

BROADBAND NETWORKS IN K-12 PUBLIC EDUCATION:

Achieving Last Mile Connectivity to California Schools

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Corporation for Education Network Initiatives in California

4665 Lampson Avenue

Los Alamitos, CA 90720

www.cenic.org

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EXECUTIVE SUMMARY

Background

The Digital California Project (DCP) is a statewide initiative providing K-12 schools with access to the high-speed advanced services network, CalREN, serving higher education and research institutions. The CalREN network extends from San Diego along the coast to the San Francisco Bay area, to Sacramento and then through the Central Valley and back to Southern California. The DCP helps provide network connectivity among K-12 schools, districts, county offices of education, and California higher education sites by extending the CalREN network to at least one K-12 location in each county. Through the CalREN network K-12 educators and students benefit from reliable access to advanced on-line teaching and learning resources, professional development materials and advanced technologies, such as Internet-based video conferencing and Web-casting.

CalREN is operated by the Corporation for Education Network Initiatives in California (CENIC), a not-for-profit corporation serving California Institute of Technology, California State University, Stanford University, University of California, University of Southern California, California Community Colleges and the statewide K-12 education system. CENIC's mission is to facilitate and coordinate the development, deployment and operation of a set of robust multi-tiered advanced network services for this research and education community.

CENIC's Digital California Project has made significant progress in accomplishing its original goal of providing CalREN access points or "nodes" in all 58 counties in California. **Schools in 56 of the 58 counties in California now have the ability to access the CalREN network, and CENIC expects the remaining two counties, Del Norte and Humboldt, to have nodes by the summer of 2003.** With the backbone network close to completion, attention is now shifting to identifying strategies that address "last mile" connectivity between the CalREN nodes in each county and approximately 1,500 unconnected district offices and schools. This report examines the status of last mile connectivity in California's K-12 educational system as of December 2002, offering recommendations for increasing connectivity. In addition to the statewide report, a series of 11 regional/county reports is under development. These reports will provide a snapshot of current network connectivity to build awareness of the

importance of the last mile issue in California and to offer potential approaches for helping 100 percent of California's K12 schools obtain network connectivity.

This study of last mile connectivity was a cooperative effort of CENIC, the California Department of Education (CDE), K-12 networking professionals throughout California and telecommunications carriers in California. The CDE provided baseline information, including school enrollment data; the K-12 networking professionals throughout the state provided connectivity data; and CENIC and the telecommunications carriers prepared cost data.

Scope

For purposes of this report, the last mile is recognized to include both the **external connection** from the school to the county-based node on the CalREN network and the **internal school infrastructure**. The internal school infrastructure comprises many components such as ventilation and power, electrical wiring, local area network cabling and equipment, desktop computers, software and technical support. It also includes the professional development and training necessary for teachers and staff to use technology effectively. While it is understood that solving internal school infrastructure issues is critical to the successful use of technology in K-12, the focus of this report is on the **external connection**. Data were gathered on both the existence and the speed or bandwidth of connections from each of California's approximately 9,000 K-12 public schools and district offices to the CalREN county-based node sites.

Major Findings

Findings from the study on last mile connectivity of schools and districts indicate:

- 71 percent of California's schools, serving over 4 million students, and 82 percent of the district offices are connected to CalREN.
- 84 percent of schools and 79 percent of district offices are connected to CalREN or a commercial Internet Service Provider (ISP) at the minimum speed of T-1 (1.5 Mbps) or greater, the bandwidth deemed necessary for even the smallest school to take advantage of network-based educational, professional development, and collaborative resources and technologies.
- Of the 16% lacking T-1 connectivity, the impact in rural areas is striking. More than half the schools in Region 1 (Del Norte, Humboldt, Mendocino, and Sonoma) and well over one-third of the schools in Region 2 (Butte, Glenn, Lassen, Modoc, Plumas, Shasta, Siskiyou, Tehama, and Trinity) and Region 3 (Alpine, Colusa, El

Dorado, Nevada, Placer, Sacramento, Sierra, Sutter, Yolo, and Yuba) do not have T-1 or greater connectivity.

- The data suggest that installation costs for T-1 upgrades to roughly 1,500 sites would be approximately \$4 million. Monthly connection fees would yield an annual operating cost of approximately \$8 million. Please note that potential discounts from the California Teleconnect Fund and the Federal e-rate program are not included in these estimates. Furthermore, because cost and availability of T-1 connectivity vary significantly by geography, provider, and possible special construction due to unique circumstances, additional analysis is required to determine the true cost of connecting any given site.
- Recognizing that T-1 speed will not be sufficient to support a growing demand for network delivered interactive and multimedia learning resources, many California schools have acquired higher capacity connectivity. Data indicates that nearly 800 schools and over 100 district offices have network connectivity at DS-3 (thirty times faster than T-1) or higher speeds. Anecdotal information suggests that many more schools and districts are moving in this direction.

Assumptions and Recommendations

The recommendations contained within this report are based on the assumptions that:

- The major obstacles to increased connectivity are costs and funding;
- Access to network-based learning resources and use of technology are important to ensuring that California remains competitive in the 21st Century;
- Bandwidth needs will grow rapidly over the next decade as network-based resources evolve and as users become more proficient in the use of such resources.

