Sujansky & Associates LLC

Applicability of the California Telehealth Network as the Network Infrastructure for Statewide Health Information Exchange

An Assessment of the Optimal Roles for the CTN in California's HIE

Prepared for the California HealthCare Foundation

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Executive Summary

Sujansky & Associates evaluated whether the envisioned California Telehealth Network (CTN) should be expanded to comprise the infrastructure for statewide Health Information Exchange (HIE), or whether the goals and scope of the CTN be confined to enabling telehealth services for rural areas?

The evaluation began the assumption that the CTN is needed for telehealth applications in rural areas because commercial broadband services with the required technical capabilities are not yet available in these areas at a cost that is feasible for many rural providers. To assess whether the CTN should be expanded to meet additional healthcare networking needs, we divided the question into three parts:

1. Is the CTN also needed for "non-telehealth HIE" (ntHIE) applications in rural areas?
2. Is the CTN also needed for telehealth applications in urban areas?
3. Is the CTN also needed for ntHIE applications in urban areas?

To address these questions, we researched the following topics:

- What are the networking requirements for telehealth applications?
- What are the features of the CTN relative to existing commercial networking options that enable it to meet the requirements of telehealth applications (with respect to geographical coverage, technical capabilities, cost, etc.)?
- What are the networking requirements for ntHIE applications, including SaaS EHRs?
- What are the existing commercial networking options available to health care facilities in California, with respect to geographical coverage, technical capabilities, cost, and ease of procurement/use? How do these options compare with the planned attributes of the CTN and the networking requirements of telehealth and HIE applications?

Based upon our findings, we make the following recommendations:

A. <u>Is the CTN needed for ntHIE applications in rural areas?</u>

YES.

Many rural areas in California still do not have residential broadband service, so this highly cost-effective means of connecting to a statewide HIE is not available to them. Although T1 lines are available through phone carriers in almost all rural areas of California (including quite remote areas), the cost of subscribing to these lines is significantly higher than in urban areas because "distance charges" are frequently assessed. These charges can result in total costs of $800 - $1200 per month for a T1 line.

Hence, if the CTN can provide T1 grade service to rural healthcare facilities at rates comparable to CalNET-2 pricing (i.e., $767 per month), it may be the most cost effective way for such facilities to achieve the broadband networking required for ntHIE applications. Even if the remainder of the state HIE uses the public internet as its network infrastructure, rural sites connected via the CTN will be able to interact with the HIE through the internet bridge that the CTN will include. Although the MPLS-based security, tiered quality-of-service, and ultra-low latency and packet loss of the CTN will not be needed for ntHIE applications, these features will not impede the utility of the CTN as a general networking solution for rural facilities seeking to participate in the state HIE.

B. Is the CTN needed for telehealth applications in urban areas?

Videoconferencing: MAYBE
Store-and-Forward: NO.

Videoconferencing
Real-time videoconferencing applications require symmetrical connections, minimum bandwidth of 0.3 Mbps – 1.0 Mbps for each concurrent session*, and a very high quality-of-service (QoS) with respect to latency and packet loss. Although high-speed residential broadband services (DSL and cable) are available in almost all urban areas, they do not provide the symmetrical connectivity nor level of QoS adequate for healthcare videoconferencing.

Commercial T1 lines do provide the requisite symmetrical connectivity, bandwidth, and levels of latency and packet loss (at least between the end node and the internet service provider) needed for videoconferencing. T1 lines are available in urban areas at costs generally below that of CalNET-2 pricing. As a result, certain telehealth networks use commercial T1 lines today.

However, commercial T1 customers typically rely on the public internet backbone to transmit network traffic between internet service providers (ISPs) which subjects telehealth applications to periodic transmission delays due to traffic congestion and routing anomalies. For example, we learned that one telehealth network that uses the public internet occasionally finds the image and audio quality of its videoconferencing to be inadequate. If high-quality videoconferencing is required 100% of the time, then a private network such as the CTN is required for telehealth applications in urban areas.

Furthermore, facilities that concurrently use both videoconferencing and ntHIE applications will require a dedicated T1 line for videoconferencing, because the absence of two-tiered QoS on commercial T1 lines may cause the quality of videoconferencing to degrade to unacceptable levels when contending with other network traffic over the same line. A single CTN connection, however, could handle concurrent videoconferencing and ntHIE applications because the QoS features of the CTN will prioritize the videoconferencing packets over the ntHIE packets. Hence, if the cost of a commercial T1 line for videoconferencing and a second broadband connection for ntHIE communications exceeds the cost of a single CTN connection, it may be more cost effective for healthcare sites in urban areas that use both services to receive their network connectivity through the CTN. This determination, however, depends both on the final costs negotiated for the CTN and on the prospect for faster commercial network services (such as fiber-to-the-premises) in the near future.

Store and Forward
Store-and-forward telehealth applications that handle large imaging studies may require bandwidths of 10 Mbps or more, although they do not require the rigorous QoS of

* Depending on the use of standard-definition versus high-definition video

videoconferencing applications. If the CTN pricing follows the CalNET-2 price schedule, a 10 Mbps CTN connection will cost approximately $3,700 per month. However, 55% of California households already have access to commercial residential broadband services with download speeds of 10 – 100 Mbps at a cost under $275 per month (primarily through fiber-to-the-premises and high-speed cable). As these high-speed residential services expand to other urban locations, the cost-effectiveness of the CTN for store-and-forward applications may decrease further. Urban locations without access to these residential services may still be eligible for commercial DS3 lines, which provide symmetrical bandwidth of 44.6 Mbps at costs of between $1,500 and $5,000 per month (depending on location). FQHC's and other non-profit health facilities are eligible for a 50% discount off of this price. Hence, for store-and-forward applications that require very high bandwidths, the CTN may already be less cost-effective than commercial alternatives in many urban areas, and the number of areas in which the CTN is economically competitive for these applications is likely to diminish over time.

C. <u>Is the CTN needed for ntHIE applications in urban areas</u>?

NO.

The networking requirements for ntHIE applications are less stringent than those for most telehealth applications (particularly store-and-forward and real-time videoconferencing applications). ntHIE applications entail the transfer of less data (typically < 1 MB per transaction) and are more resilient to network latency and packet loss (because the applications do not entail real-time video and audio communications). Although security requirements for ntHIE applications are equal to those of telehealth applications, rigorous security can be achieved through the use of authentication and encryption technologies that operate over the public internet (such as SSL and IPSec). In this regard, it may be more productive to establish standards for secure interoperability among healthcare applications over the existing public network than to build a new statewide private network.

Residential broadband service (cable or DSL) of at least 0.5 – 1 Mbps download speed is available in all urban areas, and some rural areas, of the state. In many urban areas, speeds well in excess of 1 Mbps are available. These services are generally very cost effective, running less than $200/month for most grades of service in most locations. For applications or health care sites that require guaranteed service levels and/or symmetrical (upload and download) speeds, T1 lines (1.5 Mbps) are widely available today in all urban areas. Most urban facilities can lease these lines for approximately $500 per month, including internet connectivity and a managed router. In addition, FQHCs are eligible for 50% discounts to these prices through the California Teleconnect Fund. If CTN services are priced similarly to the CalNET-2 pricing schedule, a T1 line with equivalent bandwidth obtained through the CTN will cost $767 per month.

In addition, technology changes may result in even faster and less expensive alternatives in urban areas to the planned CTN. Residences and businesses in certain metropolitan areas, such as Sacramento and Southern California, already have access to low-cost fiber-optic network services. These symmetrical network connections provide speeds of 1 – 10 Mbps at a cost of $30-$50 per month and speeds of 10 – 50 Mbps for $50 - $250 per month. Additionally, cable service is now available in select areas with download speeds up to 50 Mbps at a cost of less than $200 per month. Although fiber-to-the-premises (FttP) and high-speed cable are still limited, they are spreading and may provide very high speed and low cost networking in many urban areas in the near to medium future. Unless the CTN offers additional “value-added” capabilities relative to high-speed residential broadband and T1 lines (which it does plan to develop), the CTN may not be economically competitive after the FCC-funded subsidy expires.

1 Introduction

The planned California Telehealth Network (CTN) is a private, high-speed network to support telehealth applications for rural health facilities in California. Planning is also underway in California for a statewide health information exchange (HIE) infrastructure that can support the electronic communication of patient-specific health data among the many organizations involved in the delivery and payment of health care. The HIE infrastructure has a broader scope than that of the CTN, in that it is intended to support a variety of health-related applications, not only and not even necessarily telehealth. These applications may include e-prescribing, lab result reporting, and medical records sharing. With the increasing popularity of EHR systems that are remotely hosted (i.e., under the "software as a service" or SaaS model[1]), the state's wide area networking (WAN) infrastructure may also be called upon to support real-time EHR functionality.

Given these concurrent initiatives related to telehealth and health information exchange, the following question has arisen: *Should the envisioned CTN be expanded to comprise the general infrastructure for the statewide HIE, or should the goals and scope of the CTN be confined to enabling telehealth services for rural areas?* This report addresses that question.

1.1 Definitions

To more precisely frame the question, we first defined the following terms[*]:

<u>Telehealth Application</u>: An application of information technology that enables a patient and a provider who are not physically co-located to engage in a clinical encounter for purposes of diagnosis, treatment, or medical training. Examples include videoconferencing, store-and-forward imaging, and remote telemetry.

<u>Non-Telehealth H.I.E. (ntHIE) Application</u>: Any application of information technology that (1) entails the electronic communication of patient-specific health data over a wide-area network, usually across organizational boundaries and (2) is not a telehealth application. Examples include electronic prescribing, lab-result reporting, and SaaS-based electronic health records.

<u>Urban Area</u>: A geographical tract in the state of California with a Rural-Urban Commuting Area (RUCA)[2] score of 1 – 3. In 2000, 29% of the state's land mass was urban by this definition, and 93% of the state's population resided in urban areas[3].

<u>Rural Area</u>: A geographical tract in the state of California with a Rural-Urban Commuting Area (RUCA) score of 4 – 10. In 2000, 71% of the state's land mass was rural by this definition, and 7% of the state's population resided in rural areas.

1.2 Research Questions

The CTN's primary utility will be for telehealth applications in rural areas because (1) rural areas have the greatest need for telehealth and (2) commercial broadband services with the required technical capabilities are not yet available in rural areas at a cost that is feasible for many rural

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[*] Different definitions certainly exist, particularly for distinguishing between "urban" and "rural" areas. For example, see http://www.ers.usda.gov/Data/RuralDefinitions/CA.pdf.

providers. To assess whether the CTN should be expanded to meet additional healthcare networking needs, we divided the question into three parts:

1. Is the CTN also needed for "non-telehealth HIE" (ntHIE) applications in rural areas?
2. Is the CTN also needed for telehealth applications in urban areas?
3. Is the CTN also needed for ntHIE applications in rural areas?

Table 1 illustrates the combinations of application types and geographical designations that we assessed.

Table 1. Combinations of application types and geographical areas to which the CTN may be applicable.

	Rural Area	**Urban Area**
Telehealth	YES	??
Non-Telehealth HIE	??	??

If the answers to all of these questions are "yes," then the CTN would, indeed, be applicable as the network infrastructure for all manner of HIE in all parts of California. To evaluate these questions, we collected information on the following topics:

- What are the networking requirements for telehealth applications?
- What are the features of the CTN relative to existing commercial networking options that enable it to meet the requirements of telehealth applications (with respect to geographical coverage, technical capabilities, cost, etc.)?
- What are the networking requirements for ntHIE applications, including SaaS EHRs?
- What are the existing commercial networking options available to health care facilities in California, with respect to geographical coverage, technical capabilities, cost, and ease of procurement/use? How do these options compare with the planned features of the CTN and the networking requirements of telehealth and HIE applications?

The following sections present our findings with respect to these topics. Based on these findings and our analysis, we make specific recommendations about the applicability of the CTN beyond support for telehealth applications in rural areas. These recommendations appear in Sections 4.1, 4.1, and 4.2.

2 Methods and Sources

Our research generally followed a two-phase pattern. First, we conducted online research to gather relevant data. Second, we interviewed domain experts to gain additional information and corroborate the data that we gathered during step one. This two-phase process was repeated multiple times to ensure the accuracy of our data. Please see Appendix E for a complete list of the information sources we used, including interview subjects and reviewed documents.

3 Research Findings

This section presents our research findings on the following topics:

- Networking Requirements of Telehealth Applications
- Planned Features of the California Telehealth Network (CTN)
- Networking Requirements of Non-Telehealth HIE (ntHIE) Applications
- Networking Requirements of Remotely Hosted EHR Applications (SaaS)
- Existing Commercial Alternatives to the CTN

3.1 Networking Requirements of Telehealth Applications

In this report, we define telehealth as any application of information technology that enables a patient and a provider who are not physically co-located to engage in a clinical encounter for purposes of diagnosis, treatment, or medical training. Examples of telehealth applications include video-conferencing, store-and-forward imaging, remote telemetry, and clinical messaging. Certain of these applications have special networking requirements whereas others do not. The sections below describe these requirements with respect to several important network characteristics, such as bandwidth, latency, and security (these terms are defined in the glossary in Appendix F). Table 2 summarizes these requirements.

Bandwidth

The required bandwidth for effective video-conferencing depends mostly on screen resolution. Standard-definition video-conferencing operates well at 300 Kbps, whereas high-definition video-conferencing requires at least 1 Mbps. Store-and-forward operations also require medium to high bandwidth. To forward average-sized files (such as single images), 500 Kbps is usually adequate. Transferring large files (such as entire DICOM studies) would be impractical over a network with an available bandwidth of less than 10 Mbps, unless the transfers were carefully scheduled for low-usage times (such as overnight). Other telehealth applications (e.g., audio-conferencing, clinical messaging and telemetry) can be adequately conducted over lower bandwidth connections.

