Tele-Health Requirements and Bandwidth Utilization: Evaluating Demands for Rural Health Care Support Over Time

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With Case Studies from the Alaska Native Tribal Health Consortium

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This paper documents trends in rural tele-health service utilization in Alaska since the FCC's launch two decades ago of the Rural Health Care (RHC) program supporting universal service among healthcare providers (HCPs) serving rural America.[1]

Growing Demand for Rural Health Care Support

For the past several years, HCP demand for funding from the RHC program has exceeded the budget established by the FCC, beginning with Funding Year 2016, and continuing with Funding Year 2017. As of this writing, the Universal Service Administrative Company (USAC) has not yet released final figures for demand from qualified applicants for RHC support for Funding Year 2018 (which started July 1, 2018).

While the FCC recently raised the annual RHC program budget from $400 million to $571 million to reflect 20 years' worth of inflation, and added an automatic annual inflation adjustment going forward,[2] this change alone will not be sufficient to ensure that the program will meet the needs of HCPs serving rural areas of the nation. This is due in part to FCC expansion of eligibility for RHC support, and wider participation in the program among eligible HCPs (particularly in Alaska); but equally importantly, it is due to the evolving ways in which rural HCPs deliver modern tele-health services – requiring far more bandwidth than 20 years ago, and requiring more sophisticated telecommunications and IT solutions.

This paper explores how rural HCPs in Alaska are delivering modern tele-health services, including their evolving tele-medicine techniques, their more sophisticated use of a range of technologies, and their changing telecom strategies, all of which have driven increased demand for bandwidth and advanced services supported by the RHC program.

In this paper, Alaska Communications describes escalating bandwidth requirements for tele-health applications. Other changing tele-health requirements also are explored, including increased demand for network security, route redundancy, network reliability, and dynamic management services. These developments have improved the quality of tele-health services but added to the cost, and to the demand for greater support from the FCC's RHC Program.

Alaska Communications

Alaska Communications is a long-time provider of telecommunications and related services supporting tele-health in rural Alaska. The company has direct experience with the challenge faced by rural HCPs in Alaska, and witnessed the life-saving and life-changing effects of tele-health services on rural residents with extremely limited access to medical services. With assistance from the RHC program, rural HCPs have dramatically expanded the availability of medical care, improved the quality of care, and reduced the cost of care in rural Alaska.

Alaska Native Tribal Health Consortium & Alaska Tribal Health System

For more than 18 years the organizations in the Alaska Tribal Health System (ATHS) have participated in the RHC program to improve tele-health services and healthcare outcomes in rural Alaska, especially for native Alaskans. The ATHS includes more than 30 Tribal Health Organizations (THOs) providing care at more than 200 sites throughout Alaska.

The Alaska Native Tribal Health Consortium (ANTHC) has provided critical input on delivering tele-health services in Alaska from the HCP's perspective. Their contribution to this analysis is offered in the form of "case studies" identified in marked text boxes. ANTHC provides real-world examples of advances in tele-health services in the ATHS over two decades, demonstrating why demand for RHC support continues to increase: to support store-and-forward capability for healthcare-related images, increased use of real-time video-conferencing in tele-health services, and the adoption of a uniform regime for electronic health records.

Evolving Bandwidth Requirements for Tele-Health Services

There is no doubt that bandwidth-hungry services have proliferated in the two decades in which the FCC has funded the Rural Health Care Program, but this has been especially true in the most recent decade. The escalating demand for bandwidth can be traced to several healthcare developments, including new regulatory requirements as well as evolving healthcare industry norms. Collectively, this sector's tele-health service requirements have developed from a simple T-1 (1.544 Mbps) circuit[3] to high-bandwidth, virtual private network (VPN) requirements that include such capabilities as secure transmission, storage and retrieval of large volumes of customer records, and increasing use of images and video content for remote diagnosis, testing and treatment of patients.

Indeed, the FCC today defines "advanced" telecommunications capability as a minimum of 25 Mbps for residential users. For rural HCPs, circuits of 10 to 25 Mbps are commonplace, and bandwidths of 100 Mbps or more are not uncommon.[4]

While greater demand for high-bandwidth services is only part of the picture, as discussed below, it is an important example of the rapidly changing tele-health requirements that directly affect demand for RHC support.

