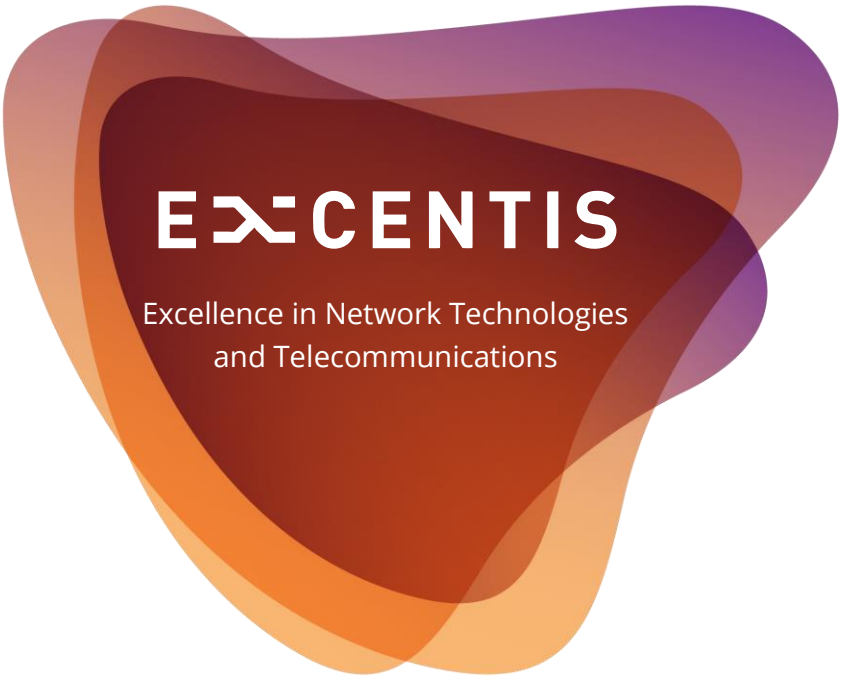

Telenor Denmark

Wi-Fi user experience assessment of Danish router/APs

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Project reference:	PROJ/2022/0184
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1. Executive summary

The aim of this test campaign was to show which gateways are more successful in delivering multiple wireless services to customers. For this, we tested and compared 11 selected gateways from the Danish market.

To achieve this goal, we created scenarios that approach real-life user cases as much as possible.

1. The definition of realistic scenarios implies that multiple users connect to the Wi-Fi network simultaneously for different common purposes like video conferencing, online gaming and media streaming.

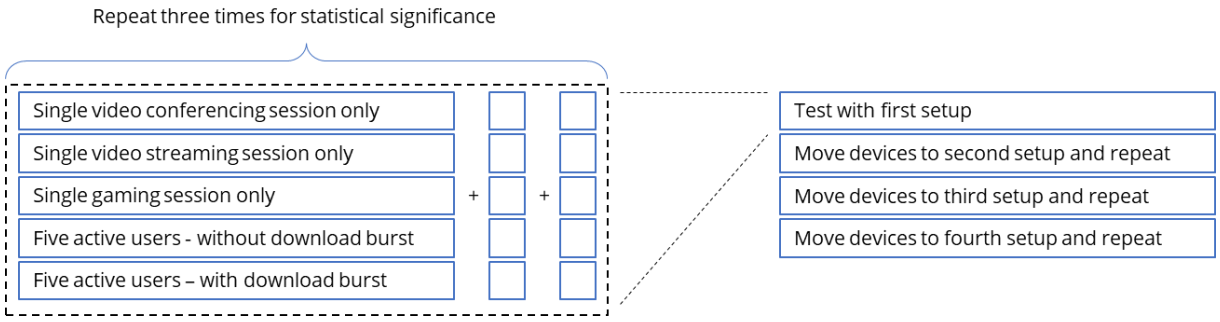
2. All testing was done in Excentis' Wi-Fi test house, which is a residential house that perfectly represents typical user environments. This yields more genuine results than doing similar testing in shielded Wi-Fi test boxes for instance.

To generate realistic load (media streaming, gaming traffic, …) for the Wi-Fi network, we made use of the Excentis ByteBlower solution.

Results overview

The results from the test campaign are presented in a table format. It shows how often the video conferencing, gaming and media streams could be used successfully over the tested scenarios.

Overview of the tested scenarios:



This approach resulted in 60 scenarios per gateway.

The table below shows how often the different user scenarios were successful for each gateway.

	Success rate of Wi-Fi test scenarios		
Gateway	**Video conferencing**	**Streaming media**	**Online gaming**
Kaon FA7550	96%	65%	85%
Technicolor DGA4330	96%	100%	94%
Kaon AP2400TN	92%	79%	96%
ZyXel E3300	96%	100%	88%
Sagemcom D6	92%	100%	100%
Icotera i4850	92%	93%	98%
ZTE MC801A	67%	71%	85%
Huawei H138	92%	90%	85%
Sagemcom F@ST3890V3	100%	60%	98%
Huawei H122	83%	86%	94%
Icotera i4882	100%	100%	100%

Legenda

Success rate	User experience
[98 – 100%]	Excellent
[95 – 98%]	Average
[85 – 95%]	Below average
< 85%	Unusable

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Figure 1: Succes rate of network applications for each gateway

Conclusions:

1. **Icotera i4882** performed best and had no scenarios where services were unavailable or showing unacceptable lag.
2. **Technicolor DGA4330, ZyXEL E3300, Sagemcom D6 and Icotera i4850** performed good with a limited number of failed scenarios (never below 85% success rate)
3. Average performance for:
    a. **Kaon AP2400TN and Sagemcom F@ST3890** for a very low success rate in a single particular service (for example conferencing and media are good, but gaming results are bad).
    b. **Huawei H138** for a low success rate overall.
4. **Kaon FA7550, ZTE MC801A, Huawei H122** performed below average the most for multiple services.

Additional observations:

1. During testing, the 5 GHz SSID on Icotera i4850 was no longer present on a single occasion. This was verified with a wireless scan. A device reboot restored proper operation.
2. Both Huawei gateways cannot be configured to have the same SSID on both the 2.4 and 5 GHz band. This negatively affected the wireless clients' choice of optimal Wi-Fi band during testing.
3. The Icotera i4882 does not allow web page access when it is offline. This is just a remark as it has not influenced the behaviour or test results.

2. Devices under test

Gateway 1

- Model: Kaon FA7550
- Firmware: FA7550.V1.04-234314
- Serial number: 080220900216

Gateway 2

- Model: Technicolor DGA4330
- Firmware: 18.3
- Serial number: CP2007RA6JE

Gateway 3

- Model: KAON AP2400TN
- Firmware: 1.0.22
- Serial number: 073220800000570

Gateway 4

- Model: ZyXEL EX3300-T0
- Firmware: V5.50 (ABVY.3.1)C0
- Serial number: S220Y24084033

Gateway 5

- Model: Sagemcom 5380 D6
- Firmware: SGI210120C
- Serial number: N7220887O004132

Gateway 6

- Model: Icotera i4850
- Firmware: 4850-1.19.2
- Serial number: 4850000922303972

Gateway 7

- Model: ZTE MC801A
- Firmware: BD_FITELIAMC801AV1.0.0B1
- Serial number: 863671046348409

Gateway 8

- Model: Huawei H138-380
- Firmware: 11.0.5.51 (H14OSP13C9831)
- Serial number: SMF6R22526000123

Gateway 9

- Model: Sagemcom F@ST3890V3
- Firmware: F@ST3890V3_TDC_SIP_sw18.76.10.11i
- Serial number: DM1815618005326

Gateway 10

- Model: Huawei H122-373
- Firmware: 11.0.2.9
- Serial number: 49VUT21524002484

Gateway 11

- Model: Icotera i4882-71
- Firmware: unknown (no web page access)
- Serial number: 4882710011117

3. Project description

The goal of this test campaign is to find out how well Wi-Fi gateways can provide service to multiple users that occupy the Wi-Fi network with common use cases. This includes video conferencing, video streaming, gaming and file downloads.

To achieve this, the focus of the work was on latency measurements in scenarios that approach this realistic customer behaviour.

Devices and test locations

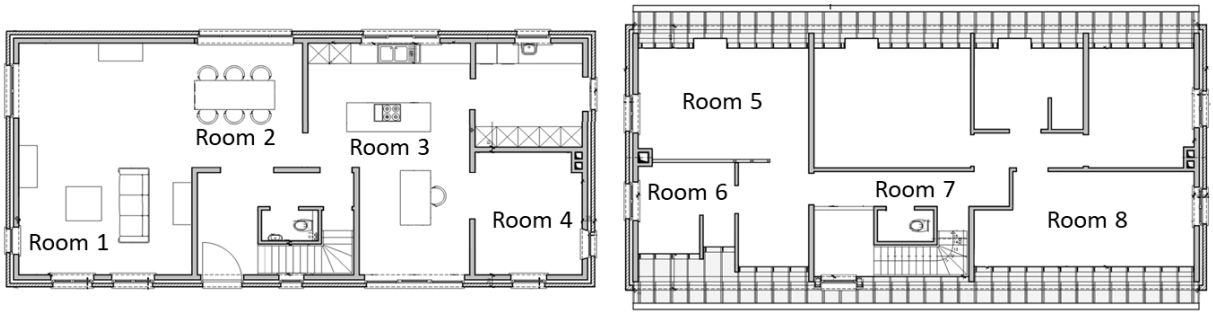
Six Wi-Fi users were defined with their own network occupation:

1. One user participates in a video conference.
2. Three users are watching video streams.
3. One user is gaming.
4. One user downloads a file.

Additionally, three of the users are mobile and will be tested in different rooms of the house.

1. The video conferencing user is tested in rooms 1, 2, 3 and 4.
2. One of the video streaming users is tested in room 3, 4, 5 and 6.
3. The gaming user is tested in rooms 6, 7, 8 and 1

The remaining three users are in fixed locations.



The location of all six users in the different test iterations is shown in the appendix document paragraph 1.

The pictures below give an impression of the environment in which the tests are done, to accentuate the real-life character.

Figure 2: outside view of the test house

Figure 3: Living room on the ground floor

Wi-Fi gateway configurations

All the gateways were left on their out-of-the-box default settings as much as possible. Only the SSID and passwords were changed to let all the wireless clients connect to new gateways without manual intervention.

4. PASS/FAIL criteria

4.1 Video streams

The user experience criteria that are defined for a video stream are the following:

1. Video must play uninterrupted

   This is related to the minimum throughput required to keep the video buffer filled up. Occasional dips or gaps in the throughput are not a problem as long as the buffer never runs empty.

   The example below shows a fail case, where no video packets are incoming during the length of User 6's download burst.

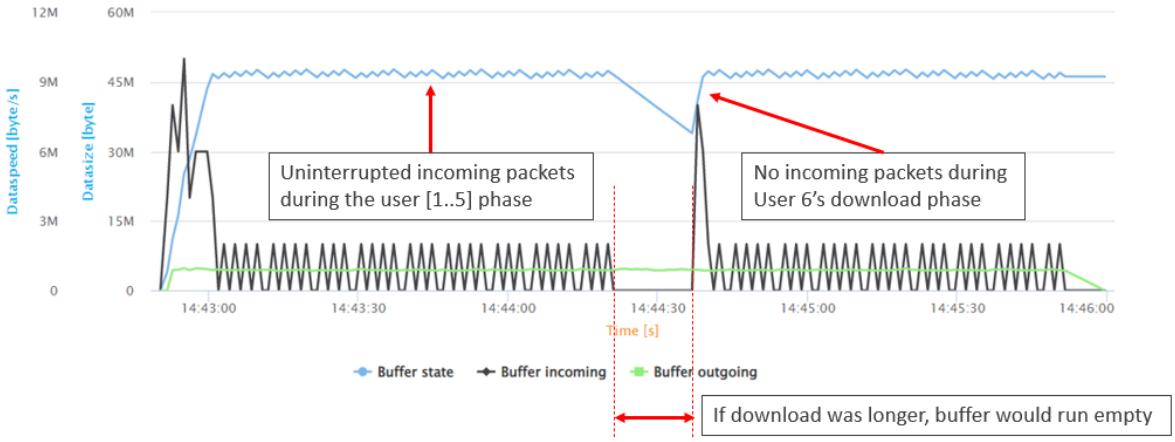


Figure 4: Example FAIL case during the download burst

2. Video must start fast enough at the start

   The initial data rate is higher than the stable video rate because the video buffer needs to fill up. Once the buffer has been filled up sufficiently, the video starts playing. This delay should not be too large. Latency parameters for a video stream are less important once the video is playing.

   The example below shows interrupted incoming packets and a delay larger than 5 seconds before video starts.

