画像情報特論 (1)
Advanced Image Information (1)

Introduction and Streaming Background

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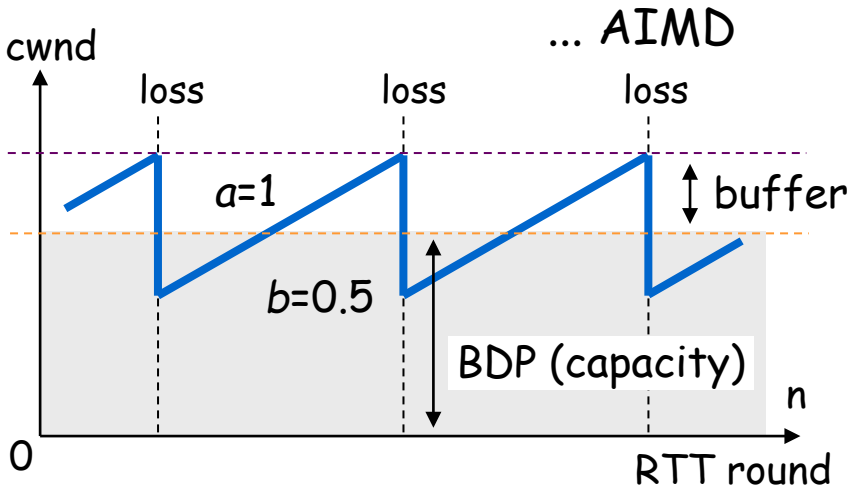
Introduction

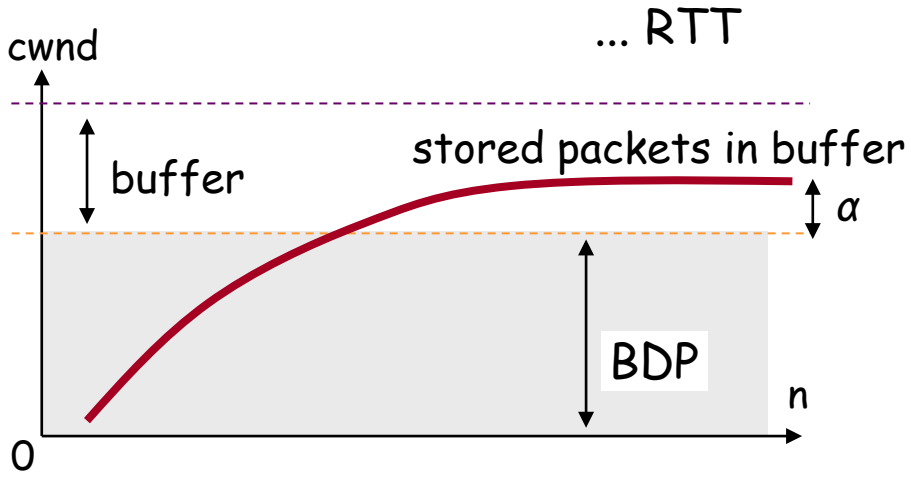
TCP Variants

- Loss-based



TCP-Reno, High-Speed TCP,
TCP-Westwood, CUBIC-TCP, …

- Delay-based



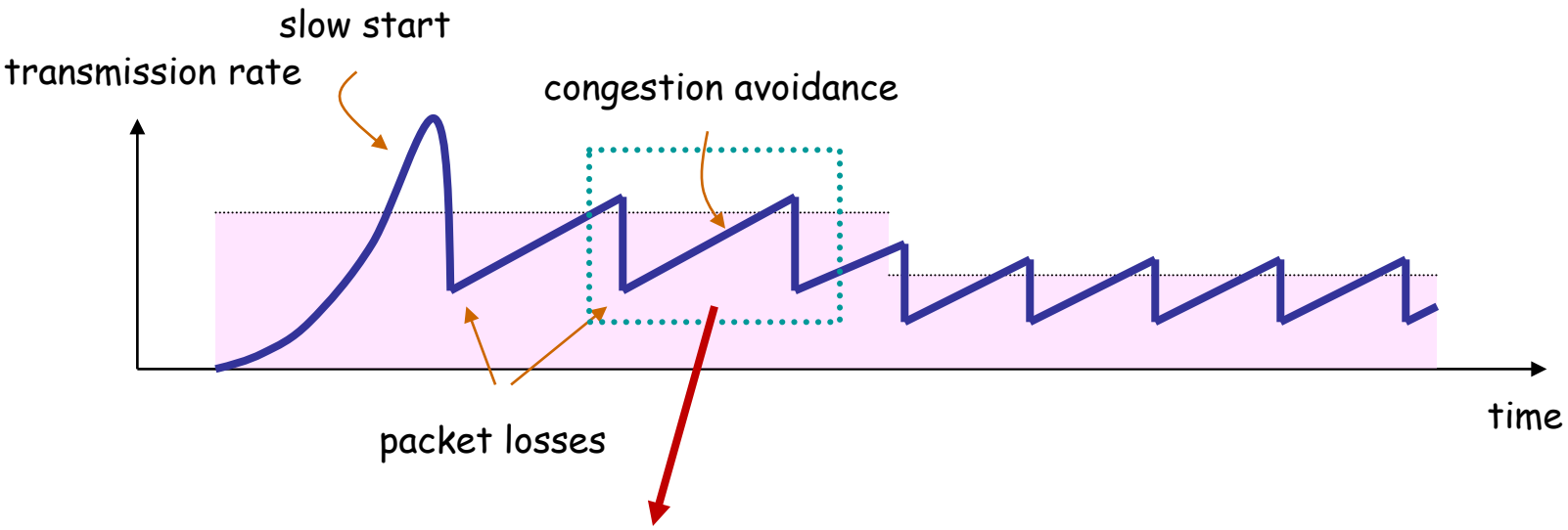
TCP-Vegas, FAST-TCP

- Hybrid — Compound TCP
- TCP-BBR

BDP: Bandwidth-Delay Product

RTP and TFRC

- TFRC (over RTP/UDP)



