Real Time Communication

Time Awareness for QoE

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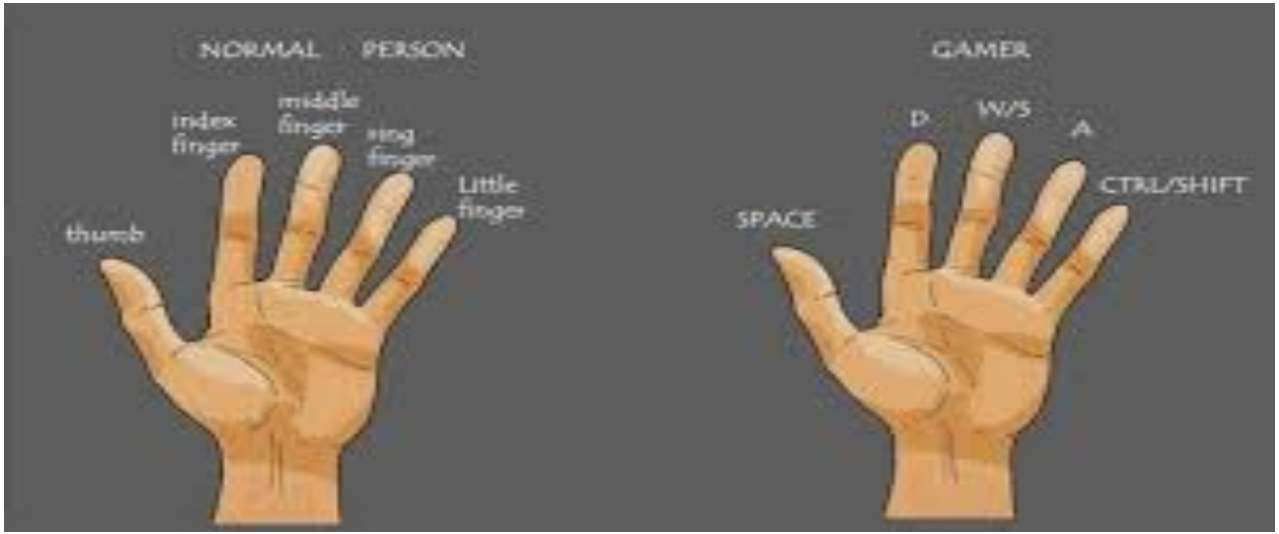
Some Context

- EU COST Action
- Autonomous Control for a Reliable Internet of Services
- TAACCS Subgroup
  - Time Awareness
    - SDN
    - Gaming
    - WebRTC

Progress Report

- Better Time Awareness for RTC QoE
  - Cloud Gaming MMOG
    - Gaming Anywhere Platform
      - Game server
      - Network
  - WebRTC M2E Delay Analysis
    - Black Box testing
    - Forensic analysis
    - Jitter Buffer design

Anatomy of a Gamer



Cloud Gaming

- Recent evolution in Gaming
  - High growth potential
- Thin client + Fat pipe
  - Game hosted on cloud
  - User client device sends user control-events to server
  - Server replays actions, renders scene and streams data flow video to client
  - Client displays scene
- Online connectivity critical  ???


VIDEO GAMES
DON'T MAKE
YOU VIOLENT
LAG DOES!

Lag_1 = Response Delay

Response delay (RD)

- time diff between a user submitting a command and the corresponding in-game action appearing on the screen

- Processing delay (PD)
  - time required for the server to receive/process a player's command, encode/ transmit the corresponding frame
- Playout delay (OD)
  - time required for the client to receive, decode, and render a frame on the display
- Network delay (ND)
  - Round Trip Delay
- RD = PD + OD + ND

Lag & QoE

OD ND PD

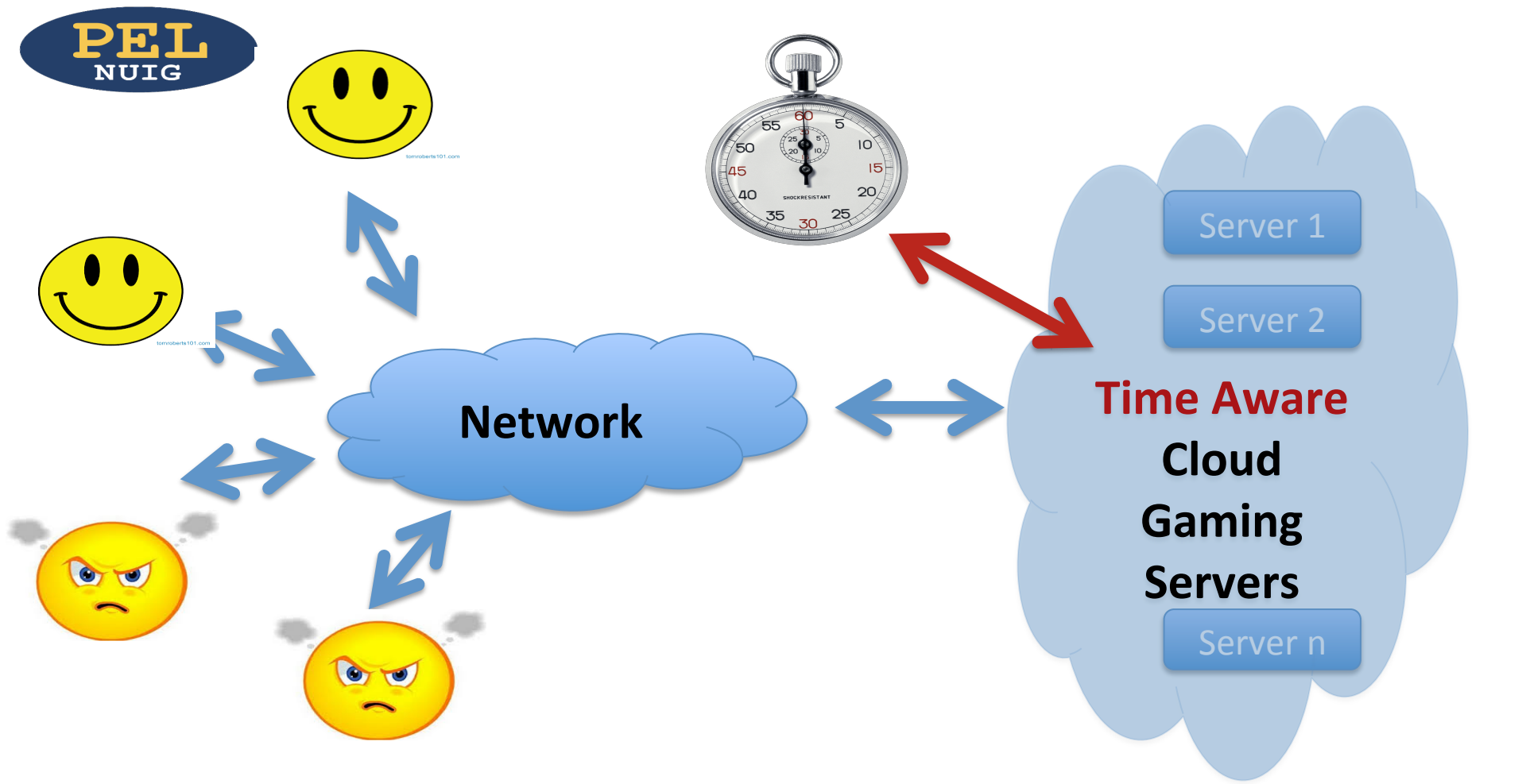
Network

Server

OD ND PD

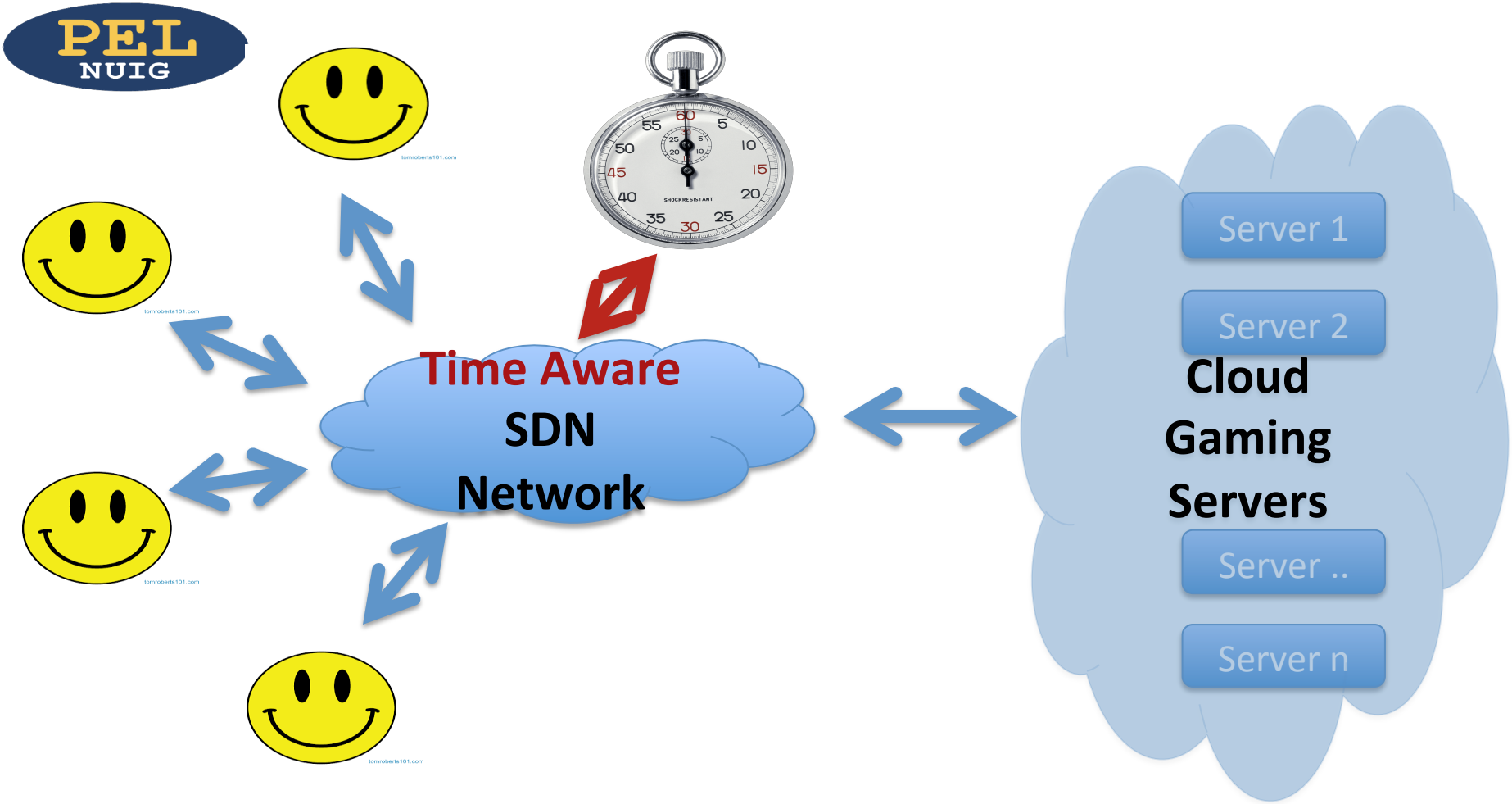
Recall Phase 1 –Server side

- Monitor – Model – Manage - Test
- Process
  - Realtime network delay (ND) calculations
  - QoE model : delay ←→ QoE
  - Server side delay management
  - Subjective Testing