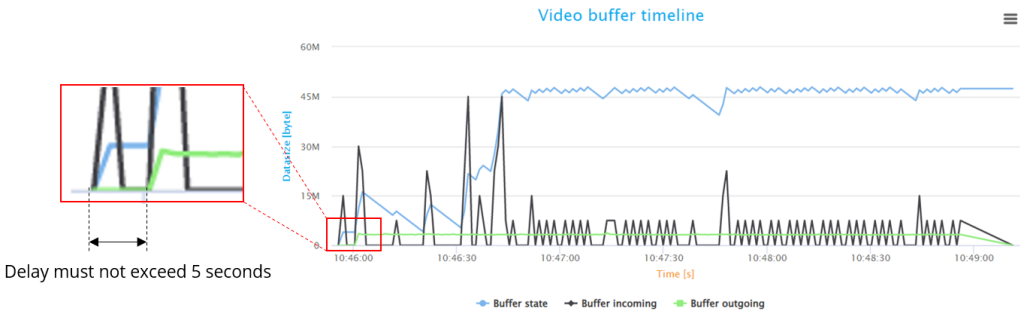


Figure 5: FAIL case for video start delay

4.2 Video conference

Unlike a video stream, a video conference does suffer from latency much more. The user experience is characterized by:

1. Latency cannot be too high.

   Any voice or video call with excessive lag causes the conversation to be very unpleasant. Note that latency on the Wi-Fi layer is added on top of the access network latency. With an advertised access network maximum of [100-150 ms] maximum, the Wi-Fi layer can only constitute a small portion of that. In the absence of clearly defined minima and maxima, this project used a limit of 40 ms.

2. The data speed must remain high enough to support the media session.

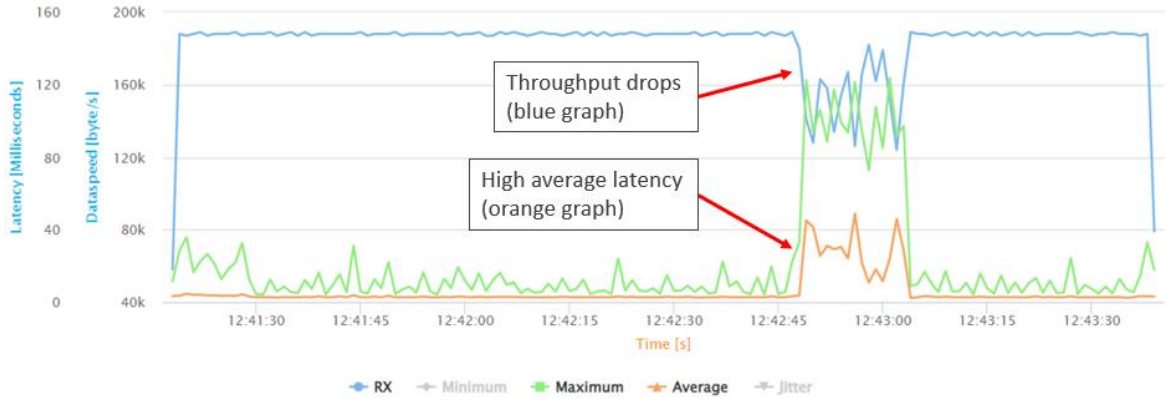


Figure 6: FAIL case: 20 second interval with high latency and throughput drop

4.3 Online gaming

Similar to the video conference, the focus for online gaming user experience is on low-latency. An online gamer with a lagging game will complain about very poor user experience.

The criteria are more strict than for a video call. The total latency, including access network latency, must not exceed 100 ms and is recommended to be below 40 ms. This means that the latency in the Wi-Fi layer itself must be well below that.

The example below shows a gaming session with excessive latency, especially during the first 30 seconds.

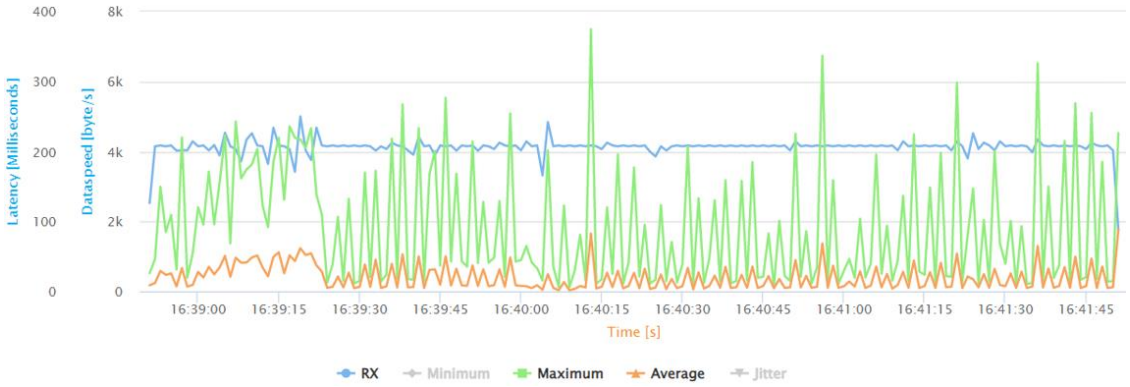


Figure 7: High latency during gaming session

5. Traffic patterns

Video conference

The video conference is built up of two flows:

- Downlink UDP flow 1.5 Mbps
- Uplink UDP flow 1.5 Mbps

Online gaming

- Consists of two flows (downlink + uplink)
- UDP with mixed packet sizes between 22 and 1480 byte payload.
- Packet rate 30 fps.
- Modelled after captures of actual gaming sessions.

Video stream

- Video streams are a downlink 6.4 Mbps TCP flow.

Download burst

- The download burst is a UDP flow with a duration of 15 seconds that occurs in the middle of the 3-minute flows of the other users.
- It was found that during the scenarios with all six clients sharing Wi-Fi airtime, this flow would top around 60 Mbps. This rate was then set as fixed for the UDP download to represent a high airtime user. Higher rates than 60 Mbps only resulted in higher packet loss for this particular flow.

6. Results

6.1 User 1 (video conference)

Use the appendix document paragraph 2.2 and the Excel analysis sheet "User 1"

The Excel sheet shows the detailed latency information for each iteration for each gateway. The fail cases are marked in red.

Gateway	Success rate	Remark
Kaon F7550	96 %	In a few scenarios, latency peaks are present and data speed drops during the dowload burst.
Technicolor DGA4330	96 %	
Kaon AP2400TN	92 %	High latency peaks in slightly more scenarios.
ZyXEL EX3300	96 %	In a few scenarios, latency peaks are present and data speed drops during the dowload burst.
Sagemcom D6	92 %	High latency peaks in slightly more scenarios.
Icotera i4850	92 %	
ZTE MC801A	67 %	Higher latencies and data speed drop in a large number of scenarios, in particular all scenarios with the download burst.
Huawei H138	92 %	All data stopped during download burst in one iteration.
Sagemcom F@ST3890V3	100 %	There were no large latency peaks or data speed drops.
Huawei H122	83 %	Data forwarding stopped during some scenarios with the download burst.
Icotera i4882	100 %	Even though there were some larger peaks in maximum latency, the average latency remained low.

6.2 User 2 (video stream)

Use the appendix document paragraph 3.2 and the Excel analysis sheet "User 2"

The Excel sheet shows the detailed buffer information for each iteration for each gateway. The fail cases are marked in red.

Gateway	Success rate	Remark
Kaon F7550	100 %	Even though many gaps are present in the incoming data, the video buffer is never at risk of running empty
Technicolor DGA4330	100 %	Video playback starts quickly and no gaps in the data
Kaon AP2400TN	100 %	
ZyXEL EX3300	100 %	
Sagemcom D6	100 %	
Icotera i4850	92 %	Gaps in the data during the download burst
ZTE MC801A	92 %	
Huawei H138	92 %	
Sagemcom F@ST3890V3	33 %	No incoming data packets during any of the multi-user scenarios
Huawei H122	83 %	Large data gaps in iteration 3, with no recovery after the download burst.
Icotera i4882	100 %	Video playback starts quickly and no gaps in the data

6.3 User 3 (online gaming)

Use the appendix document paragraph 4.2 and the Excel analysis sheet "User 3"

The Excel sheet shows the detailed buffer information for each iteration for each gateway. The fail cases are marked in red.

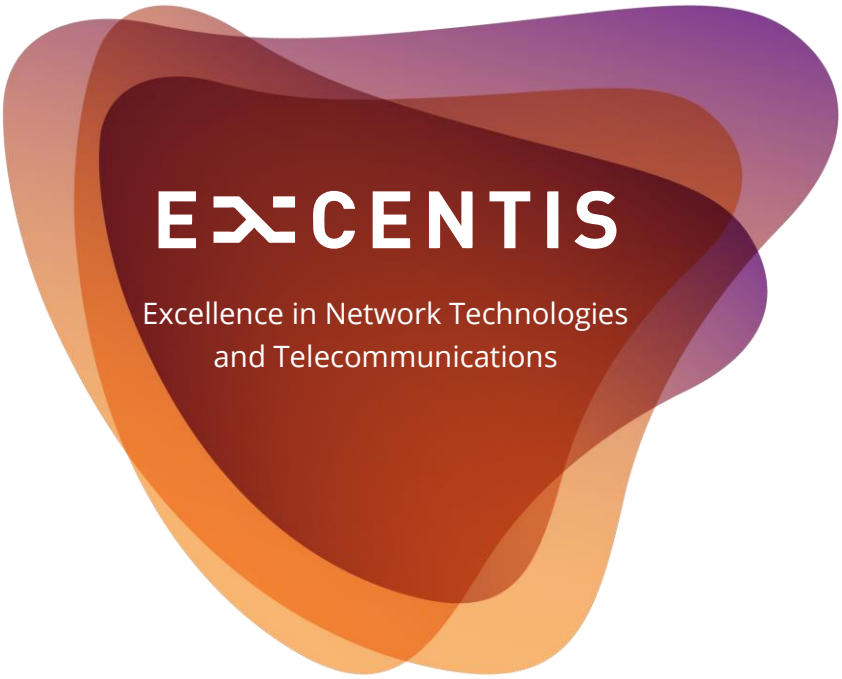
Gateway	Success rate	Remark
Kaon F7550	85 %	High uplink latency during download burst in most scenarios
Technicolor DGA4330	94 %	High uplink latency during download burst in some scenarios
Kaon AP2400TN	96 %	High uplink latency during download burst in a few scenarios
ZyXEL EX3300	88 %	High latency peaks even outside the download burst, but only in the first iteration.
Sagemcom D6	100 %	Low latency and no data speed drops
Icotera i4850	100 %	
ZTE MC801A	85 %	Latency peaks and data speed drops during the download bursts.
Huawei H138	85 %	
Sagemcom F@ST3890V3	100 %	Low latency and no data speed drops
Huawei H122	94 %	Very high but short latency peaks during the download burst.
Icotera i4882	100 %	Low latency and no data speed drops

6.4 Users 4 + 5 (video streams)

Use the appendix document paragraph 5.2 and the Excel analysis sheet "User 4 and 5"

The Excel sheet shows the detailed buffer information for each iteration for each gateway. The fail cases are marked in red.

Gateway	Success rate	Remark
Kaon F7550	38 %	Many large data gaps with User 5 in all scenarios, gaps with User 4 in some scenarios.
Technicolor DGA4330	100 %	Relatively short gaps with User 5, but video buffer never runs empty
Kaon AP2400TN	63 %	Large data gaps in multiple scenarios for User 5
ZyXEL EX3300	100 %	Relatively short gaps with User 5, but video buffer never runs empty
Sagemcom D6	100 %	
Icotera i4850	94 %	No data during the download burst in iteration 3
ZTE MC801A	56 %	Many largedata gaps with User 5 in all scenarios, gaps with User 4 in some scenarios.
Huawei H138	88 %	Gaps in the data during the download burst in some iterations
Sagemcom F@ST3890V3	81 %	Large gaps in the data during iteration3, even outside the download burst.
Huawei H122	88 %	Gaps in the data during the download burst in some iterations
Icotera i4882	100 %	Relatively short gaps with User 5, but video buffer never runs empty



Telenor Denmark

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Iteration 1

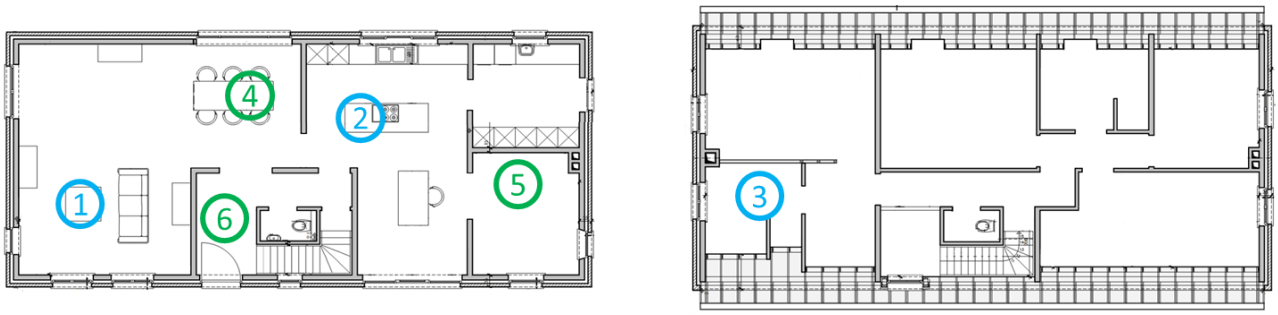


Figure 1: Iteration 1 – device positions on ground floor (L) and top floor (R)