Modeling of steady-state TCP behaviors

$$R = \frac{1}{RTT}\sqrt{\frac{3}{2p}}$$

p: packet loss rate

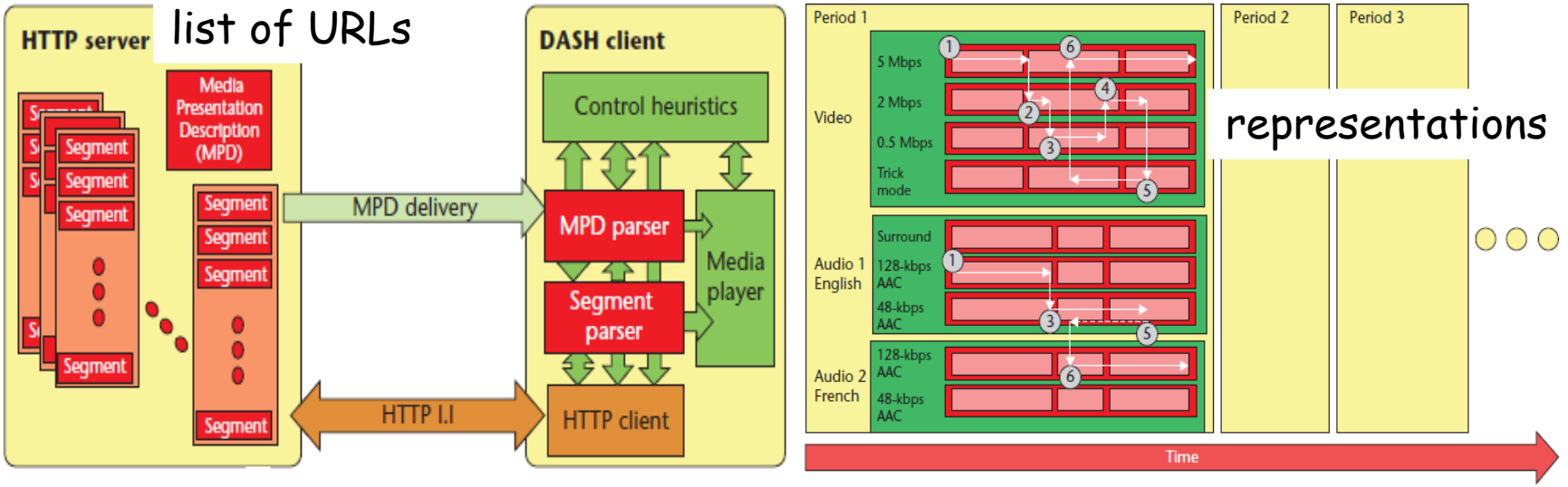
BDP/Buffer relationship

small buffer → × efficiency
large buffer → × delay

TFRC: TCP Friendly Rate Control

HTTP and MPEG-DASH

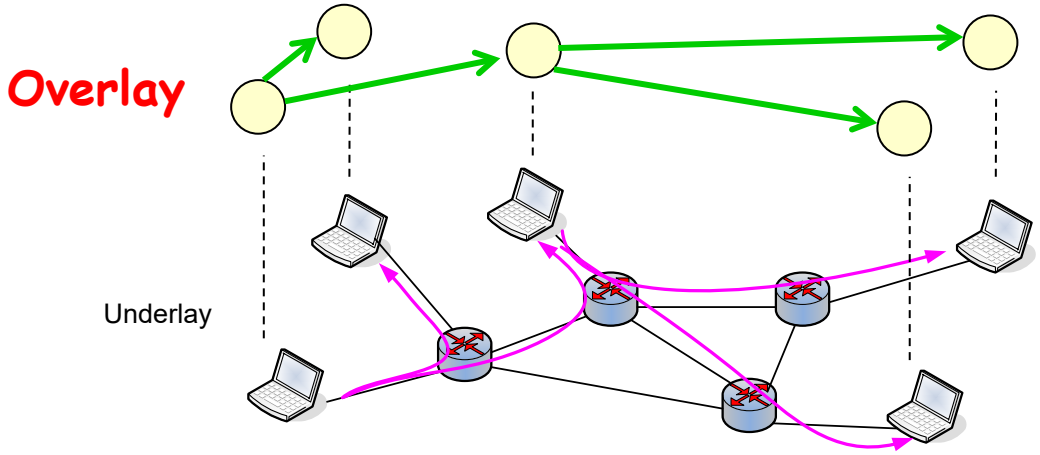
- MPEG-DASH: Dynamic Adaptive Streaming over HTTP
  - Multiple (bitrate, resolution) pairs … representation
  - Adaptive selection of representations



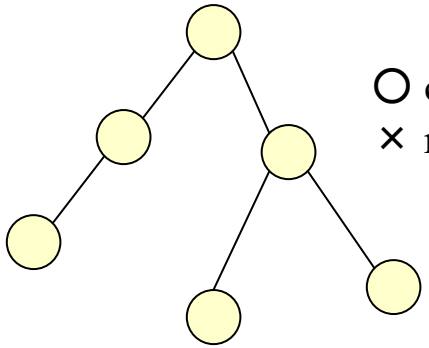
I. Sodagar, et al. : The MPEG-DASH Standard for Multimedia Streaming Over the Internet, IEEE Multimedia, Apr.2011.