PEL
NUIG
Network
Server 1
Server 2
Time Aware
Cloud
Gaming
Servers
Server n

Recall Phase 2 –Network side

- Monitor – Model – Manage - Test
- Process
  - Realtime network delay (ND) calculations
  - QoE model : delay ⬅➡ QoE
  - SDN Controller – Traffic prioritisation
  - Subjective Testing


PEL
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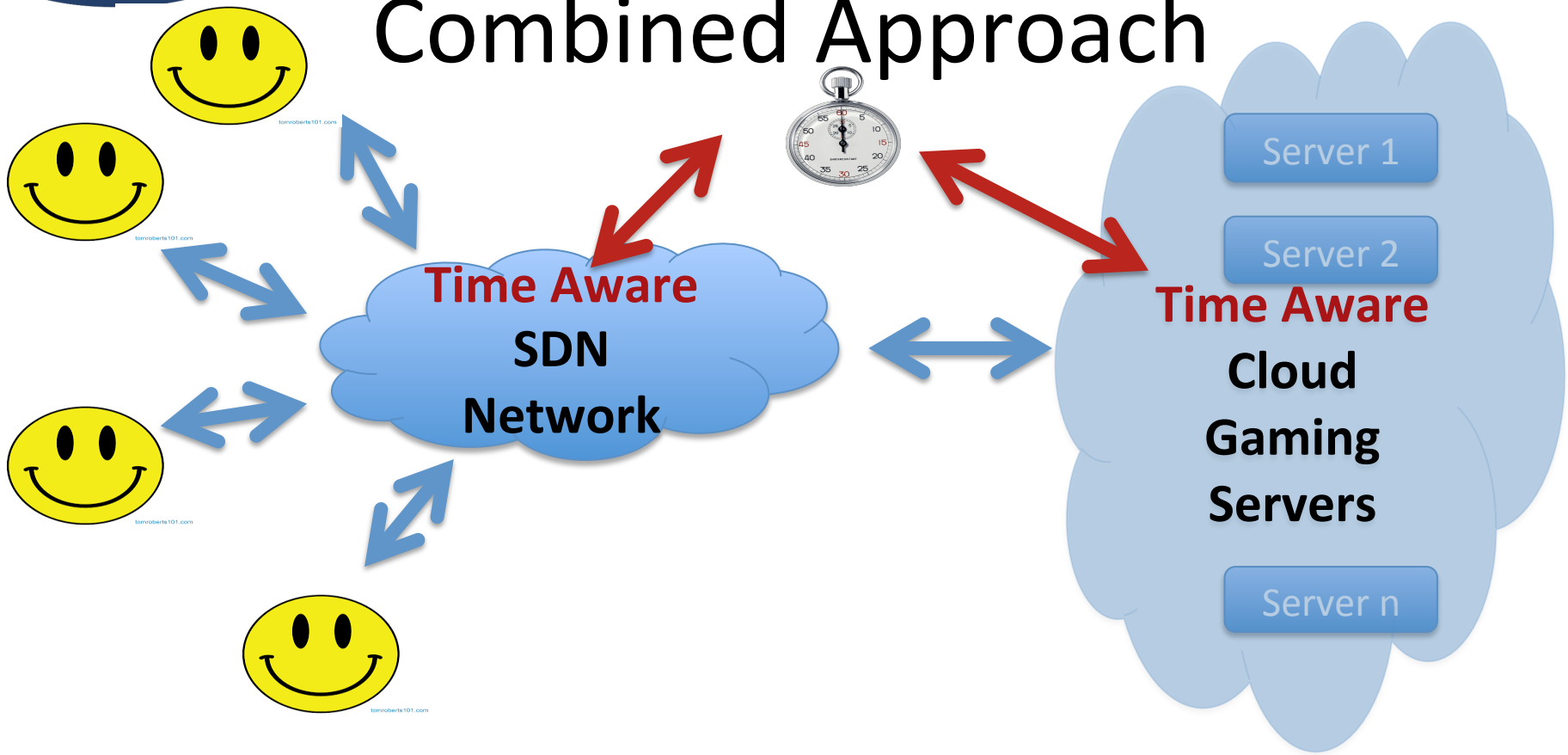
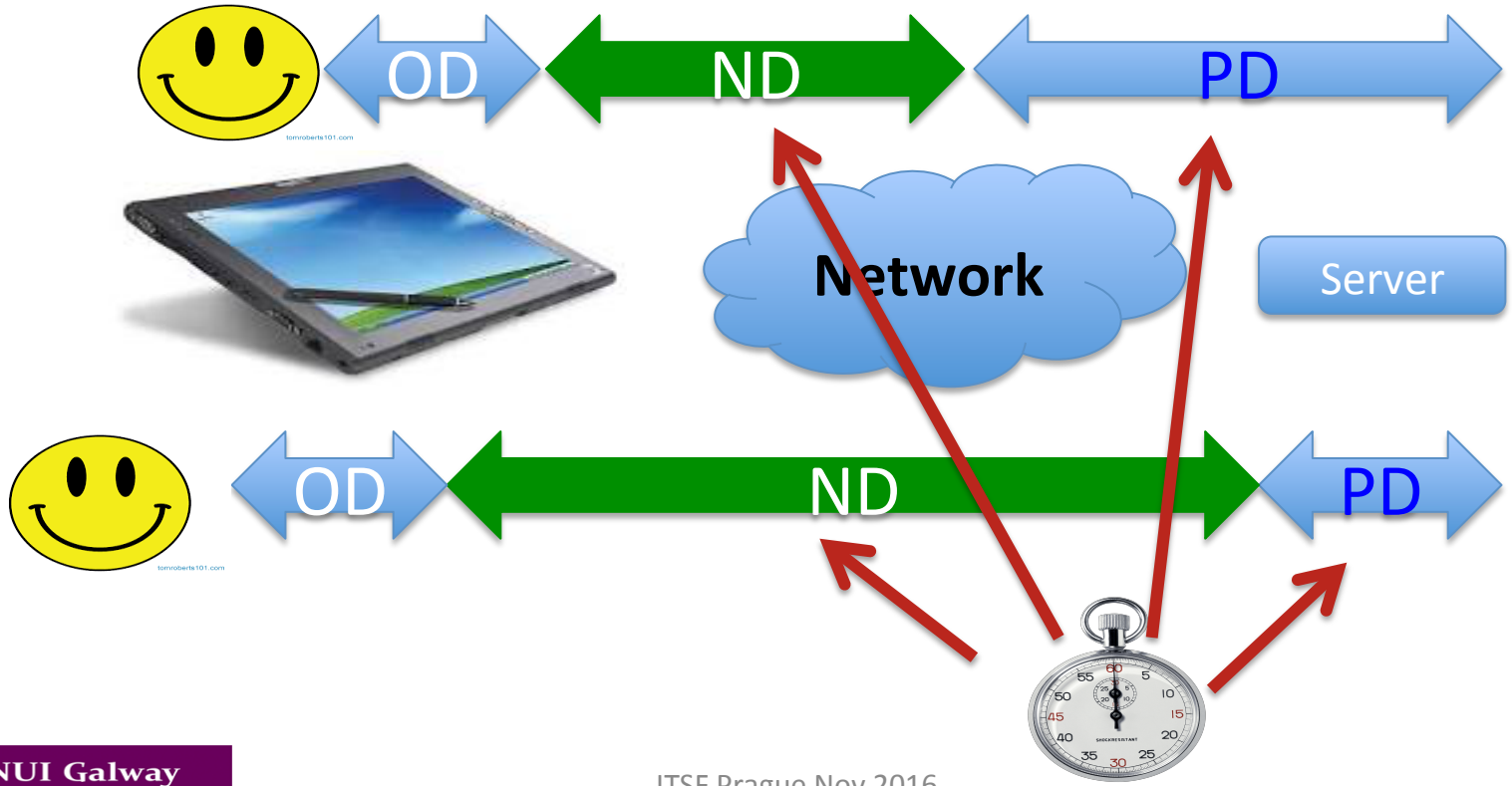
Server ..
Server n

Combined Approach



QoE Optimisation



Case Study : Gaming Anywhere

- Open source Cloud Gaming Platform
  - Released 2013
  - http://gaminganywhere.org/
- Platform for
  - Researchers
  - Game Developers

Gaming Anywhere[1]

