2. Introduction

Broadband is a term used to identify high-speed data transfer and access on the Internet. Broadband allows Internet users to access a variety of information using a range of technologies. Broadband is essential for such activities as online video, streaming media, voice over Internet phone service, interactive websites and secure business applications. Broadband differs from dial-up Internet access in speed, capacity and the ability to provide uninterrupted service when in use. It supports a wide variety of online applications in business, education, healthcare, public safety, government and entertainment which has access to high-quality broadband services important as part of daily life.

Broadband is a vital element of economic sustainability that has only begun to take shape in the early 21st century. Where our road systems provide the infrastructure necessary to connect our communities physically, broadband provides the digital infrastructure necessary to connect our communities virtually to the rest of the electronic world. As more of our everyday lives are lived online, broadband has becomes increasingly important, for our homes, businesses, and communities. Broadband reaches many facets of everyday life by improving the delivery of healthcare services, enriching the educational experiences of children and adults, aiding in the management and conservation of energy resources, assisting public safety personnel in the performance of their duties, and facilitating citizen interaction with government agencies. For businesses, broadband has become a driving force behind competitiveness, innovation, and efficiency. Affordable, available access to broadband means the difference between thriving in the new economy[2] and becoming obsolete.

Business, education, healthcare, agriculture, public safety, and government are reliant on broadband services as more of their functions are enhanced through the Internet

Broadband is a transformational infrastructure that transcends physical limitations of more traditional infrastructure, such as road systems and electric grids. Rather than connecting one community to another, it connects a community to the entire electronic world and global marketplace. This is a key reason why broadband is so important to the future of communities. Communities that have access to high-speed broadband will continue to take advantage of all of the opportunities the global

[2] A coined term describing new, high-growth industries that are on the cutting edge of technology and are the driving force of economic growth. The new economy is commonly believed to have started in the late 1990s, as high tech tools, such as the internet, and increasingly powerful computers, began penetrating the consumer and business marketplace.

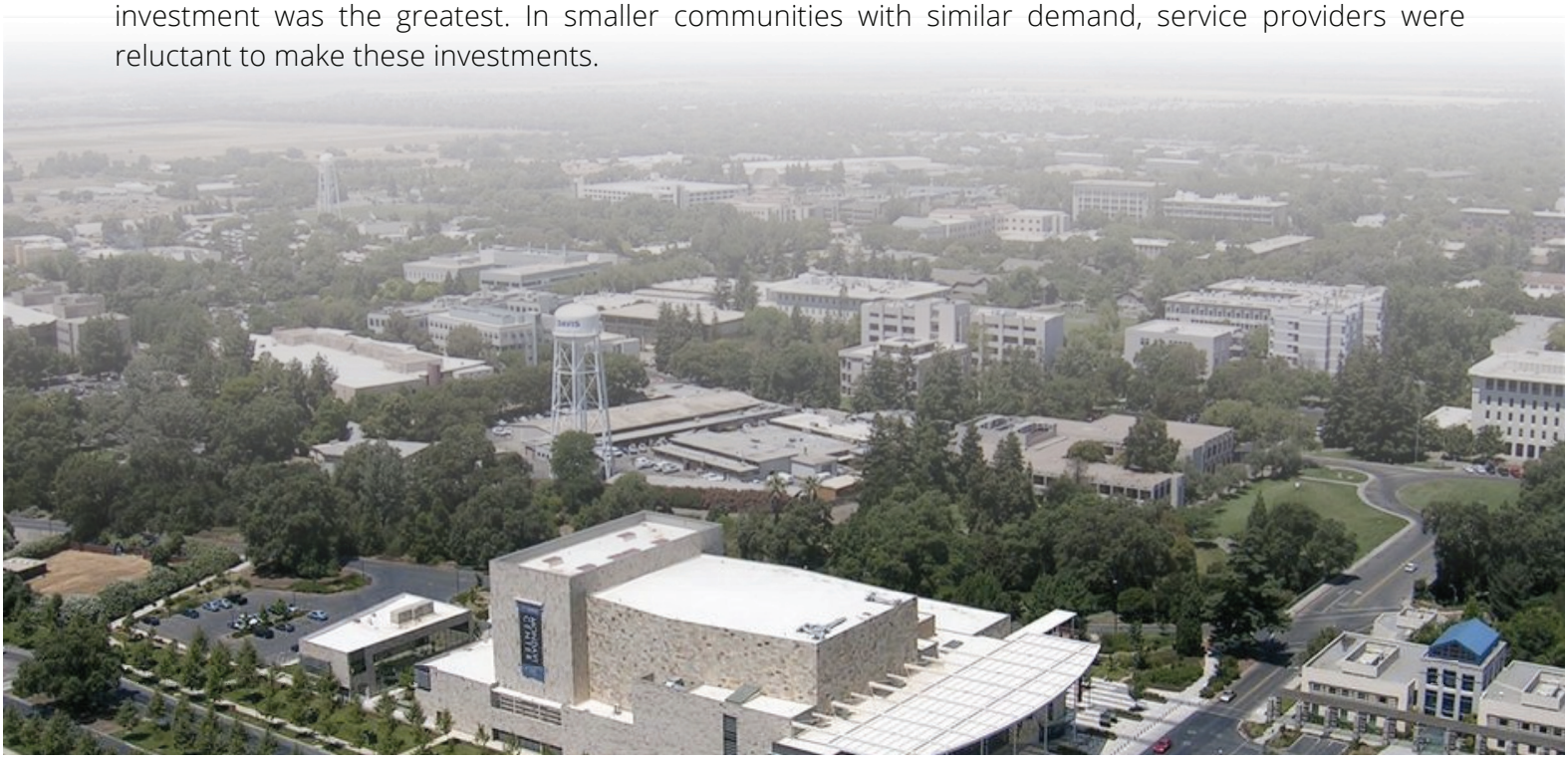
marketplace affords them in business, education, healthcare, entertainment, and general well-being. Communities that lack access to this infrastructure or do not have ubiquitous access to it will be less equipped to thrive in the digital economy.

A. Broadband is a Local Issue for Yolo

For Yolo's communities, affordable access to broadband services is a critical aspect to support long-term needs of its residents, businesses, and anchor institutions. Yolo's diverse mix of demographics among rural and urban centers results in an uneven distribution of broadband services and as a result, some users receive satisfactory broadband services while others don't have access to or cannot afford the services they need. Urban areas, such as Davis and West Sacramento receive higher speeds and reliability generally, whereas rural areas such as Esparto and Knight's Landing have no broadband services available to them.

