Exploits latest *Future Internet Architecture* research

- **Mobility** – eliminate need for special mobility overlays
- **Security** – guarantee the integrity of every data object
- **Storage** – dynamic placement of information anywhere in the network

What Information Centric Networking brings

THREE MAJOR COMPONENTS



- Improved object-based security
- Secure in-path caching
- Supports multipath / multicast capabilities

- Enables dynamic content-based routing
- Network based “DNS equivalent”
- User / Application identity no longer tied to IP address supporting mobility, multipath / multicast

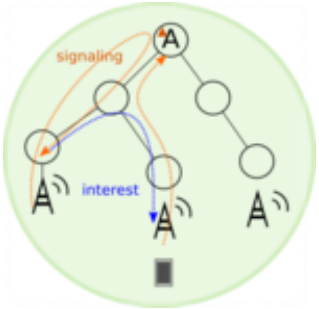
- Pull-based at network layer (not HTTP)
- Connectionless (robust to mobility)
- Exploits local cache for reuse or error recovery
- Unified unicast/multicast model

ICN advantages for 5G

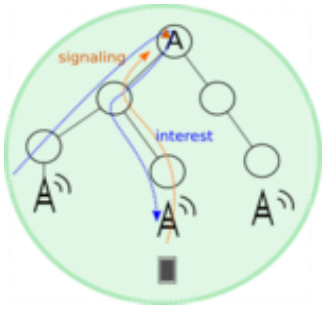
- Simplified core network architecture through built-in L2-agnostic anchorless mobility support
- Seamless communication over an heterogenous and mobile access through connectionless receiver-driven natively multipath transport
- Latency-reduction via in-network control and hop-by-hop dynamic forwarding
- Better user experience with transport cost reduction via edge caching/processing
- Unified unicast/multicast communication
- Improved security/confidentiality, flexibility to support different models
- Richer network-aware content analytics

Mobility management approaches

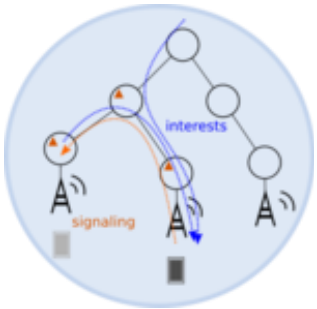
- Consumer mobility is natively supported, in virtue of the **connectionless** and **pull-based** communication model.
- Producer mobility is more challenging. Different categories of approaches: Global Routing (GR) requiring all routers to be updated, or



Resolution-based (DNS-like)



Anchor-Based or Trace-based in ICN

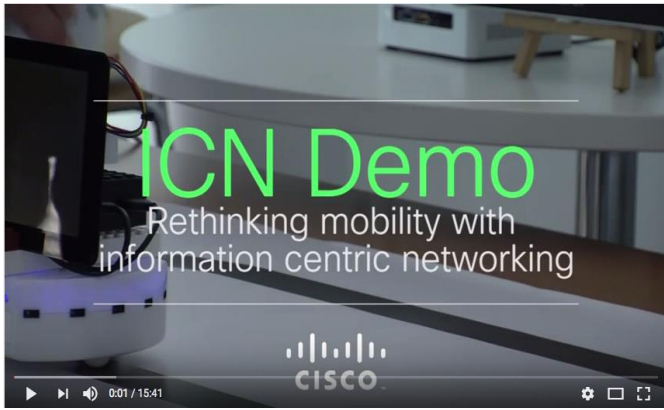


Anchor-Less

Our contribution: an anchorless solution

MAP-Me, an anchorless mobility management protocol for data delivery in ICN that:

- is access-agnostic, in order to cope with highly heterogeneous wireless access and multi-homed/mobile users
- works at network layer and at forwarding timescale to be reactive enough to support real-time applications between mobile consumers/producers
- leverages core ICN features like distributed hop-by-hop stateful forwarding, connectionless communications, object-based security
- doesn't require any control/management plane operations
- has low overhead in terms of signaling, additional state at routers and computational complexity in order to scale with large network size

