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Metadata and Telemetry Support to Enable Telecom for Healthcare Opportunities

A Technical Paper prepared for SCTE by

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1. Executive summary

The delivery of healthcare is undergoing seismic shifts. From remote consultations to remote patient monitoring, the healthcare of tomorrow will look and feel different than it does today. Numerous technological advancements have enabled these transformations, but each comes with a series of challenges to solve. These challenges include issues such as connecting devices to a local network, guaranteeing optimal bandwidth and latency, ensuring that services are being properly delivered by providers, and ensuring that patients are adhering to treatment plans. Cable operators are well-positioned to assist in developing standards to address these obstacles.

In this paper, we describe at a high level some of the services that tomorrow's healthcare will offer, the stakeholders that interact with these services, and the needs of each stakeholder according to the service. We then define four types of data categories and how they address the series of challenges that tomorrow's healthcare services face. We also provide recommendations on how cable operators can support these data needs and high-level architecture of a potential implementation for data collection, access, and analysis.

2. Introduction

The Healthcare industry is going through a major transformation to modernize the infrastructure, reduce the cost and increase the quality of care. In a series of articles, we have suggested how the Telecom industry can assist the Healthcare industry [1][2][3]. We call this inter-industry collaboration Telecom for Healthcare (T4H). Even though the T4H opportunity is not limited to these two major intersection points, we focus on Aging in Place (AIP) and Telehealth use cases to illustrate our thoughts on the end-to-end T4H architecture. (Refer to [4] for six different opportunities that a Telecom operator can address through the T4H architecture covered in this paper.) The SCTE Data Standards Subcommittee, in which the authors are members, is actively working on T4H solutions for the AIP and Telehealth areas in working groups three [5] and four [6]. The current paper on telemetry and metadata can be reviewed with the companion paper on the end-to-end T4H architecture published in the 2021 SCTE Expo [7] for a detailed understanding of the solution.

Figure 1 provides an intuition for the data needed from a T4H solution from per platform users (including the payor, who are not extensively considered in this paper) per type of services point of view. These data needs are categorized into four groups in the following section for further detailed purpose-driven analysis from telemetry and metadata points of view.

The players involved in the T4H solutions include the users (for AIP these are the elders, and for Telehealth¹, these are the patients who want to use the platform being developed in [5][6]), the service providers (such as the doctors, caregivers, etc.), and the other stakeholders (such as the family, legal guardians, trusted circle, etc.). These players use the platform for the following services:

- Use the platform for **communicating with different T4H players** (unified collaboration and communication (UCC)), and **communicate different information** relevant for the success of

¹ The US Department of Health and Human Services (HHS) defines telehealth as “the use of electronic information and telecommunications technology to support and promote long-distance clinical health care, patient and professional health-related education, and public health and health administration”. It encompasses everything from video calling to text messaging. In the realm of reimbursement, insurances may cover different levels of telehealth. The level of reimbursement has also changed after changes that came with COVID. Within telehealth here are four other broad categories: Synchronous, Asynchronous (store-and-forward), Remote Patient Monitoring, and Other Services such as mobile health (mHealth).

T4H Service	Basic Responsibilities	T4H Roles		
		Users/Patients (Telehealth and AIP)	Family, Legal Guardian, Trusted Circle, etc.	Doctors, Professional Caregivers, etc.
 Communication	North and Southbound Connections, Unified Communications	<ul style="list-style-type: none"> Reliable connection Better <i>Quality of Experience</i> Ease of use 	<ul style="list-style-type: none"> <i>Access anywhere</i> Better Quality of Experience Ease of use 	<ul style="list-style-type: none"> Reliable access to customers Capability to <i>service remotely</i> Fool proof <i>billing capability</i>
 Monitoring	Remote Patient Monitoring, Behavioral Monitoring, Convenience	<ul style="list-style-type: none"> <i>Healthcare</i> support <i>Independent living</i> <i>Problem solving</i> 	<ul style="list-style-type: none"> Assist family Assist independent living <i>Remote support</i> capabilities 	<ul style="list-style-type: none"> <i>Monitor the problem</i> remotely Assist the users <i>Increase</i> relevant <i>follow-ups</i>
 Management	Notification and Governance	<ul style="list-style-type: none"> Inform the right stakeholder <i>Govern the problem</i> <i>Reduce costs</i> 	<ul style="list-style-type: none"> Get <i>timely notifications</i> <i>Reduce costs</i> <i>Demonstrable improvement</i> 	<ul style="list-style-type: none"> <i>Manage the user status</i> Demonstrable improvements <i>Billability governance</i>

T4H Data Needs

Figure 1 Understanding the T4H services, different roles, and their data needs

T4H services. For the users to adopt these services, they need to have a reliable connection with quality of experience and that is easy to use. For the stakeholders, in addition to the needs of the users, they should be able to access the services from anywhere. For the providers, the platform shall provide reliable remote service to the customer and an accountable billing capability.