Specific recommendations are:

1. Community education leaders and policy makers should work together with CENIC to explore means of obtaining funding for minimum T-1 speed connectivity between all unconnected schools and districts and CalREN. Where appropriate, consideration should be given to the marginal costs of acquiring higher speed connectivity to meet longer term needs; and
2. In selected communities within the state, education leaders and policy makers should work with CENIC to explore and consider strategies for providing more bandwidth by aggregating the requirements of K-12 with those of libraries, health services, governmental agencies, and economic development and community service groups within counties or geographic regions.

INTRODUCTION

This report attempts to answer fundamental questions regarding high capacity networking in K-12 education in California:

- Why are broadband networks essential to teaching and learning in the 21st Century?
- What is the current state of networking among California schools, districts, and county offices of education? How close is this to achieving needed “broadband” connectivity?
- What steps are necessary to ensure K-12 education networking needs are met, both in the short term and over time as needs grow?

Post-industrial nations are moving toward an “always-on” connected society in which computers and handheld communications devices are increasingly viewed as personal, lifestyle accessories. These devices support social and economic interaction, as well as work needs. Above all, the connected society represents an “anytime, anywhere” universe of information and services, real-time interactions and collaboration, virtual communities, and integrated multimedia communications. All of this requires broadband networking and the technologies that support its use.

Worldwide, a number of strategies are being used to provide technical and economically viable solutions to serve research, education and socio-economic needs. For example, several municipalities in Canada are developing their own citywide network infrastructures to serve government, education, health services, businesses and the home. In Alberta, Canada the provincial government has created a public/private partnership to provide high-speed networking to every school, library, hospital and government office in its territory, an effort designed to enhance the quality of life and expand business and education opportunities. Although Alberta’s population is only 3 million, it covers a larger land area and is as geographically diverse as California. Alberta expects to have its SuperNet completed in three years.

Within the United States, at least thirty-nine states have launched major statewide K-20 high speed networking initiatives. Iowa, Michigan, Missouri, New York, North Carolina, Ohio, Washington and Wisconsin have extended their connections beyond educational institutions to government agencies, libraries, non-profit organizations, hospitals and others.

Education, at all levels, stands at the center of this social and technological revolution. The next generation of citizens must be trained to cope with, navigate in, and benefit

from the connected society. The crucial question may be whether the educational system itself can be a leader in this effort. Ubiquitous broadband deployment in California's schools guarantees the infrastructure necessary to ensure that public education can be a leader, and positions public education to help all students obtain the technical knowledge and skills necessary to succeed in the 21st century.

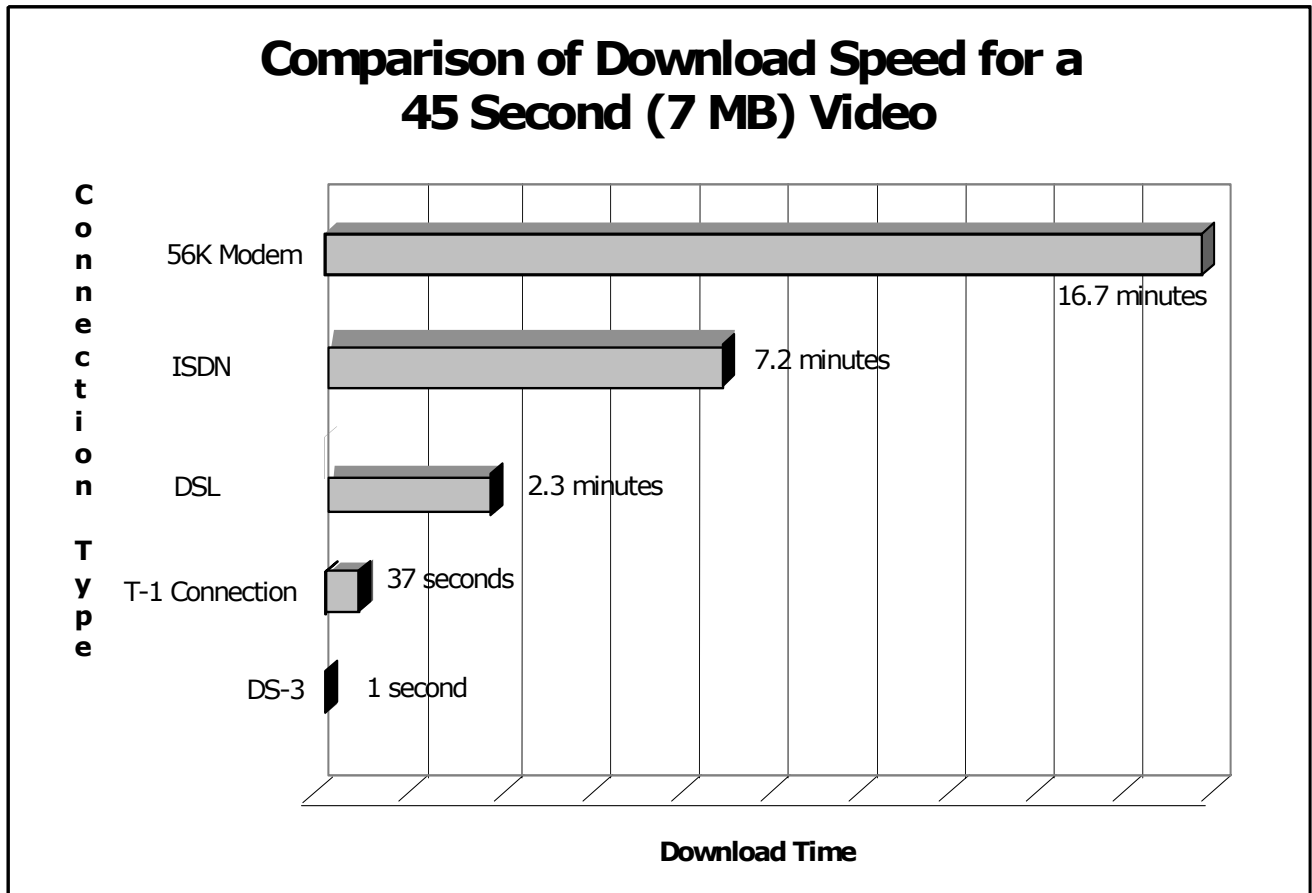
WHAT IS BROADBAND?