Iteration 2

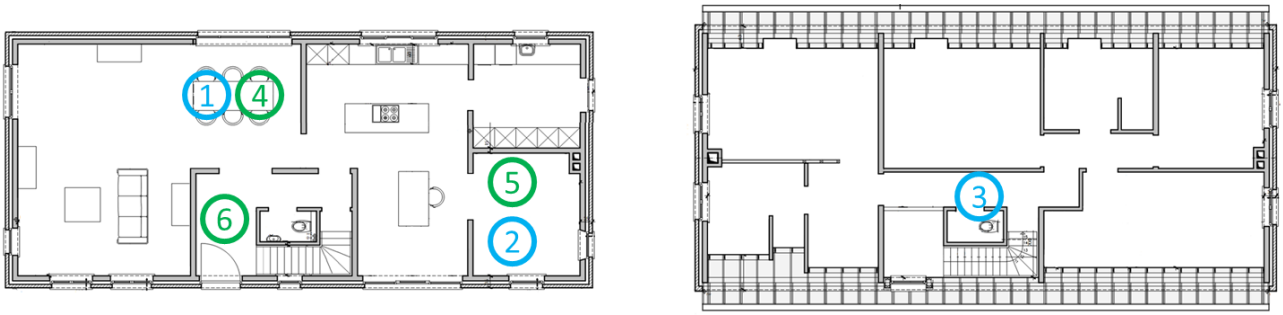


Figure 2: Iteration 2 - device positions on ground floor and top floor

Iteration 3

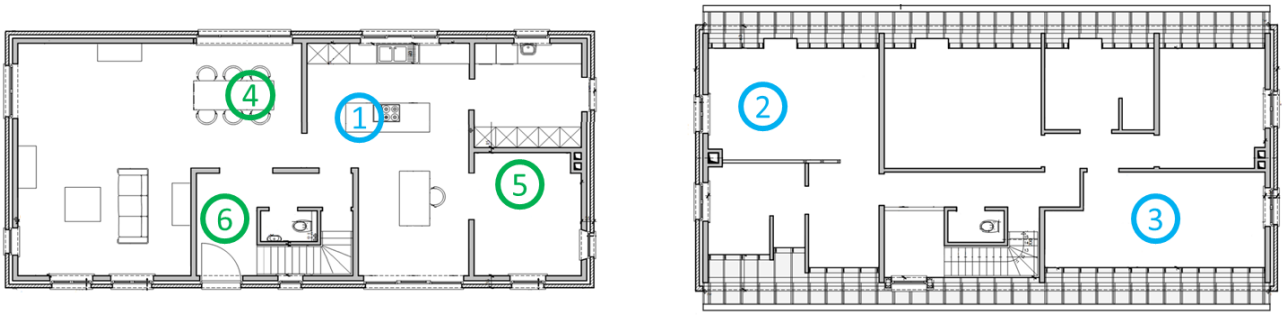


Figure 3: Iteration 3 - device positions on ground floor and top floor

Iteration 4

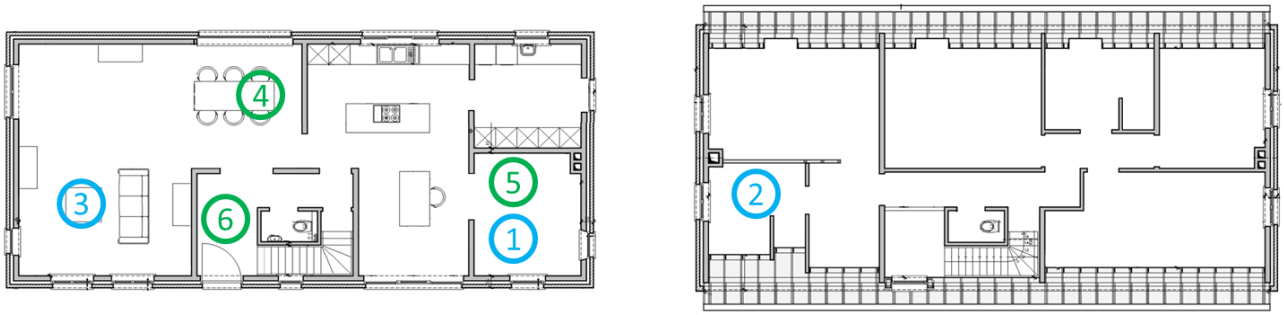


Figure 4: Iteration 4 - device positions on ground floor and top floor

2. User 1 (video conference)

2.1 Description

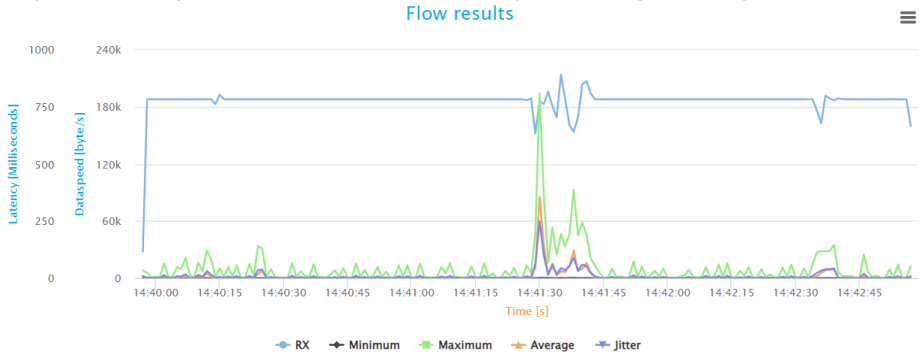
The paragraph below focuses on showing the issues found for each gateway. All other results were similar or better. A bad result for User 1 is characterized by:

- Data speed drop, both during but especially outside the download burst.
- High average latency (> 40 ms) which adds to the access network latency.

2.2 Example results for each gateway

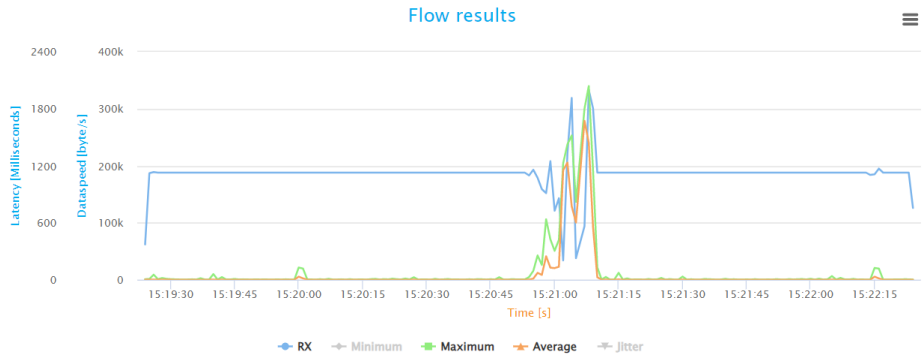
Gateway 1 – Kaon F7550

From iteration 4: Uplink data speed is unstable and latency is too high during download burst.



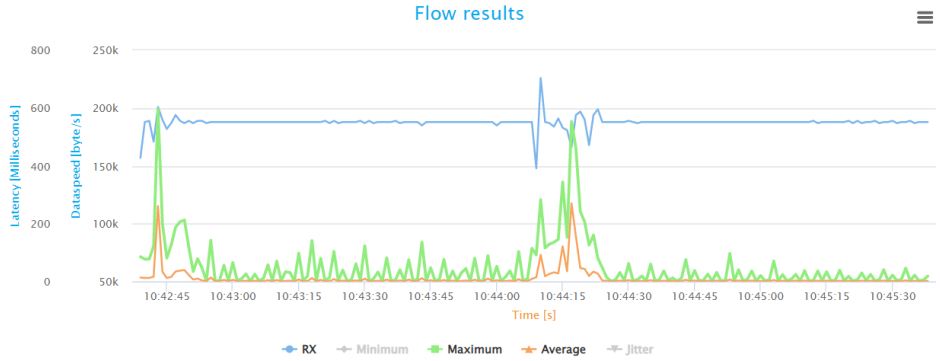
Gateway 2 – Technicolor DGA4330

From iteration 4: Uplink data speed is unstable and latency is extremely high during download burst.



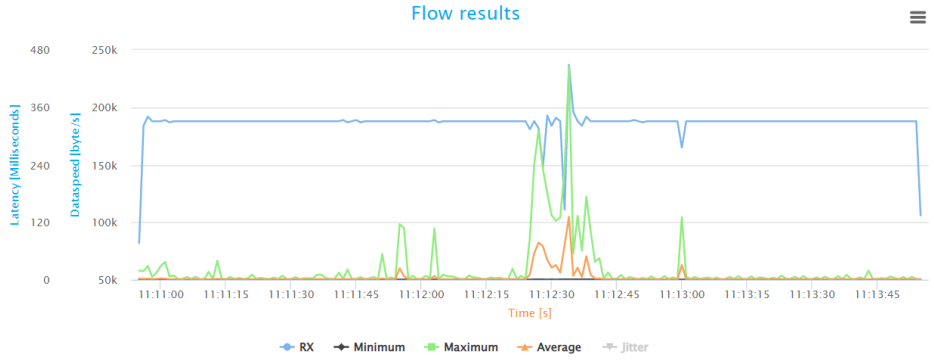
Gateway 3 – Kaon AP2400TN

From iteration 4: High uplink latency peaks during download burst and during initial video buffer fill-up.



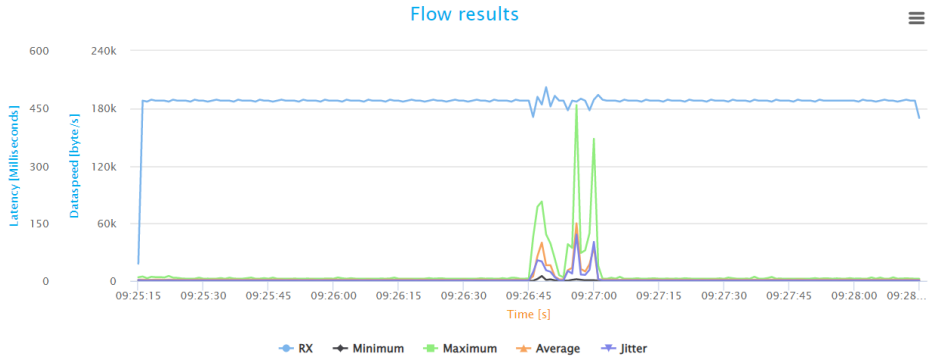
Gateway 4 - ZyXEL EX3300

From iteration 4: high average latency during download burst.



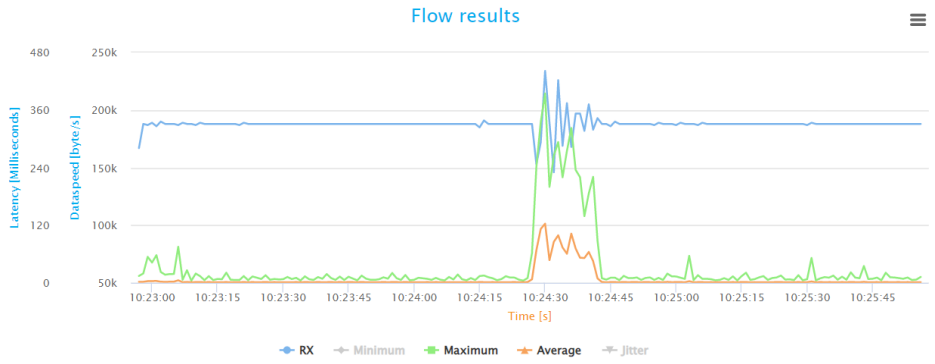
Gateway 5 – Sagemcom D6

From iteration 1: high average and maximum latency for both downlink and uplink during download burst



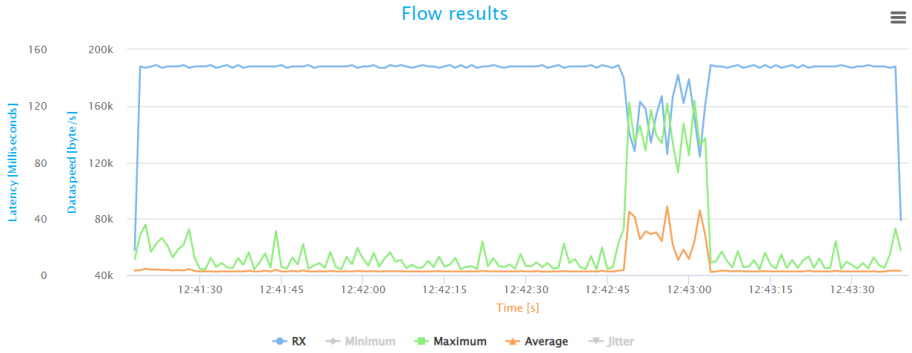
Gateway 6 – Icotera i4850

From iteration 1: unstable uplink dataspeed and high latency during download burst



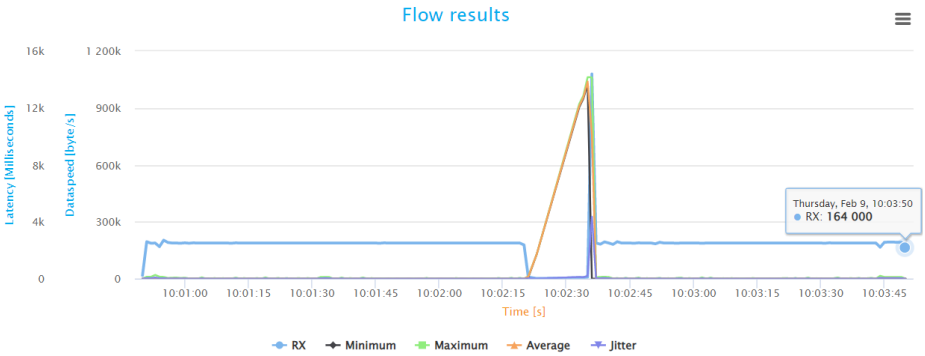
Gateway 7 – ZTE MC801A

All iterations: High average latencies (uplink and downlink), unstable dataspeed during download burst.