- The players in the T4H space are very interested in **the monitoring capabilities** of the platform. The users are interested in healthcare and non-healthcare (independent living) needs. The incentive for them to use this platform is its problem-solving capabilities using the data that they assemble from different sources. The stakeholders, in addition to supporting their loved ones with their needs, have to provide these monitoring services remotely. The service providers shall be able to effectively monitor the problems remotely, improve the quality of care and reduce the overall cost of care.
- Use the platform to **manage timely notifications** and **govern the condition** of the user. To enable such functionality, the user depends on the timely assessment of the problem and reduces the cost through the management infrastructure. The stakeholders depend on timely notification, cost reduction, and most importantly the demonstrable improvement. The providers, on the other hand, in addition to the user status management, shall be able to claim the billability of the services.

In the next sections, we elaborate on T4H data categories based on the high-level incentives that we discussed in this section, expand on each of these categories in the following section, summarize the findings and propose the next steps.

3. Telecom for healthcare data categories

By analyzing the T4H users, stakeholders, and service providers, we categorize the metadata or telemetry data collected from the T4H platform, as shown in Figure 2, into four categories. (Note that the data collected in the metadata and telemetry cases are the main data streams provided by the devices, but are the supplemental information provided to assist the T4H players). They are:

- **Quality of Experience (QoE):** The questions to be answered by the T4H platform include - are T4H services meeting stakeholder experience needs and are users engaging with services? The data collected here such as bandwidth availability, latency behavior, platform experience for back-office, and individual connections represents the customer adoption.
- **Monitoring:** The goal of this set of data is to evaluate if we are providing useful T4H services? The types of data collected here are healthcare and non-healthcare related streams, sensor and UCC flow information, network and device status, etc.
- **Connectivity:** As opposed to the quality of the service, reliable and highly available communication infrastructure is essential for providing these emotionally sensitive AIP and Telehealth services. The connectivity metrics offer these parameters. They are measured using platform availability, SLA (Service Level Agreement) guarantees, service up times, zero-touch provisioning, etc.
- **Accountability:** Are the service providers delivering expected results? Are the users adhering to the treatment plan? Is the provider's billing in line with the services they offered? These accountability metrics include – Quality of Care, timely resolutions, problem resolution rate, timely status notifications, etc.

