5G-Xcast Tutorial

Broadcast and Multicast Communications Enablers for 5G

WP5: Unified Content Delivery on Fixed and Mobile Networks

WP5

Presenters:

Steve Appleby (BT)

Rui Andrade (BundlesLab)

Disclaimer

The current presentation shows **work in progress**, supported in part by the European Commission under the 5GPPP project 5G-Xcast (H2020-ICT-2016-2 call, grant number 761498).

The content is not yet approved nor rejected, neither financially nor content-wise by the European Commission. The approval/rejection decision of work and resources will take place **at the Mid-Term Review Meeting planned in September 2018 and the Final Review Meeting**, after the monitoring process involving experts has come to an end.

Public Deliverables

- **D5.1**: Content Delivery Vision, Nov. 2017.
  Download
  News
- **D5.2**: Key Technologies for the Content Distribution Network, Aug. 2018.
- **D5.3**: Application and Service Layer Intelligence, Nov. 2018.

Work package 5 goals

- Take the perspective of the Content Service Provider
- Provide a view of future content consumption patterns
- Challenge the notion that all requirements should be met with a network solution
- Build PoCs to demonstrate non-network QoE management
- Provide a framework to guide the architectural activities in the other workpackages

Large-scale content delivery

Two worlds

Traditional Broadcast

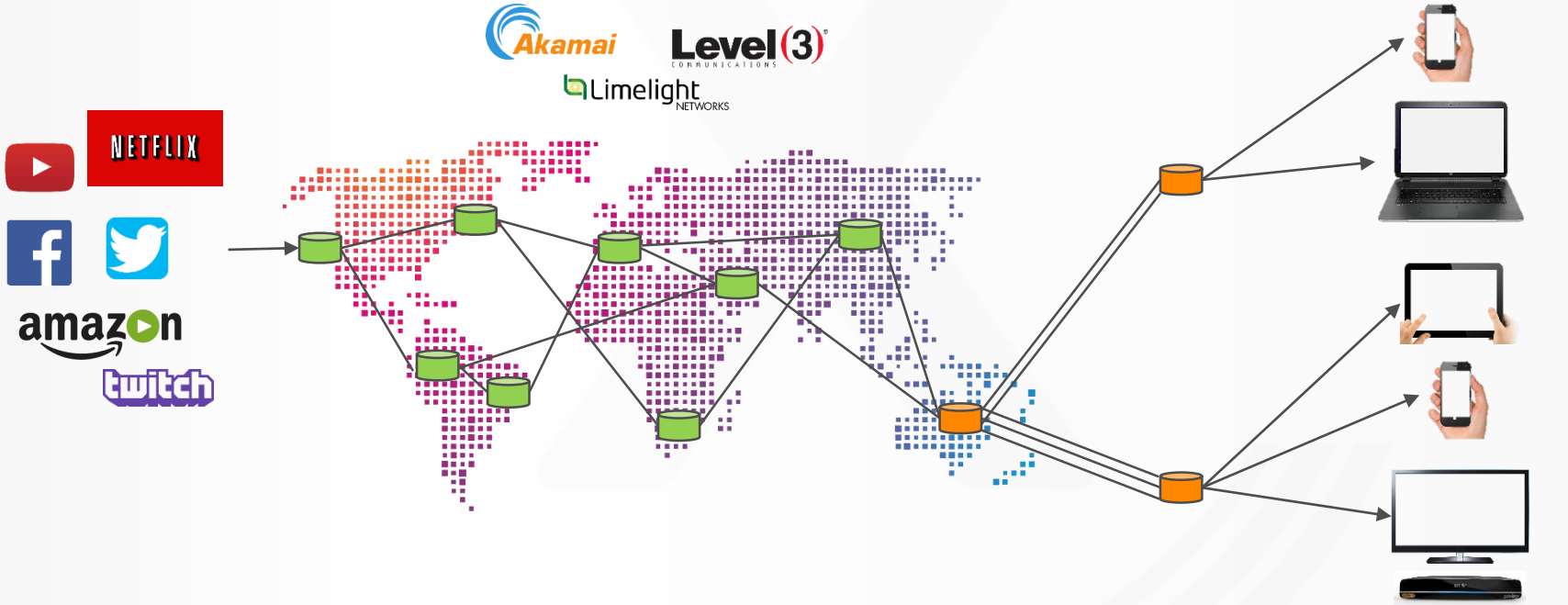
- Only supports TV
- Optimised network for national coverage of popular content
- Highly efficient use of spectrum for simultaneous delivery at edge of network
- High barrier to provisioning a new service
- Only support linear delivery

Internet

- Supports many services
- Non-optimised network for global coverage
- Unicast at edge of network inefficient for simultaneous delivery
- Very low barrier to provisioning a new service
- Supports linear and on-demand

Content Delivery Networks

Content Service Provider | Content Delivery Network | Network Service Provider | End User



The rise of the global platforms

Live

amazon

twitch

On demand

NETFLIX

amazon

twitch

Delivery

Limelight NETWORKS

Akamai

Level (3) COMMUNICATIONS

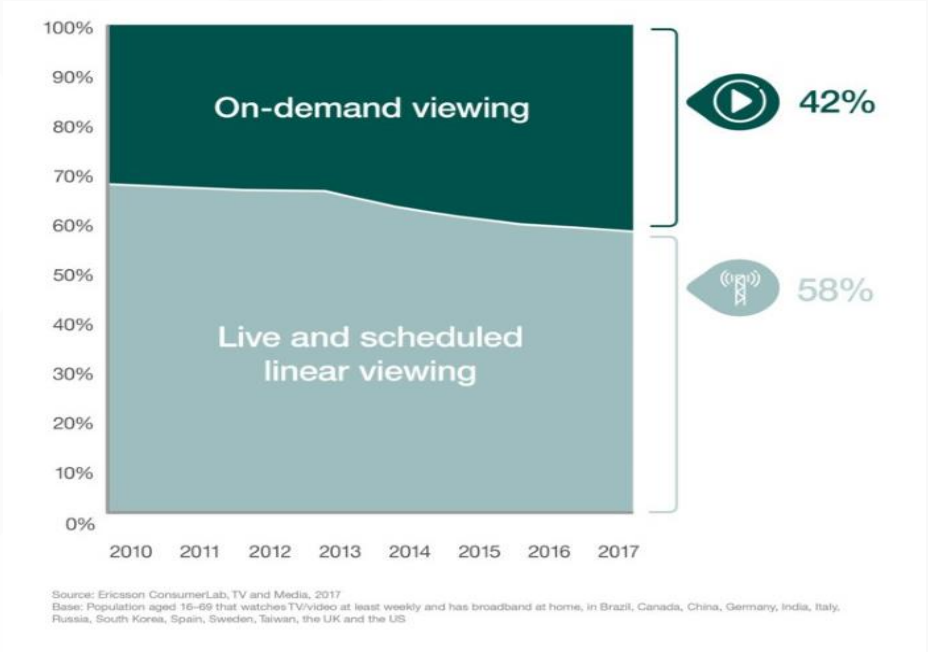
So that’s it!
– Everything over the Internet?

Some types of content really need multicast/broadcast

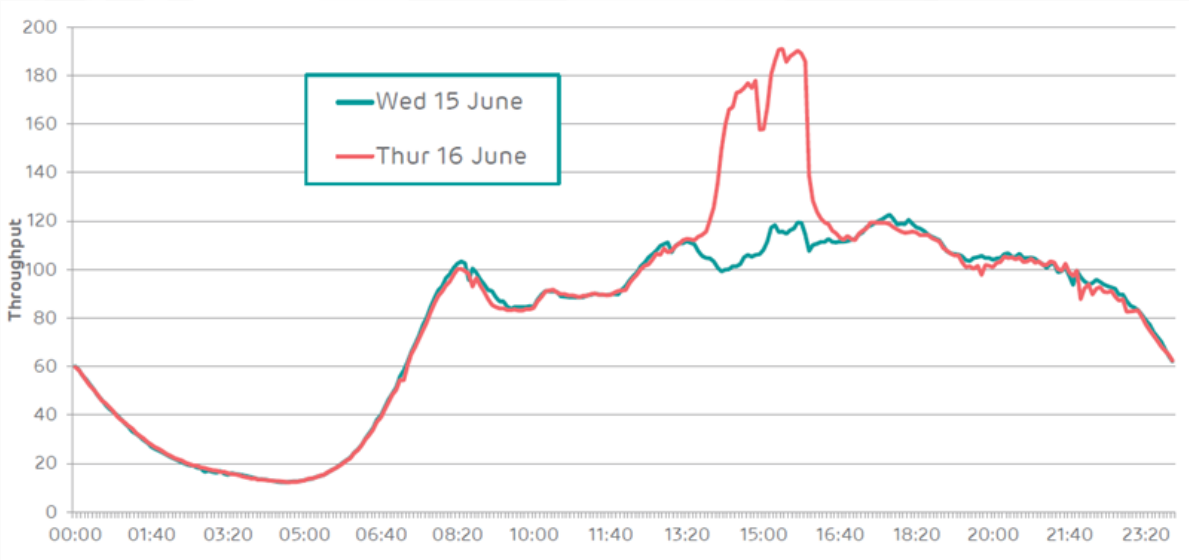
…and the Internet isn’t very good at this

Linear TV in decline

Active viewing hours of on-demand vs live and scheduled linear TV

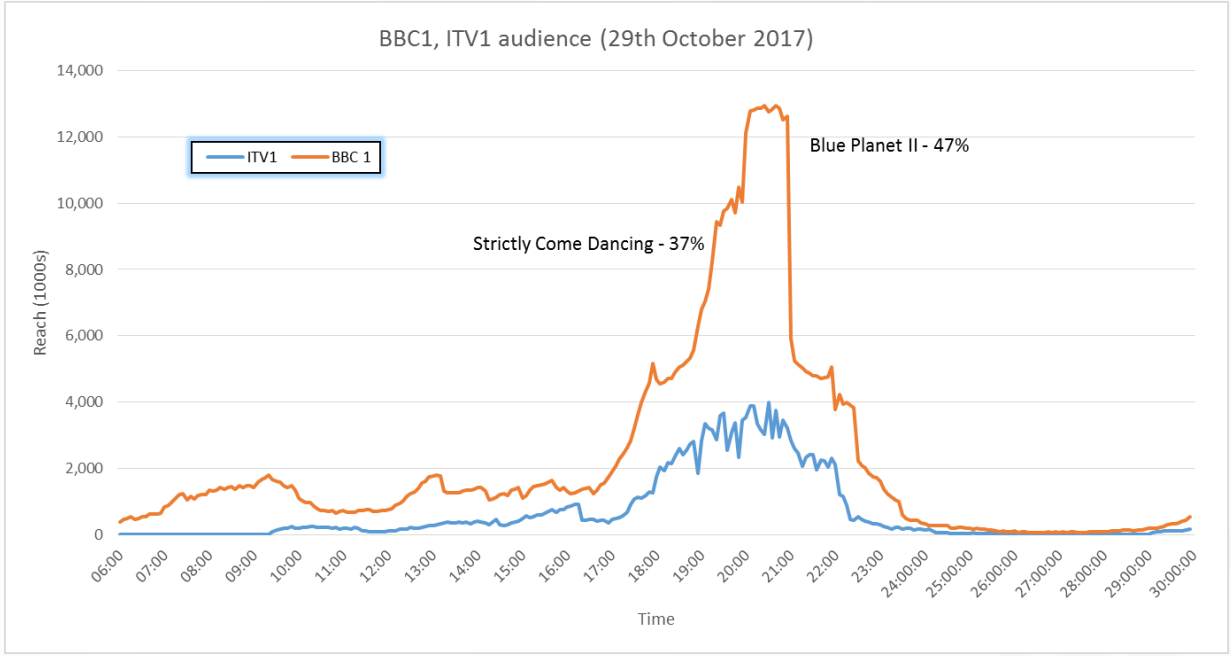


Live audiences are very dynamic



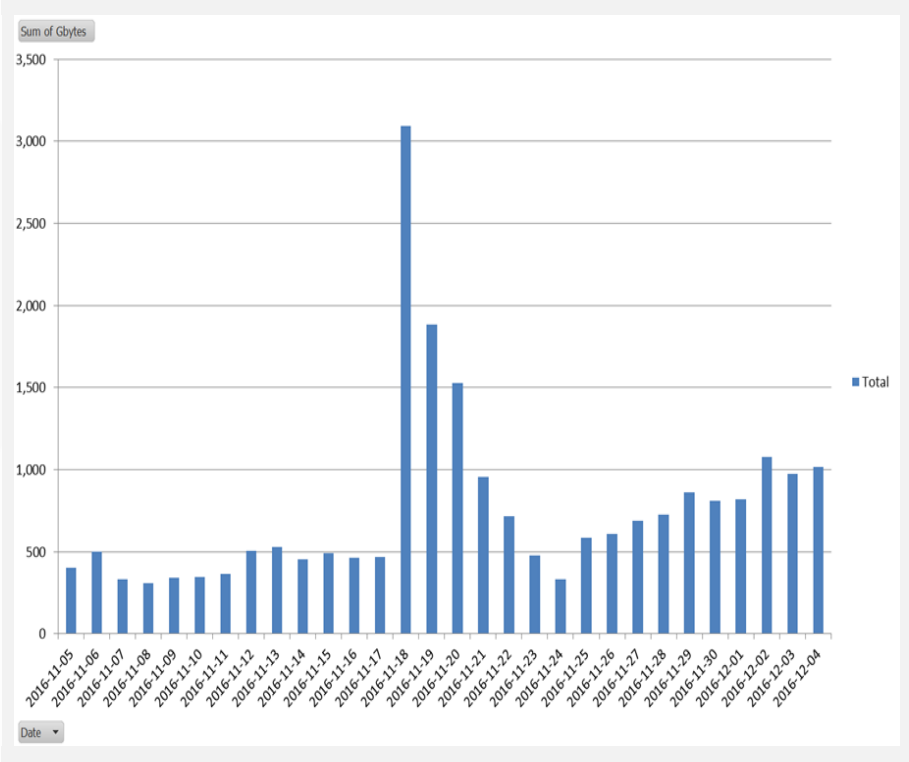
Traffic volumes over the EE network during the England vs. Wales football match during Euro16 compared with the previous day.