Latency, Jitter and Packet Loss

Because video- and audio-conferencing are real-time applications, they are very sensitive to latency (delay in delivery of data packets), jitter (variations in latency over time) and packet-loss. Natural conversations require latencies under 300 ms. Higher levels of latency disrupt natural verbal and visual communication patterns. Furthermore, conferencing applications require stable rates of latency over time. Excessive jitter causes data buffers to function inadequately, which decreases the quality of a video or audio feed. High levels of packet loss or packets arriving out of order can lead to perceptible gaps in an audio or video feed.

Telehealth applications other than video- and audio-conferencing are not real-time and thus can tolerate higher levels of latency and packet-loss. Jitter does not at all affect such asynchronous applications.

Quality of Service

Video-conferencing is unique among telehealth applications due to its medium to high bandwidth requirements and its sensitivity to latency, jitter, and packet-loss. Therefore, video-conferencing is frequently done over a network that can provide quality of service (QoS), a mechanism by which various types of network traffic can be prioritized or a guaranteed level of network performance provided. When QoS is available, video-conferencing packets are usually prioritized higher than other types of data, resulting in higher bandwidth and less latency, jitter, and packet loss. In contrast, the public internet is a "best effort" network that does not offer QoS. Thus, video-conferencing is often (but not always) conducted over private networks. QoS is not as important for other telehealth applications since they do not have the same bandwidth and latency requirements as video-conferencing.

Downtime Sensitivity

Most telehealth applications have relatively low sensitivity to network downtimes of modest duration (i.e., up to one hour). Except in cases of emergencies, a patient appointment via video-conference can be rescheduled if the network is not available. Likewise, a clinical message or static radiology image may be resent when the network is available again. Continuous telemetry is an exception to this generalization because it is frequently used for the real-time monitoring of critically ill patients whose health status can change rapidly. Loss of network connectivity for such applications could lead to important events being missed by the telemetric monitors.

Security

Telehealth applications transmit personal health data over the network. Therefore, strong authentication and encryption are required features of these applications.

Table 2 provides a summary of the networking requirements for several types of telehealth applications. Appendix C provides more complete information regarding the networking requirements of these applications.

Table 2: Network Characteristics of Telehealth Applications

Category	Application	Acceptable Latency Level	Acceptable Packet Loss	Downtime Sensitivity	Minimum Bandwidth
Conferencing	high definition video-conferencing	Low (<150 ms). Can not tolerate any recognizable delay.	Minimal. Recognizable gaps in video and audio feed are unacceptable.	Medium. Typically, tele-consultations do not involve emergency care, thus some downtime can be tolerated.	1 Mbps (symmetrical) for single video channel; 2 Mbps (symmetrical) for two video channels
	standard definition video-conferencing	Low (<150 ms). Can not tolerate any recognizable delay.	Minimal. Recognizable gaps in video and audio feed are unacceptable.	Medium. Typically, tele-consultations do not involve emergency care, thus some downtime can be tolerated.	300 Kbps (symmetrical) for single video channel; 600 Kbps (symmetrical) for two video channels
	audio-conferencing	Low (<150 ms). Can not tolerate any recognizable delay.	Minimal. Recognizable gaps in video and audio feed are unacceptable.	Medium. Typically, tele-consultations do not involve emergency care, thus some downtime can be tolerated.	18 Kbps
Store-and-Forward	e.g., diabetic retinal examination, diagnostic image review, etc.	High.	High. Lost packets can be resent.	Low.	0.5 Mbps (except for full radiological studies, which require high bandwidths, e.g., > 10 Mbps)
Telemetry	continuous telemetry (e.g., ECG, ICU monitors)	High. Reviewing provider does not need to get data at exact moment of recording (i.e., 1-5 second delay acceptable)	Medium. Lost packets can be resent. Applications can utilize buffers to handle packet loss.	High. Important clinical events can be missed if the network is down even temporarily.	0.5 Mbps (possibly less, depending on number of data channels required)
	periodic telemetry (e.g., BP, blood glucose)	High.	High. Lost packets can be resent.	Medium. Data may be resent after network is back up.	56 Kbps per data channel
Clinical Messaging	i.e., provider - patient exchange of email, instant messages, text messages, etc.	High.	High. Lost packets can be resent.	Medium. Data may be resent after network is back up.	56 Kbps
Education / Research	e.g., continuing medical education, grand rounds, population health research, etc.	High.	High. Lost packets can be resent.	Low.	Asynchronous activities require 0.5 Mbps, synchronous activities require 1 Mbps

3.2 Planned Features of the California Telehealth Network (CTN)

The California Telehealth Network (CTN)[4] is a planned private network intended to support the specific requirements of telehealth applications in rural areas. The proposed features, services, and pricing schedules of the CTN are designed to fill gaps in the prevailing commercial network offerings in California. These gaps currently prevent many rural sites from effectively using telehealth applications.

The California Telehealth Network Consortium request for proposal (RFP)[5] describes the proposed features, services, and pricing of the CTN. We relied upon this RFP as our source of information about the planned CTN, because a winning proposal has yet to be selected and the exact nature of the CTN has yet to be firmly established. One of the goals of our analysis is to understand those capabilities and benefits that the CTN will provide that are not available in the commercial market for networking services. This characterization informed our assessment of which applications and which geographical areas may benefit from the special capabilities of the CTN and which are unlikely to require them. In this section, we review the technical capabilities, cost, geographical coverage, and ease of procurement and use of the proposed CTN.

3.2.1 Technical Capabilities

The CTN RFP states that the minimum bandwidth for any participant site will be 1.54 Mbps. This speed is equivalent to what is commercially known as a T1 circuit. The bandwidth of these circuits is symmetrical, meaning that each site is able to simultaneously download and upload data at 1.54 Mbps. The RFP assumes that some sites, especially those that will serve as telehealth centers (i.e., universities and large medical centers), will require significantly more bandwidth than the minimal configuration if they wish to support multiple, concurrent telehealth activities. To this end, the RFP indicates that circuits must be able to support up to 10 Mbps symmetrically. Furthermore, any participant site must be able to upgrade to a higher bandwidth in the event that the site's need for telehealth increases.

The CTN specifies a network architecture that enables multi-protocol label switching (MPLS), a network routing technique in which every packet of information sent between certain applications is given a label. MPLS packet labeling provides two distinct advantages over networks that lack this feature. First, it allows private connections between any two parties on the network without the need for additional VPN (virtual private network) hardware and/or software and the requisite configuration that these solutions require to secure traffic between two points. On MPLS-enabled networks, traffic between any two points is automatically isolated from all other points on the same network, preventing unauthorized parties from seeing the data. This feature provides "HIPAA-compliant security" for network participants, a stated goal of the CTN.

The other advantage provided by an MPLS network is the ability to offer quality of service (QoS) functionality. QoS permits network administrators to preferentially route packets of data for certain high-priority applications. Labeled packets get priority over unmarked packets (or packets marked with lower priority labels) when there is traffic contention on network routers. Telehealth networks that use MPLS routing typically give highest priority to real-time applications such as video and audio conferencing, since these applications have the greatest sensitivity to network effects. QoS prevents two problems that lead to quality degradation of conferencing sessions: 1) long, circuitous network paths which results in latency and 2) out-of-order packet arrival which results in packet loss.

In addition to QoS, the CTN RFP specifies a service level agreement (SLA) for certain basic network performance characteristics, such as network availability and maximum levels of latency, packet loss, and jitter (the specific SLA requirements are listed in Table 3 below).

Table 3: Service Level Agreement Requirements Specified in the CTN RFP

Service Parameter	Required Service Level
Network Availability	99.2%
Packet Latency	130 ms (one way)
Network Jitter (Variability in Latency)	< 15 ms
Packet Loss	Maximum 0.5%

In addition to the inherent qualities of the proposed CTN network, the RFP requires that the network provider offers bridges to other networks. Specifically, the CTN consortium intends to peer with the California Research and Educational Network (CalREN), a high bandwidth regional optical network in California operated by the Corporation for Education Network Initiatives in California (CENIC). Peering with CalREN will give CTN users access not only to the public internet but also to two national backbone networks, National LambdaRail and Internet2. While specific services have not yet been considered for use on these backbone networks, the connection to these networks lays the groundwork for participation in a possible nation-wide telehealth network in the future.

3.2.2 Pricing

At the time of this report, the CTN's network provider has yet to be selected. Therefore, our cost analysis relies on certain assumptions about the price sites will pay to connect to the CTN. Specifically, the CTN RFP requests that vendors offer the CTN program a pricing schedule at least as favorable as that available under the CalNET 2 State of California Master Service Agreements (MSAs)[6]. These MSAs specify extensive price schedules for various kinds and grades of network services available to state agencies in California. For the purpose of comparing CTN pricing to commercial network pricing , we have chosen the following network configuration, which is specified as the minimal configuration in the CTN RFP:

- T1 level service (1.54 Mbps bandwidth);
- Managed router (hardware monitored and supported by the network provider);
- MPLS routing;
- QoS (at least one level for audio/video conferencing applications).

The corresponding CalNET 2 price for this set of services (from the MSA-3 pricing schedule, section 6.3.3.8) includes an initial setup cost of $615 and a monthly recurring cost of $767. The price for a high-end connection (10 Mbps) is listed in the MSA-3 pricing schedule as $1,415 for setup and a monthly charge of $3,733. The CTN RFP stipulates that pricing levels at least as favorable as the CalNET 2 MSAs must be available statewide to CTN participants, regardless of a facility's location (i.e., "postalized" rates). Furthermore, the RFP requires that the pricing remained unchanged for the three-year term of the initial contract with the network provider.

It is our understanding that the cost of a connection to the internet is not included in the rates listed above. However, there is uncertainty on this point. Representatives of UC Davis have indicated that internet connectivity will be available via the CTN gateway to CalREN and LambdaRail, provided by CENIC. Conversations between CENIC and CTN regarding internet connectivity and costs have yet to be initiated. The actual rates will depend on factors including the number of sites connecting to the internet and the usage volume for those sites, neither of which has been yet established. Using the CalNET 2 price schedule for internet-dedicated access, the additional cost may be between $209/month and $366/month for a CTN site to access the internet.

Importantly, funding from the Federal Communications Commission Rural Health Care Pilot Program[7] will enable the CTN to provide substantial discounts below CalNET 2 rates to participating sites for a period of three years. During this subsidy period, the "retail" cost of T-1 grade connections via the CTN may be as little as $100/month, and 10 Mb/sec connections as little as $300/month. Subsequent to this period, participating sites may be required to pay subscription full CalNET 2 rates as described above (depending on whether additional grant funding from the FCC or other sources can be secured at that time).

3.2.3 Geographical Availability

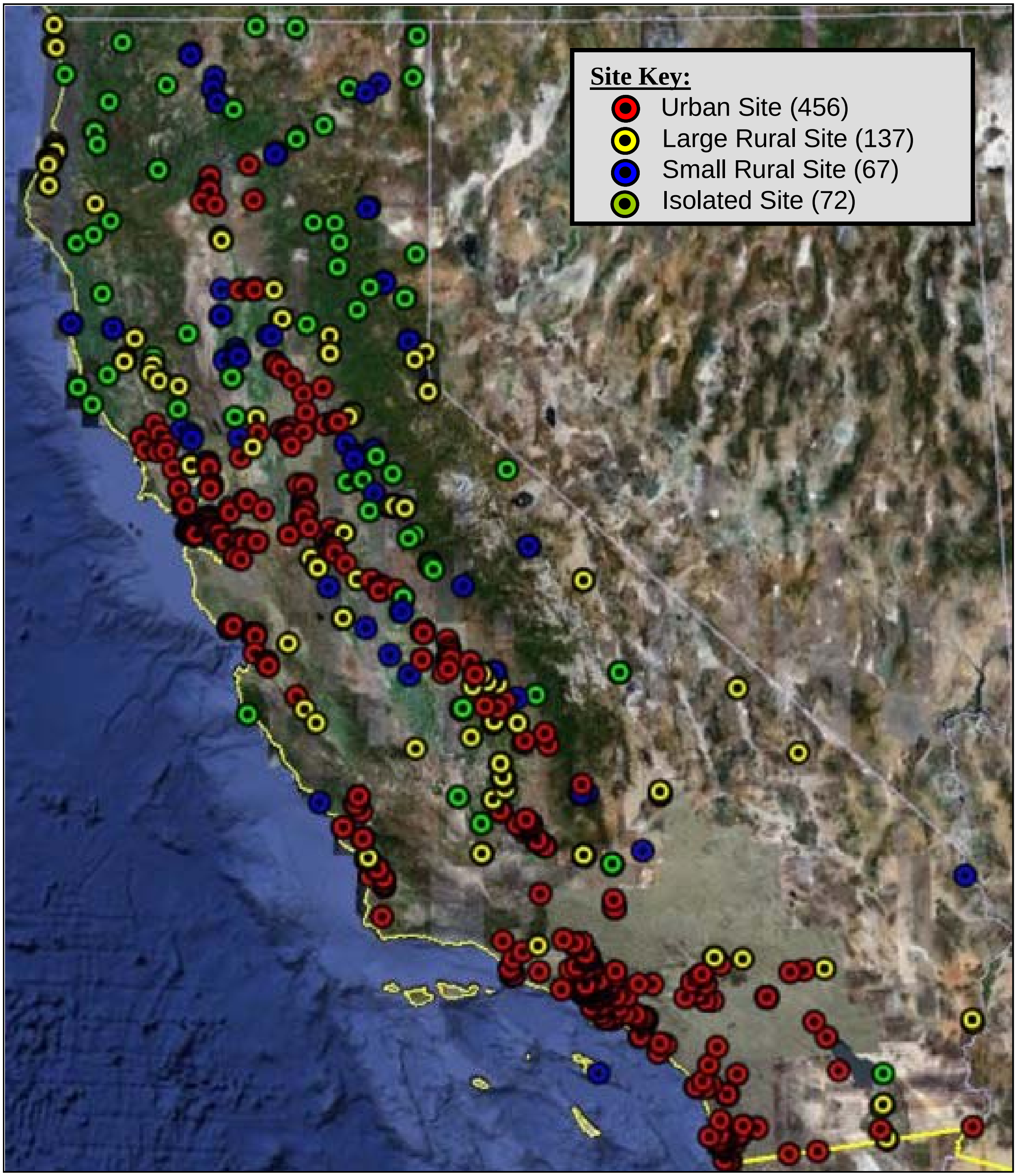
The CTN intends to extend to any medical facility in California, including all rural locations. To date, over 730 sites have submitted letters of agency and have signed up to participate in the CTN. These sites include private medical practices, federally qualified health centers (FQHCs), county health service agencies, and major medical centers in all parts of the state. The CTN RFP contains a list of healthcare facilities that have already expressed their intention to participate in the CTN. The list includes site details such as name, address, and the RUCA code for the census tract in which the site is located. Based on this RUCA information, the urban-rural distribution of the prospective sites is shown in Table 4.

