Scaling User Plane Functions for home broadband over Fixed-Wireless Access

White paper

5G fixed-wireless access (FWA) is rapidly emerging as an option for expanding broadband capacity and coverage for underserved homes and businesses in areas where trenching fiber is too costly or time consuming.

This paper compares deploying physical routers as User Plane Functions (UPF) and servers running virtualized UPFs to enable cost and performance-optimized broadband services over FWA.

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Introduction

5G fixed-wireless access (FWA) is a promising option for expanding broadband service coverage in various application scenarios:

- Spot coverage in high-density urban population centers and public venues.
- Expand capacity for underserved homes with legacy copper and coaxial access,
- Expand coverage in rural areas and manage the cost and lead time of new fiber deployments.

To complement (or compete with!) wireline access, broadband services delivered over 5G FWA must support an equivalent service mix and user experience at a comparable price point. Although it uses wireless access, 5G FWA will exhibit the same service characteristics as wireline broadband services:

- There are limited mobility requirements (e.g., X2 handover in case of eNB outages) as the residential gateway is stationary and maintains a static, always-on session for up to a dozen user devices such as TVs, PCs, game consoles and tablets.
- Residents may use these devices concurrently for several hours per day.
- Monthly data usage per home averages several hundreds of Gigabytes that are charged at a monthly flat rate, without usage caps for the highest service tiers.

Table 1. Comparing residential and mobile broadband characteristics

Service characteristic	Residential broadband	Mobile broadband
Devices per session	10+ per home (TVs, PC, etc)	1 (smart phone)
Session duration	Always-on, static	Short, dynamic
Average bandwidth	Order of Mbps	Order of Kbps
Monthly data usage	Hundreds of Gigabytes	Several Gigabytes
Data plan	Unlimited	Usage quota

Scaling challenges

User plane scalability poses a challenge for mobile operators because the bandwidth requirements of home broadband services over FWA are 20 to 50 times higher than mobile broadband services and can rapidly surpass mobile broadband traffic, even at low subscriber take rates.

Fundamentally there are two implementation options for user plane functions:

1. Virtualized on x86 server appliances, or
2. Physical on IP routers in the network

Mobile gateways generally use a virtualized user plane because mobile applications have specific user and charging features that demand stateful deep packet inspection (DPI) capabilities. These high-value applications scale well on virtualized servers powered by general purpose CPUs such as Intel Xeon.

FWA gateways have comparable service requirements as Broadband Network Gateways (BNGs) and must be cost-optimized for high-bandwidth applications such as IPTV/video, high-speed Internet, on-line gaming, and VPN access. These applications scale better on IP routers with custom network processors that are design-optimized for high-bandwidth services with deterministic Quality of Service.

This paper compares the scaling properties of virtualized and physical user plane options to determine the most cost-effective option for scaling FWA services.

Modeling assumptions

For the TCO analysis we compared the performance of scaling User Plane Functions (UPFs) on the Nokia 7750 SR-1x routers powered by FP5 silicon with virtualized UPFs on HPE Proliant DL365 Gen 10+ servers with 2 Intel Xeon CPUs and 4 100GE Network Interface Cards. The performance benchmarks of these systems are listed in Table 2.

Table 2. System benchmarks

Specification	7750 SR-1x-48D router	HPE DL365 Gen 10+ server
Processor	2x Nokia FP5 NPU	2x Intel Xeon 8380 CPU
Chassis size	2 rack units	1 rack unit
Bandwidth capacity	2.4 Tb/s	248 Gb/s
Subscriber capacity	256,000	256,000
Energy consumption	1100 Watt	680 Watt

We compared the user plane scaling properties for a deployment starting with 250,000 subscribers with an average bandwidth of 5 Mb/s in Year 1, increasing to 10 Mb/s in year 5. This reflects the evolution of video streaming from Full High Definition (3 to 6 Mb/s bit rates) to Ultra-High Definition and 4K (bit rates range from 12 to 32 Mb/s). FWA service uptake is growing vigorously year over year, which reflects the reality of several large scale FWA deployments (e.g., Verizon, AT&T, T-Mobile).

Table 3. Subscriber and traffic growth assumptions

Network assumptions	Y1	Y2	Y3	Y4	Y5
Subscriber growth		80%	70%	65%	50%
Subscribed homes	250,000	450,000	765,000	1,262,250	1,893,375
Bandwidth/home (Mb/s)	5	5	5	7	10
Total bandwidth (Tb/s)	**1.25**	**2.25**	**3.83**	**8.84**	**18.93**

The study analyzed the differences in Total Cost of Ownership (TCO) by comparing rack space and energy consumption, which are limited resources with a recurring operational cost. The network design assumes 1+1 UPF redundancy meaning that each FWA gateway node consists of at least two systems (routers or servers) in case one of them fails. The study made no assumptions on system locations, but it is good network practice to geographically distribute nodes.