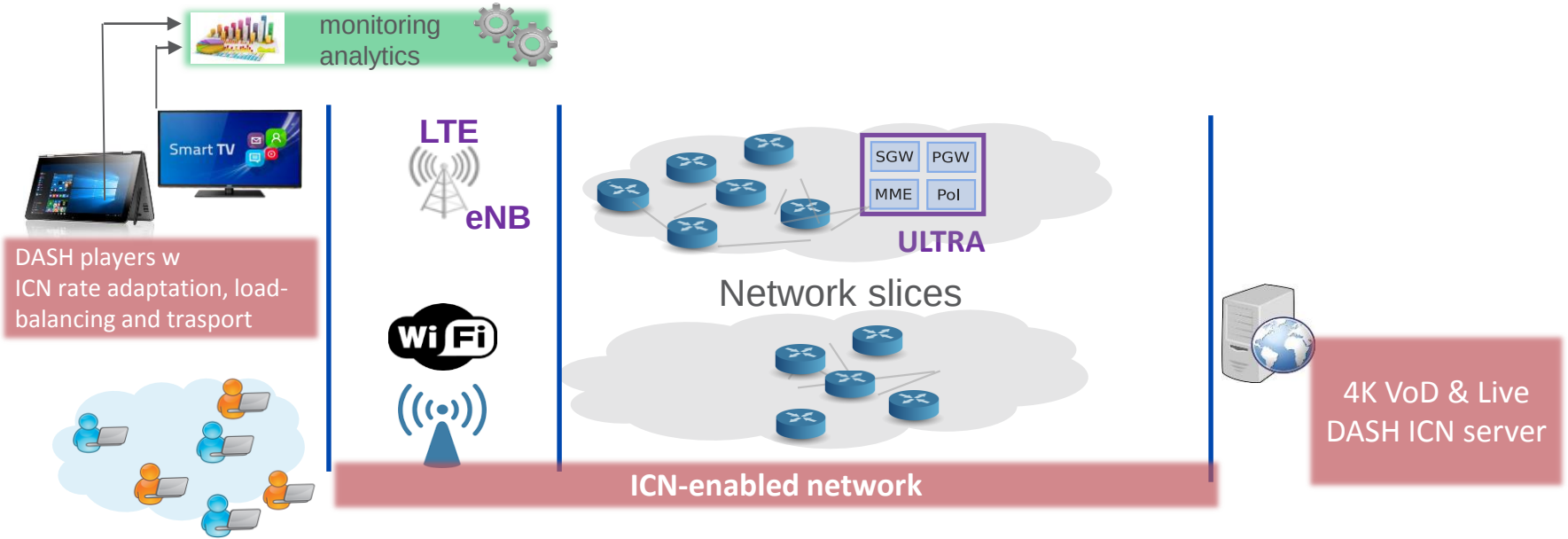


https://www.youtube.com/watch?v=p26GODPxGGE

Cisco Mobility demo @ MWC'16

J.Augé, G. Carofiglio, G. Grassi, L. Muscariello, G. Pau, X. Zeng, *MAP-Me: Managing Anchor-less Producer Mobility in ICN, under submission, accessible at* http://arxiv.org/abs/1611.06785