Table 4: Distribution of Registered CTN Participant Sites by RUCA Category

RUCA Category	Associated RUCA Codes	Number of CTN Sites	Proportion of CTN Sites
Urban	1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1, 10.1	456	62%
Large Rural	4.0, 4.2, 5.0, 5.2, 6.0, 6.1	137	19%
Small Rural	7.0, 7.2, 7.3, 7.4, 8.0, 8.2, 8.3, 8.4, 9.0, 9.1, 9.2	67	9%
Isolated	10.0, 10.2, 10.3, 10.4, 10.5, 10.6	72	10%

The geographical distribution of the 730 sites is shown in Figure 1.

Figure 1 - Geographic Distribution of the Proposed CTN Sites, by RUCA Category.



3.2.4 Ease of Procurement and Use

The telecommunications vendor that wins the CTN bid will handle all physical network construction (where existing copper lines do not yet extend between a central office and the practice site), site installations, and hardware management. The rollout schedule described in the

RFP indicates that the vendor will connect at least 100 sites each year for 3 years. The RFP also describes a "centralized network monitoring facility" that will be staffed 24/7 to provide network monitoring and support. The monitoring facility will perform quality and utilization reporting that may be used to ensure that the network provider is meeting the terms of the contract.

The CTN is interested in providing additional network-support services to participating sites, such as internal LAN configuration, firewall management, etc. However, additional sources of funding beyond those available through the FCC Rural Health Care Pilot Program may be required to provide such services.

3.3 Networking Requirements of Non-Telehealth HIE (ntHIE) Applications

Non-telehealth health information exchange (ntHIE) entails the electronic communication of patient-specific health data for a variety of purposes aside from telehealth. Examples of ntHIE transactions include:

- Two providers from separate organizations exchange a patient health summary;
- A provider transmits an e-prescription from her EHR to an e-prescription clearinghouse;
- A provider sends a laboratory test order to an external laboratory and subsequently receives the laboratory results electronically.

Table 5 provides a more comprehensive list of ntHIE transactions and their networking requirements.

ntHIE applications generally have less stringent networking requirements than telehealth applications, especially with respect to bandwidth, latency, jitter, and packet loss. The sections below describe the most important of these requirements.

Bandwidth

Typically, ntHIE transactions are file-based. Common file types include images, audio recordings, spreadsheets and ASCII text files (e.g., HL7 messages, XML files, unstructured text files). The majority of ntHIE transactions involve small file sizes (less than 100 KB), which can be adequately performed over low-bandwidth network connections (less than 500 Kbps). Certain ntHIE transactions involve the transfer of larger files (i.e., radiological studies, multimedia files, etc.), and these transactions will benefit from higher bandwidth availability (500 Kbps – 1.5 Mbps). However, with the exception of applications that exchange entire radiological studies (such as complete CT or MRI studies, which can exceed 1 GB in size), bandwidth in excess of 1.5 Mbps is unlikely to be required for ntHIE.

Acceptable Delay in Delivery Time

Most ntHIE transactions do not require real-time response. If applications are designed such that ntHIE transmissions can be queued and delivered asynchronously (as opposed to blocking the user from further operations until the transmission is complete), up to a few minutes delay in data delivery is usually acceptable.

Latency and Packet Loss

ntHIE transactions entail asynchronous communications (i.e., communications that do not require immediate responses). Like email, the window of acceptable transmission time for an ntHIE transaction can range from sub-second to hours, depending on the application. Given their asynchronous nature, these transactions can tolerate high levels of network latency, and latency of even a few seconds will not negatively affect application functionality. Packet loss (data packets sent but never received, necessitating a retransmission) is also a minor concern for ntHIE applications since their asynchronous nature allows time for lost packets to be resent and reintegrated, thereby preventing data loss.

Downtime Sensitivity

ntHIE applications vary with regard to downtime sensitivity (i.e., the impact on clinical activities when the network connection is lost). Long downtimes are unacceptable for certain ntHIE applications, such as e-prescribing, which require near- time completion. Other activities, such as transmitting a radiological image or a clinical message, are less sensitive to brief network outages. The effects of a lost network connection also depend on the design of a given ntHIE application. Some applications can queue transactions initiated during network downtime and then transmit queued items when network connectivity is restored, thereby reducing the impact on user work-flows. Applications that do not support queuing may require users to later manually re-attempt transactions.

Security

All ntHIE applications transmit personal health data across wide area networks. Therefore, strong authentication and encryption are mandatory features of all such applications.

Table 5 provides a summary of the networking requirements for several types of ntHIE transactions. Appendix D offers more complete information regarding the networking requirements of these transactions.

Table 5: Characteristics of ntHIE Transactions

Operation	Typical Data per Transaction Size	Acceptable Delay in Delivery Time*	Acceptable Latency Level	Acceptable Packet Loss	Downtime Sensitivity*	Required Bandwidth
e-Prescribe	<100 KB	Up to a few minutes	High	High	High	Low
Order/receive real-time laboratory report	100 KB	Up to a few minutes	High	High	Medium	Low
Exchange unstructured clinical documents	100 KB	Up to a few minutes	High	High	Medium	Low
Exchange structured patient health summary	100 KB	Up to a few minutes	High	High	Medium	Low
Query medication history	100 KB	Up to a minute	High	High	High	Low
Exchange clinical messages	100 KB (without attachments)	Up to a few minutes	High	High	Medium	Low
Transmit a radiological image	2 MB	Up to a few minutes	High	High	Low	Low
Transmit a complete radiological study	1 GB	Up to an hour	High	High	Low	High
Transmit dictation audio file	500 KB	Up to a few hours	High	High	Low	Low
Transmit aggregated population data	Variable	Up to a few hours	High	High	Low	Low
Query patient identity service	<100 KB	Up to a minute	High	High	High	Low
Exchange other multi-media documentation	> 1 MB	Up to an hour	High	High	Low	Medium

* Assumes that applications can queue requested transmissions, allowing users to continue with other functions before a transmission has completed.

3.4 Networking Requirements of Remotely Hosted EHR Applications (SaaS)

An increasing number of EHR products are being offered as remotely hosted applications to which medical facilities *subscribe* rather than purchase and install. This "software as a service" (SaaS) model permits most application functionalities and most data to reside on servers outside of medical facilities. Personnel at the facilities access the EHR using thin-client workstations (typically web browsers) that communicate with the servers over wide-area networks. Although the SaaS model can be more convenient and cost effective than client-server applications, it also introduces special networking requirements (i.e., independent of any ntHIE transactions that the server components of these EHRs may perform).

To determine whether the CTN is needed by facilities that choose the SaaS model for their EHR systems, we identified the specific operations of such systems that involve WAN communications and we characterized the networking requirements of these operations. These operations include:

- Search for a patient record;
- Retrieve clinical details about a patient (e.g., medications and problems lists, allergies, etc.);
- Document patient care (e.g., progress note, history and physical, etc.).

Table 6 provides a full list of these “network intensive” operations. Based on the nature of these operations, the frequency with which they are typically performed, and volume of data that they entail, we are able to characterize the general requirements of SaaS EHRs with respect to the following network characteristics.

Bandwidth

On the whole, SaaS applications require low to moderate bandwidth. However, the SaaS applications currently on the market vary greatly with regard to their underlying software technologies, and these variances produce differences in the size and frequency of data transactions. These differences create moderately different bandwidth requirements. In the sections below, we describe three technologies used by applications in today's market and their effects on the bandwidth requirements of SaaS EHRs.

- **Simple HTML**

  With simple HTML applications, almost all user-initiated functions require sending an HTTP request to the server and result in a complete page change/refresh (which consists of downloading an entire HTML file and sometimes multimedia files such as images, audio, video, etc.). The bandwidth requirements of plain HTML applications depend on the application's complexity and use of graphics. Low bandwidth connections (less than 500 Kbps) may not provide adequate response times if the application's pages are long and/or include many multi-media files. However, standard broadband connections (e.g., DSL or cable) provide sufficient bandwidth for most simple HTML applications.

- **HTML with AJAX**

  To reduce response times for user-initiated operations, many modern SaaS applications leverage a technique called AJAX (Asynchronous JavaScript and XML). When AJAX is employed, the server does not send entire web pages back to the client browser. Typically, the server will need to only send small bits of data and/or small portions of an HTML page in response to a user request. This obviates the need to refresh static portions of the application (such as the header, footer and navigation menu), which results in much faster response times. Also, EHRs that use AJAX can “pre-fetch” data in the background, as users process data sent earlier, thereby further reducing perceived wait times for page refreshes. Hence, use of AJAX can reduce the bandwidth requirements of complex SaaS EHR applications considerably, such that even slower DSL connections (< 1 Mbps) may be adequate.

- **Browser Plug-Ins**

  Some SaaS applications utilize web browser plug-ins to augment the application's interactivity. The most common plug-in currently used is Adobe Flash Player; however, Microsoft recently released a competing technology called Silverlight. Unlike simple HTML and AJAX applications, which require frequent communications between the client and server to refresh the browser view, these plug-in applications require a one-time, initial download of the application's entire user interface. Subsequent communications between client and server consist of small bits of data only. In general, plug-in applications do not require high bandwidth since data transactions are small and infrequent, although initially downloading or upgrading an application over a low bandwidth connection (< 500 Kbps) may take several minutes.

Acceptable Delay in Delivery Time

Most SaaS activities require near-real-time response for acceptance among clinical users. Therefore, network delays in data delivery should be less than one second.

Latency and Packet Loss

All SaaS application operations are synchronous (i.e., the user waits for a response before continuing to the next step of his work-flow), but they do not require precise real-time synchronization (unlike video-conferencing applications, for example). Response-time delays should be minimal, but can range up to 500 ms (especially if the server response time is very short). Therefore, SaaS applications can tolerate higher levels of latency (defined as greater than 300 ms) and packet loss (defined as greater than 1%) than can video-conferencing applications. Even moderate latency and packet loss will rarely, unto themselves, cause response times greater than one second.

Network Downtime

SaaS applications are critically sensitive to network downtime because most EHR functions, by design, require network connectivity and because a SaaS EHR's operations usually fall within the critical path of clinical work-flow (i.e., subsequent tasks can not be started until the current operation is completed). Very recently, emerging technologies such as Adobe Air and Google Gears attempt to address the problem of network downtime. These new technologies locally store a cache of both data and application functionality to permit users to continue their operations when the network is unavailable. To date, however, few clinically-oriented SaaS applications employ these new technologies.

Security

Like HIE applications, SaaS clinical applications transmit personal health data. Therefore, strong encryption and authentication methods are necessary to protect these data.

Table 6 provides a summary of the networking requirements for typical operations performed by a SaaS EHR.

Table 6: Characteristics of Browser-Based SaaS Clinical Operations*

Operation	Typical Data per Transaction Size	Acceptable Delay in Delivery Time	Acceptable Latency Level	Amount of Packet Loss Acceptable	Downtime Sensitivity	Required Bandwidth
Search for patient record	10 - 100 KB	< 1 second	High	High	High	Low
View clinical summary page	10 - 100 KB	< 1 second	High	High	High	Low
Retrieve clinical details	10 - 100 KB	< 1 second	High	High	High	Low
Download file (text or image)	100 KB - 2 MB	Up to a few minutes	High	High	High	Medium
Graph data trend	10 - 100 KB	< 1 second	High	High	High	Low
Document patient care	10 - 100 KB	< 1 second	High	High	High	Low
Write order	10 - 100 KB	< 1 second	High	High	High	Low
Run decision support	10 - 100 KB	< 1 second	High	High	High	Low
Register patient	10 - 100 KB	< 1 second	High	High	High	Low
Exchange clinical message	100 KB (with no attachments)	< 1 second	High	High	High	Low
Manage work-flow	10 - 100 KB	< 1 second	High	High	High	Low
Upload file (text or image)	100 KB - 2 MB	Up to a few minutes	High	High	High	Medium
Record real-time dictation	500 KB	< 1 second	High	Moderate	High	High
Schedule appointment	10 - 100 KB	< 1 second	High	High	High	Low
Perform billing-related function	10 - 100 KB	< 1 second	High	High	High	Low
Write letter	10 - 100 KB	< 1 second	High	High	High	Low
Run report on patient population	Variable	Up to a few minutes	High	High	High	Medium
Record real-time biometric data	Not applicable	< 1 second	High	Moderate	High	Low

*This table applies to browser-based SaaS EHRs only. Please see the subsequent section for information about SaaS solutions based on remote desktop architectures.

