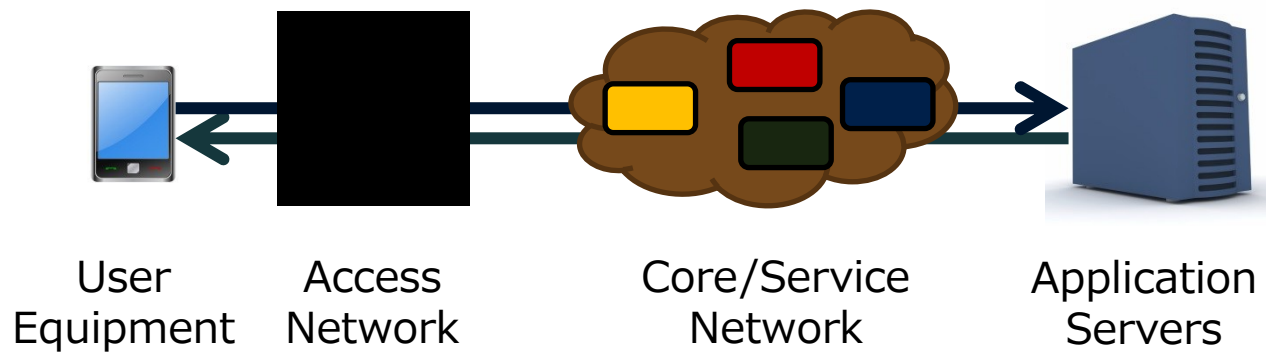# ICN & 5G

Dr.-Ing. Dirk Kutscher
Chief Researcher Networking
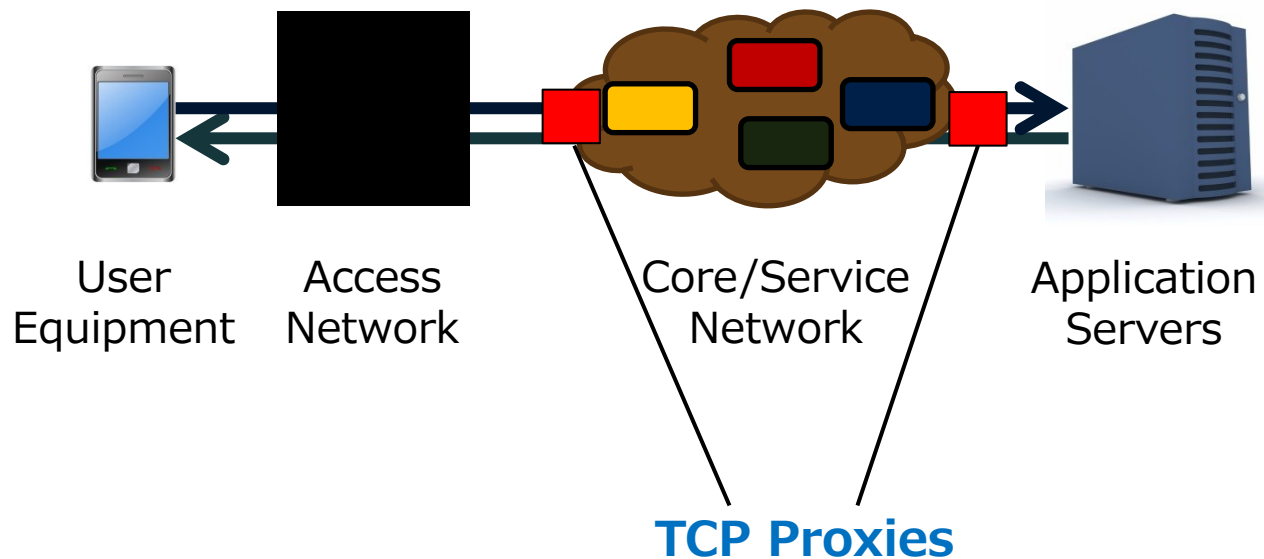
NEC Laboratories Europe
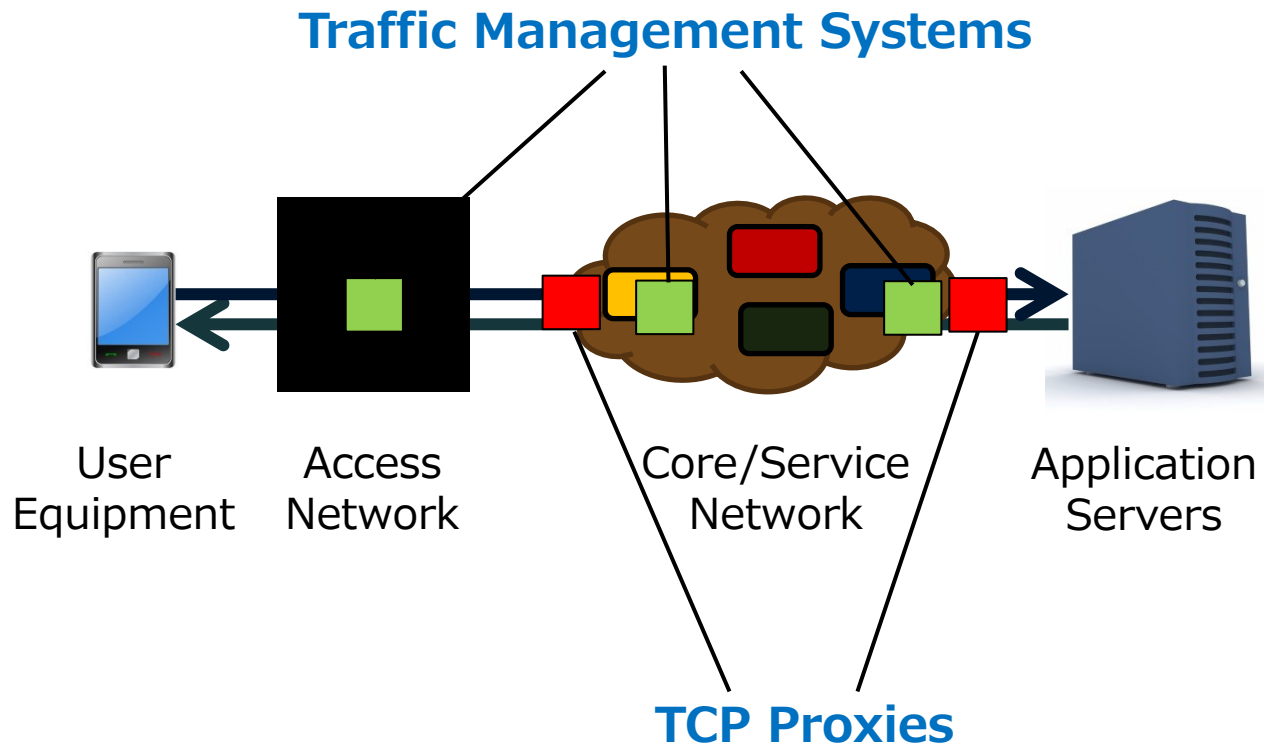
User Equipment   Access Network   Core/Service Network   Application Servers