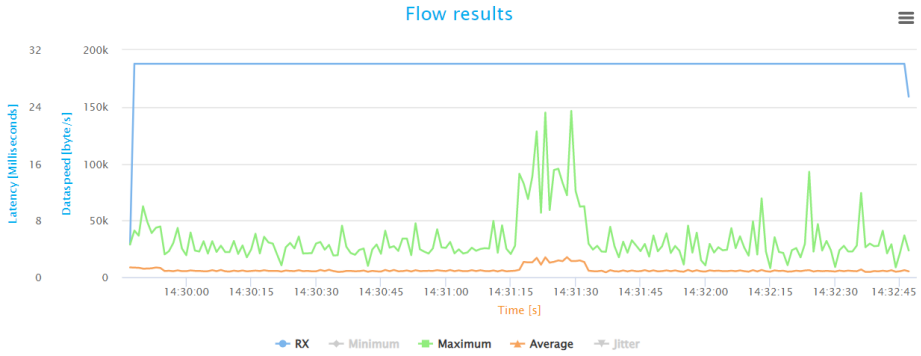
Gateway 8 – Huawei H138

Iteration 4: Uplink transmit opportunities stopped altogether during the download burst.



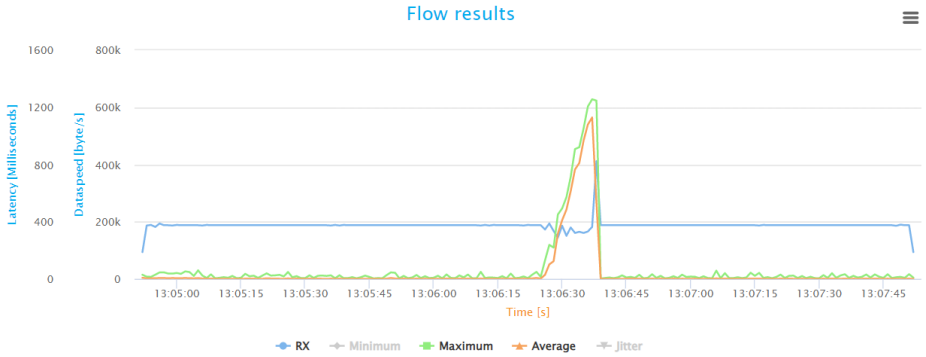
Gateway 9 – Sagemcom F@ST3890V3

All iterations: Very low latency during download burst compared to the other gateways.



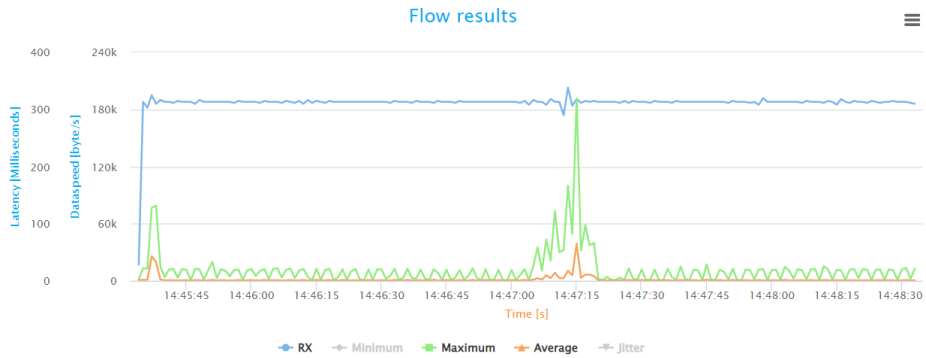
Gateway 10 – Huawei H122

From iteration 3: data speed loss + latency increase in downlink. The same was also seen in uplink.



Gateway 11 – Icotera i4882

From iteration 4: High short peaks in latency, but average latency remains much lower than other gateways.



3. User 2 – Video stream

3.1 Description

The paragraph below focuses on showing the issues found for each gateway. All other results were similar or better. A bad result for User 2 is characterized by:

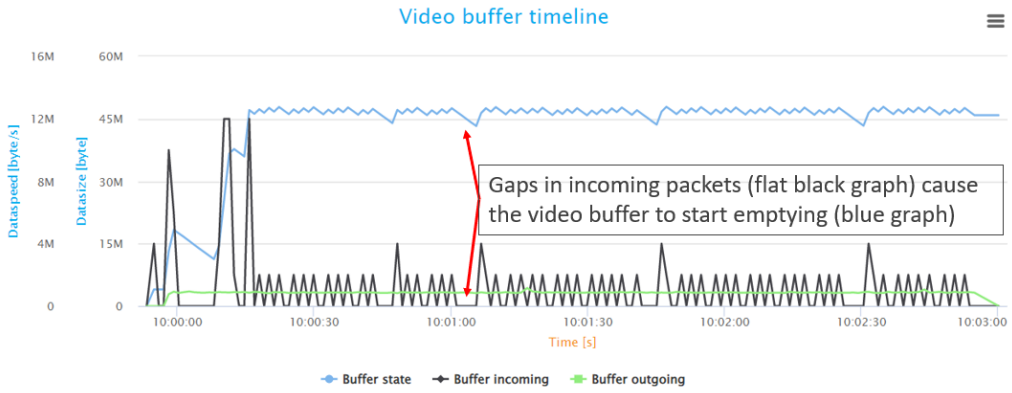
- Gaps in incoming packets that are wide enough to empty the video buffer.
- Gaps that span exactly the width of the download burst, indicating that no packets are received during the download.

3.2 Example results for each gateway

Gateway 1 – Kaon FA7550

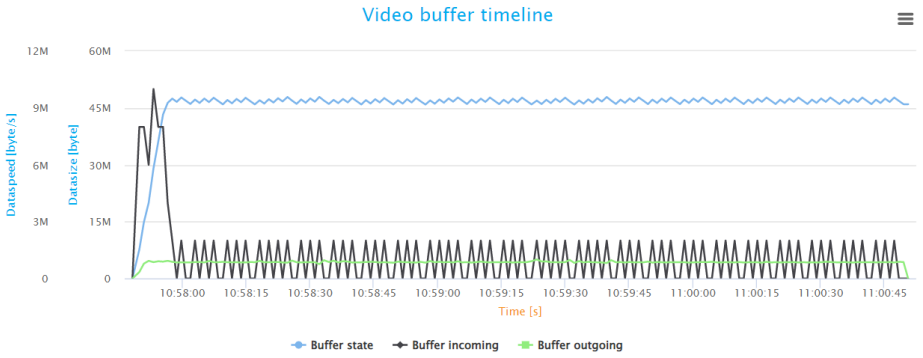
All scenarios show many unexpected but short traffic gaps. The video buffer never runs dry though, so these are not counted as fail cases.

These gaps are already present in the scenarios where user 2 is the only active user and does not have to share airtime.



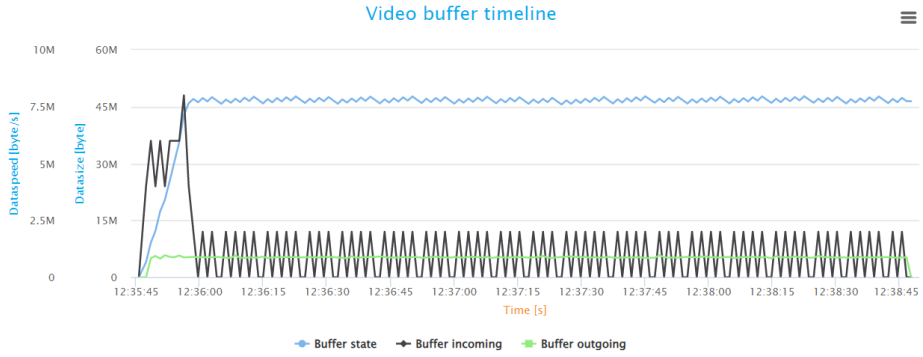
Gateway 2 – Technicolor DGA4330

All scenarios show a quick video buffer fill-up and no interruptions in incoming video packets. Video playback start within a few seconds.



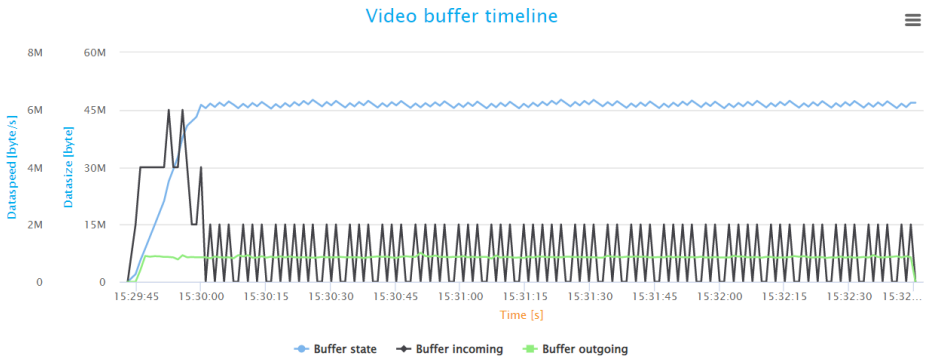
Gateway 3 – Kaon AP2400 TN

All scenarios show a quick video buffer fill-up and no interruptions in incoming video packets. Note that a quick buffer fill-up means that videos starts playing as soon as possible.



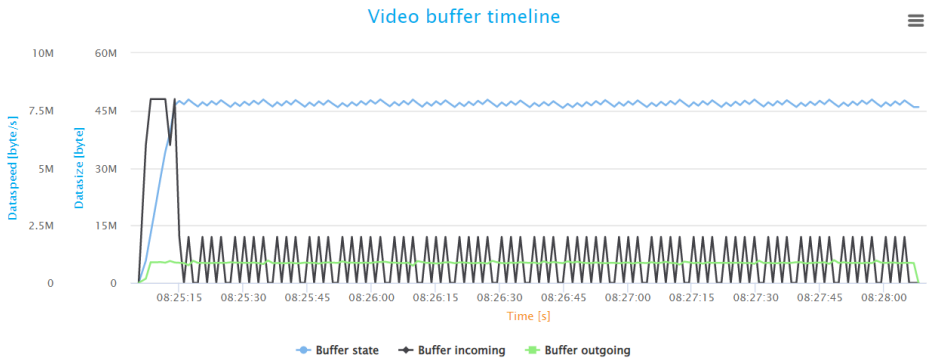
Gateway 4 – ZyXEL EX3300

All scenarios show a quick video buffer fill-up and no interruptions in incoming video packets.



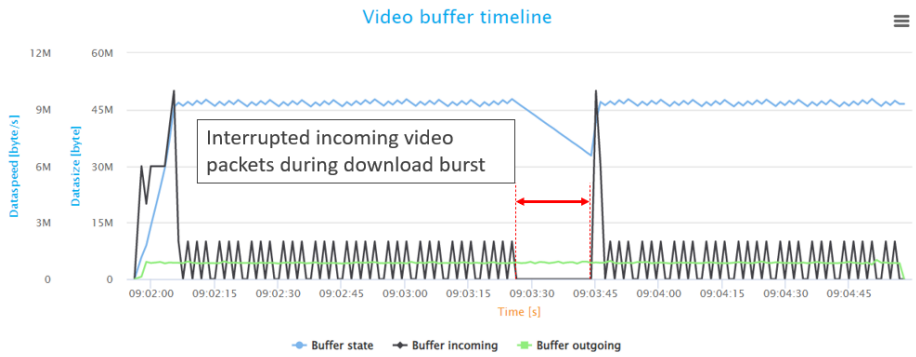
Gateway 5 – Sagemcom D6

All scenarios show a quick video buffer fill-up and no interruptions in incoming video packets.