“Appointment to view” broadcast audiences are very dynamic

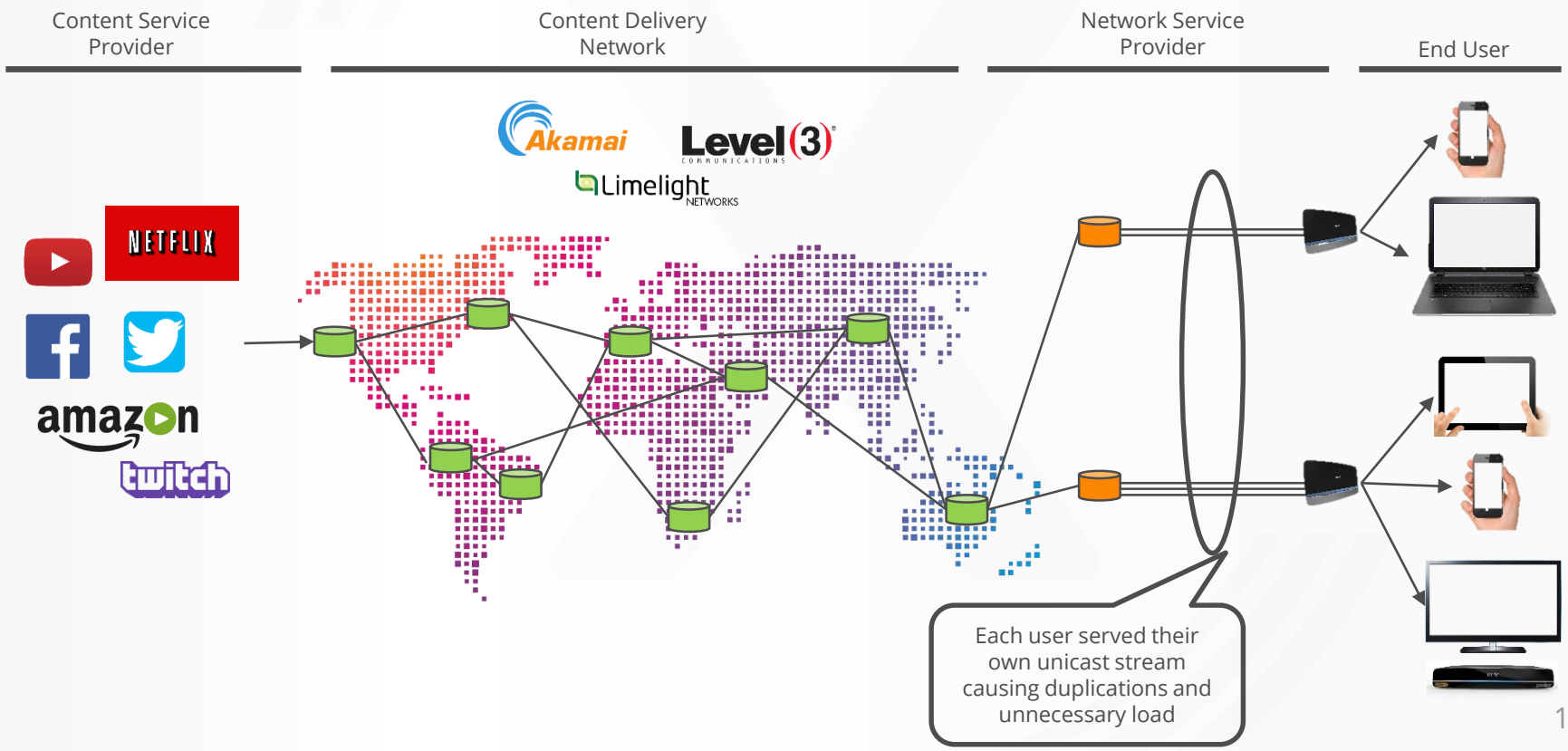


And VOD too…

- Appointment to view VoD has a similar profile to live and linear with a huge spike in demand when initially released
- Consumers want to watch together and engage in social media commentary and
- Traffic profile would suit carousel broadcast and/or push prepositioning



NSP needs capacity for many unicast streams



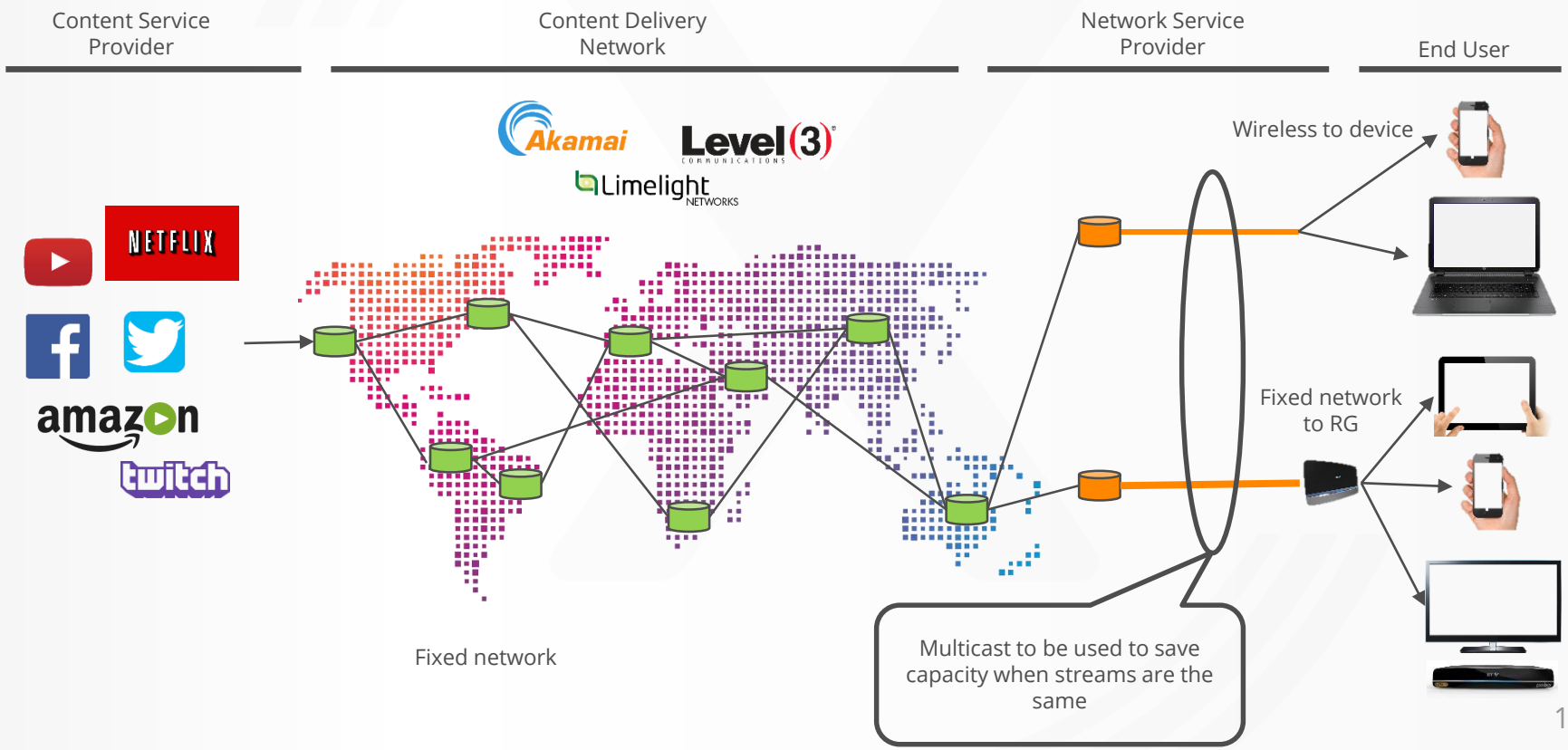
Observations

- Concurrent viewing of popular events drives traffic volumes
  - It doesn't just change *what* people are watching, it drives overall demand volumes
- This creates a capacity planning challenge
- Broadcast and multicast can help manage peaks and simplify capacity management

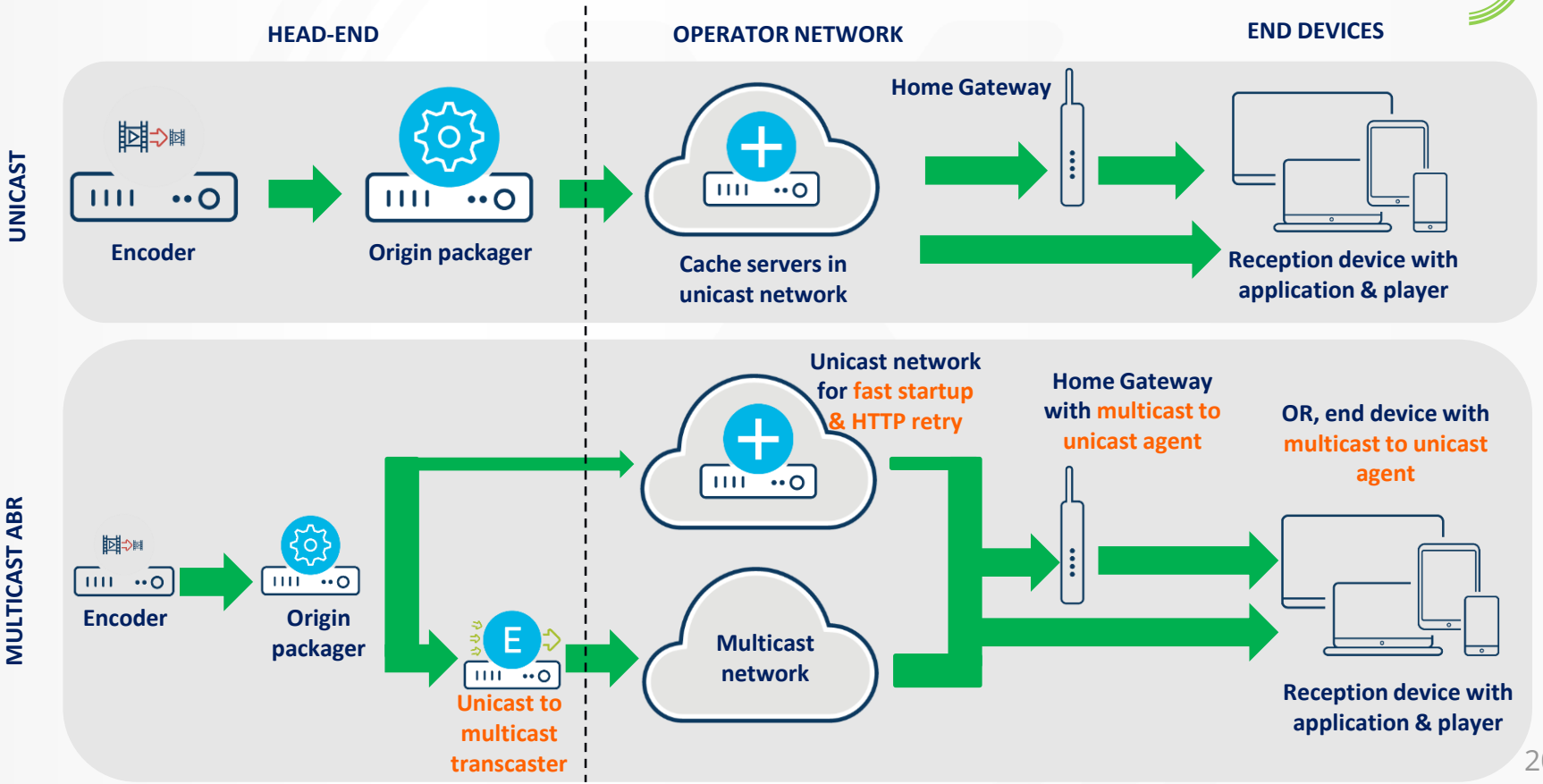
What’s the solution then?

