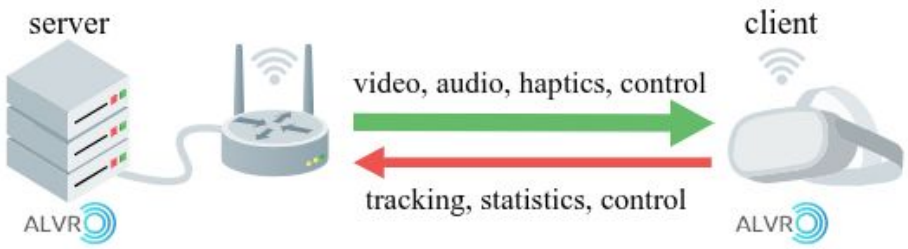
VR streaming over Wi-Fi: Lessons Learned

Date: 2025-3-6

Source:

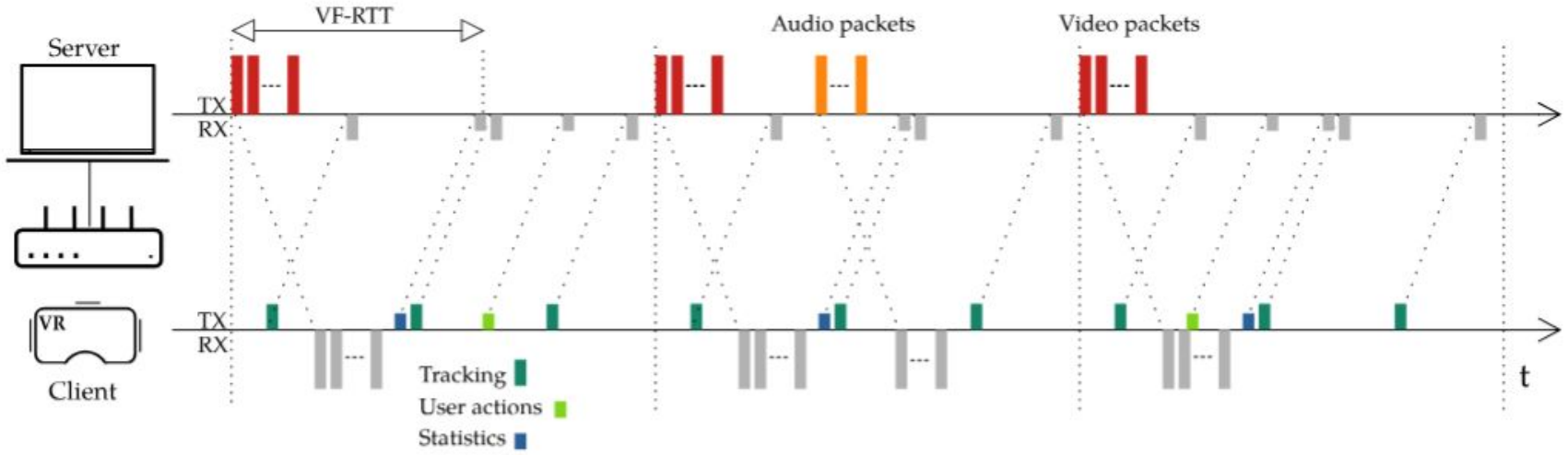
Affiliation	Contact	Email
Pompeu Fabra University (UPF)	Boris Bellalta	boris.bellalta@upf.edu
Pompeu Fabra University (UPF)	Francesc Wilhelmi	francesc.wilhelmi@upf.edu

VR streaming over Wi-Fi



COMPARISON OF NETWORK DELAY BUDGETS.