ANTHC Case Study: Store and Forward Telehealth

Store and Forward Telehealth (SFT) relies on the capture of data (typically images) that is then transmitted to a consulting site. The quality of digital cameras has grown dramatically in the last 20 years with higher quality images being generated by cameras with more pixels. That has resulted in larger files sizes. Combined with the overall growth in usage, this has driven bandwidth demands in recent years.

The table below shows the average size of a digital camera image (by fiscal year) received at the Alaska Native Medical Center (ANMC) as part of the AFHCAN telemedicine system, as well as the total number of images and the total disk space used by these images.

	Number of Images	Average File Size (Bytes)	Total Gigabytes (GB)
FY01	148	216,693	30.6
FY02	439	201,742	84.5
FY03	1,738	249,061	412.8
FY04	2,384	223,347	507.8
FY05	2,551	242,718	590.5
FY06	3,716	400,856	1,420.6
FY07	3,330	626,185	1,988.6
FY08	3,348	1,068,684	3,412.2
FY09	4,857	1,238,799	5,738.1
FY10	4,469	1,260,312	5,371.4
FY11	7,607	1,073,102	7,784.9
FY12	15,032	1,008,131	14,452.2
FY13	33,308	950,564	30,194.7
FY14	47,996	906,127	41,475.8
FY15	63,168	977,190	58,867.6
FY16	76,660	899,946	65,793.8
FY17	102,541	877,822	85,842.8
FY18	118,098	893,711	100,656.1

The average size of a digital image doubled between FY02 and FY06 (5 years), and then doubled again in the next 5 years. The number of images transported for telehealth grew dramatically, increasing by an average of 50% every year for the past 7 years.

The numbers shown above apply only to images received at ANMC. There is a significant usage of the system that does not reach ANMC, so this is not intended to be a complete statewide analysis. But the general conclusion applies across the entire ATHS: SFT usage has grown significantly over the years, the size of images has increased by a factor of 4, and the combined effect is to require higher bandwidth and greater reliability as telehealth becomes mission critical.

All Bandwidth Is Not Created Equal

In Alaska, service providers, such as Alaska Communications, offer both Ethernet and Multi-Protocol Label Switching (MPLS) services to healthcare providers, but these services are not necessarily interchangeable. Each service features its own unique capabilities in terms of available bandwidth during peak periods of demand, service quality, network reliability, network and data security, route redundancy, and other characteristics that are meaningful to HCP customers.

Alaska Communications believes that MPLS and similar services featuring carrier-managed routing are particularly well-suited to the needs of the healthcare sector. Like Ethernet, MPLS can deliver high-capacity bandwidth such as 100 Mbps or more. Also, like Ethernet, MPLS networks can carry IP traffic, and a local area network ("LAN") switch or router can be connected to the network.

However, MPLS delivers the capability whereby virtual circuits can be defined with strict quality-of-service (QoS) settings that enable differentiation and prioritization of different types of traffic, end-to-end, across the network. This is critical in the tele-health environment, as HCPs commonly use the same transport service for a mix of higher-priority (*e.g.,* real-time video-conferencing) traffic and other, lower-priority traffic. MPLS, along with the QoS guarantees, also can be especially well suited to integration of high-speed transport with offerings from third-party Application Service Providers (*e.g.,* an imaging service or electronic healthcare records service). MPLS allows for both dynamic routing (fully managed) and static routing options. Most service providers do not offer managed routing with Ethernet service, meaning more expertise (or the ability to outsource the service configuration) is required of the customer.

In addition, MPLS traffic can be assigned to different service levels for purposes of network latency, jitter and packet loss – effectively allowing packet prioritization where it is necessary for particular medical applications – a feature not found in Metro Ethernet networks. The use of fully meshed architecture and IP addresses also help MPLS networks to avoid the "flooding" of packets (and associated network congestion and latency) that are known to occur on Metro Ethernet networks.[5]