Video PoC architecture and components



PoC components

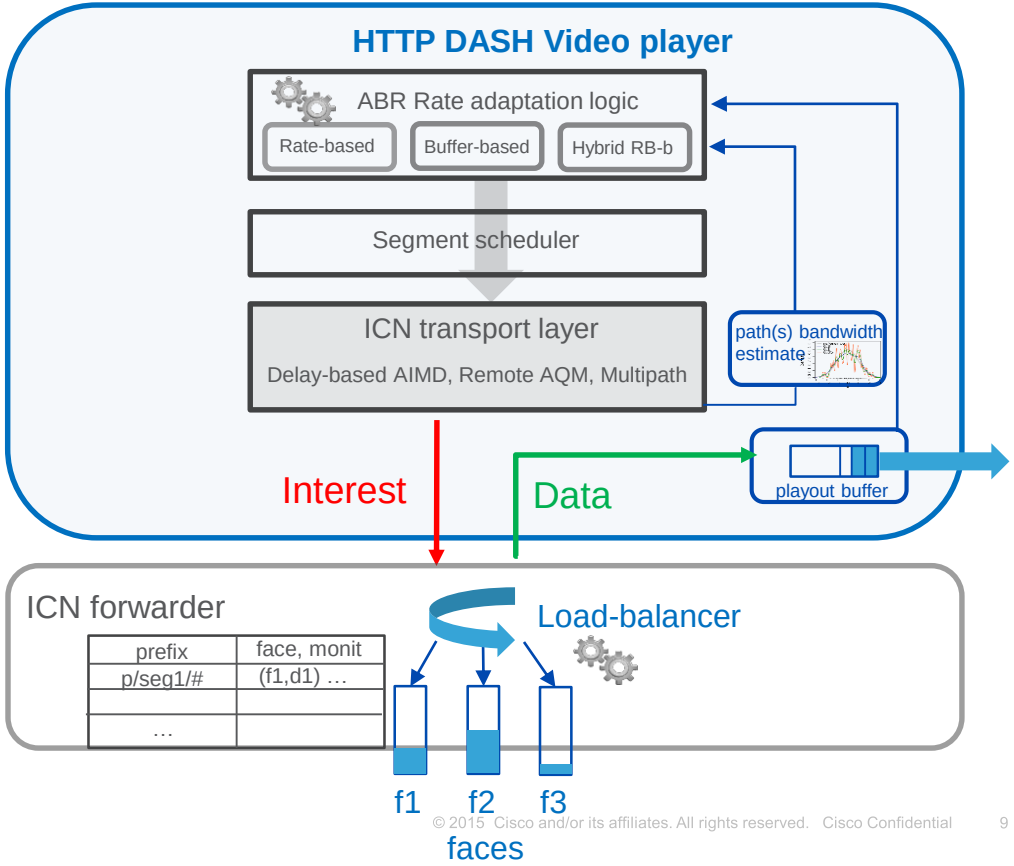
1. ICN-enabled DASH video client
2. Hetnet Access (WiFi, LTE)
3. Virtualized ICN forwarders (vICN)
4. ICN-enabled DASH video server

ICN DASH Video client architecture

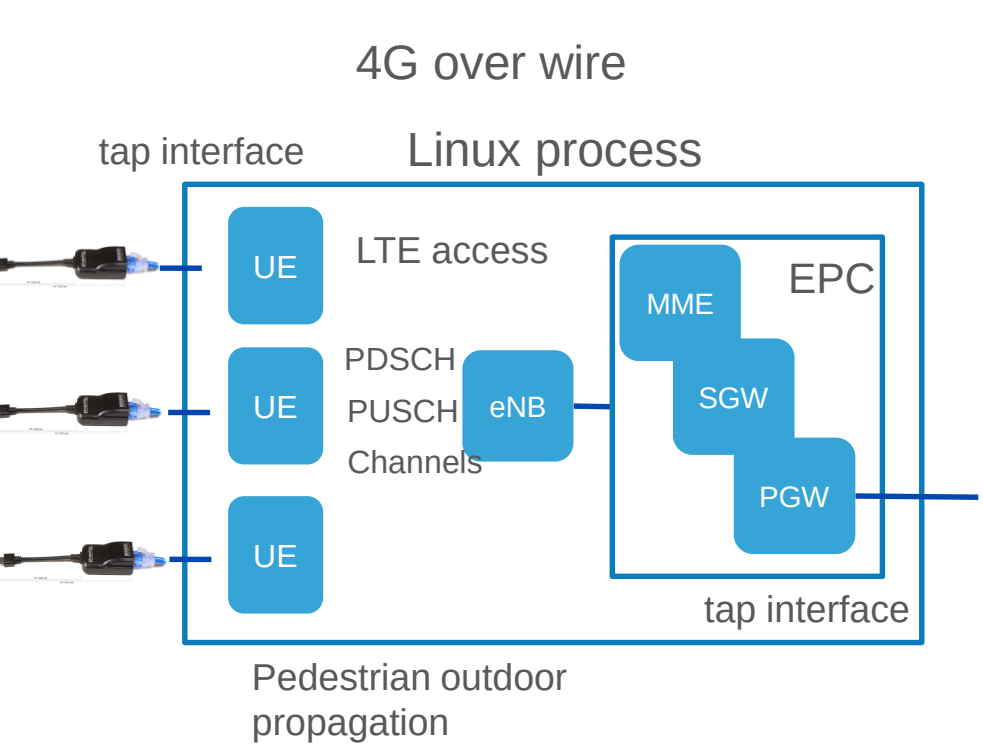
- DASH video is partitioned into 2s segments that the player may ask at different encoding bitrates depending of network conditions
- The birate adaptation logic can be
  - **Rate-based**
  - **Buffer-based**
  - **Mixed Rate and Buffer based**