The 5G-Xcast Content Delivery Framework

Best of both: CDN for global - dynamic selection of multicast at edge

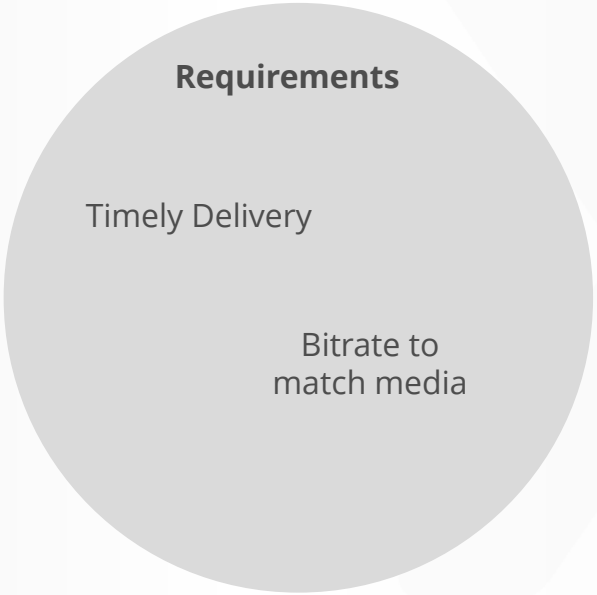


Unicast vs multicast setup



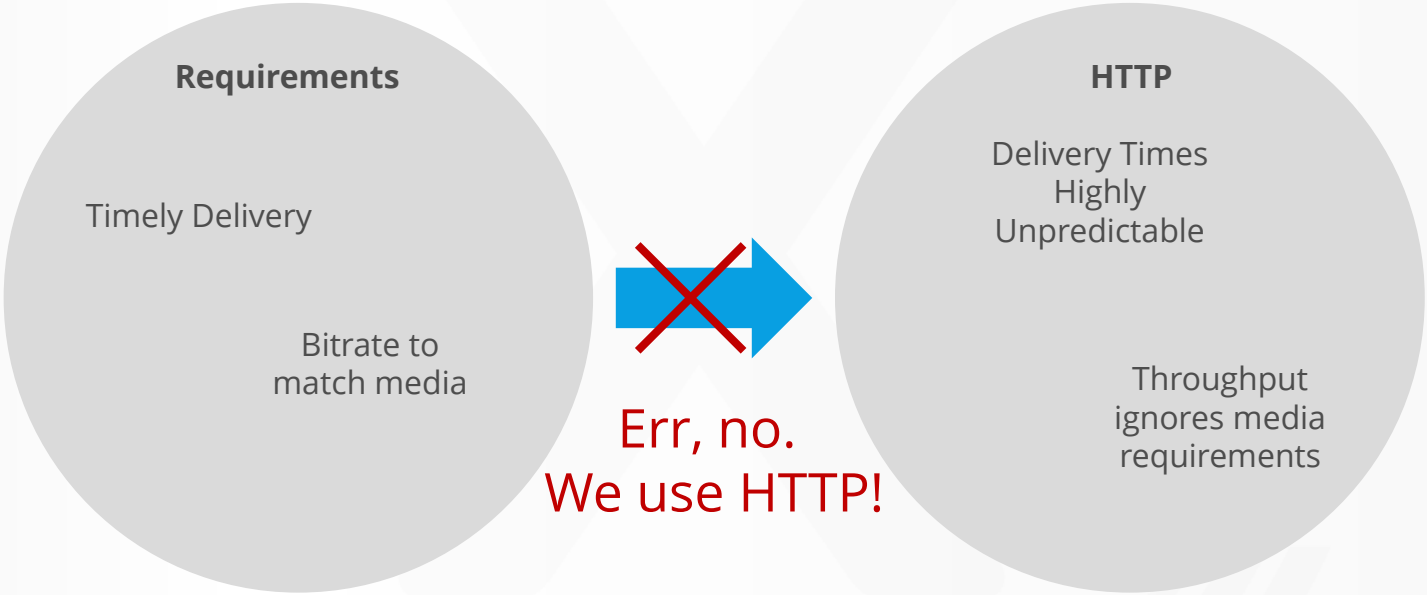
How should we go about this?
… how does the Internet work exactly?

For video streaming



So, we use UDP/RTP + network QoS?

For video streaming

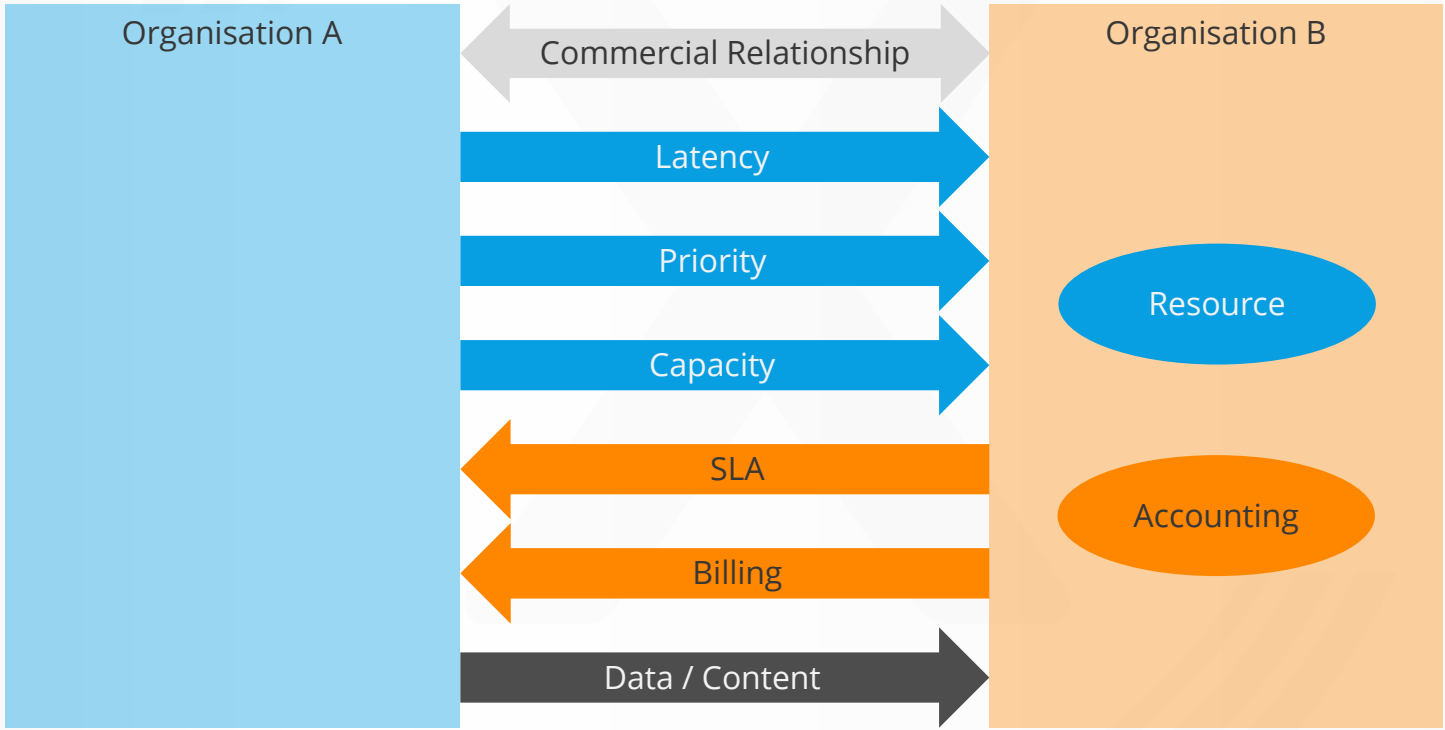


What went wrong?

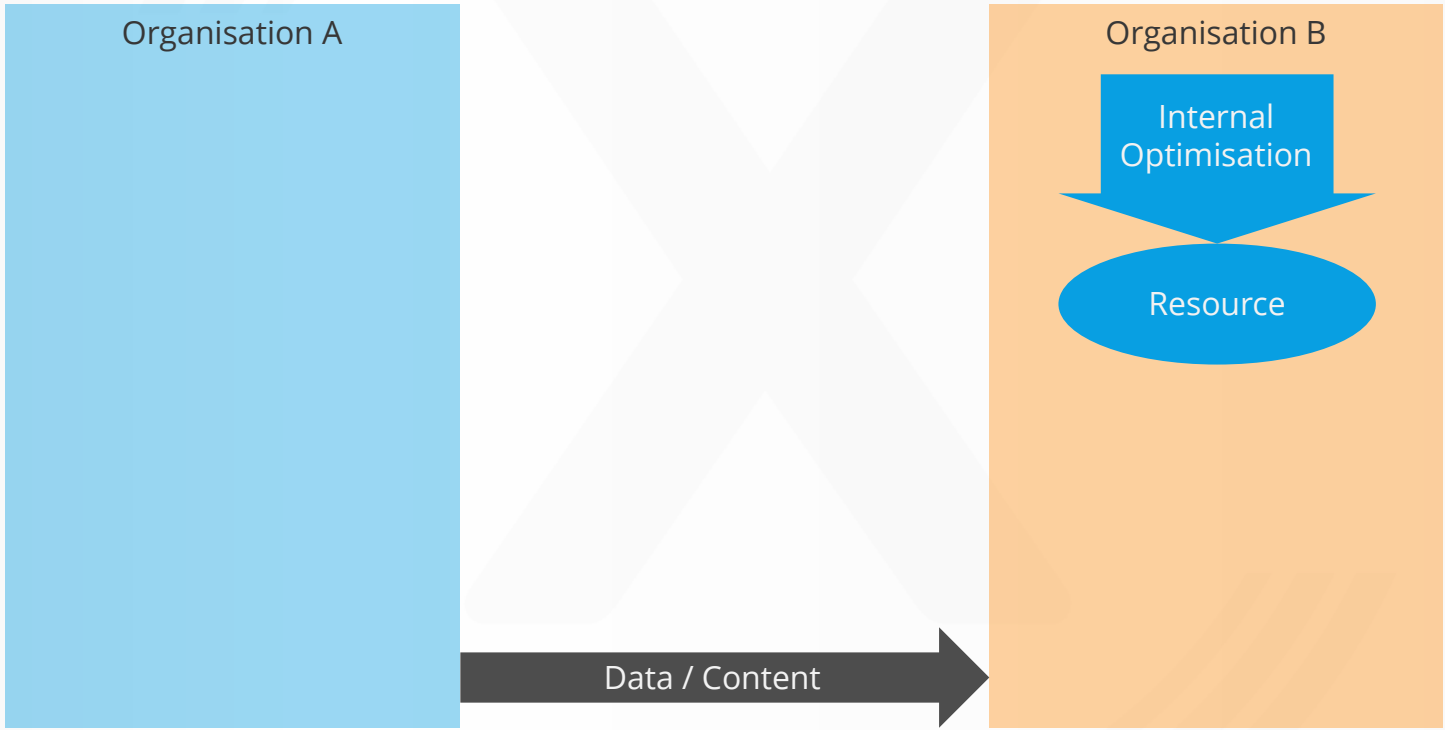
Global Platforms Use HTTP

- Generic technology is good
- Non-specialist commoditised servers
- Readily passes through firewalls
- Don’t require specialist software or licences

Cross-organisational resource reservation is challenging

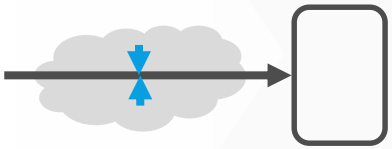
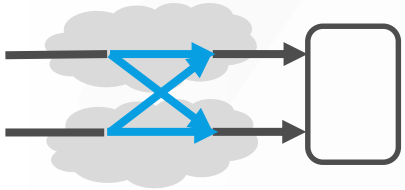
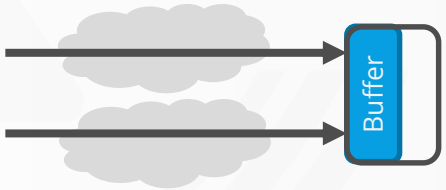


Prefer Autonomous Resource Allocation



Clever apps preferred over clever networks

…and avoid complex app<>network APIs

	Clever Network	Clever App
Throughput Variation	Guaranteed Bandwidth 	Adaptive Bitrate Streaming 
Network Handover	Complex Network Handover 	Streaming Buffer Management 

Lessons from HTTP's success

It is not at all obvious would be a one-size-fits all protocol. *HTTP is sub-optimal for everything, but we use it for just about everything.*

HTTP dominates because it really simplifies the interface between those using networks (CSPs) and the network operators. *Keeping this interface simple and generic is critical.*

We observe that 'value-added' features of the network are sometimes not successful as products. E.g. QoS and multicast. We believe that the value that they add is often more than offset by the complexity of their integration.