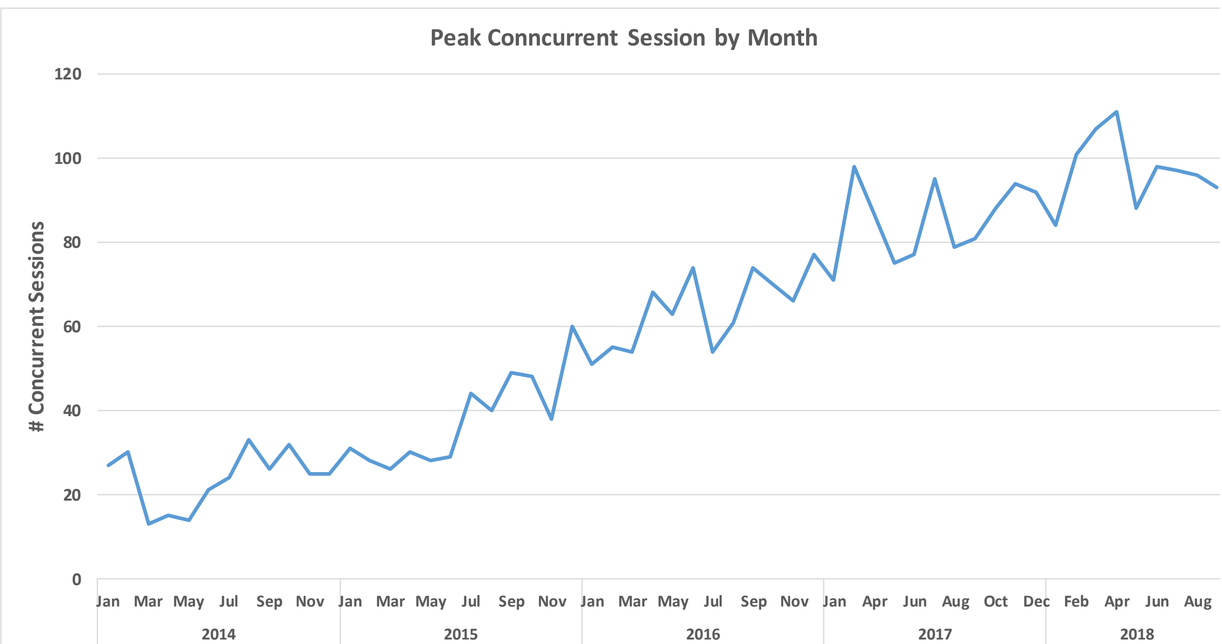
Given its benefits for the types of applications used by healthcare providers, MPLS often is the most cost-effective option for rural telehealth, even though it may cost more than some other services that offer similar bandwidth.

ANTHC Case Study: Videoconferencing

The ATHS relies primarily on a shared "Vidyo" platform for video-conferencing, with numbers quickly growing over the past 4 years:

	FY15	FY16	FY17	FY18
Total # Calls	26,569	40,955	99,533	134,968
Total # Minutes on calls < 10 hrs	400,381	821,495	5,043,109	3,671,330
Bytes Transmitted (GB)	2,237	4,590	28,181	20,515
Average Concurrent Use	3.20	6.56	40.30	29.34

Demand for bandwidth is driven not only by the total number of sessions and bytes exchanged, but also by the peak number of concurrent sessions. For example, two non-concurrent video-conferencing sessions in a single day only need the bandwidth for one session at a time; but two sessions taking place at the same time require double the bandwidth of a single session. The graph below shows how the number of peak concurrent sessions has grown across the statewide Vidyo infrastructure. The peak number of concurrent sessions per month has grown exponentially, from 25 in 2014 to 50 in 2016 to 100 in 2018. This essentially means that the amount bandwidth required for these sessions is also doubling each year.



ANTHC expects usage to continue to grow, in terms of the number of users, the number of sessions, and the number of concurrent sessions. In addition, improvements in video quality are expected to drive bandwidth demand. The use of 1080p and now 4K televisions has raised the awareness of the value of high-quality video. ANTHC expects the average bandwidth demand for video-conferencing to double, from 3 Mbps (currently) to 6 Mbps per user within the next two years.

ANTHC Notes on Videoconferencing Case Study:

- Due to limitations in data logging within the Vidyo system, calls over 10 hours are excluded from the above analysis.
- This data includes every participant in the call, so a call between two people will be counted twice.
- Bytes Transmitted is based on an average consumption of 3 Mbps for each user on a call. Since this is bidirectional, 1.5 Mbps is used for calculations.
- Average Concurrent Use is based on an 8-hour day with 5 working days per week.

The Role of Service Quality & Network Reliability in Tele-Health Services

As the healthcare industry transforms from a traditional paper record-keeping system to an all-electronic ecosystem, bandwidth needs grow, and the quality of the network also becomes increasingly important. Healthcare organizations are frequently demanding high-bandwidth transmission capability across long distances, often between Alaska and the Lower 48 states. Loss of packets can interrupt critical real-time applications such as medical consultations via video-conference, and can delay service during large file transfers.

