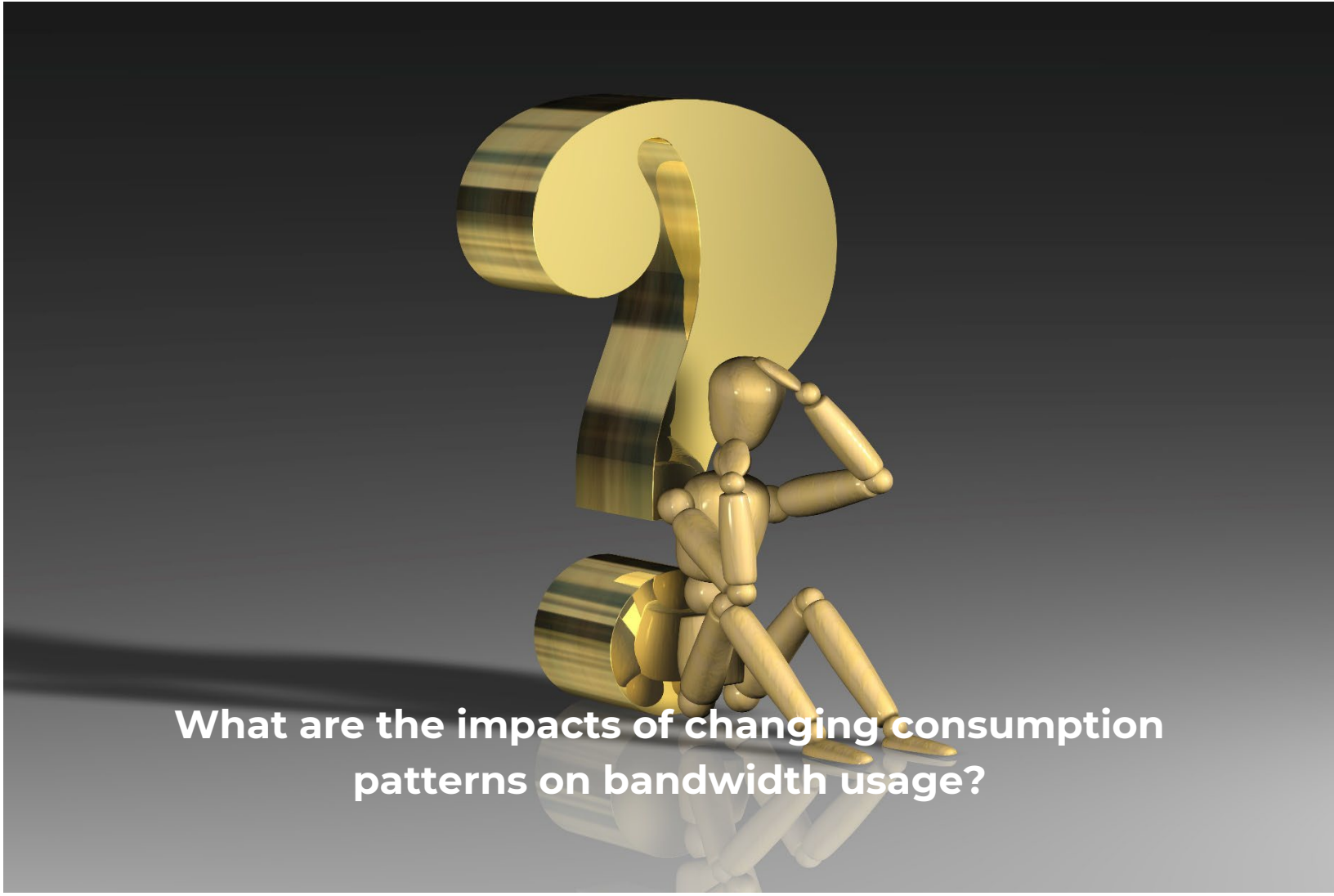

What are the impacts of changing consumption patterns on bandwidth usage?

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What is the problem?

Changing bandwidth consumption patterns due to evolving next generation in home services are going to drive the future capacity needs of an access network. Overlaying this with the COVID-19 (current and future) impact on accelerating the newer service adoption is going to expedite the need for such analysis. This document provides our initial thoughts on analyzing these bandwidth consumption patterns.