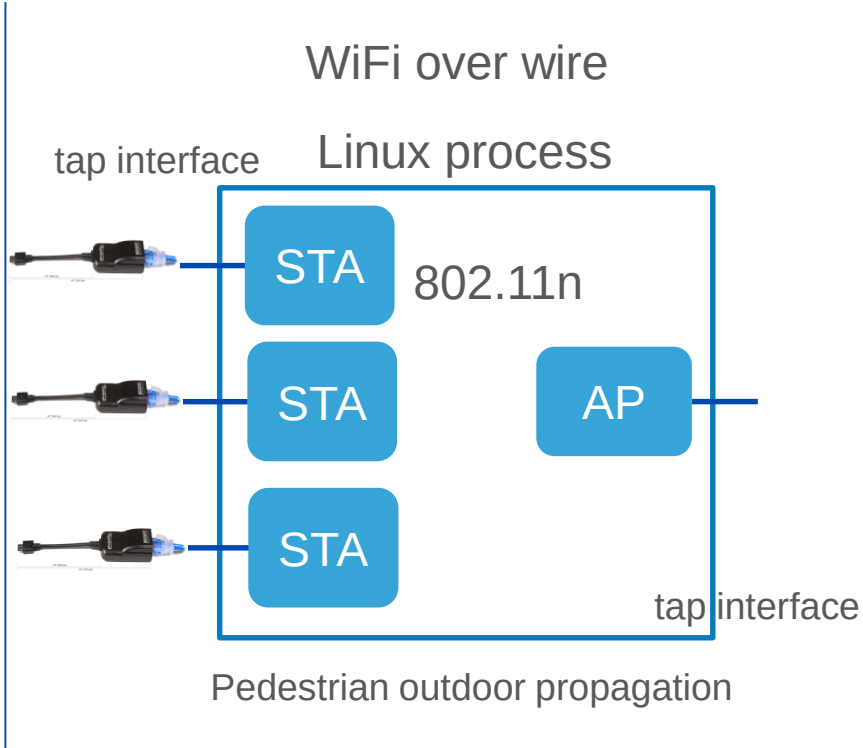
ICN advantages:

- **Receiver-based** transport model, with less throughput oscillations and smaller retx delays via **in-network retransmission (WLDR)**
- **Fine granular per-packet** network view to feed rate adaptation logic
- **Multipath-capable** transport layer that does not require a-priori knowledge of sources/paths