We need to ensure that the 5G-Xcast approach takes this into account and to achieve this, we adopt several principles.

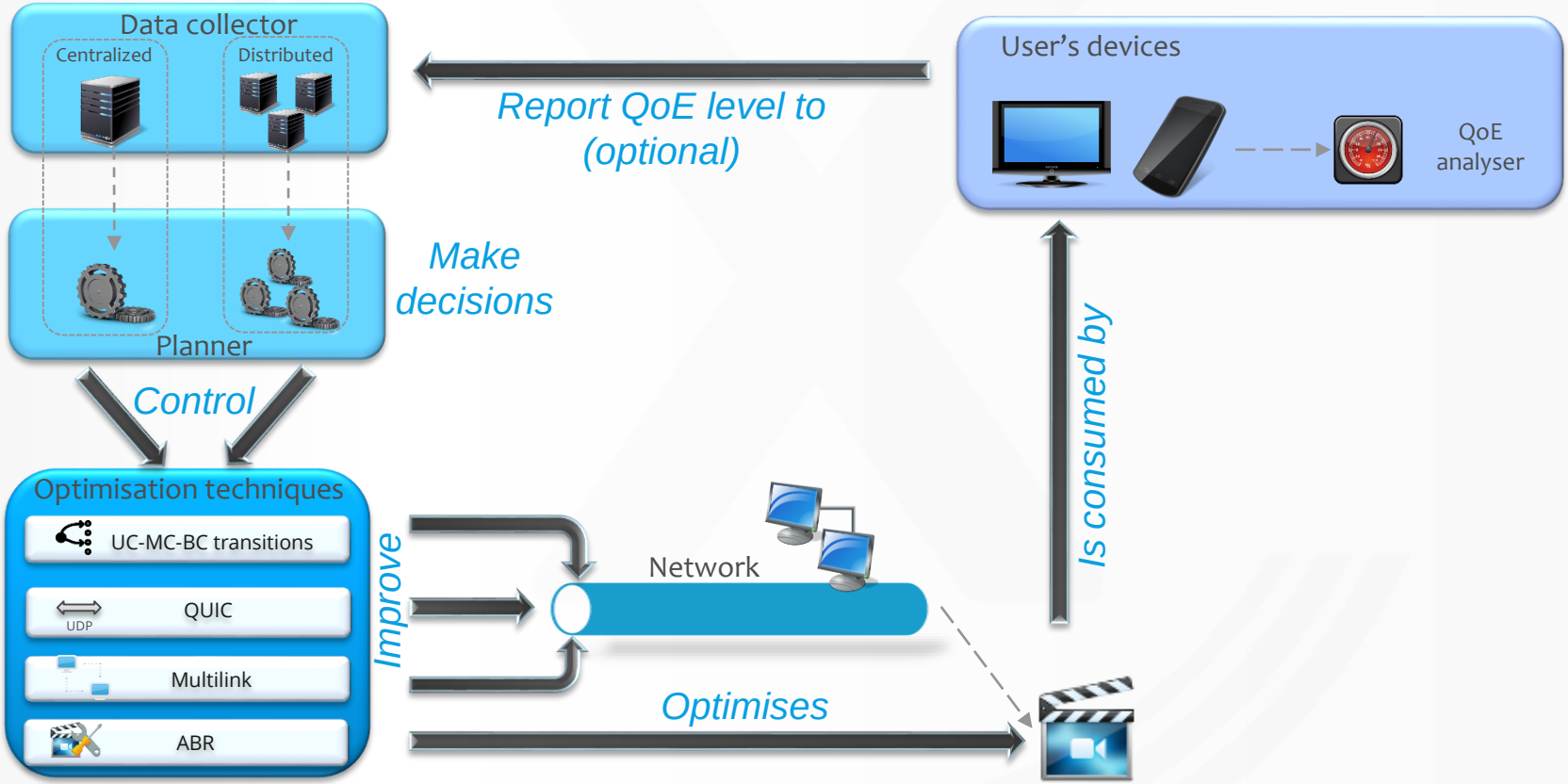
Content Delivery Framework Design Principles

- Combine CDN for global reach with multicast/broadcast for edge optimisation
- Multicast/broadcast as internal network optimisation, rather than service to be sold
- Servers and client applications work with unicast with standard Internet protocols (HTTP)
- Application layer intelligence preferred over network signalling

Extra-network intelligence

Network solutions are not always the right solution

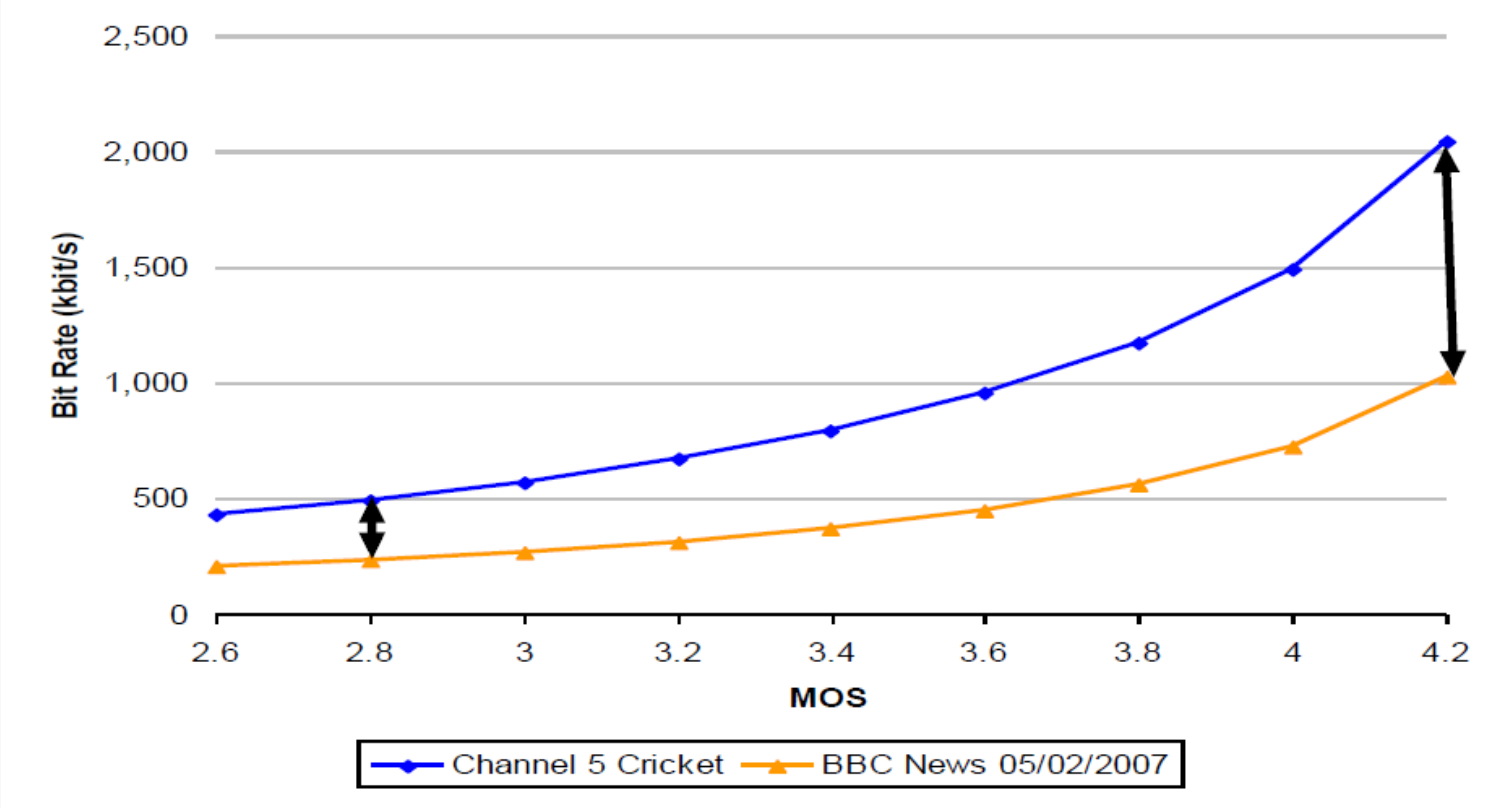
What can be done, without explicit network support to manage QoE?



Case study 1

Application layer QoE management for video streaming

What is the relationship between bitrate and quality?



Which is separable…

Separability means

$$bitrate_i = complexity_i . f(qual_i)$$

Now drive congestion response proportional to complexity

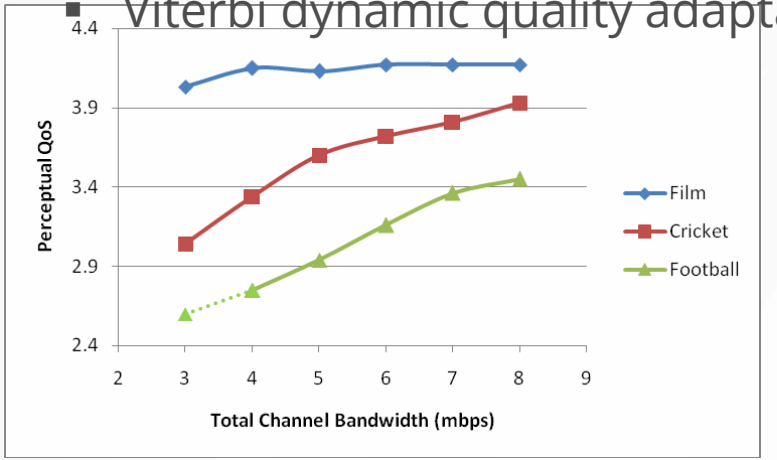
$$bitrate_i = B . \frac{complexity_i}{\sum complexity_j}$$

Quality equalises for all streams

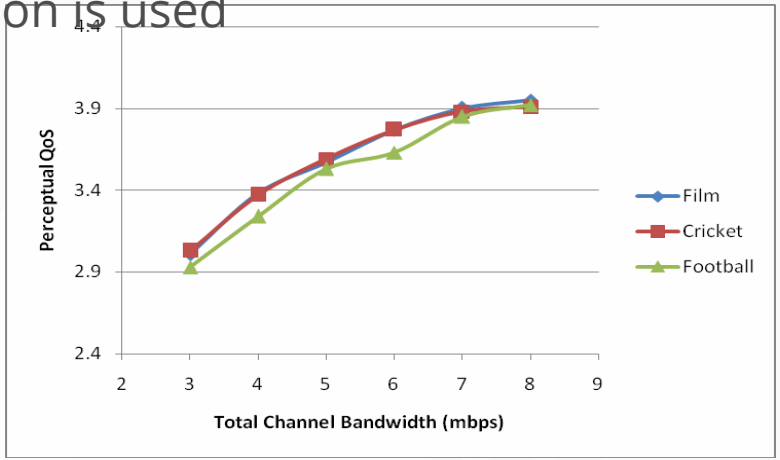
$$qual_i = f^{-1}\left(\frac{B}{\sum complexity_j}\right)$$

QoE management using TCP congestion response

- 3 video sessions were started at the same time
- Bottleneck link capacity is varied from 3 to 8 MBit/s
  - This is divided between the sessions by TCP and MulTCP
- Viterbi dynamic quality adaptation is used