Key Takeaways

Bandwidth consumption per sub is a very important metric for operators profitability analysis.

- Classify applications and their usage patterns
- Understand the impact of demographics
- Understand the time of day behaviors

Finally, overlay your NexGen application behvaior to get a good understanding on their impact on bandwidth consumption

Key words: Consumption, T4H, QoE, Bandwidth Usage

DTS consumption analysis framework

The network operators and the policymakers are trying to understand how the per-home data consumption is going to grow. This consumption growth has significant impacts on their access network planning [1]. Creating per home forecast includes a lot of crystal balling. Also, the changing traffic patterns due to COVID-19 are not easy to anticipate, model and make an educated guess on how it is going to evolve. To provide a logical way to analyze this complex problem, in this section, we provide an analysis framework to forecast per home consumption.

As shown in Figure 1, we first understand the classes of applications and their impact on the per home bandwidth consumption. As a next step, we overlay it with the usage patterns such as when will people access such an application (Time of Day usage, number of such devices, etc.). Next, we overlay this with the characteristics (here the throughput) of these applications. And finally, we open a crystal ball to forecast how these needs are going to change for the next few years.

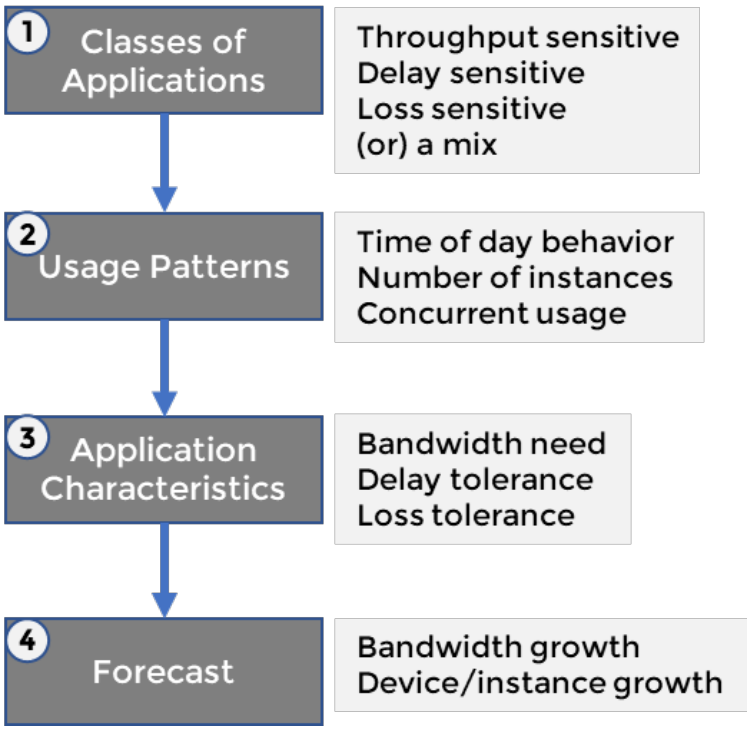

Figure 1 Bandwidth consumption analysis framework

Classes of applications

All applications Quality of Experience (QoE) characteristics can be classified into three dimensions, as presented in [2], [3]. These dimensions are throughput sensitivity (how much bandwidth is considered good quality), delay tolerance (what level of delay is tolerated by the application user), and loss tolerance (how much data loss is ignored by the user). Refer to the insert "what are application characteristics?"

Here are some examples to unclutter these concepts:

Netflix application: Netflix has higher throughput needs (of course depends on the type of screen on which you are watching the video), higher delay tolerance (typically delay is managed through buffering), and higher lower loss tolerance.

Gaming application: A gaming application typically has higher throughput needs, lower delay tolerance, and moderate loss tolerance. Refer to [3] for a detailed understanding of gaming QoE.

Virtual monitoring application: Monitor a home (Aging in Place or other virtual care related) healthcare offering is one of the next-generation applications that have started to become mainstream due to COVID-19. As these healthcare applications are evolving, here, we consider one such application and analyze it for its characteristics. A family member is monitoring an aging parent. This includes a combination of the sensory network and the real-time interaction capabilities. More details of this is not in the scope of this document. Such application is throughput sensitive, moderately delay-tolerant, and moderately loss tolerant (loss of certain video frames is less important than delay in the data stream).