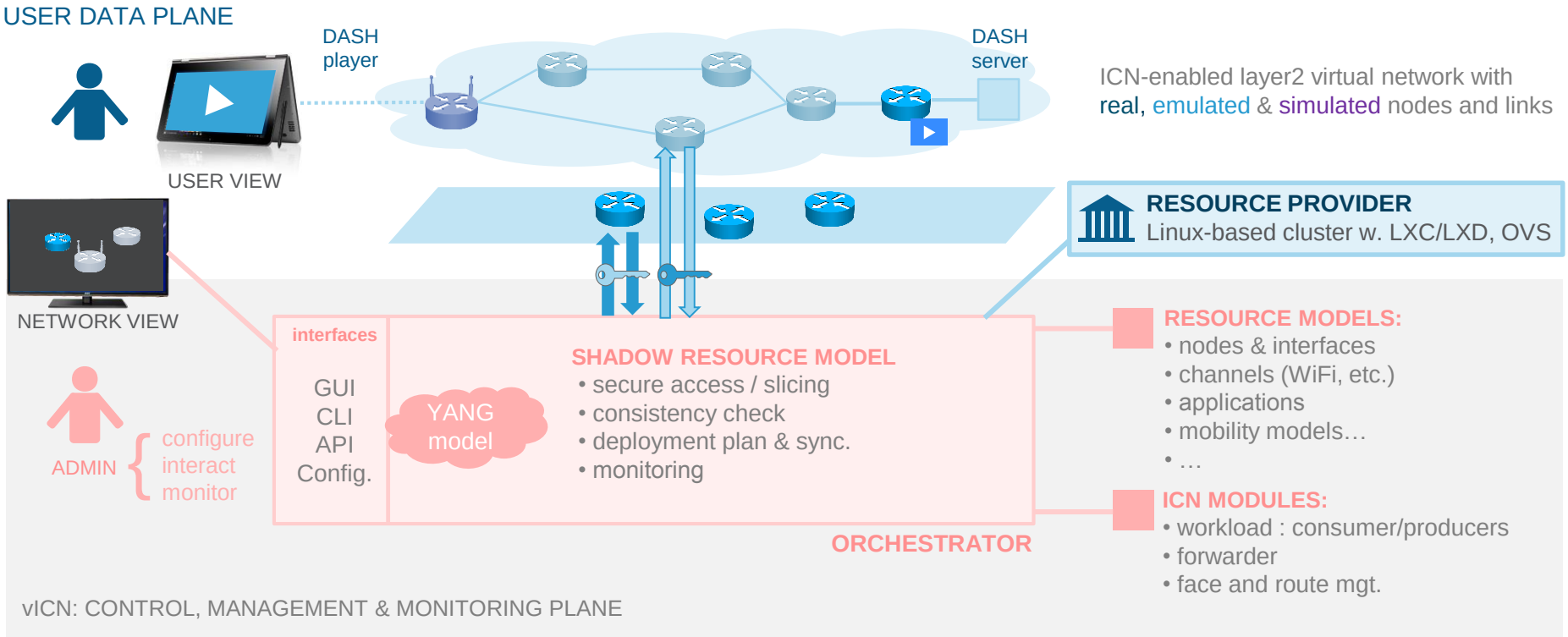


Heterogeneous access

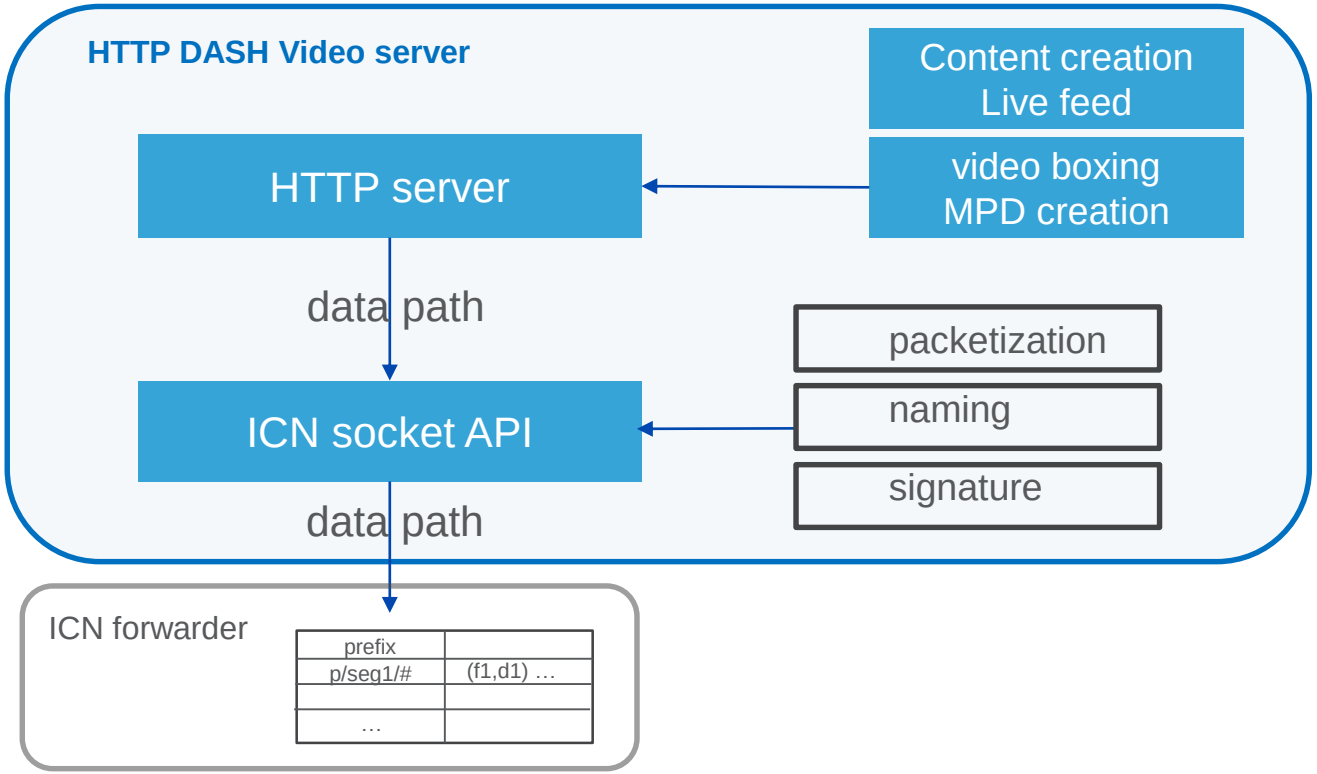




Virtualized ICN architecture (vICN)



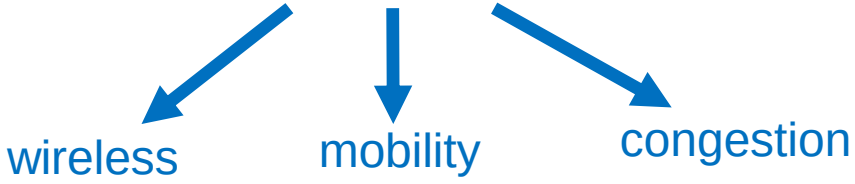
ICN DASH Video server architecture



In-network loss detection and recovery

A result of connectionless request-reply ICN transport model

- Why a powerful feature:
  - Standard TCP/IP congestion control poorly performs in presence of wireless losses and does not handle mobile
  - End-to-end control even loop is slow (at least 1 RTT)