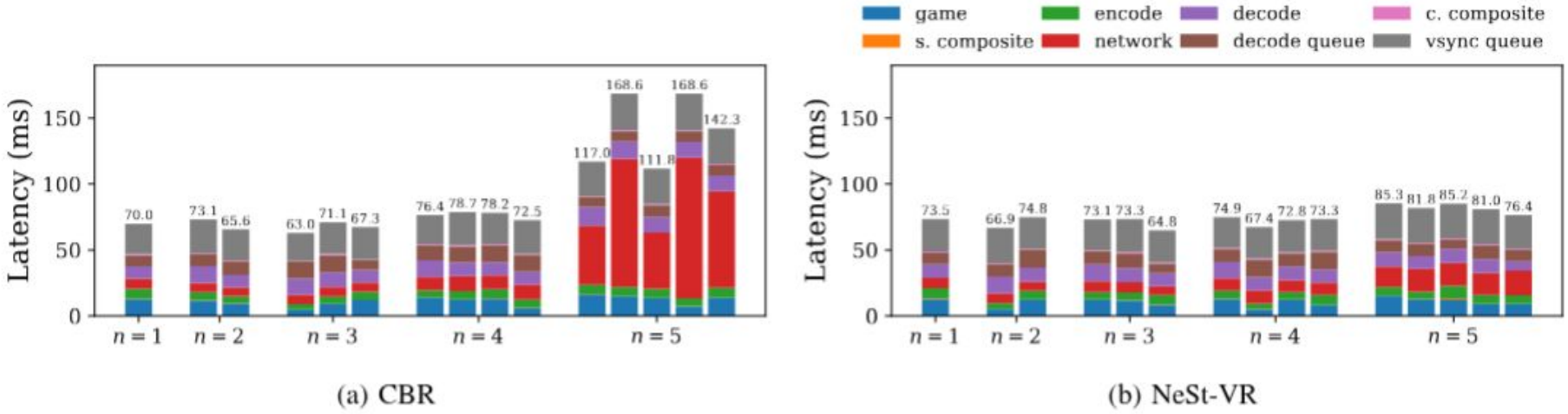
	Downlink delay	Uplink delay	Latency
3GPP [13]	20 ms	10 ms	50 ms
ITU-T [14]	5 ms (or 2 ms)	5 ms (or 2 ms)	50 ms
Wi-Fi Alliance [15]	P75 < 5 ms	P90 < 2 ms	-
This work	4 ms	2 ms	50 ms



Figures and results from [1] and [2].

Wi-Fi 6: How many simultaneous VR users?

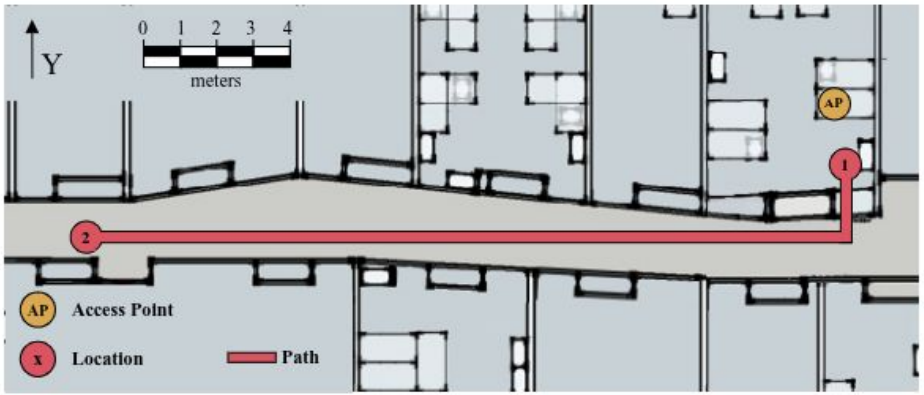
- 1-5 VR users
- 100Mbps@90fps
- EDCA, 80 MHz, 2 SS
- MCS 11



- Network congestion appears with 4 users (CBR).

Mobility, and Performance Anomaly

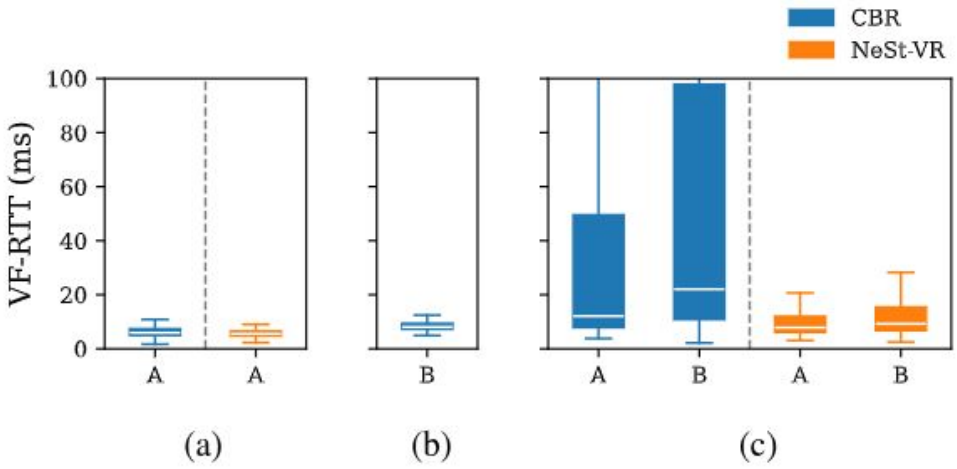
- 100Mbps@90fps
- EDCA, 80 MHz, 2 SS
- Variable MCS
- User A: Moves from 1 to 2
- User B: Placed at 2