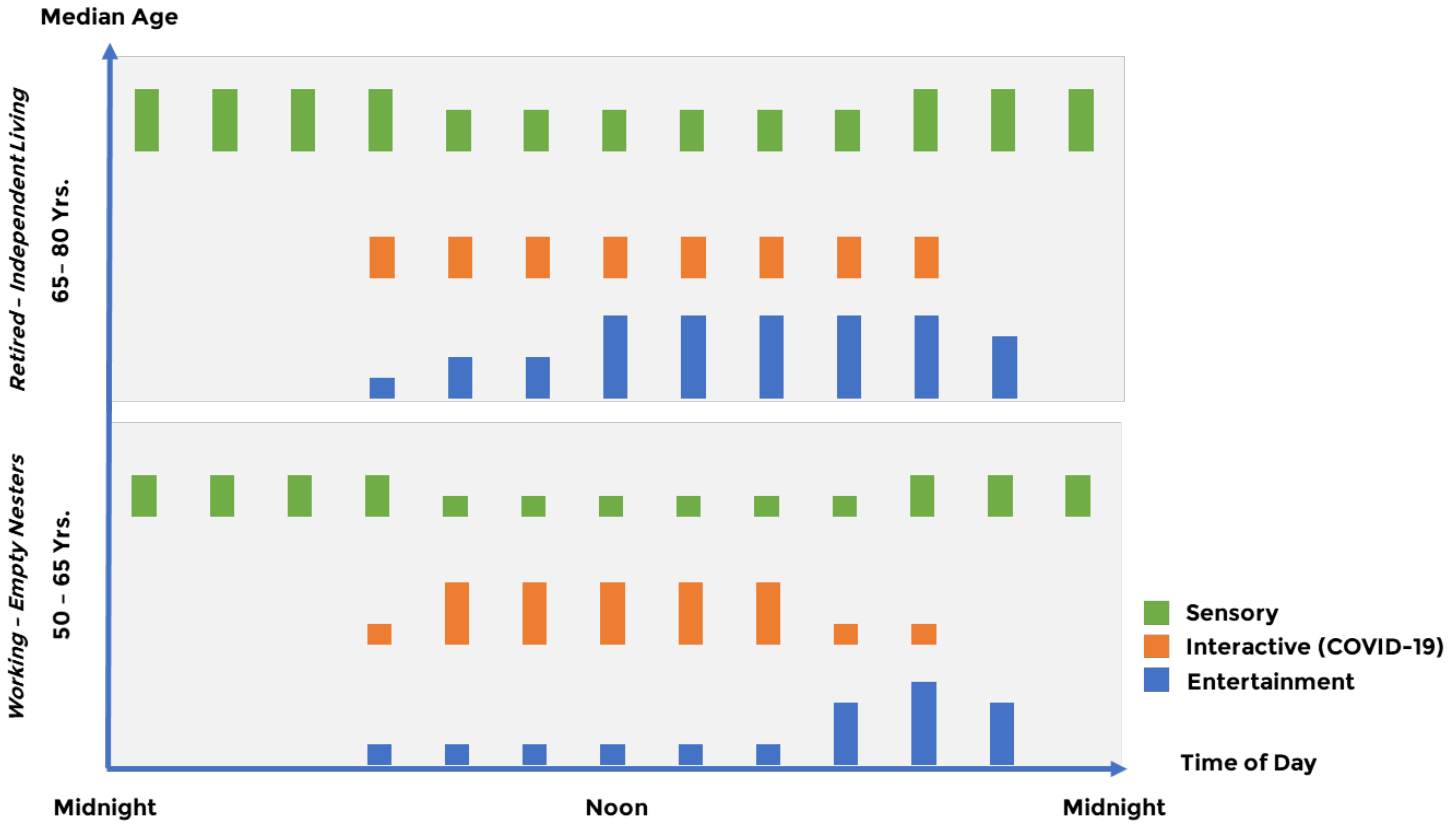

Figure 2 Typical bandwidth consumption patterns by category of application by median age group

Usage pattern analysis

In-home applications are evolving into three categories. They are –

Entertainment and basic services: These are services such as video streaming, music streaming, and internet browsing. These are either through operator offered services or over the top (OTT) services such as Netflix.