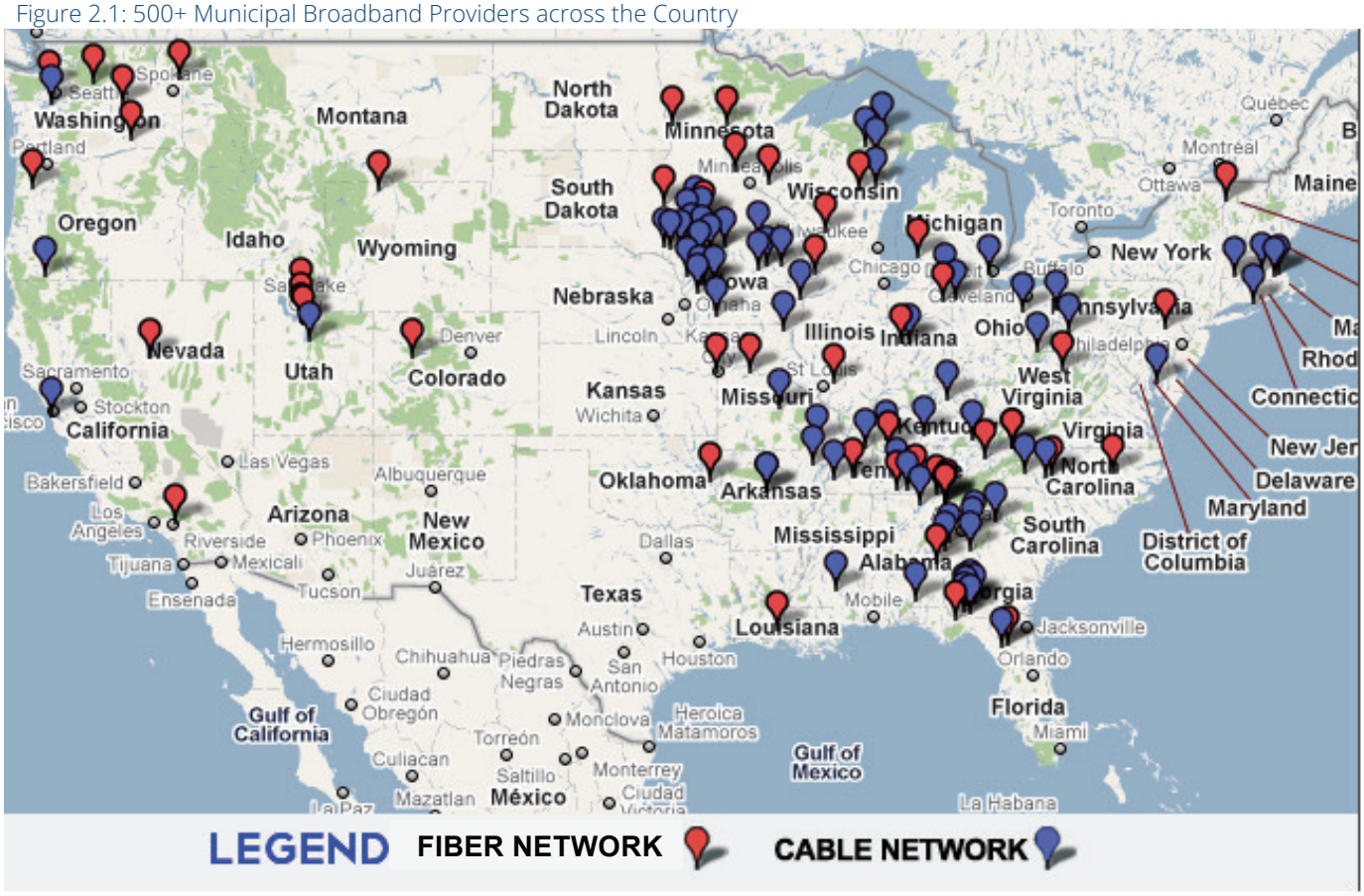
As broadband demand and Internet penetration grows among these communities, it is important for Yolo to take an active role in ensuring end users are receiving the services they need. In cases where they are not, Yolo County and the cities have the opportunity to take action by utilizing reasonable measures to improve services across their communities. Using a combination of broadband-friendly public policy initiatives that accelerate the deployment of broadband and strategic investments in broadband infrastructure, Yolo County and the cities have opportunities to help ensure their communities have the services they need to succeed in the digital economy.

Traditionally, broadband providers have been solely responsible for the development of broadband services in communities. In the mid-1990s, local governments began to take notice of a developing trend within their communities; demand for broadband services was growing. Businesses needed more bandwidth. Schools, hospitals, and government organizations were shifting more of their operations online. Residents were accessing more applications. As this pace accelerated, broadband supply was not keeping up with broadband demand. To meet the demand, service providers began upgrading their networks in the largest cities where density was the highest and where return on investment was the greatest. In smaller communities with similar demand, service providers were reluctant to make these investments.



This trend has become more pronounced as communities' demand for bandwidth has increased exponentially. Over the past 15 years, many local governments have taken an active role in ensuring their communities are equipped with the broadband services they need. It has become a local issue for many communities as broadband has become a public necessity. It has also become a local issue because the infrastructure that powers broadband services is local itself; installed in underground conduits or on poles within the community. Communities that believe it is a public necessity have taken an active role in ensuring their citizens and businesses have access to affordable broadband services. They have done so by using broadband-enhancing public policy and strategic investments in broadband infrastructure to complement the networks of private broadband providers. In most cases they have developed public-private partnerships with these providers to utilize their public broadband infrastructure. These networks have significantly improved broadband access and affordability in their local communities. In addition, these networks have become platforms of innovation to fulfill and enhance other community needs.

Figure 2.1: 500+ Municipal Broadband Providers across the Country



For Yolo County and its cities, strategic initiatives such as broadband-enhancing public policy and strategic investments in broadband infrastructure, will directly impact the accessibility and affordability of broadband services in local communities. However, this infrastructure is capable of much more than just providing broadband services. It can provide a publicly owned communications infrastructure that can be used for additional public benefits, including enhanced municipal utilities, new e-government applications, technology collaboration, and infrastructure sharing programs. In addition, a community-

owned broadband infrastructure for Yolo will provide a platform for long-term innovation of Smart Community technologies and applications, ranging from smart homes to energy conservation and management to green building programs. While the initial goal of this infrastructure is to enhance local broadband services, it will become a long-term asset to support Smart Community programs that increase efficiency, lower cost, reduce environmental impact, and enhance quality of life.

Reasons Why Local Governments Are Investing in Broadband Infrastructure

Broadband Services

- Common backbone for all anchors
  - County & City
  - Schools
  - Libraries
  - Hospitals
  - Clinics
  - Public Safety
  - Community Support
- Interconnection with service providers
- WiFi in public centers

IT Collaboration

- E-Government applications
- Bulk Internet purchasing
- Application sharing
- Disaster recovery
- EOC communications

Public Safety Applications

- Video monitoring
- First responder support
- Collaboration with State & Federal agencies
- FirstNET preparedness

Future Energy & Utility Management

- Smart Grid & Demand Response
- Automated Meter Reading
- Advanced Metering Infrastructure
- SCADA communications and control

B. The Yolo Broadband Strategic Plan

Yolo communities want to ensure that affordable broadband is available to its citizens, businesses, and anchor organizations across urban and rural populations. These services support Yolo's educational institutions to expand online programs and blended learning while ensuring school districts meet their electronic testing requirements with the State of California. They support Yolo's hospitals and clinics by enabling electronic health records and telehealth applications. They support Yolo's public safety organizations ensuring vital communications are available for fire, police, and emergency responders. They support the local government applications and how these organizations interface with citizens. They are also essential to enhance Yolo's economic development strategies, support local businesses, and attract new industries. They also support technology transfer[3] programs from the University of California Davis that result in new startups within the community.

Broadband is a fundamental requirement for Yolo County's citizens, businesses, and anchors to ensure they have access to all of the opportunities the Internet has to offer.

Public organizations in Yolo have the opportunity to positively influence the deployment of broadband services for the benefit of the community. Yolo County and the cities of Davis, West Sacramento, Winters, and Woodland can positively impact the accessibility and affordability of broadband services by utilizing a combination of public policy tools, education and adoption programs, and public investment in broadband infrastructure. The Yolo County Broadband Strategic Plan provides the strategies that Yolo County and the cities can utilize to improve access and affordability of broadband across their communities. It provides a roadmap for broadband development based on an understanding of each community's needs and how the Yolo's local government organizations can utilize public policy and new investment to ensure their needs are met. The Plan sets forth achievable short, mid, and long-term initiatives for Yolo County and the cities to achieve in order to meet the broadband requirements of their communities. The Plan includes the recommendations, action plans, and timelines for Yolo County and the cities to utilize to implement broadband-friendly public policy, develop strategic partnerships and fund key investments in broadband infrastructure.

[3] Technology Transfer, also called Transfer of Technology (TOT), is the process of transferring skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments or universities and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services.

Yolo's Communities Must Have Affordable Access to High-Speed, Reliable Broadband Services to Compete, Innovate, and Thrive in the 21st Century Economy.