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User Equipment — Access Network — Core/Service Network — Application Servers

TCP Proxies

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Traffic Management Systems

TCP Proxies

User Equipment

Access Network

Core/Service Network

Application Servers

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Application (Video) Optimizers

Traffic Management Systems

User Equipment

Access Network

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TCP Proxies

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Application (Video) Optimizers

Traffic Management Systems

User Equipment | Access Network | Core/Service Network | Application Servers

Mobile Throughput Guidance

TCP Proxies

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Motivation

TCP proxies
- Lack of AQM and ECN deployment
- Sub-optimal performance: e2e control loop over heterogenous networks

Traffic management systems
- Lack of AQM and ECN deployment
- Lack of incentives for adaptive applications
- Perceived need for policing applications depending on access network conditions
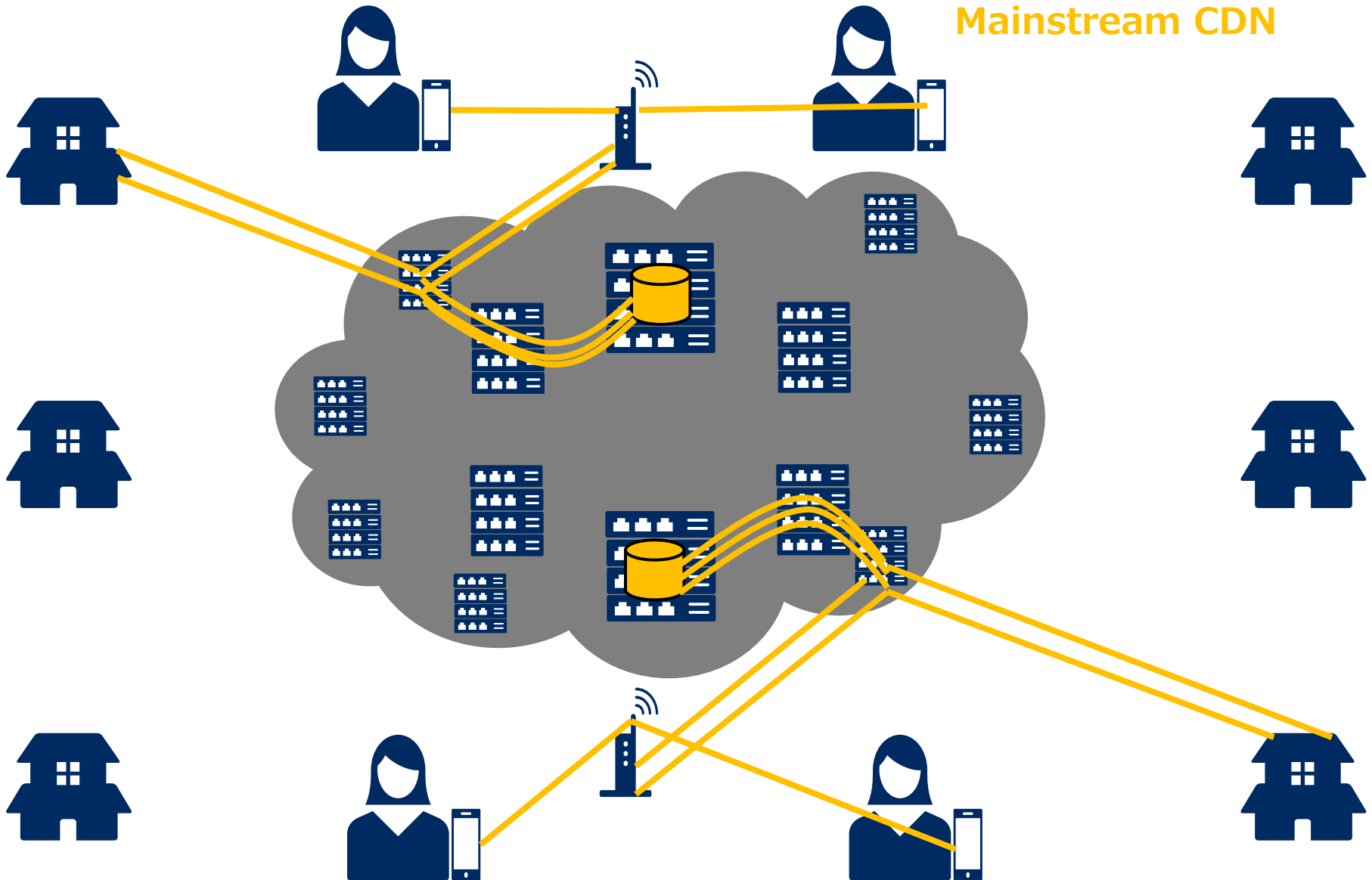
Application optimizers
- Operator resource conservation and performance concerns
- Access to user data for analytics

Mobile Throughput Guidance
- All of the above

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Mainstream CDN

Mainstream CDN

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Mainstream CDN
VOD CDN
Social Network CDN