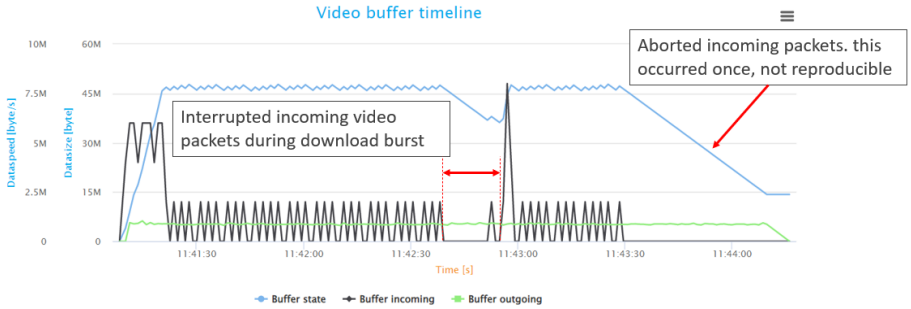
Gateway 6 – Icotera i4850

Iteration 2: Incoming video packets are interrupted for the duration of the download burst. If this burst had been wider, the video buffer would run empty. This was not seen during the other iterations, most likely due to different Wi-Fi band assignments that are unique for each iteration.



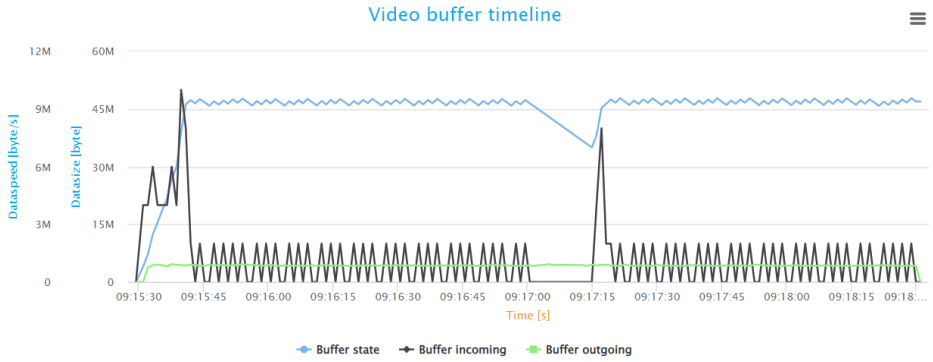
Gateway 7 – ZTE MC801A

Iteration 1: The gap in incoming video packets spans the width of the download burst, so a larger burst has a high risk of emptying the video buffer completely. The gap in the last part happened just once during all testing, and was not seen during reruns.



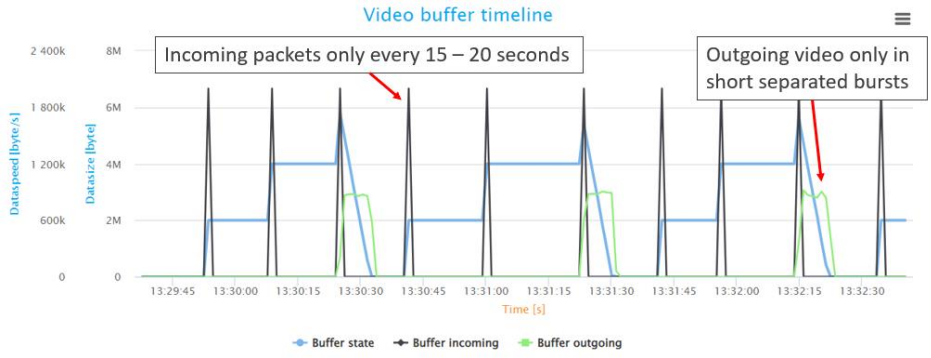
Gateway 8 – Huawei H138

Iteration 3: The gap in incoming video packets spans the width of the download burst, so a larger burst has a high risk of emptying the video buffer completely.

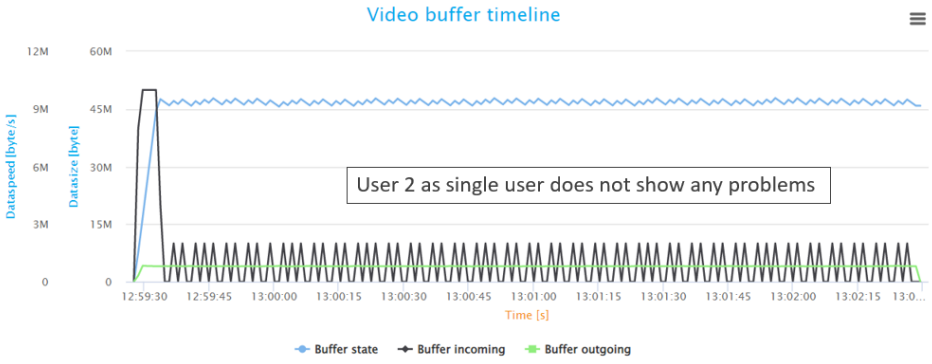


Gateway 9 – Sagemcom F@ST3890V3

During all iterations, User 2 gets no incoming video packets at all in the multiclient scenarios.

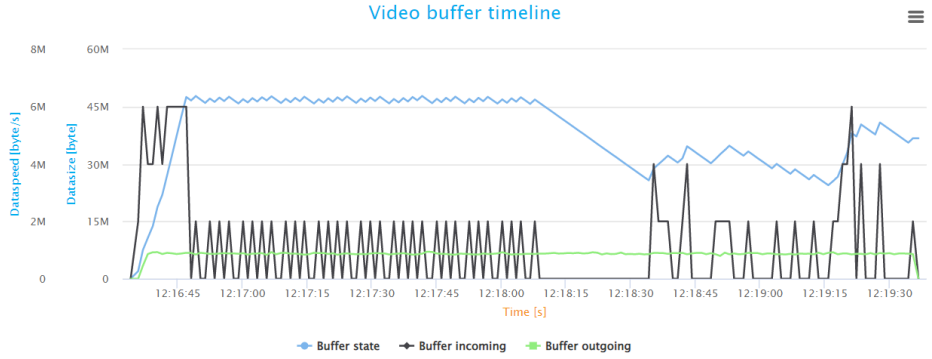


In between the multiclient scenarios, the User-2-only test showed no problems with this user.



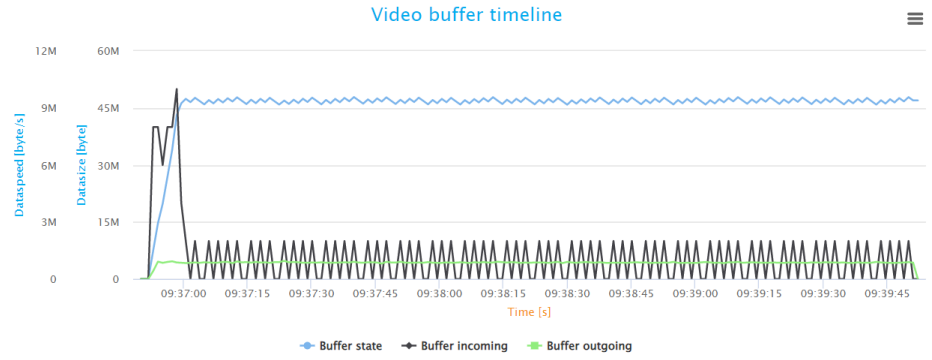
Gateway 10 – Huawei H122

Iteration 3: Incoming video packets stop during the download burst. After the burst, the flow struggles to recover as incoming packets are still intermittently absent.



Gateway 11 – Icotera i4882

During all iterations, the video buffer fills quickly and both incoming packets and video playout are uninterrupted.



4. User 3 – Online gaming

4.1 Description

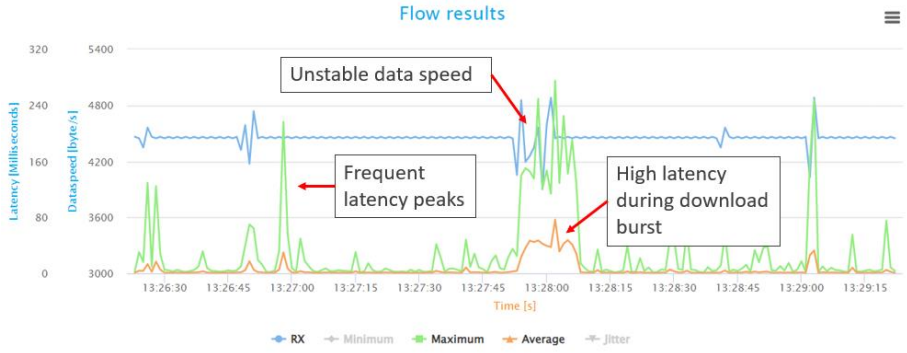
The paragraph below focuses on showing the issues found for each gateway. All other results were similar or better. A bad result for User 3 is characterized by:

- Data speed drop, both during but especially outside the download burst.
- High average latency (> 30 ms) which adds to the access network latency.

4.2 Example results for each gateway

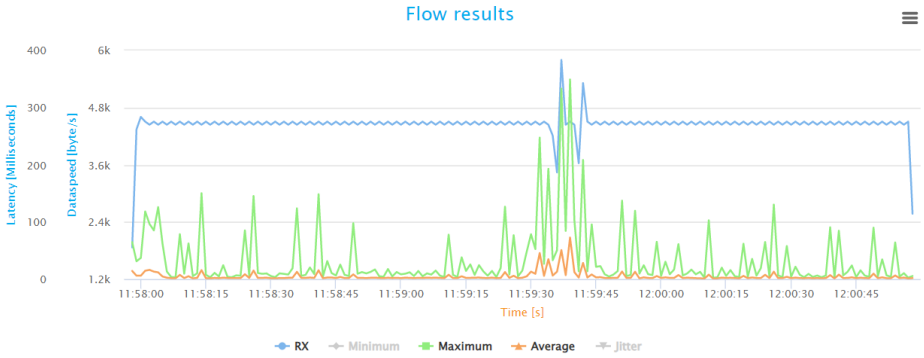
Gateway 1 – Kaon FA7550

The occasional short latency peaks may have limited influence, but the large average latency during the download burst will cause notable lag in the game. The data speed also becomes unstable during the download burst.



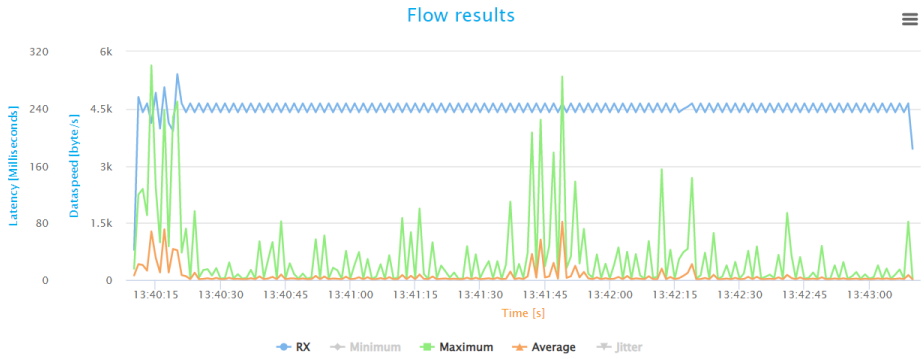
Gateway 2 – Technicolor DGA4330

The download burst has a logical influence on latency. The average latency during the burst does not increase as much as it did with Gateway 1.



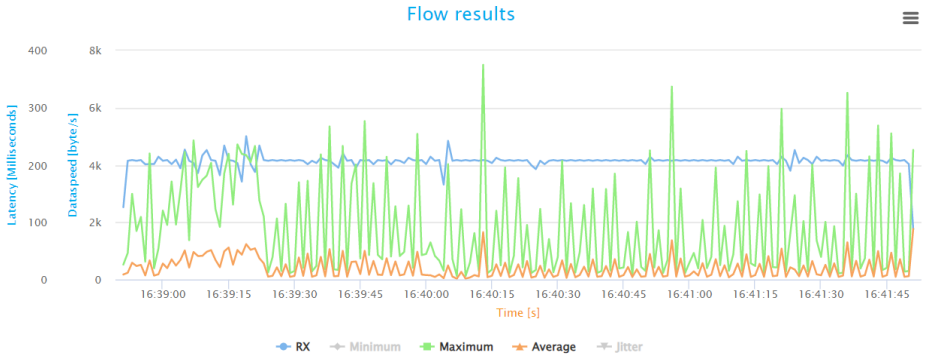
Gateway 3 – Kaon AP2400TN

Apart from the expected higher latency during the download burst there is also a notable latency increase during the initial seconds. This is caused by the higher data rates during video buffer fill-up.