C. Project Background & Methodology

i. Overview

In September of 2013, the Local Agency Formation Commission of Yolo County issued a Request for Proposals seeking a qualified consultant to develop a Yolo Broadband Strategic Plan. The goals of the RFP were focused on how Yolo's public organizations could participate in the development of broadband within the County through the utilization of public policy tools, grant opportunities, public-private partnerships and potential public investment in broadband infrastructure. A Broadband Working Group composed of representatives from the LAFCo, Yolo County, and member cities was assembled to conduct the evaluation and selection of the consultant. Magellan Advisors was selected through a competitive procurement to assist the Broadband Working Group and LAFCo develop the Yolo Broadband Strategic Plan. Magellan specializes in developing broadband strategies that local governments can use to foster the development of affordable, high-speed broadband services, in conjunction with local service providers, community anchors, businesses, and residents.

Magellan and the Working Group began the project in October of 2013 and through a 9-month planning process developed the Yolo Broadband Strategic Plan. The project began with a thorough needs assessment for Yolo. Magellan conducted significant outreach with Yolo's stakeholders across business, agriculture, education, healthcare, local government, public safety, and community support organizations. This process also included city and county economic and community development initiatives to ensure that the Strategic Plan accounted for each community's long-range planning needs. The needs assessment conducted a series of interviews and group meetings that helped gain an understanding of how these organizations utilized broadband, sufficiency of their current services, issues, and future needs. This information was analyzed by Magellan and the Broadband Working Group to determine common themes around how broadband was currently used by Yolo's organizations and some of the key issues they faced in receiving adequate services.

In addition to the stakeholder outreach, an online survey was conducted of residential and business broadband subscribers in Yolo. The surveys provided insight on residential and business broadband penetration in Yolo, including:

- Types of services and providers
- Pricing for services
- Issues with services
- How services were utilized

The survey was posted in late 2013 and was presented to residents and businesses through the outreach efforts, which included distribution through city and county agencies, libraries and community groups. Over the 9-month period, 919 unique residents and 131 unique businesses responded to the survey. A listing of the relevant survey questions and response summaries are provided in Appendices B and C. Raw response data is provided in an attached Excel file that accompanies this report, named Yolo Survey Response Data.xlsx.

Magellan also conducted a countywide market analysis that evaluated the current broadband environment in Yolo and documented the services, pricing, providers, and availability of broadband services. Recent FCC, CPUC and information collected from the business and residential surveys was utilized to build broadband availability and penetration maps across Yolo. These maps provided indications of current broadband penetration, speeds and coverage gaps. CPUC broadband data and corresponding broadband maps were also reviewed for their accuracy in reporting broadband availability in Yolo. CPUC broadband availability data was cross-referenced against local data collected through survey information and through FCC Form 477 data to identify any discrepancies that misrepresented broadband speeds and availability. This analysis was not able to precisely identify discrepancies between CPUC data and the project data in every case; however, it did provide indications of errors in CPUC data in certain cases. In these cases, Yolo can work further with the CPUC to refine the CPUC's maps to more accurately represent broadband speed and availability in Yolo. The accuracy of these maps is important to support State and federal public policy initiatives such as broadband grants for Yolo's communities.

Information in the needs assessment, surveys and market analysis was utilized to identify key issues facing Yolo, focused on availability and access to broadband services in its communities. An analysis was conducted comparing the current availability and pricing for services against the needs of the community stakeholders. This analysis evaluated the gaps in availability and affordability of broadband services within each community. Based on the gaps that were identified, strategies for each city and Yolo County were developed that would aid in bridging these gaps over short, mid and long-term periods. These community strategies focused on initiatives that Yolo County and cities could undertake to positively influence the affordability, availability, and expansion of broadband services in Yolo. Finally, a list of action items was developed for Yolo County and each of the cities to begin implementing in their communities to achieve these goals.

ii. Broadband Working Group

The Broadband Working Group was established to engage in the development of the Broadband Strategic Plan in conjunction with Magellan Advisors as the prime consultant on the project to Yolo LAFCo. The Broadband Working Group is composed of representatives from Yolo County and the Cities. Over the 9-month span of the project, the Broadband Working Group has worked with LAFCo and Magellan Advisors to engage stakeholders in the strategic planning process, coordinate local resources, provide input on organizational needsfor broadband and provide guidence on the development of the Plan. Members of the Broadband Working Group include:

Name	Position	Organization
Rob White	Chief Innovation Officer	City of Davis
Sarah Worley	Deputy Innovation Officer	City of Davis
Diane Richards	Economic Development Director	City of West Sacramento
John Donlevy	City Manager	City of Winters
Lynn Johnson	Senior Management Analyst	City of Woodland
Wendy Ross	Economic Development Manager	City of Woodland
Ken Hiatt	Community Development Director	City of Woodland
Kevin Yarris	Director, Dept of General Services	Yolo County
Patty Wong	County Librarian	Yolo County
Christine Crawford	Executive Officer, LAFCo	Yolo LAFCo
Tracey Dickinson	Associate Management Analyst	Yolo LAFCo

iii. Detailed Stakeholder & Community Outreach

In the needs assessment process, LAFCo, the Broadband Working Group and Magellan Advisors conducted significant stakeholder and community outreach across the County to understand current and future broadband needs. The information collected included the current inventory of current broadband infrasructure assets from organizations including Yolo County, the Cities of Davis, West Sacramento, Winters and Woodland, UC Davis, the Yolo Flood Control District and Yolo Transportation District. This information was utilized to build a comprehensive broadband map of public infrastructure in Yolo. In addition, each organization included in the outreach process provided anecdotal information about their current broadband penetration, future needs and the technologies that are driving those needs. Magellan utilized this information to compile both the Countywide needs assessment and the individual Community Profiles within this Plan.

Summarizing the findings of the outreach resulted in several common themes that were consistent across the entire County. In each case, users cited a growing requirement for reliable, high-speed broadband services to support the business requirements of their organizations. Businesses, schools, hospitals and government organizations all noted the same trend that more of their operations were being transitioned online, requiring robust broadband Internet connections to support these applications.

Overall, local government connectivity needs are rather similar in that more bandwidth is required between sites, connectivity for cameras and wireless is required throughout areas of each city and more collaboration across city boundaries is deemed beneficial to the region. The County and Cities have worked to establish a collaborative approach to building infrastructure through an interlocal MOU, but have acknowledged that this process needs improvement to be effective at a Countywide level.

Small and medium businesses Countywide reported general dissatisfaction with their current broadband Internet services, citing issues with speed, reliability, and consistency. The majority of the businesses interviewed utilized cable or DSL services with a few of the larger businesses connected via fiber-optic. A few businesses also utilized wireless connectivity for their Internet services.

Economic development agencies all viewed reliable, affordable broadband as a key issue facing Yolo's ability to attract and retain businesses. Agencies realized that Yolo competes with Sacramento County for businesses, and that Yolo is currently not as well supplied with broadband as Sacramento County, which has a negative impact on business recruitment.

A more detailed account of the key needs of each sector, across Yolo County and each city can be found in the individual Community Profiles within this Plan.

Stakeholder Meetings – January 28 – 31, 2014

- California Telehealth Network
- City of Woodland IT Department
- Yolo County IT Department
- UC Davis IT Department
- Woodland Small & Medium Businesses
- West Sacramento Chamber of Commerce
- City of Davis IT Department
- Winters Broadband
- Winters Healthcare Foundation
- "West of 505" Community Meeting
- CPUC & CA Department of Technology
- Yolo County Office of Education
- Yocha Dehe Wintun Nation
- West Sacramento City and IT Departments
- Davis Small & Medium Businesses
- California Emerging Technology Fund
- Om Networks
- CommuniCare
- Yolo County Housing

Magellan Advisors' first site visit in Yolo County took place between January 28 - 31, 2014. The Yolo LAFCo team scheduled meetings with a diverse group of stakeholders throughout the region from government, healthcare, education, and business sectors. In nearly each instance, the need for high-speed connectivity was deemed necessary within the region and each city.

