



Creating Infinite
Possibilities.

WAN And LAN Speed and Service Matching – Are We Engineering It Correctly for Consumer Services Growth In The Next 5+ Years

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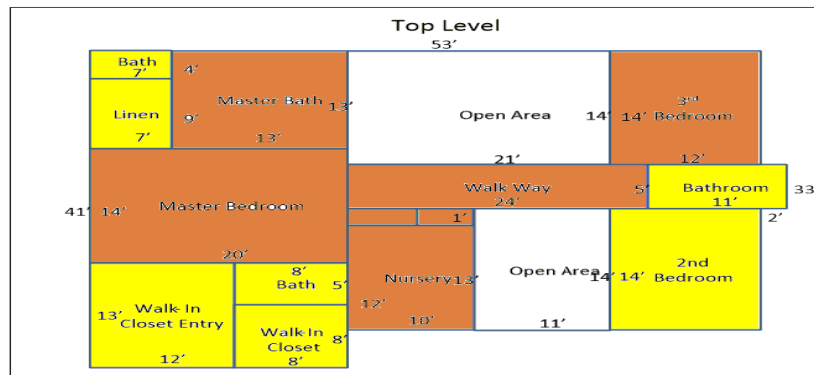
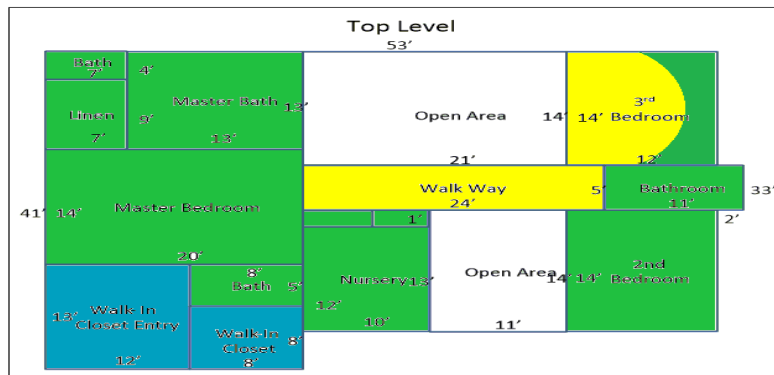
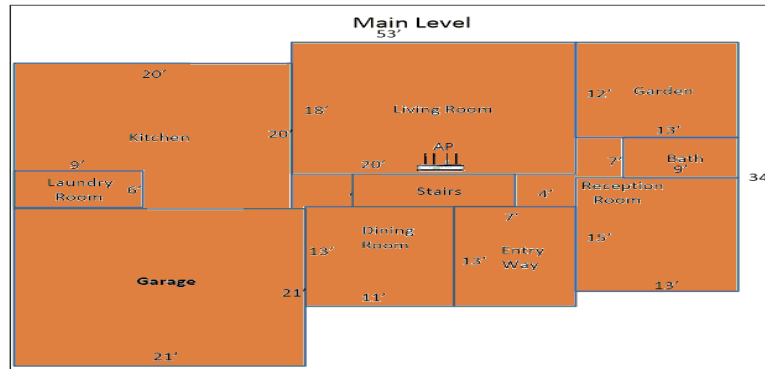
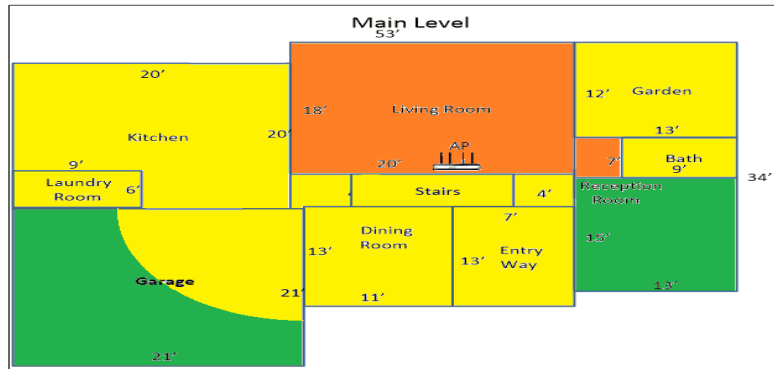
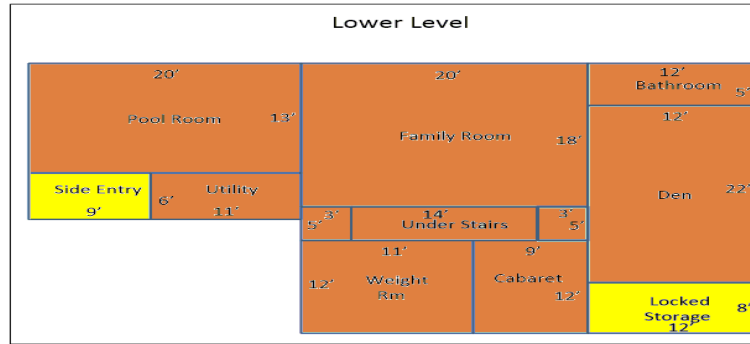
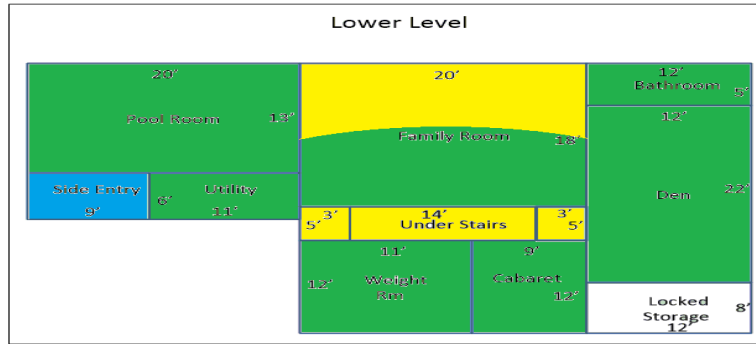
Both the Home LAN and the DOCSIS WAN are making plans for expanded bitrate coverage; are these efforts in sync?

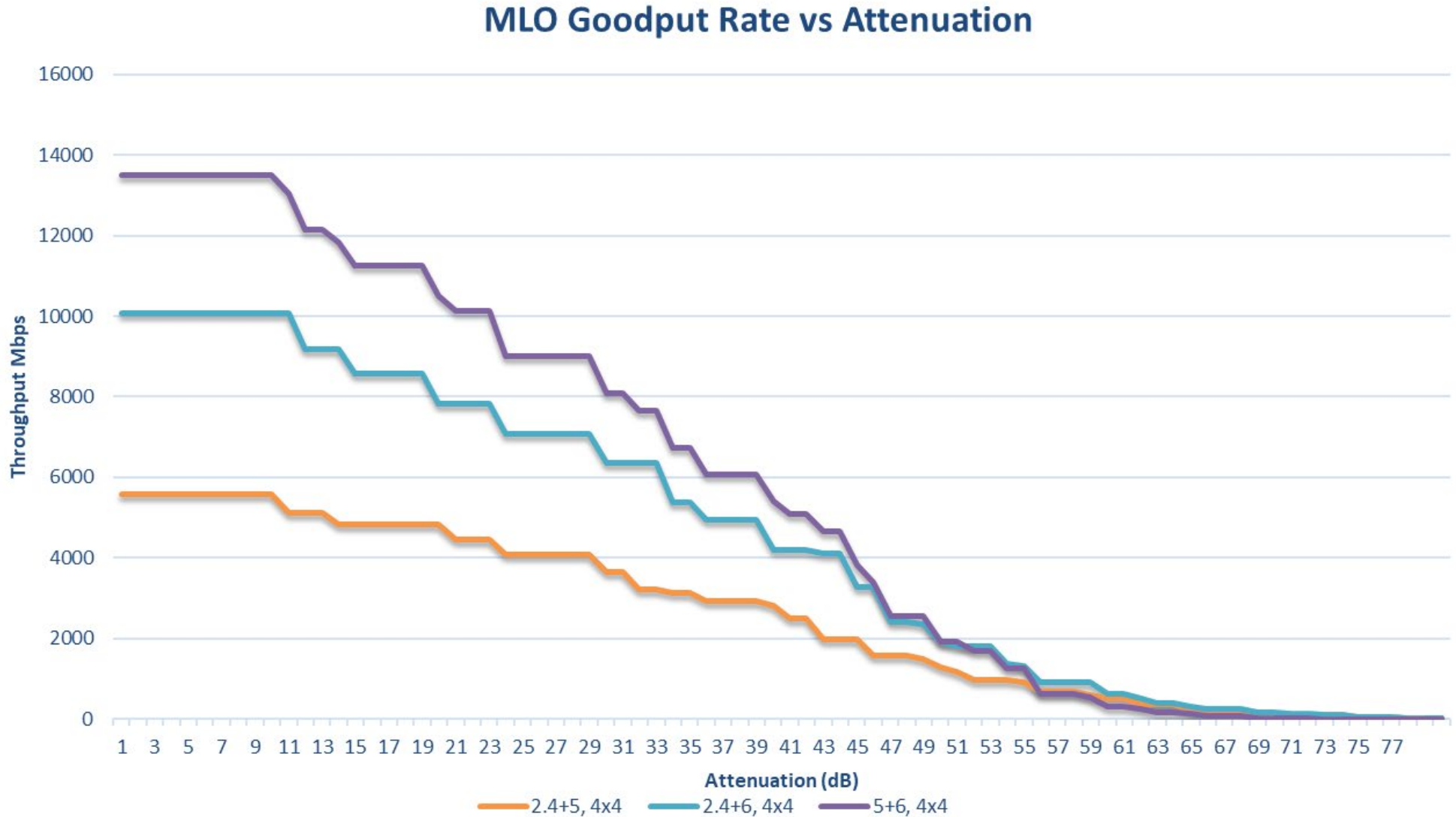
The Home LAN is rapidly expanding from Wi-Fi MAC 5 through 6E and 7 – the latter by next year. Standard Power will also be available in the 6 GHz band.