Interactive services: These services started with zoom (or what's app) calls to family to (now due to COVID-19) the rampant interactivity for office purposes, healthcare purposes and educational purposes.

Sensory services: These are the evolving IoT-based services such as the Aging in Place monitoring (such as motion sensors, activity trackers, etc.), healthcare monitoring services for future Home as Hospital services (such as medical monitoring, etc.).

Application	*Downstream (Mbps)*	*Upstream (Mbps)*	*Delay Tolerance*	*Loss Tolerance*
Netflix[1]	5 – 25 Mbps	0.5 Mbps	High	Low
Zoom[2]	1.5 - 3 Mbps	1.5 - 3 Mbps	Low	Medium
Microsoft Teams[3]	1 - 2 Mbps	1 – 2 Mbps	Low	Medium
Virtual Learning[4]	1.5 – 2 Mbps	1.5 – 2 Mbps	Low	Low
Gaming[5]	6 – 12 Mbps	1 – 3 Mbps	Low	Low
Telehealth[6]	1.5 - 3 Mbps	1.5 - 3 Mbps	Low	Low
AIP monitoring[7]	1 Mbps	3 Mbps	Medium	Medium

Figure 3: Bandwidth consumption analysis framework

In Figure 2, we have provided a typical hourly traffic pattern by median age groups. Note that we have considered only two age groups here, a working-age empty nester (who are busy with their pre-retirement highly interactive office life) and an independent living retired household. In addition to the age group, the bandwidth consumption also depends on other demographic parameters such as income levels and education levels. Refer to some of these details in [1].

We will not go into an in-depth discussion on the reasoning behind the traffic patterns and the presumed magnitude of the hourly bandwidth projections. Typical applications such as the OTT video, conferencing tools, social video interactions, healthcare monitoring constitute these projected bandwidth demands.

Application needs characterization

As a next step to project the customer broadband consumption growth, we need to understand the popular application needs. The table below provides the characteristics of typical applications.

Note that in this analysis although we are only considering the throughput needs, the delay (that includes delay, latency, jitter) tolerance and loss tolerance also deserve due consideration. Such considerations are part of the in-home technologies such as WiFi6 initiatives [4] and access technology developments such as low latency DOCSIS [5]. Also note that when calculating per home bandwidth demand, there may be concurrent sessions with similar characteristics, such as multiple Netflix sessions, multiple video conferences while your kid is playing an online game. These assumptions are relevant for the overall bandwidth projection in the next section. The concurrency of similar applications across the households (that is from your neighbors) is not important to this discussion

[1] Netflix recommends a minimum of 0.5 Mbps, 3 Mbps for SD quality, 5 Mbps for HD quality and 25 Mbps for ultra HD quality (source here)
[2] Zoom callers recommends 1.5/1.5 Mbps for 720p HD and 3/3 Mbps for 1080p HD video (source here)
[3] Microsoft recommends 1/2 Mbps for HD group video calling (source here)
[4] Virtual learning platforms such as Google classroom recommends 2/2 Mbps for their learning platform (source here)
[5] Noncompetitive games such as Minecraft have lower end bandwidth needs while competitive games such as Overwatch requires higher quality and better response from network (source here)
[6] Same level as zoom calling for the basic Telemedicine interaction
[7] AIP monitoring assumes a constant video stream (upstream intensive) and other sensory IoT devices

but is important when performing a capacity needs projection for an access network.

Bandwidth needs forecasting

Telecom operators plan their access network to meet the upstream and the downstream peak time bandwidth consumption. This is typically between 7 PM – 11 PM. This peak time downstream traffic is mainly driven by video consumption habits. Even though COVID-19 has changed the time of day consumption patterns [6] and significant growth in upstream/downstream [7], the peak time consumption is still driven by the prime time video streams. Hence understanding the video screen capabilities (primary and secondary), the number of video devices, compression improvements, as shown in Figure 5, will provide a good estimate of a per home consumption.