CDN, P2P & Cloud

- Overlay networks

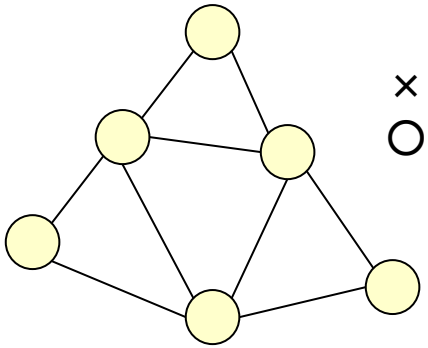


- tree



○ complexity
× robustness

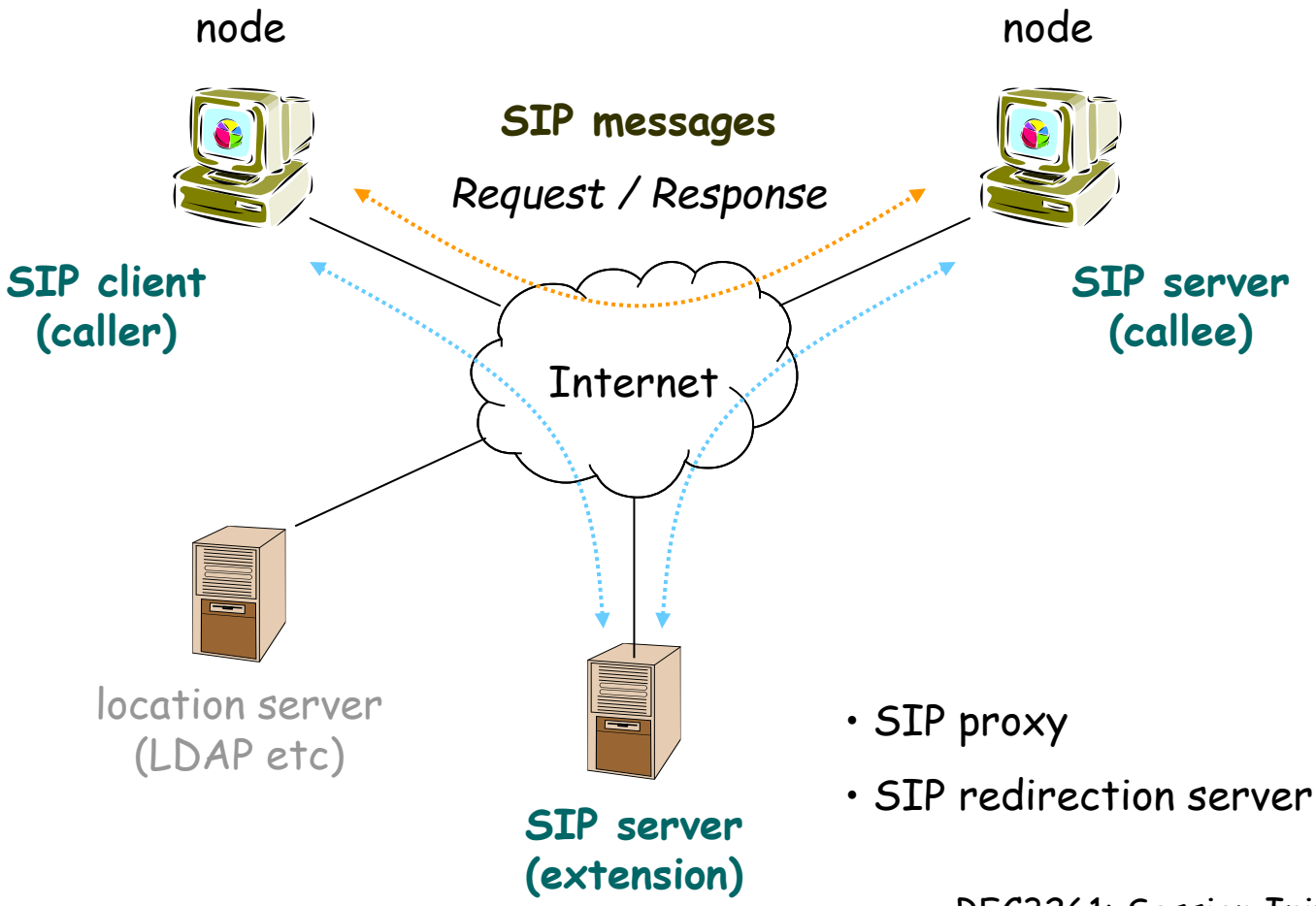
- mesh



× complexity
○ robustness

SIP and WebRTC

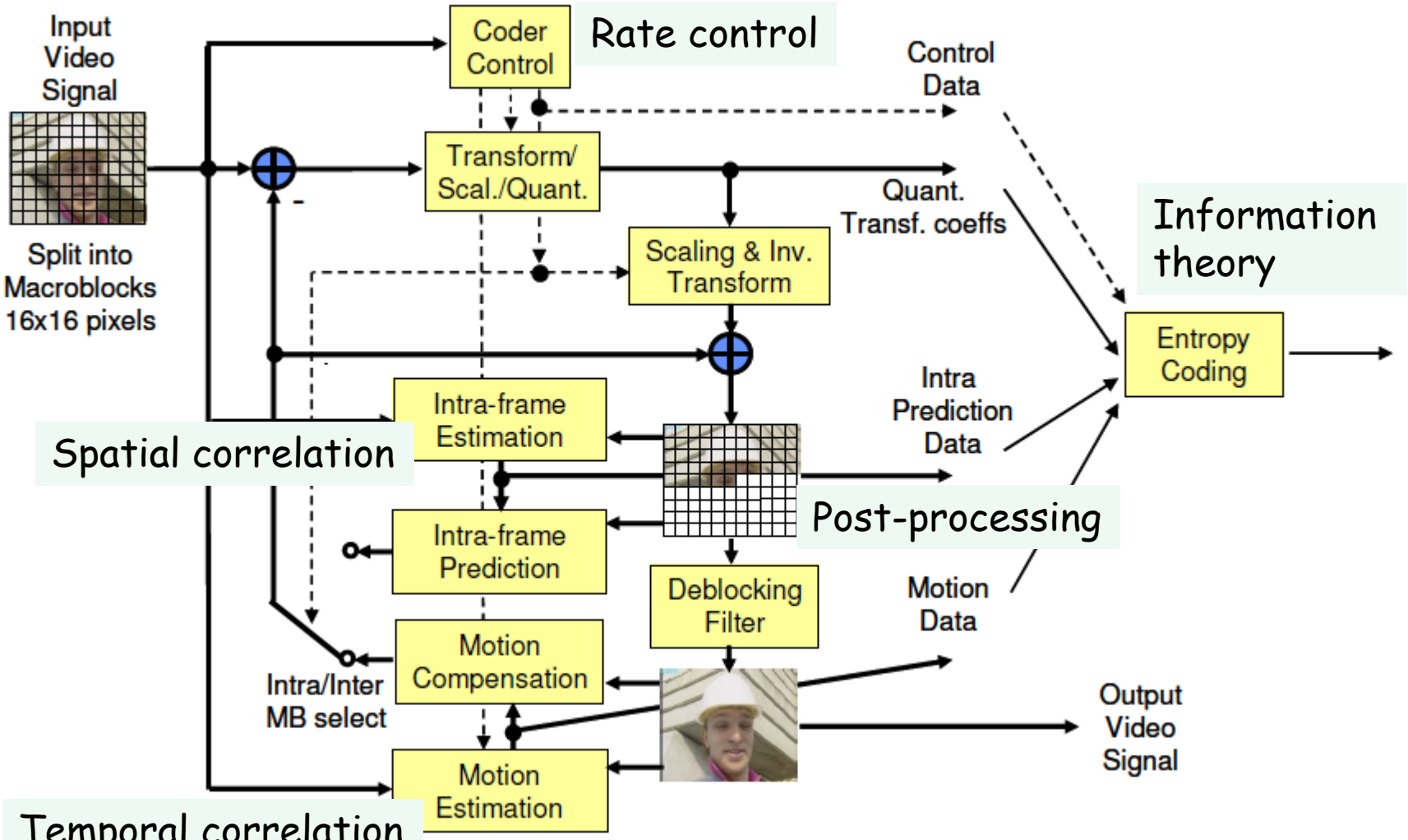
- SIP: Session Initiation Protocol



- SIP proxy
- SIP redirection server

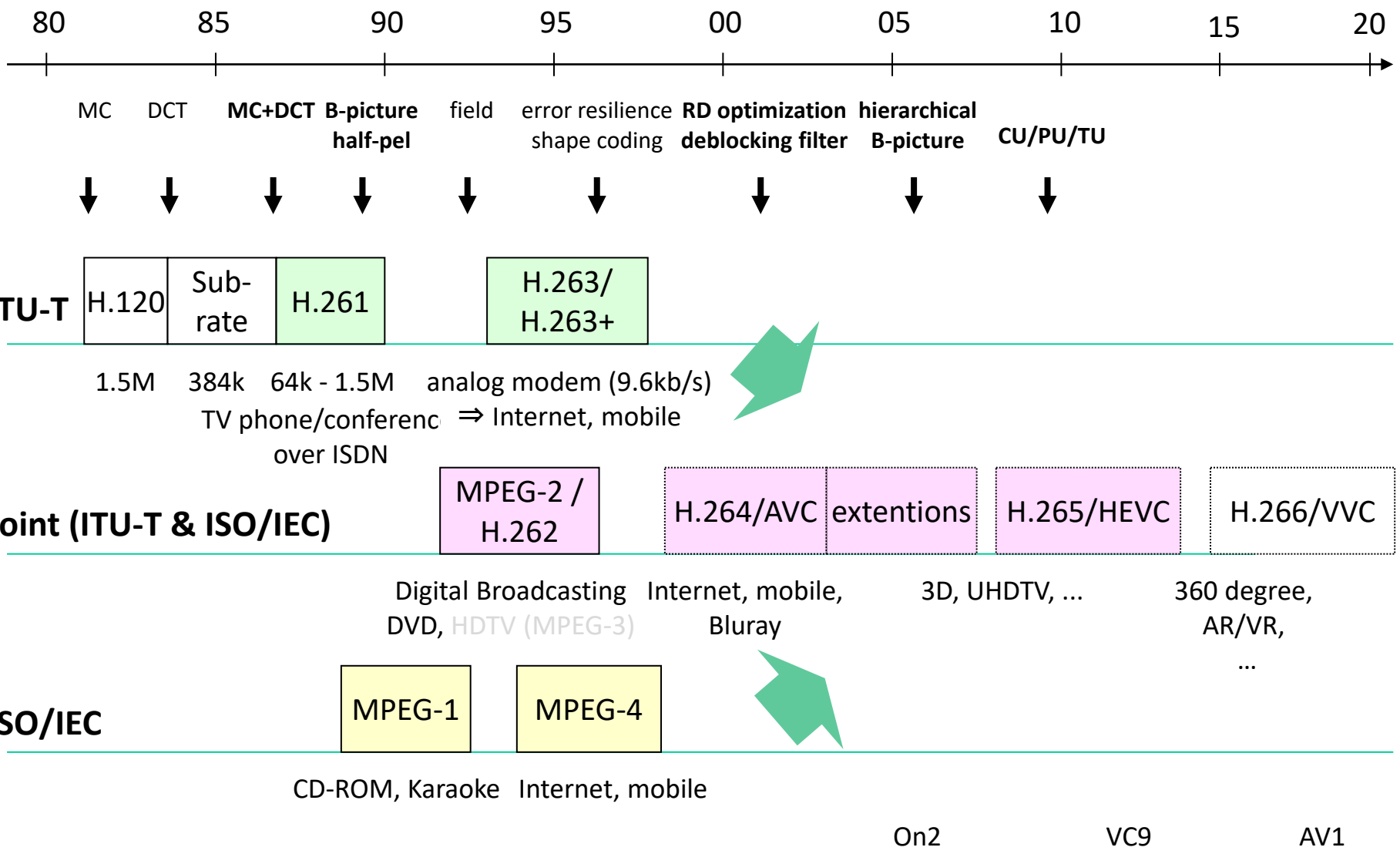
RFC3261: Session Initiation Protocol

Video Compression Basics



T.Ebrahimi: "Trends and Challenges in Video Coding", June.2009.