Jitter and latency are two most common technical measures of network quality. Jitter is the variance in delay between data packets across a network, and latency is the delay of data packets over a network. In many cases sending healthcare records will fail due to latency. This is especially true in a “best efforts” network environment, such as the public Internet, where there are no quality guarantees to ensure retransmission of corrupted or lost packets, no service reliability requirements, and therefore frequent failures during file transfers. Data packet prioritization using Class of Service (CoS) is a way that managed network technology can improve the service quality, and address problems like latency and jitter.

In remote locations, when large files are sent over long distances, network latency or congestion is often the culprit. This scenario is referred to in the industry as a *long fat network*. What happens on the network is the network Transmission Control Protocol (TCP) works to send the file, network equipment buffers can fill up waiting for confirmation a data packet was received on the far end, or if the latency or network congestion is simply too much, a network transfer can simply time out if the TCP determines that it is taking too long to get a confirmation response from the far end.

When sending medical data such as imaging or Intensive Care Unit (ICU) data, service quality and reliability are paramount. If the data transmission were to fail during a live procedure a loss of life could occur. In a less extreme case but still detrimental to care, a patient could go for hours not receiving critical care, because the doctor and patient are waiting for the imaging study to be sent to a radiologist to be read for a diagnosis to begin treatment.[6]

As described above, technologies such as MPLS allow for the creation of virtual private, managed networks, so data packets do not have to contend with "best efforts" network traffic, and the most important data are prioritized. WAN optimization devices are commonly used to help combat the effects of latency and jitter, and improve transmission performance over multiple technology platforms.

Using a combination of private networks, technology, and service configurations, high-quality, reliable tele-health services are possible even in remote parts of Alaska. These services are critical to the delivery of modern healthcare services in remote rural areas. Without these high-quality telecommunications networks and advanced services, critical telehealth services simply would not be possible.

ANTHC Case Study: Electronic Health Records (EHRs)

With the advent of modern EHR technology, there has been a significant migration from self-hosted EHRs to remote-hosted EHRs. This is due to the complexity of these systems and the ability to leverage cloud-based solutions (*e.g.,* data analytics).

Historically, the vast majority of THOs relied on an EHR system (RPMS) that could be accessed over low-bandwidth, high-latency circuits; each THO had RPMS running at its own central location or a hosted server in Anchorage. In 2019 ANTHC expects to have 94% of all THOs (30 of 32) on non-RPMS EHRs. With the exception of one THO (YKHC), THOs require connectivity outside of Alaska to reach EHRs on hosted systems in the lower 48. But even the YKHC Cerner system, while hosted in Bethel, requires connectivity for access to the EHRs from the 47 village clinics that are supported by YKHC. As a result, the following statements apply to 2018/2019 EHR technology in the ATHS:

- 90% of the THOs rely on a hosted EHR located in the lower 48.
- 96% of all ATHS sites depend on connectivity to reach the EHR being used at the facility.
- 100% of all ATHS sites rely on connectivity to communicate the next level of care, to transfer patients, to communicate with patients, and to manage care of patients.

This has driven bandwidth requirements in multiple ways:

- Bandwidth. Each user connecting to the EHR requires sufficient bandwidth to have reasonable performance for the rich Graphical User Interface (GUI) of the EHR. A recent analysis of connectivity at the Alaska Native Medical Center determined that each user requires approximately 20-30 Kbps to connect to the EHR. The shared Cerner EHR system has a peak utilization of 2,400 users which then can require up to 72 Mbps for connectivity. A remote hospital may have 300 of these users and would then require a bandwidth of 9 Mbps of connectivity to Anchorage and then to the remote-hosted EHR.

- Other Services. An EHR also has ancillary issues that drive bandwidth requirements. Scanning of documents – especially batch scanning of large numbers of documents –requires burst connectivity for large data sets. The use of remote-hosted dictation services or remote-hosted “voice to text” systems (*e.g.,* Dragon/Nuance) requires reliable and higher bandwidth to stream voice from multiple users at once. Access to real-time analytics, quality measures, patient portals, *etc.,* all drive connectivity beyond the normal “user” of the EHR.

- Latency. Cerner estimates that it is important to maintain an overall latency of 80 milliseconds (msec) for users reaching a remote hosted EHR to provide adequate functionality. This is especially true for hospital systems, where the high pace of care will not tolerate a slow EHR. Consequently, it is impossible to provide connectivity for hospitals in Alaska without terrestrial connectivity. Due to distance and routing complexities, latencies can extend beyond 100 msec or more for hospitals in Alaska (which ANTHC finds to be tolerable).