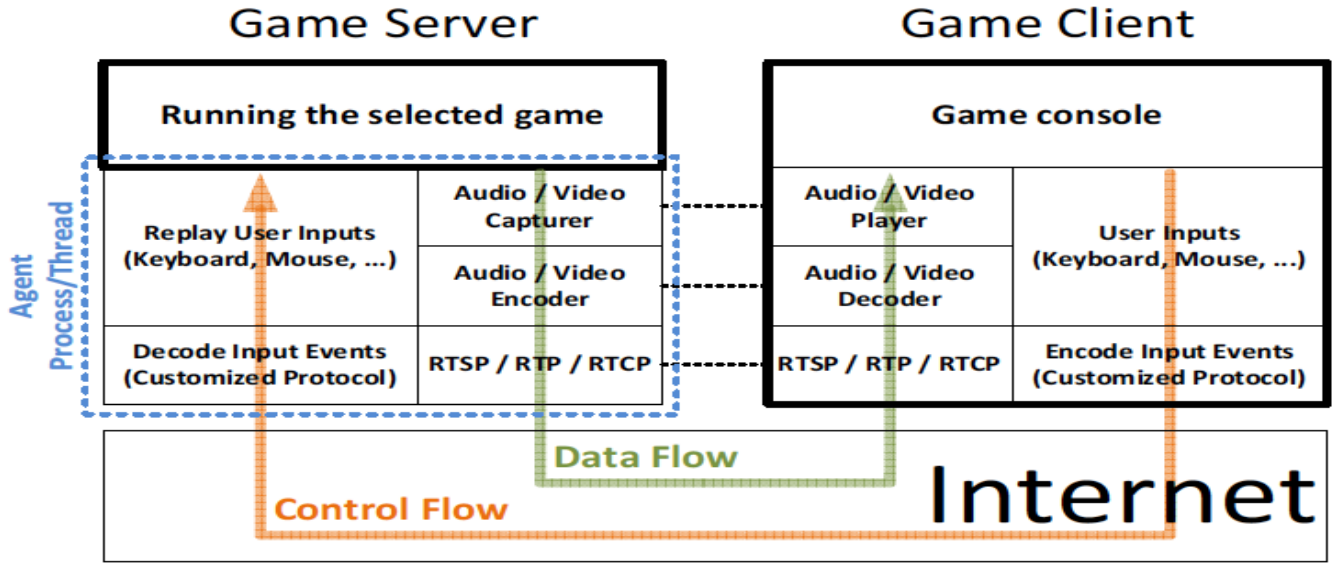


Figure 2: A modular view of GamingAnywhere server and client.

GA – Time Awareness

- Control Flow
  - User events sent to server
- Data Flow
  - Video streaming from server to client
- Use of RTP/RTCP
  - Facilitates delay measurement via NTP
  - Similar to SDN approach

Phase 1 –Server side

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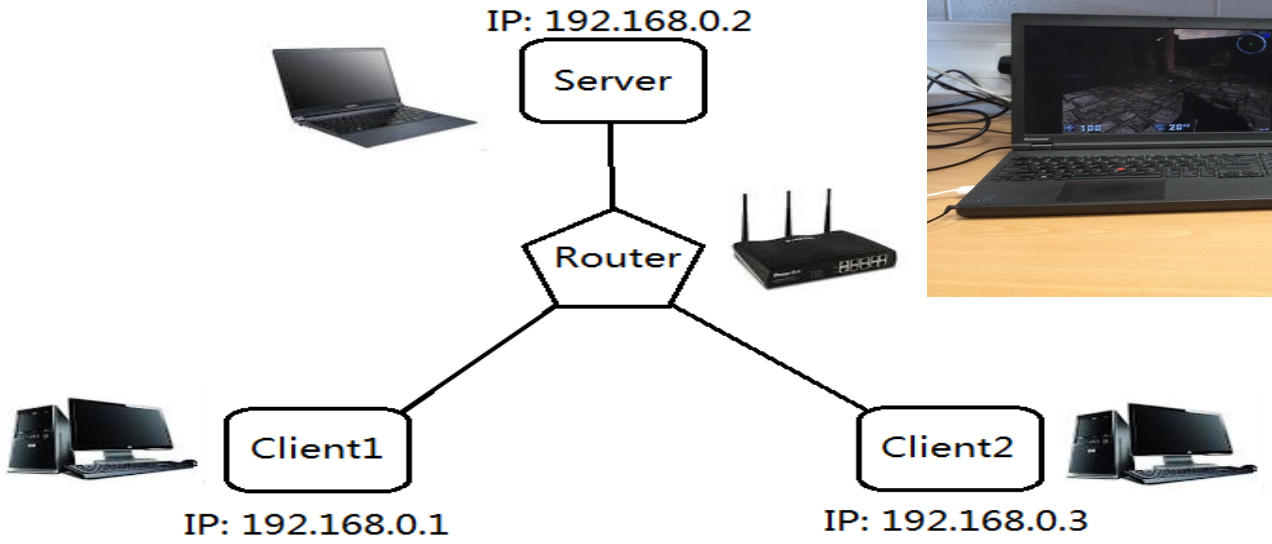
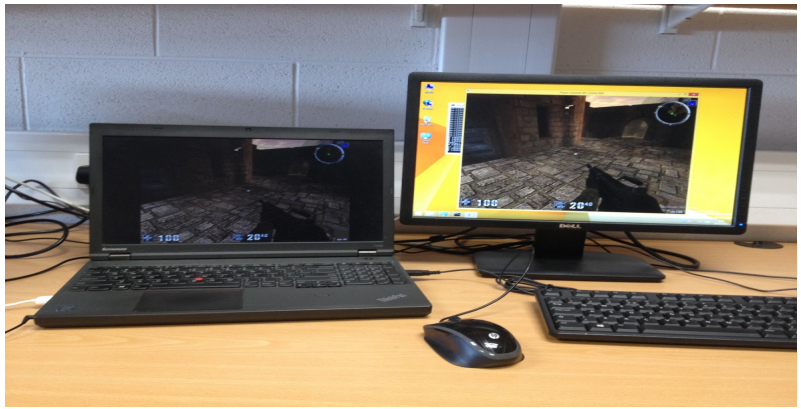
  - Server side delay management
  - Subjective Testing

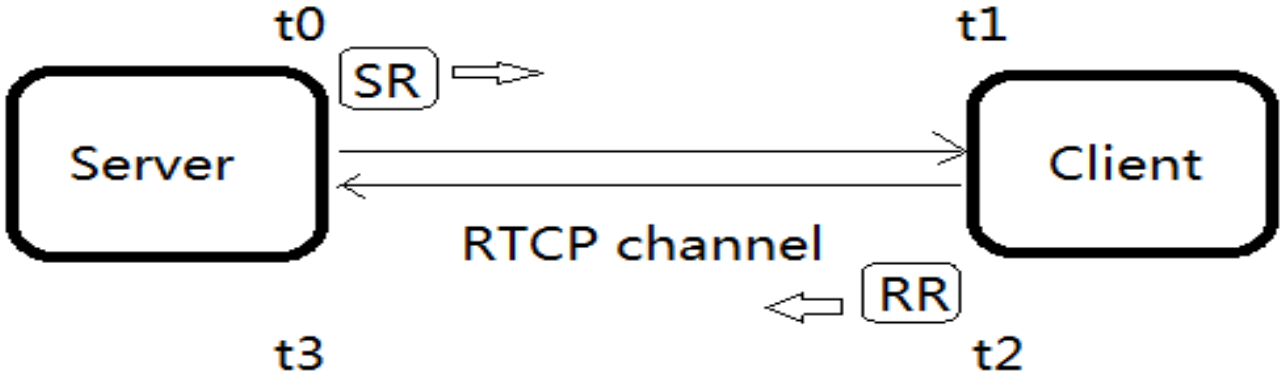
Testbed


IP: 192.168.0.2
Server
Router
Client1
IP: 192.168.0.1
Client2
IP: 192.168.0.3



Capturing each way delays

RTD = S➔C + C➔ S



File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

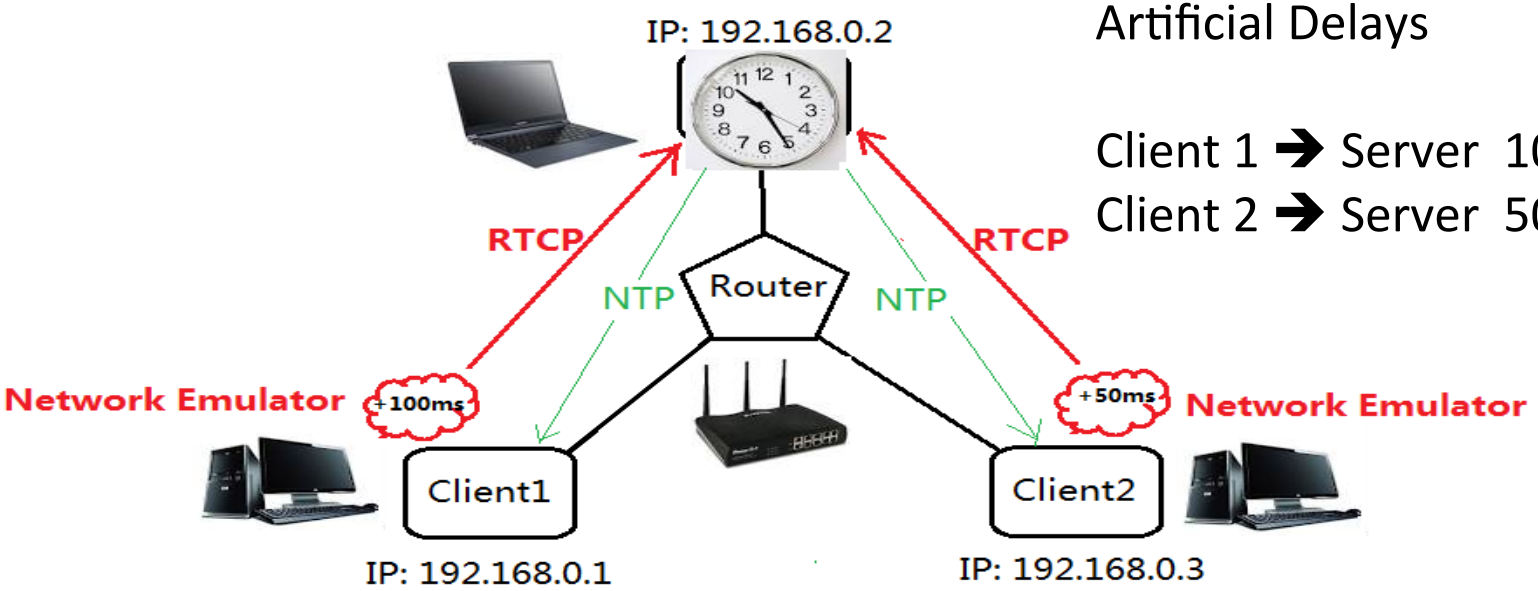
Filter: rtcp Expression... Clear Apply Save