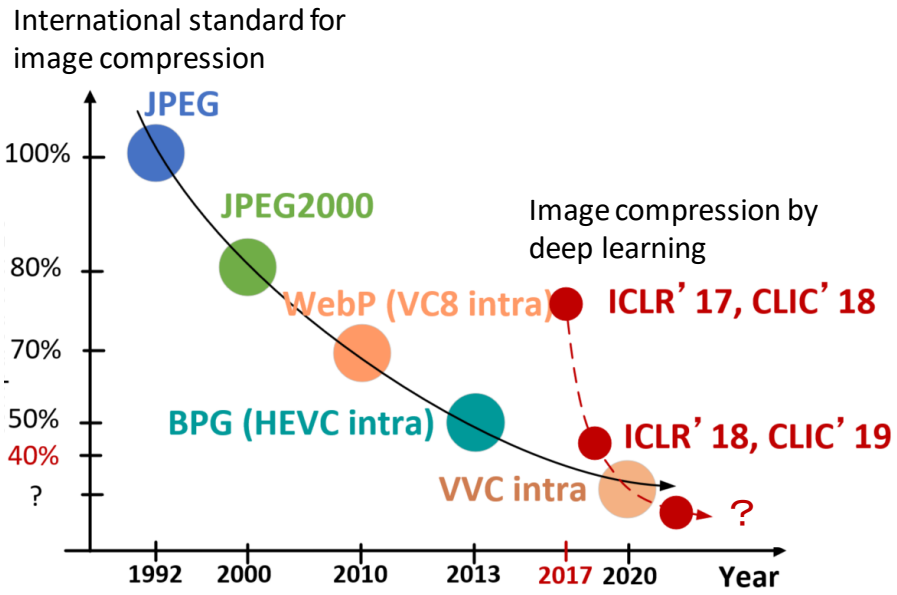
Video Compression History



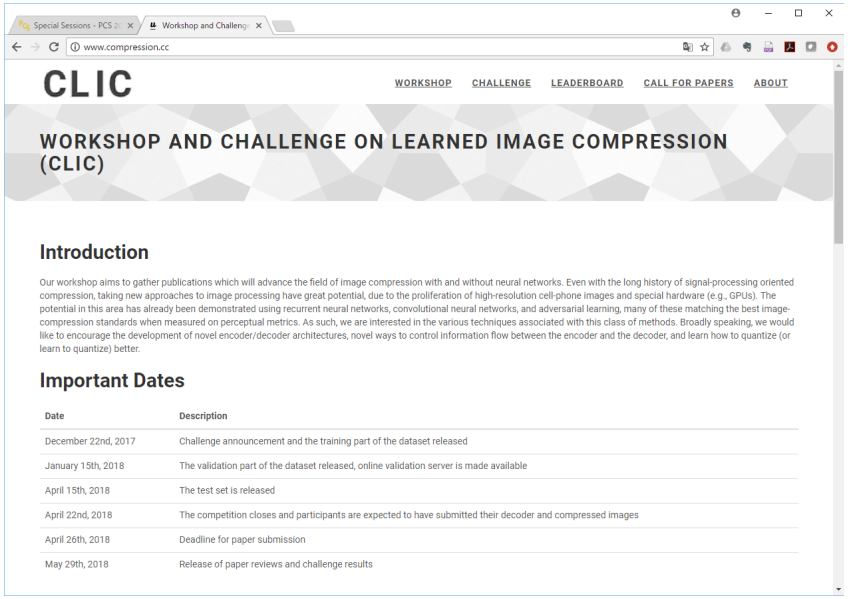
Learned Image Compression

- Active topics in these three years

Compression performance



CLIC in CVPR 2020 in June



http://www.compression.cc/

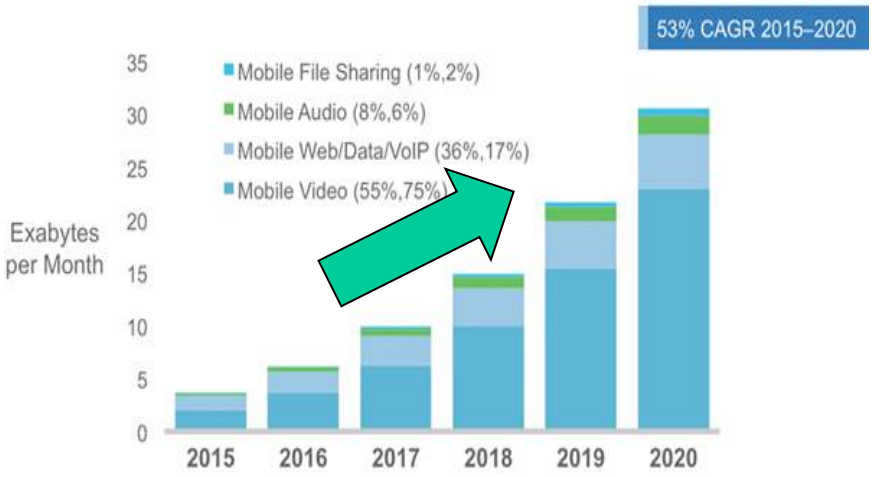
Handouts

- Check handouts on Waseda Moodle

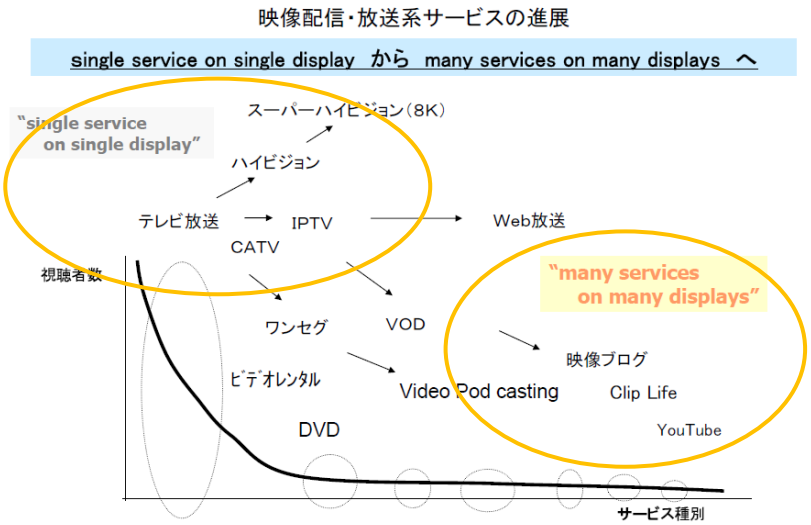
Streaming Background

Recent Trends

- Drastic Increase of Video Traffic on Internet
  - more than 70%
- Evolution of Various Video Services
  - higher resolution and personalization