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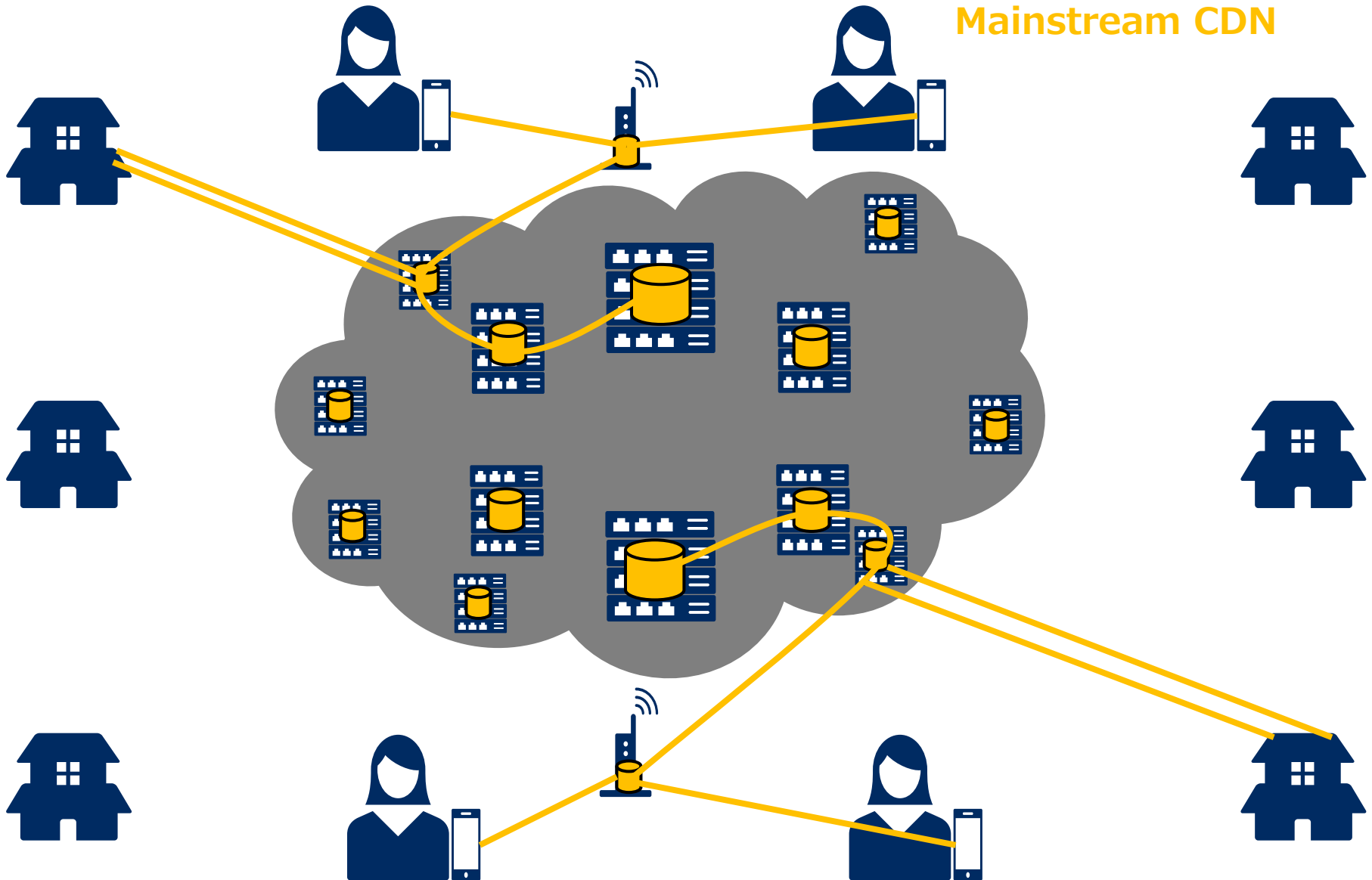