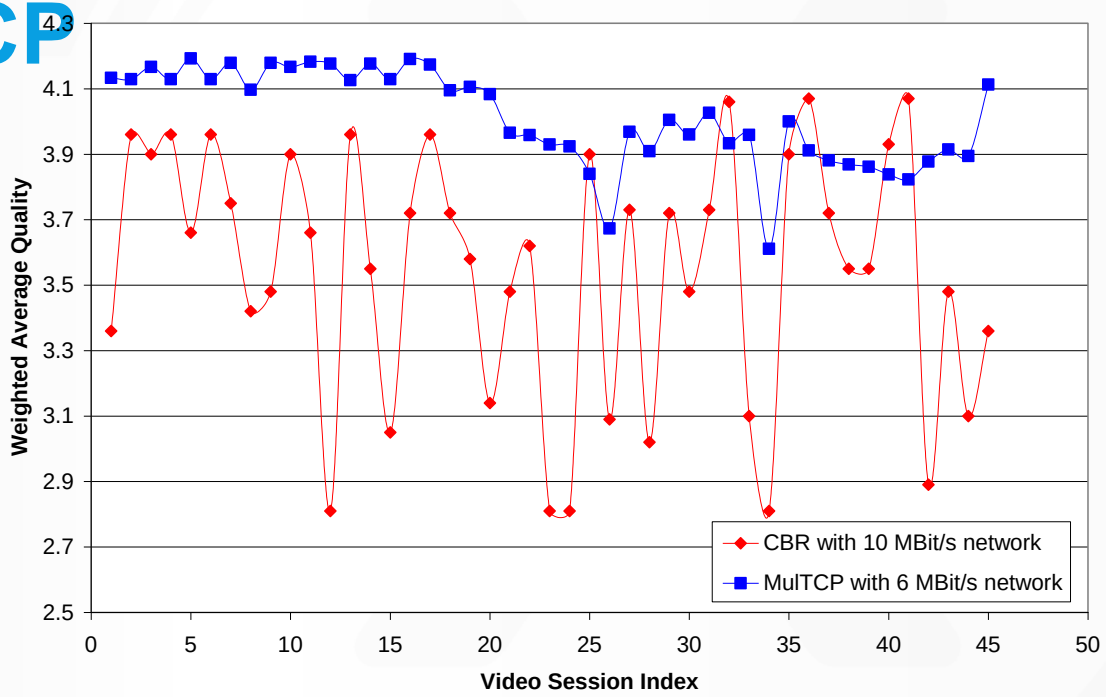


TCP
Each stream is delivered at different quality over the whole bit rate range



MulTCP
Each stream is delivered at the same quality over the whole bit rate range

Comparison of CBR and Viterbi over MulTCP

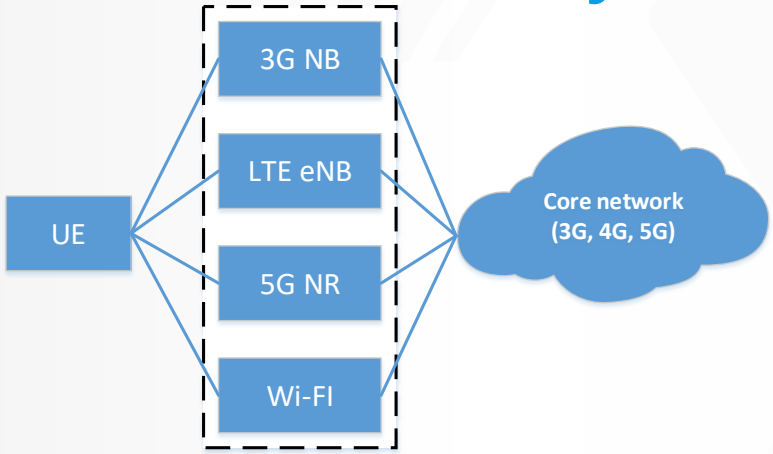


MulTCP and Viterbi give more consistent quality

Case study 2

Multilink technology to provide best user experience and seamless transitions

5G architecture with Multi-connectivity on different layers



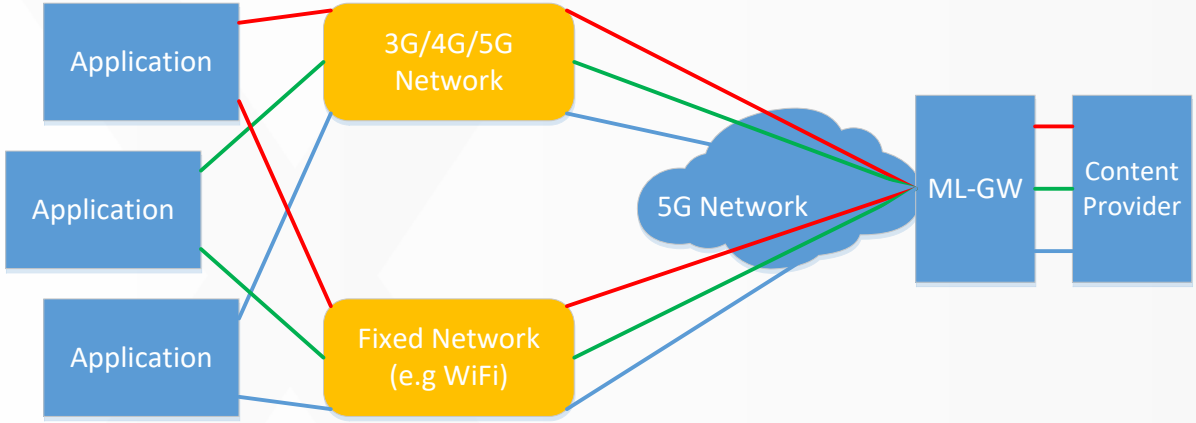
Aplication	Aplication	Aplication	Aplication
MPQUIC	MP-TCP	Bonding	
UDP / UDP	TCP / TCP	TCP/UDP / TCP/UDP	TCP/UDP
IP / IP	IP / IP	IP / IP	IP
PDCP / PDCP	PDCP / PDCP	PDCP / PDCP	PDCP
RLC / RLC	RLC / RLC	RLC / RLC	RLC / RLC
MAC / MAC	MAC / MAC	MAC / MAC	MAC / MAC
PHY / PHY	PHY / PHY	PHY / PHY	PHY / PHY

Multi-connectivity (MC) of single user terminal to multiple radio access points is a 5G key enabler in order to satisfy the demanding requirements on 5G mobile networks. Multi-connectivity supports simultaneous connectivity and aggregation across different technologies such as 5G, LTE, and unlicensed technologies such as IEEE 802.11 (Wi-Fi)

Multilink approach for the content delivery

Multilink attractive for:

- ✓ Huge file transfer;
- ✓ High/very high definition video streaming;
- ✓ Object based content delivery.



The content transmitted from the ML-GW down to the viewing device is split or duplicated over available links which are possibly from different operators, or uses different technologies or IP routes according to their temporal performance. The decision whether to split or to duplicate depends on the desirable gains in throughput, ancillary information and reliability, and a function of the link conditions. The content is then reassembled at the viewing device (with eventual duplicates removed) as a coherent data stream ready for viewing. The content itself is not manipulated which means that the delivery is completely agnostic to the content.

Bonding QoE in WP5

Use cases:

- ✓ On the edge of the broadcast/multicast areas
- ✓ “Heavy” content delivery
- ✓ Object based content delivery

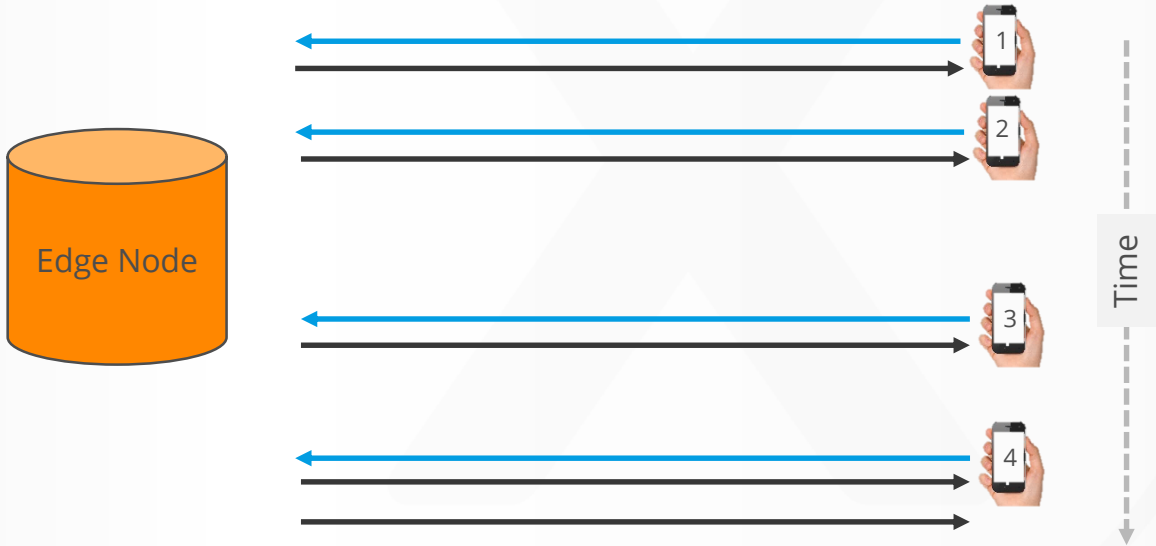
QoE:

- ✓ Seamless transition between different service areas
- ✓ Reliability and availability of the service
- ✓ Mobility support
- ✓ Overall bandwidth

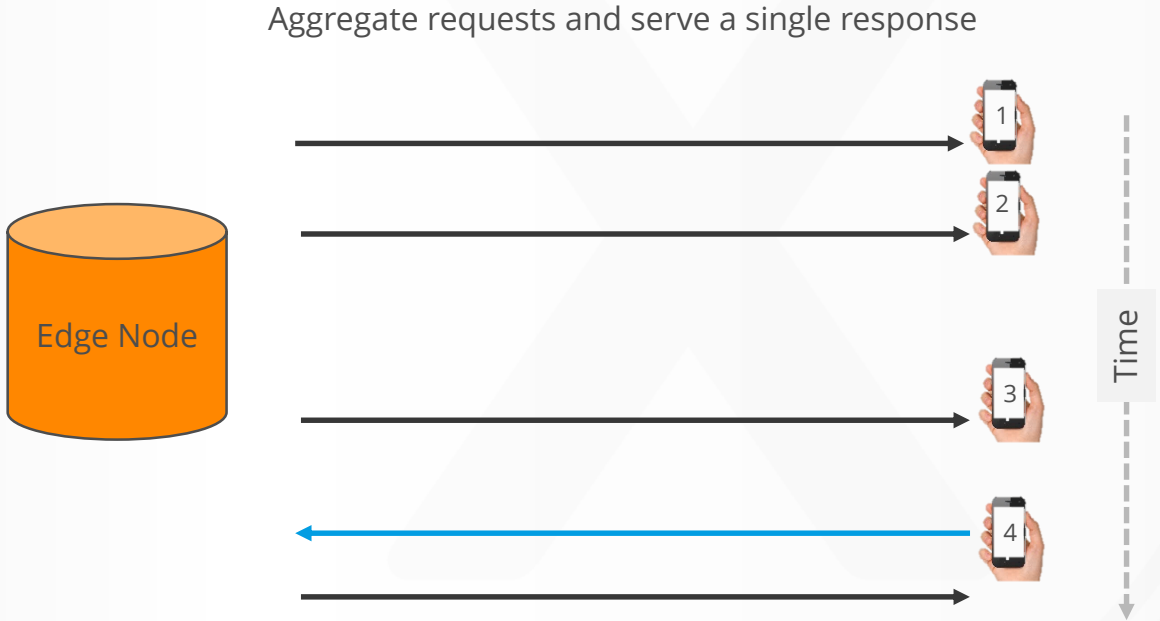
Unified Content Delivery - Challenges

Synchronous Delivery of Asynchronous requests

Independent, asynchronous HTTP requests usually responded to individually

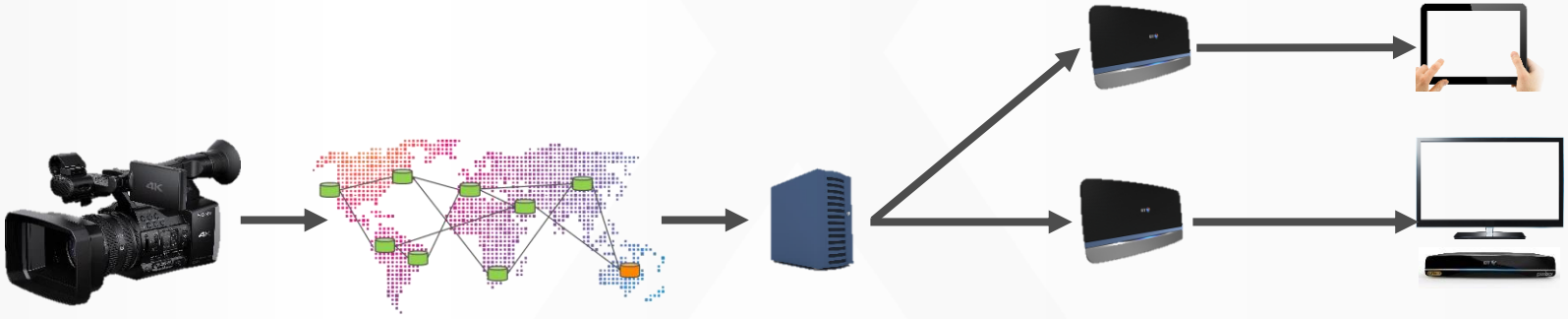


Synchronous Delivery of Asynchronous requests



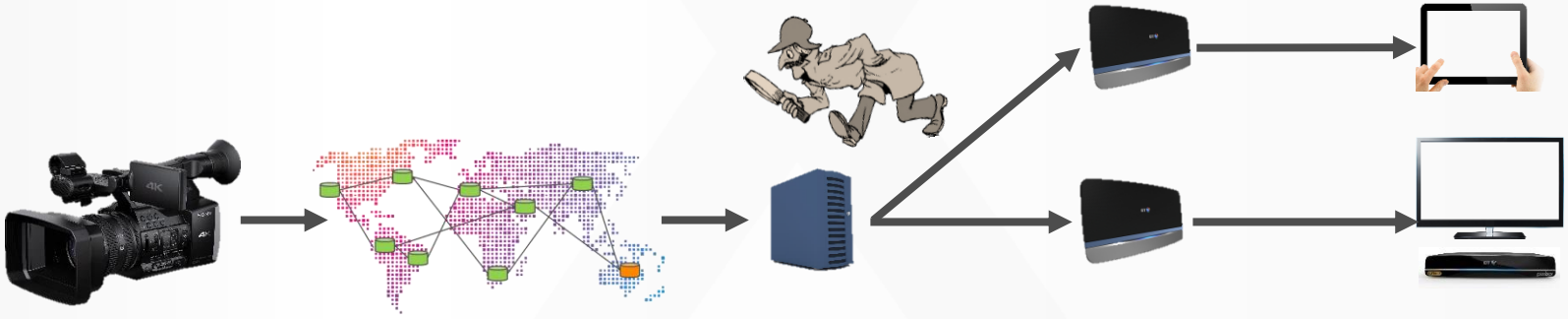
Quality control

- How do we keep end to end delay low enough for live?
- How do we make it work with ABR?