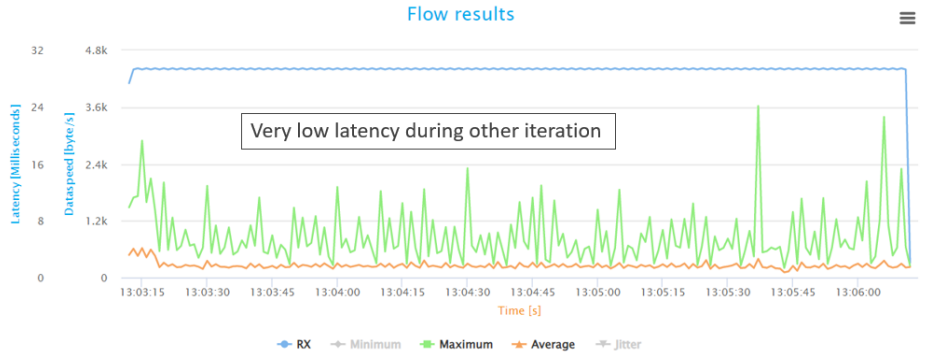


Gateway 4 – ZyXEL EX3300

Iteration 3: Remarkably high latency peaks throughout the entire traffic session, even outside of the download burst.

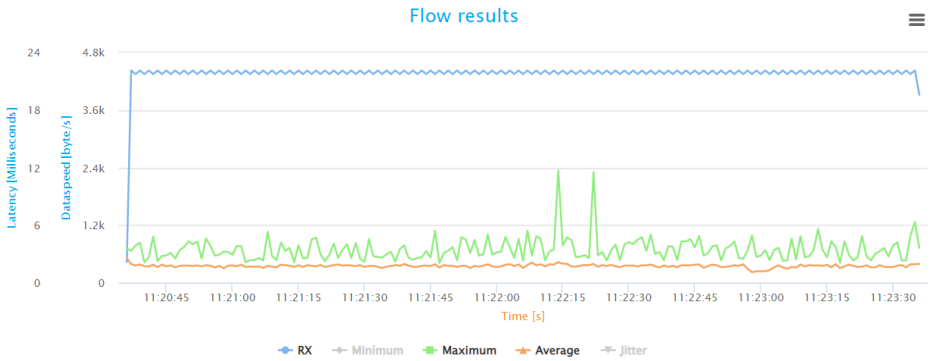


Note that during the other iterations, these peaks are absent. This is most likely related to the unique Wi-Fi band assignments during each iteration.



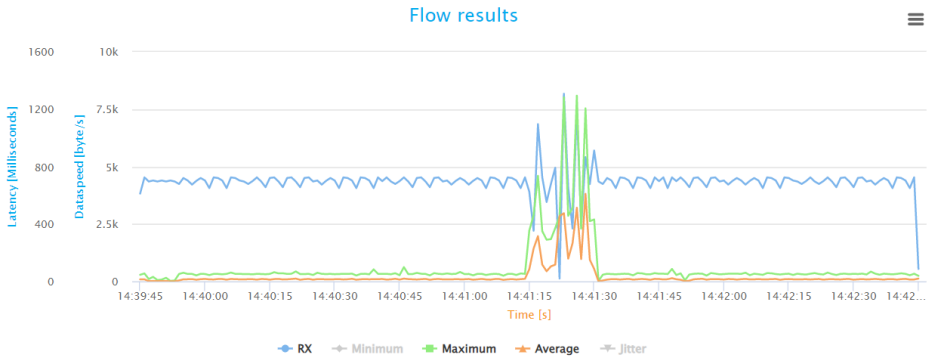
Gateway 5 – Sagemcom D6

All iterations: The graphs show very few latency peaks. Additionally, the few peaks are very low as well.



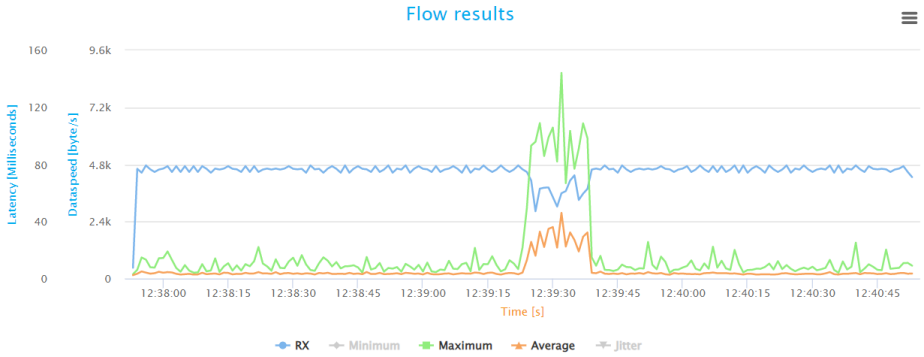
Gateway 6 – Icotera i4850

Iteration 4: Very high average latency (200 ms) during the download burst.



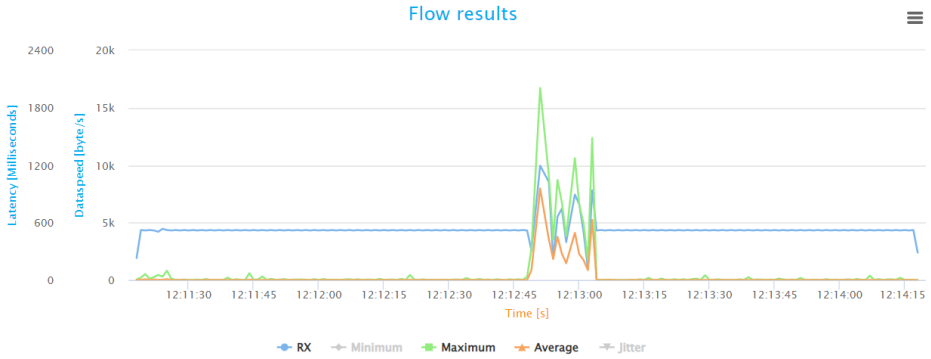
Gateway 7 – ZTE MC801A

All iterations: Average latency increases to 30 ms and a noticeable drop in data speed during the download burst.



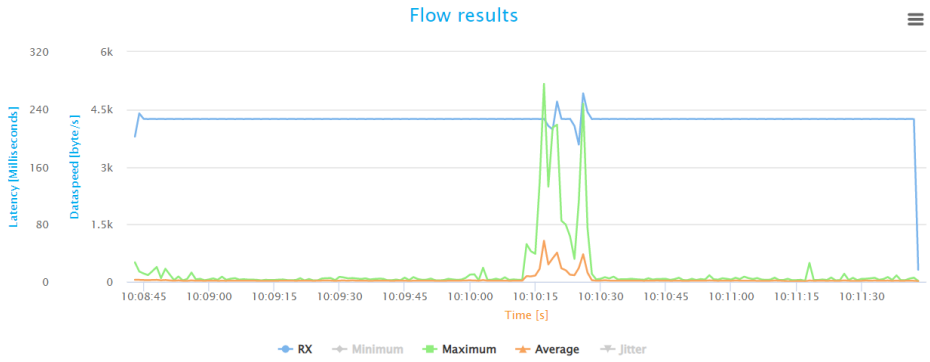
Gateway 8 – Huawei H138

Iteration 4: Very high average latency (300 ms) and unstable data speed during the download burst. This was present during all iterations.



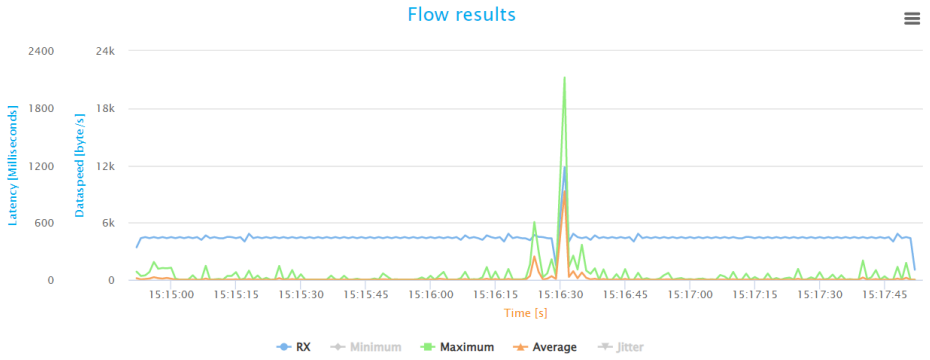
Gateway 9 – Sagemcom F@ST3890V3

Iteration 3: Average latency increases to around 40 ms during the download burst but overall, this result is better than many of the other gateways.



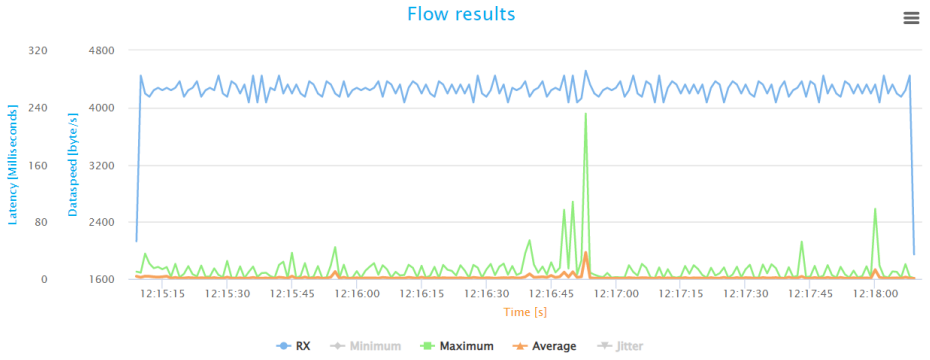
Gateway 10 – Huawei H122

Latency is characterised by a single very high peak. This was seen in multiple iterations.



Gateway 11 – Icotera i4882

All iterations show a limited increase in latency during the download burst but the average latency remains low and there are no data speed drops.



5. User 4 – Video stream

5.1 Description

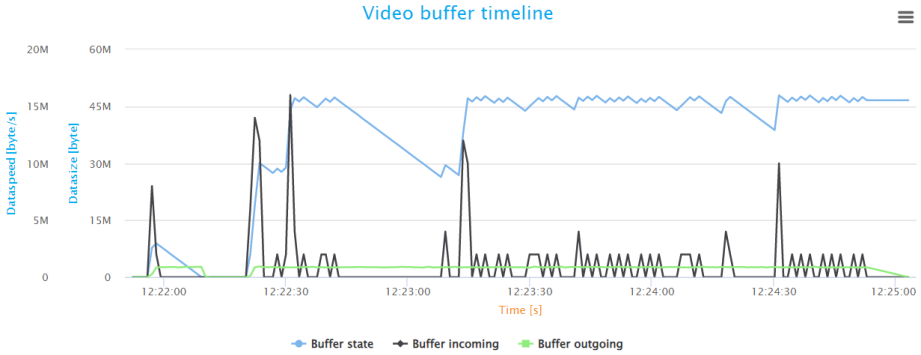
The paragraph below focuses on showing the issues found for each gateway. All other results were similar or better. A bad result for User 4 is characterized by:

- Gaps in incoming packets that are wide enough to empty the video buffer.
- Gaps that span exactly the width of the download burst, indicating that no packets are received during the download.

5.2 Example results for each gateway

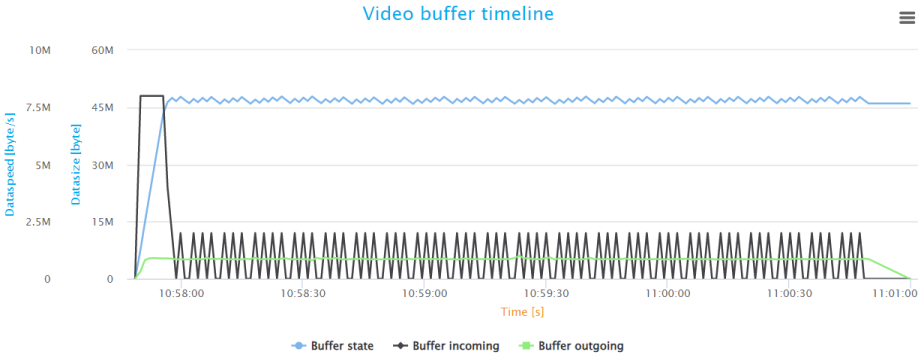
Gateway 1 – Kaon FA7550

Iteration 3: Large gaps at the beginning cause video playback to be interupted shortly after the start.



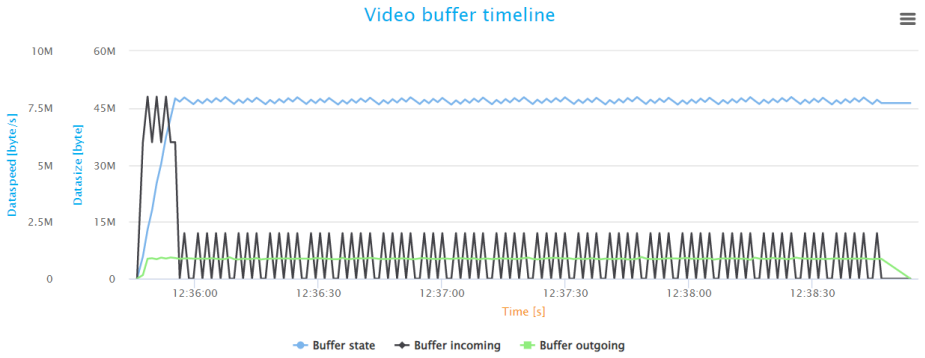
Gateway 2 – Technicolor DGA4330

All runs with User 4 showed very good results without gaps in incoming video packets.