The Magellan team met with each city in Yolo and Yolo County IT Departments to discuss the government organizations' needs around connectivity. Several organizations currently operate fiber optic networks throughout their territory in addition to services provided by local service providers. The County owns and operates a fairly extensive network throughout the City of Woodland and greater

Yolo County. The County has taken advantage of opportunities to jointly build their fiber network on the backs of other service provider and capital improvement initiatives. The County has also led an effort to develop an MOU for joint trenching throughout the region, however it doesn't appear as though all parties have embraced this concept. Each of the Cities currently depend on service providers to provide a major portion of their local connectivity requirements. Each constructs conduit and fiber infrastructure as opportunities present themselves, however, it doesn't appear to be a coordinated effort, even within each local organization. The City of Davis currently operates a dark fiber I-NET (Institutional Network) provided by Comcast through the City's cable franchise agreement. The franchise agreement ends in the coming years, and it has been noted that there is a good chance that Comcast will not honor the I-NET going forward. Overall, the Cities connectivity needs are rather similar in that more bandwidth is required between sites, connectivity for cameras and wireless are required throughout areas of each city and more collaboration across city boundaries is deemed beneficial to the region.

During our meeting with the California Telehealth Network (CTN) it was discovered that CTN started in 2007 through the business incubator at UC Davis. CTN is charged with increasing access to healthcare through the innovative use of technology, including telehealth, telemedicine and health information exchange. Their mission is to promote advanced information technologies and services to improve access to high quality healthcare focusing on medically underserved and rural Californians. CTN secured a $22 million grant from the Rural Health Pilot Program and is currently serving 265 healthcare facilities throughout California with an additional 30 sites pending connection.

UC Davis has significant high-speed connectivity requirements to support its research initiatives. It has built fiber infrastructure throughout sections of the City of Davis where high-speed connectivity is required and utilizes commercial carriers in other instances. The University also maintains high-speed connectivity to the CENIC network (4 – 10Gb connections), National Lambda Rail, Internet 2, and Digital California. UC Davis has a requirement for 6 facilities within the city to be connected to fiber and would welcome faster service to commercial apartments and house rentals throughout the area, as this impacts the student's and faculty's ability to interact with the University off campus.

During business group meetings in Woodland and Davis, our team had the ability to hear first hand from business and local users. In numerous instances we heard that businesses have issues getting access to the services they need and that speed and reliability are both major concerns that impact businesses throughout the region. While DSL and Cable services are widely available in the cities, fiber access is more difficult to come by and when available is very expensive. Economic Development is stating that "one of the first things companies are asking for is telecommunications availability," the problem is that this data is not readily available. During our meeting with the "West of the 505" group, the Mayor of Winters communicated her concerns for the rural areas. She is very concerned that children in the area are required to sit at the library till all hours to access Internet service. Many of the rural areas are either underserved or the families simply lack the ability to pay for Internet based services.

While visiting the City of Winters, our team had the opportunity to meet with the Winters' Healthcare Foundation, a local clinic. The clinic just switched to Wave Broadband when it was made available and are currently reviewing options to connect to the California Telehealth Network. The medical records system is in the cloud, therefor high-speed, reliable connectivity is key to the operation. Winters' Healthcare Foundation is unable to service the community when its connections are down as all applications and records depend on connectivity, nothing is stored locally.

The Yolo County Office of Education provides fiscal oversight for the County while each City has its own District. During this meeting the Office of Education, Davis School District, Woodland School District, West Sacramento School District and the Washington School District were present. The Winters School District was unavailable. Every district manages E-Rate independently. The Districts procure and maintain their own connectivity between facilities and each District has a connection back to the Office of Education to access shared services. The Districts bandwidth requirements are expected to grow as state mandated online testing comes online and to support BYOD and 1 to 1 initiatives. The Office of Education and the Districts are concerned about the low-income neighborhoods and children on the free and reduced lunch program. A few districts provide wireless air-card services to children, and other partner with providers such as Comcast for lifeline Internet programs.

The Yolo County Housing Authority operates water, sewer, and electric utilities in many areas of the region, primarily supporting the thousands of housing units under their control. The Housing Authority has developed a strategy to implement community Wi-Fi hotspots at various locations under their management and has had discussion to expand this service. The Authority has done quite a bit of research into various technologies that could be used to expand its services and has spoken with numerous providers. California AB 1299 allows the California Advanced Services Fund to spend money on broadband in public-housing projects. The Housing Authority is considering making application for funds to expand its service capability.

Stakeholder Meetings – March 19 – 21, 2014

- Clark Pacific
- Yolo County Flood Control and Water Conservation District
- Nugget Markets
- Woodland Community College
- City of Winters/PG&E
- Pacific Coast Producers
- Yolo Transportation District
- Woodland Memorial Hospital
- UC Davis Real Estate
- Marrone Bio Innovations
- FMC/Shilling Robotics
- DMG Mori
- Old Sugar Mill
- City/County Managers
- Los Rios Community College
- Nippon Shokken
- West Sacramento Economic Commission
- J Burton & Associates

The second site visit to Yolo was from March 19 – 21, 2014. The plan for this visit was to continue to meet with project stakeholders as well as key businesses throughout the region and more specifically in the cities of Woodland, Davis, Winters and West Sacramento. These meetings provided additional data in support of the need for highly available fiber based broadband services in these areas.

The meeting with the Yolo County Flood Control and Water Conservation District provided great insight into the SCADA (Supervisory Control and Data Acquisition) systems utilized throughout the district for monitoring, and control of the various water resources and structures managed by the agency. Staff also detailed the extensive wireless network utilized to provide access to dozens of sites throughout and outside of Yolo County. While the wireless network cannot be utilized as an asset in the Yolo Broadband planning process, there is potential for collaboration on tower sites, which are required to provide basic wireless connectivity for the districts systems. District staff may provide a "towers" layer in GIS outlining the current tower infrastructure, pending management approval.

Meetings with Woodland Community College and Los Rios Community College proved to be interesting in that the need for broadband access between these two organizations were at polar opposites. Woodland Community College uses CENIC (Corporation for Education Network Initiatives in California) and has access to the bandwidth and services needed to support current operations. Los Rios Community College in West Sacramento also uses CENIC where possible; however, connectivity between the remote campuses is provided over AT&T Optiman fiber service. Los Rios reported that data needs for the college continues to increase exponentially and current bandwidth levels are insufficient and are currently constrained due to cost of services. Los Rios would welcome new cost effective methods for providing connectivity to its various sites.

During Magellan's visit with the Yolo Transportation District, staff provided us with the "vision" for technology infrastructure as it relates to the transportation services provided throughout Yolo County. There are several plans for digital signage at bus stops, wireless networks on the buses as well as advanced communications between the vehicles and headquarters. Currently, the district relies heavily on 3G/4G mobile devices which currently only provide enough bandwidth to provide AVL (Automatic Vehicle Location) services. Higher speed wireless and connectivity at bus stop locations would be valuable to the district in support of these organizational goals.

UC Davis Real Estate handles all architectural, construction/project management and real estate development services for UC Davis. During our discussions with staff, and review of infrastructure maps, we learned the extent of the University's fiber network. The entire campus, as well as a few off campus locations, is served by the University's network. This could potentially be a valuable asset for the Yolo Broadband project as the fiber passes through several business/industry parks located around the UC Davis campus. Additionally, the University maintains facilities in downtown Davis, which are not currently served by fiber. There could be opportunities for fiber sharing/swapping agreements in the future.

The additional meetings included a number of businesses in the region, mainly large/medium size organizations. These meetings reinforced a number of the issues we've heard regarding the local

broadband offerings, primarily around the concepts of a lack of local access and non-existent service. Some businesses have the services they require because they were lucky to have fiber infrastructure nearby, some stated service was in the area but costs to connect were too great, while others learned to "work with what they have" because services are not available in their area. A few businesses we met within Davis stated they currently have fiber-based access primarily because they were fortunate to be able to afford the $30,000+ capital construction fees to connect. These construction fees are normally collected upfront to offset the costs the provider must bear in order to connect the customer. These can typically be paid upfront or in some cases, rolled into the monthly recurring charge (MRC). During another meeting, a company representative explained to us how his company recently invested $30 million to build a manufacturing plant located in Southport Industrial Park in West Sacramento. During the completion of the site, a T-1 (1.554 Mbps) circuit was installed at the site, and later upgraded to bonded (2) T-1 circuits capable of delivering 3 Mbps of bandwidth to the site. The business has stated it would take a fiber-based service as soon as one is made available, as the current connection is in adequate to support the North American operation.