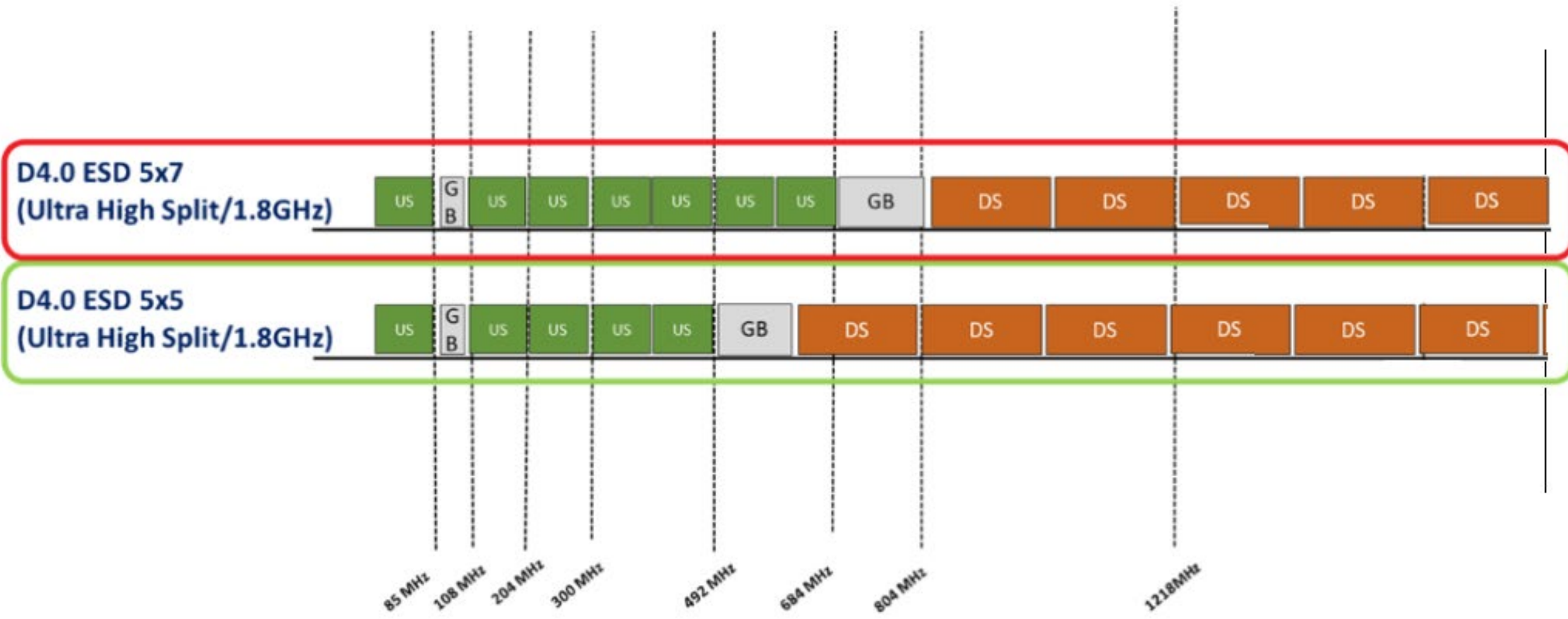
DOCSIS is pushing through the vestiges of 3.1 and onto D4.0 ESD and FDX

Do these two efforts properly anticipate coming in-home services' data requirements? Is bitrate enough?

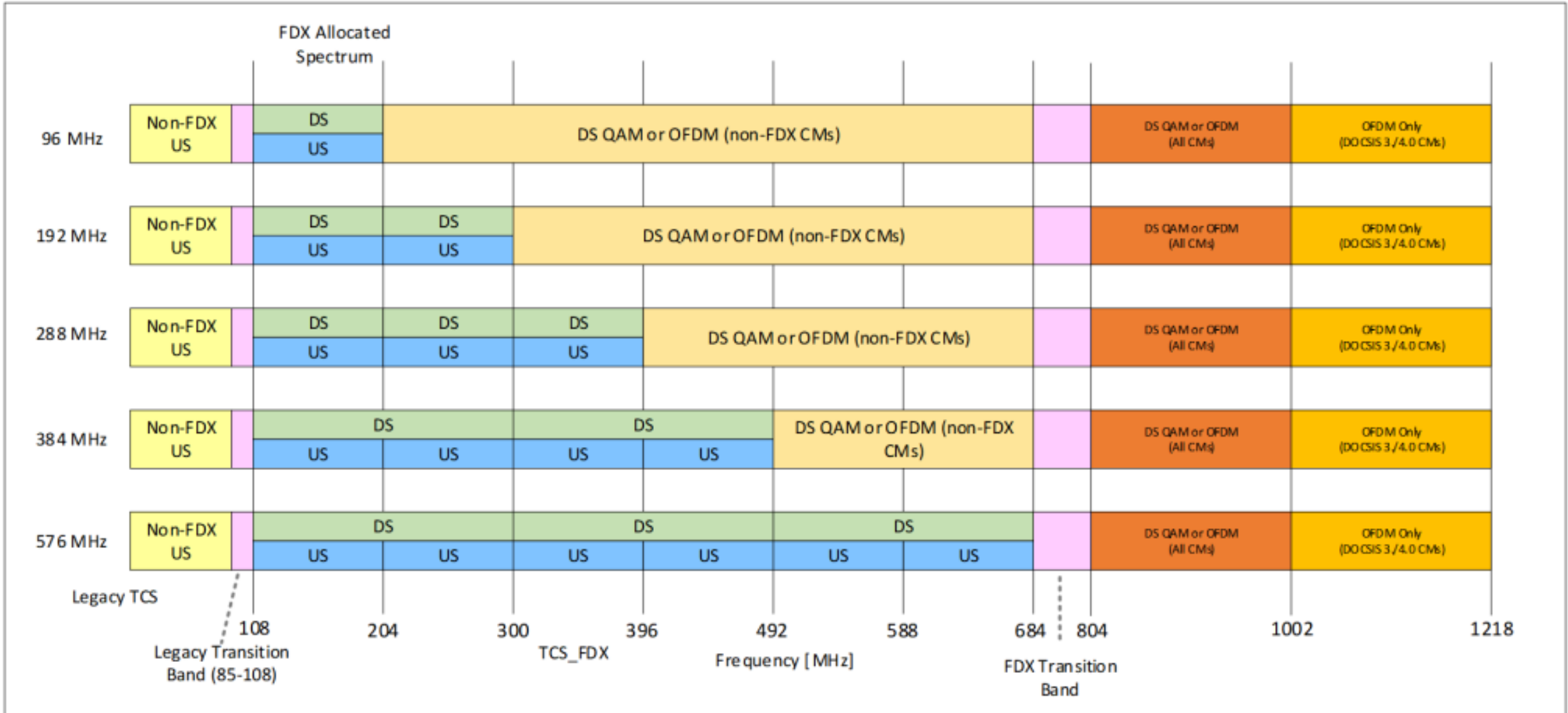
Wi-Fi 6E LPI to SP Benefits







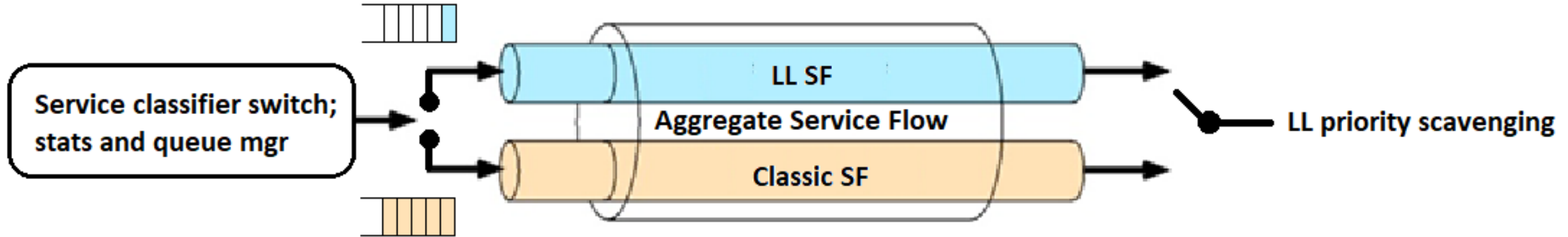
DOCSIS 4.0 FDX Views



(CM/CMTS RTT)

	<i>When Idle</i>	<i>Under Load</i>	<i>99th Percentile</i>
<i>DOCSIS 3.0 Early Equipment</i>	<i>~10ms</i>	<i>~1000ms</i>	<i>~1000ms</i>
<i>DOCSIS 3.0 w/ Buffer Control</i>	<i>~10ms</i>	<i>~100ms</i>	<i>~100ms</i>
<i>DOCSIS 3.1 Active Queue Management</i>	<i>~10ms</i>	<i>~10ms</i>	<i>~100ms</i>
Low Latency DOCSIS 3.1	~1m	~1ms	~1ms

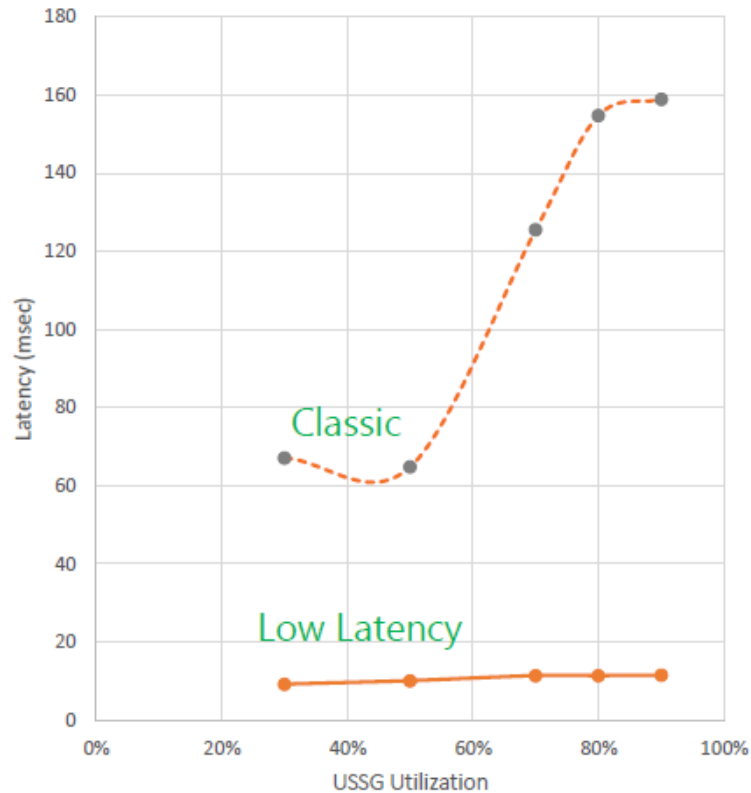
Schema of LLD operation



Impact of LLD operation on latency and jitter

High Classic Traffic

p99 Latency vs USSG Utilization
(90% classic Traffic)

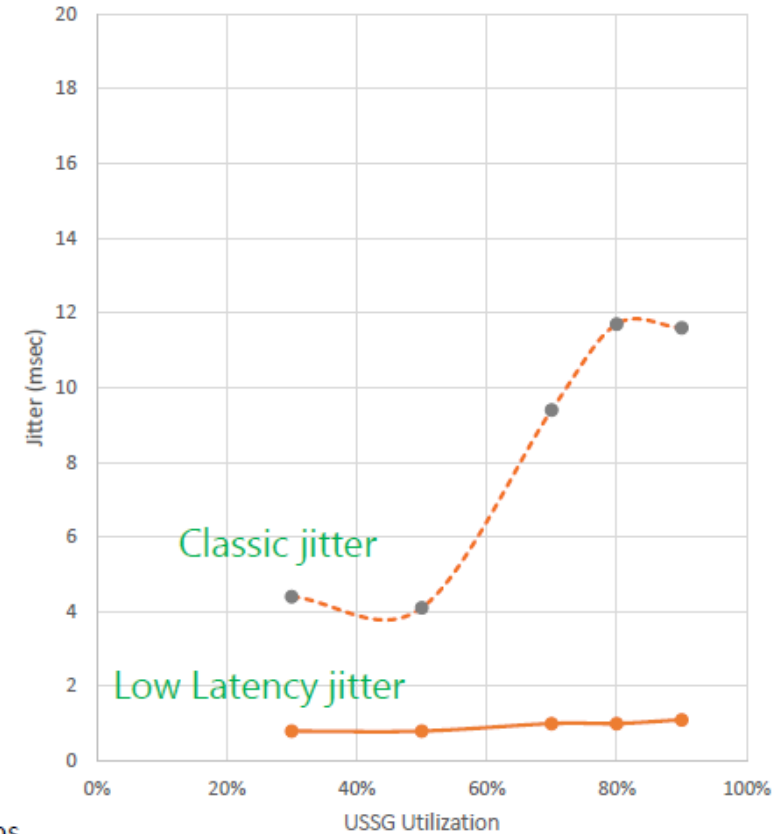


Tmax: 20 Mbps

USSG Capacity: 200 Mbps

High Classic Traffic

Jitter vs USSG Utilization (90% classic Traffic)