- ICN enables sub-RTT loss detection and recovery by delegation at key network nodes (consumer/producer/access points) of



- WLDR, MLDR (Wireless, Mobility Loss Detection and Recovery) mechanisms, the latter generalized to congestion case.

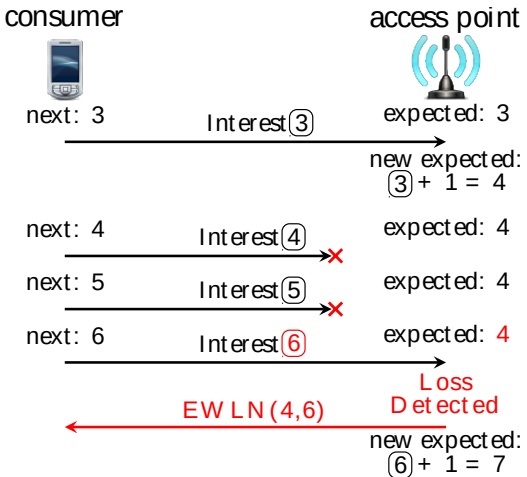
N.Rozhnova, G.Carofiglio, L.Muscariello, M.Papalini, *Leveraging ICN in-network Control for Loss Detection and Recovery in Wireless Mobile Networks ,* in Proc. of ACM ICN 2016, Kyoto, September 2016.