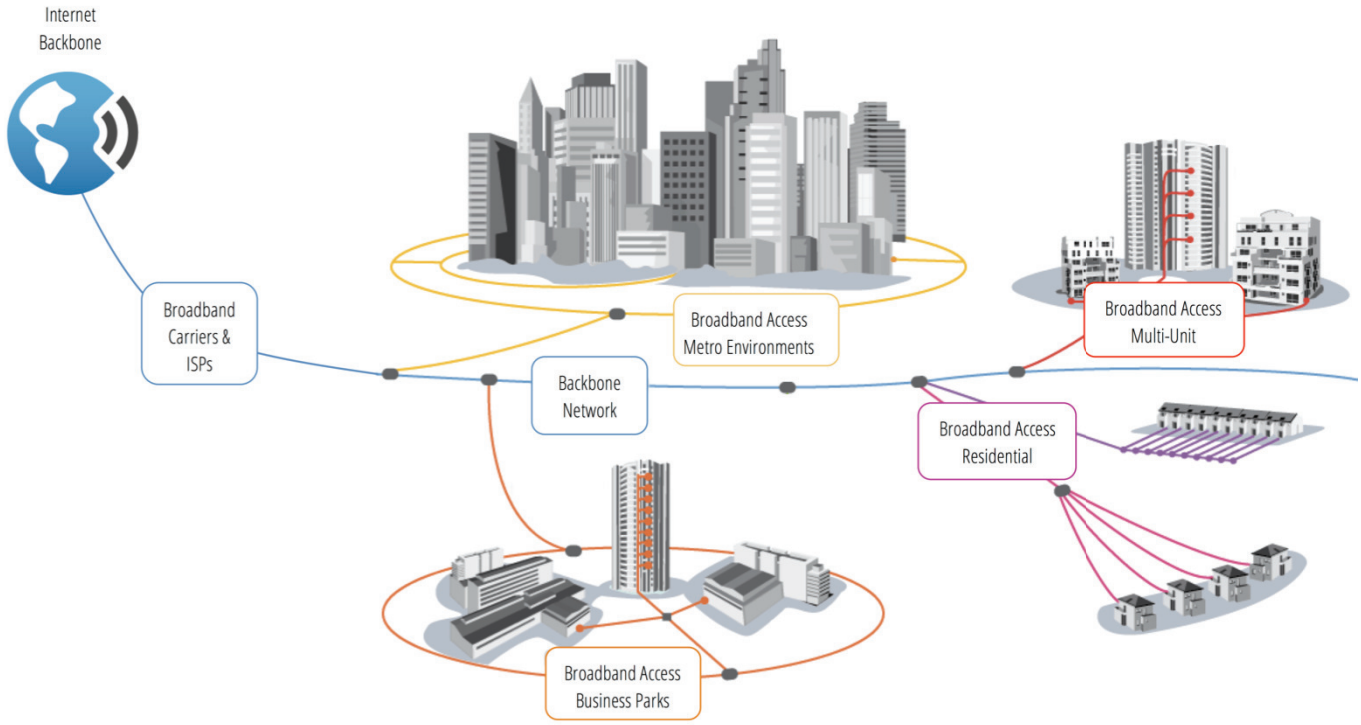
This last instance is really the worst-case scenario for broadband access in an industrial park, which is highly marketed, and core to the City of West Sacramento's Economic Development strategy. This is a prime example of a situation where any high-tech company moving to the area would most likely pass on choosing a site in this industrial park because of a lack of broadband access.

D. Overview of Broadband Technologies

Broadband is deployed throughout communities as wired and wireless infrastructure that carries digital signal between end users and the content they want to access. The content comes in many forms and from many locations across the world in the networks that connect the local community to the Internet backbone. Websites, television, streaming video, videoconferencing, cloud services, and even telephone service are just a few types of content that are delivered across local broadband networks. Access to this content is made available through the type of infrastructure and kinds of connections available in the local network. Robust local infrastructure results in faster, more reliable access to content. Conversely, local infrastructure that is aging and built on older technologies results in slower, less reliable access to content.

Broadband bandwidth, or speed, is commonly measured in megabits per second. "Meg" or "Mbps" are generally used to describe the rate of data transfer through a broadband connection. Broadband connections have a download rate, the rate that data is transferred to the subscriber from the broadband network, and upload rate, the rate that data is transferred from the subscriber to the broadband network. The greater the bandwidth, the faster a subscriber is able to access information over the network, such as Internet web pages. Greater bandwidth also allows subscribers to utilize real-time applications, such as Internet video services such as Netflix and Hulu. Without sufficient bandwidth, these applications do not function because the subscriber is not able to access this content at a fast enough rate through the broadband connection, which results in these applications not functioning correctly and the subscriber experiencing "freezing" or "buffering" conditions when trying to view online content such as web pages, images, and videos.

Figure 2.2: How Broadband Connects Our Communities



The majority of America still utilizes copper-based broadband infrastructure to transmit information from a user to the Internet; this media includes twisted-pair copper telephone and coaxial cable lines. Most of this infrastructure was installed years ago but in many areas of the country, it is still being installed in new communities today. As time has progressed, broadband providers have continued to upgrade equipment in their networks to make these lines faster and more reliable, however; several fundamental issues exist with underlying copper infrastructure:

- Broadband signals degrade significantly as distances increase in copper-based networks.
- Broadband signals are susceptible to electrical interference and signal degradation in copper-based networks, particularly as they depreciate.
- Copper-based networks delivering broadband services generally utilize shared bandwidth among pools of users that results in an uneven distribution of speed to these users.

The limitations of local copper-based networks are overcome by deployment of new technologies such as fiber-optic infrastructure. The old standard of copper in local broadband networks is transitioning to fiber-optic, however; the pace of this transition is slow. Costs for deployment of fiber-optic infrastructure are extremely high, particularly in areas where no fiber-optic infrastructure exists. Providers understand that fiber-optic broadband provides the only long-term solution to the ever-growing bandwidth needs of homes, businesses, and community anchors. Fiber-optic broadband connectivity is considerably different than its copper-based predecessor, in the following ways:

- Fiber optic technology converts broadband data signals to light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber transmits data at speeds far exceeding current DSL or cable modem speeds, typically by tens or even hundreds of Meg.
- Actual speeds are always dependent on the services provisioned by the service provider who operates the system, however; speeds generally range from 10Mbps to 100Gbps
- Telecommunications providers sometimes offer fiber broadband in limited areas and have announced plans to expand their fiber networks and offer bundled voice, Internet access, and video services.
- Variations of the technology run the fiber all the way to the customer's home or business, to the curb outside, or to a location somewhere between the provider's facilities and the customer

Figure 2.3 compares traditional broadband technologies such as DSL, cable, and wireless to fiber-based next-generation broadband. Whereas traditional broadband technologies have an upper limit of 150Mbps, next-generation broadband surpasses these limitations and can provide 1Gbps and greater.[4]