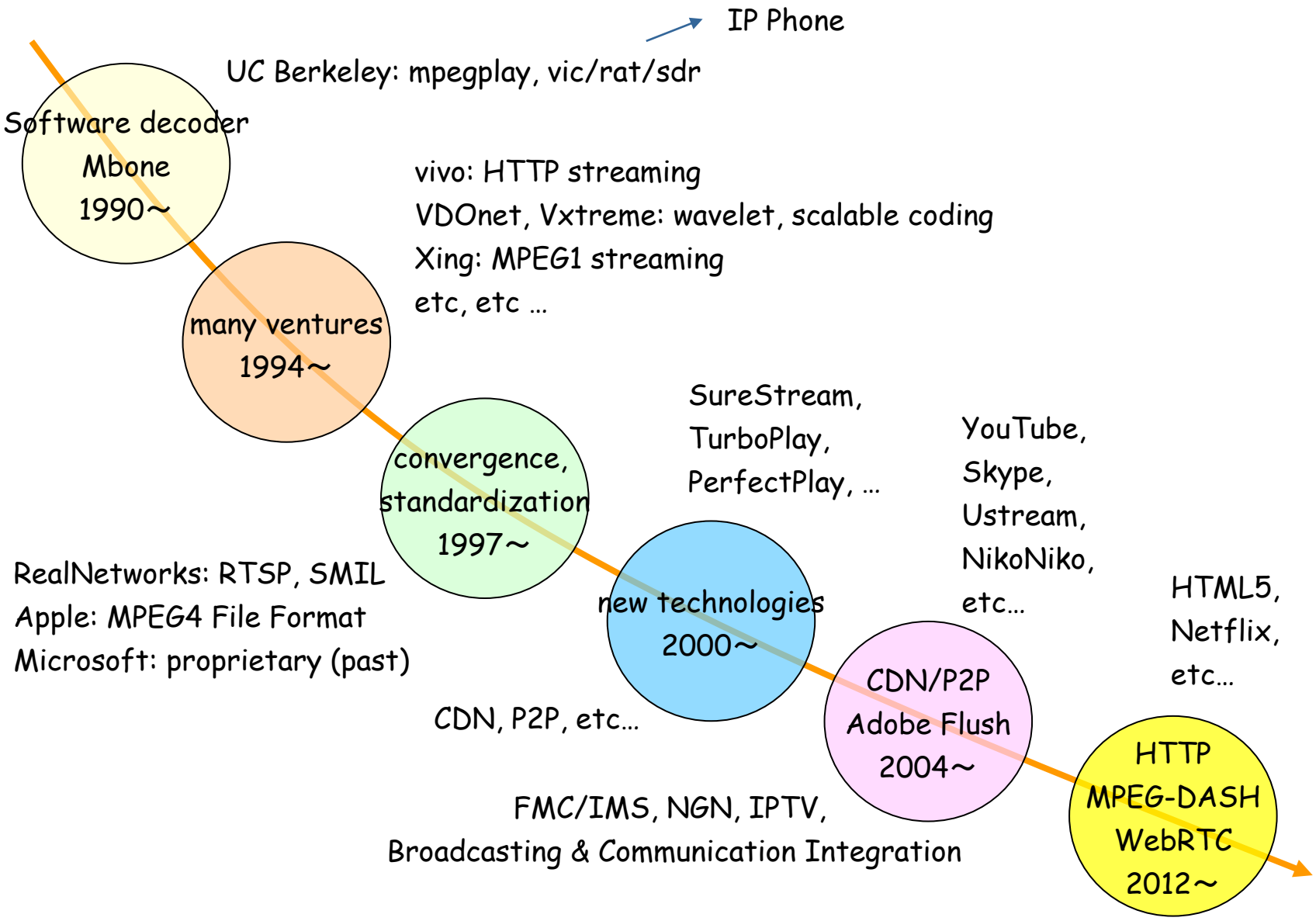


(Cisco VNI, 2016)



(MIC Report, 2008)

History of Video Streaming



Protocol Stack of RTP/UDP Video Streaming (and IP phone)

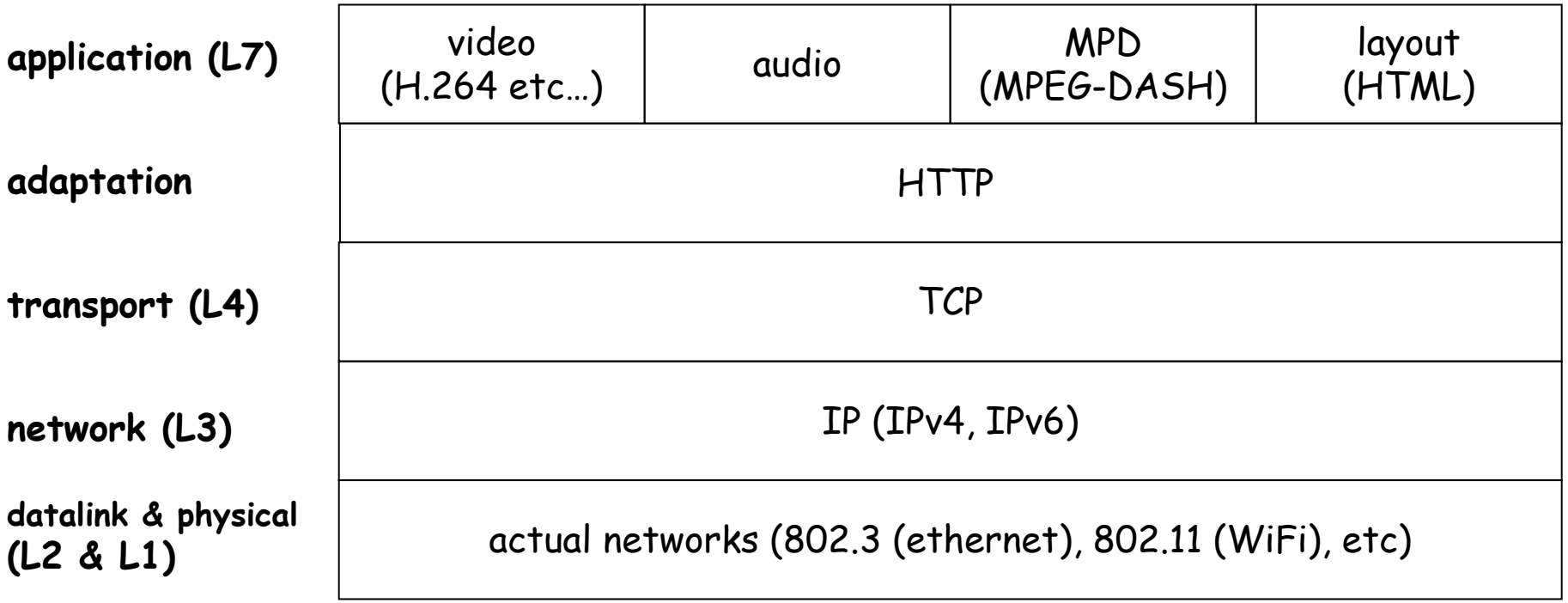
protocol stack for low-delay & interactive video streaming (e.g. conference)

<table>
<tr><td>application (L7)</td><td>video
(H.264 etc…)</td><td>audio</td><td>SDP</td><td>layout
(HTML. SMIL)</td></tr>
<tr><td>adaptation</td><td colspan="2">RTP / RTCP</td><td>RTSP, SIP, SAP*</td><td>HTTP</td></tr>
<tr><td>transport (L4)</td><td colspan="2">UDP / TCP / DCCP</td><td colspan="2">TCP / UDP / SCTP</td></tr>
<tr><td>network (L3)</td><td colspan="4">IP (IPv4, IPv6, IP-multicast)</td></tr>
<tr><td>datalink & physical (L2 & L1)</td><td colspan="4">actual networks (802.3 (ethernet), 802.11 (WiFi), etc)</td></tr>
</table>