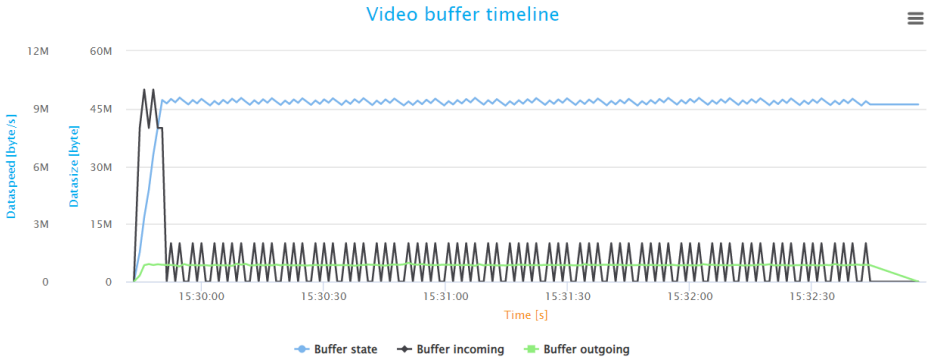
Gateway 3 – Kaon AP2400TN

All runs with User 4 showed very good results without gaps in incoming video packets.



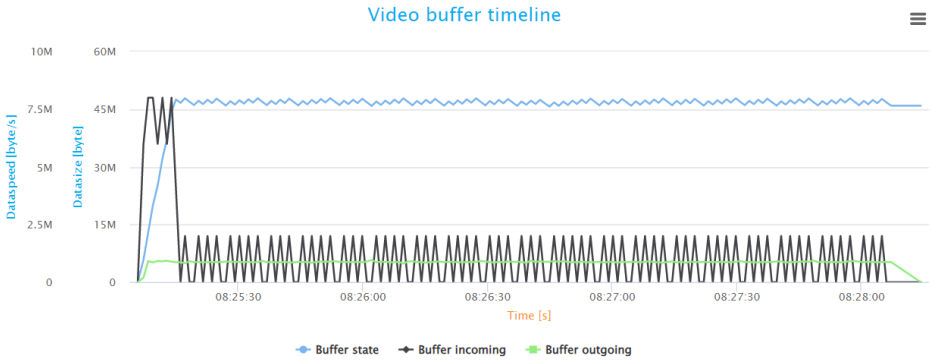
Gateway 4 – ZyXEL EX3300

All runs with User 4 showed very good results without gaps in incoming video packets.



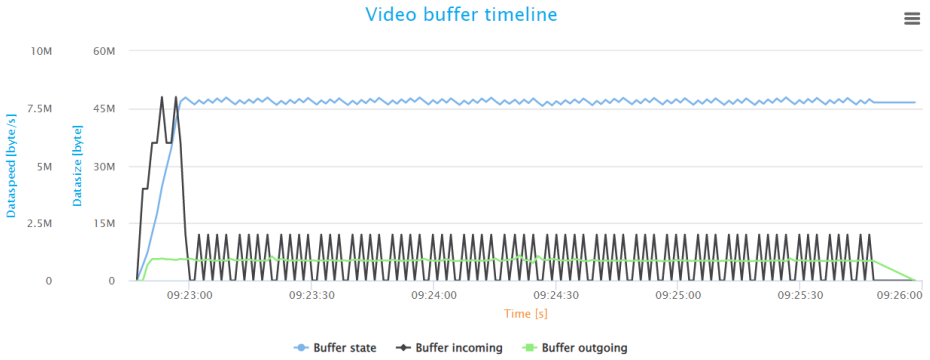
Gateway 5 – Sagemcom D6

All runs with User 4 showed very good results without gaps in incoming video packets.



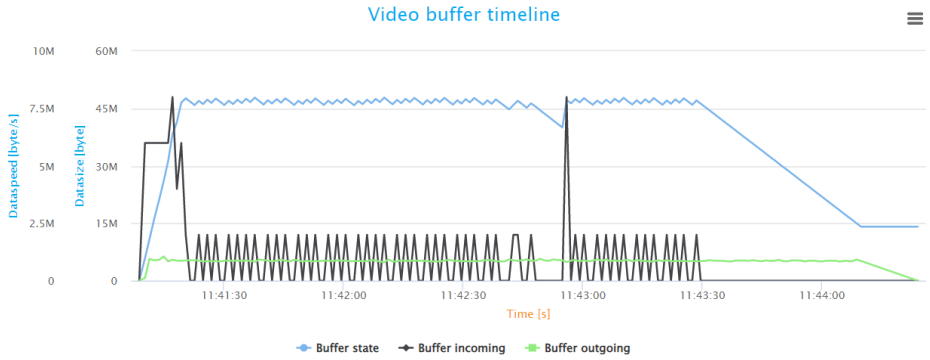
Gateway 6 – Icotera i4850

All runs with User 4 showed very good results without gaps in incoming video packets.

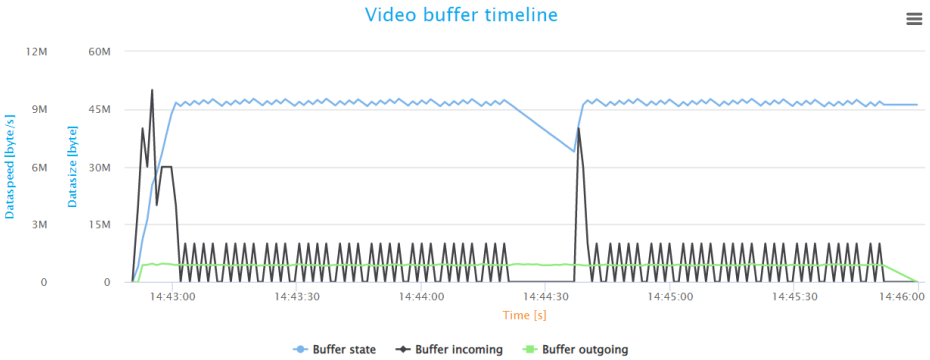


Gateway 7 – ZTE MC801A

Iteration 1: The flow of incoming video packets stopped, causing the video buffer to run empty.

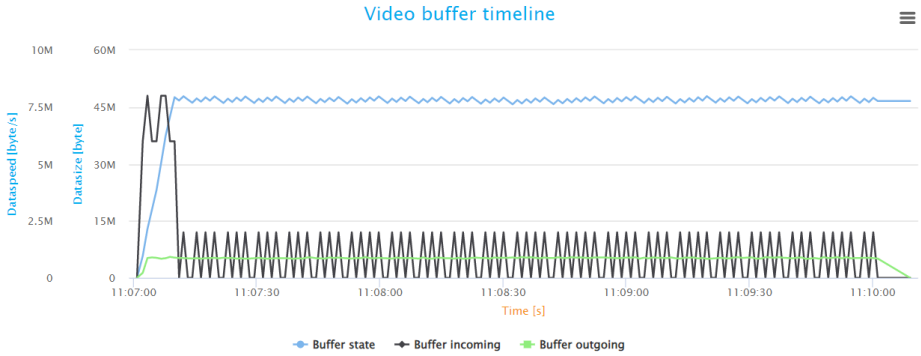


Iteration 4: the gap in incoming packets matches the download burst exactly. This means that a longer burst would have emptied the video buffer.



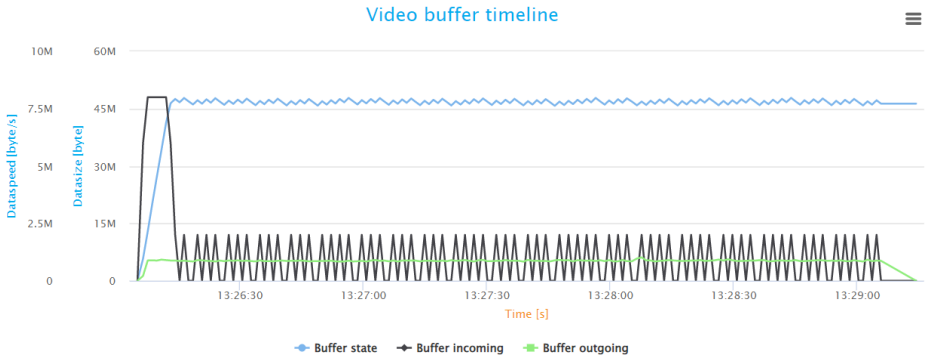
Gateway 8 – Huawei H138

All runs with User 4 showed very good results without gaps in incoming video packets.



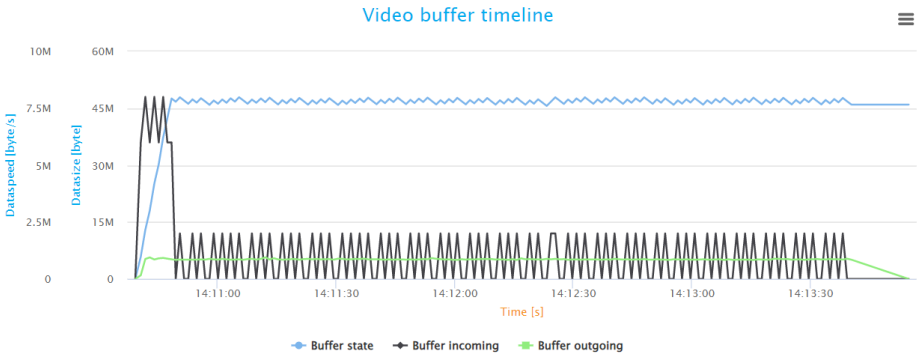
Gateway 9 – Sagemcom F@ST3890V3

All runs with User 4 showed very good results without gaps in incoming video packets.



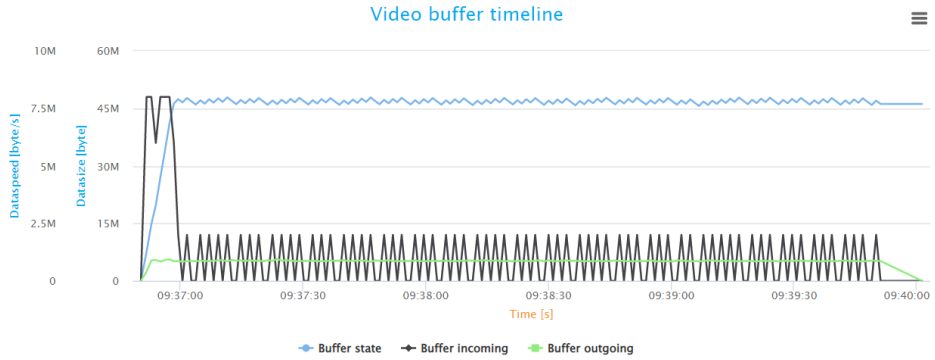
Gateway 10 – Huawei H138

All runs with User 4 showed very good results without gaps in incoming video packets.



Gateway 11 – Icotera i4882

All runs with User 4 showed very good results without gaps in incoming video packets.



6. User 5 – Video stream

6.1 Description

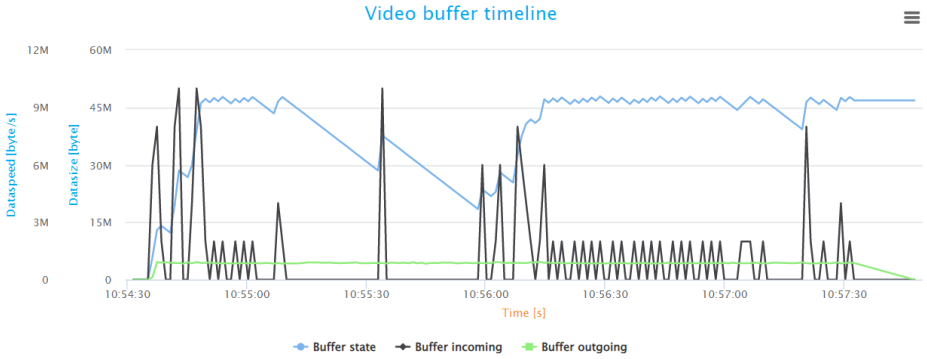
The paragraph below focuses on showing the issues found for each gateway. All other results were similar or better. A bad result for User 5 is characterized by:

- Gaps in incoming packets that are wide enough to empty the video buffer.
- Gaps that span exactly the width of the download burst, indicating that no packets are received during the download.

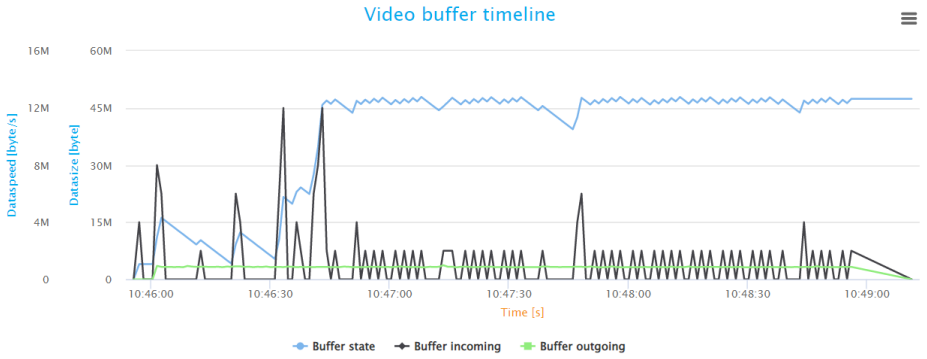
6.2 Example results for each gateway

Gateway 1 – Kaon FA7550

The graphs show very long gaps in the incoming packets. There is a high risk of the video buffer running dry.