There is no common definition of broadband networking. However, the term is normally used to refer to high speed networking to support commonly used applications, such as high quality, high resolution video, multimedia presentations, web casts or other communications that require transferring large amounts of data from one location to another. Even small schools need a minimum connection at T-1 speed (1.5 Mbps) to utilize these. Generally, however, speeds of DS-3 (45 Mbps) and greater are best to support these uses and are required where multiple simultaneous users of video teleconferences, high bandwidth multimedia content, Web casts, etc. exist.

Although lower speed connections afford some level of access to multimedia resources, differences in network speeds can produce huge variations in the quality of a student's learning experience. Figure 1 compares the time it takes to download resources based on the speed of the network connection. Downloading a 45-second instructional video (7MB file) with a dial-up connection to the Internet, using a 56kbps modem, would take a student about 16.7 minutes. With a connection at 128 Kbps over a technology called ISDN, the time would be 7.2 minutes, and with a low-end so-called DSL connection the wait would be 2.3 minutes. However, with a T-1 connection, the time required would be reduced to 37 seconds; with a DS-3 connection, it would take merely 1 second.

These figures graphically demonstrate why it is widely believed that connection speeds below T-1 are not adequate to support on-line resources. High speed networking is not simply a matter of convenience; it is the defining factor in whether or not an on-line resource is usable in the classroom. The April 25, 2001 issue of *Ed Week*, reporting on the findings of a nationwide study, found that 60 percent of teachers use the Internet less than 30 minutes a day. Fully 50 percent of those teachers blamed slow access speed for low Internet use. These survey results and the simple illustration in Figure 1 provide evidence why a T-1 connection is considered to be a minimum baseline speed for multimedia applications (pictures, graphics, video, etc.) and why a higher level of connection is desirable.

Figure 1



IMPORTANCE OF BROADBAND TO TEACHING AND LEARNING

The State's investment in establishing a high speed, broadband network for K-12 education represents a critical piece of the infrastructure necessary for teachers and learners to keep pace with the "anytime, anywhere" universe of information services emerging in the private sector. This infrastructure lays the groundwork for:

1. Synchronous (real time) and asynchronous (on demand) interaction and collaboration across distances, enhancing access to professional development workshops, degree and certification programs, virtual tours, field trips, special events, etc.

For example, elementary school teachers participating in selected state-funded professional development programs get online math and reading professional development resources and training accessible at school or other locations on the CalREN network. Students benefit from virtual field trips, such as those provided by the California State Parks, where students who would otherwise be

deprived of park access can enjoy park resources virtually and receive lessons pertaining to parks from a distance. Park rangers from places such as Crystal Cove and the State Capitol already interact with classrooms in this manner.

Networking can help address the demand for more teacher professional development at a time when funds are being reduced. Video conferencing and Web-casts, both of which require significant network bandwidth, can improve access while reducing travel and training costs. External evaluations of such "virtual" events conducted over the CalREN network consistently show that such events increase access for individuals who would otherwise be unable to participate in such activities.

2. Greater use of data, text, graphics, voice, and video to supplement textbooks and instruction with multimedia formats that tap into the many different learning styles of students and teachers. For instance, several content providers offer vast libraries of digital images and videos that can be viewed on-line, on-demand to support teaching and learning.
3. The ability to model or simulate "what-if" scenarios to help students understand difficult concepts.
4. On-line delivery of instruction by highly qualified teachers for courses where the number of students is too small or a teacher is not available. A growing number of students in small, rural districts are now able to access advanced placement courses delivered on-line and supported by an on-line instructor and on-line student mentors.
5. Training students in the use of technology through integration with academic instruction in a meaningful way enhances learning and ensures that students have the skills necessary to be successful in today's knowledge-based workforce. For students who do not have computer and Internet access at home, the school may be their only chance to develop computer literacy skills and information competency.
6. Resource sharing and cost savings through joint licensing to leverage resources for maximum benefit. Ohio serves as an example of a state that supports the statewide licensing of online content and databases for K-20 and public library use. Representatives of the program in Ohio note that the combined purchasing power and streamlined distribution model have reduced costs from commercial prices by nearly 50 percent.

7. Administrative applications and efficiencies. For example, the El Monte School District, working with SBC, and its networking equipment vendors, created the capability for Gigabit bandwidth on demand to every high school in the district. Among other things, the new network capacity allows the district to reduce administrative costs related to the distribution of educational materials and the maintenance and support of separate servers at each individual school site.
8. Delivery of student support services to help with course selection, college placement, and entrance exam information, as well as career and vocational counseling. A wide range of network-based, student-guidance resources is available on the network. For example, the CaliforniaColleges.edu Website has been developed in collaboration with the California State University (CSU), University of California (UC), California Community Colleges (CCC), Association of Independent California Colleges and Universities (AICCU), and the California Department of Education to allow students to obtain information about higher education opportunities in California. The site aims to become a portal for all colleges and universities in the state, providing assistance to students applying for admission and financial aid, virtual campus tours, criteria searches, a student-campus matching assistant and course selection counseling for first-year and transfer students.
9. Student data management to transfer voluminous student information. The state-funded California Student Information Services (CSIS) project, initiated to reduce workload associated with state reporting requirements and enhance access to information to support student transfers between schools and districts, requires the high bandwidth CalREN network to be most effective. The network also has potential to provide a medium to support the sharing of data required by the federal No Child Left Behind (NCLB) Act.