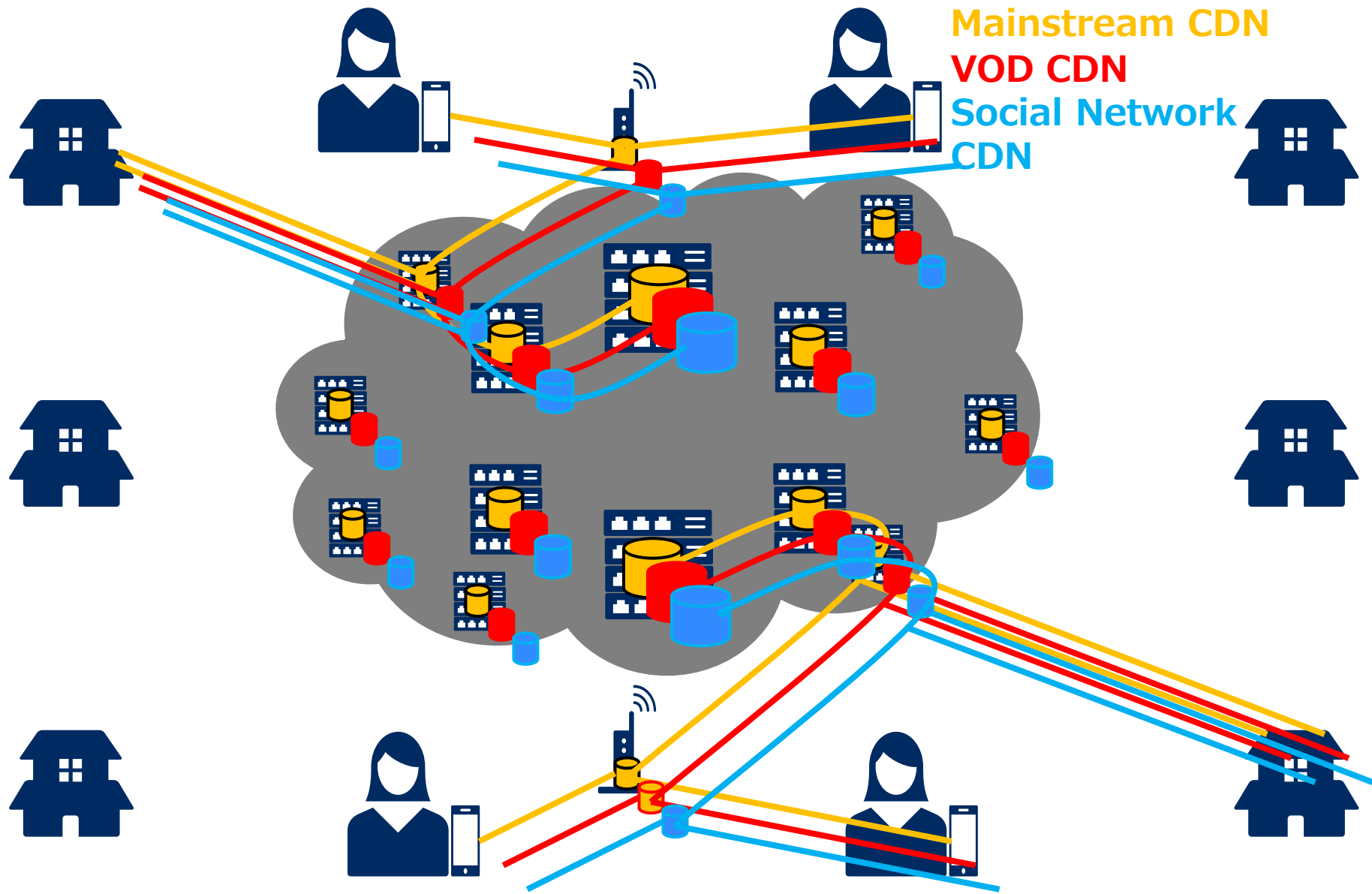
Mobile Throughput Guidance
- All of the above