No.	Time	Source			Destination		Protocol	Length	Info
64	7.398843000	192.168.0.2	Server	SR	192.168.0.3	Client2	RTCP	90	Sender Report Source description
65	7.406136000	192.168.0.2			192.168.0.3		RTCP	90	Sender Report Source description
389	9.129072000	192.168.0.3	Client2	RR	192.168.0.2	Server	RTCP	98	Receiver Report
703	9.820571000	192.168.0.2	Server	SR	192.168.0.1	Client1	RTCP	90	Sender Report Source description
704	9.820642000	192.168.0.2			192.168.0.3		RTCP	90	Sender Report Source description
879	10.088929000	192.168.0.3			192.168.0.2		RTCP	98	Receiver Report
971	10.247112000	192.168.0.1	Client1	RR	192.168.0.2	Server	RTCP	98	Receiver Report
1036	10.327148000	192.168.0.1			192.168.0.2		RTCP	98	Receiver Report
1039	10.352359000	192.168.0.2			192.168.0.1		RTCP	90	Sender Report Source description
1040	10.352439000	192.168.0.2			192.168.0.3		RTCP	90	Sender Report Source description
3492	14.313382000	192.168.0.3			192.168.0.2		RTCP	98	Receiver Report
3614	14.479642000	192.168.0.1			192.168.0.2		RTCP	98	Receiver Report
4039	14.922493000	192.168.0.3			192.168.0.2		RTCP	98	Receiver Report

Validating Mechanism

Emulator introduces
Artificial Delays

Client 1 ➔ Server 100ms
Client 2 ➔ Server 50ms



Client to Server Delavs

C:\ga-log\1499843820.dat - Notepad++

File Edit Search View Encoding Language Settings Macro Run Plugins Window ?

1499843820.dat | 3408064083.dat | 4115382362.dat | 179088728.dat

```
1  server_ssrc:3438222183;  client_ssrc:1499843820;  rtt:138;  s_to_c:25;  c_to_s:113
2  source identifier  destination identifier  roundTrip time  server_to_client  client_to_server
3  server_ssrc:3438222183;  client_ssrc:1499843820;  rtt:128;  s_to_c:17;  c_to_s:111
4
5  server_ssrc:3438222183;  client_ssrc:1499843820;  rtt:128;  s_to_c:17;  c_to_s:111
6
7  server_ssrc:3438222183;  client_ssrc:1499843820;  rtt:128;  s_to_c:17;  c_to_s:111
8
9  server_ssrc:3438222183;  client_ssrc:1499843820;  rtt:122;  s_to_c:6;  c_to_s:116
```

C:\ga-log\179088728.dat - Notepad++

File Edit Search View Encoding Language Settings Macro Run Plugins Window ?

1499843820.dat | 3408064083.dat | 4115382362.dat | 179088728.dat

```
1  server_ssrc:2261224598;  client_ssrc:179088728;  rtt:77;  s_to_c:8;  c_to_s:69
2  source identifier  destination identifier  roundTrip time  server_to_client  client_to_server
3  server_ssrc:2261224598;  client_ssrc:179088728;  rtt:71;  s_to_c:5;  c_to_s:66
4
5  server_ssrc:2261224598;  client_ssrc:179088728;  rtt:71;  s_to_c:5;  c_to_s:66
6
7  server_ssrc:2261224598;  client_ssrc:179088728;  rtt:66;  s_to_c:6;  c_to_s:60
8
9  server_ssrc:2261224598;  client_ssrc:179088728;  rtt:66;  s_to_c:6;  c_to_s:60
10
11 server_ssrc:2261224598;  client_ssrc:179088728;  rtt:79;  s_to_c:15;  c_to_s:64
12
```

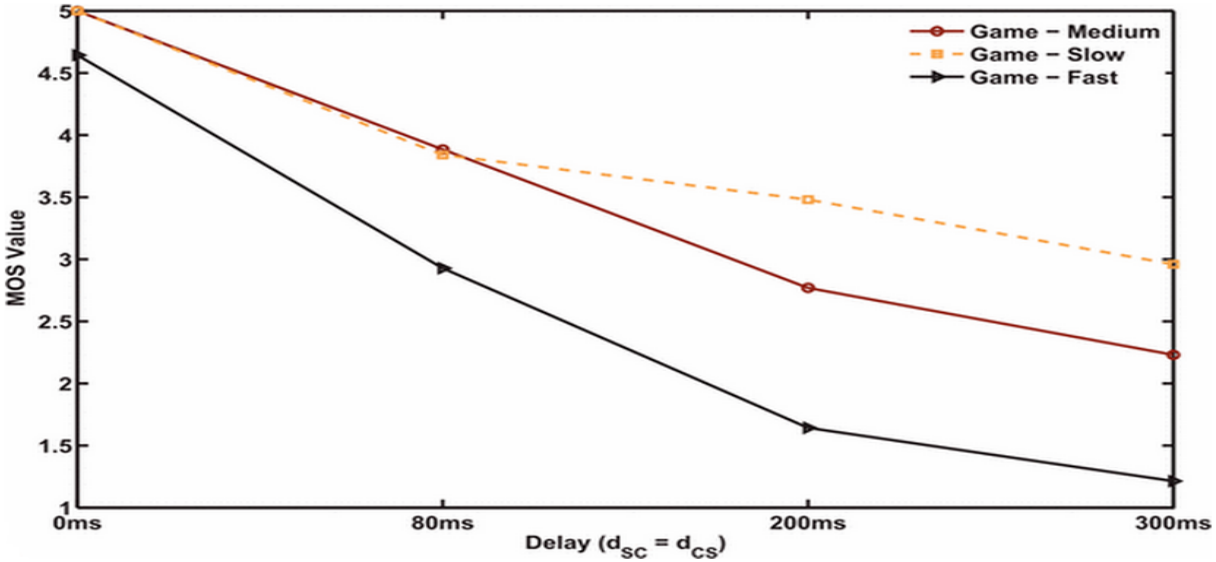
Spot typo? RTD , not RTT !

Phase 1 –Server side

- Monitor – Model – Manage - Test
- Process
  - Realtime network delay (ND) calculations
  - QoE model : delay ⟷ QoE
  - Server side delay management
  - Subjective testing

