THE NORTH CAROLINA SCHOOL CONNECTIVITY INITIATIVE

A public-private approach to improving school data networks

AN EDUCATION CASE STUDY

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INNOSIGHT INSTITUTE

December 2010 | E-CS-005
www.innosightinstitute.org

EXECUTIVE SUMMARY

In 2006, Education Week gave North Carolina a "D" on its report card for Internet access. The problem was not a lack of world-class Internet resources. North Carolina had a flagship network, the North Carolina Research and Education Network (NCREN), which provided fiber-optic infrastructure to many of the state's higher education institutions. But K–12 public schools lagged behind. Fifteen percent of districts relied on wireless or copper connections for their wide area networks (WANs), instead of faster, more reliable, fiber-optic connectivity. Almost all the districts negotiated their own contracts with third-party Internet service providers, which often led to high rates, excessive overage fees, and latency issues. Rural areas particularly struggled because their sparse populations and rocky terrain created a shortage of supply of Internet service providers.

As the demand for online learning options grew and as the state sought to administer a standardized student information system over the Internet, the need for high-speed, reliable connectivity swelled.

Launching the project

North Carolina's General Assembly voted in 2006 to allocate $6 million as an initial investment in the North Carolina School Connectivity Initiative. A public-private team came together to launch the project, including experts from the state's higher education system, state agencies, for-profit telecom providers, NCREN, and the K–12 sector. The legislature directed the project team to begin to expand broadband at schools, selectively build out networks to rural and underperforming schools, and develop a statewide model for scalable implementation.

Designing NC EdNet

The team outlined a plan for a new public-school network architecture, which it called NC EdNet. The design called for a shared education backbone; the leveraging of existing core networks, such as NCREN; fiber-based WANs wherever possible; common service agreements with last-mile providers negotiated by the state; and a technical support bureau to help district network engineers. The team decided to make participation in the network and services voluntary.

The plan also envisioned an E-Rate[1] support bureau to help districts navigate the bureaucratic challenge of obtaining federal E-Rate discounts for telecommunications and Internet services, which districts had heretofore handled on their own with no support. In the years from 2002 to 2006, districts on average requested a total of $81 million per year in E-Rate monies, but only received 64 percent of these requests. The team hoped to improve this capture rate and streamline the application process.

The three-year implementation

By 2008, the General Assembly pledged a recurring line item of $12 million annually to fund the three-year implementation. The next year it allotted an additional $10 million per year, which brought the total to $22 million annually. The Connectivity Initiative planned for E-Rate funds to provide substantial revenue on top of the state funds.

Year one (FY2007–08) implementation activities included interconnecting local providers with the NC EdNet backbone, identifying districts to transition to NC EdNet, setting up the technical and E-Rate support bureaus, and completing a master plan to prioritize network development across schools. In year two (FY2008–09), the team continued to build out the NC EdNet backbone, focused on providing solutions for underserved districts, and continued extending fiber connectivity. Year three (FY2009–10) centered on finalizing the NC EdNet backbone and upgrading backbone capacity to support load.

Results

By November 2009, only 6.5 percent of the approximately 2,400 schools in the state did not have fiber connecting them to their district WANs. In addition, all 115 public school districts now were connected to NCREN to access content and administrative applications from the state. Furthermore, 41 percent of districts also were using NCREN to access the public Internet.

As the project moved forward, the team grappled with the increasing demand for bandwidth, which was rising as fast as 20 percent per year or more at some districts. Districts that had adequate infrastructure by the end of year three were already finding that their systems were under stress.

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[1] E-Rate, or the Schools and Libraries Program of the Universal Service Fund, provides discounts to assist U.S. schools and libraries in obtaining affordable telecommunications and Internet access. The funding is administered by the Universal Service Administration Company under the direction of the Federal Communications Commission.

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A public-private approach to improving school data networks

This case study explores how a diverse range of partners in the education, technology, and business community worked together to improve Internet access across all North Carolina schools, regardless of geography or economic conditions. Through a collaborative public-private partnership, the North Carolina School Connectivity Initiative brought greatly improved capacity and reliability to data networks among the state's 115 public school districts in only three years (Appendix A provides a map of all schools in North Carolina). To do so, the collaborative leveraged federal E-Rate funds[1] and existing network resources, particularly the higher-education broadband networks already in place, to improve K–12 connectivity without relying only on allocations from North Carolina's General Assembly.

A growing need

As the first decade of the 21st century dawned, North Carolina's public schools needed high-capacity, reliable Internet connectivity more than ever. Online learning options were beginning to play a larger role throughout the K–12 education system, such as by providing Advanced Placement and other specialized courses for accelerated students, as well as by offering more convenient credit- and dropout-recovery options. The state began contemplating plans for the North Carolina Virtual Public School (NCVPS), an Internet-based school to provide online courses to high school students, and later to middle school students. NCVPS needed dependable connectivity to allow students to run the multimedia and streaming content embedded throughout the curriculum.

In traditional classrooms, educators also were finding that reliable Internet access enhanced their ability to engage and motivate students by offering an alternative instructional medium for hard-to-reach students. But presenting online content in a way that engaged students required a rich interface. As multimedia, streaming video, and interactive learning tools played an increasingly important role in the classroom, the need for robust connectivity grew.