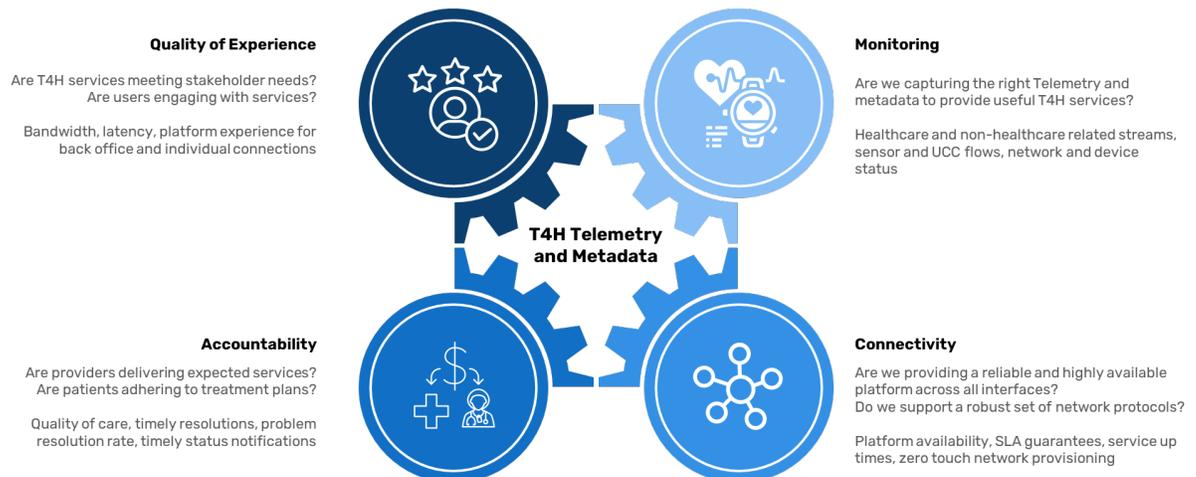


Figure 2 T4H telemetry and metadata categories

4. Metadata details

Figure 2 provides an end-to-end T4H architecture based on the framework proposed in [4][7]. There are multiple locations, as shown in the figure, where the T4H related metadata and telemetry information can be gathered. These data collection points include:

- **In-home device interface:** This interface is used to monitor the in-home T4H sensor and interactive devices. The QoE metadata can be monitored from this data collection point.
- **In-home network interface:** The north-bound interface of the sensor network gateway can be used for the aggregated in-home information such as broadband connectivity-related data and per session-related monitoring.
- **T4H sensor network interface:** The reliability and availability metrics can be monitored from the T4H sensor network infrastructure.
- **T4H service back-office interface:** This interface provides the overall service level QoE metrics, aggregate service level information, Quality of Care analysis metrics, governance metrics, etc.

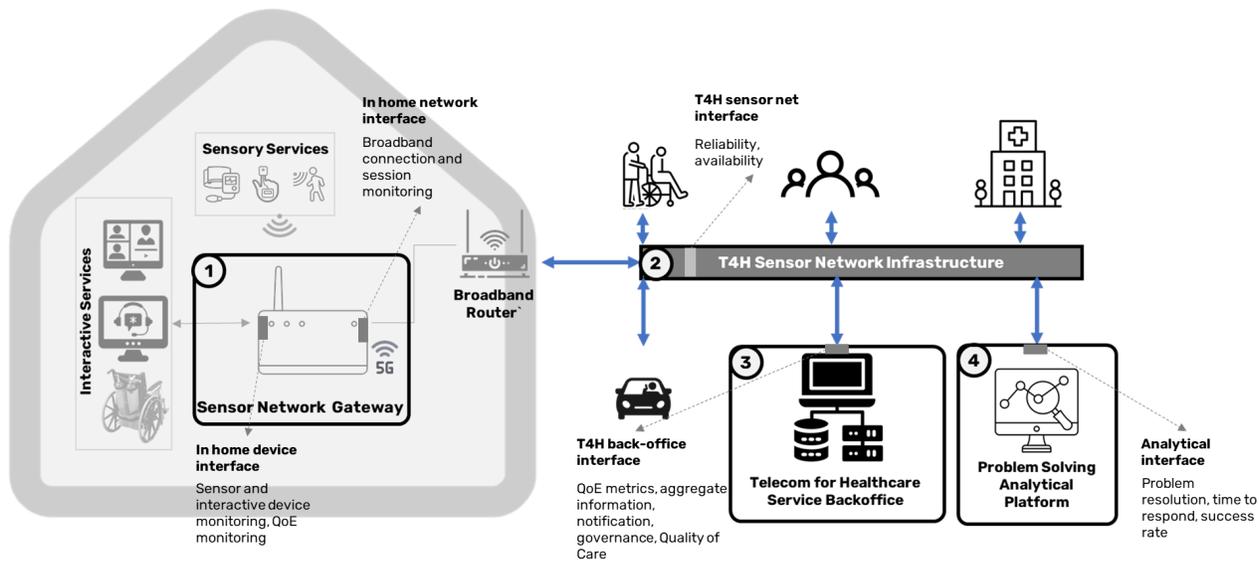


Figure 3 Different monitoring points in Telecom for Healthcare architecture

- T4H analytical interface: This interface provides the responsiveness, accuracy, and success rates of the problem-solving analytical infrastructure.

The information collected from the above interface must be securely collected and shall follow HIPAA privacy compliance [10]. We will not elaborate on these requirements in this document. In the following sections, we will highlight some of the details behind the proposed metadata and telemetry classes of information.

4.1. Quality of Experience related data

Understanding the QoE needs of different applications [8] and measuring them to see if the platform is meeting the needs, is essential for the adoption of T4H services. The applications used in the T4H environment are sensor and interactive applications. These application’s QoE is measured at in-home for individual usage and at back-office service infrastructure that hosts the applications for aggregate usage.