Delay ←→ QoE_2

- Wurzburg $University_2$
- University of Zagreb



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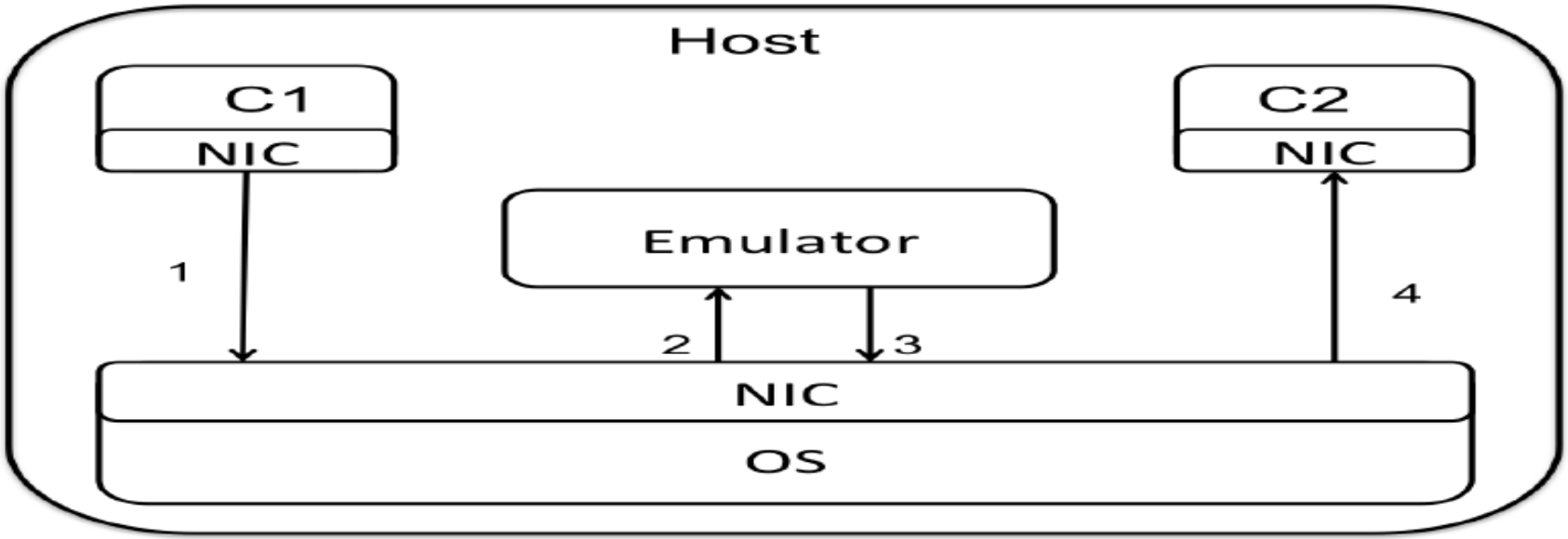
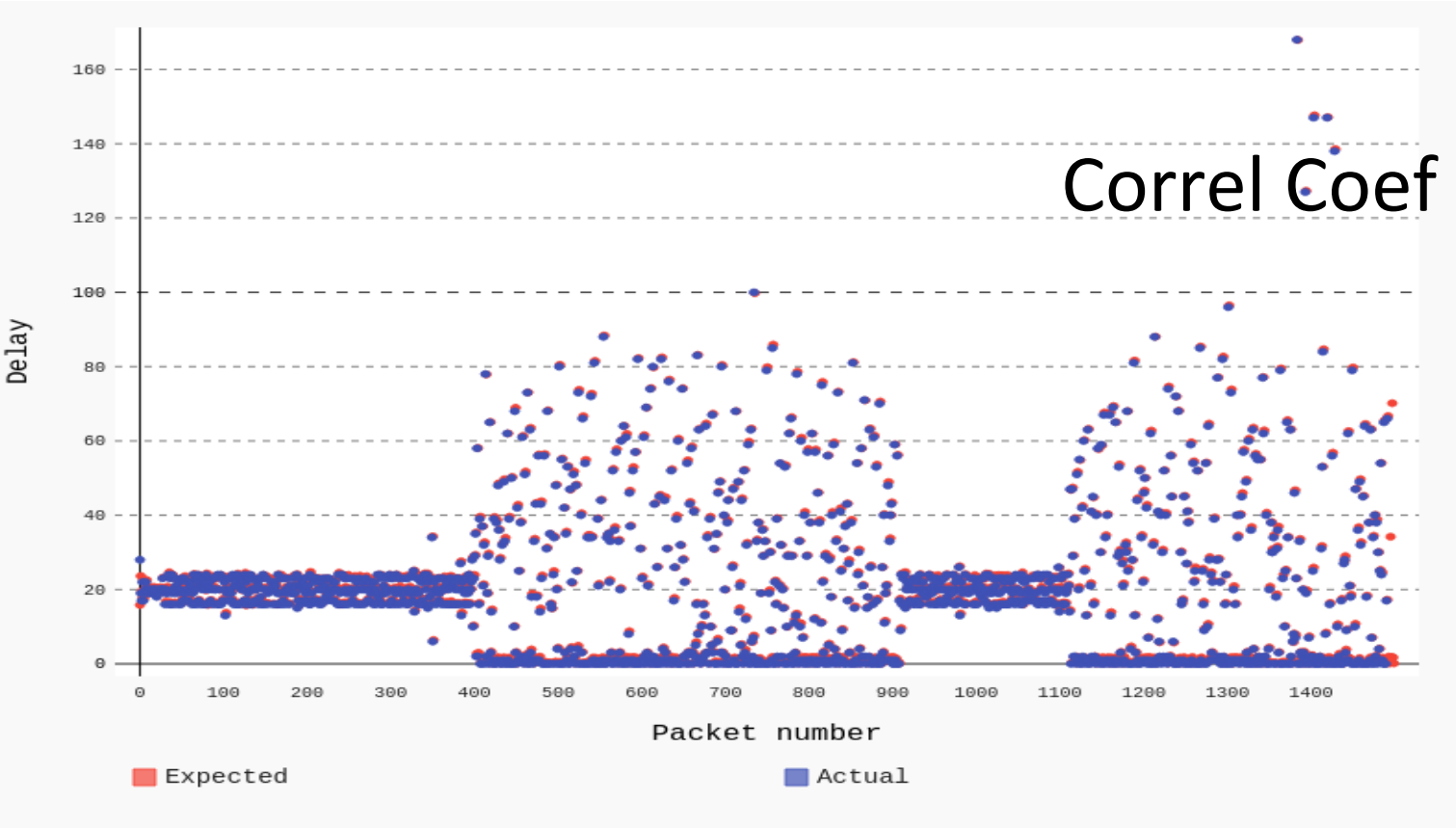
Delay Emulator: Linux Containers



Actual delay v Emulation ms



Correl Coef > 0.99

Phase 1 –Server side

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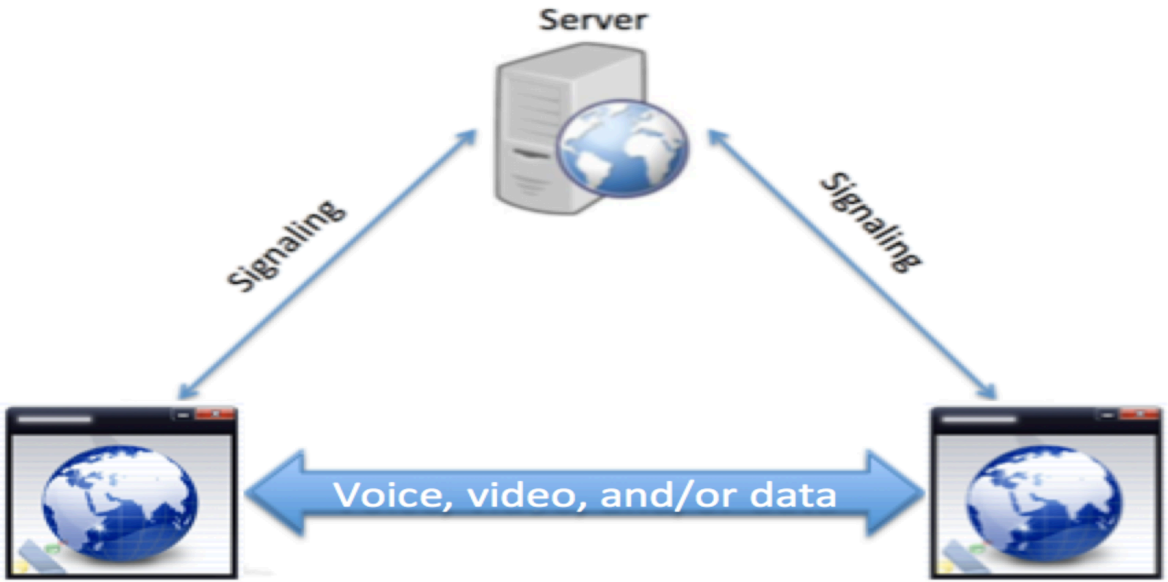
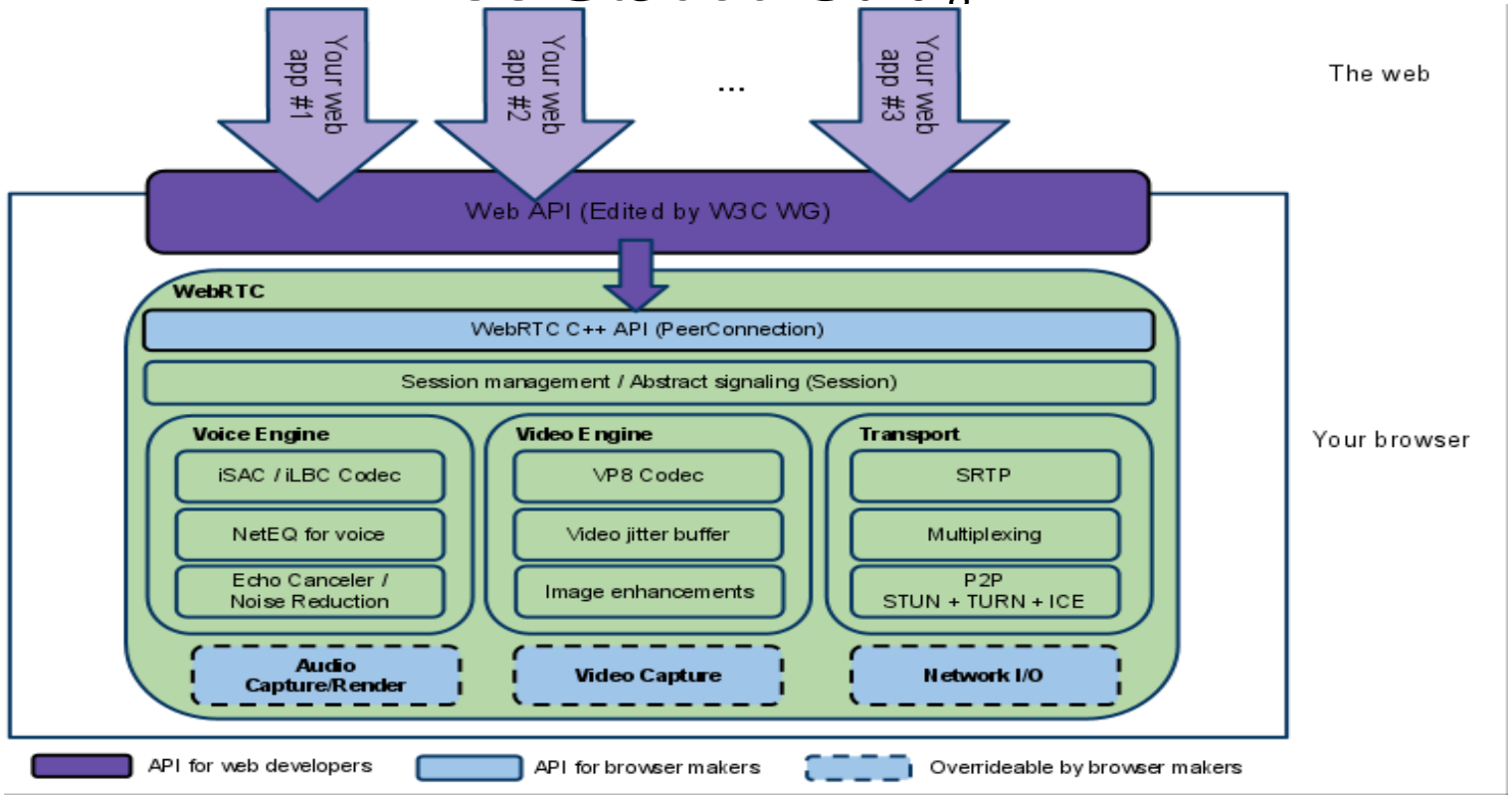
  - Subjective testing
    - University of Zagreb Spring 2017

WebRTC: Browser based RTC (2011)