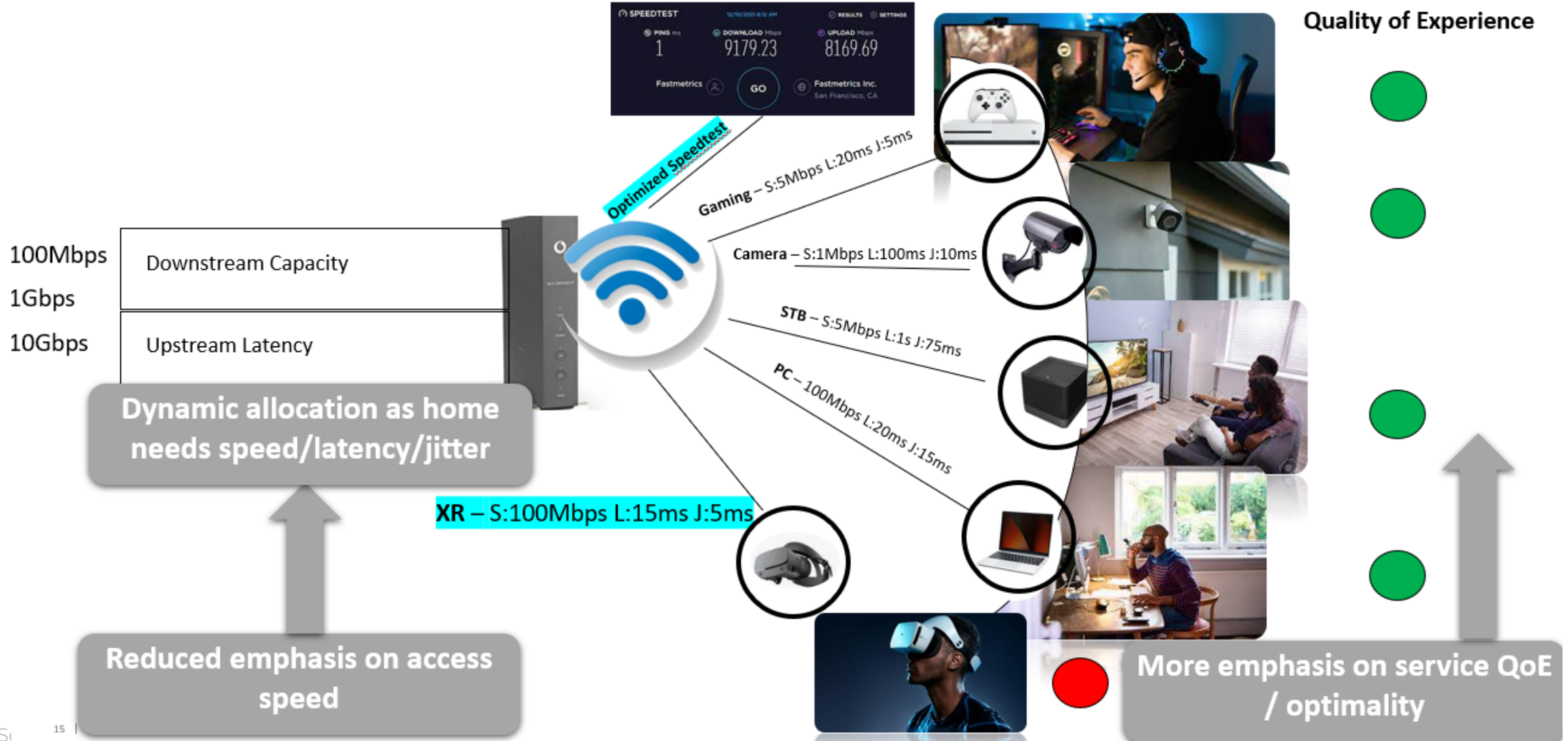


Flow Mapping for Typical Data Services

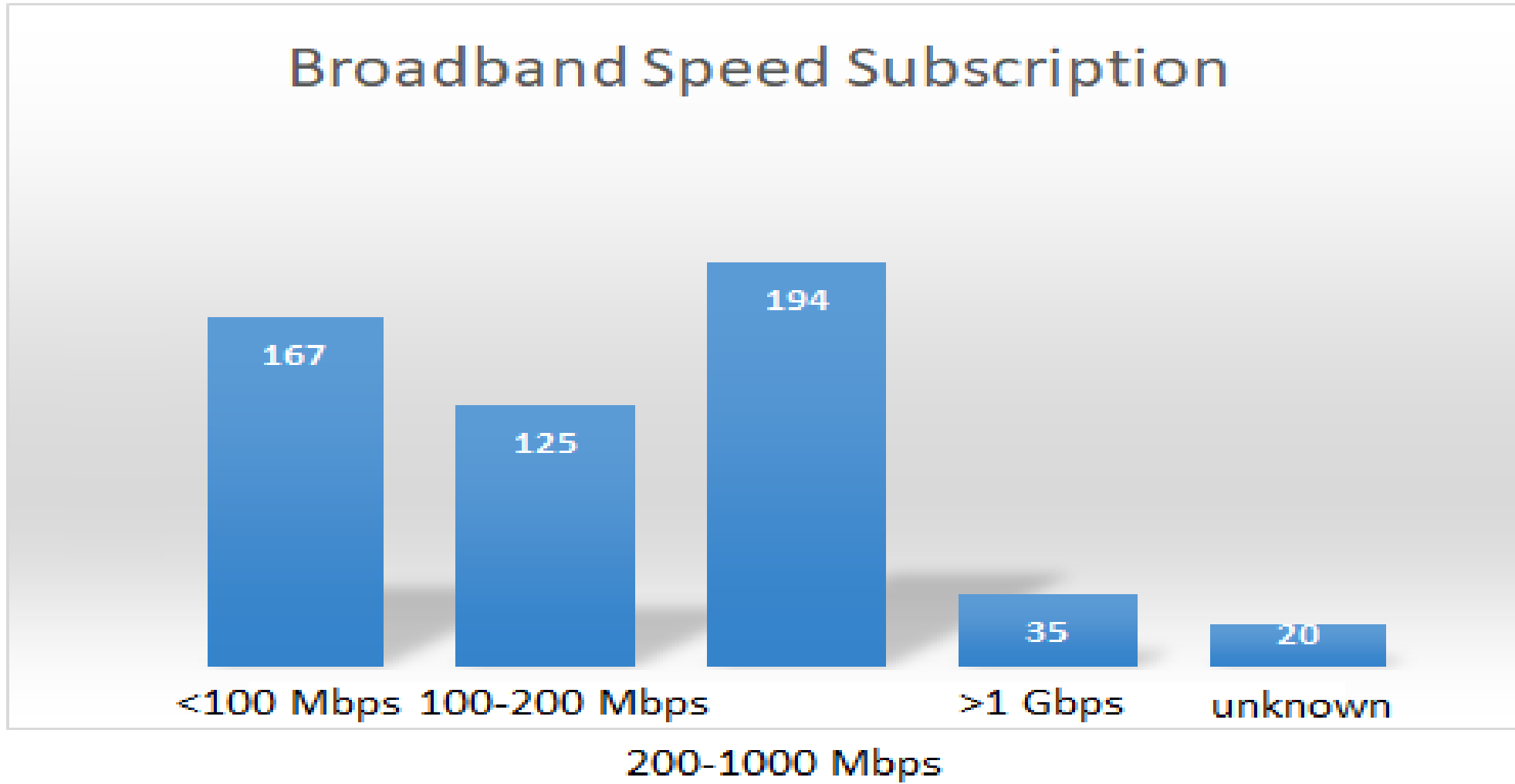
Low Latency	Bulk/Background
Web	Software Updates
Videoconferencing	Dropbox
Audio Streaming	Email
VOIP	VPN*
Gaming	Video