Implications of Remote-Desktop as the Architecture for SaaS EHRs (e.g., Citrix)

Our preceding discussion of SaaS EHRS purposefully excluded systems that use remote-desktop technologies, such as Citrix. Like web-based systems, remote-desktop solutions require only a thin client at the medical facility, with the bulk of data and processing residing on an off-site server. However, the client software in these cases is not a standard web browser or a browser plug-in, but a proprietary software application that communicates with the remote server in a very different way. Rather than communicating via an HTML or XML data stream , the server sends to the client window-display information that displays the current state of the remote desktop screen, and the client sends to the server all keystrokes, mouse movements and mouse clicks[*].

[*] Note: It is also possible to upload and download individual files from the client to the server, for functions such as image capture and voice dictation.

Remote-desktop solutions typically require higher bandwidth than browser-based applications because large images files are being transmitted whenever there is motion on the screen (including user input). Indeed, bandwidth needs increase as screen resolution increases. Unlike browser-based applications, where individual mouse and keyboard functions are processed locally and entail no network transmission, remote desktop solutions require sufficient levels of bandwidth to maintain smooth mouse tracking and immediate screen output of entered keystrokes (although certain remote desktop applications mitigate this problem with special, client-side technologies that compensate for network delays).

With remote-desktop-based EHR solutions, network transactions are fundamental to almost every action of the user, and even transient network delays (for example, if a large file or image is being transferred) become quickly apparent and tedious. When multiple remote-desktop-based EHRs are operated concurrently at a single facility, each one contributes a separate and continuous network load.

3.5 Existing Commercial Alternatives to the CTN

This section contains a summary of our findings on the commercial alternatives to the CTN for healthcare network services (i.e., the technical capabilities, costs, and geographic coverage of commercial networking options available to health care facilities in California). Table 7 below shows summary information for each option we considered in this report. Appendix A includes a much more comprehensive description of our findings.

3.5.1 Types of Commercial Networking Services

There are two tiers of existing commercial networks that we reviewed for the report, business-grade services and residential services[*]. In this report we equate business-grade service to a full T1 circuit (described below). Residential network services include asynchronous digital subscriber line (ADSL), cable, and fiber-to-the-premises (FttP). Wireless networking options (satellite and terrestrial wireless) also exist for businesses and residences, but we did not consider these services as viable alternatives to the CTN given their high latency and packet loss.

3.5.2 Technical Capabilities

Downstream Bandwidth

The CTN and commercial T1 networks both transfer data at 1.54 Mbps. Advertised rates of residential broadband can range from 500 Kbps up to 50 Mbps. It is important to note that residential services are advertised as having bandwidth “up to” a given rate. Actual downstream rates observed by residential customers are rarely as high as the advertised rates and commonly range between 50 – 75% of the advertised rate.

Symmetrical Upstream Bandwidth

The bandwidth of commercial T1 circuits is bi-directionally symmetrical, providing simultaneous upstream and downstream bandwidth of 1.54 Mbps. Residential broadband

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[*] Note that businesses are not excluded from purchasing residential services, and many small businesses do use DSL and cable for their internet connectivity.

internet options, with the exception of the new FttP services, are asymmetrical with upstream rates a fraction of downstream bandwidth (typically between 10% and 25%).

End-to-End QoS

Full end-to-end QoS is a feature unique to private networks like the CTN. Commercial T1 providers can offer QoS only within their own networks (i.e., between the customer site and the network provider's central office). Once traffic from a T1 line reaches the public internet, however, it is subject to the "best-effort" nature of that medium and end-to-end QoS is not possible. QoS is not an option on any segment of a residential internet connection.

Security

All commercially available networking options reviewed for this report have equivalent security capabilities because they all utilize the public internet, which is inherently insecure. Therefore, to guarantee data privacy, all data must be encrypted on a secure channel using VPN hardware or software. Additionally, the computer system or local area network (LAN) connected to the public internet must be secured using a firewall that can filter traffic and prevent unauthorized access. Both of these solutions require administrative overhead for network configuration and maintenance. However, when utilized together, they provide security of data in transit that is equivalent to that of an MPLS network.

3.5.3 Pricing

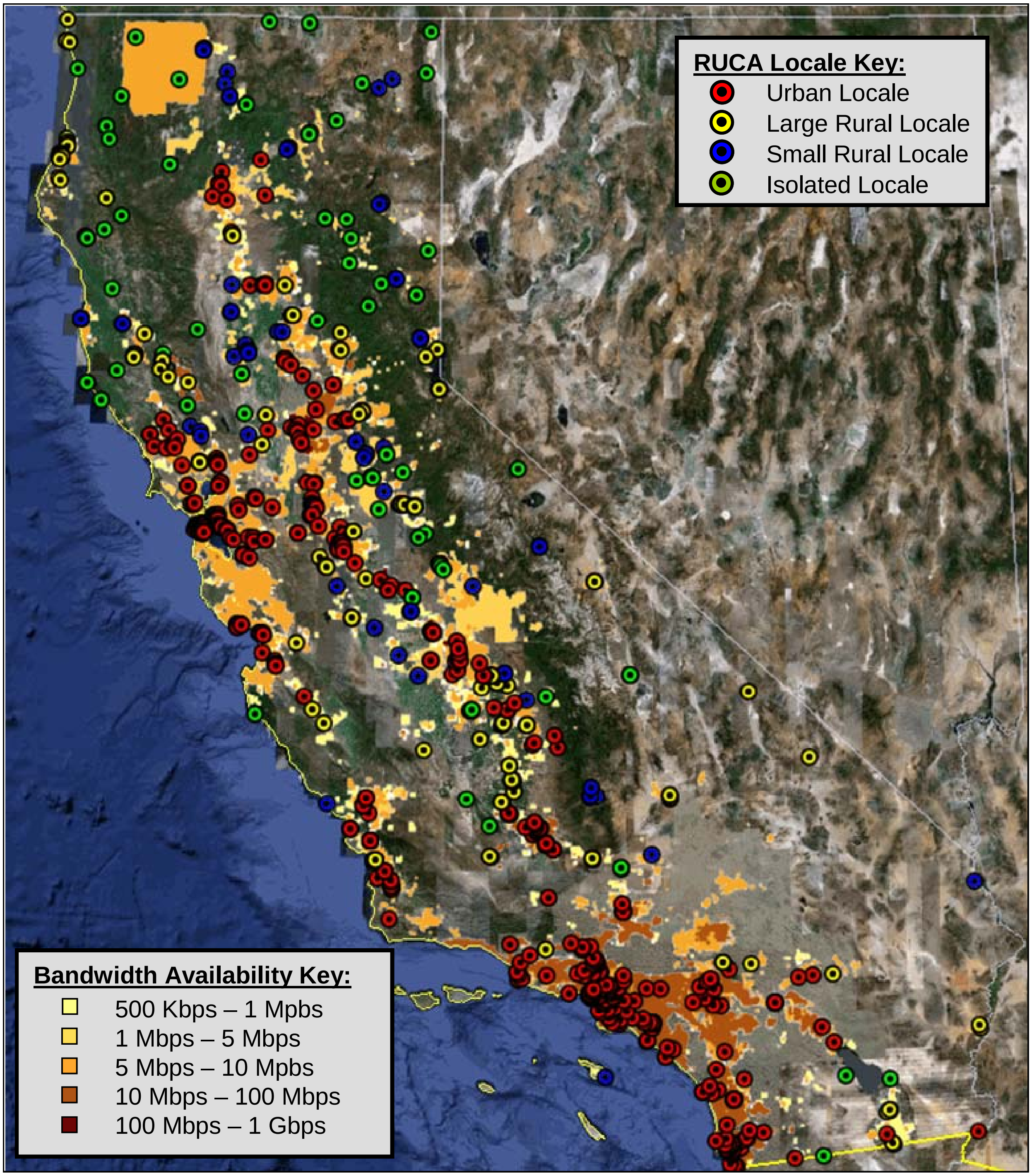
Residential internet service is available for under $100 per month. Commercial T1 pricing is dependent on whether the customer site is within the network provider's service area and how far the customer site is from the telecom provider's central office. Based on a representative sample of ten urban sites, we found that the price for T1 to the internet ("T-to-I") in urban areas is $486 per month. T1 prices for rural areas range from $486 to $1,200 per month depending on where the T1 line terminates. For more information on T-to-I pricing, please see Appendix B.

Note that federally Qualified Health Clinics (FQHCs) and other non-profit health facilities in California are eligible for 50% discounts on T1, DSL, and DS3 lines through the California Teleconnect Fund[8].

3.5.4 Geographical Availability

The 2007 California Broadband Task Force study[9] found that 4% of California residences could not obtain residential broadband internet at any speed. We therefore assume that a similar proportion of health care facilities (largely in rural areas) also cannot access residential broadband services. However, commercial T1 service is available anywhere that is served by the telephone companies, including the most rural parts of California.

Figure 2 – Commercial Broadband Availability in California (does not include T1 circuits)*



* Broadband availability data was provided by and used with the permission of the California Emerging Technology Fund (CETF), 2007, San Francisco CA. Note that the study did not include availability of T1 circuits, which this report addresses in Appendix A.

3.5.5 Ease of Procurement and Use

For T1 circuits, the service provider installs the necessary hardware (routers) and configures the IP addresses and any firewall security. If a copper line already exists between the business and the CO, installation typically takes no more that 10 days. If new lines must be run between the CO and the business or if repeater boxes must be installed to reach remote sites, installation may take significantly longer (e.g., 30 – 45 days).

The procurement of ADSL, cable, and FttP residential internet service is a very consumer-friendly process. If these services are available in an area, the physical wiring to the premises is usually already in place. A service technician may need to rewire the internal wiring of the residence or business to get the connection endpoint to the most convenient location for the customer. Next, the hardware (modems and routers) must be provisioned and connected to the provider's network. In most cases, installation rarely requires more than a few hours.

For T1 lines, the service provider manages the on-site router hardware and troubleshoots problems with the connection or the router configuration. Because these lines come with service-level guarantees, the vendors are relatively responsive to issues. For residential service (cable, ADSL, and FttP), the hardware provided by residential ISPs is not managed by the service provider and users can expect only basic customer service.

Table 7 - Commercial Network Options Summary

Service Type	Downstream Bandwidth (Mbps)	Symmetrical Upstream Bandwidth?	End-to-end QoS Available?	Price	Security	Availability
CTN (Minimum Mandatory Configuration)	1.54	Yes	Yes	$767/mo (assumes CalNET 2 pricing)	MPLS network with any-to-any connect-ivity	Anywhere the phone company serves, including most rural areas
T1 to the Internet	1.54	Yes	No	$486 (urban); $486 - $1,200 (rural)	VPN & firewall required	Anywhere the phone company serves, including most rural areas
Residential ADSL	0.5 – 25	No (0.2 – 5 Mbps)	No	$10-$80/mo	VPN & firewall required	Available in urban & large rural RUCA areas, not available in many small rural/isolated areas
Residential Cable	0.5 – 15	No (0.05–1.5 Mbps)	No	$10-$80/mo	VPN & firewall required	Available in urban & large rural RUCA areas, not available in many small rural/isolated areas
Residential FttP	1 – 50	Yes – most plans	No	$30-$50/mo (<10Mbps) $50-$250/mo (>=10Mbps)	VPN & firewall required	Only available in select urban areas

4 Recommendations

4.1 Is the CTN Needed for ntHIE Applications in Rural Areas?

We DO believe that the CTN is needed for ntHIE applications in rural areas. Many rural areas in California still do not have access to residential broadband service. Although T1 lines are available through phone carriers in almost all rural areas of California (including quite remote areas), the cost of subscribing to these lines is significantly higher than in urban areas because "distance charges" are frequently assessed (resulting in total costs of $800 - $1200 per month). Therefore, the prohibitive price of high-speed internet for these rural health care providers may prevent them from participating in statewide HIE.

If the CTN can provide T1-grade service to rural healthcare facilities at rates comparable to CalNET 2 pricing (i.e., $767 per month), this approach may be the most cost effective way for such facilities to achieve in the long run the broadband networking required for non-telehealth clinical applications. In the short run (during the period of FCC funding), the cost will be substantial lower.

Even if other ntHIE participants use the public internet as a network infrastructure, rural sites connected via the CTN will be able to interact with the HIE through the internet bridge that the CTN will include. Although the MPLS-based security, tiered QoS, and ultra-low latency and packet loss of the CTN will not be needed for non-telehealth applications, these features will not impede the utility of the CTN as a general networking solution for rural facilities seeking to participate in statewide HIE.

4.2 Is the CTN Needed for Telehealth Applications in Urban Areas?

We believe that the CTN MAY BE needed for videoconferencing applications in urban areas, although it IS NOT needed for store-and-forward applications. Real-time videoconferencing applications require symmetrical connections, minimum bandwidth of 0.3 Mbps – 1.0 Mbps for each concurrent session , and a very high quality-of-service (QoS) with respect to latency and packet loss. Although high-speed residential broadband services (DSL and Cable) are available in almost all urban areas, they do not provide the symmetrical connectivity nor level of QoS adequate for healthcare videoconferencing.

Commercial T1 lines do provide the requisite symmetrical connectivity, bandwidth, and levels of latency and packet loss (at least between the end node and the ISP) for videoconferencing. T1 lines are available in urban areas at costs generally below that of CalNET-2 pricing. As a result, certain telehealth networks use commercial T1 lines today.