WebRTC.org

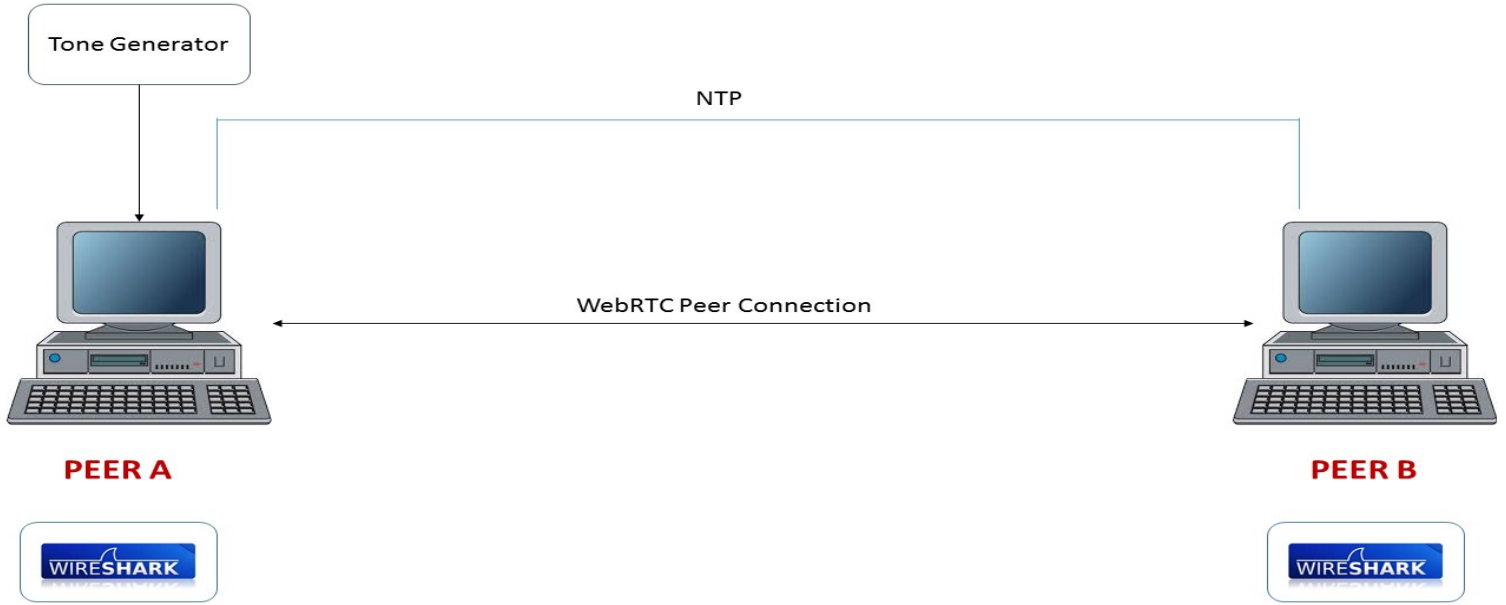

Your web app #1
Your web app #2
...
Your web app #3
The web
Web API (Edited by W3C WG)
WebRTC
WebRTC C++ API (PeerConnection)
Session management / Abstract signaling (Session)
Voice Engine
iSAC / iLBC Codec
NetEQ for voice
Echo Canceler / Noise Reduction
Video Engine
VP8 Codec
Video jitter buffer
Image enhancements
Transport
SRTP
Multiplexing
P2P STUN + TURN + ICE
Audio Capture/Render
Video Capture
Network I/O
Your browser
API for web developers
API for browser makers
Overrideable by browser makers

Scope of work

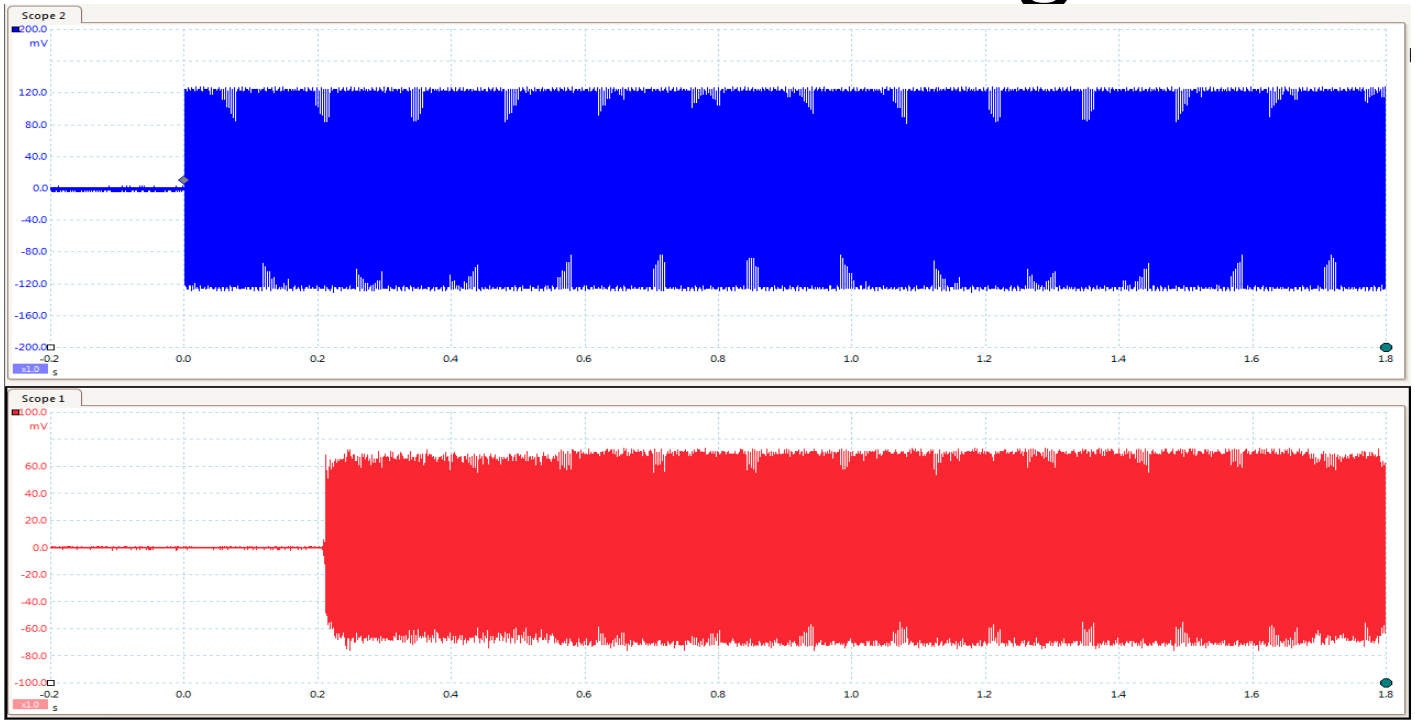
- Black box M2E delay testing
- Forensic M2E Analysis – packet timelines
- Time aware Jitter Buffer management

- Context ITU-T G.114
  - M2E delay
    - < 150 ms ideal
    - 150- 400 ms tolerable
    - > 400 unacceptable

Blackbox M2E Analysis



Blackbox Testing



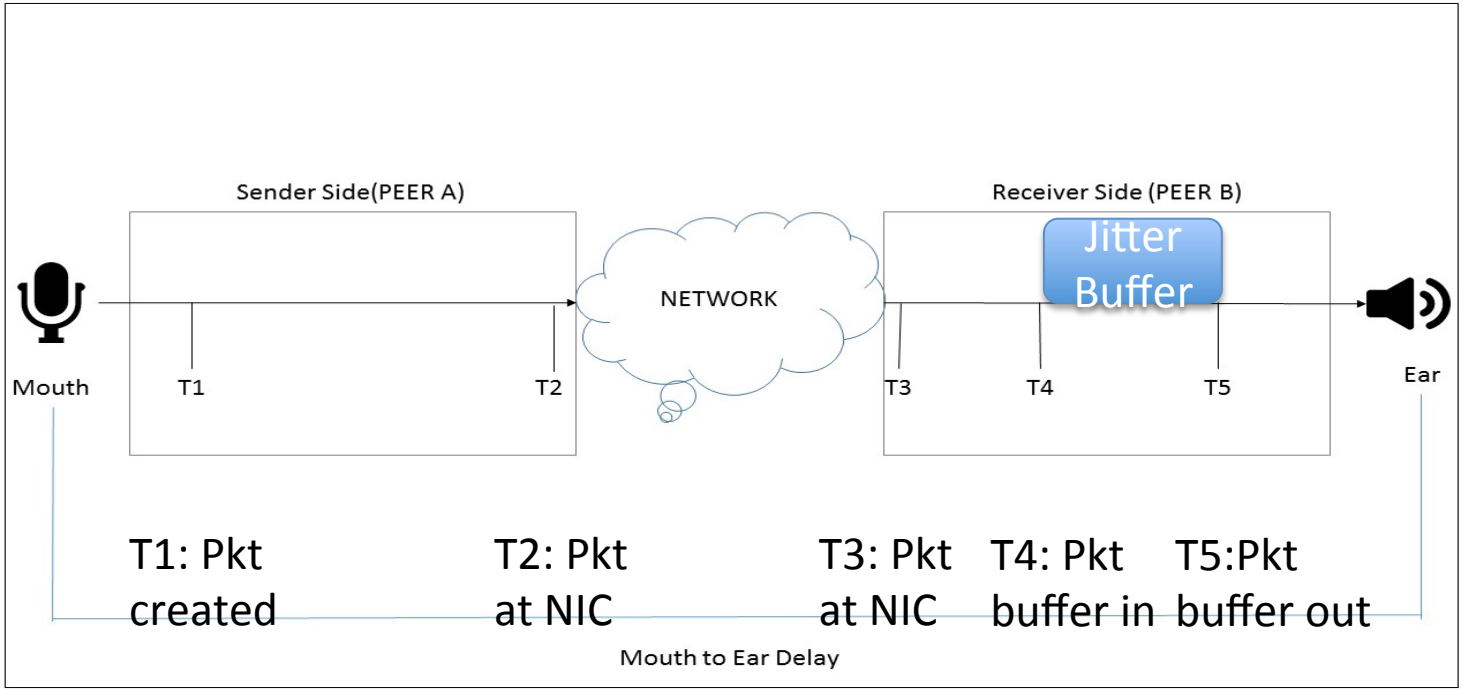
Blackbox Results
Enterprise LAN : < 2 ms delay