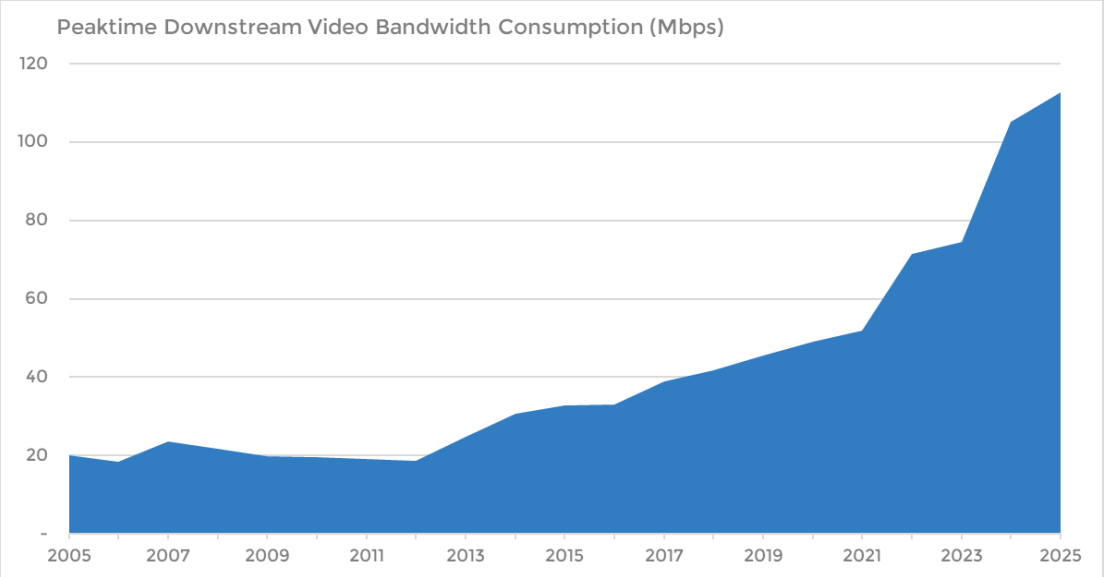

Figure 4: Typical bandwidth consumption for a 50 - 65 year working empty nester

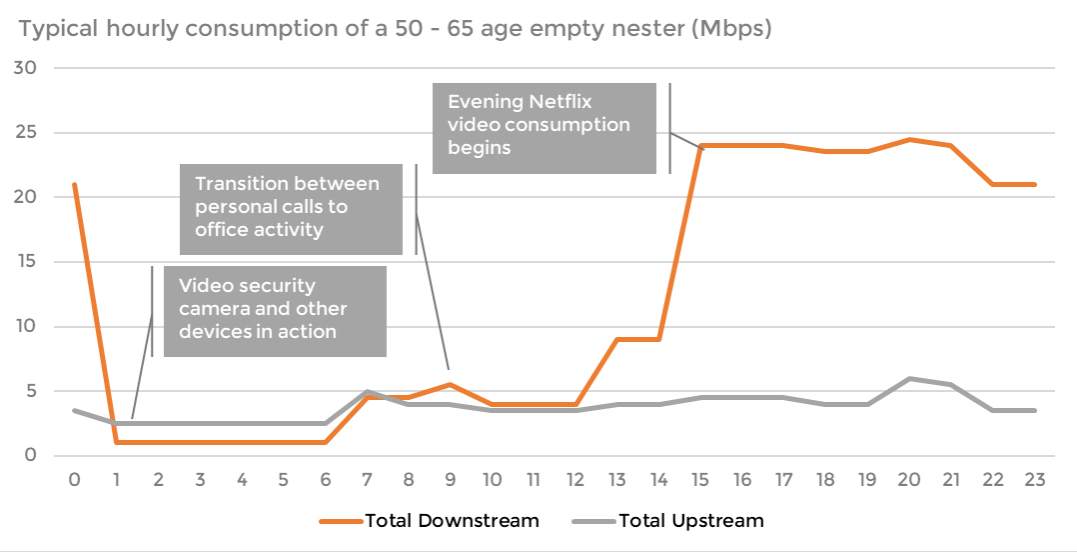

Figure 5: Projected peak time downstream consumption in a typical home

As discussed in the *Usage pattern analysis* section, a given household's hourly traffic pattern depends on the household's medium age (other demographics are not considered in this paper). We have projected a typical age-based time of day bandwidth consumption pattern in Figure 4. In addition to the video bandwidth consumption, due to COVID-19, the video conferencing applications [8], driven by working from home and home education, is also driving the traffic patterns. Note that, as mentioned before, the operator's network is dimensioned for a peak time bandwidth consumption in the downstream and the upstream directions. Hence it does not matter when the bandwidth consumption peaks but by how much (due to events such as COVID-19 and organically) and how is it compared to other households in the same node. Hope this gives you some ideas on the bandwidth consumption forecasting and the drivers behind them.