Connecting schools to CalREN is an important first step for ensuring that the K-12 community is given adequate network bandwidth to take advantage of these types of possibilities. The ability to utilize a full range of multimedia and interactive learning resources depends on the speed of the connection. It is, quite literally, a question of how much data, graphics, voice, and video information can be transmitted, and how quickly this occurs. As noted earlier, T-1 is the minimum bandwidth required for basic usability. As use grows, so too, will bandwidth needs.

BROADBAND AND THE NET-GENERATION

Perhaps the most compelling reason why broadband must become a reality in K-12 education is the students themselves. Consider what is known about the new Net-

savvy generation, and the technology-driven culture that is increasingly taking technology for granted.

In a report published earlier this year by the UCLA Center for Communication Policy, Internet use was found to be highest among those age 35 and under, with especially high use among those 18 and under (99 percent). Today's K-12 students are "connected" to a web of people and information that surpasses anything in human history.

Author Dan Tapscott has studied the Net Generation in some detail on several continents. Among other things, he describes the shift from traditional "broadcast education" to interactive learning as movement from linear to hypermedia learning; from instruction to discovery and learning by doing; from absorbing information to navigating and using it; from studying alone to studying collaboratively and globally; from mass education to mass customization; from learning as work to learning as entertainment and fun; and from teacher as transmitter to teacher as facilitator.

Many students can download and customize their own CDs with MP3 music technology; design, mix and match, and order their clothes without malls or salespersons; order a computer like they do a burger. For them, learning is not a matter of mass assimilation of information, but a very personal journey of discovery and of creating knowledge from thousands of sources.

In short, the distinctions between education and the world of work, or education and the world of leisure and entertainment, are becoming less clearly defined. Integrated technologies as ubiquitous as the ATM and as easy to use as the telephone will help break down the notion that school or learning itself is limited to a unique, scheduled, and separate activity. Knowledge will be available to be acquired in an anytime, any place, and on-demand fashion.

There is one important caveat to this. Network technology is an enabler in the learning process; it is not learning itself. Its ubiquity, speed, convenience, interactivity, imagery, and enormous scope of resources make the network a powerful enabler, but no more so than a great library. In the famous words of Richard Clark, "educational delivery systems by themselves have no more to do with learning than the grocery truck has to do with diet." A key ingredient will be the degree to which there is public access to high quality learning resources.

THE LAST MILE

Computers in the K-12 classroom have historically been viewed as stand-alone appliances used to play CDs for multimedia learning, produce spreadsheets and

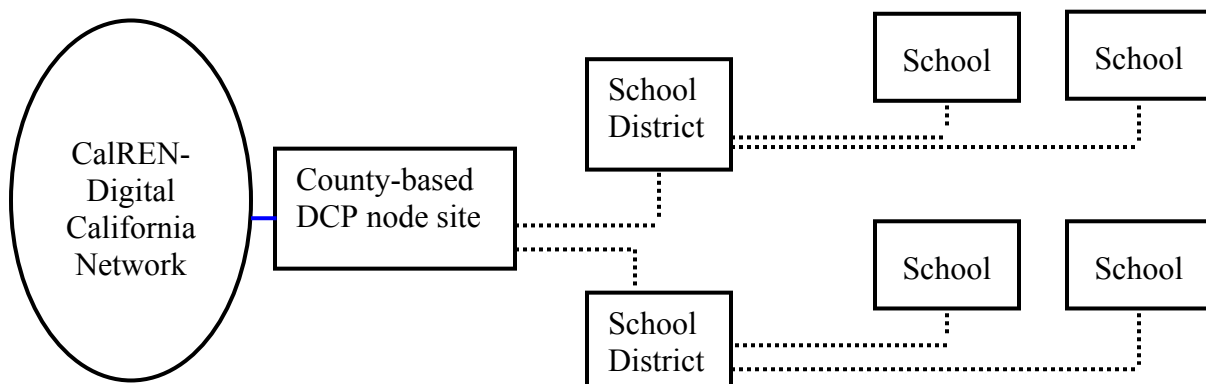
graphics, do word processing and facilitate class presentations. With the advent of the Internet, the computer became synonymous with the network. In K-12, higher education, and society generally, educational technology must now be redefined in that context. Simply stated, the value of a computer lies in its ability, through networks, to transcend the boundaries of space and time. More than connecting computers, networks are about enabling human and intellectual connections to the outside world.

Yet, therein lies one of the most crucial and vexing problems — traversing the “last mile” from the computer and wall outlet in a home or school to the worldwide Internet. Although the statewide network backbone may have massive capacity, getting from this backbone to the classroom at sufficient speed to be useful remains a challenge for too many schools. Since network speeds determine the quantity and quality of connections that students and teachers can make with computers, and the corresponding quality of those experiences, the last mile is a critical challenge.