CDN
- Network offloading
- QoE improvement through latency reduction
- Moving data and computation closer to the edge
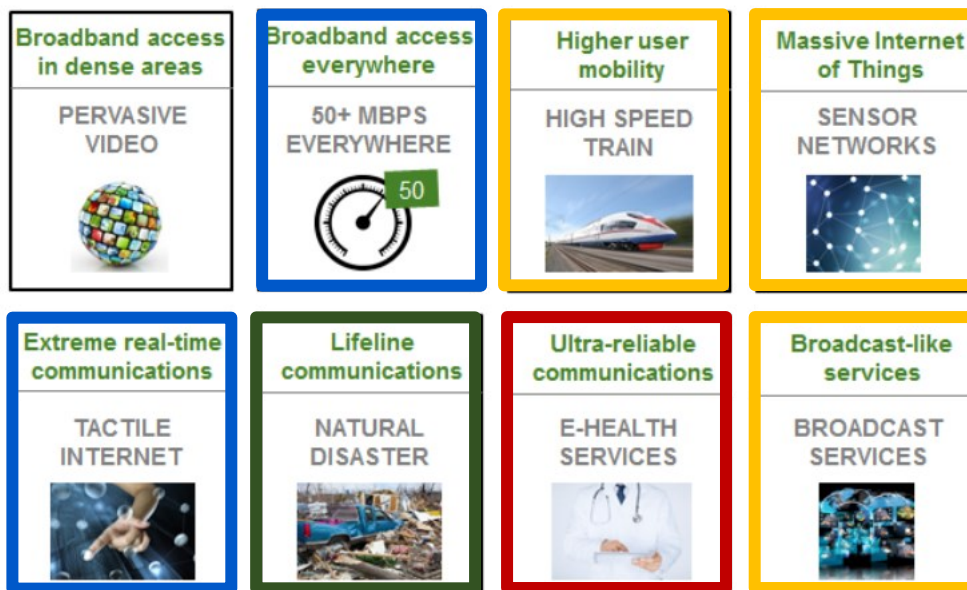- Application-layer request/content routing policies

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Observations

Significant infrastructure required to make things „only work" today
- Overcoming TCP e2e performance issues in heterogenous networks

Caching deemed important for scalable, low-latency data access
- Deployment likely going to increase in next generation networks (edge caching)
- General CDN and application-specific CDN deployments (new OTT services)
- How many different CDN-like overlays will you have to run as an ISP?

What does that mean for 5G networks?

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NGMN 5G Use Cases

**Low latency,
local loop communication**

**Optimized Forwarding
for Heterogenous Access**

**Broadband access
in dense areas**

PERVASIVE
VIDEO

**Broadband access
everywhere**

50+ MBPS
EVERYWHERE

50

**Higher user
mobility**

HIGH SPEED
TRAIN

**Massive Internet
of Things**

SENSOR
NETWORKS

**Extreme real-time
communications**

TACTILE
INTERNET

**Lifeline
communications**

NATURAL
DISASTER

**Ultra-reliable
communications**

E-HEALTH
SERVICES

**Broadcast-like
services**

BROADCAST
SERVICES

**Decentralized
Communication**

**Security,
User Privacy**

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**Security,
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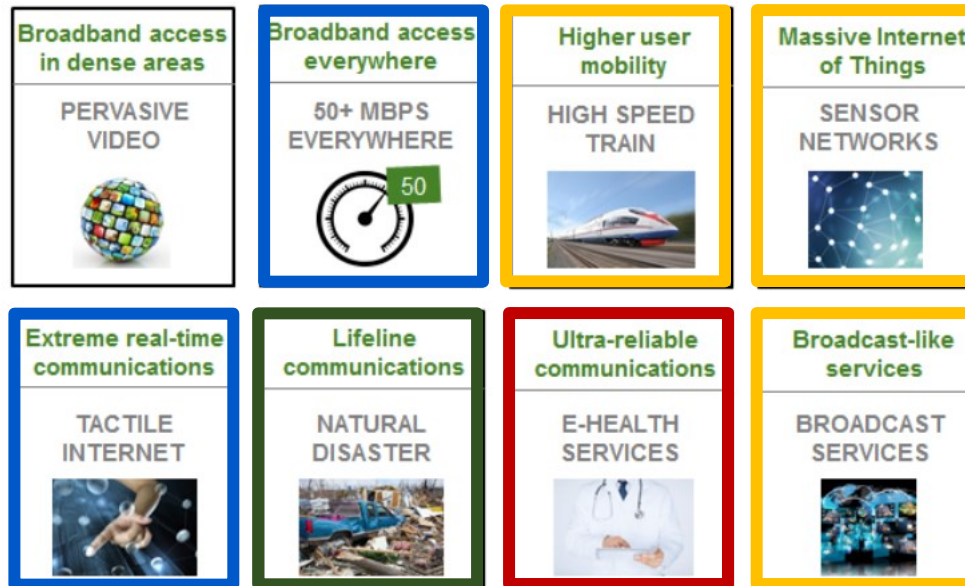
HTTP/2 is here to stay

