

Tracking Mobile Video QoE in the Encrypted Internet

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Rise of Encryption

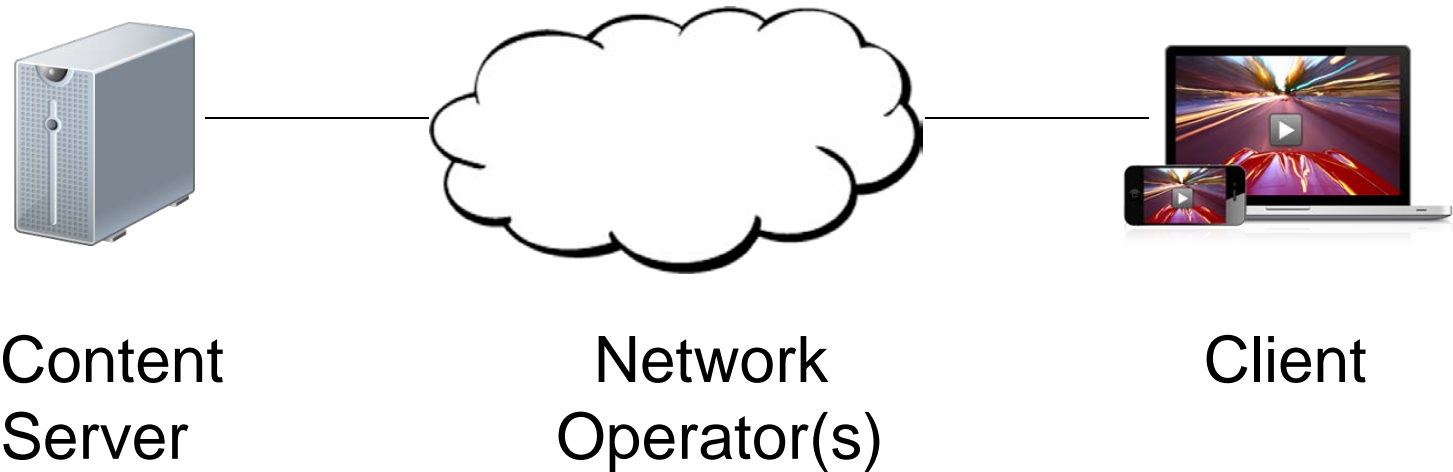
- HTTPS deployment is accelerating
 - YouTube uses encryption by default
 - Netflix expected to start using encryption by 2016
- Encryption adoption in new protocols
 - HTTP/2 (major browsers only support encryption)
 - QUIC (encryption by default)
- Encrypted traffic = 75% Internet traffic (by 2016)

Sandvine

Video Quality-of-Experience

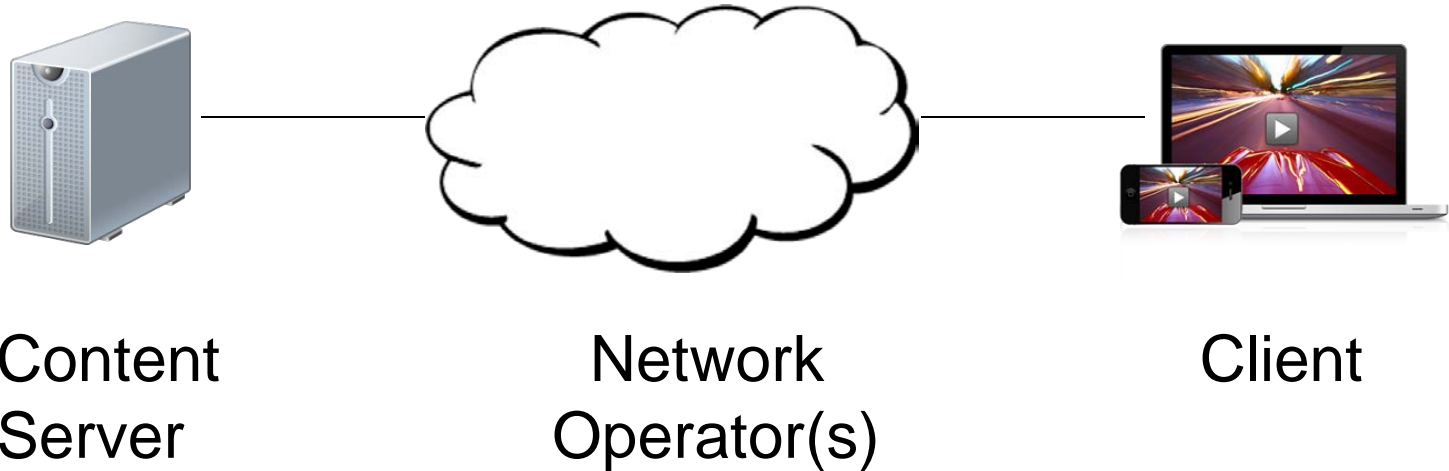
- Video is popular on mobile networks
 - Video makes up > 50% of global mobile data traffic
- MOS is not measurable at scale
- Objective QoE metrics
 - Buffering
 - startup delay
 - fluctuations

Video Stakeholders



- Client-side instrumentation
 - Information from video players to track QoE metrics
 - **[SIGCOMM'11] [IMC'12] [SIGCOMM'13]**

Video Stakeholders



- Network-side instrumentation?
 - DPI: Monitor HTTP headers to track video QoE
- QCI (QoS Class Indicators) mapping for traffic flows
 - Used by eNodeB (scheduling weights, queue thresholds, link layer protocol configurations, admission thresholds)
 - SON (self-organizing networks) --> 5G

Video Stakeholders



Content
Server

Network
Operator(s)

Client

- Network-side instrumentation
 - Not possible with end-to-end encryption
- Potential impact due to non-optimal QCI marking
 - Proprietary base station schedulers
 - Performance degradation for TCP flows **[IMC'15]**

Way Forward

- Non-cooperative
 - Rely on lower-layer meta data
- Cooperative
 - APIs for information exchange

Non-Cooperative

- TCP/IP headers and radio network statistics
 - Layers 2, 3, 4 heuristics
 - Works with encrypted traffic
 - Avoid DPI
- A bag of heuristics fed into ML algorithms
 - Predict vulnerable video sessions
 - Large-scale monitoring of video quality
 - More details in [**SIGMETRICS'14**] paper

Issues

- High-overhead, frequent updates
- Adversarial behavior from content providers
- Heuristics vary for different content providers

What's next: Cooperation

- In-band approaches
 - Mobile Throughput Guidance
 - SPUD
 - ECN
 - Multi-Context TLS (mcTLS) [**SIGCOMM'15**]
 - TLS-AUX
- Out-of-band approaches
 - Push APIs
 - REST APIs
 - Pub/Sub