However, commercial T1 lines typically use the public internet backbone to connect between ISPs, which subjects telehealth applications to transmission delays due to traffic congestion and routing anomalies. For example, we learned that one telehealth network that uses the public internet occasionally finds the image and audio quality of its videoconferencing to be inadequate. If high quality videoconferencing is required 100% of the time, then a private network such as the CTN is required for telehealth applications in urban areas.

Furthermore, facilities that concurrently use both videoconferencing and ntHIE applications will require a dedicated T1 line for videoconferencing, because the absence of two-tiered QoS on commercial T1 lines may cause the quality of videoconferencing to degrade to unacceptable levels when contending with other network traffic over the same line. A single CTN connection, however, could handle concurrent videoconferencing and ntHIE applications because the QoS features of the CTN will prioritize the videoconferencing packets over the ntHIE packets. Hence, if the cost of a commercial T1 line for videoconferencing and a second broadband connection for ntHIE communications exceeds the cost of a single CTN connection, it may be more cost effective for healthcare sites in urban areas that use both services to receive their network connectivity through the CTN. This determination, however, depends both on the final costs negotiated for the CTN and on the prospect for faster commercial network services (such as fiber-to-the-premises) in the near future.

Store-and-forward telehealth applications that handle large imaging studies may require bandwidths of 10 Mbps or more, but they do not require the stringent QoS of videoconferencing applications. If the CTN pricing follows the CalNET-2 price schedule, a 10 Mbps CTN connection will cost approximately $3,700 per month. However, 55% of California households already have access to commercial residential broadband services with download speeds of 10 – 100 Mbps at a cost under $275 per month (primarily through FttP and high-speed cable). These costs are lower than even the initial subsidized pricing for 10 Mb/sec connections that the CTN is likely to offer. As these high-speed residential services expand to other urban locations, the cost-effectiveness of the CTN for store-and-forward applications may decrease further. Urban locations without access to these residential services may still be eligible for commercial DS3 lines, which provide symmetrical bandwidth of 44.6 Mbps at costs of between $1,500 and $5,000 per month (depending on location). FQHC's and other non-profit health facilities are eligible for a 50% discount off of this price. Hence, for store-and-forward applications that require very high bandwidths, the CTN will be less cost-effective at the time the FCC-funded subsidy expires than commercial alternatives in many urban areas, and the number of areas in which the CTN is economically competitive for these applications is likely to diminish over time.

4.3 Is the CTN Needed for ntHIE Applications in Urban Areas?

We DO NOT believe that the CTN is needed for non-telehealth HIE applications in urban areas. The networking requirements for ntHIE applications are less stringent than those for most telehealth applications (particularly store-and-forward and real-time videoconferencing applications). ntHIE applications entail the transfer of less data (typically < 1 MB per transaction) and are more resilient to network latency and packet loss (because the applications do not entail real-time video and audio communications). Although security requirements for ntHIE applications are equally stringent to those of telehealth applications, rigorous security can be achieved through the use of authentication and encryption technologies (such as SSL and IPSec) that operate over the public internet. In this regard, it may be more productive to establish standards for secure interoperability among healthcare applications over the existing public network than to build a new statewide private network.

Residential broadband service (cable or DSL) of at least 0.5 – 1 Mbps download speed is available in all urban areas, and some rural areas, of the state. In many urban areas, speeds well in excess of 1 Mbps are available. These services are generally very cost effective, running less than $200/month for most grades of service in most locations. For applications or health care sites that require guaranteed service levels and/or symmetrical (upload and download) speeds, T1 lines (1.5 Mbps) are widely available today in all urban areas. Most urban facilities can lease these lines for approximately $500 per month, including internet connectivity and a managed router. In addition, FQHC and other non-profit health facilities are eligible for 50% discounts to these prices through the California Teleconnect Fund. If CTN services are priced similarly to the CalNET-2 pricing schedule at the time the FCC-funded subsidy expires, a T1 line with equivalent bandwidth obtained through the CTN will cost $767 per month.

In addition, technology changes may result in even faster and less expensive alternatives in urban areas to the planned CTN. Residences and businesses in certain metropolitan areas, such as Sacramento and Southern California, already have access to low-cost fiber-optic network services. These symmetrical network connections provide speeds of 1 – 10 Mbps at a cost of $30-$50 per month and speeds of 10 – 50 Mbps for $50 - $250 per month. Additionally, cable service is now available in select areas with download speeds up to 50 Mbps at a cost of less than $200 per month. Although the availability of FttP and high-speed cable is still limited, these services are spreading and may provide very high-speed and low-cost networking in many urban areas in the near to medium future. Unless the CTN offers additional “value-added” capabilities relative to high-speed residential broadband and T1 lines, the CTN may not be economically competitive after the FCC-funded subsidy expires.

Will the CTN be beneficial in the event of a natural disaster or terrorist attack?

One of the intended goals of the CTN project is to "utilize the CTN for ongoing disaster preparedness training to enhance California's ability to provide a rapid and coordinated response to a national crisis." If the sole intent of this goal is to provide educational materials (e.g., training videos for first responders) related to disaster preparedness, then this goal will easily be met by the proposed CTN, as well as by various commercial broadband options that support streaming video, webcasts, etc. If the goal, however, is to also provide additional network redundancy and prevent network or internet outage for health care providers, the necessity of the CTN is less clear.

The CTN RFP contains a requirement that, in the event of an emergency, voice and video traffic used by first responders will be prioritized over the standard video conferencing traffic. This provision would ensure that critical communication gets through, assuming that the CTN is still operational. However, the public internet has proven to be extremely resilient to disruptions in traffic routing during disasters. After the terrorist attacks of September 11, 2001, traffic on the internet was largely unaffected, despite the fact that a large routing facility went offline in Manhattan when a Verizon building was damaged in the attack[1] and the fact that network traffic increased significantly as citizens around the world followed the events. Overall availability of the internet dropped only 8% (to 88%, down from 96%) immediately following the attack. The largest issue of traffic contention was the inaccessibility of some major news websites (i.e., CNN.com). These facts demonstrate the resiliency of the internet and show how its degree of redundancy, a degree much higher than that of the proposed CTN, can prevent problems with internet traffic routing.

If the disaster were severe enough to physically knock out the public internet, the circuits that carry the CTN traffic would also likely be affected. The CTN will not consist of physically separate lines but will instead utilize the same lines that comprise the telecommunication vendor's existing network infrastructure. If those lines are severed, then the CTN will suffer as much as other networks using those same circuits. For example, in April 2009, Santa Cruz County lost all telephone and internet service when the single network backbone line serving the county was severed. Because the CTN would likely be using the same line that was cut, those medical practices connected to the CTN would have also been without service. There has been some discussion of relying on satellite networks for redundancy and for providing access to the most remote of medical practices. However, as discussed in the section Wireless Broadband Technologies, satellite networks are insufficient for the rigorous demands of telehealth networks. A connection to private academic networks (Internet 2 and National LambdaRail) would provide some degree of network redundancy, as these private networks consist of physically separate lines.

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[1] The internet Under Crisis Conditions: Learning from September 11; (http://www.nap.edu/catalog.php?record_id=10569); Last accessed June 14, 2009

5 Conclusions

The CTN will provide an important resource for rural health facilities that wish to provide telehealth services and participate in the state health information exchange. However, the availability of more cost-effective and equally suitable networking alternatives for non-telehealth HIE in urban areas does not warrant the expansion of the CTN for this use. Although adequately securing patient data that are shared over the public internet will require the establishment of security standards and sound practices, this strategy may be more feasible than convincing urban health facilities to purchase networking services from the CTN that will likely be more costly than those available from commercial providers by the time the FCC-funded subsidy expires. Urban health facilities that engage in both videoconferencing and ntHIE, however, may find the CTN to be the most cost-effective option today and in the future. In contrast, urban facilities that use store-and-forward telehealth for large imaging studies (but do not use videoconferencing) will probably find the most cost-effective network services in the commercial market, especially if they are non-profit organizations eligible for the 50% discount offered by the California Teleconnect Fund.

Table 8. Applicability of the CTN with respect to application types and geographical areas.

	Rural Area	**Urban Area**
Telehealth	YES	MAYBE / NO
Non-Telehealth HIE	YES	NO

6 Endnotes

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[1] Also known as the "Application Service Provider" (ASP) model. See http://www.chcf.org/documents/healthit/PhysicianPracticesASPProviders.pdf.

[2] For information about RUCA scores, see http://depts.washington.edu/uwruca/.

[3] See http://www.ers.usda.gov/Data/RuralDefinitions/CA.pdf, slide #8.

[4] See http://www.caltelehealth.org/.

[5] http://www.ucdmc.ucdavis.edu/ctn/rfpmain.html

[6] See http://www.calnet.ca.gov/.

[7] See http://www.fcc.gov/cgb/rural/rhcp.html

[8] See http://docs.cpuc.ca.gov/telco/public+programs/ctf_faq.htm.

[9] http://www.calink.ca.gov/pdf/CBTF_FINAL_Report.pdf.

Appendix A Existing Commercial Alternatives to the CTN: Details

This supplemental section provides further details about the technical capabilities, cost, availability, security, and ease of procurement and use of commercial networking options that could serve as alternatives to the CTN. As in the body of the report, this section describes two tiers of commercial networking options, business-grade service and residential internet service.

A-1 Commercial T1 to the Internet Service (Business-Grade)

The minimal configuration of the CTN includes a circuit with a bandwidth of 1.54 Mbps. This bandwidth is equivalent to the widely available commercial T1 service, also known as a DS-1 circuit. T1 circuits can be used to connect two or more locations, forming a private LAN. T1 circuits can also be used to provide a high availability, high quality connection to the public internet (i.e., a "T1-to-the-internet" or "T-to-I" configuration). We consider such a T-to-I configuration as the prevailing commercial alternative to the CTN minimal configuration for statewide HIE, because HIE requires "many-to-many" connectivity rather than "point-to-point."

A-1.1 Commercial T1 Technical Capabilities

A T1 circuit is a high-speed (1.54 Mbps) copper line that may be used to offer voice (up to 24 separate channels operating at 64 Kbps), broadband data, or a combination of the two (referred to as an "integrated circuit"). Like the planned CTN capabilities, commercial T1 bandwidth is symmetrical.

If bandwidth greater that 1.54 Mbps is required, multiple T1 lines may be bonded together, resulting in a linear increase in the maximum bandwidth of the circuit (i.e., two bonded T1s provide 3 Mbps, three bonded T1s provide 4.5 Mbps, etc). If speeds greater than 4.5 Mbps are required, then other technologies, such as fiber (5+ Mbps) and DS-3 (44.6 Mbps) become economically competitive with bonded T1 lines.

T1 circuit providers can offer QoS between the customer site and the central office (CO), allowing service guarantees such as caps on packet loss, latency and jitter. However, because T-to-I necessarily includes network traffic going out over the public internet, end to end QoS is not possible[*]. In addition to connecting to the internet, it is possible for businesses with T1 service to peer with other private networks, as long as those networks have a presence on the provider edge (i.e., a connection can be established at the CO between a customer's T1 circuit and a private network, such as the CTN). In these cases, QoS between the business and another site on the private network may be possible, assuming that both networks can support the same QoS protocols.

Businesses that purchase business-grade services such as T1 lines are assigned a number of static IP addresses by the service provider. The use of static IP addresses makes it possible for the business to operate servers (i.e., web servers, FTP servers, and software-as-a-service servers) that can be connected to by client applications over the internet.

[*] Once the network packets leave the CO, they are subject to the routing decisions and network traffic of the public internet, which provides no guarantees with respect to latency, jitter, or delivery time.

A-1.2 Availability of Commercial T1 Service

T1 service is available anywhere in California that the phone company serves, including rural areas. Note that the availability of broadband service via T1 lines was not addressed by the CETF survey, so that the map in Figure 2 does not reflect T1 availability. For sites that are located a significant distance from the CO, repeater boxes that amplify the voice/data signal moving over the circuit must be installed to ensure adequate performance of T1 circuits.

A-1.3 The Price of Commercial T1 Service

The price of commercial T1 to the internet service is $486/month in urban areas (see Appendix B). In rural areas the price can range between $486 and $1,200/month. This price includes the physical T1 leased line, a connection to the internet, and a network router managed by the service provider. Setup fees are usually waived for customers that sign a three year contract. The prices obtained for this report were obtained from an authorized reseller of AT&T telecommunications services. Detailed information on how the prices for T1 to the internet service were obtained is provided in Appendix B.

The actual price of T1 service, especially in rural areas, is dependent on whether the site is within the telecommunication company's (e.g., AT&T's) service area and on the distance between the customer site and the provider's CO. If the customer is located in the provider's service area and is also within 50 miles of the nearest CO, then the price is a flat $486/month. If the site is further than 50 miles from the nearest CO, but still inside the telecom company's service area, then there is an additional $210/month cost, bringing the monthly price to $696. For those sites outside of the AT&T service area (i.e., within the Verizon service area) the price can range from $800 - $1,200/month depending on the location of the site.

For sites that require a business-grade circuit with bandwidth greater than 1.5 Mbps, the customer may purchase bonded T1 service. Prices for bonded T1 service scale linearly with the number of purchased T1 lines.

A-1.4 Security of Commercial T1 Service

The security of a T-to-I network connection can be equivalent to that of the proposed CTN. The primary difference between the CTN and commercial T-to-I is that commercial T-to-I cannot rely on the MPLS router technology to automatically establish a private connection among sites (see Section 3.2.1). Because a commercial T-to-I circuit relies on the public internet to connect to other locations, sites that implement commercial T-to-I lines must rely on a combination of firewalls and VPN technologies to establish secure connections. However, the use of these standard technologies makes communication over the public internet as secure (if not as convenient) as that over the CTN.