Connection-based encryption on transport layer (TLS)

- Encrypt connection (and authenticate endpoints)
- Encrypted channel for all communication

De-facto ubiquitous (client implementations…)

No (easy) way for traffic management (based on flow/application information)

Major concerns with network operators

- See recent GSMA/IAB workshop on Managing Radio Networks in an Encrypted World (MaRNEW)
- Many of the previously mentioned optimization become difficult/expensive/impossible

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TLS and Future Deep CDN

CDN and TLS

- CDN nodes maintain certificates on keying material on behalf of publishers
- Managing those certificates/keys is an important function of any CDN
- Protecting those certificates/keys is an important security requirement

Scaling CDNs

- More attack surfaces
- More challenges to certificate/key management
- User-privacy only guaranteed for connection to CDN proxy

Are there better ways?

- Object-based security
- Generic object caching & forwarding infrastructure
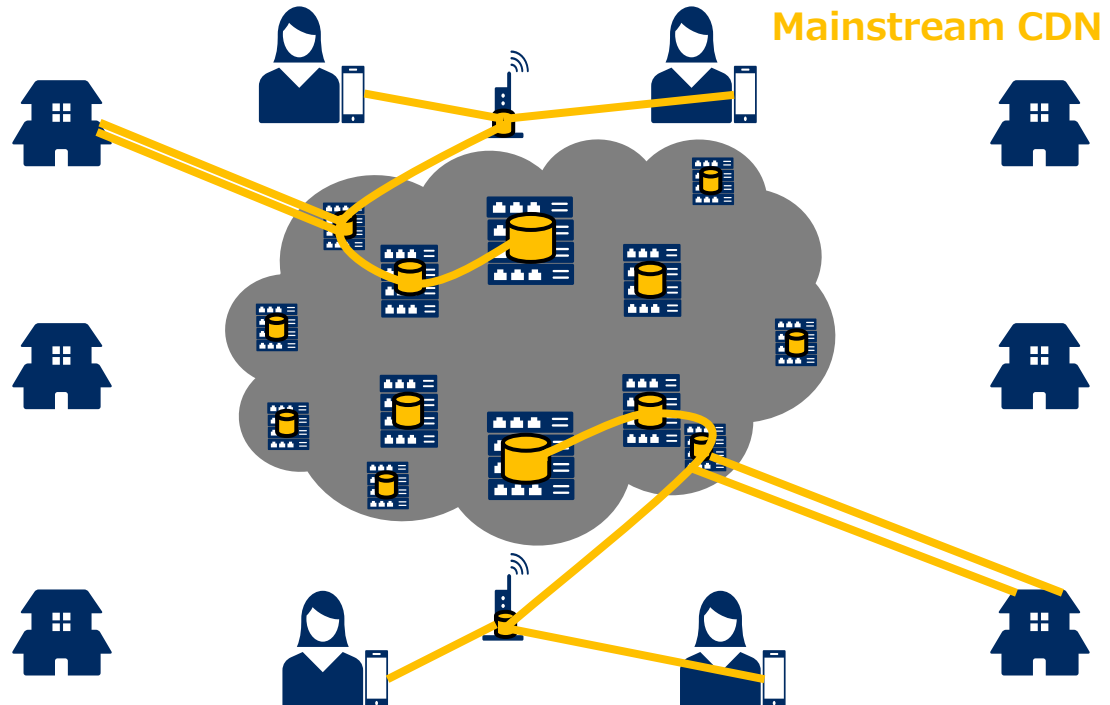
Mainstream CDN

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Optimized Forwarding for Heterogenous Access

Broadband access in dense areas

PERVASIVE VIDEO

Massive Internet of Things

SENSOR NETWORKS

Broadcast-like services

BROADCAST SERVICES

Higher user mobility

HIGH SPEED TRAIN

Low latency, high-bandwidth
- Fiber, new radios

Slow, ad-hoc, unpredictable
- Low-power radios, sleep/duty cycles
- Constrained devices

Massively scalable distribution
- Server-push or pub/sub style
- Possibly in-network adaptation

Variable performance
- Dynamically changing network conditions
- Disruptions and delays
- On-board caching for all applications & protocols