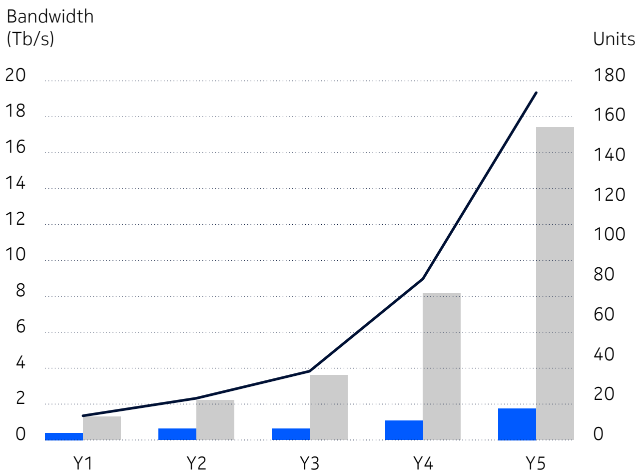
The study solely focused on user plane function scaling because control plane functions can scale independently on virtual servers with Control User Plane Separation (CUPS).

Modeling results

Table 4 plots the total number of units needed to support the subscriber count and bandwidth requirements. Because 7750 SR routers (SR UPF) deliver much higher performance than virtualized servers (VR UPF), far fewer system units are needed to address bandwidth requirements, especially in later years as the average peak bandwidth increases to 10 Mb/s per home.

Table 4. Total units required for UPF scaling

System units

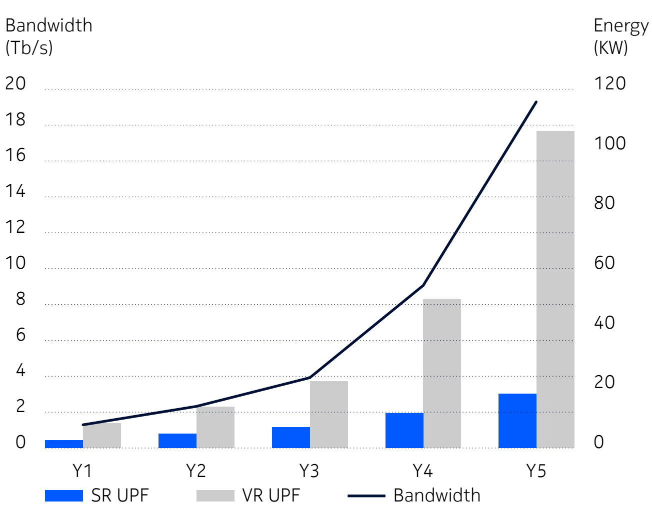


	Y1	Y2	Y3	Y4	Y5
SR UPF	2	4	6	10	16
VR UPF	12	20	32	72	154
Bandwidth	1.25	2.25	3.83	8.84	18.93

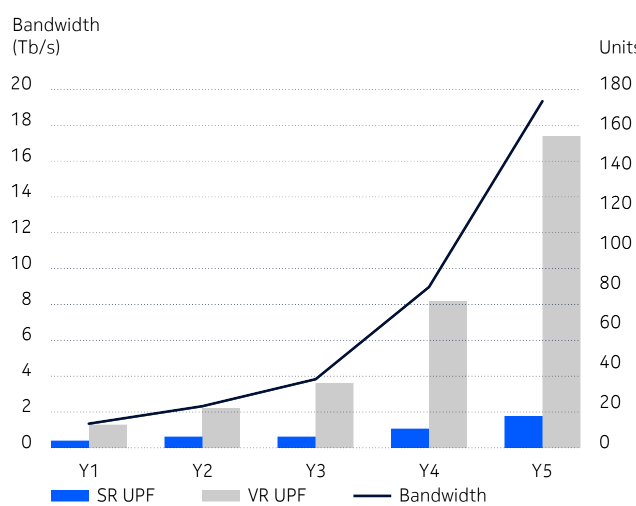
Table 5 compares the rack space and energy use of scaling UPFs on service routers versus virtualized routers. By Year 5, deploying a physical UPF on Nokia 7750 SR routers consumes almost 5 times less rack space and 6 times less energy than virtualized router deployments. The actual cost savings when using service routers are even higher when factoring in the additional Top of Rack switches that would be needed to interconnect virtualized UPF servers.

Table 5. Rack space and energy consumption

Energy Use



System units



Conclusion

Fixed-wireless access (FWA) is a promising option for delivering broadband services to unconnected and underserved homes and businesses. Since FWA service requirements are comparable to wireline broadband network gateways, there is an opportunity to leverage similar service routing platforms to scale FWA gateway user plane functions.

- When comparing the scaling properties of virtualized and physical user plane options, our network modeling found that Nokia 7750 Service Routers powered by FP5 silicon consumed up to 5x less rack space and up to 6x less energy than current virtual server appliances based on Intel Xeon. The comparison assumed a typical broadband service offer consisting of high-speed Internet with IPTV content services (ie., broadcast TV and on-demand video content such as Netflix).
- Energy and rack space are precious resources that represent a recurring operational cost that accumulates over time. Scaling FWA UPFs on service routers should also yield substantial savings on platform hardware and software licenses, but these savings depend on commercial aspects that are outside the scope of this study.
- The Nokia Multi-Access Gateway enables operators to efficiently scale their FWA UPFs on services routers, and seamlessly integrate with 3GPP service-based architectures through standard interfaces in 5G non-standalone or 5G standalone mode.

To learn more, please visit the Nokia Multi-Access Gateway website or read our FWA solution brochure.

Table references

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