	G.711 10ms	G.711 20ms	G.711 40ms	Opus 10ms	Opus 20ms	Opus 40ms
min	100	119	158	108	126	137
max	161	141	170	164	142	173
average	125.93	128.19	163.64	129.47	134.69	163.81

Blackbox Results
Emulated Network: 50 ms +/- 10%

	G.711 10ms	G.711 20ms	G.711 40ms	Opus 10ms	Opus 20ms	Opus 40ms
min	173	193	222	177	202	228
max	227	221	304	201	233	340
average	190.2	203.18	255.63	192.4	210.8	260.73

Forensic M2E Analysis



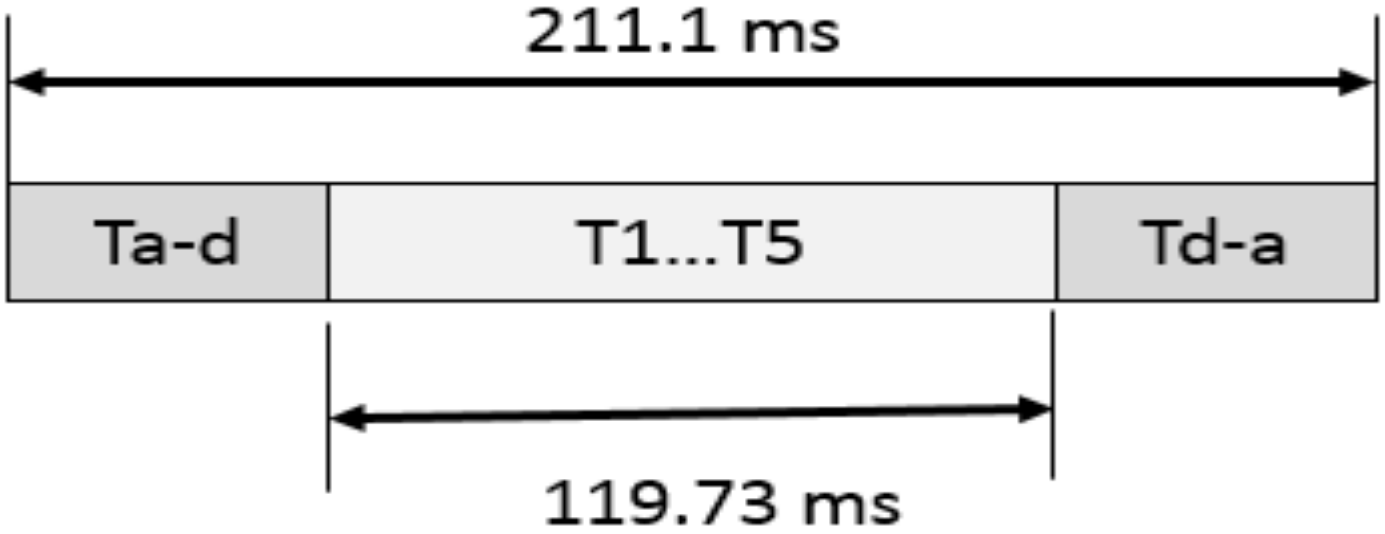
Forensic Timeline

	t2-t1	t3-t2	t4-t3	t5-t4
Seq	ms	ms	ms	ms
23085	1	3	9	74
23086	0	3	10	94
23087	0	0	7	95
23088	-1	0	7	106
23089	0	12	5	66
23090	3	12	7	80
23091	-2	9	6	101

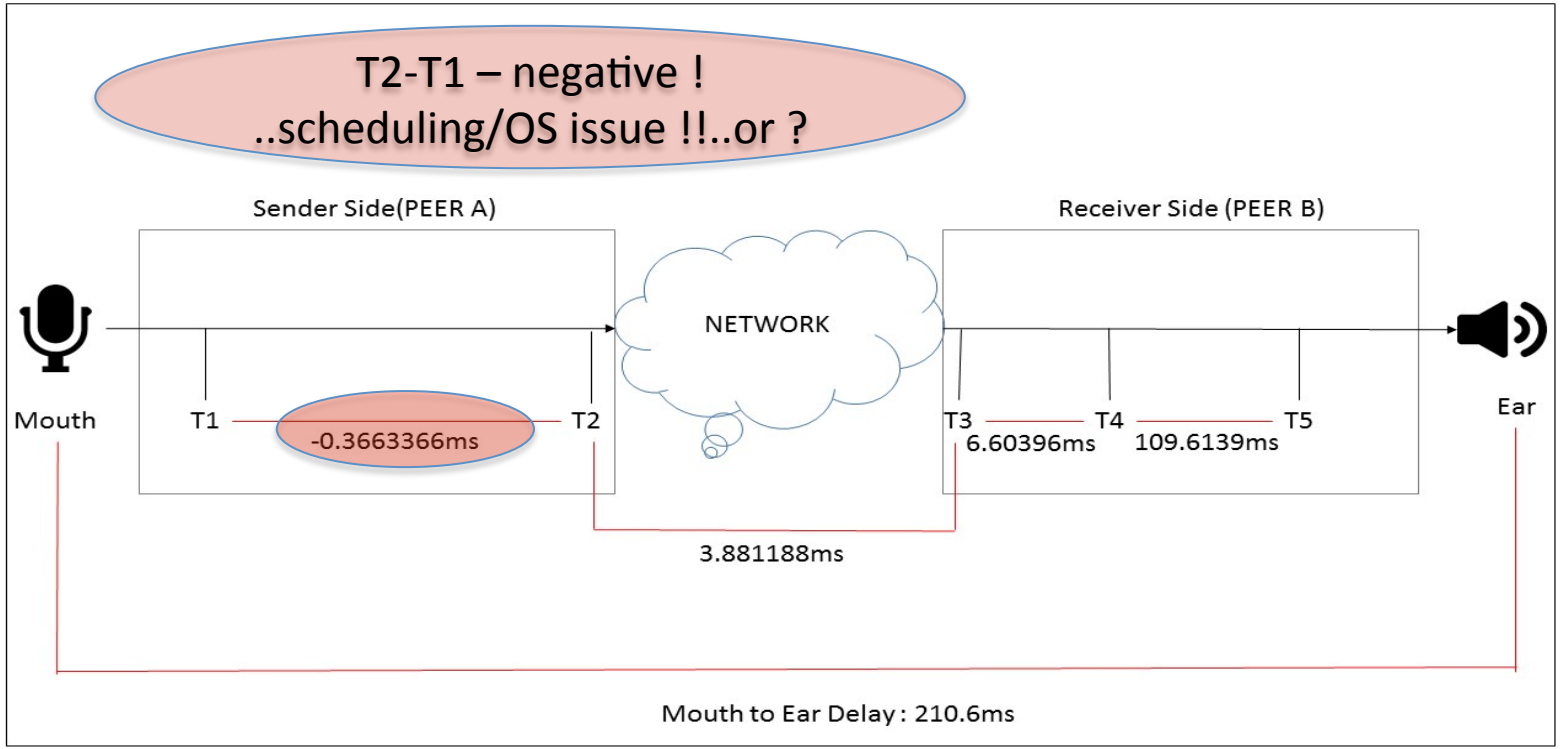
23184	0	6	6	106
23185	-2	4	6	120
AVERAGE	-0.4	3.9	6.6	109.6

-ve !!!