In conclusion, as entertainment services are maturing, interaction and sensory services are still in their nascent stage. In future, the interactive services such as healthcare-related enhanced unified communications (to bring the patient, the provider, the family, and the support teams together), and proliferation of 24x7 data generating sensory services (such as motion

sensors for Aging in Place homes) are going to consume a significant amount of bandwidth. We believe understanding the classes of applications, their behavior and their adoption based on the demographics are essential to analyze the bandwidth needs of a home.

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Appendix: Healthcare applications impact on bandwidth demand

Many inter-industry opportunities are evolving for the Telecom operators. Healthcare is one of them that is taking the center stage for cable operators (refer to [1], [2], [3], [4]). These are mainly driven by the adoption of IoT technologies and fundamental shifts in accepting technology to solve complex healthcare industry problems (refer to [5], [6]).

Given the significant adoption in Telehealth and Aging in Place opportunities, Duke Tech Solutions (DTS) is evaluating different Telecom for Healthcare (T4H) opportunities and their impact on Cable operators [7]. We are getting ready to release a Telehealth market opportunity report in early December 2020 [8]. In Figure 6, we give you a preview of the opportunities the Telecom operators are going to have in the healthcare sector and their relative size. One fundamental observation that can be made in T4H is the adoption depends on the medical acuity expected of the end-user. This will be further elaborated in the report.

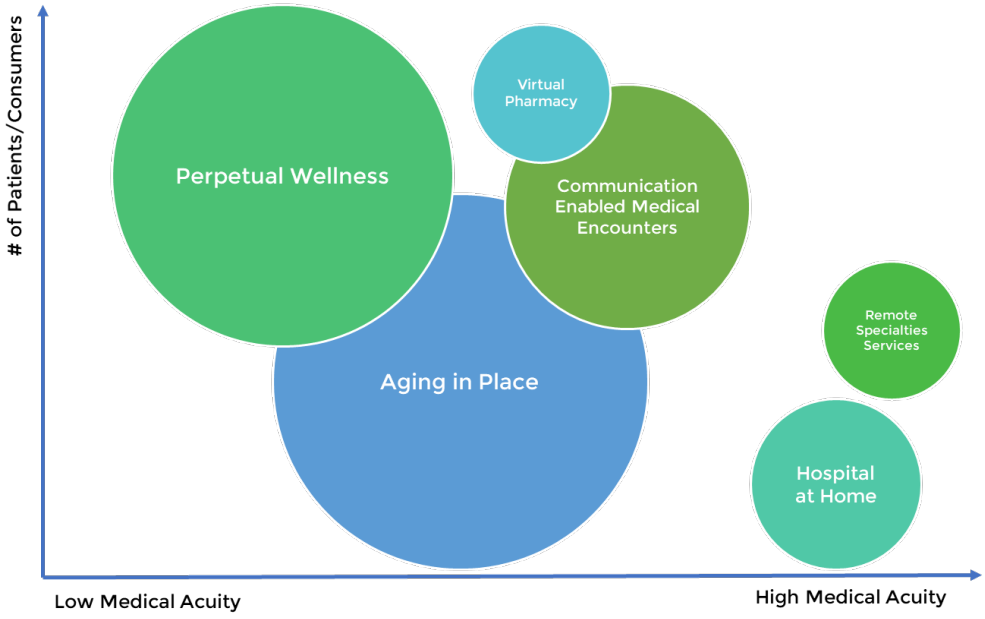

Figure 6: Different T4H opportunities based on the size and physician

As mentioned in this document, these opportunities depend on the demographics. Focusing on the *same median age group (50 -65) as considered in the main report*, the opportunities for the Telecom operators are in the areas of early-stage Aging in Place adoption, communication-enabled medical encounters, early-stage hospitals at home, and a medium level interest in perpetual wellness.