One major caveat must be noted. The last mile is a multi-faceted puzzle. In broadest terms, the last mile includes both the **external connection** from the school to the county-based node on the CalREN network and the **internal school infrastructure**. The internal school infrastructure includes many components such as ventilation and power, electrical wiring, local area network cabling and equipment, desktop computers, software and technical support. It also includes the professional development and training necessary for teachers and staff to use technology effectively

This report deals with one piece of the puzzle, namely the **external connection** between the schools and school district offices and the closest county-based node on the CalREN network (as depicted by the dotted lines in Figure 2). These connections allow desktop computers in schools to reach a rich outside world of educational resources.

Figure 2 - Model of School Connectivity to CalREN



This study of last mile connectivity was a cooperative effort of CENIC, the CDE, K-12 networking professionals throughout California and telecommunications carriers in California. The CDE provided baseline information, including school enrollment data;

the K-12 networking professionals throughout the state provided connectivity data; and CENIC and the telecommunications carriers prepared cost data.

The remainder of the report addresses the following questions:

- How close are California's schools and district offices today to achieving minimum baseline (T-1) "last mile" connectivity?
- What would it cost to connect or upgrade the remaining schools and district offices to this minimum T-1 bandwidth?
- What "last mile" connectivity speeds can we anticipate needing to optimize e-learning in California within the next three to five years, and how close are California's schools and district offices to achieving this level of connectivity?
- What are the barriers to moving California's schools toward these higher levels of last mile connectivity?
- What are the alternatives, technical and financial, that would enable schools to achieve these higher levels of connectivity?

K-12 PLANNING REGIONS

There are eleven (11) K-12 educational planning regions in California commonly recognized throughout the education community (Figure 3). Within these regions lie California’s 58 counties, containing almost 8,000 elementary, middle, and high schools and 985 district offices. As might be expected in a state the size of California, these educational planning regions are characterized by enormous geographic, social and economic diversity. That diversity is reflected in access to technology resources among the schools and districts.

Figure 3



With just under 6 million students, and almost 300,000 teachers, the size and diversity of the California education system matches that of the state generally. One-third of the schools enroll fewer than 500 students, yet five percent enroll more than 2,000. Tables 1 and 2, based on the 2001-02 academic school year, reflect this diversity. For the purposes of this report, school sites where permanent network connections are problematic (typically community day schools), were not included in the data.

Table 1. Number of Schools and Enrollment by Region

Region Number/ Region Name	Number of Schools	FY 2000 Enrollment
1. North Coast	315	115,196
2. Northeastern	328	94,892
3. Capital	624	362,798
4. Bay	992	618,974
5. Central Coast/South Bay	558	360,213
6. Delta Sierra	362	231,806
7. Central Valley	584	356,030
8. Costa Del Sur	572	381,964
9. Southern	1166	978,148
10. RIMS	788	699,129
11. Los Angeles	1629	1,629,496
Total	7918	5,828,646

Table 2. Number of Schools by Region and Enrollment Category

Region Number/ Region Name	School Size by Region					
	School Enrollment Categories					
	0-500	501-1,000	1,001-2,000	2,001-5,500	No Data	Total
1. North Coast	215	54	17	2	134	422
2. Northeastern	269	52	13	1	150	485
3. Capital	273	235	60	17	144	729
4. Bay	438	376	110	24	144	1092
5. Central Coast/South Bay	206	257	62	13	106	644
6. Delta Sierra	130	166	30	17	88	431
7. Central Valley	208	286	37	21	176	728
8. Costa Del Sur	200	277	45	29	128	679
9. Southern	236	609	201	79	140	1265
10. RIMS	121	441	145	57	103	867
11. Los Angeles	296	745	384	163	136	1724
TOTALS	2592	3498	1104	423	1449	9066

FINDINGS

As noted in the Introduction, this study poses five questions. Following are the major findings.

How close are California's schools and district offices today to achieving minimum baseline "last mile" connectivity to CalREN?

Fully 84 percent of K-12 schools and 79 percent of districts in California already have network connections of T-1 or greater to CalREN or a commercial Internet Service Provider (ISP). Bringing last mile, baseline connectivity to the remaining schools and district offices, approximately 1,500 sites statewide, is an issue of equity and should be a priority for California.

Tables 3 through 5 provide summaries of school and district connectivity levels by region. They show where the sub T-1 schools and district offices are located and the relative magnitude of the problem in each region. Clearly, the North Coast and Northeastern regions have the highest percentages of schools and districts with less

Table 3. School Connection Speeds by Region

Region Number/ Region Name	Connection Speed in Megabits							Total
	<T-1	T-1	>T-1 ≤10Mb	>10 ≤45Mb	>45 ≤100	>100 ≤155	>155	
1. North Coast	139	128	23	6	16	2	1	315
2. Northeastern	113	182	4	13	15	0	0	327
3. Capital	128	315	100	14	36	18	12	623
4. Bay	51	787	58	22	36	9	29	992
5. Central Coast/ South Bay	78	365	88	1	1	10	15	558
6. Delta Sierra	34	249	45	8	27	0	0	363
7. Central Valley	40	328	113	22	67	3	10	583
8. Costa Del Sur	213	178	97	28	51	0	5	572
9. Southern	201	783	92	15	30	4	40	1165
10. RIMS	114	534	67	38	24	3	9	789
11. Los Angeles	193	1242	63	19	57	1	54	1629
Total	1304	5091	750	186	360	50	175	7916

than T-1 connectivity. The Costa Del Sur region is a close third, while the other regions show notably lower percentages for sub T-1 connectivity.