- Redundancy. Hospitals cannot rely solely on a single provider or connection to reach a remote hosted EHR. Consequently, redundant circuits or satellite backup circuits must be available round the clock in a fail over mode. This can double the cost of connectivity.

Meeting the Future Requirements of Tele-Health Services

Alaska Communications believes that the future for tele-health services is promising. While the demands on healthcare providers, especially in the most rural and remote parts of the nation, continue to grow, their ability to meet those needs will continue to expand with advancing technology. The only question is whether they will have access to the technology they need in the locations they serve, at prices they can afford. Specific, sufficient and predictable funding from the FCC's RHC program remains critical to answering that question. With further increases to the RHC budget, and the full support promised by the Communications Act to meet the needs of healthcare providers serving rural Americans, tele-health can bridge the gap between healthcare services available in rural and urban areas.

Tele-Health Positive Outcomes

Below are just a few examples of improvements in health care and patient outcomes made possible through tele-health services:

- Efficacy of telemedicine for stroke:
    - http://www.ncbi.nlm.nih.gov/pubmed/22400970

- Beacon trial reduced readmissions of heart patients to 3% using home video conferences:
    - http://medcitynews.com/2012/09/beacon-trial-reduced-readmits-of-heart-patients-to3-using-home-video-conferences/

- Multicenter Study of ICU Telemedicine Reengineering of Adult Critical Care:
    - http://journal.publications.chestnet.org/article.aspx?articleid=1788059

- U.S. Department of Veterans Affairs: Impact of Tele-ICU on Patient Outcomes:
    - http://www.ruralhealth.va.gov/docs/issue-briefs/Impact of TeleICU on Patient Outcomes.pdf

- Comparing Virtual to Traditional Consults:
    - http://www.biomedcentral.com/content/pdf/1472-6947-12-65.pdf

- *Telemedicine and e-Health* (June 2013): Increasing Access to Chronic Disease Self-Management Programs in Rural and Remote Communities Using Telehealth:
    - http://online.liebertpub.com/doi/pdfplus/10.1089/tmj.2012.0197

- School-based Telehealth Program in Rural Western North Carolina:
    - http://crhi.org/MY-Health-e-Schools/index.html

END NOTES

[1] Although the Federal Communications Commission (FCC or the Commission) created the basic structure of the RHC program in 1997, 15 months following passage of the statutory directives set forth in the Telecommunications Act of 1996, *see Federal-State Joint Board on Universal Service*, CC Docket No. 96-45, Report & Order, 12 FCC Rcd 8776, ¶¶608 *et seq.* (1997) (subsequent history omitted) ("*RHC First R&O*"), the RHC was not officially launched until January 1, 1998. *See Federal-State Joint Board on Universal Service*, CC Docket No. 96-45*,* Third Report & Order, 12 FCC Rcd 17469 (1997) ("*RHC Third R&O*"). Thus, this paper draws on available data from January 1998 to January 2018.

[2] *Promoting Telehealth in Rural America*, WC Docket No. 17-310, Report & Order, 33 FCC Rcd 6574 (2018). The FCC also is considering other reforms to the RHC program in light of market changes since 1998. *See Promoting Telehealth in Rural America*, WC Docket No. 17-310, Notice of Proposed Rulemaking and Order, 32 FCC Rcd 10631 (2017); *Bureau Seeks Additional Comment on Determining Urban and Rural Rates in the Rural Healthcare Program*, Public Notice, WC Docket No. 17-310, DA 18-1226 (Wireline Competition Bur. rel. Dec. 4, 2018).

[3] *RHC First R&O*, ¶620 ("universal service support mechanisms for health care providers should support commercially available services of bandwidths up to and including 1.544 Mbps, or the equivalent transmission speed, but not higher speeds"); *id.* ¶622 (stating that only one party supported RHC funding for greater than T-1 service capacity); *id.* ¶707 (basing the initial budget of $400 million (including USAC administrative expenses) on assumption about demand from 12,000 eligible rural HCPs requesting support for a service of no more than 1.544 Mbps each).

[4] For a discussion of minimum recommended bandwidths for HCPs, see: https://www.healthit.gov/faq/what-recommended-bandwidth-different-types-health-care-providers

[5] Additional information on advanced technologies for tele-medicine can be found at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3341457/

[6] For further discussion of latency and throughput, see: https://www.spirentfederal.com/documents/tcp_network-latency-and-throughput_whitepaper.pdf