* SAP: delivered by IP-multicast for program advertisement

Protocol Stack of HTTP Video Streaming

protocol stack for one-way video streaming



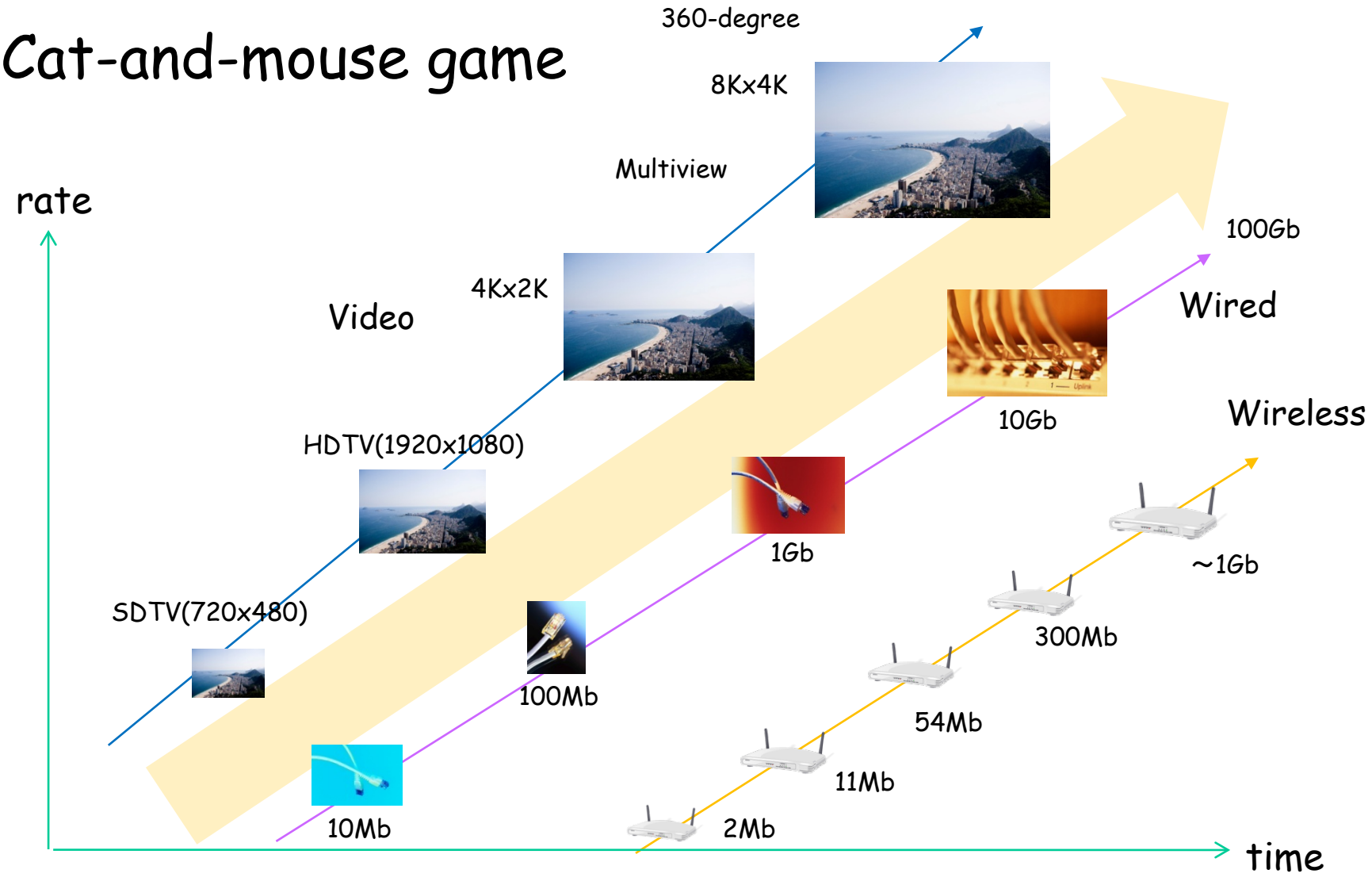
Protocol Stack of WebRTC

protocol stack for low-delay & interactive video streaming (e.g. conference)

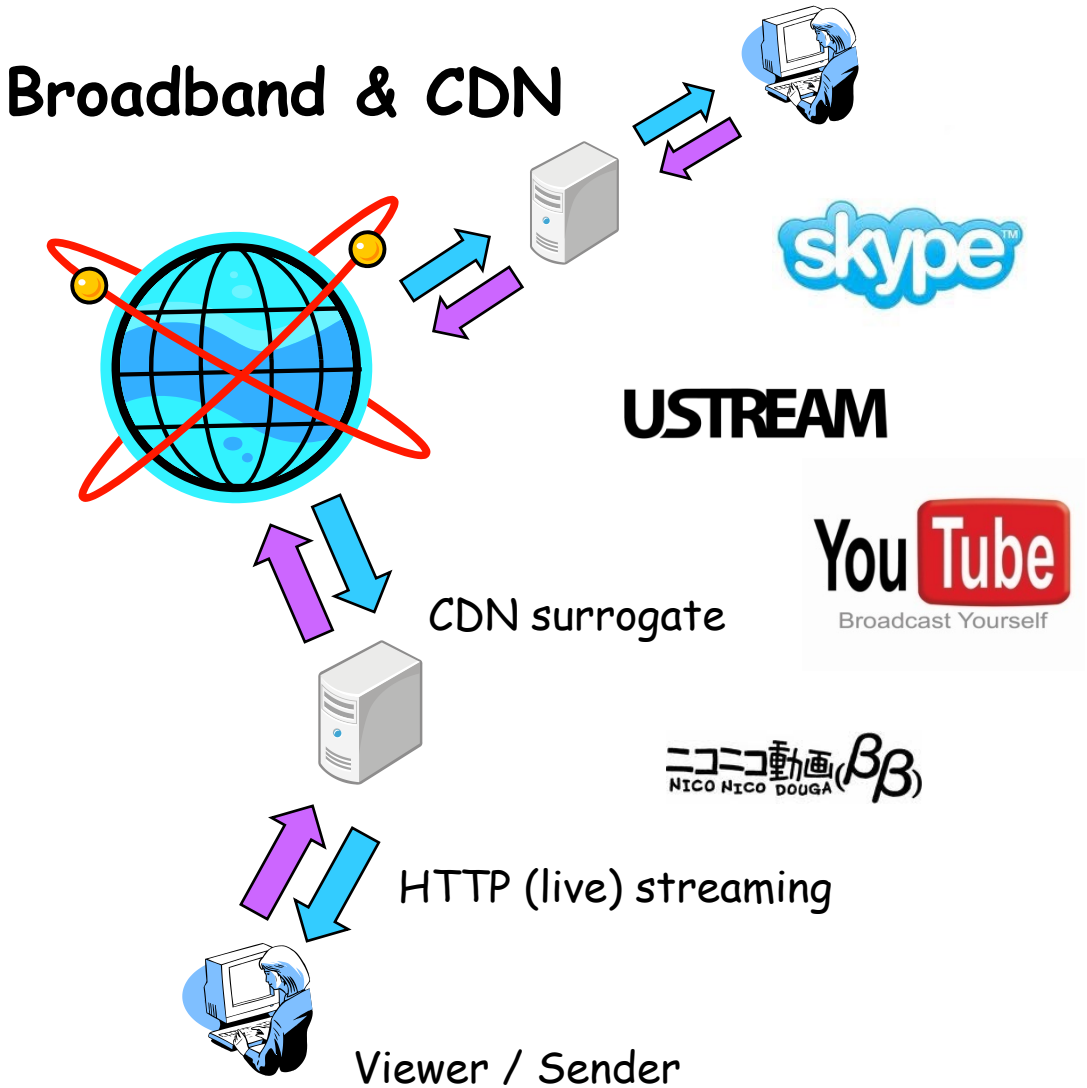
<table>
<tr><td>NAT traversal</td><td colspan="2">media</td><td>data</td><td>signaling</td></tr>
<tr><td></td><td>video</td><td>audio</td><td>data</td><td>SIP, SDP</td></tr>
<tr><td>STUN, TURN</td><td colspan="2">SRTP</td><td>SCTP/DTLS</td><td>HTTP/TLS,
WebSocket</td></tr>
<tr><td colspan="3">UDP</td><td colspan="2">TCP</td></tr>
<tr><td colspan="5">IP</td></tr>
<tr><td colspan="5">MAC / PHY</td></tr>
</table>

Networks and Multimedia

- Cat-and-mouse game



Broadband and CDN



RTP/UDP & RTSP & TFRC

→ HTTP/TCP streaming

- Broadband
- CDN (Akamai, Lime Networks)
- Firewall (port 80)
- …

One-way (on-demand / live)

- large buffer

Bi-directional (interactive)