these applications. There many IoT technologies such as wearables that generate very low bit rate data streams, these are not considered in our analysis. That said, we would like to caution the readers again that throughput is only one aspect of the quality of experience measure for an application. A well-performing network should also consider the application's delay and loss tolerance. We will provide additional details on

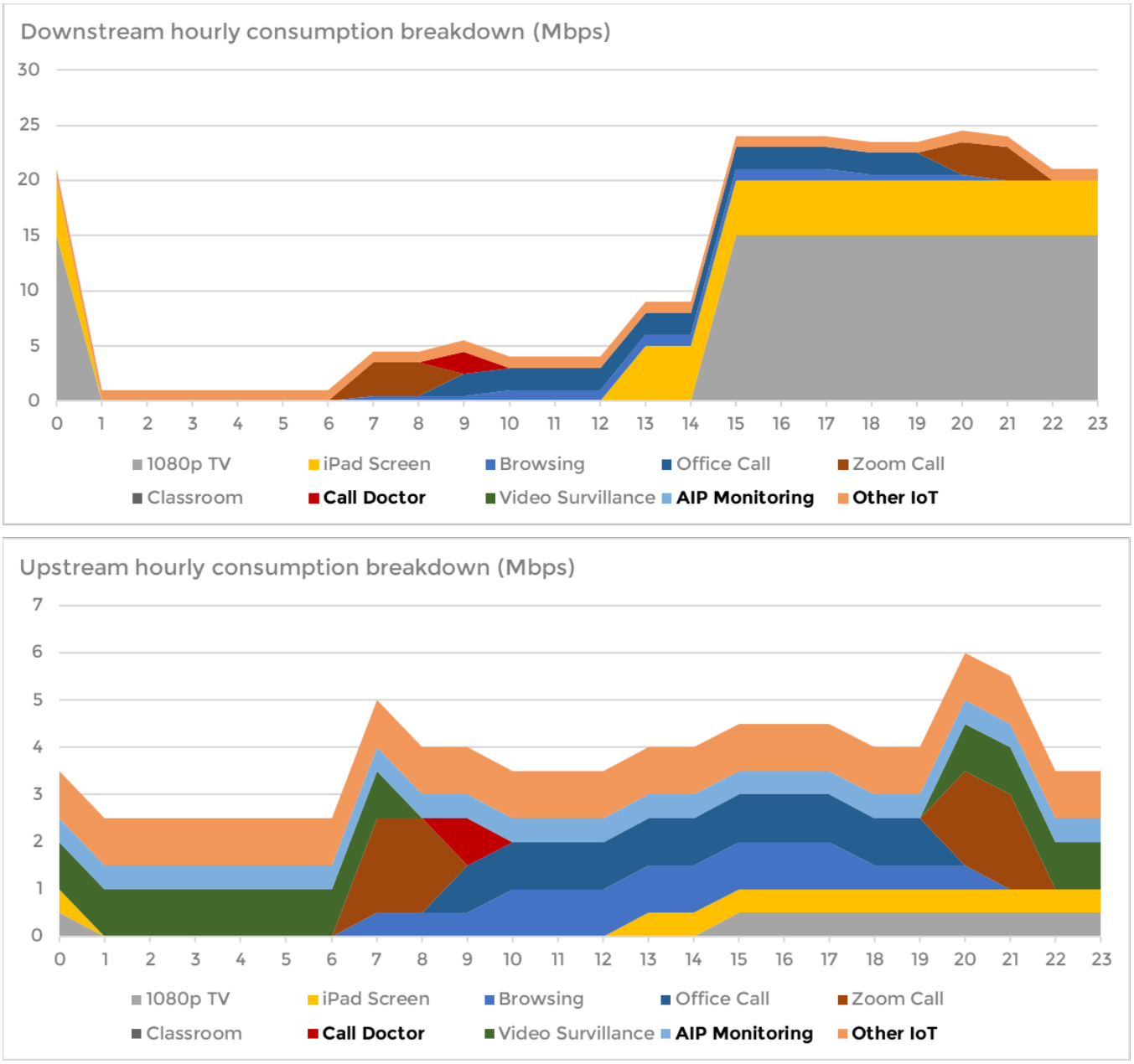

Figure 7: Detailed down and upstream BW consumption for T4H and other services

Figure 7 gives a detailed bandwidth consumption for healthcare related and non-healthcare related devices in a typical empty nester's home. Please pay attention to the relative bandwidth needs for how T4H is going to increase per home bandwidth consumption later.