Forensic v M2E



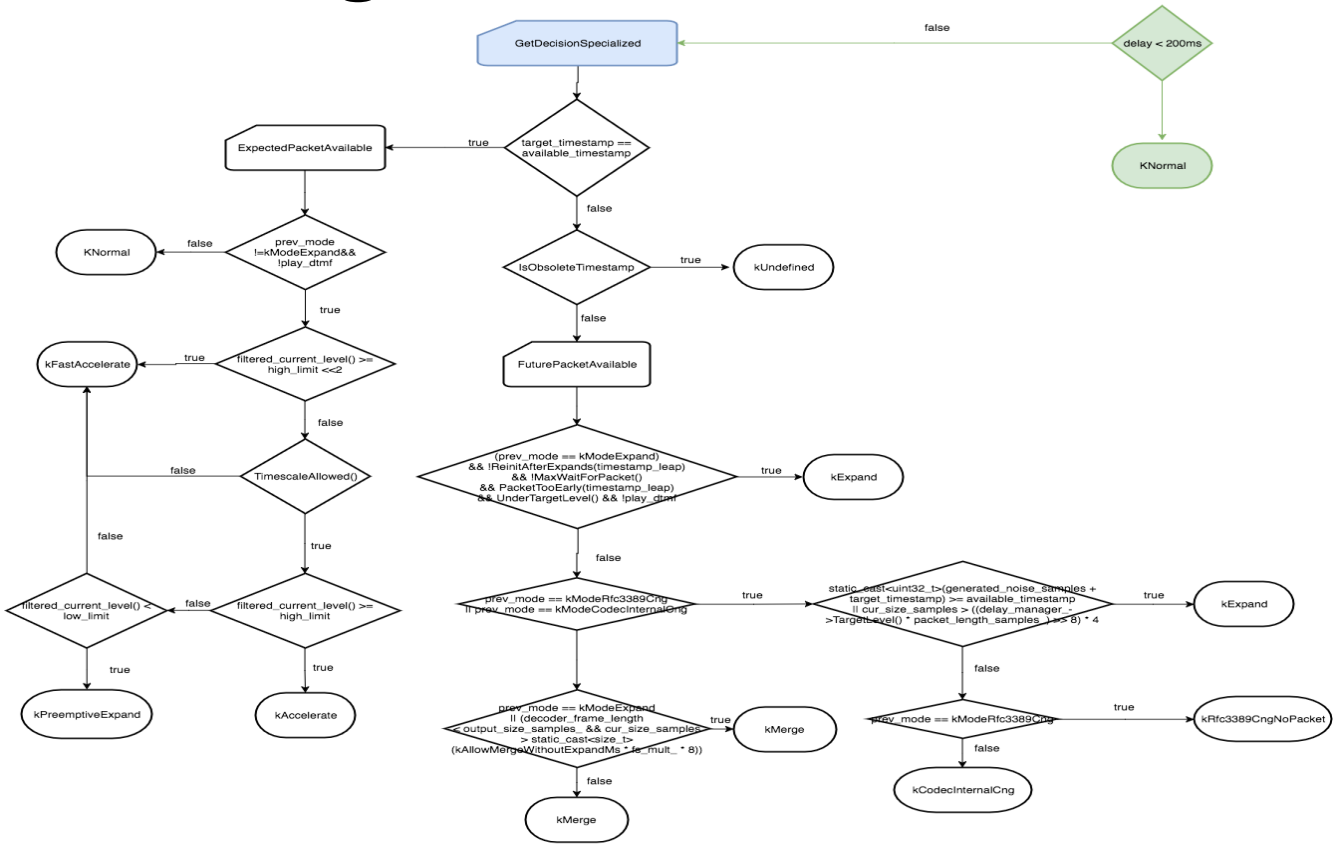
Forensic v M2E



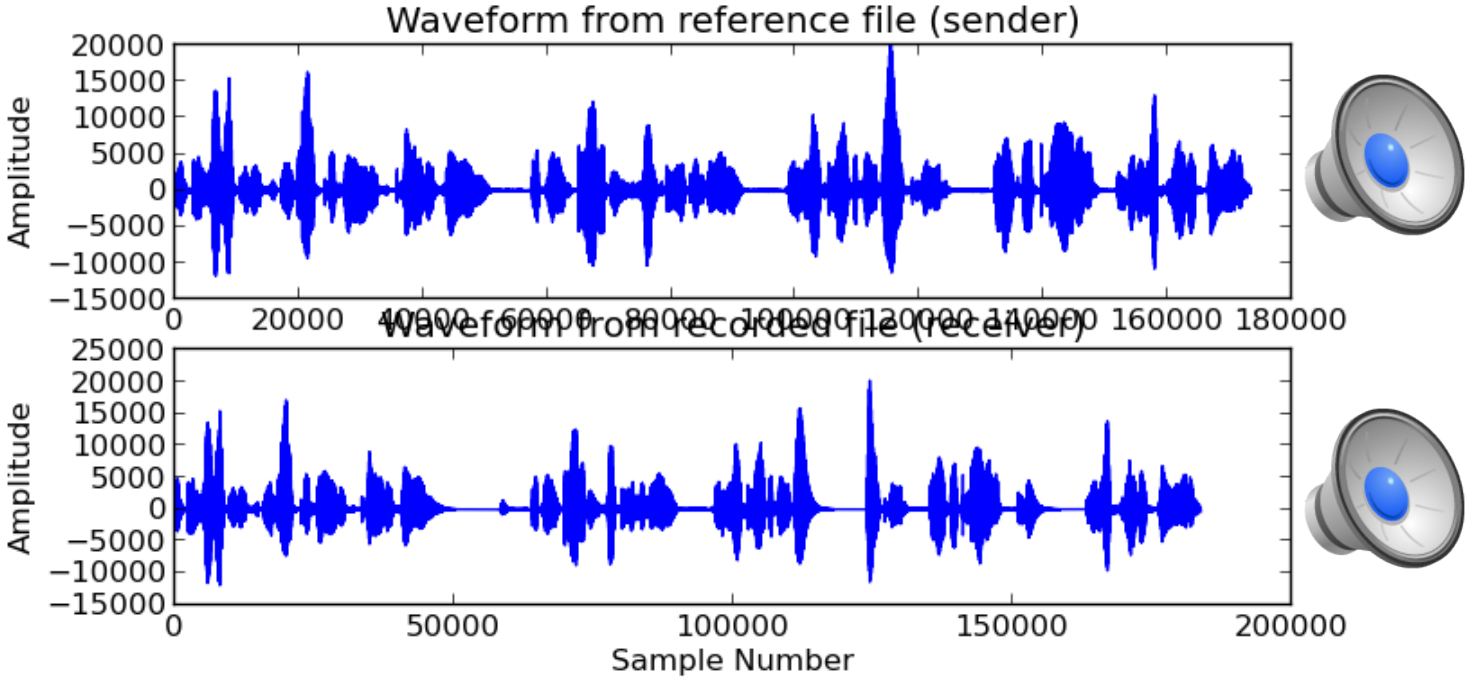
Insights

- Jitter buffer is key contributor
  - even when network delay is < 2 ms across enterprise LAN
- Need to target jitter buffer for M2E delay ⟷ QoE improvements
- Objectives : Time Aware Jitter Buffer
  - More informed playout delay
  - Reduced packet scaling

Existing WebRTC Jitter Buffer



Packet Scaling



Time Aware Jitter Buffer

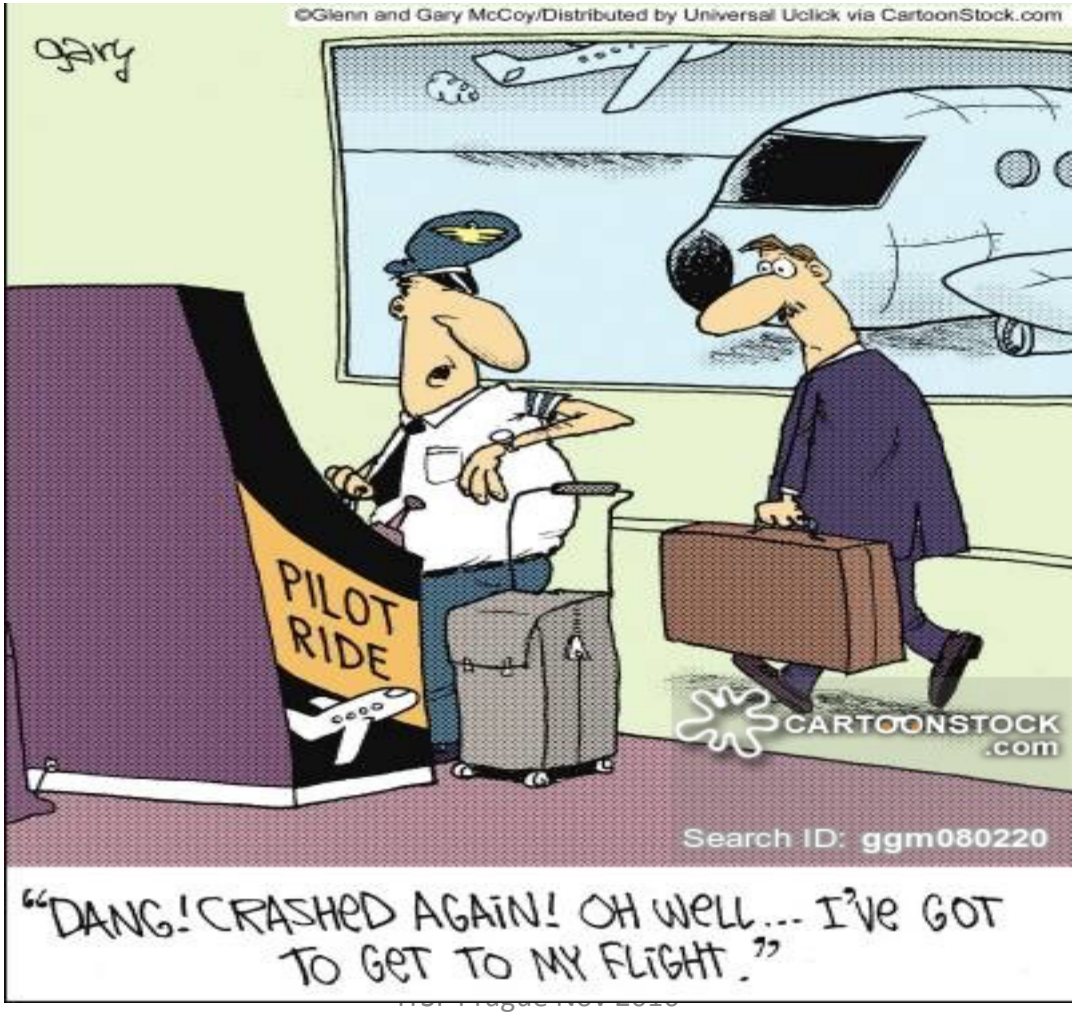
- Decisions made in context of ITU-T G.114
- Packet scaling
  - Useful mechanism to deal with
    - network jitter
    - clock skew
  - However
    - Adds complexity & delay
    - Impact on speech quality
    - ➔ Both impact negatively on QoE
- Time Awareness
  - Minimise delay
  - Minimise extent of scaling
  - Skew compensation during silence periods

Conclusions

- Time Awareness for RTC
  - Cloud Gaming
  - VoIP
- QoE improvement is driving factor
  - Cloud Gaming
    - Level the playing field for all
  - VoIP
    - Minimise
      - Delay
      - Extent of packet scaling
    - Better voice quality
- Endpoint Time Awareness is an ongoing concern
  - TAACCS & TCC (Time Coordinated Computing)

References

1. Chun-Ying Huang, Cheng-Hsin Hsu, Yu-Chun Chang, and Kuan-Ta Chen, "GamingAnywhere: An Open Cloud Gaming System," Proceedings of ACM Multimedia Systems 2013, Feb, 2013
2. Michael Jarschel, Daniel Schlosser, Sven Scheuring, Tobias Hoßfeld, "An Evaluation of QoE in Cloud Gaming Based on Subjective Tests", accessed on IEEE Xplore.
3. Claypool, Mark and Kajal Claypool, "Latency Can Kill: Precision and Deadline in Online Games", the Association for Computing Machinery, 2010.
4. Yusuf Cinar, Moha Alahmadi, Peter Pocta , and Hugh Melvin, "Containerisation in Multimedia Research Test Beds ", PQS, Berlin, Aug 2016
5. Moha Alahmadi, Yusuf Cinar, Peter Pocta, and Hugh Melvin, "Investigating the Extent and Impact of Time-Scaling in WebRTC Voice Traffic Under Light, Moderate and Heavily Congested Wi-Fi Aps", PQS Berlin, Aug. 2016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"DANG! CRASHED AGAIN! OH WELL... I'VE GOT TO GET TO MY FLIGHT."