A-1.5 Ease of Procurement of Commercial T1 Service

When a business purchases a T1 circuit, the service provider installs the necessary hardware (routers) and configures the IP addresses and any firewall security. If a copper (telephone) line already exists between the business and the CO, installation typically takes no more that 10 days. If new lines must be run between the CO and the business or if repeater boxes must be installed to reach remote sites, installation may take significantly longer (e.g., 30 – 45 days).

The term of a standard contract for T1 service is three years. Shorter-term contacts are available. However, service providers waive setup fees for thee-year contacts. For shorter terms, the business will be required to pay setup costs.

A-2 ADSL, Cable, and FttP Services (Residential)

In 2007, The California Broadband Task Force released a report on the availability of residential broadband services across California. This report included information about the statewide availability of asymmetrical DSL (ADSL), cable, and fiber-to-the-premises (FttP) services as well as wireless networks (satellite and terrestrial wireless). Residential internet services such as these are very cost effective for consumers or small businesses that do not need guaranteed high-quality connectivity to the internet, nor wish to connect their LAN across business locations, nor are running server applications that must be broadly available across the public internet. This section describes the features of the available commercial networking options for such residential customers.

A-2.1 Technical Capabilities of Residential Internet Services

Advertised bandwidth of cable and ADSL services ranges from 256 Kbps to 25 Mbps. Newer FttP and cable services offer even higher maximum download speeds, reaching 50 Mbps[*]. However, residential networks were developed with a focus on downstream bandwidth under the assumption that most residential internet users would be consuming content, rather that producing it. As a result, most residential internet service providers offer asymmetrical services, with upload speeds significantly lower than those of the advertised download speeds. Cable and DSL upstream bandwidth ranges from 56 Kbps to 10 Mbps (typically 10% - 20% of the downstream bandwidth for a given service). The exception for residential services is FttP, which offers symmetrical downstream and upstream bandwidth.

Another important point to note about residential services is that the advertised bandwidth rate is not guaranteed. Service plans are advertised as offering bandwidth “up to” a specified rate, but the actual speeds experienced by a user are usually significantly lower. A recent study looking specifically at actual ADSL downstream speeds compared to the advertised speeds showed that, on average, for services advertised as delivering "up to" 8 Mbps download speeds, the average maximum speed was 4.3 Mbps (56% of the advertised speed) and the average speed was 3.6 Mbps (45% of the advertised speed and 81% of the maximum average speed)[†]. The study also showed that customers in urban areas saw downstream speeds 15% higher on average than rural customers. Therefore, QoS and service level agreements (SLAs) are not available for residential internet services.

For ADSL networks, the distance between the customer and the ADSL-provider CO determines the maximum speed of the connection. The greater the distance, the slower the maximum bandwidth will be. DSL providers are not able to offer service to customers greater than 5 miles

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[*] High-speed cable is currently available in certain parts of the state. See http://www.comcast.com/About/PressRelease/PressReleaseDetail.ashx?PRID=841.

[†] UK Office of Communications, UK broadband speeds 2008 – Consumer experience of broadband performance: initial findings (http://www.ofcom.org.uk/research/telecoms/reports/bbspeed_jan09/bbspeed_jan09.pdf), last accessed 6/18/2009

from a CO. For cable and FttP networks, bandwidth rates will be dependent on the amount of local neighborhood traffic because a single line is shared for all internet traffic for a neighborhood.

Finally, residential internet service providers do not offer static IP addresses to their customers. IP addresses are dynamic and can change at anytime without warning by the internet service provider. The lack of static IPs can make it more challenging to connect to computers with applications that are dependent on the consistent assignment of an IP address.

A-2.2 The Price of Residential Internet Services

One of the major benefits of residential services is the price. The competitive nature of the market has pushed the price of these services below $200/month, with most services even more affordable at under $100/month. The price for ADSL and cable internet service ranges from $10 - $100/month. The price for FttP services is between $30 - $50/month for plans that offer downstream bandwidth of 1-10 Mbps. The price for FttP plans that offer bandwidth greater than 10 Mbps can climb as high as $260/month. Set-up fees are commonly waived by residential ISPs but can cost as much as $200/month. The monthly price of service also includes the lease of hardware such as a broadband modem and, in some cases, a consumer-grade network router. However, unlike business-grade services, the hardware provided by residential ISPs is not managed by the ISP and only basic customer service is offered to the user.

A-2.3 Availability of Residential Internet Services

According to the 2007 California Broadband Taskforce report, 96% of residences in California have access to broadband internet that is at least 500 Kbps. This leaves 4% of Californians (1.4 million) without any residential broadband internet access. It can be assumed that a proportionate number of medical practices also lack residential broadband access at any speed.

Cable and DSL providers are available in all metropolitan and some of the larger rural areas of California, though these services are not offered in the most rural parts of the state (see Figure 2). FttP is currently being rolled out in some urban markets of California though availability statewide is extremely limited. Residential fiber networks are currently being built out in Southern California and Sacramento.

A-2.4 Security

In general, the same internet security concerns apply to cable, ADSL, and FttP services that apply to commercial “T1 to the internet” services. A combination of VPN and firewall applications must be used to control internet access and encrypt network traffic, which provides thoroughly secure communication between two points on the internet.

A-2.5 Procurement of Residential Internet Service

The procurement of residential internet service is a very consumer-friendly process. For services like ADSL and cable internet, the physical wiring for these services is usually already in place by virtue of a residence having telephone or cable TV service. For residences in neighborhoods that offer FttP, a new fiber optic line must be run by a service technician from a neighborhood cabinet to the home. After a service is selected, a service technician may need to rewire the internal wiring of the residence or business to get the connection endpoint to the most convenient location for the customer. Next, the hardware (modems and routers) must be provisioned and connected to the provider's network. In most cases, installation rarely requires more than a few hours.

A-3 Wireless Broadband Technologies

Wireless broadband is a sub-type of residential internet service that consists of (1) terrestrial wireless networks (the same technology used for cellular phone networks) or (2) satellite service. Terrestrial services are available anywhere that cell phone coverage exists, and are particularly suited for mobile applications. Bandwidths range from 200 kbps to 1.4 Mbps and the cost is approximately $60/month. Satellite services are provided by small network service providers in rural areas without other broadband options. Bandwidths for these satellite services range from 768 kbps to 3 Mbps and costs fall between $30/month and $130/month.

The California Broadband Taskforce found that wireless broadband access was available to 95% of Californians. Although the bandwidth and costs are comparable to lower-grade cable and DSL services, the reliability of wireless broadband is generally lower. Internet traffic on wireless broadband networks is subject to extreme latency (especially for satellite networks where a one-way latency is never better than 500 ms due to the distance the signal must travel from the ground to low earth orbit and back). In addition, due to the nature of the medium (radio waves traveling through the air, subject to great variability due to weather conditions) there can be significant packet loss on these networks. These limitations make wireless broadband unsuitable for telehealth applications involving real-time video and audio conferencing. However, depending on the bandwidth available to them, rural facilities that otherwise lack broadband could use terrestrial wireless networks for ntHIE applications.

Appendix B

Pricing Methodology for Commercial T1 Lines to the Internet

This appendix describes the methodology employed to determine the price of commercial T1 with public internet service across the state of California. As a starting point for this analysis, we selected a representative subset of the medical organizations that have signed up to be CTN participant sites. We chose these sites because they are broadly distributed across the state in both urban and rural areas and because the RUCA scores of the sites were readily available to us. We selected the sites and determined their pricing for T-to-I services as follows:

1. The list of CTN participant sites was obtained from the CTN RFP materials, available online as a Microsoft Excel spreadsheet (http://www.ucdmc.ucdavis.edu/ctn/CTN-RFP-C.xlsx). This spreadsheet contains information for 732 participant sites, including the site name, address, and RUCA code designation for the census tract in which the site is located.

2. The sites were grouped into four categories based on the U.S. Census Division classification of RUCA codes:

    1. Urban
    2. Large Rural
    3. Small Rural
    4. Isolated

    Additional information about RUCA codes and the category classifications can be found at http://depts.washington.edu/uwruca/index.html.

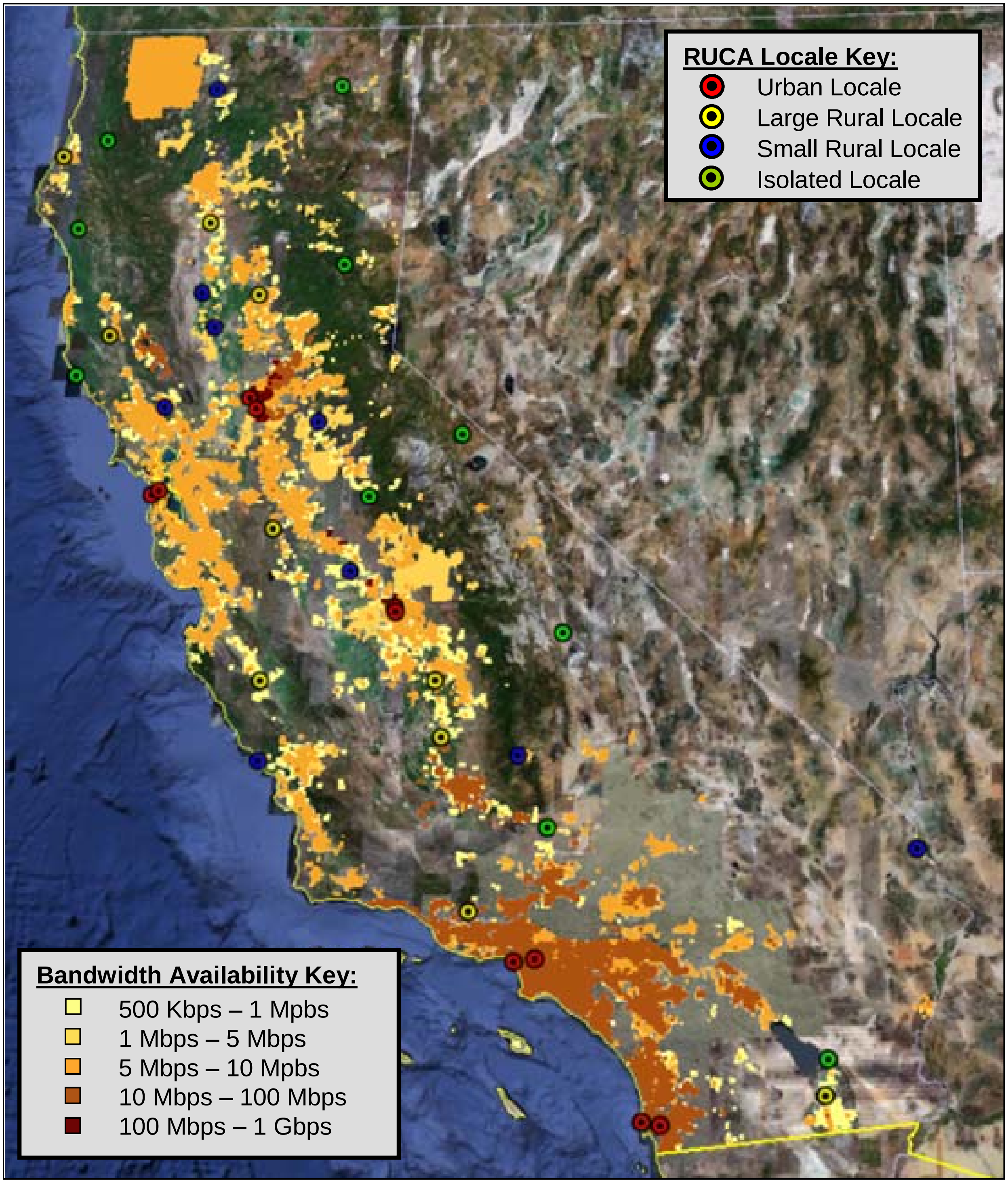
3. The addresses of the sites were geo-coded (converted into latitude and longitude values) using the web application http://www.batchgeocode.com. Data were exported from this web application as a .KML file, an XML-based format that is used by the Google Earth desktop application (http://earth.google.com).

4. Using Google Earth, 10 sites were handpicked from each RUCA category, for a total of 40 sites. Care was taken to ensure that the selected sites were evenly distributed throughout the state of California. The map in Figure 3 shows the locations of the sites by RUCA category, as well as the relationship of the sites to the areas of broadband coverage per the California Broadband Task Force study.

5. The list of 40 sites was submitted to Best Business Telecom (http://www.bestbusinesstelecom.com), an authorized reseller and provider of AT&T networking solutions, including T1 with internet service. The supplied addresses were entered into an AT&T database available to AT&T agents that provides price quotes based on the location of the business and the services requested.

6. The database search resulted in 3 tiers of prices for the submitted sites (see Table 9 below). The prices include the T1 line, a connection to the internet and a router that is managed by the service provider. The price for a given site is dependent on whether or not the site is within the AT&T service area and how close the site is from the nearest AT&T CO. For some sites that were outside the AT&T service area, the AT&T database was able to provide a price quote for setting up a T1 connection with Verizon. Set-up prices would be waived with a 3 year contract.

Figure 3 – Sites used for T1 pricing survey in CA: Location, population density and broadband availability.*



* Broadband availability data was provided by and used with the permission of the California Emerging Technology Fund (CETF), 2007, San Francisco CA. Note that the broadband availability study did not include availability of T1 circuits.

Table 9: Commercial T1 with Internet Pricing Tiers

Price Tier for Commercial T1 Line to Public Internet	Conditions of Price Tier
I: $486/month	The site is within the AT&T service area and within 50 miles of an AT&T central office.
II: $696/month	The site is within the AT&T service area but further than 50 miles from an AT&T central office.
III: $800 - $1,200/month	The site is outside of the AT&T service area (in the Verizon service area). The actual price is dependent on how far the site is from the nearest Verizon central office.