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Optimized Forwarding for Heterogenous Access

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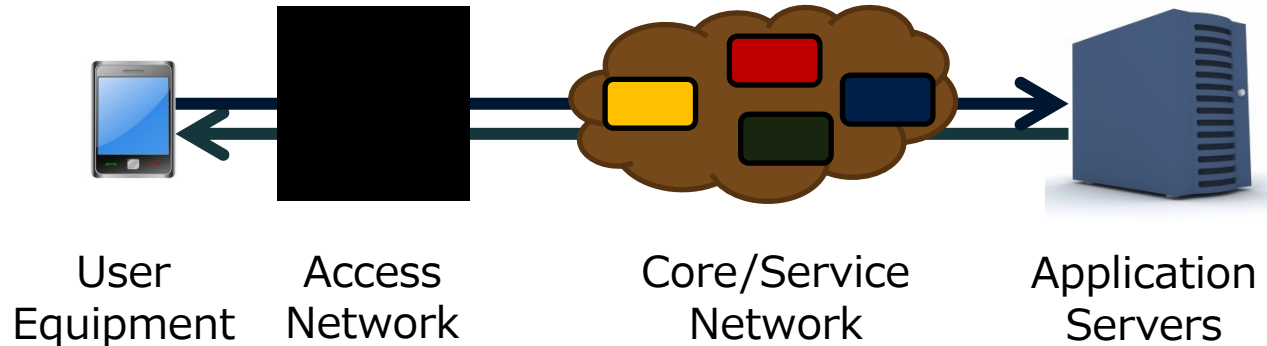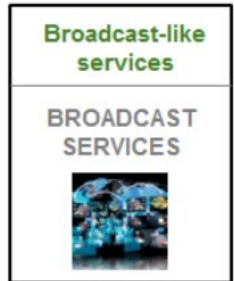
- Will be difficult to implement with TCP as is
- Remember: reduced deployment options for application-layer gateways
- Network of TCP proxies does not sound convincing

- **Need more powerful forwarding layer and transport services**
  - Potential for hop-by-hop forwarding strategies
  - Caching for local retransmissions