Figure 2.3: The Evolution of Broadband Speeds Across Technologies

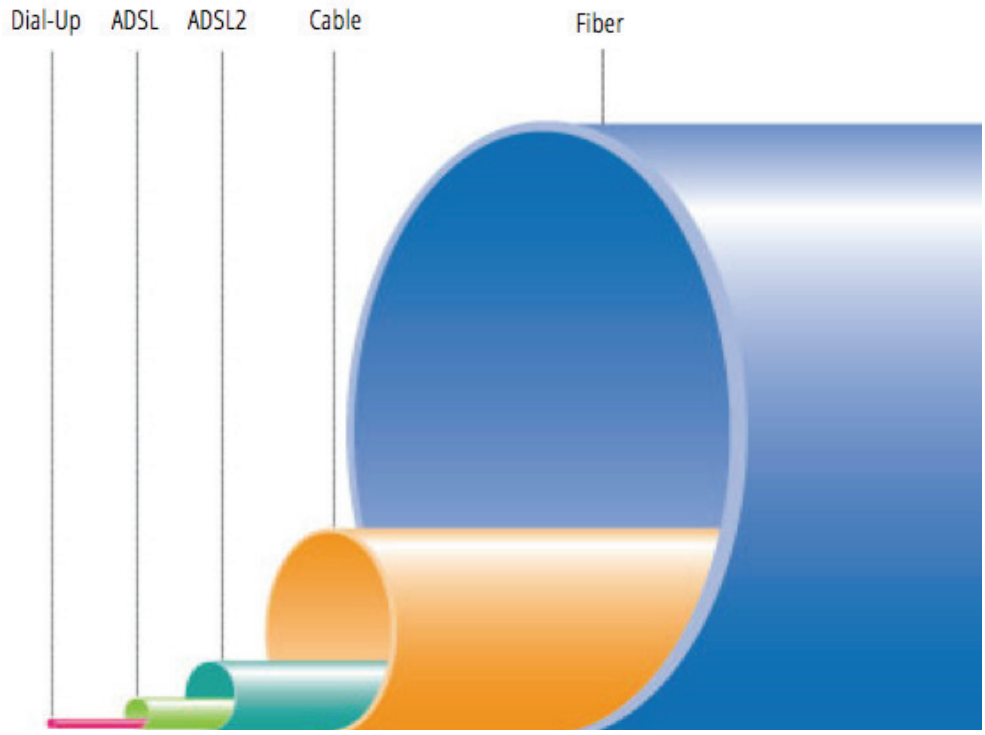
Dial-Up – 56Kbps
- Legacy technology
- Shared Technology

ADSL – 10Meg
- First Generation of DSL
- Shared Technology

ADSL2 – 24Meg
- Second Generation DSL
- Shared Technology

Cable – 150Meg
- DOCSIS 3.0
- Shared Technology

Fiber – 1Gbps
- PON, Active Ethernet
- Shared and
- Dedicated Technology

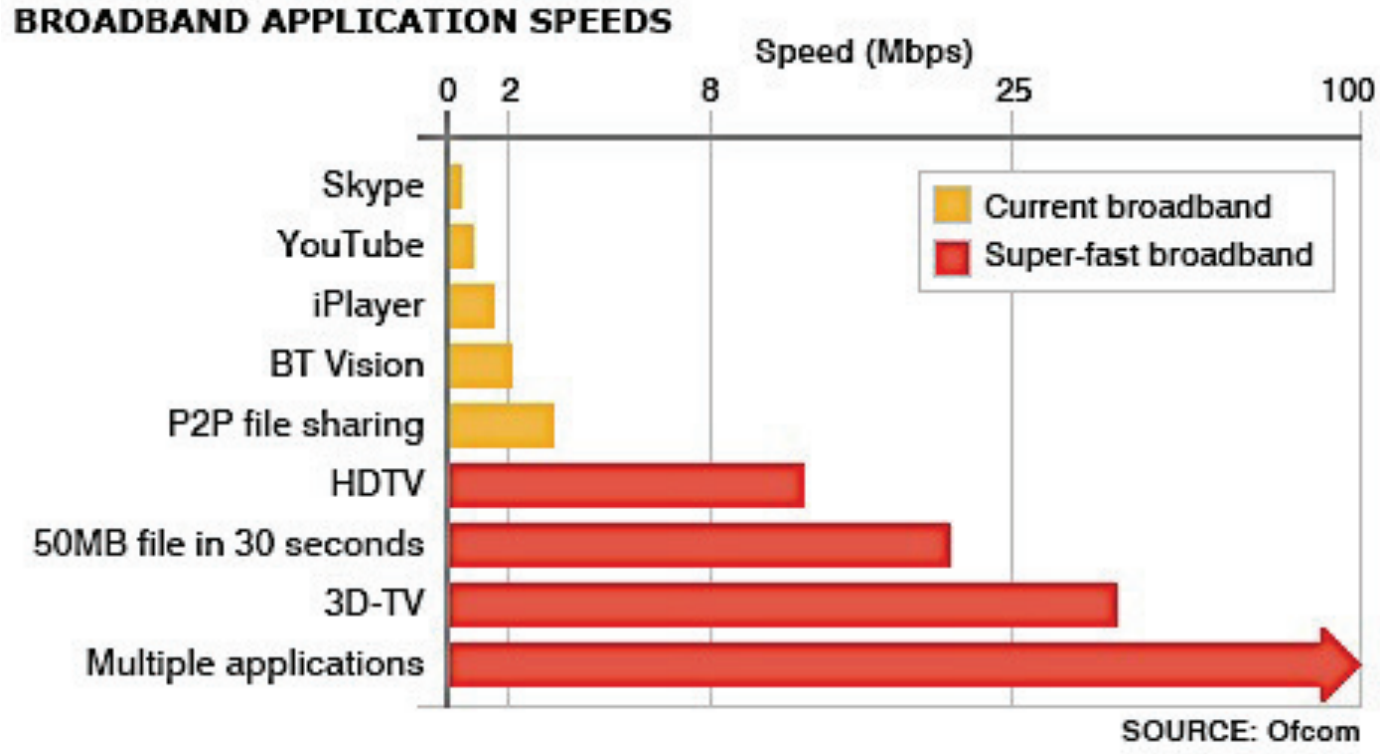


[4] Actual speed and quality of service will depend on the specific service contracted by the end user, whether using a traditional broadband service or a next-generation broadband service.

E. What is Driving Broadband Demand?

Broadband technologies have evolved to carry more and more data because of the advancements in online applications. Every application requires a certain amount of bandwidth on a broadband connection to function properly. As time has progressed, we have witnessed significantly more applications and significantly more bandwidth used by those applications. Figure 2.4 illustrates the bandwidth requirements of common applications and the impact of multiple applications running across a broadband connection.