7. The full set of pricing results for all 40 sites is shown below in Table 10. Summary information of the obtained pricing for the selected sites is shown in Table 11. Notably, over half of the sites (23) qualify for the $486/month price for T1 with internet service. Specifically, this price is available to every submitted urban site (10) and also for half of the large (6) and small (5) rural sites, as well as two of the isolated sites. Eleven sites qualified for the $696/month service price. The $800-$1,200/month price was quoted for 6 of the sites (3 small rural sites and 3 isolated sites).

Table 10: Commercial T1 with Internet Pricing for Select Sites

Site Name	Site Address	Site RUCA Code	T1 w/ Internet Price per Month
RUCA Category Classification: Urban Locale			
St. Anthony Free Medical Clinic	150 Golden Gate Ave., San Francisco, CA 94102	1.0	$486
Eisner Pediatric & Family Medical Center	1530 S. Olive St., Los Angeles, CA 90015	1.0	$486
Westside Family Health Center	1711 Ocean Park Boulevard, Santa Monica, CA 90405	1.0	$486
Health and Life Organization, Inc., Sacramento Community Clinic	2200 Del Paso Blvd, Sacramento, CA 95815	1.0	$486
San Francisco Community Clinic Consortium, North East Medical Services Sunset Clinic	2308 Taraval Street, San Francisco, CA 94116	1.0	$486
Family Health Centers of San Diego, Beach Area Family Health Center	3705 Mission Boulevard, San Diego, CA 92109	1.0	$486
Sequoia Community Health Foundation, Sequoia Community Health Centers	3727 North 1st Street, Fresno, CA 93726	1.0	$486
Communicare Health Centers, Salud Clinic	500B Jefferson Blvd, Suite 180, West Sacramento, CA 95605	1.0	$486

Site Name	Site Address	Site RUCA Code	T1 w/ Internet Price per Month
Family Health Centers of San Diego, City Heights Family Health Center	5379 El Cajon Boulevard, San Diego, CA 92115	1.0	$486
Sequoia Community Health Foundation, Sequoia Community Health Centers	6011 North Fresno Street, Fresno, CA 93710	1.0	$486
RUCA Category Classification: Large Rural Locale			
Tulare Community Health Clinic, Pediatric Clinic	1186 E. Leland Ave., Tulare, CA 93274	4.2	$486
Golden Valley Health Centers, Patterson	200 C Street, Patterson, CA 95363	4.2	$486
Clinica de Salud del Valle de Salinas, King City Clinic	223 Bassett Street, King City, CA 93930	4.2	$486
Del Norte Clinics, Inc., Oroville Family Health Center	2800 Lincoln Boulevard, Oroville, CA 95966	4.2	$486
Mendocino Community Health Clinic, Inc., Hillside Health Center	333 Laws Ave., Ukiah, CA 95482	4.0	$486
Clinicas del Camino Real, Incorporated, Clinicas del Camino Real, Fillmore	355 Central Ave., Fillmore, CA 93015	4.2	$486
Delano Regional Medical Center, Delano Women's Medical Clinic	1201 Jefferson Street, Delano, CA 93215	4.2	$696
Greenville Rancheria Tribal Health, Red Bluff Clinic	1425 Montgomery Road, Red Bluff, CA 96080	4.0	$696
Pioneers Memorial Healthcare District, Pioneers Medical Center	205 West Legion Road, Brawley, CA 92227	4.2	$696
Open Door Community Health Centers, Eureka Community Health Center	2412 Buhne Street, Eureka, CA 95501	4.0	$696
RUCA Category Classification: Small Rural Locale			
Glenn Medical Center	1133 W. Sycamore St., Willows, CA 95988	7.0	$486
MACT Health Board, Jackson Health Complex (Medical)	12140 New York Ranch Road, Jackson, CA 95642	7.0	$486
Community Health Centers of the Central Coast, CHC Cambria	2515 Main Street, Cambria, CA 93428	7.0	$486
Del Norte Clinics, Inc., Colusa Family Health Center	555 Fremont Street, Colusa, CA 95932	7.0	$486
Community Health Clinic Ole, St. Helena	661 Main Street, St. Helena, CA 94574	7.3	$486
Mercy (Catholic Healthcare West), Mercy Medical Center Mount Shasta Physical Therapy, Alamo Square	100 Alamo Square, Weed, CA 96094	7.0	$696
Madera County Behavioral Health Services, Chowchilla Counseling Center	1200 Ventura, Chowchilla, CA 93610	7.0	$696

Site Name	Site Address	Site RUCA Code	T1 w/ Internet Price per Month
Colorado River Medical Center	1401 Bailey Ave., Needles, CA 92363	7.0	$800-$1200
Modoc Medical Center, Modoc Medical Center Clinic	228 W. McDowell St., Alturas, CA 96101	7.0	$800-$1200
Clinica Sierra Vista, Kern Valley Medical Center	6310 Lake Isabella Boulevard, Lake Isabella, CA 93240	7.3	$800-$1200
RUCA Category Classification: Isolated Locale			
Redwood Coast Medical Services, Inc., Redwood Coast Medical Services	46900 Ocean Drive, Gualala, CA 95445	10.0	$486
John C. Fremont Healthcare District, Northside Clinic	6386 Greeley Hill Rd, Coulterville, CA 95311	10.4	$486
Tehachapi Family Health Center	2041 Belshaw Street, Mojave, CA 93501	10.4	$696
Canby Family Practice Clinic	670 County Rd 83, Canby, CA 96015	10.3	$696
Eastern Plumas Health Care, Graeagle	7597 Hwy 89, Graeagle, CA 96103	10.0	$696
Humboldt County Department of Health and Human Services, Willow Creek Clinic	77 Walnut Creek, Willow Creek, CA 95573	10.5	$696
Clinicas de Salud del Pueblo, Inc., Niland Clinic	8027 HWY 111, Niland, CA 92257	10.6	$696
Humboldt County Department of Health and Human Services, Garberville Clinic	727 Cedar Street, Garberville, CA 95542	10.0	$800-$1200
Sierra Park Bridgeport Family Medicine	1000 Twin Lakes, Bridgeport, CA 93517	10.6	$800-$1200
Southern Inyo Healthcare District, Southern Inyo Rural Health Clinic	510 East Locust St., Lone Pine, CA 93545	10.5	$800-$1200

Table 11: Summary of Pricing for Commercial T1 with Internet

Pricing Tier	# Urban Sites	# Large Rural Sites	# Small Rural Sites	# Isolated Sites	Total # of Sites
$486/month	10	6	5	2	23
$696/month	0	4	2	5	11
$800/month - $1,200/month	0	0	3	3	6

Appendix C Networking Requirements of Telehealth Applications: Details

Table 12. Detailed Networking Requirements of Telehealth Applications.

Category	Application	Notes	Synch?	Currently used?	Data Types	Acceptable Latency Level	Acceptable Packet Loss	Downtime Sensitivity	Required Security Level	Minimum bandwidth
Conferencing	high definition video-conferencing *(used for remote encounters such as dermatology examinations, psychiatry consultations, ENT examinations, ophthalmology consultations, ultrasound examinations, etc.)*	*May include secondary video feed such as:* ECG monitoring vitals monitoring dermoscopy otoscopy ophthalmoscopy colposcopy endoscopy auscultation ultrasound fluoroscopy image viewing	yes	yes, but not commonly	bi-directional video at a minimum resolution of 720 p and 30 frames per second, using H.323 protocols	Low (<150 ms). Can not tolerate any recognizable delay.	Minimal. Recognizable gaps in video and audio feed are unacceptable.	Medium. Typically, tele-consultations do not involve emergency care, thus some downtime can be tolerated.	High. Patients are easily identified by their voice or visual appearance, so this data stream would be very sensitive.	1 Mbps (symmetrical) for single video channel; 2 Mbps (symmetrical) for two video channels
	standard definition video-conferencing *(used for remote encounters such as dermatology examinations, psychiatry consultations, ENT examinations, ophthalmology consultations, ultrasound examinations, etc.)*	*May include secondary video feed such as:* ECG monitoring vitals monitoring dermoscopy otoscopy ophthalmoscopy colposcopy endoscopy auscultation ultrasound fluoroscopy image viewing	yes	yes, widely	bi-directional video at resolutions below 720 p and 30 frames per second, using H.323 protocols	Low (<150 ms). Can not tolerate any recognizable delay.	Minimal. Recognizable gaps in video and audio feed are unacceptable.	Medium. Typically, tele-consultations do not involve emergency care, thus some downtime can be tolerated.	High. Patients are easily identified by their voice or visual appearance, so this data stream would be very sensitive.	300 Kbps (symmetrical) for single video channel; 600 Kbps (symmetrical) for two video channels
	audio-conferencing *(used for provider to provider consultations)*		yes	yes	bi-directional audio	Low (<150 ms). Can not tolerate any recognizable delay.	Minimal. Recognizable gaps in video and audio feed are unacceptable.	Medium. Typically, tele-consultations do not involve emergency care, thus some downtime can be tolerated.	High. Presumably the audio content will have identifying details about one or more patients.	18 Kbps
Store and Forward	e.g., diabetic retinal examination, diagnostic image review, etc.	*Examples include:* radiological image/study review examination image review pathology image review video review	no	yes	binary image (e.g., tiff, jpg, png files), video (e.g., avi, wmv, mpeg, mov) or audio (e.g.,	High.	High. Lost packets can be resent.	Low.	High. These images presumably have human-readable, identifying labels on them.	0.5 Mbps (full radiological studies would require higher bandwidth, e.g., > 10 Mbps)
Telemetry	continuous telemetry	*Examples include:* continuous vitals continuous EEG continuous ECG continuous fetal heart monitor	yes	yes	binary	High. Reviewing provider does not need to get data exactly when recorded (1-5 second delay acceptable)	Medium. Lost packets can be resent. Applications can utilize buffers to handle packet loss.	High. Important clinical events can be missed if the network is down.	High. Even if the data is anonymous, spoofing and other attacks must be prevented.	0.5 Mbps (possibly less, depending on number of data channels required)
	periodic telemetry	*Examples include:* periodic vitals periodic blood glucose level periodic pulmonary function periodic medication compliance	no	yes	text or binary	High.	Medium. Lost packets can be resent.	Medium. Data may be resent after network is back up.	High. Data that identifies the patient will accompany the clinical data.	56 Kbps per data channel
Clinical messaging	e.g., provider - patient exchange of email, instant messages, text messages, etc.		no	yes	text + attachments of various file types (attachments also usually text or image file)	High.	Medium. Lost packets can be resent.	Medium. Data may be resent after network is back up.	High. Data that identifies the patient will accompany the clinical data.	56 Kbps
Education/Research	e.g., continuing medical education, grand rounds, population health research, etc.	*Examples include:* streamed video web cast streamed audio data sharing	yes or no	yes	highly variable: video (e.g., mpeg, mov, flash), audio (e.g., wav, mp3), image (e.g., tiff, jpg, png)	High.	High. Lost packets can be resent.	Low.	Low if patient data is not involved. However, educational sessions such as grand rounds might involve patient data. In this case the security needs would be high.	Asynchronous activities require 0.5 Mbps, synchronous activities require 1 Mbps

Appendix D Networking Requirements of ntHIE and SaaS EHRs: Details

Table 13. Networking Requirements of non-telehealth HIE (ntHIE) applications.

Operation	Notes	Transaction frequency	Sending application(s)	Prevalence of sending application	Receiving application(s)	Synch?	Currently used?	Data types	Typical file size	Large file size	Acceptable delay in delivery time[1]	Acceptable latency level	Acceptable packet loss	Downtime sensitivity[1]	Required security level	Required Bandwidth
e-Prescribe		High	EHR	High	Pharmacy app, eRx clearinghouse	No	Yes	ASCII text	<100 KB	200 KB	In most cases, up to a few minutes	High	High	High	High	Low
Order/receive real-time laboratory report		High	Laboratory app	Low	EHR, PHR, repository, dz mgmt app	No	Yes	ASCII text (HL7), XML text	100 KB	200 KB	In most cases, up to a few minutes	High	High	Medium	High	Low
Exchange unstructured clinical documents	e.g., radiology reports, transcription reports, progress notes, other unstructured documents, etc.	Medium	EHR, PHR, radiology app, repository, dz mgmt app, nursing home app	Low	EHR, PHR, repository, dz mgmt app	No	Yes	Text (e.g., MS Word documents, text files, etc.)	100 KB	500 KB	In most cases, up to a few minutes	High	High	Medium	High	Low
Exchange structured patient health summary	e.g., CCD, CCR documents for discharge summary, transfer of care, specialty referral, emergency care	Medium	EHR, PHR, repository, nursing home app, dz mgmt app	High	EHR, PHR, repository, nursing home app, dz mgmt app	No	Yes	ASCII text, XML text	100 KB	500 KB	In most cases, up to a few minutes	High	High	Medium	High	Low
Query medication history		Medium	Pharmacy/PBM app, prescription clearinghouse, repository	High	EHR, PHR, repository, nursing home app, dz mgmt app	Yes	Yes	ASCII text	100 KB	250 KB	In most cases, up to a minute	High	High	High	High	Low
Exchange clinical messages	secure email (provider to provider) that includes patient data	Medium	EHR, PHR	Medium	EHR, PHR	No	Yes	Text + any file type attachment	100 KB (without attachments)	25 MB (if includes large attachment)	In most cases, up to a few minutes	High	High	Medium	High	Low
Transmit a radiological image	e.g., chest x-ray (images do not have a diagnostic quality resolution)	Low	Radiology app	Low	EHR, PHR, repository, dz mgmt app	No	Yes	Binary image (e.g., jpg, tiff, png)	2 MB	5 MB	In most cases, up to a few minutes	High	High	Low	High	Low
Transmit a complete radiological study	e.g., CT or MRI study	Low	Radiology app, EHR, PHR, repository	Low	EHR, PHR, repository	No	No	Binary image (e.g., DICOM)	1 GB	2 GB	In most cases, up to an hour	High	High	Low	High	High
Transmit dictation audio file		Low	EHR	Low	Transcription service app	No	Yes	Binary audio (e.g., wav)	500 KB	1 MB	Up to a few hours	High	High	Low	High	Low
Transmit aggregated population data	batch files of data for more than one patient	Low	EHR, PHR, repository, dz mgmt app	Low	Quality reporting app, public health app, repository, dz mgmt app	No	Yes	Text	Variable		Up to a few hours	High	High	Low	High	Low
Query patient identity service	i.e., resolve patient's demographic data to a globally unique ID	Low	EHR, PHR, repository	Low	EHR, PHR, repository	Yes	Yes	Text	<100 KB		In most cases, up to a minute	High	High	High	High	Low
Exchange other multi-media documentation	e.g., share a video related to an encounter or other health care function	Low	EHR, PHR, repository, nursing home app	Low	EHR, PHR, repository, nursing home app, dz mgmt app	No	No	Binary video	> 1 MB	> 100 MB	Up to an hour	High	High	Low	High	Medium

1. Assumes that applications can queue requested transmissions, allowing users to continue with other functions before a transmission has completed.