Class of applications*	Throughput sensitive	Loss sensitive	Delay sensitive
Onetime measurements	X	X	
Video monitoring	X		X
Sensor monitoring	X	X	
Video communications	X		X

Figure 4 Quality of Experience needs of T4H applications

Generic metadata required to support QoE metrics:

- Sensor instrument-related metadata: Sensor id, type, group, priority (critical, high, medium, low), location in the house, vendor information, etc.
- Interactive applications-related metadata: UCC id, UCC type, application location (home, caregiver, provider, family), UCC vendor information, application experience (e.g., 5-star scale), etc.

QoE specific metadata: As discussed in [8], and as shown in Figure 4, the application QoE can be grouped into throughput, loss, and delay sensitivity.

- Throughput sensitivity data: This includes bits per second (Peak, Min, Average) metric. The monitoring locations include sensor hub and back-office hosting. The level granularity of this metric should be per session and per aggregated (per sensor or UCC id) stream.
- Latency sensitivity data: This includes one-way delay (Peak, Min, Average) metric. The monitoring location should be at the back-office hosting at a granularity of per session. To analyze latency the relevant communicated information should be timestamped.
- Loss sensitivity data: The data points lost per minute (Peak, Min, Average) will give the performance of the underlying communication infrastructure. This data needs to be monitored at the back-office hosting location at the granularity of per session. To measure the loss statistics the data needs to be time sequenced.
- Experience-related data: As an overall experience metric for the application, the user experience rating (from 1 to 5) per usage may be monitored. This can be tracked at different aggregation points based on the scope.

4.2. Monitoring related data

As shown in Figure 5, the applications that are offered and hence are monitored are the sensor and interactive applications. They can support both healthcare and non-healthcare applications. The idea of these data needs does not include the core data streams such as the temperature from a thermometer, but the additional metadata/telemetry that supports the players.

Generic metadata required to support monitoring data:

- Additional sensory applications metadata to support monitoring capabilities: Status (up or down), start time, healthcare or non-healthcare related, etc.
Additional interactive applications metadata to support monitoring capabilities: Start and end times of the sessions, type of interactive application use (video, audio, video +audio), number of sessions, etc.

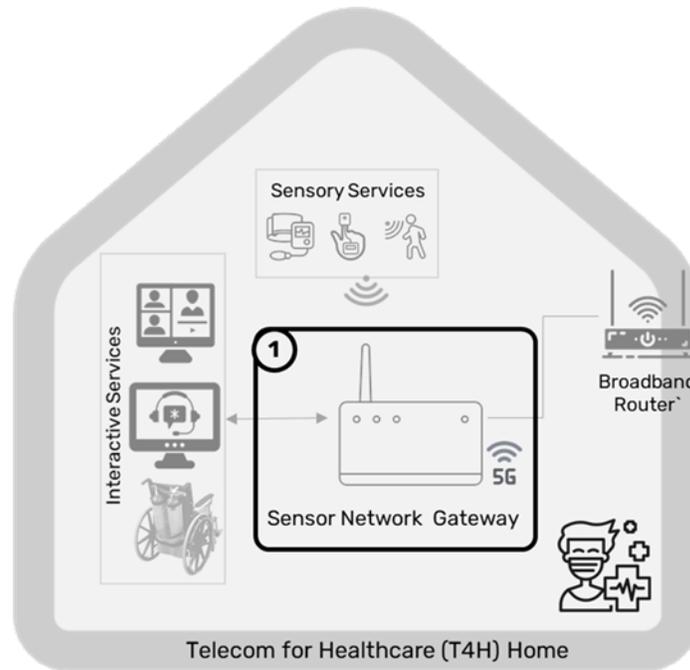


Figure 5 T4H monitoring services

Monitoring specific metadata: To provide a responsive platform to different healthcare and non-healthcare needs, we need to capture different metadata from the monitoring streams. The data can be monitored at the aggregation point in the home (sensor network gateway, as discussed in [7]) or at the hosted service back office. These metadata include:

- Sensor monitoring data: Priority of the sensor, privacy level of the data (generic, provider-specific, stakeholder, the user alone, etc.), urgency level of the notification (such as threshold crossing alarms)
- Interactive services monitoring data: Session related (number of legs, number of streams, etc.), stream related (QoE measures, transcriptions, metadata, etc.)