Table 4. District Office Connection Speeds By Region

Region Number/ Region Name	Transfer Rate (in Megabits)							Total
	<T-1	T-1	>T-1 ≤10Mb	>10 ≤45Mb	>45 ≤100	>100 ≤155	>155	
1. North Coast	46	27	10	3	6	0	0	92
2. Northeastern	54	54	2	7	2	0	0	119
3. Capital	19	52	7	2	5	3	0	88
4. Bay	11	47	21	9	0	1	1	90
5. Central Coast/ South Bay	11	32	29	6	0	0	1	79
6. Delta Sierra	2	51	2	3	0	1	0	59
7. Central Valley	15	77	20	12	1	1	1	127
8. Costa Del Sur	28	45	25	1	1	0	0	100
9. Southern	4	29	18	16	10	1	7	85
10. RIMS	3	34	21	4	1	1	1	65
11. Los Angeles	15	41	23	1	0	0	1	81
Total	208	489	178	64	26	8	12	985

Complicating factors include distance and terrain between schools and district offices and the CalREN network's county-based node sites. These geographic challenges affect both the cost and availability of network connectivity. In remote areas of the state, a school district may have limited connectivity options available. Some local exchange providers may not be willing or able to install any circuit above a T-1 connection. In many cases, even where available, the cost of a high-speed circuit may exceed a district's budget.

Still, many of California's schools, recognizing the need for higher bandwidth to support interactive and multimedia educational resources and more powerful administrative tools, have acquired higher capacity connectivity. Data indicates that nearly 800 schools and over 100 district offices have network connectivity at DS-3 or higher speeds. This is thirty times faster than T-1. Anecdotal information suggests that many more schools and districts are moving in this direction.

An illustrative example is the El Monte Union High School District. Working with SBC/Pacific Bell and its networking equipment vendors, EMUHSD has provided the

capability for gigabit bandwidth on demand to all of the district’s high schools. The economically disadvantaged district, which qualifies for a 90% E-Rate match, used a creative design that placed Layer 3-capable gigabit cards in existing routers, upgraded their current voice switching equipment, and took advantage of fiber infrastructure improvements in order to save \$1M over other alternative proposals. Integrated into the design are links between the schools as well as directly to the district office for ongoing usability in the case of partial network failure. Plans for E-Rate Year 6 monies will complete the final “ring” design for enhanced reliability. This innovative solution gives each school access to scalable, high-performance networking applications such as Voice-over-IP, large bandwidth Internet access, and streaming video.

Table 5. Number and Percent of Schools and District Offices with Sub T1 Connections

Region Number/ Region Name	Number of Schools and District Offices					
	Number and Percent Sub T1 within each region					
	Schools	Sub T1	Percent	Districts	Sub T1	Percent
1. North Coast	315	138	43.81%	92	46	50.00%
2. Northeastern	327	113	34.56%	119	54	45.38%
3. Capital	623	128	20.55%	88	19	21.59%
4. Bay	992	51	5.14%	90	11	12.22%
5. Central Coast/South Bay	558	78	13.98%	79	11	13.92%
6. Delta Sierra	363	33	9.09%	59	2	3.39%
7. Central Valley	583	40	6.86%	127	15	11.81%
8. Costa Del Sur	572	213	37.24%	100	28	28.00%
9. Southern	1165	201	17.25%	85	4	4.71%
10. RIMS	789	114	14.45%	65	3	4.62%
11. Los Angeles	1629	193	11.85%	81	15	18.52%
Total	7916	1302	16.45%	985	208	21.12%

What would it cost to connect or upgrade the remaining schools and district offices to this minimum T-1 bandwidth?

CENIC worked with telecommunications carriers to develop cost estimates for connecting or upgrading the remaining schools and district offices to T-1 speeds based on available data on installation costs and monthly rates by region. It should be noted that these findings provide only a snapshot of estimated costs at a single point in time. Such costs change on a continual basis due to ongoing investments in school/district infrastructure, as well as changes in network fees, costs for installation and equipment, and changes in the technologies themselves.

The data suggest that installation costs for T-1 upgrades to roughly 1,500 sites would be approximately \$4 million. Monthly connection fees would yield an annual operating cost of approximately \$8 million. Please note that potential discounts from the California Teleconnect Fund and the Federal e-rate program are not included in these estimates. Furthermore, because cost and availability of T-1 connectivity vary significantly by geography, provider, and possible special construction due to unique circumstances, additional analysis is required to determine the true cost of connecting any given site.

What "last mile" connectivity speeds will be required to optimize e-learning in California within the next three to five years, and how close are California's schools and district offices to achieving this level of connectivity?

As noted earlier, the ultimate goal is to move all K-12 schools to much higher bandwidth than the T-1 baseline — i.e., to DS-3 (45Mbps) and above. While T-1 connectivity may meet short term needs, and while scarce educational dollars ought not be diverted into excess network capacity that goes unused for a lengthy period of time, it is important to plan ahead to ensure that teachers' and students' needs are met. In a TechNet publication entitled "A National Imperative: Universal Availability of Broadband by 2010" industry leaders recently called for universal network connectivity of 100 Mbps nationwide by the year 2010. Over time the bandwidth need is certain to grow.

IMPLEMENTATION BARRIERS AND OPTIONS

What are the barriers to moving California's schools toward higher levels of last mile connectivity?

The major obstacles to greater connectivity are costs and funding. In some cases, communications carriers have circuits available to provide the needed connectivity, but schools and districts do not have resources available to purchase them. In other cases, the carriers do not have circuits readily available, resulting in even higher costs than if such infrastructure were in place.