Table 14. Networking Requirements of Software as a Service (SaaS) EHRs.

Operation[2]	Notes	Transaction frequency[3]	Sending application(s)	Prevalence of sending application	Receiving application(s)	Synch?	Currently used?	Data types	Typical data per transaction size	Large data per transaction size	Acceptable delay in delivery time[4]	Acceptable latency level	Acceptable packet loss[5]	Downtime sensitivity[6]	Required security level	Required Bandwidth
Search for patient record		High	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
View clinical summary page		High	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Retrieve clinical details	detail on a prescription, diagnosis, allergy, etc.	High	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Download file	images, documents, videos, etc.	Medium	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Any file type	100 KB - 2 MB	5 MB	In most cases, up to a few minutes	High	High	High	High	Medium
Graph data trend		Medium	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Document patient care	e.g., progress notes, history and physical notes, etc.	High	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Write order	e.g., eRx, lab and radiology orders, etc.	Medium	ASP EHR browser	Medium	ASP EHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Run decision support	e.g., run a drug-drug interaction check, clinical reminders	Low	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Register patient		Medium	ASP EHR browser	Medium	ASP EHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Exchange clinical message		Medium	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	100 KB (with No attachments)		< 1 second	High	High	High	High	Low
Manage work-flow	i.e., task lists, route tasks, etc.	High	ASP EHR browser	Medium	ASP EHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Upload file	e.g., scanned form, image, voice recordings, etc.	Low	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Any file type	100 KB - 2 MB	5 MB	In most cases, up to a few minutes	High	High	High	High	Medium
Record real-time dictation		Low	ASP EHR browser	Medium	ASP EHR server	Yes	No	Binary audio	500 KB	1 MB	< 1 second	High	Moderate	High	High	High
Schedule appointment		Medium	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Perform billing-related function	e.g., eligibility look-up	Medium	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Write letter	e.g., patient letter, referral letter, etc.	Low	ASP EHR browser	Medium	ASP EHR server	Yes	Yes	Text	10 - 100 KB		< 1 second	High	High	High	High	Low
Run report on patient population		Low	ASP EHR browser	Medium	ASP EHR server	Yes	Yes	Text	Variable		In most cases, up to a few minutes	High	High	High	High	Medium
Record real-time biometric data	e.g., ECG, O2 saturation, etc.	Low	ASP EHR browser, PHR browser	Medium	ASP EHR server, PHR server	Yes	Yes	Text or binary	N/A		< 1 second	High	Moderate	High	High	Low

2. This table is not applicable to SaaS EHR solutions based on remote desktops (like Citrix).

3. For applications based on applet technologies, such as Flash, Java applets, and ActiveX controls, the initial transaction of loading the applet is excluded.

4. This delay only relates to transit time of the data over the wire. It does not include server processing time.

5. On most networks, a "high" level of packet loss rarely exceeds 5%. At 5% packet loss, the user would not be able to detect any delay in delivery time.

6. This column assumes that the SaaS EHR is completely dependent on a connection to the server. It ignores emerging technologies like Adobe Air and Google Gears which permit client-side processing when a network connection is not available.

Appendix E Sources of Information

Table 15: Expert Interviews

Name	Affiliation	Subject
Anderson, Frank	Open Door Community Health Centers	Telehealth
Brennan, Jerry	Philips VISICU	Telemetry
Burrage, Bruce	Tandberg, Inc.	Video-Conferencing
Chong, Rachelle	Commissioner, California PUC	Policy
Coye, Molly	CalRHIO	Policy
Dolgonas, Jim	CENIC	Networking
Evans, Bob	Fiber internet Center; Best Business Telecom	Networking
Folger, Jeff	LifeSize, Inc.	Video-Conferencing
Frohlich, Jonah	California Health and Human Services Agency	Policy
Gatchalian, Romeo	PolyCom, Inc.	Video-Conferencing
Hackett, Daniel	gisFX	GIS
Harry, David	CTN Director of Operations	Telehealth / Networking
Katz-Bell, Jana	UC Davis School of Medicine	Video-Conferencing
Kizaraly, Salim	InterComponentWare	HIE
Kurywchak, Daniel	Telemedicine.com, Inc	Urban Telehealth
Monk, Consuella	NextGen	SaaS EHR
Mouser, Kristy	DrFirst	E-prescribing
Nemana, Ravi	CTN Advisory Committee	Networking
Nesbitt, Tom	UC Davis Health System	Telehealth
Nitta, Wes	Department of Technology Services	CalNET 2 Pricing
Quaceknbush, David	Central Valley Health Network	Telehealth
Schoenbach, Neal	Global Media	Video-Conferencing, Other Telehealth
Stever, Anthony	Central Valley Health Network	Telehealth
Takai, Teri	California State CIO	Policy
Thomas, Susan	Northern Sierra Rural Health Network	Telehealth

Table 16: Documents and Web Sites

Author	Title	Link
Roudsari, Abdul. Hicks, Roger. Boulos, Maged Kamel.	Applications: Telemedicine and Telehealth in Some Specialties	http://tinyurl.com/noshdy
Telemedicine Information Exchange	Telemedicine and Telehealth in California	http://tinyurl.com/loehyt
Hersh, William et al.	Diagnosis, access and outcomes: update of a systematic review of telemedicine services.	http://tinyurl.com/mbhshb
CableLabs	DOCSIS – Project Primer	http://tinyurl.com/ks3khz
Federal Communications Commission	Cable Modem Technologies	http://tinyurl.com/ncx2gl
California Broadband Task Force	The State of Connectivity, Building Innovation Through Broadband	http://tinyurl.com/38nrnv
Mitchell, Bradley	Cable Speed – How Fast Is Cable Modem internet?	http://tinyurl.com/9vw565
California Broadband Task Force	Advertised Broadband Price and Speed Survey	http://tinyurl.com/n9owms
DSLReports.com	Latency versus Bandwidth	http://tinyurl.com/n62nnt
Cable Modem Technologies	Latency Issues	http://tinyurl.com/2j7p
Mitchell, Bradley	DSL vs. Cable Modem Comparison – Security	http://tinyurl.com/ea3df
DSLReports.com	Broadband User Map	http://tinyurl.com/zdsp6
Federal Communications Commission	Digital Subscriber Line (DSL) Services	http://tinyurl.com/lzdgu8
DSLReports.com	Why is distance important with DSL?	http://tinyurl.com/l3jpmg
Federal Communications Commission	Wireless Broadband Technologies	http://tinyurl.com/lpqty4
Mitchell, Bradley	What is Fixed Wireless Broadband internet Access?	http://tinyurl.com/n76lc5
Mitchell, Bradley	EV-DO	http://tinyurl.com/mj6lw6
Mitchell, Bradley	How Fast is a Cell Phone Modem	http://tinyurl.com/kjlrh2
Claypool, Mark et al.	Characterization by Measurement of a CDMA 1x EVDO Network	http://tinyurl.com/mgga55
Mullins, Michael	Understand how the EV-DO standard boosts wireless security	http://tinyurl.com/4d85oe
Broadbandinfo.com	Where are T1 and T3 internet Connections and Who Uses Them	http://tinyurl.com/mzjply
Enterprise VoIP	Bonding T1 Lines to Create Bigger Data Pipes	http://tinyurl.com/mm2lw7
EzineArticles	Just What is a Bonded T1 and What Does it Give You	http://tinyurl.com/lfgv3k
BuyerZone	Understanding T1 Connections	http://tinyurl.com/mb4jb7
California Telehealth Network	Request For Proposal	http://tinyurl.com/m5flte
California Telehealth Network	California Telehealth Network Proposal	http://tinyurl.com/ngq77r
UK Office of Communications	UK broadband speeds 2008 Consumer experience of broadband performance: initial findings	http://tinyurl.com/nkhb6t
Knol.google.com	Streaming video over wireless networks: Why wireless networks and video don't mix	http://tinyurl.com/lx4hs4
VoIPTroubleshooter.com	Indepth: Jitter	http://tinyurl.com/mcbvl9

Appendix F Glossary

Term	Definition
ADSL	ADSL (asynchronous digital subscriber line) uses the telephone line infrastructure to deliver broadband Internet access to users. Upstream and downstream bandwidth is asymmetrical, with upstream bandwidth typical 10-25% of the downstream bandwidth.
AJAX	AJAX is a technique used to create interactive web pages. AJAX permits the web browser to exchange data with the remote web server without forcing a page change or refresh. The data sent back to the browser only modifies a portion of the current web page. This technique increases the response time of web pages since only small portions of the page need to be updated.
Bandwidth	Bandwidth is the throughput rate of data over a network connection. It is usually measured in kilobits per second (Kbps) or megabits per second (Mbps).
Bonded T1	Bonded T1 lines combine individual T1 lines into a single data pipe. Each additional T1 that is bonded increases bandwidth linearly.
Cable (broadband Internet access)	Cable Internet uses the cable TV infrastructure to deliver broadband Internet access to users over coaxial cable lines.
Cache	A cache is a copy of data from a remote server that is stored on the local client. Software applications often use the cache to improve application performance and/or to offer backup copies of data.
Central Office (CO)	A central office (CO) is an office in a locality to which subscriber home and business lines (i.e., phone, T1, etc) are connected on what is called a local loop. The central office has switching equipment that can switch voice and network data within the telecom company's backbone network or interconnect lines to peer networks.
DS-3	A dedicated circuit delivered by a service provider via traditional local copper networks (sometimes fiber). A DS-3 has the same capacity of 28 T1s. A DS-3 can deliver 45 Mbps of bi-directional data. A DS-3 can be channelized to deliver voice as well as data.
Fiber-to-the-Premises (FttP)	Fiber-to-the-Premises is a method of delivering broadband Internet access over a fiber-optic cable connecting the user to the network provider’s central office. This method provides higher speeds compared to older technologies that rely on copper wire connections to the user.
Fixed wireless (broadband Internet access)	Fixed wireless broadband uses radio antennae to wirelessly deliver broadband Internet access to a user who is in a fixed location.
High-definition video conferencing	Video conferencing at a resolution of 720 p or greater. Comparable to high definition television resolution.
Jitter	Jitter is the variability of network latency over time. This variability can be caused by network traffic, router queuing and path changes.
Local area network (LAN)	A local area network (LAN) is a group of computers and associated devices that share a common communications line or wireless link, usually within a small geographic area (i.e. a building).
Latency	Latency is the time delay between one computer sending a message and the destination computer receiving the message. It is normally expressed in milliseconds (thousandths of a second). Latency over a computer network is due both to physical characteristics (e.g., the material used to transfer data), logistical characteristics (i.e., how many routers lie between two points on the network), and hardware characteristics (i.e., what types of routers are used).
Mobile wireless (broadband Internet access)	Mobile wireless broadband uses radio antennae to wirelessly deliver broadband Internet access to a user who is mobile (i.e., using a mobile device such as a smart phone).
Packet	A packet is a unit of data specially formatted to be transmitted over a packet-switched network. When a message is sent from one computer to another over a packet-switched network, the message is broken into multiple packets, which travel independently across the network.

Packet loss	Packet loss occurs when a packet sent over a network by one computer never arrives at its destination. A packets can be lost if its address is damaged in route. In other cases, a network router may deliberately "drop" (i.e., delete) a packet because network traffic is too high.
Quality of service (QoS)	Quality of service is a networking technique by which data on the network can be ranked in priority. Higher priority data are allocated greater bandwidth and shorter paths, which improves the speed and quality of these high priority data flows.
Satellite (broadband Internet access)	Satellite broadband, as its name implies, uses satellites to deliver broadband Internet access to users. This technology is particularly useful in remote areas that do not have access to terrestrial Internet connections.
Software-as-a-service (SaaS)	Software-as-a-service (SaaS) refers to a technique for delivering software applications over the Internet. SaaS applications are hosted on remote servers. Users access the application via a web browser. SaaS is an alternative to installing an application on a local area network (i.e., behind an organization's firewall).
Standard definition video conferencing	Video-conferencing at a resolution of less than 720 p (p = progressive scan). Comparable to standard definition television resolution.
T1	T1 is a copper telephone wire that has a symmetrical downstream and upstream bandwidth of 1.54 Mbps. T1 lines consist of 24 channels, each offering 64 Kbps of bandwidth. The channels can be used for voice, data, or both.