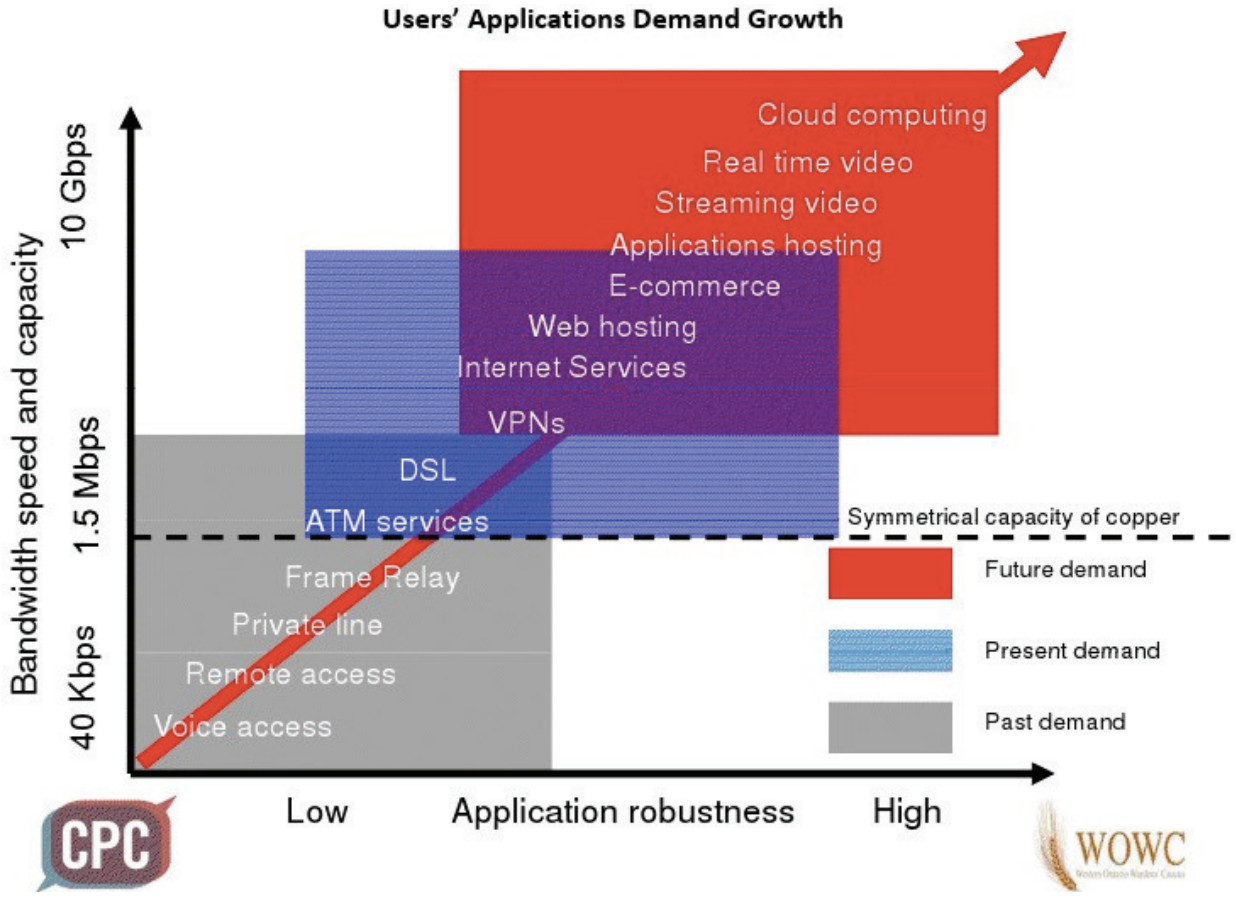
Figure 2.4: Broadband Application Speeds and The Impact of Multiple Applications



Today, broadband subscribers across every user class are utilizing more and more online applications and particularly those that consume larger amounts of high-quality bandwidth. Figures 2.4 and 2.5 illustrate user demands for applications today and the increases in broadband that are necessary to accommodate this demand. Currently, broadband subscribers make heavy use of the core Internet functions, consisting of Internet browsing, web hosting, e-commerce, virtual private network connectivity and voice services. However, subscribers are beginning to consume more real time video and streaming applications, which require significant bandwidth, reliability and performance out of their broadband connections. We are still early in the lifecycle of Internet video applications and these are expected to grow significantly over the next 10 years, replacing much of the text-based Internet.

In addition, the myriad of cloud services is driving the need for more symmetrical[5] broadband as real time and cloud applications require additional bandwidth, both in download speed and upload speed. As more of these applications are deployed and replace traditional PC-based software, broadband connections will need to accommodate the increased bandwidth load. Many times these applications synchronize in real time, meaning that they are always consuming bandwidth at a constant rate rather than only when the user is actively engaging the application.

Figure 2.5: User Demands for Applications Over Broadband Connections



Broadband and Education

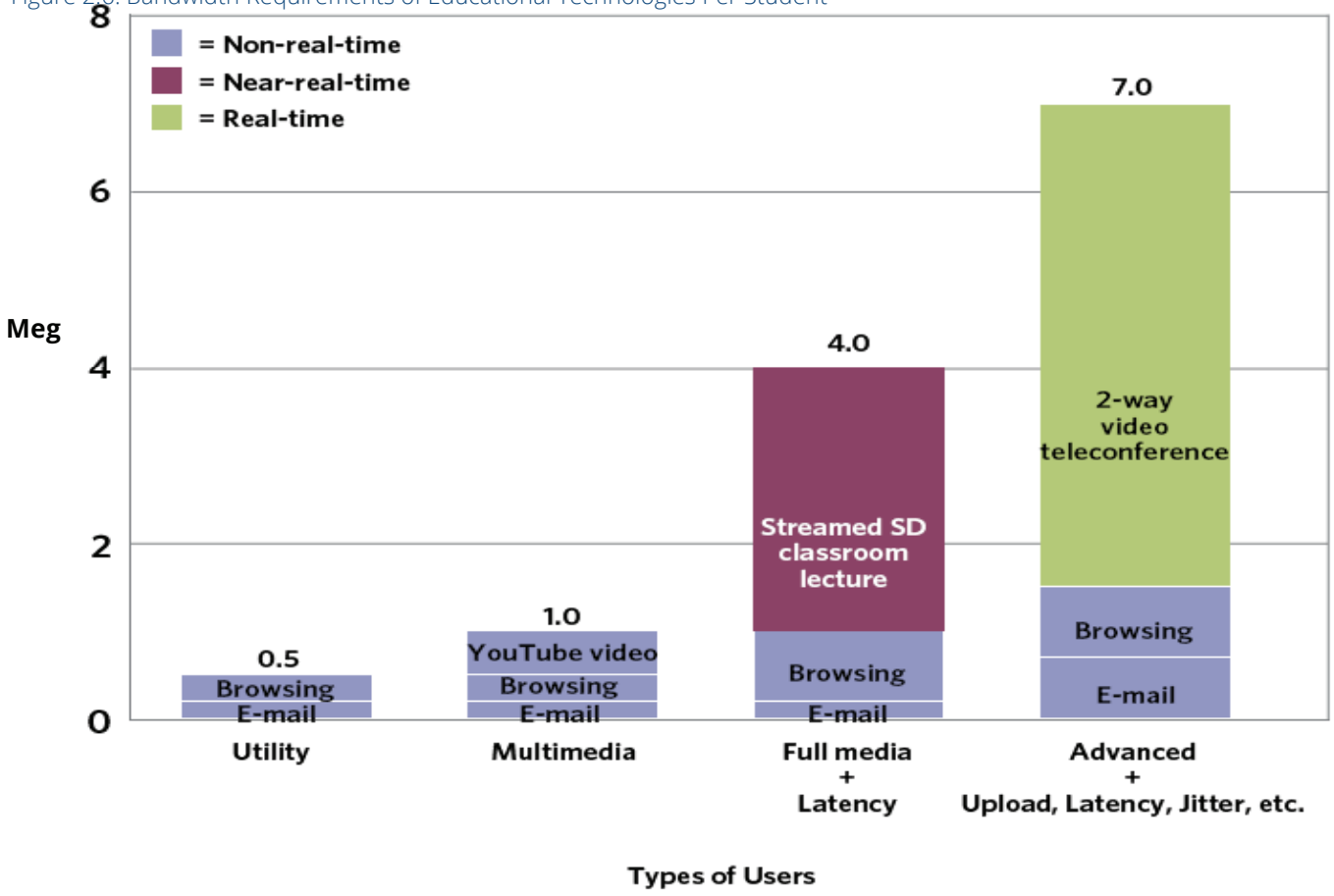
Some of the largest users of broadband services in our communities come from educational organizations and their needs continue to grow, including K-12 schools, community colleges and higher education. Online applications used by these organizations require not only high-bandwidth broadband, but also services that meet strict quality and performance requirements to support real-time video and voice applications such as distance learning and teleconferencing. In addition,

[5] Symmetrical broadband connections provide equal download and upload speeds, such as 10 Meg down, 10 Meg up, instead of traditional asymmetrical broadband services that provide unequal speeds, such as 10 Meg down and 2 Meg up.

educational institutions are utilizing more online content to support their curricula, from sources such as YouTube, Vimeo and Facebook.

Figure 2.6 illustrates the bandwidth requirements per student for common educational applications and the quality and performance requirements of these applications. Basic educational tools, such as web browsing and YouTube, consume up to about 1 Meg per student. However, moving up to more advanced educational technologies such as streamed classroom lectures and 2-way video teleconferences, use significantly more bandwidth per student, 4 Meg and 7 Meg, when combined with the basic educational tools. In addition, these advanced tools require not only more bandwidth but also strict broadband quality metrics that allow them to function properly, such as low latency and higher upload speeds.