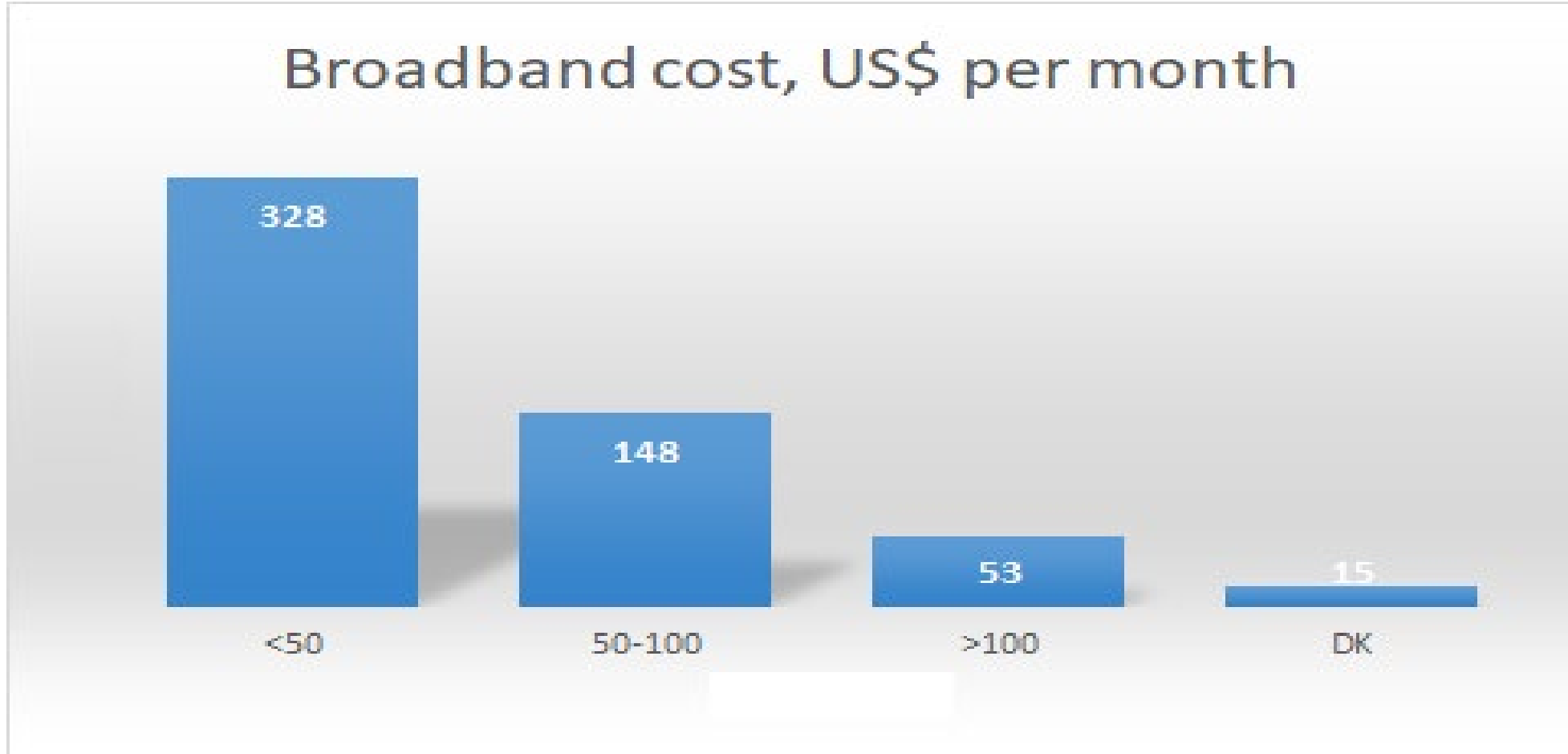
** may also require LLD treatment*

Grooming both latency and speed for new services

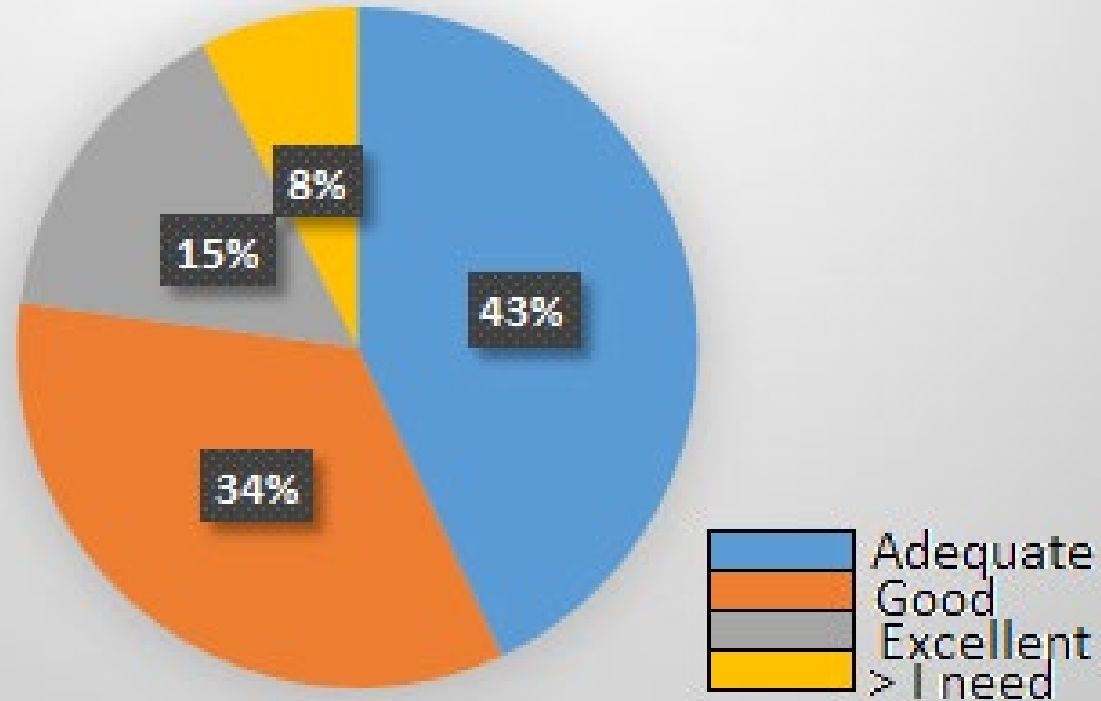


Asia-Pacific	250
North America	187
Carib./Latin America	21
Europe	80
Africa	2

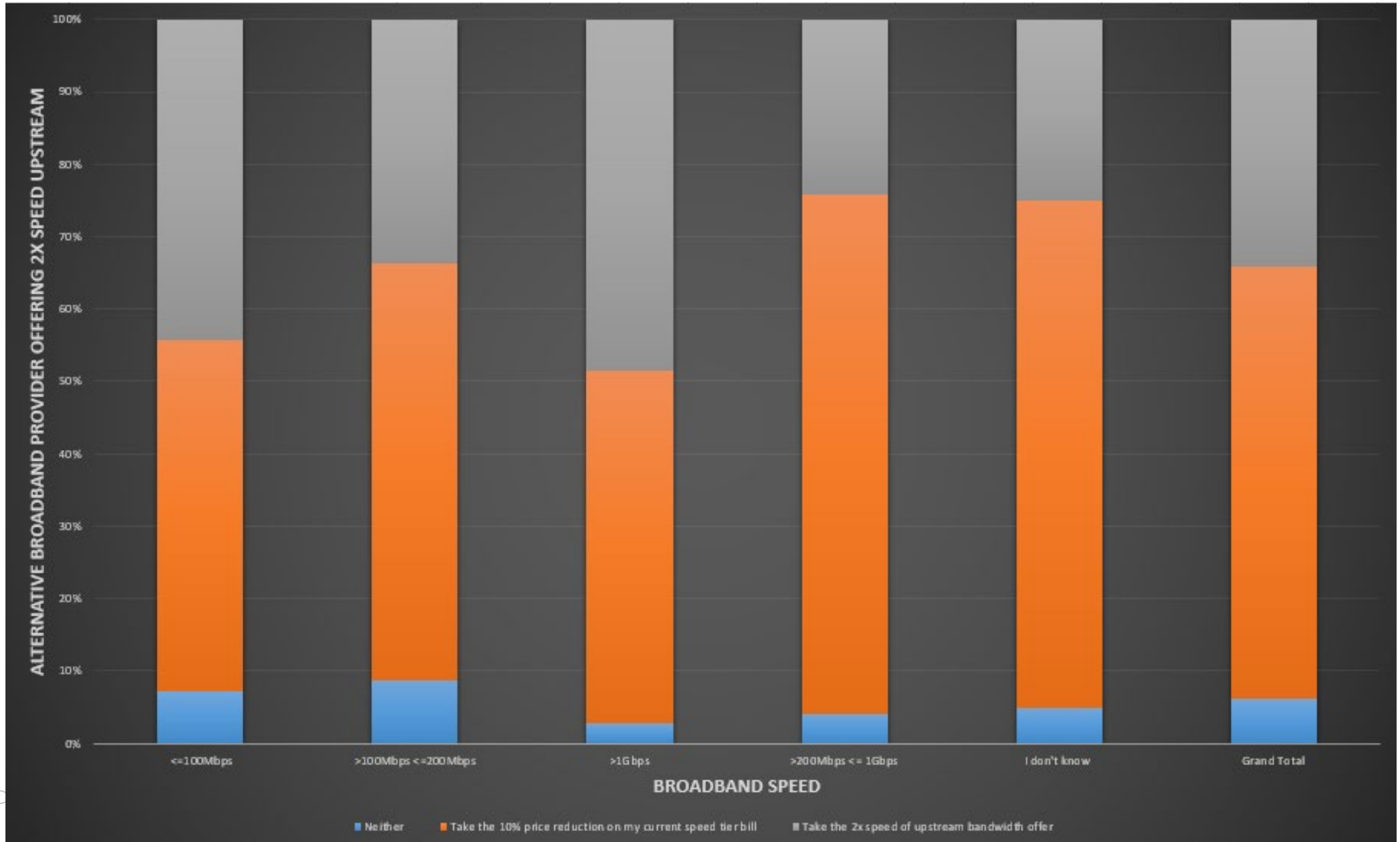




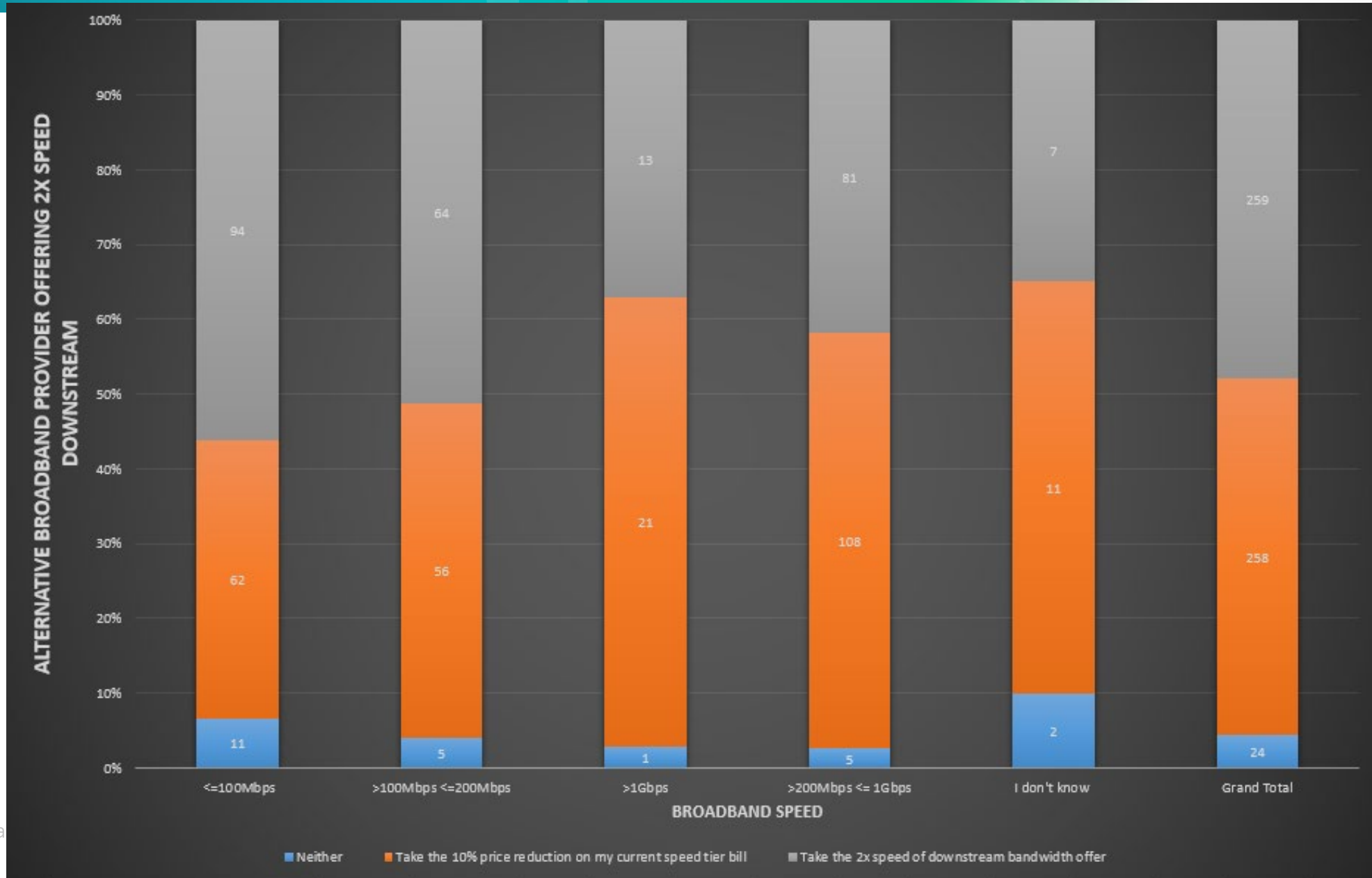
How Do You Rate Your Upstream Speed?