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[1] E-Rate, or the Schools and Libraries Program of the Universal Service Fund, provides discounts to assist U.S. schools and libraries in obtaining affordable telecommunications and Internet access. The funding is administered by the Universal Service Administration Company under the direction of the Federal Communications Commission.

Schools also needed reliable connectivity to keep up with the state's newly centralized student information system. In 2002, North Carolina's Department of Public Instruction (DPI) deployed a standard student information system for all the state's districts. The system was intended to streamline administration, reporting, and communication among the state's dispersed public schools and DPI. Yet for many districts, the system's connectivity requirements exceeded the districts' bandwidth.

Latency issues, or delays associated with the Internet connection, especially plagued the student information system. "For some districts, their systems had 29 hops in between them and the applications and content they were accessing, which increased latency," DPI's Chief Information Officer Peter Asmar said. "So no matter what the size of the pipe in those districts, applications would not perform well. These technology issues impacted students and teachers, and if there was more than 50 milliseconds latency, it was a real problem." Something as simple as taking attendance online could take over an hour if the technology loaded too slowly for each attendance recorded.

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The connectivity gap

Despite the need for high-quality broadband across all North Carolina schools, the existing demand structure did not incentivize adequate supply. A natural monopoly existed in the northeastern portion of the state, where the sparse population and difficult geography meant only one provider was present, as the small market did not support additional providers. To the west, with a small population and difficult terrain, rural communities had no dominant provider or up-to-date technology. "No one wanted to dig into rock," said Phil Emer, technology director at North Carolina State University's Friday Institute for Educational Innovation (Friday Institute).[2] Some districts struggled to secure access even in areas with enough suppliers simply because district personnel were intimidated by the complex rate structures service providers offered.

Several state programs under former Governor Jim Hunt (1977–1985 and 1993–2001) sought to improve connectivity for schools, as did efforts during the

[2] North Carolina State University's College of Education organized the Friday Institute for Educational Innovation to bring together students, teachers, researchers, policymakers, education professionals, and other community members to foster collaboration to improve education.

subsequent administration of Governor Mike Easley (2001–2009). Yet by 2006, Education Week Educational Technology Access Survey gave North Carolina a "D" on its report card for Internet access.[3] The problem was not a lack of world-class Internet resources. North Carolina already had a flagship network, the North Carolina Research and Education Network (NCREN) (Appendix B shows a map of NCREN). NCREN's fiber-optic infrastructure provided high-speed Internet to all 16 of the state's public universities, as well as many of its private universities, such as Duke and Wake Forest. The state's K–12 public schools, however, lagged behind.

The K–12 system across the state had a two-prong network architecture. The first prong was that each district aggregated its access by creating a wide area network (WAN). Schools connected to their district's WAN in one of four ways: fiber, wireless licensed, wireless unlicensed, and copper. Table 1 summarizes these four connection types, along with their performance trade-offs in terms of speed and reliability. It also states the percent of schools using each type, as of May 2007 (before the implementation of the North Carolina Connectivity Initiative).[4]

The second prong of the network was that each district connected its WAN to the public Internet. Districts negotiated yearly service contracts with Internet service providers (ISPs) to provide this connectivity. Table 2 charts the two ways that districts were accessing the Internet prior to the Connectivity Initiative, along with the costs and benefits of each approach.[5]

District administrators struggled to negotiate contracts with third-party Internet service providers. Providers typically charged by amount of traffic over the connection, so, fearing outrageous charges, most districts kept a tight cap on their connectivity. Many of the districts had developed mechanisms to get by on as little bandwidth as possible. They had traffic-shaping tools—networking appliances that managed application traffic and optimized wide area networks—that could turn applications on only when they were needed. Furthermore, individual districts had

The K–12 system had a two-prong network architecture:

1. District-wide area networks (WANs)
2. Connection from each WAN to public Internet

[3] "Technology Counts 2006," Education Week, May 2006, cited in "Developing Regional Education Networks," Business Education Technology Alliance 2006 Report to the State Board of Education and Joint Education Oversight Committee, May 2006, http://www.e-nc.org/documents/0000/0006/betabrief.pdf, accessed October 2010.

[4] Dave Furiness, Director of Network Consulting, MCNC, and Joe Freddoso, President and Chief Executive Officer, MCNC, contributed to this table. Also http://en.wikipedia.org/wiki/Broadband_Internet_access, accessed October 2010.

[5] Ibid.