4.3. Connectivity related data

Connectivity focuses on providing a highly available service platform with five 9s reliability. These measures are very important to support highly emotional and sensitive subjects of healthcare and elderly care. In addition, providing ease of configuration (zero-touch configuration) is essential for T4H adoption. The reliability is measured reliability of the devices, connections, and the platform. The availability of the end-to-end services is the uptime and Service Level Agreement (SLA) guarantees for these time-sensitive T4H services. Also, due to the number of devices and solutions that will be integrated with the T4H services, we include the ease of configuration as part of connectivity.

Generic metadata required for connectivity data:

- Additional sensor metadata to support connectivity services: Sensor uptime, sensor loss of connectivity, sensor reliability

Connectivity-specific metadata: Providing a reliable platform to demonstrate the capabilities of T4H services as a differentiator is essential for cable operators to enter this market. These metrics depend on both the device and the platform's reliability and availability.

- Reliability data: Device reliability metrics, service reliability metrics
- Availability data: User device uptime (primary connection, secondary connection), server uptime, percentage availability, service availability
- Zero-touch configuration assessment: Number of service calls during installation, failed self-installs, in-home installation percentage, and average installation duration per service offering
- Other connectivity data: Availability SLA adherence

4.4. Accountability related data

The accountability of the T4H environment is used to evaluate the Quality of Care provided by the service providers and platform providers. These assess the improvement, the timely notifications that can be provided by the platform, and the billability of the services offered by the platform (and hence the provider). In this hyper-competitive and very expensive T4H environment, demonstrating the value of the service is a critical differentiator. Also, the healthcare industry is moving towards a pay-per-performance model, which constantly checks on the accountability of the providers. Hence cable operators need to showcase how they can provide a platform to assist providers with their accountability goals (such as improve notifications to different stakeholders). Providing corroborative information to bill appropriately is an essential service that cable operator T4H should offer to make their solutions attractive.

Generic metadata to support accountability data:

- Analytical platform metadata: Efficacy of the algorithms (problem resolutions rate), speed of analysis
- Notification infrastructure metadata: Notification statistics, notifications per type of problem

Accountability specific metadata:

- Quality of care data: Time to resolve the issue, condition improvement, reduce the number of missed appointments, cost reduction (for user, stakeholder, provider)
- Notifications related data: Response time (average, peak, minimum), per problem, per provider,
- Billability related data: Session context (duration, reason, parties involved, provider information, etc.), stream context (devices, device performance, potential transcription, additional notes)
- Other related data: Other stakeholder accountability, a payor accountability measure

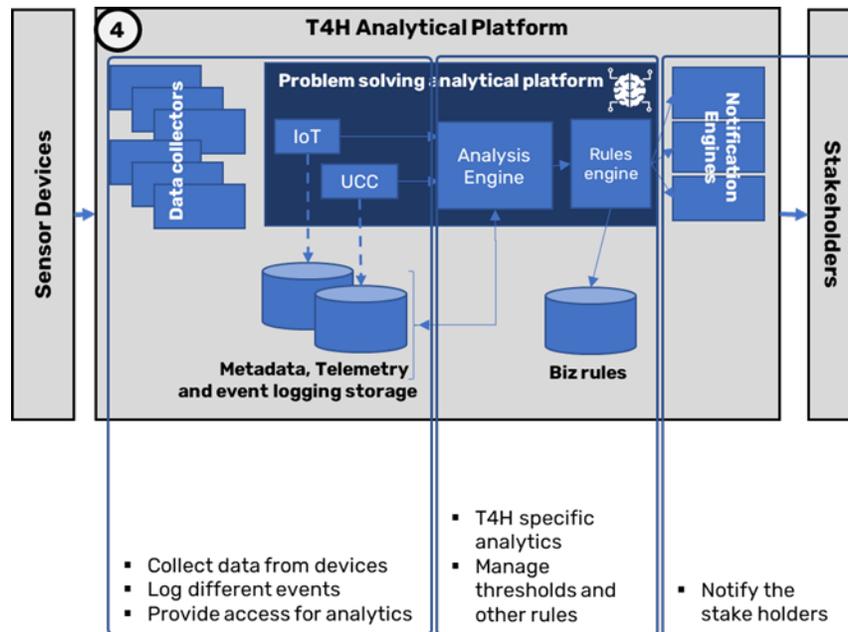


Figure 6 Using metadata to solve T4H analytical problems

5. Interaction of metadata with the analytics framework

The topic of metadata is not complete without understanding how the data is used. In [7], we explain the end-to-end T4H architecture including the analytical platform, as shown in Figure 6. The four categories of data, as discussed in the previous sections, are stored and used in the problem-solving analytical platform. The analytical platform provides the interface to different metrics as discussed in the previous sections, and assists in providing timely notifications to the stakeholders. These analytical functions that are presented in Figure 6 can be centralized or distributed in or closer to the home for availability purposes. These discussions are not in the scope of this paper.