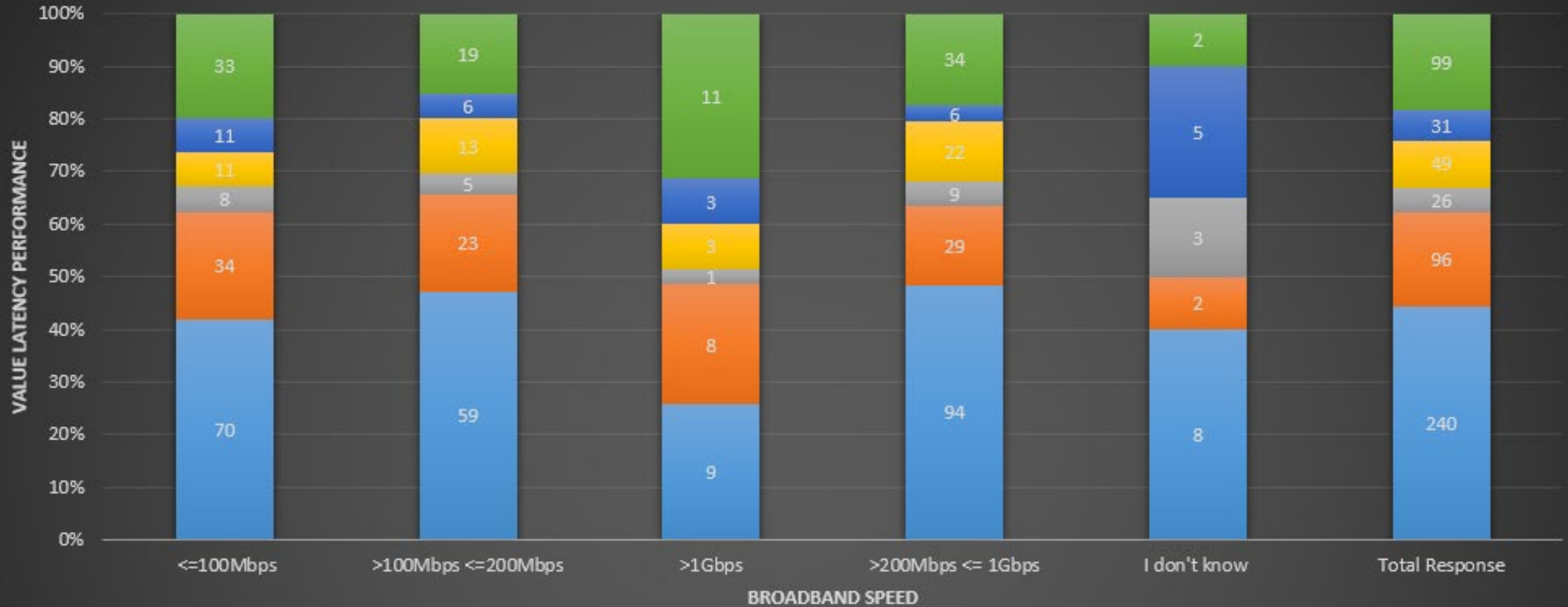
More US speed or cheaper cost?



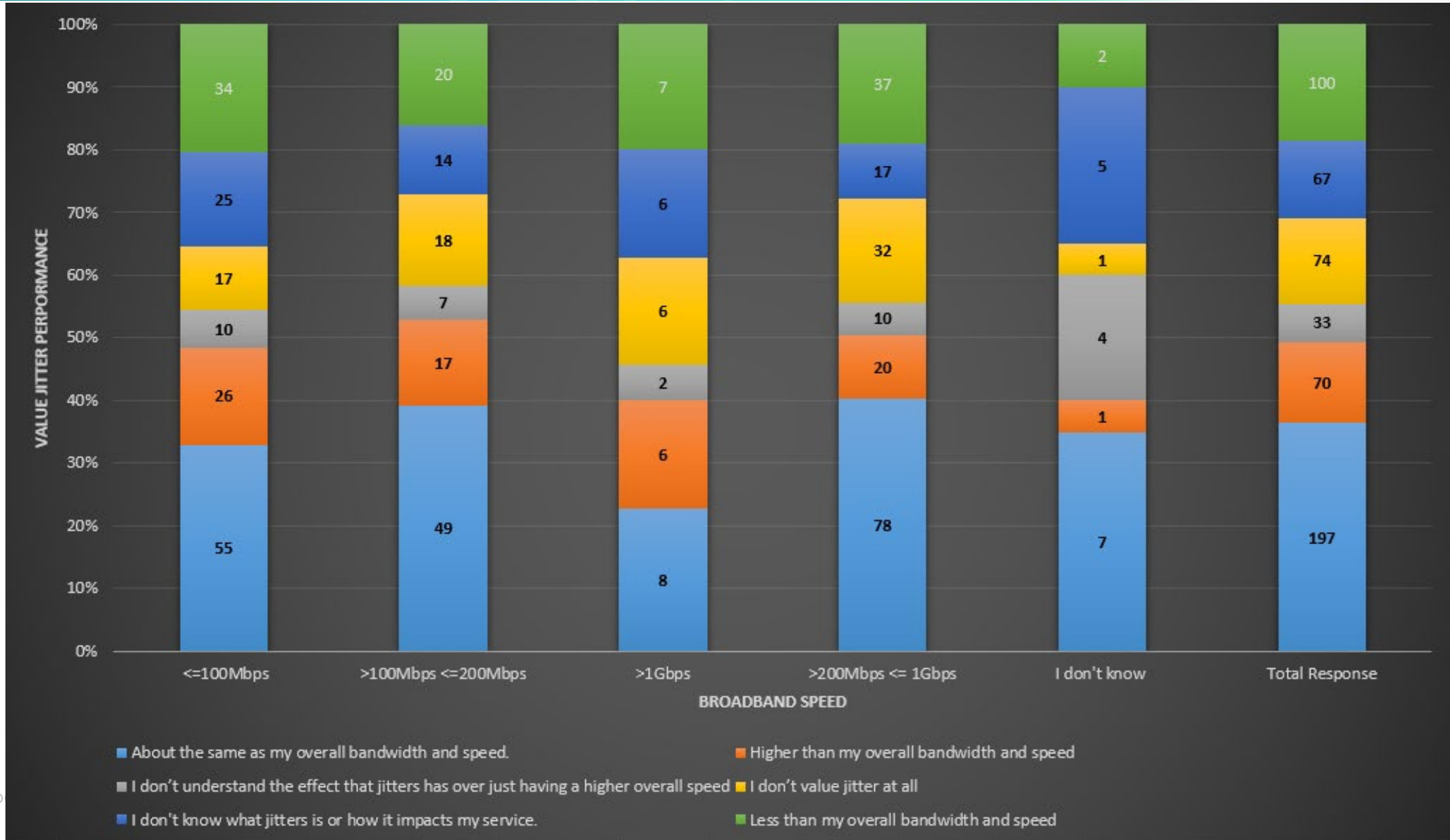
More DS speed or cheaper cost?