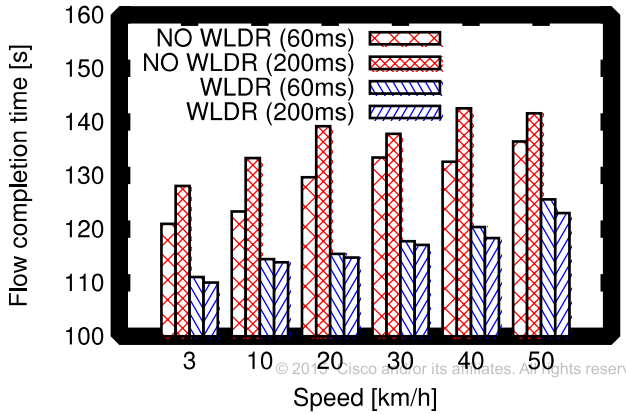
Wireless Loss Detection and Recovery (WLDR)

Key design ideas

WLDR is implemented at face level and introduces a per-face sequencing on packets to detect losses.

- Base station or Wireless node when receiving Interests or Data packets
  - Uses the sequence number in the packets to reconstruct the sequence and detect potential losses
  - If received seq differs from expected seq, sends notification to the wireless node/base station
- Base station or Wireless node when sending Interests or Data packets
  - maintains a counter per-face indicating the sequence number for the next Interest to be sent
  - Writes such sequencing when sending the packets

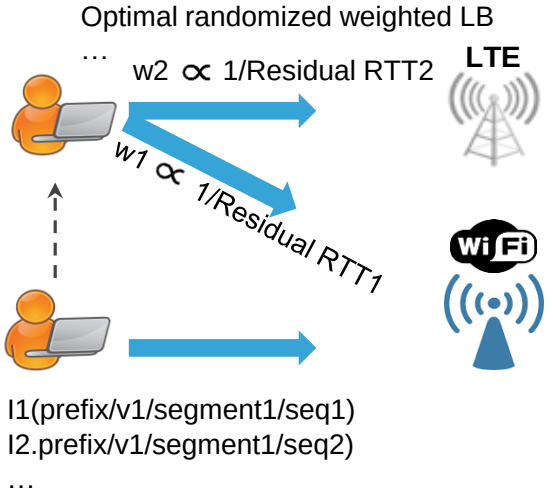




Dynamic load-balancing over hetnet access

Key features and advantages

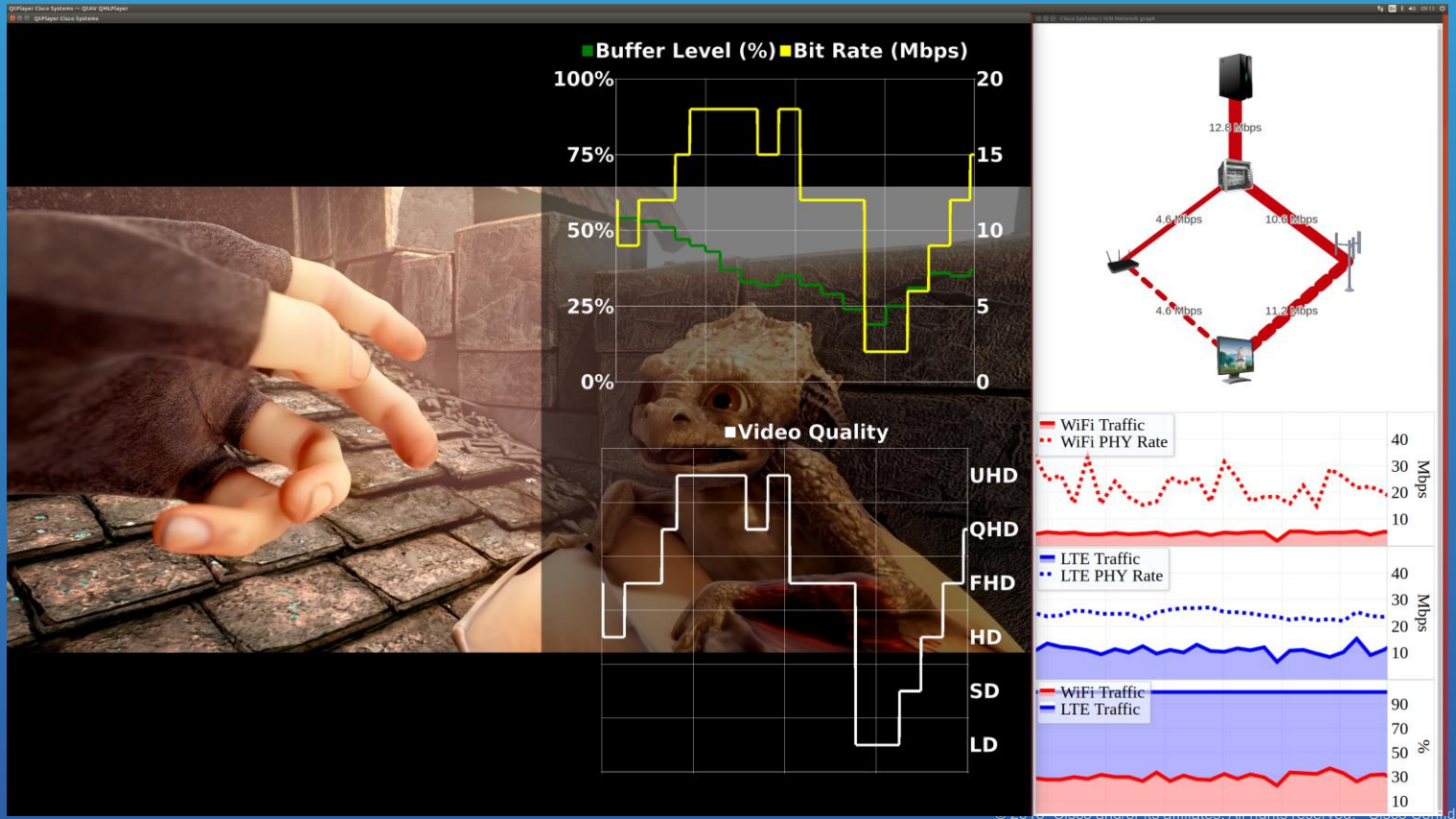
- ICN enables per-packet load-balancing (LB) over dynamically discovered paths
- Packet vs segment granularity in LB permits to exploit all available bandwidth in parallel while avoiding Head of Line blocking
- Forwarding strategies can be video-specific and quality-aware (e.g. in case of SVC for smart quality layers to faces mapping)
- Forwarding strategies can be coupled to caching policies to minimize overall latency