In cases where circuits are available but local resources are not available, every effort should be made to identify and secure new and existing resources. For example, CENIC has organized a consortium to obtain E-Rate and CTF discounts on network equipment and circuits, and has sponsored a "last mile" award program since 2001. Appendix A provides a summary of the 2002-03 award program.

In either case, the fundamental issue is the same-- the ability of the district and school to fund the cost of connectivity, however high or low.

Over the past decade, the telecommunications industry has moved toward a fiber-based cable infrastructure. However, many areas still do not have fiber cabling or the supporting electronic equipment. In many instances, industry is amortizing the cost of its copper cabling and therefore reluctant to do a widespread fiber implementation. Regulatory and environmental issues can also impact investment decisions that affect fiber deployment. This problem is especially acute for the last mile issue. While in many cases the fiber is available for long-haul transport (statewide and interstate), a 2001 CENIC study found that most telecommunications carriers did not plan on retrofitting many local areas for fiber cable in the near future.

According to a recent study by the Federal Communications Commission “the rapid investment in high-speed Internet technology, particularly among the cable companies, is beginning to slow down.” A number of smaller firms have filed for bankruptcy with industry analysts predicting more to follow.

What are the alternatives, technical and financial, that would enable schools to achieve higher levels of connectivity?

Several technical and financial options are worthy of consideration, such as:

Customer-built and owned fiber networks. In the past, the costs associated with building or buying and implementing a fiber optic infrastructure for metropolitan or wide area networks were considered prohibitive. However, the cost of fiber-optic infrastructure has dropped dramatically in the past few years, and the return on investment has declined to less than ten years and in some cases as few as four years.

The key advantage to implementing a customer-owned fiber optic network is the ability to obtain greater network capacity at low costs. Given current and planned technology, the amount of bandwidth that can be provided is quite large and will increase as new fiber-based technologies are introduced, and would meet the K-12 requirements of the foreseeable future. However, with ownership comes increased responsibility for design, implementation and maintenance of the network.

Long-term fiber/wave leases. Another fiber-based option involves leasing fiber or wavelengths from long-haul and metropolitan telecommunications vendors. Competitive access providers and cable television companies have placed fiber optic cables near or within most large and mid-sized communities. Many of these companies lease the excess capacity of fiber optic strands to customers while retaining their own transport capabilities. Usually, interested parties can negotiate either a service lease or irrevocable “right to use” agreement for dedicated strands of fiber. Because these tend to be long-term commitments, price levels can be significantly lower than obtaining services from a local exchange telecommunications company.

Wireless technologies. Wireless technologies, both in licensed and unlicensed frequencies, may offer attractive alternatives to connecting schools and district offices. Currently, bandwidth of 11 Mbps can be delivered to locations within a range of 18 to 22 line-of-sight miles. Higher bandwidth of 45 to 155 Mbps can be achieved with higher power transmitting and receiving equipment at ranges up to 38 miles with line-of-sight, unrepeated distances.

Costs for wireless circuits vary dramatically based on speed and distance. Short-distance wireless circuits can be cost-effective. Long distance high-speed circuits tend to be costly, but in some cases may provide the only viable solution in certain areas of the state due to the prohibitive costs associated with developing the necessary fiber infrastructure to support higher speed connections.

RECOMMENDATIONS

The recommendations contained within this report are based on the assumptions that:

- The major obstacles to increased connectivity are costs and funding;
- Access to network-based learning resources and use of technology are important to ensuring that California remains competitive in the 21st Century; and
- Bandwidth needs will grow rapidly over the next decade as network-based resources evolve and as users become more proficient in the use of such resources.

Specific recommendations are:

1. Community education leaders and policy makers should work together with CENIC to explore means of obtaining funding for minimum T-1 speed connectivity between all unconnected schools and districts and CalREN. Where appropriate, consideration should be given to the marginal costs of acquiring higher speed connectivity to meet longer term needs; and
2. In selected communities within the state, education leaders and policy makers should work with CENIC to explore and consider strategies for providing more bandwidth by aggregating the requirements of K-12 with those of libraries, health services, governmental agencies, and economic development and community service groups within counties or geographic regions.

This report can be found on the CENIC Web site at:
<http://www.cenic.org/DCP/2003LastMileStateReport.pdf>

For further information about CENIC, the CalREN network, or the information contained in this report, please visit our Website at www.cenic.org or contact CENIC via email to info@cenic.org.

Appendix A: CENIC 2002-03 Last Mile Award Program Information

Q1: What was the process used to pick awardees?

A1: Applications were sent to the over 500 LEA's that submitted Letters of Agency (LOAs) to join CENIC's e-rate discount consortium for 2003-2004. Over 50 districts returned completed applications to CENIC, requesting connectivity for approximately 130 sites. From the total pool of approx. 130 sites, a lottery-like, random process was used to rank the sites sequentially. No additional rating system was employed to select and rank applications. An individual district may be funded for multiple sites (as evidenced by multiple occurrences of a district name on the awardee list).

Q2: How does the award work for districts whose names were drawn more than once?

A2: Those districts drawn more than once (Manteca=5; Atascadero=3; Paradise=3; Monterey COE=2; River Delta=2) will be awarded funding to connect the number of sites drawn. Example: Manteca had 17 eligible sites in the lottery, and Manteca was chosen 5 times in the random drawing. Therefore, the implementation plan from Manteca can include 5 sites of their choosing from the 17 eligible sites in their district.