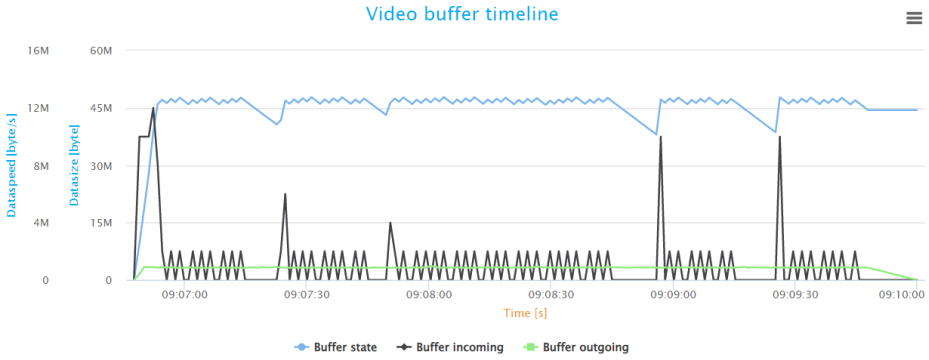


Another graph shows a very long time before the video buffer is filled.



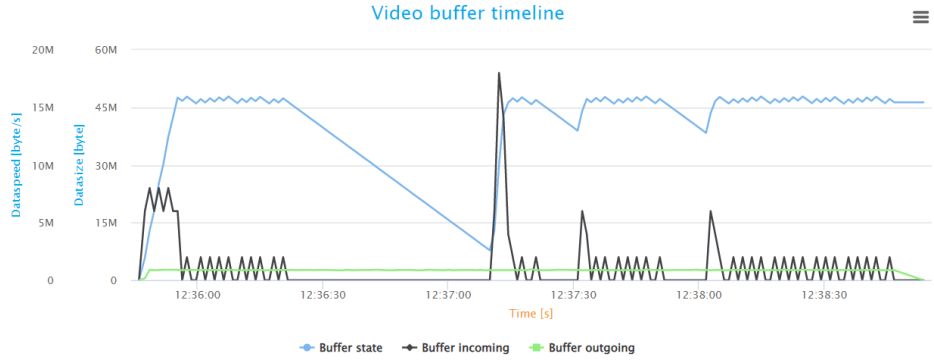
Gateway 2 – Technicolor DGA4330

Short interruptions are present, but they do not cause the video buffer to run empty.



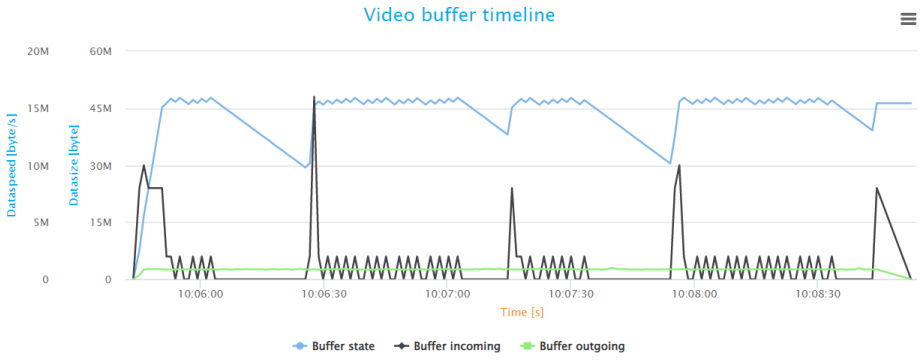
Gateway 3 – Kaon AP2400TN

Extended interruptions such as shown in iteration 1 are certain to cause the video buffer to run empty at some time, resulting in interrupted video playout



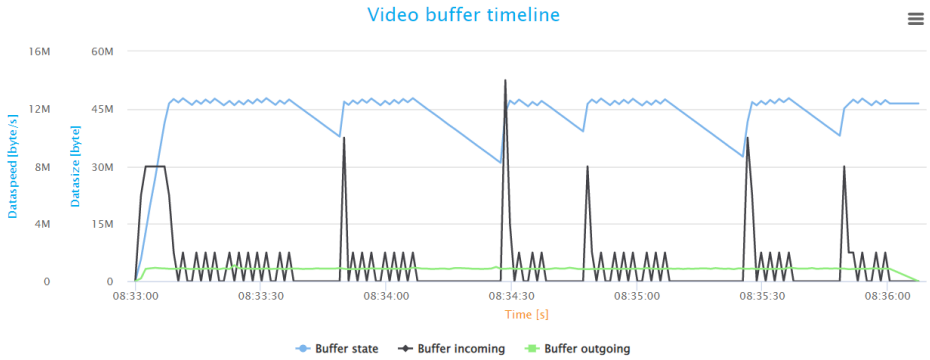
Gateway 4 – ZyXEL EX3300

Even though incoming packets are often interrupted, the video buffer does not drop below 60 %.



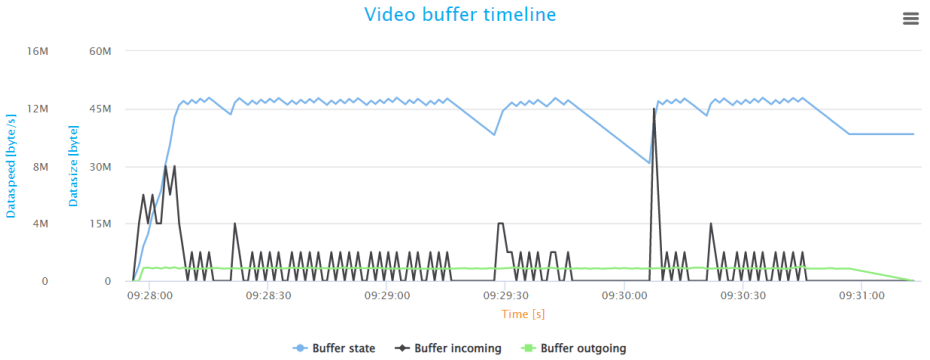
Gateway 5 – Sagemcom D6

Similar to the ZyXEL, the video buffer manages to be stable even with interrupted incoming packets.

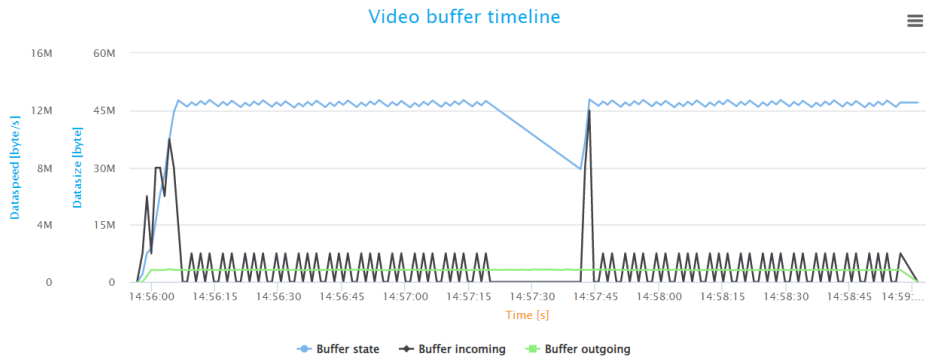


Gateway 6 – Icotera i4850

Similar to other gateways there are gaps in incoming packets but no apparent risk of an empty buffer.

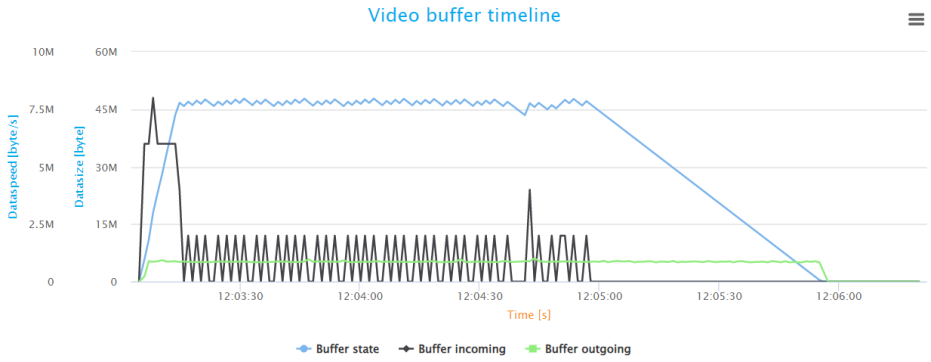


This graph from iteration 3 shows that a download burst would let the video buffer empty if the download continues for extended period of time. There are no incoming video packets for the duration of the burst.



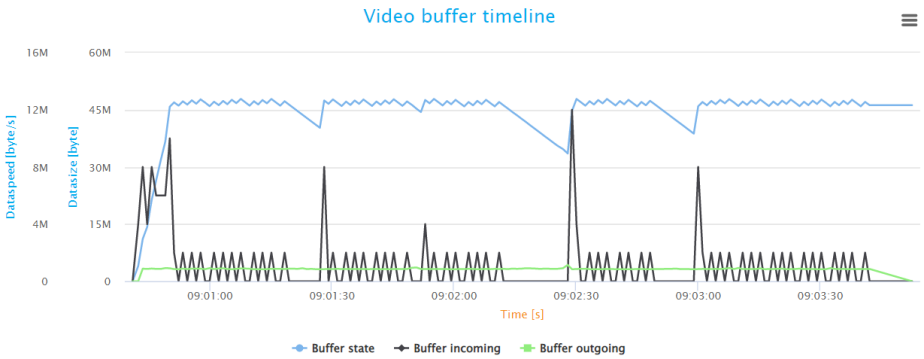
Gateway 7 – ZTE MC801A

The graph below shows the flow stopped prematurely, causing the video buffer to empty. This was seen in multiple test runs.



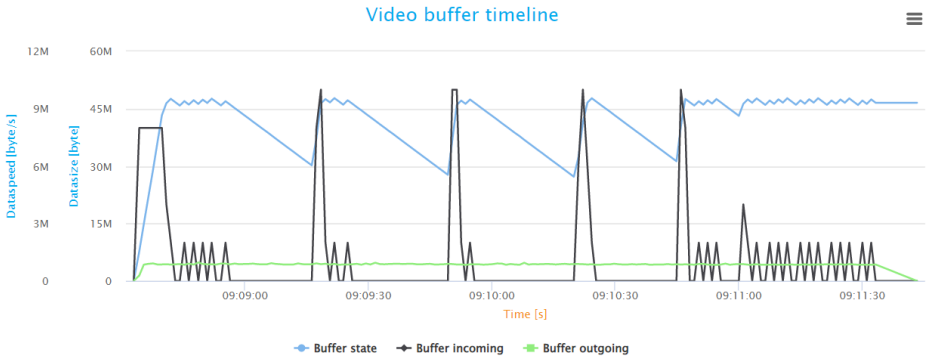
Gateway 8 – Huawei H138

In both iterations 3 and 4, the lack of incoming video packets during the download burst would cause the video buffer to run empty.



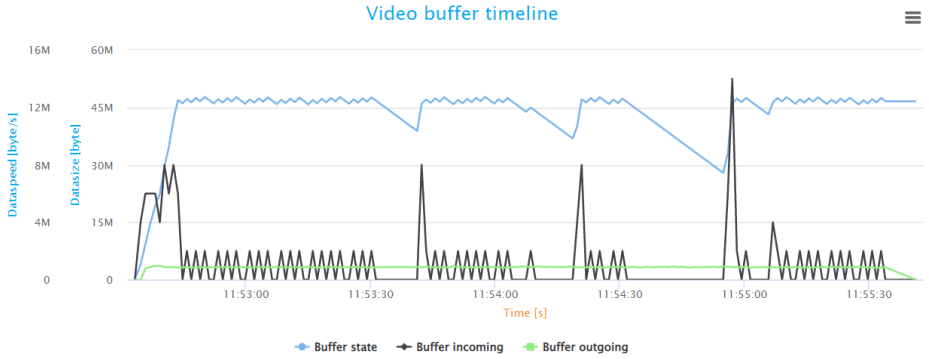
Gateway 9 – Sagemcom F@ST3890V3

Iteration 3: the gaps in incoming packets are very severe and any more missed incoming packets would let the video buffer run empty. Iteration 4 also showed no video packets during the download burst.



Gateway 10 – Huawei H122

Some scenarios had relatively short gaps, but other iterations had no video packets during the download burst.



Gateway 11 – Icotera i4882

In some iterations, some short interruptions in the delivery of incoming video packets are seen, but no scenarios where the video buffer is at risk of running empty.