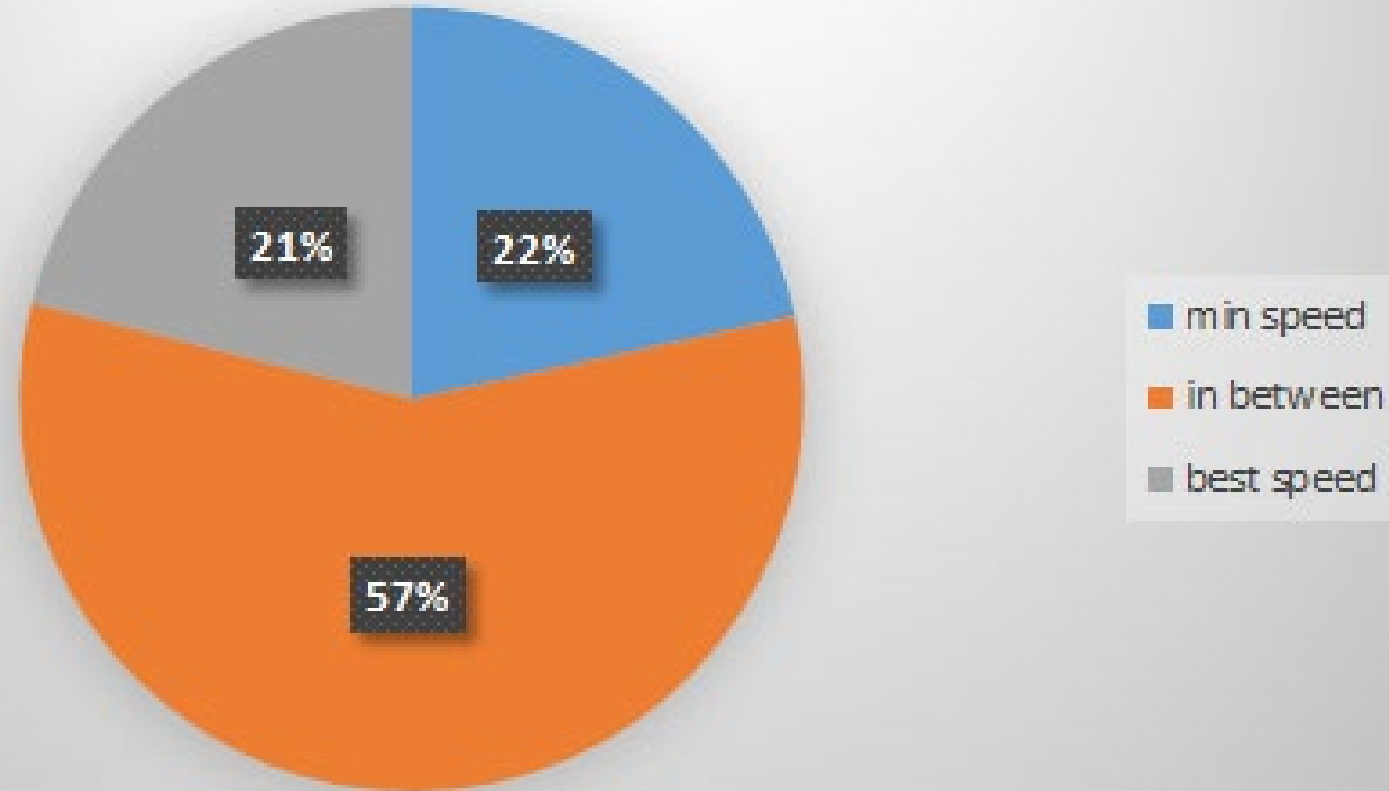
Impressions of the value of latency



Impressions of the value of jitter

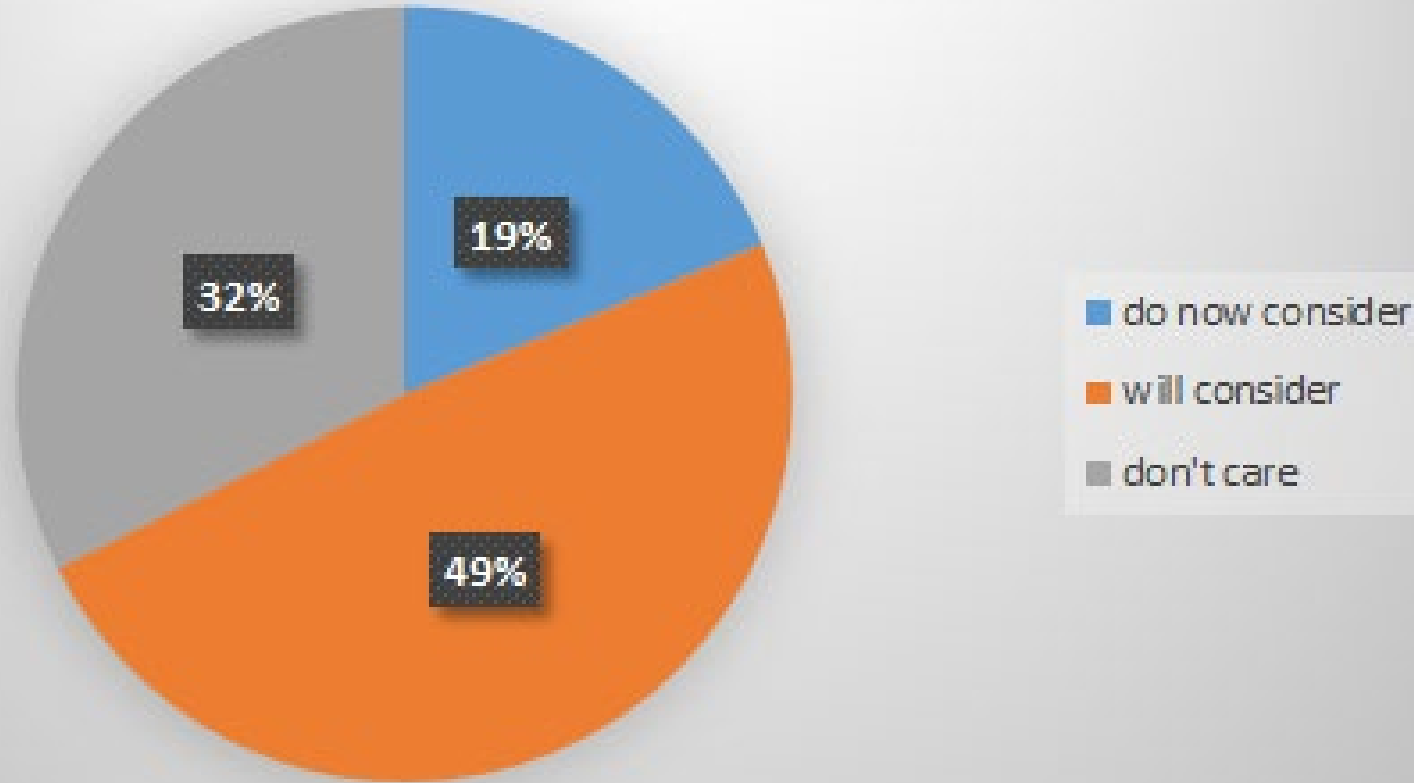


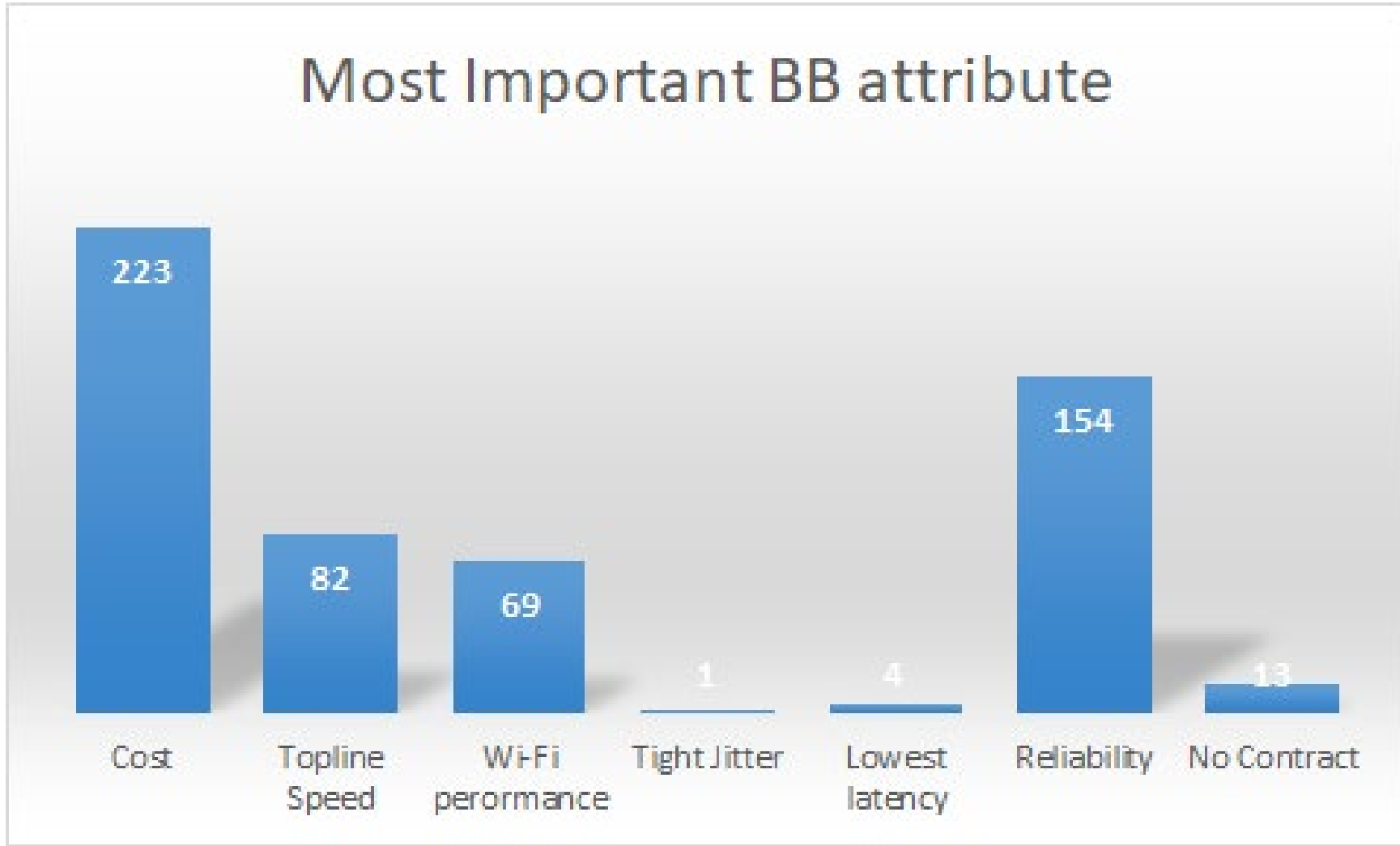
What BB Speed Grade Do You Shop?



Is VR considered in your speed calculus?