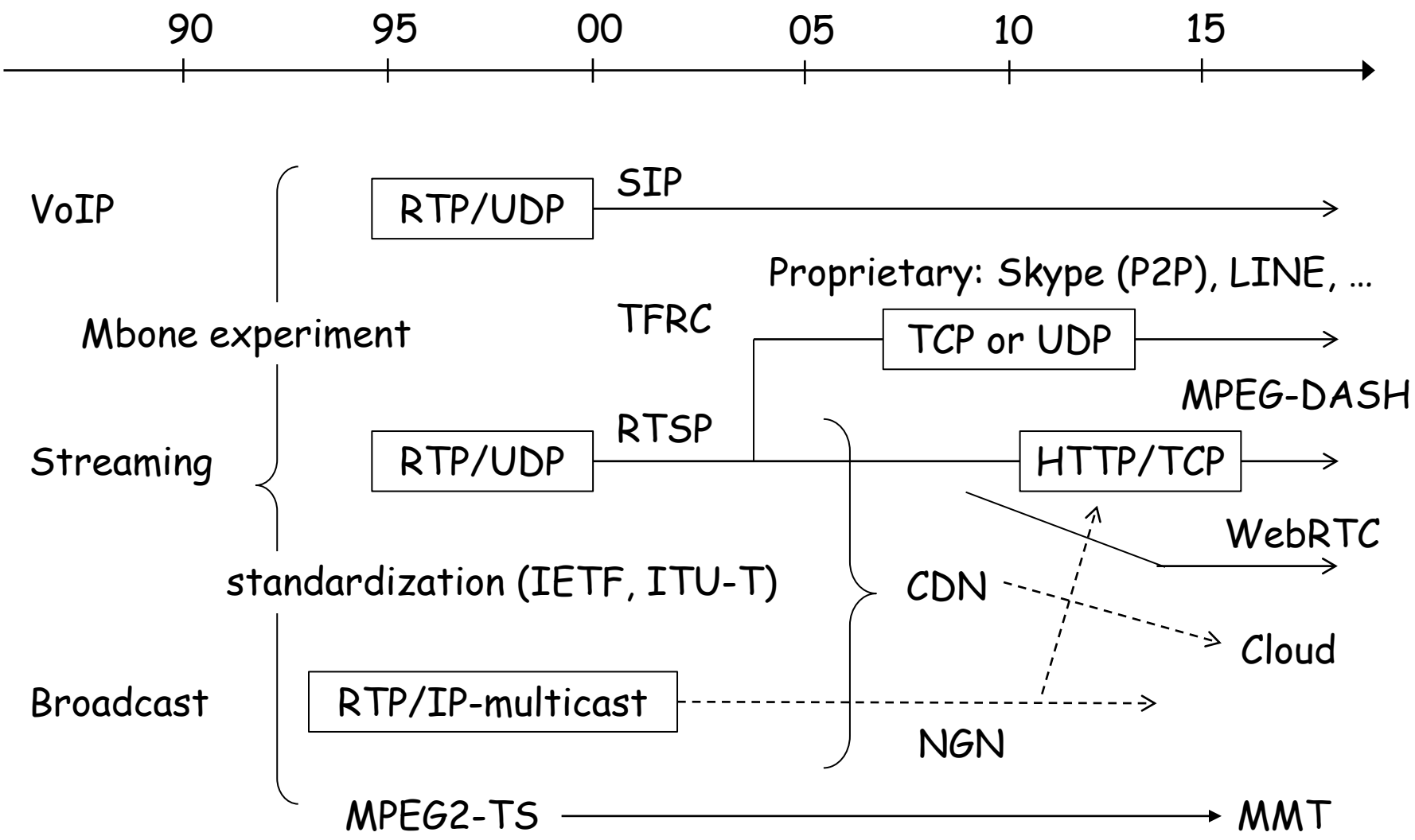
- small buffer

CDN: Content Delivery Network ⇒ Cloud

IP Video Services

Services	Examples
IP phone & conference (interactive)	Telecommunication (SIP, H.323)
IPTV (one-way)	CATV, Telecommunication (MPEG-2 TS)
Web conferencing (interactive)	Zoom, Cisco WebEx, Skype, Google Hangout, etc …
Video streaming (one-way)	YouTube, Amazon Prime Video, Facebook, etc …

Protocol Transition



TCP vs. UDP

	Reliability	Low Delay	Congestion Control	Typical Application
TCP	◎ (ACK and lost packet retransmission)	× → ○ (thanks to CDN & broadband network)	○ → ◎ (TCP versions)	One way (on-demand) streaming
UDP	× (no ACK nor sequence number)	◎ (no ACK nor packet retransmission)	× → △ (RTP/RTCP and TFRC)	Interactive (bi-directional) phone & conference

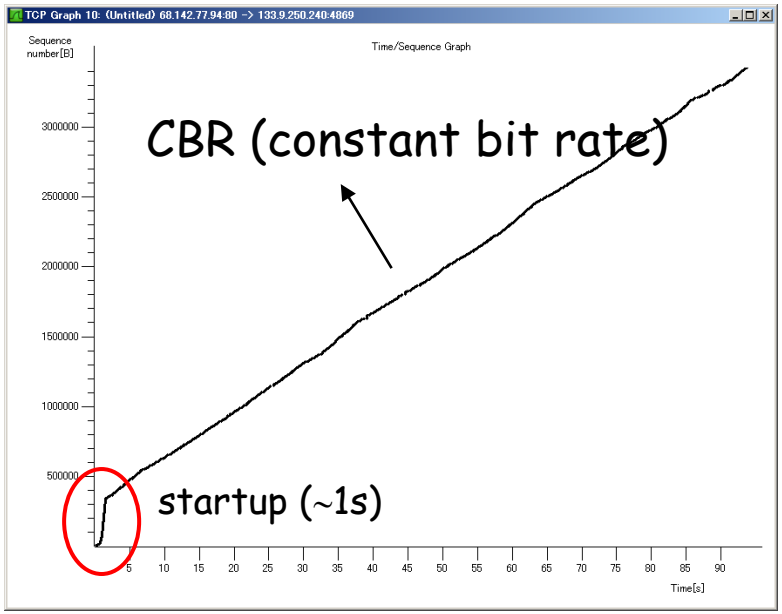
one-way streaming in 20 years ago

prefetching & CBR

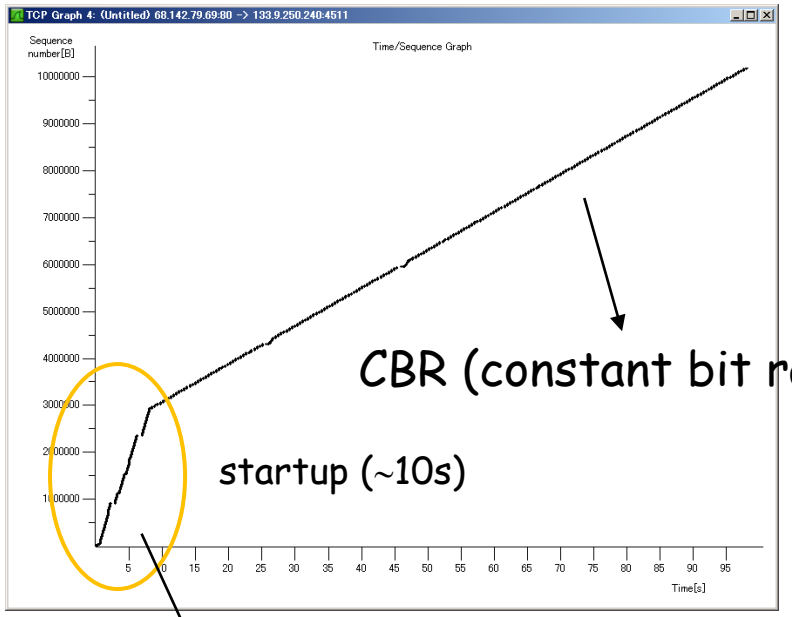
(prefetch, then CBR)