Security and Trust

- How do will it work when the content and/or transport is encrypted?
- Need to avoid having visibility of content internals



Relevant standards activity

Significant update to Multicast/Broadcast operation

IP Multicast Adaptive Bitrate

Developing Multicast ABR standard

Relevant IP standards (e.g. media encapsulation, HTTP(S)/QUIC over multicast etc.)

WP5 Plan and status

- **Done…**
  - Architectural Vision
  - Content Delivery Framework – Initial version
  - Application layer intelligence – Initial version
- **Doing or about to do…**
  - Content Delivery Framework - Final version (Aug 18)
  - Application layer intelligence - Final version (Nov 18)
  - PoCs (Aug 18/Feb 19)

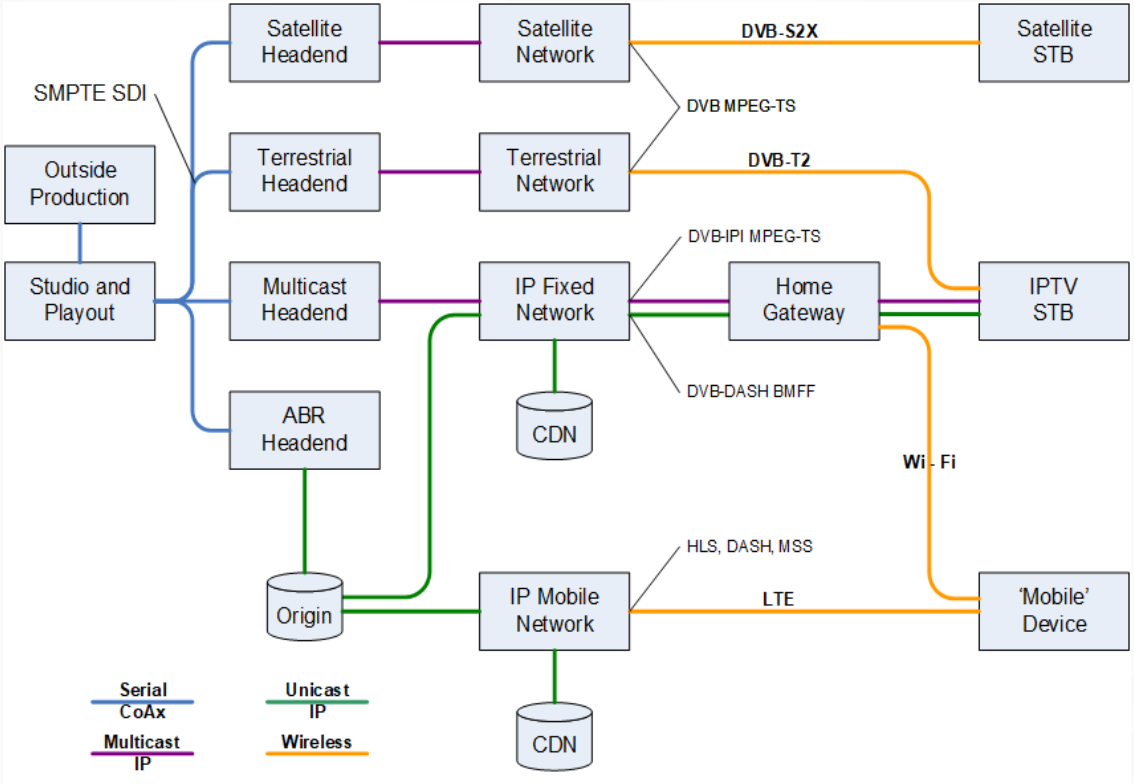
The key takeaways

- Our goal is to combine global CDNs with multicast and broadcast at the edge of the network to get the best of both worlds.
- To make multicast an easy capability to use, it should be possible to treat them as an internal optimisation capability, rather than a service to be sold. We believe this will remove a significant barrier to multicast and broadcast deployment.
- We should beware trying to “add value” to the network by over-complicating its APIs.

Where does this lead us?

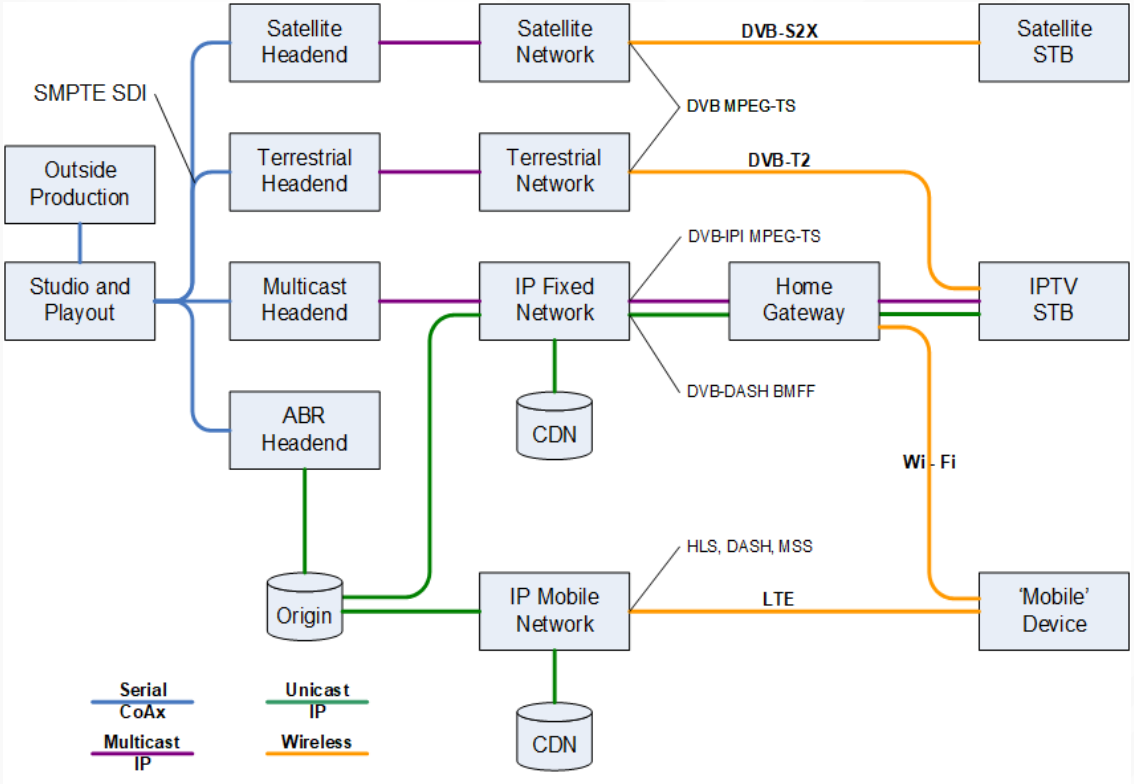
Recalling what you saw

A view of today



A view of today

Multiple technologies
multiple layers
separate distributions

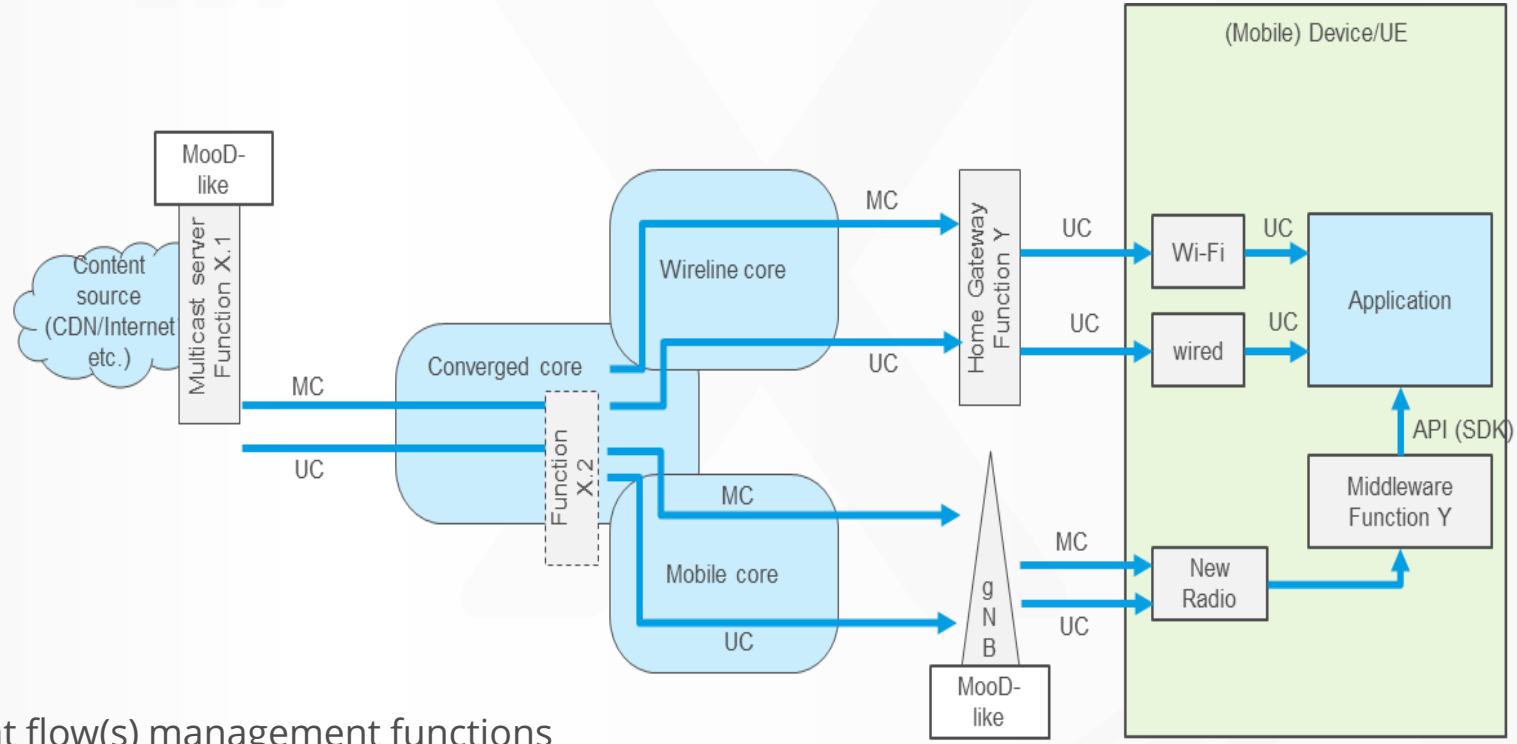


SD MPEG2 Interlaced
HD H.264 Interlaced
MPEG2-TS
DVB-CSS

SD MPEG2 Interlaced
HD H.264 Interlaced
UHD HEVC Progressive
MPEG2-TS
DASH and HLS
DVB-AES