Component	Status in MSO	Comments
Data collectors	Existing for IoT and other service info.	Need to repurpose for T4H data
Analysis engine	Existing for IoT engines	Need additional development for T4H
Rules engine	Potentially new function	Need solutioning
Notification engines	Existing with service assurance tools	Need to extend to T4H
Data privacy	Existing for PII	Need to extend to PHI
Performance	Status in MSO	Comments
Scalability	Device level alarms	Need to extend to per sub per stream
Security	SNMPv3 based	Need to validate if this is enough
Privacy	PII after collection	Need to validate if we need to anonymize at the collection points
Reliability	Reliable communication	No additional changes in our opinion
Responsiveness	Good for current use	Crucial for the success

Figure 7 Understanding the gaps in the end-to-end analytical platform

As presented in Figure 7, many of the analytical components relevant for the T4H solutions are already developed for the current Cable operator solutions. As provided in the comments section, these solutions need to be extended for the T4H requirements. Also note that the performance of the platform, which is currently tuned for the network device level needs to be scaled to per-stream level information gathering. The current Telecom solution data security and privacy constructs shall be validated against the needs of T4H needs. Although the responsiveness of the current solutions is good for the Telecom needs, using this platform for the time-critical and highly responsive T4H solutions calls for a fresh look at the data architectures. Further analysis on these architectural constructs will be conducted in the SCTE working groups [5][6].

6. Conclusion and next steps

In this paper, we have highlighted the transformations taking place in healthcare delivery and some of the challenges they pose. We have described the different needs of the various stakeholders and how they can be met with additional data and analytics. These needs include metrics to assess the quality of experience; monitoring applications; reliable, highly available, and easily configurable connectivity services; and notification and billing accountability systems. Many of these data sources and services already exist and simply need to be exposed to authorized third parties. In other instances, new infrastructure and standards are needed.

Cable operators have a unique opportunity to play a foundational role in the transformations taking place in the healthcare industry. We can take the lead in establishing standards for data transit, storage, access, security, and analysis. We can assemble a coalition of device manufacturers, inter-industry partners, and healthcare providers to ensure wide adoption. Regardless of what cable operators choose to do, these changes are coming to healthcare. By capitalizing on this opportunity cable operators can design a suite of new products to keep them relevant into the future. Failure to capitalize ensures that over-the-top solutions will emerge and eventually render them a dumb pipe.

7. References

- [1] Sudheer Dharanikota, Ayarah Dharanikota, *Why are cable operators natural fit to support Telehealth – An inter-industry perspective*, 2020 SCTE Expo, available [here](#)
- [2] Sudheer Dharanikota, Ayarah Dharanikota, Dennis Edens, Bruce McLeod, *Aging in Place business case for cable operators*, SCTE Journal, June 2021, available here
- [3] Sudheer Dharanikota, Ayarah Dharanikota, Dennis Edens, Bruce McLeod, *Telehealth business case for cable operators*, SCTE Journal, September 2021, available here
- [4] Duke Tech Solutions market research, *Telehealth market report – A Telecom based opportunity analysis*, available [here](#)
- [5] Data Standards Subcommittee, Working Group 3, *Aging in Place*, available [here](#)
- [6] Data Standards Subcommittee, Working Group 4, *Telemedicine*, available [here](#)
- [7] Sudheer Dharanikota, Clarke Stevens, *End to end Telecom for Healthcare architecture – a cable operator perspective*, 2021 SCTE Expo, available here
- [8] Sudheer Dharanikota, *Understanding the Basics of Quality of Experience – Gaming Focused*, DTS white paper, available [here](#)
- [9] Sudheer Dharanikota, *What are the impacts of changing consumption patterns on bandwidth usage?* DTS white paper, available [here](#)
- [10] HHS.gov, *Health Information Privacy*, available [here](#)