sequence number

Live



On-Demand



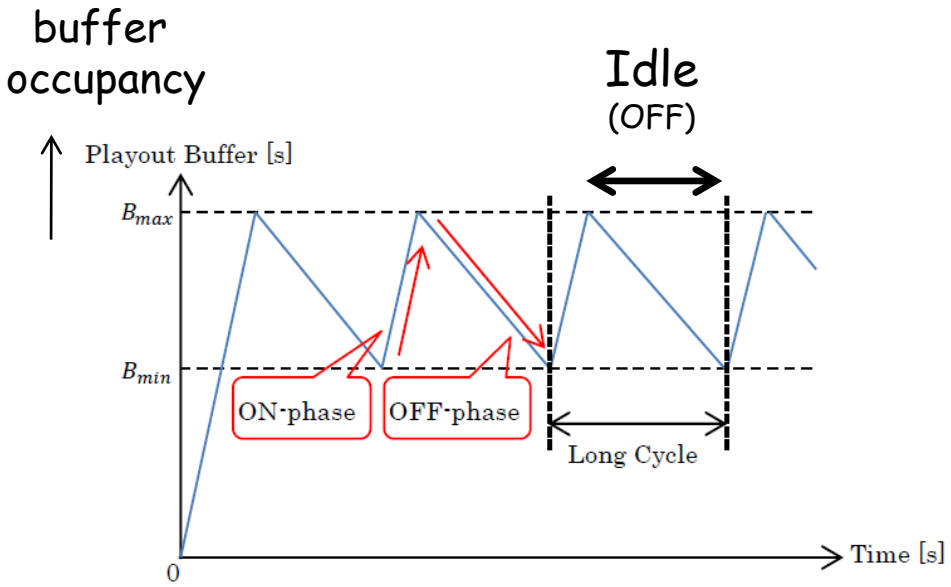
time

prefetching

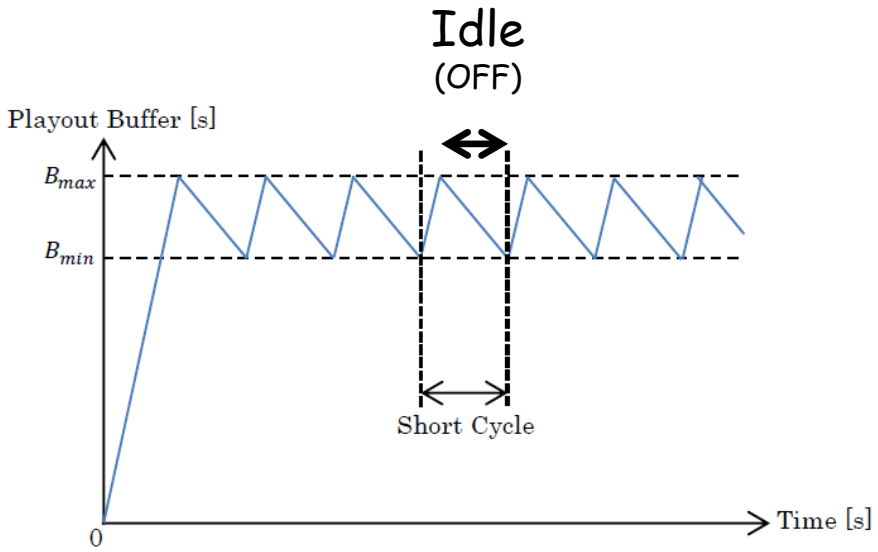
ON/OFF cycles

(prefetch & idle cycles)

- receiver buffer behaviors



(a) long ON-OFF Cycle (sawtooth)



(b) short ON-OFF Cycle (zippy pacing)

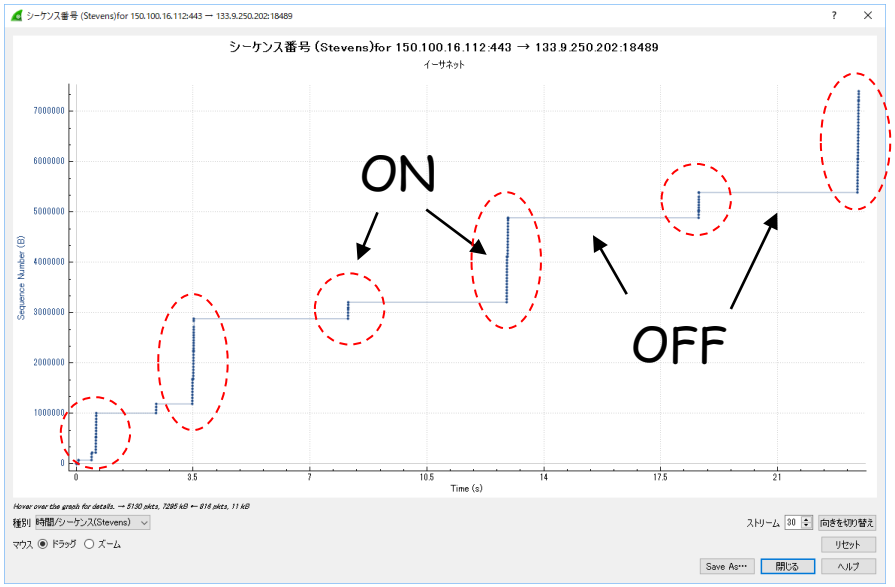
A. Rao, et al. ACM CoNEXT 2011

one-way streaming nowadays

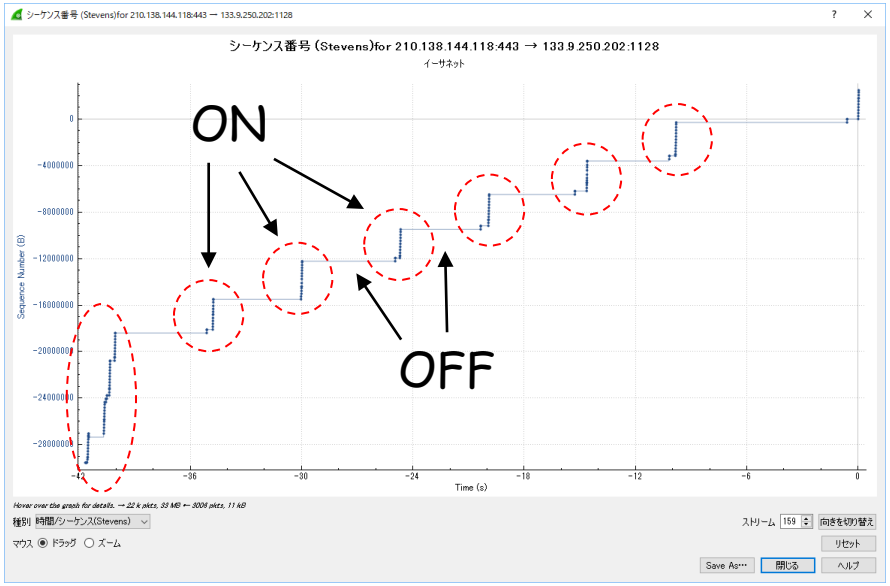
ON/OFF cycles

- sequence number behaviors

sequence number



example 1 (YouTube)



example 2 (TVer)

This year's schedule (tentative)

This Year's Schedule

tentative

(Apr 9)	Class overview and backgrounds of video streaming
(Apr 16)	TCP variants
(Apr 23)	RTP and TFRC over UDP
(Apr 30)	HTTP and MPEG-DASH
(May 7)	CDN, P2P and Cloud
(May 14)	SIP and WebRTC
(May 21)	Other topics and online test
(May 28)	Video compression basics
(June 4)	H.264/AVC
(June 11)	HEVC/H.265 and VVC/H.266
(June 18)	Learned image compression
(June 25)	tbd
(July 2)	tbd
(July 9)	Class summary and online test

----------Final report