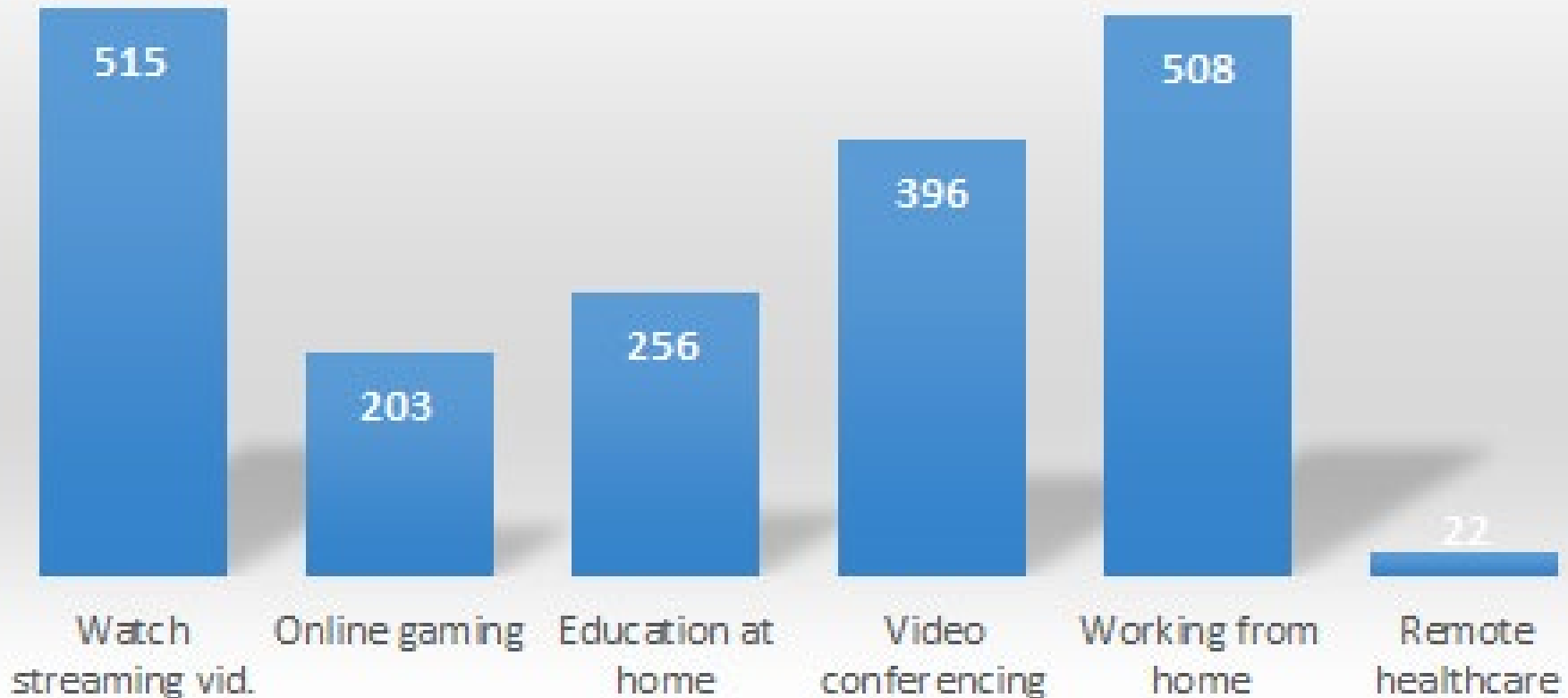
VR Impact on Network Connectivity



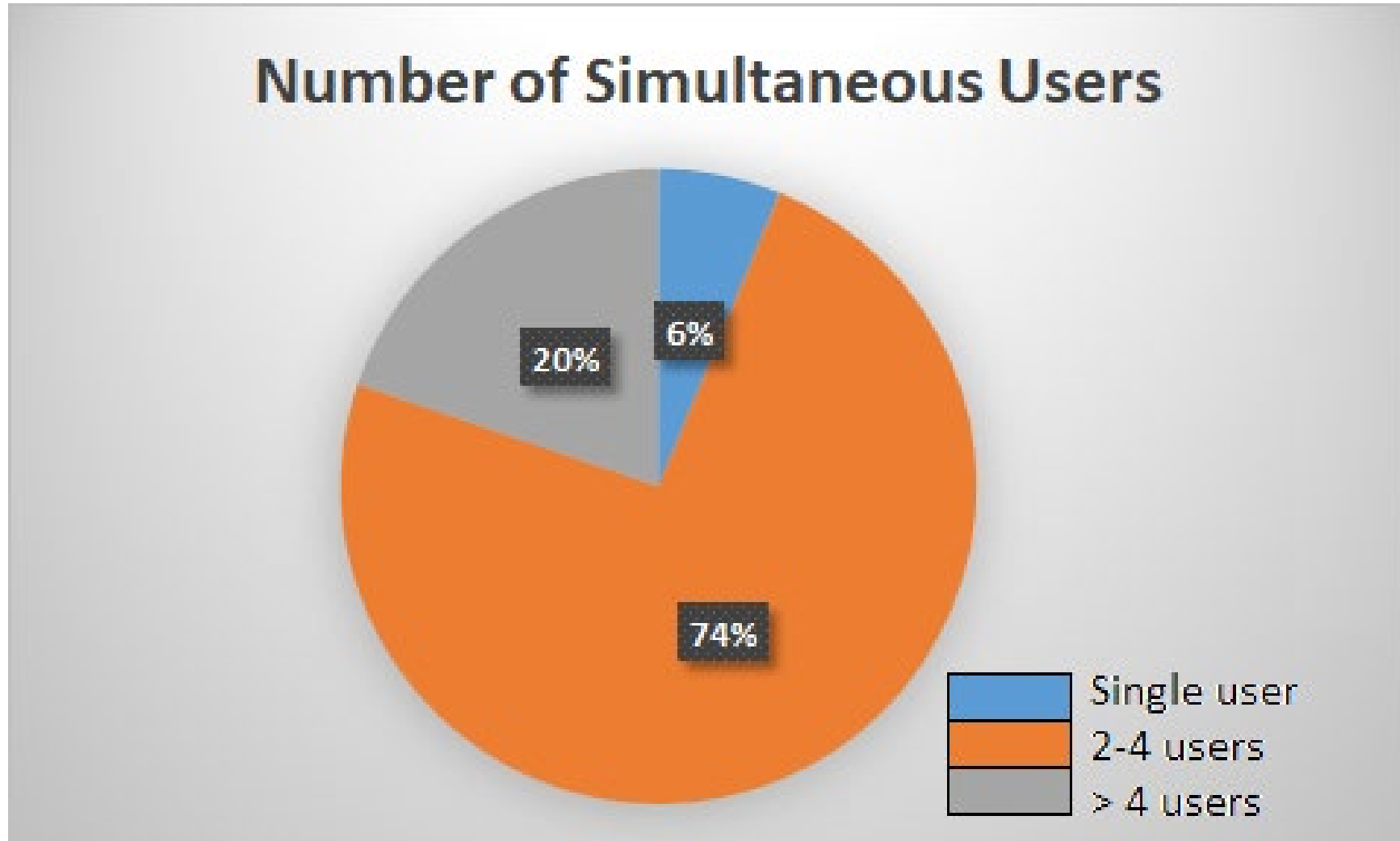


What is most important use of your network?

Network-based Activities



How many typical concurrent users?



Bandwidth Requirements of Cloud VR

- The estimated per-user bandwidths required by strong-interaction services in the three phases of Cloud VR development are as follows:

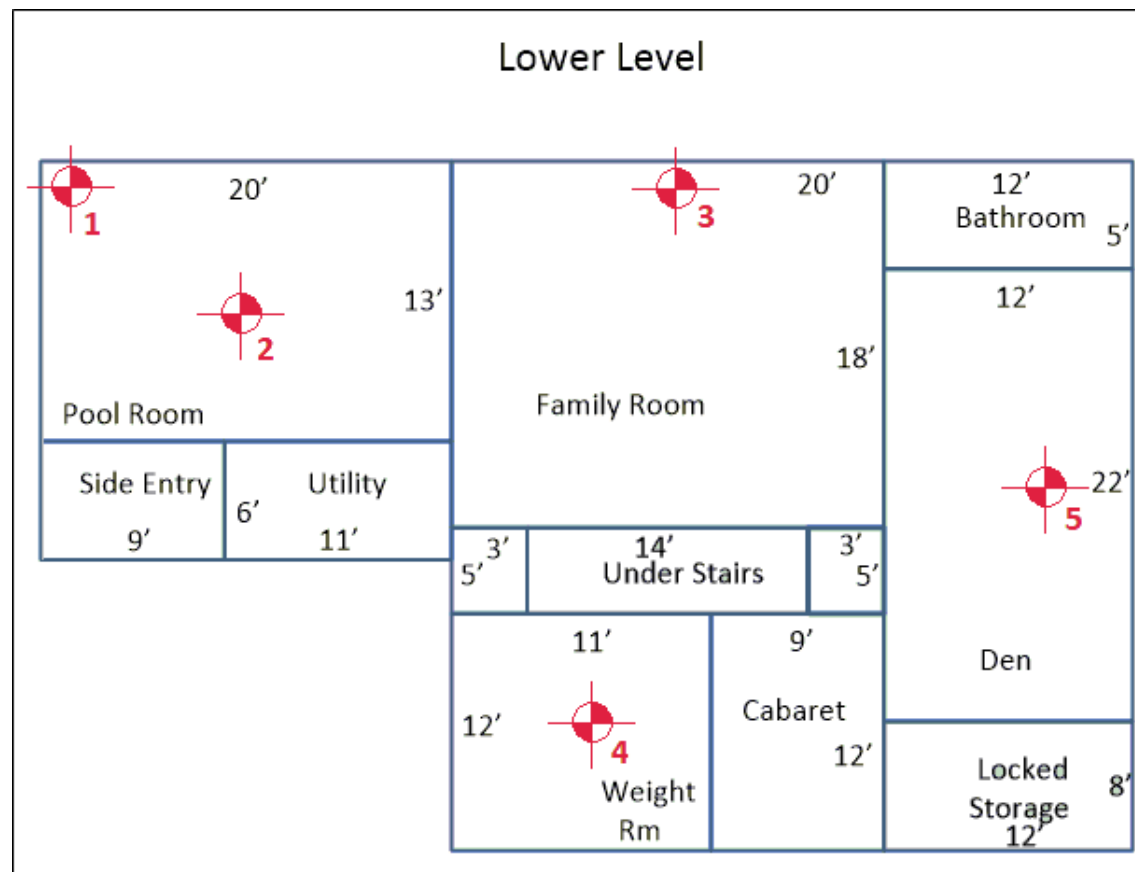
[1]

Phase		Fair-experience Phase	Comfortable-experience Phase	Ideal-experience Phase
Typical content resolution		2K (equivalent full-view resolution: 4K)	4K (equivalent full-view resolution: 8K)	8K/16K (equivalent full-view resolution: 12K/24K)
Typical terminal resolution		2K	4K	8K/16K
FOV		90° to 110°	120°	120° to 140°
Color depth (bits)		8	8	10~12
Coding standard		H.264/265	H.265	H.265/266
Compression ratio (I-frame/P-frame)		25/75	38/165	50/255(8K), 83/585 (16K)
Strong-interaction VR service	Typical bitrate	40 Mbit/s	90 Mbit/s	Full-view: 290 Mbit/s (12K) 1090 Mbit/s(24K) FOV: 155 Mbit/s (12K) 580 Mbit/s(24K)
	Typical bandwidth requirement	80 Mbit/s	260 Mbit/s	360 Mbit/s (8K) 1.5 Gbit/s (16K)