Q3: If my district has 3 sites chosen but we can connect 5 sites for our requested amount, can we do it?

A3: No. Being designated an awardee does not guarantee that you will receive the total amount of money specified in your application. CENIC will fund the actual cost to connect the number of sites chosen in the lottery. However, in the case raised in this question, the district is able to choose which 3 sites to connect with these funds based on local priorities.

Q4: What about CTF and E-rate?

A4: The expectation is that you will apply for CTF and E-rate on any new eligible service(s) funded by this award (and, hopefully, on other eligible services in your district). You should apply for CTF discounts for any new eligible service funded by this award at the time you order it from your carrier in 2003-2004.

CENIC will pay the post-discounted amounts to your district. In the event that it is necessary for CENIC to pay the pre-discount amount, and you receive discounts afterwards, you must either refund the difference or reduce your next year's award by that amount.

Please note, that, in order to be initially funded, you must have applied for, or currently be receiving, CTF discounts on some/any service in your district by May 6. We will ask for proof of this either in the form of a phone bill showing the discount or the application you sent to your carrier. This is a separate requirement from any new eligible service funded by this award.

In addition, by March 31, 2004, you must have applied for E-rate on any new eligible service funded by this award. You will be asked to provide proof of this in your implementation report, due March 31, 2004. By July 31, 2005, you must have again applied for E-rate on any new eligible service funded by this award. You will be asked to provide proof of this in your implementation report, due July 31, 2005. By July 31, 2006, you must have again applied for E-rate on any new eligible service funded by this award. You will be asked to provide proof of this in your implementation report, due July 31, 2006.

Q5: What is covered in Year 1 one-time installation/construction costs?

A5: The actual cost of necessary termination equipment (e.g., a router card or router), cabling/wiring, and incidental (minor) construction costs to establish T-1 connectivity to your network will be covered. Major improvements to your network will not be funded. End-user equipment will not be funded.

Q6: What about costs related to ISP (COE), installation of router or other necessary equipment, and annual on-going costs, etc.? Are these covered by the award?

A6: These may all be considered legitimate costs, but must be substantiated as necessary to the provision of T-1 level service to the awarded site(s). Each request will be reviewed individually and determination will be made regarding funding on a case-by-case basis.

Q7: Can we use the award for connecting a site at higher than T-1 bandwidth?

A7: You can choose to connect at greater than T-1 level, but only the cost to achieve T-1 connectivity will be covered by the award. Additional costs are borne by the applicant. Proration is an option.

Q8: Can we use the award for wireless technologies to connect the school site at higher than T-1 speed if the cost is less than installation of a traditional T-1 circuit?

A8: Depending on the technologies available and the unique challenges of using traditional circuits, you may elect to implement alternative wireless solutions. Please submit detailed plans with analysis of comparative costs for T-1 level service. Such plans will be reviewed and awards determined on a case-by-case basis.

Q9: What if a funded site wants to connect to DCP via some other route than through the district's central office or county node site?

A9: Except in rare cases dictated by access and network design (location), the funded site is expected to connect through the district's central office to the designated DCP node site. Any requests for exceptions should be accompanied by a detailed description of the circumstances.

Q10: Will there be a Last Mile Awards program again next year?

A10: A new award program next year is dependent on funding available next year. And, the particulars of any future application and award process are subject to change.

Q11: Which schools/districts were chosen to receive Last Mile awards?

A11: 24 LEA's, representing 34 sites, were finalists for the current year's Last Mile awards. The 24 finalists are: Mendocino COE, Ukiah Unified Elementary SD, Twin Ridges Elementary SD, River Delta Unified SD (2), Monterey COE (2), Atascadero Unified SD (3), Jefferson SD, Plainsburg Union Elementary SD, Golden Feather Union Elementary SD, Manteca Unified SD (5), Browns Elementary SD, Marin COE, Delphic Elementary SD, McCabe Union Elementary SD, Fort Bragg Unified SD, Paradise Unified SD (3), Manzanita Elementary SD, Delhi Unified SD, Bret Harte Union High SD, Tuolumne COE, Grenada Elementary SD, Trinidad Union Elementary SD, Willits Unified SD, and Jamestown Elementary SD. Finalists awarded funds for more than one site in the lottery are identified by number of sites awarded in parentheses (). All other finalists were awarded funds to connect one site each.

THE DCP CONNECTION

The current generation of the commercial Internet is maturing rapidly, but not sufficiently to facilitate the comprehensive sharing of resources and delivery of programs and services required within the K-20 education enterprise. Today researchers, educators, and government agencies are working together to create a new generation of high performance networks that will extend the possibilities of our “knowledge economy” far into the 21st century.

California’s contribution to this endeavor began in 1995 when five major universities came together to articulate a common vision: the innovative use of advanced technology to deliver the next generation of data communications services throughout California as part of the national Internet2 Initiative. These universities formed the Corporation for Education Network Initiatives in California (CENIC), a not-for-profit corporation serving California Institute of Technology, California State University, Stanford University, University of California, University of Southern California, California Community Colleges, and the statewide K-12 school system. CENIC’s mission is to facilitate and coordinate the development, deployment and operation of a set of robust multi-tiered, advanced network services for this research and education community.

CENIC, under contract through the University of California, operates the DCP. A Program Steering Committee (PSC), with representation from sixteen education organizations spanning K-20 in California, oversees the execution of the project.

Additional information about DCP is available on the CENIC Web site at:

<http://www.cenic.org/DCP.html>

or by sending email to:

<info@cenic.org>.