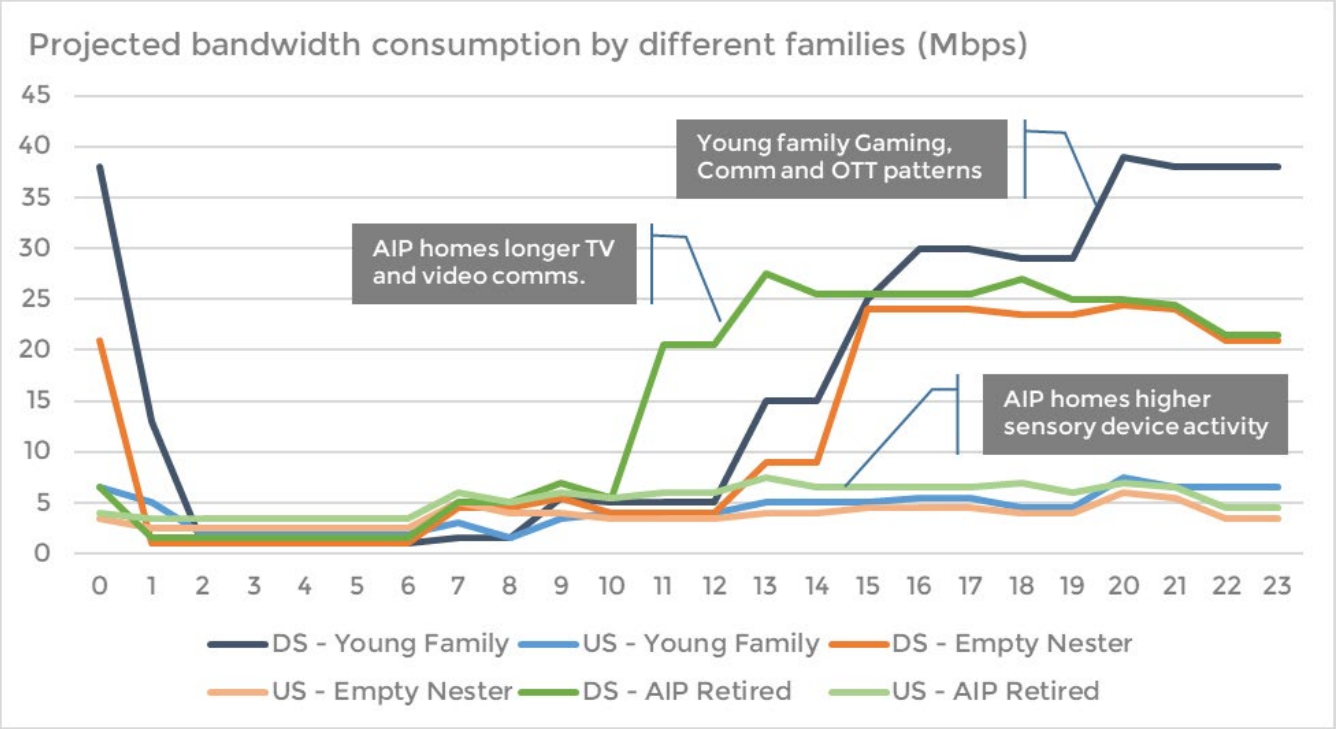

Figure 8: Projected down and upstream consumption by different median ages

As shown in Figure 8, Different age groups will have a different impact on bandwidth consumption due to the services they adopt. A retired 65+ median age family is more interested in sensory network-related devices (such as video surveillance, motion detection, health monitoring, etc.). Such healthcare sensory devices available in the market generate non-stop data for a healthcare NOC to monitor and react. Also, the needs of an aging family's social and personal interactions through video communications, along with their TV viewing hours will generate different traffic patterns, as shown in the figure. Note also that these change over time as newer technologies simplify their lifestyle.

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