G.Carofiglio, M.Gallo, L.Muscariello, M.Papalini, S. Wang, *Optimal multiapath congestion control and request forwarding in ICN ,* in Proc. of IEEE ICNP, Goettingen, October 2013.

G.Carofiglio, L.Mekinda, L.Muscariello, *FOCAL: Forwarding and Caching strategies with Latency awareness in ICN ,* in Proc. of IEEE Globecom, San Diego, December 2015, ext. version in Computer Network Journal.

Live DEMO


Buffer Level (%)
Bit Rate (Mbps)
100%
75%
50%
25%
0%
20
15
10
5
0
Video Quality
UHD
QHD
FHD
HD
SD
LD
12.8 Mbps
4.6 Mbps
10.6 Mbps
4.6 Mbps
11.2 Mbps
WiFi Traffic
WiFi PHY Rate
LTE Traffic
LTE PHY Rate
WiFi Traffic
LTE Traffic
Mbps
%

Conclusions

Demonstrated ICN advantages:

- Joint user and network-aware video rate adaptation at the client
  - User QoE combined with per-content network monitoring (congestion, cache proximity) to drive DASH rate adaptation over hetnet → **QoE optimization**
- Access-agnostic in-network Wireless Loss Detection & Recovery
  - ICN enables in-network rather than e2e control → **latency reduction**
- Mobility-robust and congestion-aware dynamic multipath
  - Seamless load-balancing over multiple available interfaces in parallel
  - Fine-granular per-packet (not per segment) load-balancing →**better performance**
- Unified unicast/multicast communication model
  - Communication becomes multicast as soon as more than one user request
  - No need for syncronisation of different flows/users →**simpler configuration**

Future challenges to address

Network-assisted video delivery

- Network-assistance to drive rate adaptation at the client
- Video/quality-aware forwarding/caching strategies at network nodes
- SVC-enabled load-balancing in the network
- Unified unicast/multicast communication model

Unified single access control framework for

- unicast/multicast
- access-agnostic (for the consumer)
- multi-source (for the producer)


Saída / Exit
CISCO

ICN deployment path & network slicing