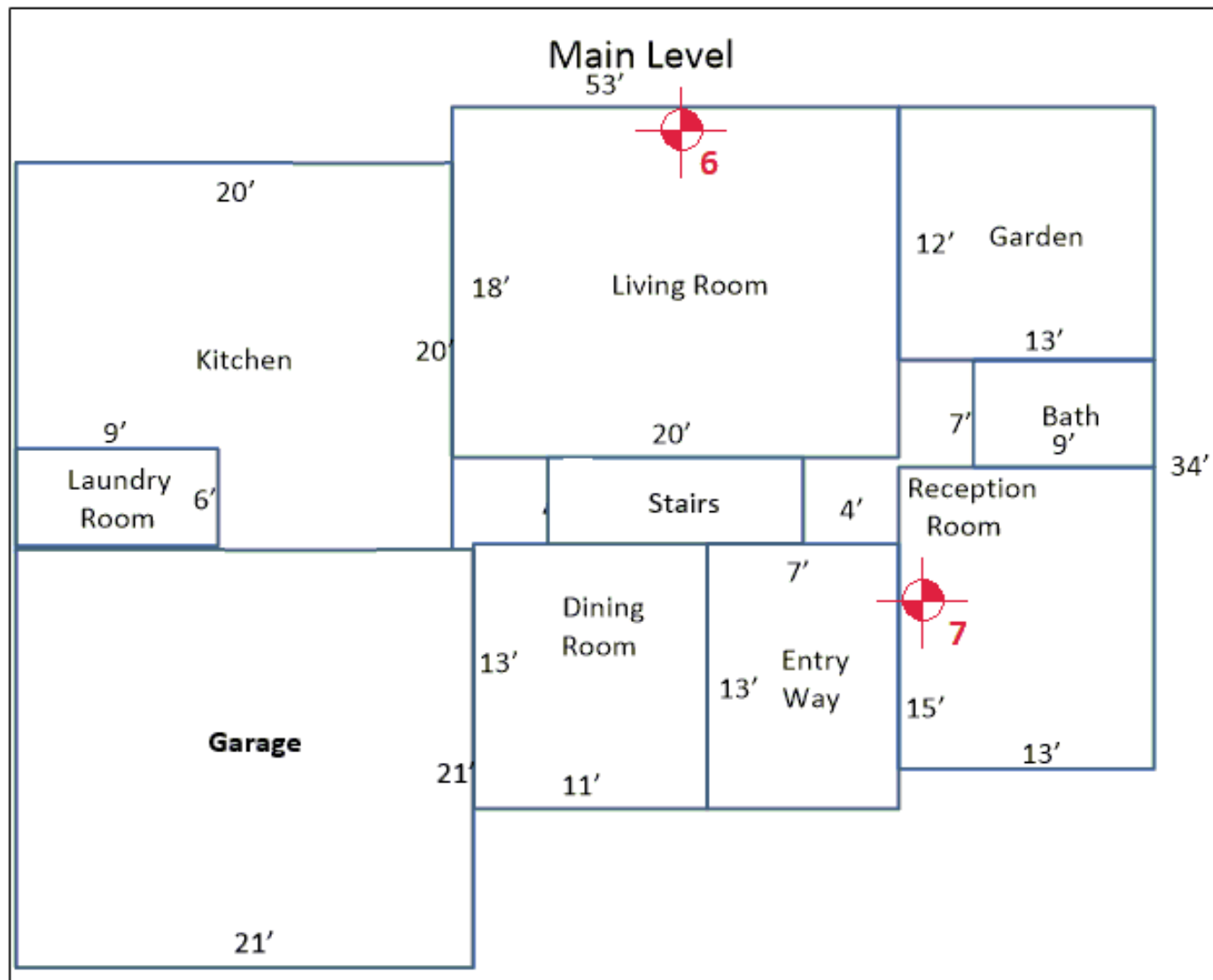


Note relentless increase in video bitrate

Study Exercise lower level



Study Exercise middle level



6



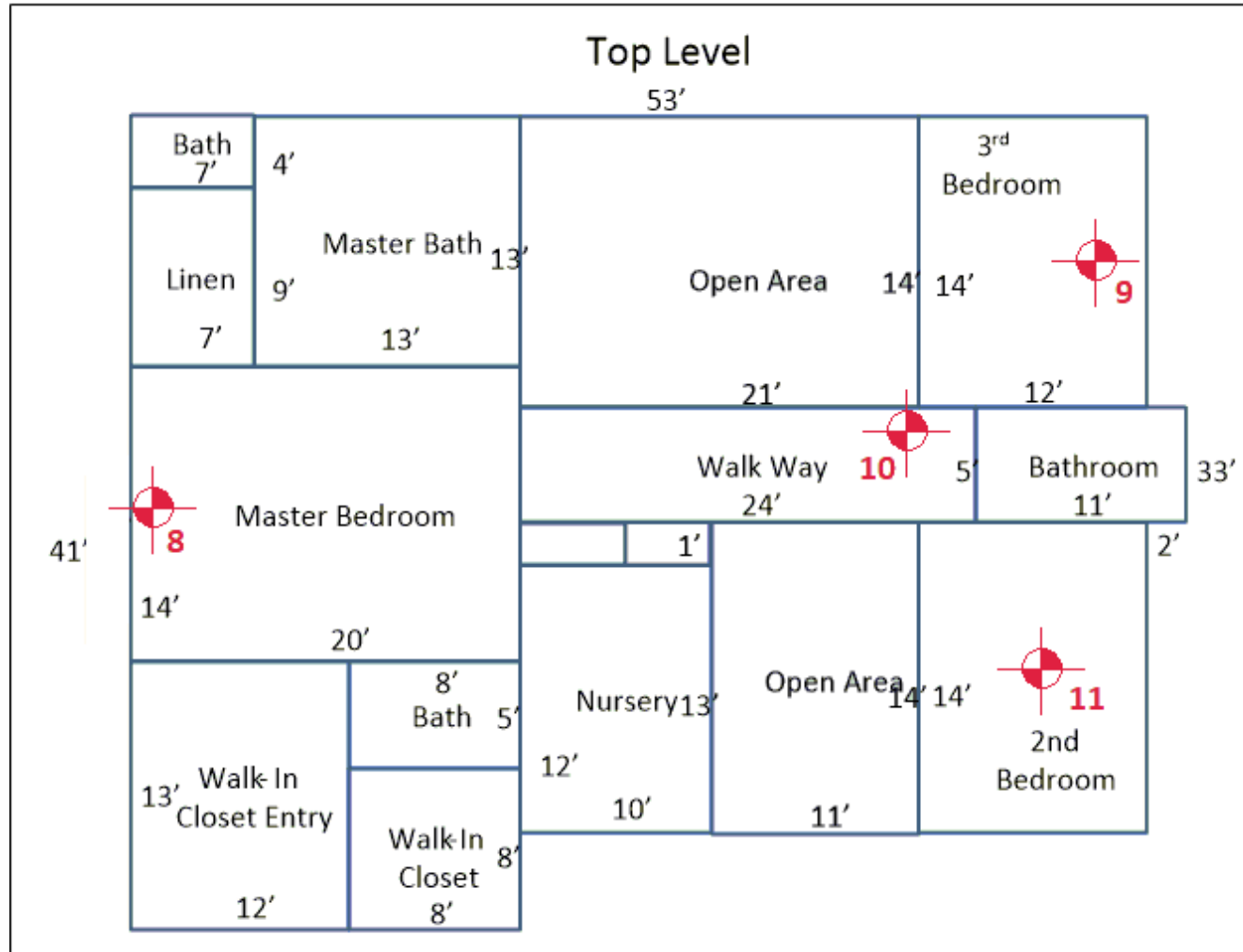
8K TV

7



iPad gaming

Study Exercise upper level



8



8K TV

9



Playstation

10



Extender

11



phone

Wi-Fi airtime stress, standard power, Wi-Fi7 and extender

Device	Location	AP	Path Loss	Link Capacity	Service Bitrate	Service Latency	Service Jitter	Airtime %	Low Latency?
VR station	downstairs pool room	Gateway	10.8 dB	6500 Mbps	100 Mbps	5 msec	2 msec	1.54	yes
8K TV	downstairs family room	Gateway	24.2 dB	5250 Mbps	50 Mbps	250 msec	50 msec	0.95	no
phone (streaming)	downstairs weight room	Gateway	35.5 dB	1800 Mbps*	2 Mbps (up)	15-20 msec	5 msec	0.11	no
laptop (SOHO, teleconf)	downstairs den	Gateway	33.3 dB	2850 Mbps*	2 Mbps (up)	5-10 msec	2-3 msec	0.07	yes
8K TV	middle level, living room	Gateway	33.8 dB	4500 Mbps	50 Mbps	250 msec	50 msec	1.11	no
iPad, gaming	middle level, reception room	Extender	25.5 dB	4950 Mbps	350 kbps	10 msec	3 msec	0.007	yes
8K TV	upstairs, master bedroom	Extender	26.1 dB	4900 Mbps	50 Mbps	250 msec	50 msec	1.02	no
Playstation gaming	upstairs, bedroom 2	Extender	13.1 dB	6500 Mbps	350 kbps	10 msec	3 msec	0.005	yes
phone (streaming)	upstairs, bedroom 3	Extender	18.1 dB	4500 Mbps*	2 Mbps (up)	15-20 msec	5 msec	0.044	no
4SS MLO Trunk (5G+6G)	pool room to upper landing	AP/EXT	35.9 dB	8250 Mbps	52.7 Mbps	< 2 msec	< 1 msec	0.64	yes
Total, Gateway:			*client upstream EIRP limited					4.42	
Total, Extender:								1.716	
Client Bitrate Service					256.7 Mbps				

Wi-Fi airtime stress, LPI only, Wi-Fi7 and extender

Device	Location	AP	Path Loss	Link Capacity	Service Bitrate	Service Latency	Service Jitter	Airtime %	Low Latency?	
VR station	downstairs pool room	Gateway	10.8 dB	6500 Mbps	100 Mbps	5 msec	2 msec	1.54	yes	
8K TV	downstairs family room	Gateway	24.2 dB	4500 Mbps	50 Mbps	250 msec	50 msec	1.11	no	
phone (streaming)	downstairs weight room	Gateway	35.5 dB	1750 Mbps*	2 Mbps (up)	15-20 msec	5 msec	0.065	no	
laptop (SOHO, teleconf)	downstairs den	Gateway	33.3 dB	2900 Mbps*	2 Mbps (up)	5-10 msec	2-3 msec	0.055	yes	
8K TV	middle level, living room	Gateway	33.8 dB	3425 Mbps	50 Mbps	250 msec	50 msec	1.46	no	
iPad, gaming	middle level, reception room	Extender	25.5 dB	4500 Mbps	350 kbps	10 msec	3 msec	0.008	yes	
8K TV	upstairs, master bedroom	Extender	26.1 dB	4500 Mbps	50 Mbps	250 msec	50 msec	1.11	no	
Playstation gaming	upstairs, bedroom 2	Extender	13.1 dB	6025 Mbps	350 kbps	10 msec	3 msec	0.006	yes	
phone (streaming)	upstairs, bedroom 3	Extender	18.1 dB	2250 Mbps*	2 Mbps (up)	15-20 msec	5 msec	0.089	no	
4SS MLO Trunk (5G+6G)	pool room to upper landing	AP/EXT	35.9 dB	6000 Mbps	52.7 Mbps	< 2 msec	< 1 msec	0.88	yes	
Total, Gateway:			*client EIRP limited						5.11	
Total, Extender:								2.093		
Client Bitrate Service					256.7 Mbps					

Wi-Fi airtime stress, Standard Power, Wi-Fi 7, no extender

Device	Location	AP	Path Loss	Link Capacity	Service Bitrate	Service Latency	Service Jitter	Airtime %	Low Latency?
VR station	downstairs pool room	Gateway	10.8 dB	6500 Mbps	100 Mbps	5 msec	2 msec	1.54	yes
8K TV	downstairs family room	Gateway	24.2 dB	5250 Mbps	50 Mbps	250 msec	50 msec	0.95	no
phone (streaming)	downstairs weight room	Gateway	35.5 dB	1750 Mbps*	2 Mbps (up)	15-20 msec	5 msec	0.11	no
laptop (SOHO, teleconf)	downstairs den	Gateway	33.3 dB	2900 Mbps*	2 Mbps (up)	5-10 msec	2-3 msec	0.069	yes
8K TV	middle level, living room	Gateway	33.8 dB	4500 Mbps	50 Mbps	250 msec	50 msec	1.11	no
iPad, gaming	middle level, reception room	Gateway	38.0 dB	3700 Mbps	350 kbps	10 msec	3 msec	0.0095	yes
8K TV	upstairs, master bedroom	Gateway	41.5 dB	2575 Mbps	50 Mbps	250 msec	50 msec	1.94	no
Playstation gaming	upstairs, bedroom 2	Gateway	42.3 dB	2450 Mbps	350 kbps	10 msec	3 msec	0.014	yes
phone (streaming)	upstairs, bedroom 3	Gateway	47.6 dB	355 Mbps*	2 Mbps (up)	15-20 msec	5 msec	0.56	no
Total, Gateway:				*client EIRP limited				6.3025	
Client Bitrate Service					256.7 Mbps				

*Current Tavg is **3.5 Mbps**

*The study impact is an untenable Tavg of 250 Mbps+ ! (SG's way too small)

*The likelihood of significant adoption of VR is major-league problematic – and Oculus' CAGR betrays some significant growth optimism; something has to give.

*Assuming “only” a bump to Tavg = **25 Mbps/HH**:

Split @ 204 MHz, BW @ 1.2 GHz, ESD could do decent SG sizes (**160+**) with an SLA of 5 Gbps

*Go to Tavg = **50 Mbps**:

Set split @ 400 MHz, BW @ 1.8 GHz, could do SGs in the range of **60+** with an SLA of 10 Gbps

- Both WAN and LAN networks are poised for necessary futureproofing
- Wi-Fi 7 and Standard Power provide more raw bitrate capacity “fat” than DOCSIS 4.0 – but both can be manipulated to introduce new (lower) tiers of controlled latency and jitter
- Vx especially represents an immersive consumption tier whose too-rapid onset adoption may overturn the customer QoS status quo perceptions – and must be monitored
- Vx aside, with proper curation of latency, fully symmetric service services up to 10G/10G do not yet appear at all imminent
- There appear to be opportunities in user education and, subsequently, curation of both latency and jitter attributes in service delivery



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Thank You!

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