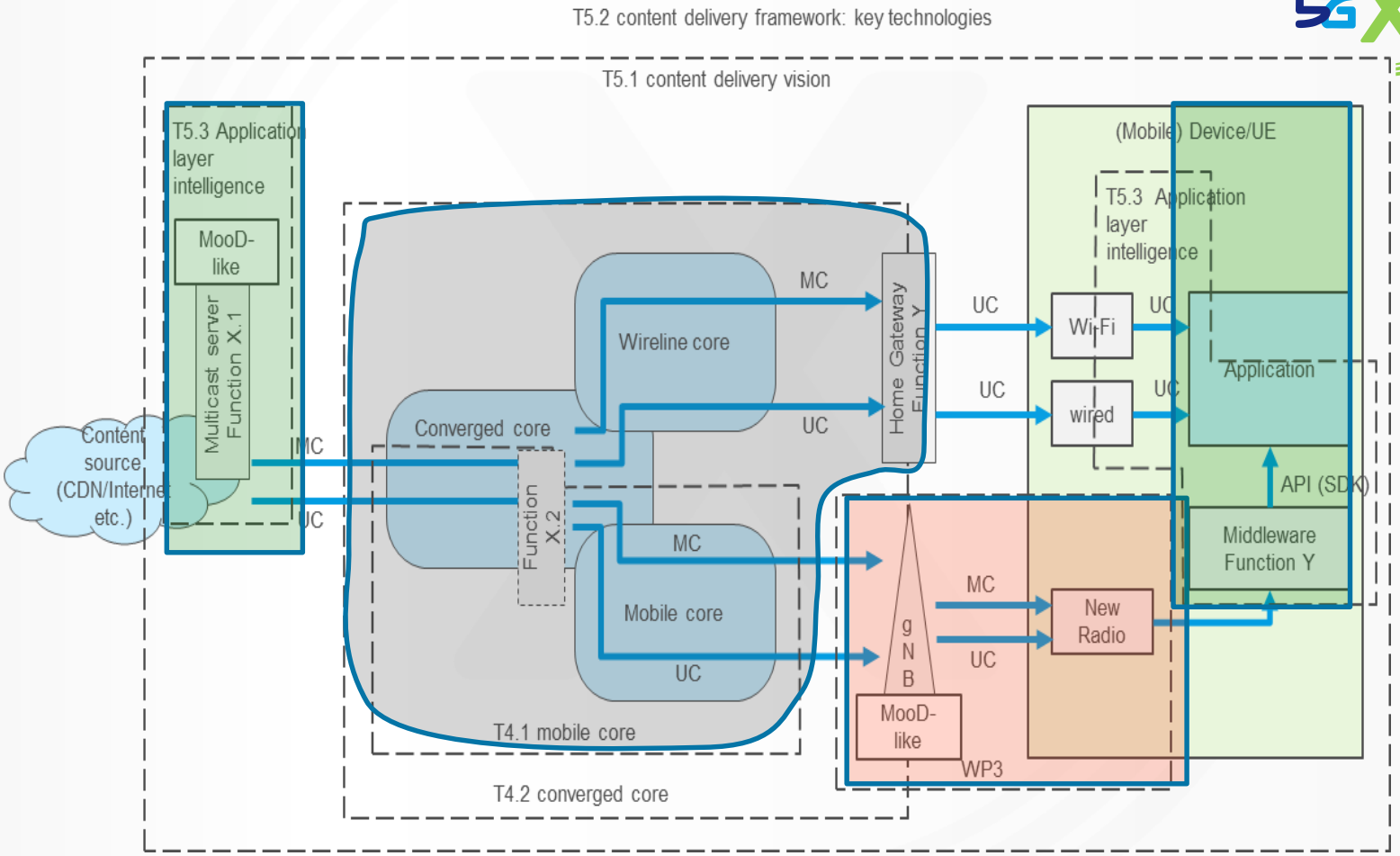
Multiple resolutions
Progressive video
H.264, HEVC
ISOBMFF
DASH, HLS and MSS
CENC

The 5G-Xcast vision



X, Y:
Intelligent flow(s) management functions

The 5G-Xcast vision



Recall: What do we pursue?

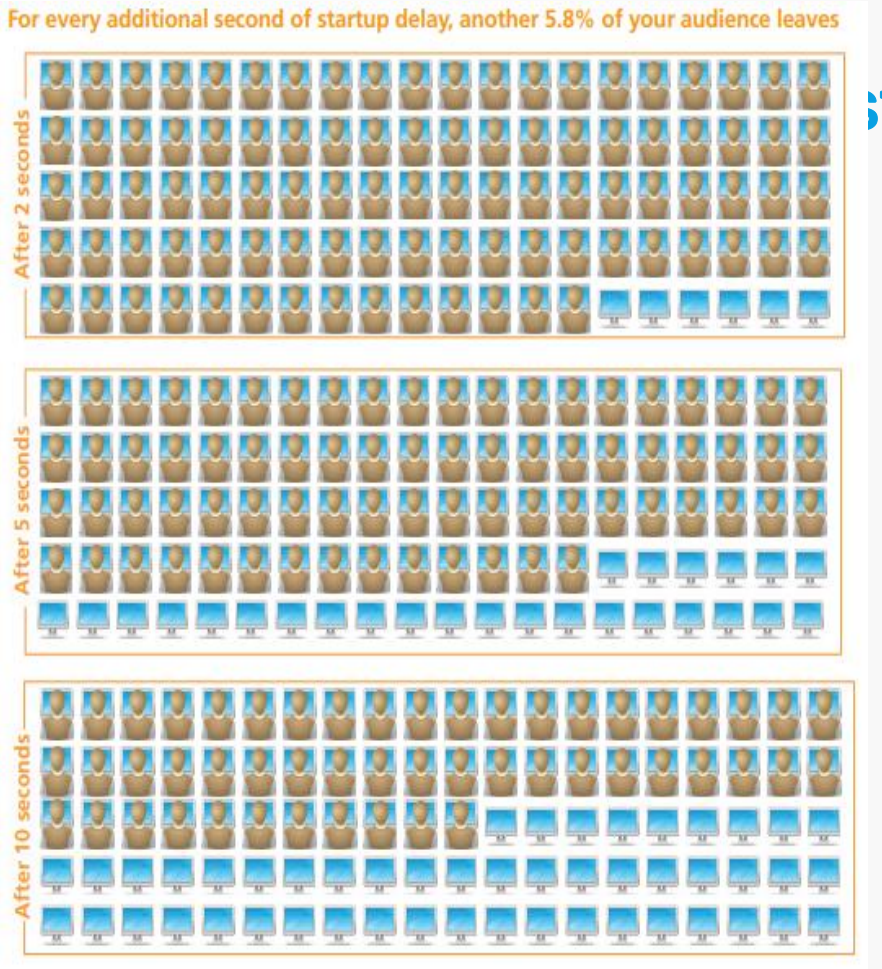
1. Better service
2. More economic service

In

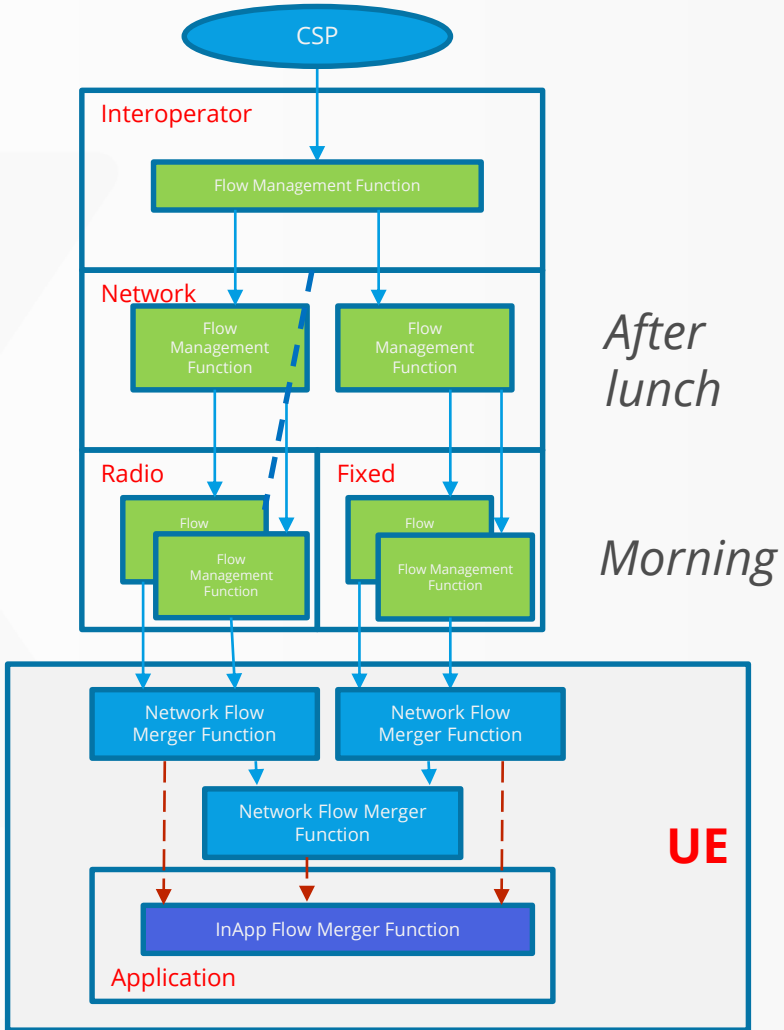
- More network types
- More devices
- Flexible business cases
- Flexible user cases

Why do we need QoE?

- Audiences are very dependent on response time
  - Gets' worse with increasing quality networks/video streams