Figure 2.6: Bandwidth Requirements of Educational Technologies Per Student[6]

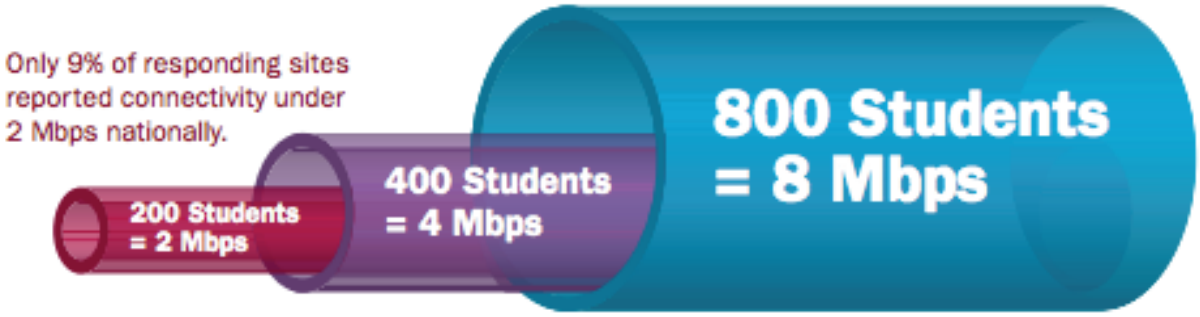


Many States have instituted requirements for online testing or are in the process of doing so. California's Common Core State Standards take effect in 2014, and districts will be moving into this program this 2014-2015 school year. These tests require approximately 20Kbps per student, and school districts will be required to dimension their broadband services to accommodate online testing.

[6] National Broadband Plan. "Current State of the Ecosystem" http://www.broadband.gov/plan/3-current-state-of-the-ecosystem/. Accessed June 2014.

For example, a school with 800 students may require up to 8 Meg of bandwidth to ensure its online testing is completed successfully. This 8 Meg is in addition to the school's existing broadband consumption, which for some schools may be a challenge, particularly because online testing may be competing for bandwidth with other online educational content that the school is using.

Figure 2.7: Bandwidth Requirements for Online Assessments[7]



Educational institutions continue to integrate online applications into their curricula, particularly emphasizing more video, including distance learning and online collaboration.

Broadband and Healthcare

Healthcare technology is rapidly evolving and in order to support these major advances in medical science, broadband infrastructure needs to be in place to allow effective management of medical data and facilitate communication between doctors and patients. Doctors are now using very advanced diagnostic imaging systems that require large amounts of storage and bandwidth to work efficiently. Patients rely on the Internet for the ability to interconnect with their healthcare providers virtually instead of making in-person visits; what traditionally required an office visit in the past can now be done virtually in many cases.

Additionally, by virtue of having high-speed, reliable broadband, healthcare organizations such as hospitals, doctor's offices, urgent care centers, and emergency first responders can all be connected to the same system, enabling virtual collaboration (in real time), remote patient diagnoses and monitoring, and other telemedicine applications. With the advancement of electronic health records, broadband infrastructure will become one of the most critical infrastructure needs for healthcare professionals and organizations. Currently, to support the use of electronic health records, the FCC recommends the following minimum bandwidth speeds:

[7] Smarter Balanced Assessment Consortium. "The Smarter Balanced Technology Framework and Testing Device Requirement", http://www.smarterbalanced.org/wordpress/wpcontent/uploads/2011/12/Tech_Framework_Device_Requirements_11-1-13.pdf, Accessed July 2014.

Single Physician Practice – 4 megabits per second (Mbps)

- Supports practice management functions, email, and web browsing
- Allows simultaneous use of electronic health record (EHR) and high-quality video consultations
- Enables non real-time image downloads
- Enables remote monitoring

Small Physician Practice (2-4 physicians) – 10 Mbps

- Supports practice management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables non real-time image downloads
- Enables remote monitoring
- Makes possible use of HD video consultations

Nursing home – 10 Mbps

- Supports facility management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables non real-time image downloads
- Enables remote monitoring
- Makes possible use of HD video consultations

Rural Health Clinic (approximately 5 physicians) – 10 Mbps

- Supports clinic management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables non real-time image downloads
- Enables remote monitoring
- Makes possible use of HD video consultations

Clinic/Large Physician Practice (5-25 physicians) – 25 Mbps

- Supports clinic management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables real-time image transfer
- Enables remote monitoring
- Makes possible use of HD video consultations

Hospital – 100 Mbps

- Supports hospital management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables real-time image transfer
- Enables continuous remote monitoring
- Makes possible use of HD video consultations

Academic/Large Medical Center – 1,000 Mbps

- Supports hospital management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables real-time image transfer
- Enables continuous remote monitoring
- Makes possible use of HD video consultations

Broadband and Public Safety

We live in a changing world where public safety agencies must address new threats and challenges both natural and man-made. It's no longer enough for first responders to rely on a push-to-talk (PTT) network for situational awareness. Police, fire, and emergency medical services (EMS) play the central roles in emergency response. Mobile technology capable of sending and receiving bandwidth-intensive information can help first responders do their jobs much more effectively and safely. These emergency response organizations need broadband networks that let them share streaming real-time video, detailed maps and blueprints, high resolution photographs, and other files that today's public safety and commercial wireless networks cannot handle, especially during major events or catastrophes.

Broadband technology and infrastructure is critical to the success of our first responders because it provides them with enhanced situational awareness in emergency situations. By leveraging broadband networks, public safety organizations can gain access to site information, video surveillance data, medical information or patient records, and other information that would be useful in an emergency situation. These networks also support and improve 9-1-1 Public Safety Answering Points (PSAPs) response time and efficiency by establishing a foundation for transmission of voice, data, or video to the responding entity.

New broadband technologies give first responders new tools to save lives. These tools include:

- Next-Generation Radio Systems
- Advanced Security Camera Systems
- Gunshot Detection Systems
- Chemical, Biological, Radiological, Nuclear, and Explosives Sensor Systems
- Body-Worn Cameras
- Next-Generation Wireless Data Systems

Broadband and Local Government

Broadband networks become key drivers of efficiency as more and more municipal applications are enabled online. As they expand online services broadband will become an even more critical component of the daily operations to serve communities. Applications migrated to a community network enjoy greater availability and increased bandwidths over what has traditionally been available; creating a more effective and efficient municipal organization. High-speed, reliable broadband enables these organizations to:

- Improve operational efficiencies
- Reduce direct and indirect costs
- Enable new interactions with citizens and businesses
- Respond more quickly to the local community
- Ensure better preparedness in times of emergency
- Provide enhancements to public safety
- Provide more information to citizens and businesses

Broadband and Community Support

In order for a community to thrive and grow, community support organizations must be in place. Organizations such as local chambers of commerce, human services organizations, churches, and other organizations that help connect people to the services they need in the community. These organizations traditionally access the needs and resources available in the community and collect the data necessary to help fill the gaps in services and investigate opportunities to solve community problems and issues.

Broadband plays a vital role in helping these types of organizations fulfill their missions. Whether it is as simple as a community church streaming their weekly service or the local chamber of commerce advertising their latest event through their web presence and email, broadband equips these organizations with one of the most critical communication tools necessary to ensure they are successful in their support roles.

Broadband availability inspires these organizations to be innovative in their use of technology and brings a higher level of welfare to the communities they serve. Take for example All Saints Church in rural Norlfolk County, UK. The church is utilizing it's spire (the tallest structure in the area) to deliver wireless Internet service to the surrounding community. Now, in a community that was lucky to see speeds up to 1 Mbps, speeds of over 8 Mbps are not uncommon. This community support organization has brought broadband service into an area that was previously underserved and is helping to bridge the digital divide that plagues many communities around the globe.