a) Only user A moving from 1 to 2

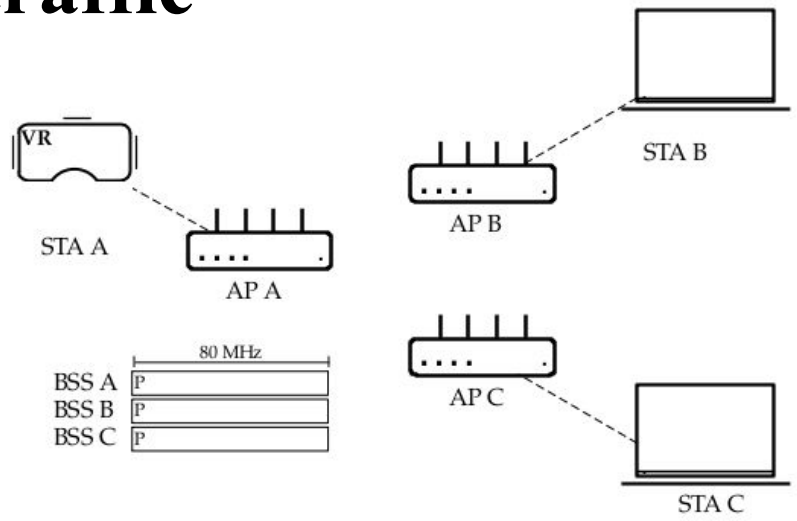
b) Only user B

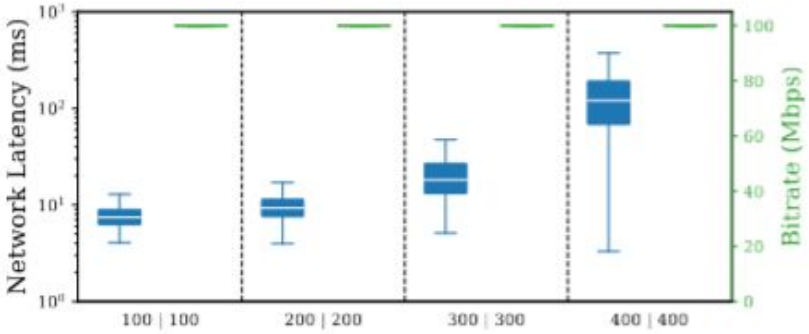
c) User A and B, A moving



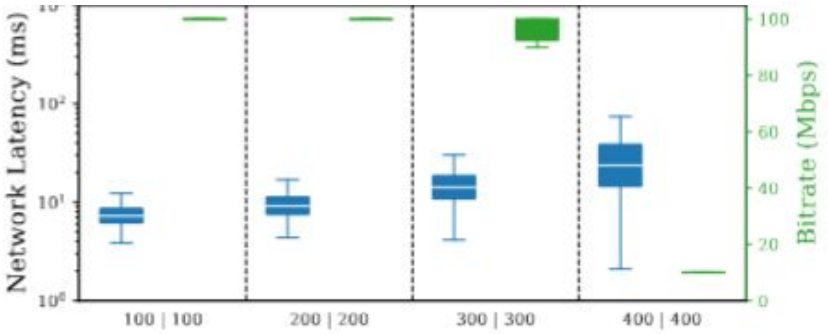
OBSS traffic

- 1 VR user
- 100Mbps@90fps
- EDCA, 80 MHz, 2 SS
- MCS 11





(a) CBR.



(b) NeSt-VR.

- 400+400 Mbps OBSS traffic (UDP) is not able to significatively disrupt VR streaming

Lessons Learned, and Remarks

- Wi-Fi 6 (802.11ax) < 6GHz supports up to four users per AP with a constant bitrate (CBR) of 100 Mbps at 90–120 fps (MCS 10-11).
- Wi-Fi 7 (802.11be) < 6GHz is expected to more than double the number of users per AP by leveraging Multi-Link Operation (MLO) and statistical multiplexing gains.
- Video quality remains visually unaffected when the bitrate is reduced to 50 Mbps, allowing for increased user capacity per AP.
- New VR video encoding and decoding techniques, including AI-enhanced methods, aim to further reduce network demands.
- Bitrate adaptation algorithms dynamically adjust quality to accommodate user arrivals/departures and capacity fluctuations due to mobility.
- The system exhibits high robustness to background traffic, with effective traffic prioritization and minimal impact from Overlapping Basic Service Set (OBSS) traffic.

References

[1] Costas Michaelides, Miguel Casasnovas, David Nunez, Boris Bellalta; "**Lessons Learned From a Large-Scale Virtual Reality Experience Over Wi-Fi**"; techrxiv, 2025.

[2] Miguel Casasnovas, Ferran Maura, Isjtar Vandebroeck, Haryo Sukmawanto, Eric Joris, Boris Bellalta; "**NeSt-VR: An Adaptive Bitrate Algorithm for Virtual Reality Streaming over Wi-Fi**"; arXiv, 2025.