Flows in a converged network, single or dual operators



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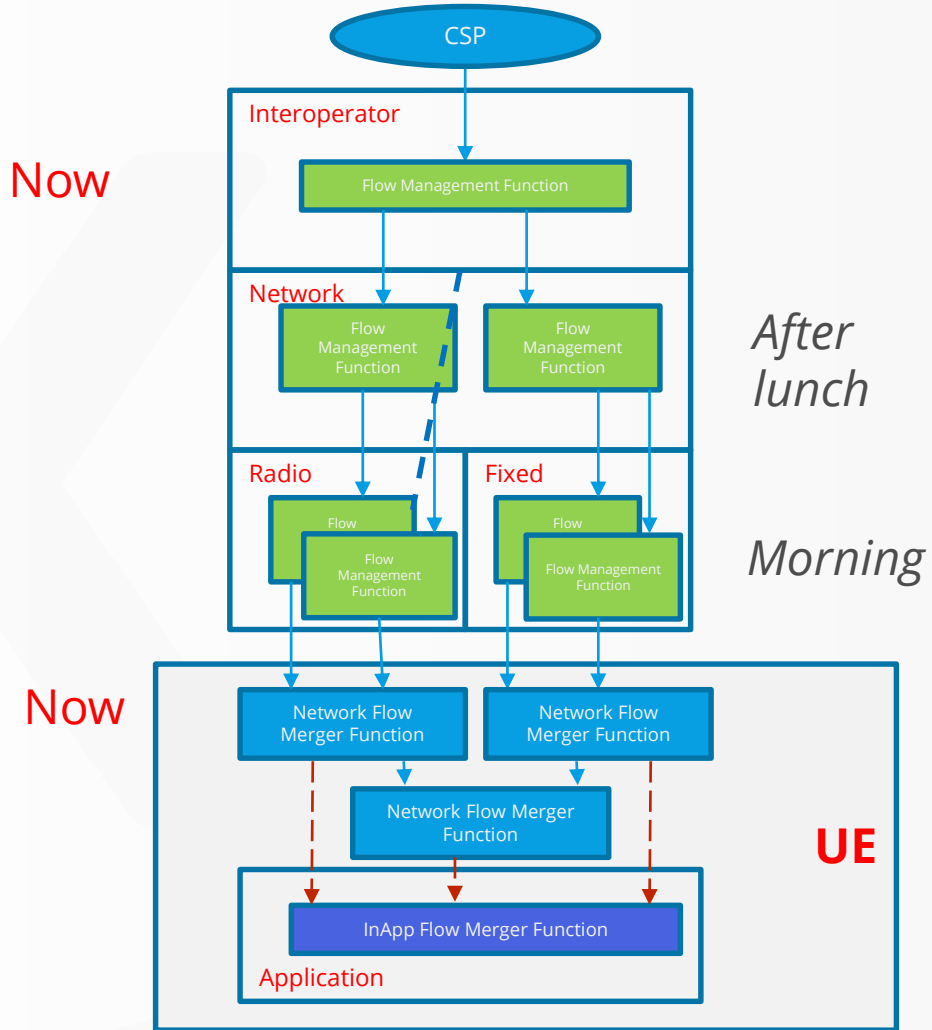
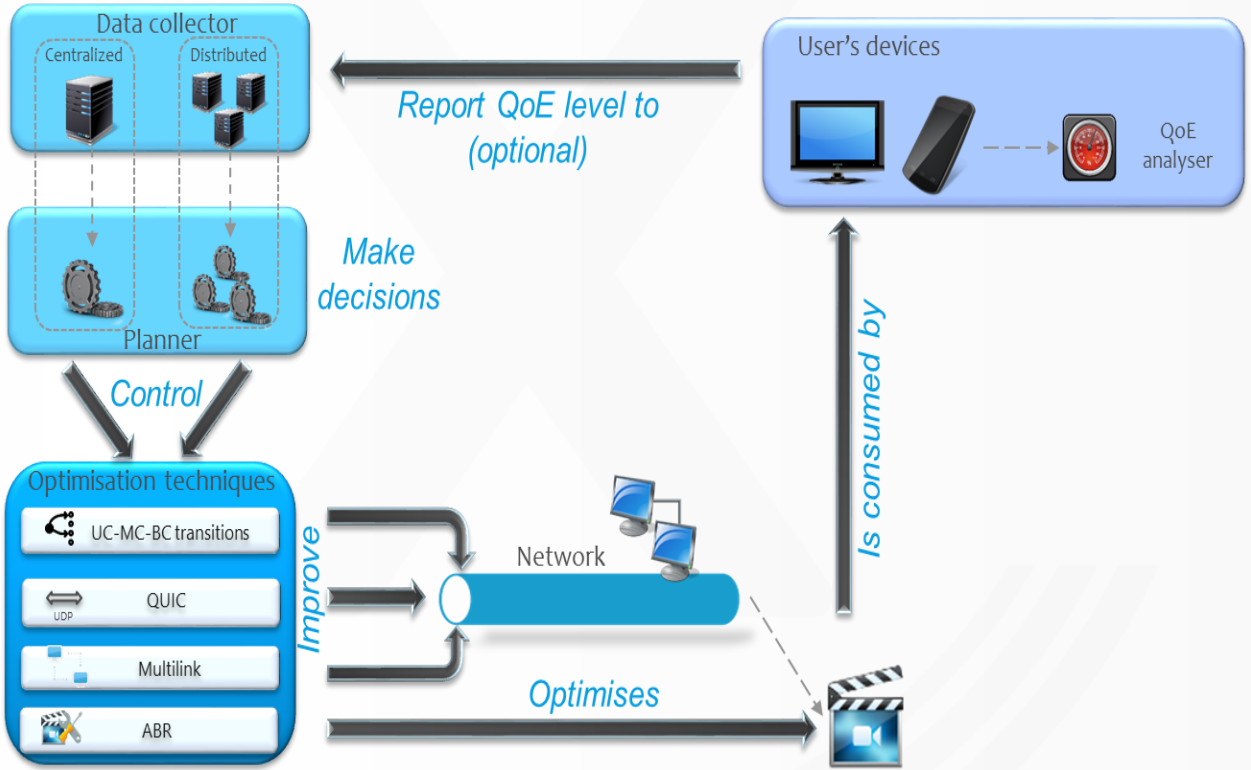
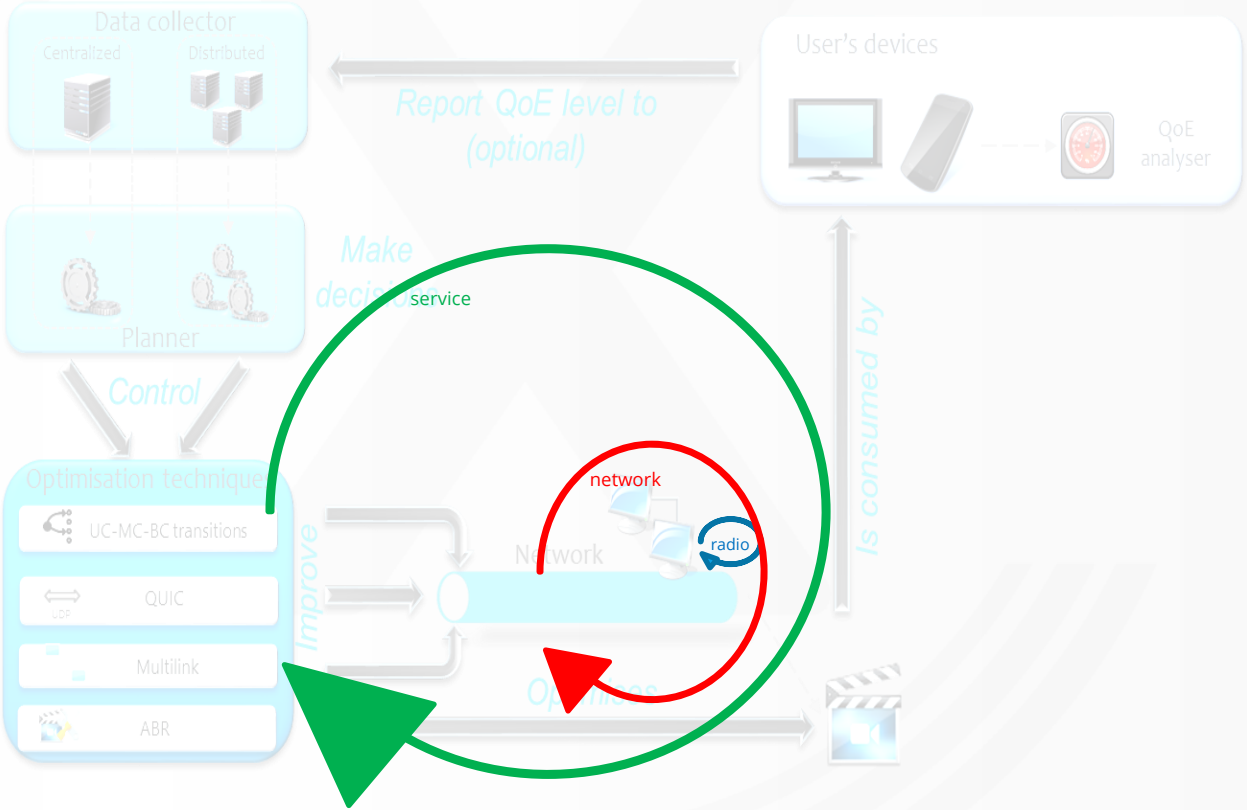


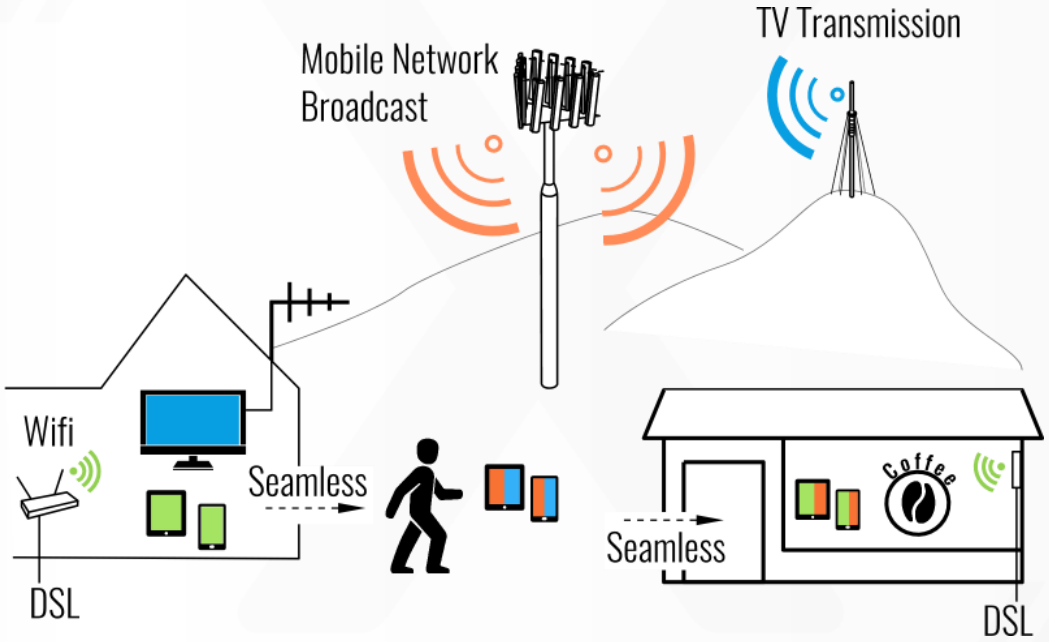
Overall QoE loop (simplified)



Overall QoE loop (not so simplified)



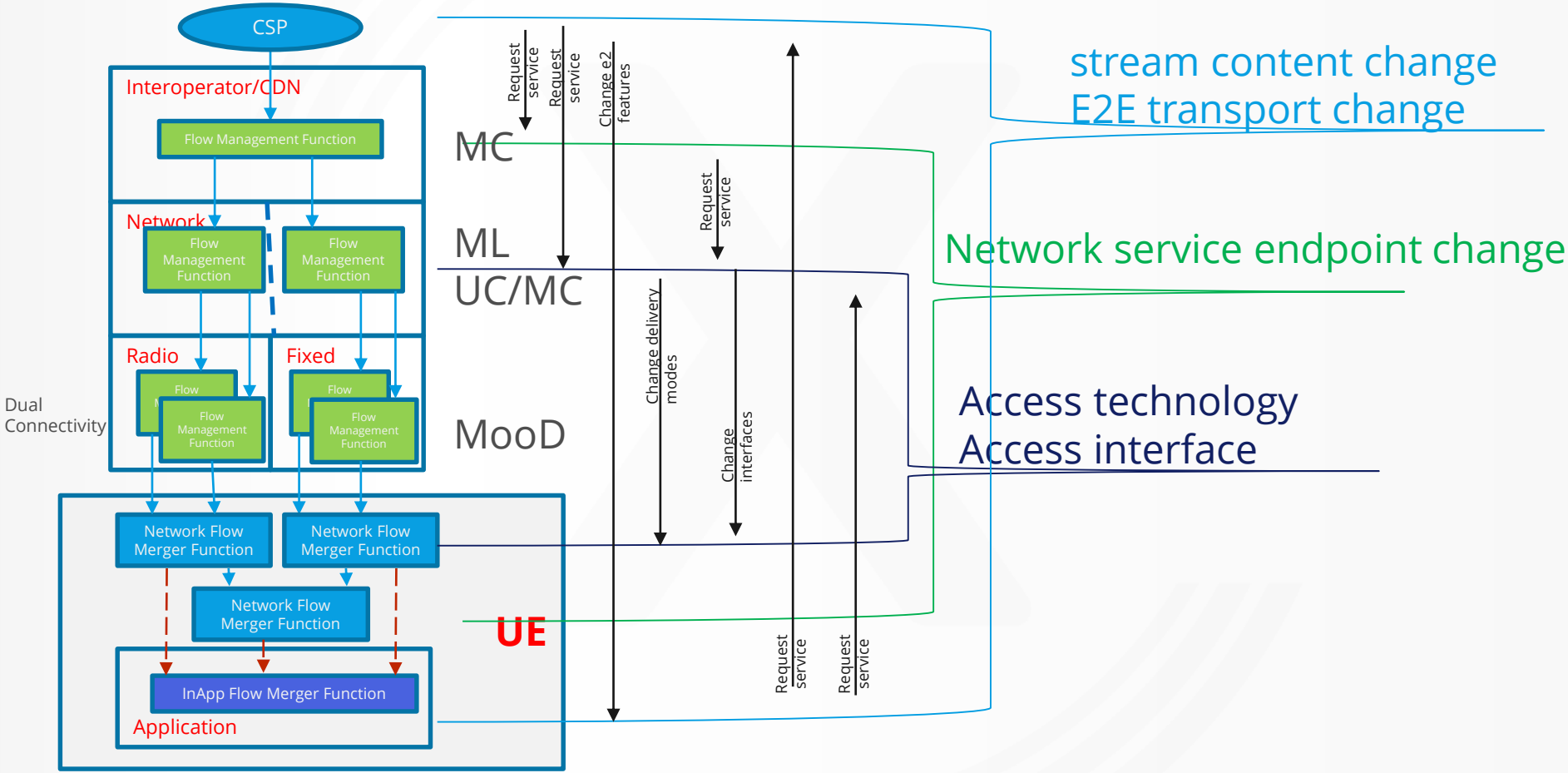
Why do we need all this?
Use case M&E 1 – Hybrid broadcast service



Taken from the document "Deliverabl eD2.1 Definition of Use Cases, Requirements and KPIs"

BundlesLab Kft
We Do Wireless

Flows in a converged network, single or dual operators: CDN < CSP



Multiple techniques are required

- **Multiple entities controlling:**
  - Content service provider
  - Network (core) service provider
  - Network (RAN optimization)
  - User
- **Multiple techniques**
  - Multilink variations
    - Dual connectivity/dual (IP) links/multiple (L4+) sessions
  - MooD
  - mABR
  - CDN

What have we achieved?

- **An integrated view on the content distribution problem**
  - For converged networks
  - With multicast/broadcast concepts integrated
- **An integrated model on the QoE optimization**
  - For converged networks
  - With multiple actors

But lots of work still ahead!

Any Questions ?