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Feedback on Blog Posting

http://dirk-kutscher.info/posts/5g-its-the-network-stupid/

Modern AQM in Telcos largely unexplored

- Could probably make quite a few optimizations obsolete

Congestion Exposure

- Principle of congestion accountability, enabling non-DPI, capacity sharing
- Would be good to get IETF ConEx ideas into 5G resource allocation discussions
- Today's application are really elastic – but need incentives and triggers
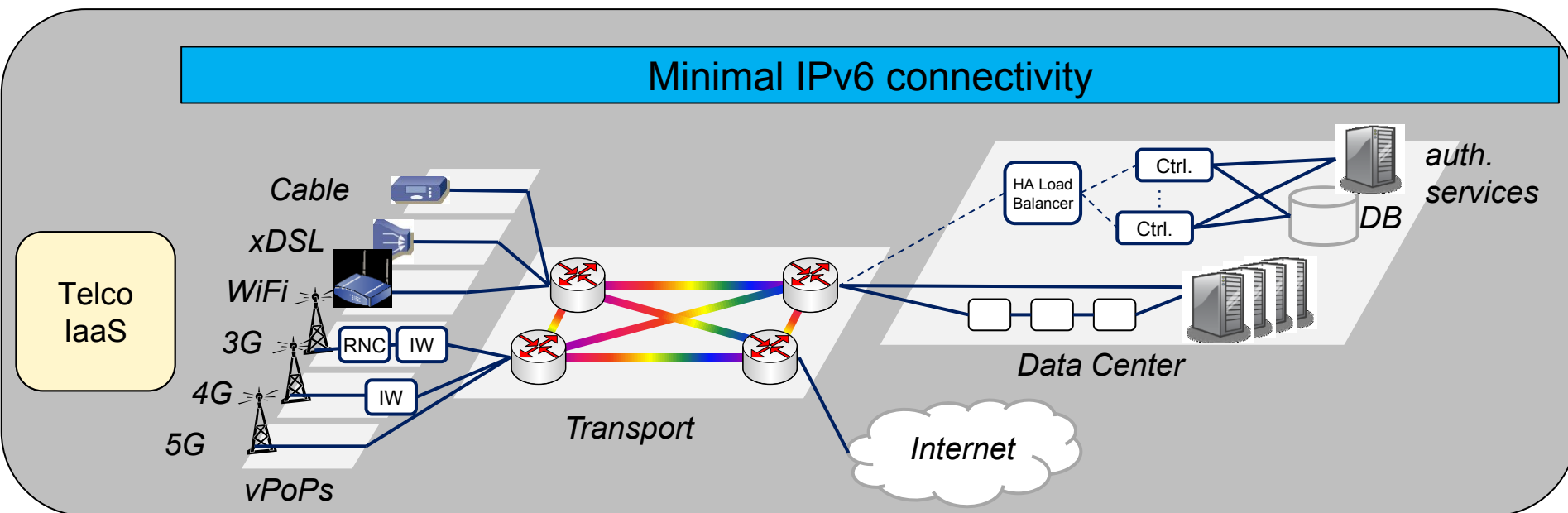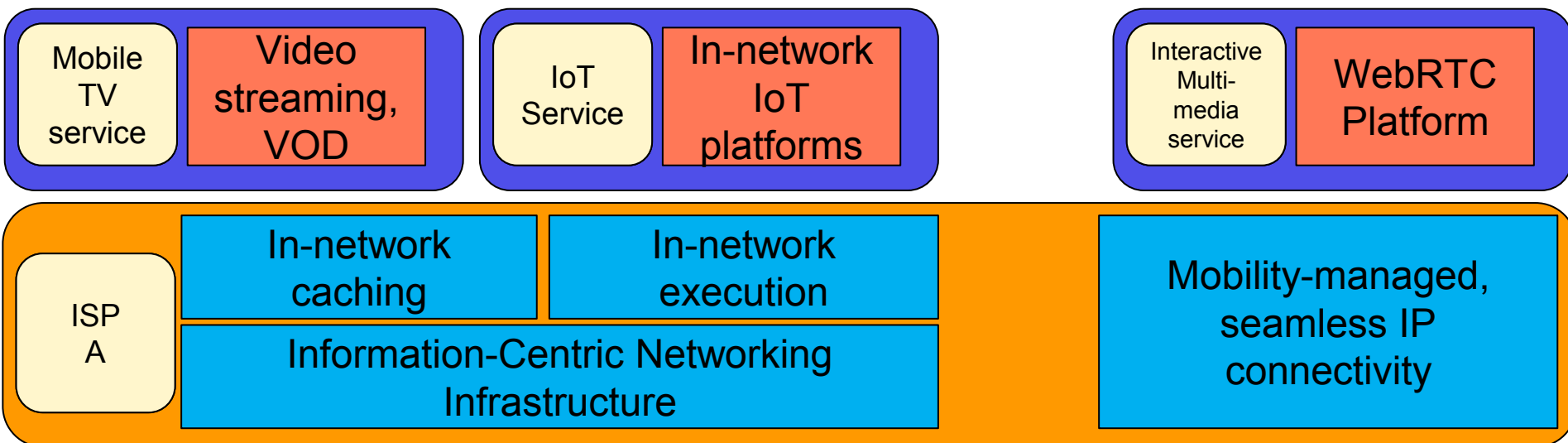
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Discussion of „Software-Defined"

- My text: SDN (network element programmability) really an implementation approach – e.g., in a network, administrative domain
- Unfortunately, the term has become useless today and is used to refer to any kind of configuration, control, orchestration
- SDN for IP (OpenFlow) uses MAC and IP address header rewriting a lot to achieve useful things – not sure that makes the network easier to manage
- SDN for ICN could be much cleaner

Slices vs. VPN

- Network slice: popular (fuzzy) term in 5G discusions
- Realls means cross layer resource pooling with isolation
- ICN angle
  1. There could be an ICN slice...
  2. Slicing could also apply to an ICN network (so, it would be orthogonal)
  3. Different forwarding abstractions may enable slicing better (e.g., consistent prefix-based forwarding strategies on set of nodes in a slice)

Possible 5G ICN Deployment Option

Mobile TV service | **Video streaming, VOD**

IoT Service | **In-network IoT platforms**

Interactive Multi-media service | **WebRTC Platform**

ISP A | **In-network caching** | **In-network execution** | **Mobility-managed, seamless IP connectivity**

Information-Centric Networking Infrastructure

Minimal IPv6 connectivity

Telco IaaS

Cable
xDSL
WiFi
3G — RNC — IW
4G — IW
5G

vPoPs

Transport

Internet

HA Load Balancer — Ctrl. — Ctrl. — DB

auth. services

Data Center

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5G: Network Management taken to the extreme

- More overlays, more application layer knowledge in network etc.
- Complexity of managing these abstractions seems untenable
- This value is too complex to likely be realized, since to be valuable, content providers need to use these functions. Are there folks interested in such network services?

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5G network architecture

- Increasing cooperation in forwarding and relaying signals, bits, packets (shared cell tower/base station/antennae across provider)
- Direct,mesh,adhoc stop just being edge notions, but are all first class part of the architecture
- There is huge tension between this trend, and e2e security

Security

- Many „trusted" middleboxes in todays ISP networks
- Dirk: This will change when mainstream CDN introduces HTTP/2 support
- Object encryption: actual e2e encryption, e.g., encrpyted user data in DCs
- http://www.telhoc.com/
- With communication over heterogeneous networks, connection-based encryption would be too expensive and too insecure

Initial Deployment and migration

- ICN as core network service or overlay (or underlay)?

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