Table 1 *Overview of connection types for district WANs*

Connection Type	Description	Speed[1]	Reliability	% of Schools, May 2007
Fiber	Optical fiber is a thin, transparent fiber that transmits light. It is flexible, which allows it to be bundled into cables. District typically contracts with a service provider to install this "to the curb."	10 Mbps to 10 Gbps	Extremely reliable. It is especially advantageous for long-distance transmissions, because light travels through the fiber with little attenuation.	84.6%
Wireless Licensed	District typically contracts with a wireless licensed provider to connect its schools using radio spectrum, which the provider has licensed from the Federal Communications Commission. Wireless is usually only used in hard-to-reach rural areas.	50 Mbps to 1 Gbps	With advanced wireless technologies, its reliability is approaching that of fiber. Because it uses dedicated spectrum, it has less interference than wireless unlicensed. Requires a line-of-sight, meaning that the signal must be unobstructed by hills or heavy foliage.	5.3%
Wireless Unlicensed	District contracts with a wireless service provider, or else a district technology manager buys routers, etc. and arranges his own patchwork of antennas mounted on radio towers, farming silos, or other tall objects to build a self-made WAN. In either case, the network uses unlicensed 802.11 Wi-Fi radio spectrum.	10 Mbps to 54 Mbps	Reliability varies but poor compared to fiber and wireless licensed. Commercial (low-grade) modems, routers, etc. use whatever spectrum is available, and therefore are competing with all kinds of other things, such as cordless phones and other radio wave emitters, even microwave ovens.	5.9%
Copper	Data travels over telephone lines.	Up to 1.5 Mbps	Least reliable, partly because the physical infrastructure is often old. Many phone lines are over 30 years old, resulting in decay.	4.3%

[1] These technologies have broader ranges for speed than those listed in this chart, depending on how engineers configure them. This chart, however, indicates the speeds specific to how district personnel were using the technology for North Carolina schools. Speeds on this chart refer to download (i.e., to the customer) speeds. Gbps stands for gigabit per second. Mbps stands for megabit per second. Kbps stands for kilobit per second. 1 Gbps = 1,000 Mbps = 1,000,000 kbps. The Federal Communication Commission's 2010 definition of broadband states that "broadband" begins with speeds as low 200 kbps, although its National Broadband Plan sets a target of actual download (i.e., to the customer) speeds of at least 4 Mbps and actual upload (e.g., from the customer) speeds of at least 1 Mbps to yield adequate broadband. See http://www.fcc.gov/cgb/consumerfacts/highspeedinternet.html and http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db0720/FCC-10-129A1.pdf, accessed October 2010.

Table 2 *Overview of district connections to the Internet*

Connection Type	Description	Costs	Latency Issues	% of Schools, May 2007
NCREN	The North Carolina Research and Education Network is the nation's first, and regarded as among the best, statewide regional optical networks.	NCREN buys bandwidth through an institutional buyer's consortium to secure the best rates possible. This allows districts to take advantage of tier-one Internet access at the same prices that large urban universities pay.	Optimizes traffic between the district and instructional and administrative content that the state delivers.	8.7%
Third-Party Provider	District contracts with an Internet-service provider (e.g., Time Warner, AT&T) for a given amount of capacity for the year.	If district finds it needs more capacity as the year progresses, it pays high fees for these overages. Capacity estimates and fee structures are hard for districts to navigate.	District has no control over service provider's traffic. For example, to connect Asheville to Raleigh, provider might route packets from Asheville to Washington, D.C. to Atlanta to Raleigh, resulting in a lag.	91.3%

trouble enough hosting and managing their server infrastructure, managing their applications and content, and keeping their technology up to date.

Complicating matters, many districts were trying to use federal E-Rate funds to pay for their WANs and Internet access. The E-Rate program provided discounts to schools, districts, and libraries across the United States to help them obtain affordable telecommunications and Internet services. In the years from 2002 to 2006, districts on average requested a total of $81 million per year in E-Rate monies, but only received 64 percent of these requests (Appendix C shows E-Rate requested amounts versus committed amounts for 2002 to 2010). "It was disheartening that so much money got left on the table," said Ed Chase, DPI E-Rate coordinator. Funding was determined through an algorithm that factored in average daily membership (ADM)—or attendance—numbers, which meant that smaller districts in rural areas had a harder time obtaining sufficient funding to provide for their pronounced connectivity shortfalls.

In addition, E-Rate was infamous for its bureaucratic application process and outdated administration system. Review and approval of applications caused up to an 18-month lag time between the districts' planning and application process and

receipt of the federal funding. Typically districts filed applications in November of the prior fiscal year for the subsequent year. "You have to plan 18 months in advance, and from a local perspective that is very difficult," Chase said. Districts had to deal with forecasting Internet capacity needs long before they knew the capacity requirements of their applications. Furthermore, staff turnover during the application process often meant submitted applications were not fully completed because an incoming district administrator had missed a deadline on any already submitted application or was not aware an application needed follow up.

Districts had to forecast Internet capacity needs at least 18 months in advance to apply for E-Rate funds.

Studying the problem

Against this backdrop, a movement began in the North Carolina statehouse to make equitable broadband access a priority across the K–12 system. In 2002, the North Carolina General Assembly established the Business Education Technology Alliance (BETA) and named as its chair Bev Perdue, then serving as lieutenant governor.[6] The alliance included key business, education, and local policy leaders, and its purpose was to advance the integration of technology into the state's school system.

Among its several objectives, BETA decided in 2004 to launch a state-wide school connectivity upgrade. Perdue lobbied the North Carolina General Assembly for $100,000 to conduct a feasibility study to create a plan and budget for the project, and she enlisted Myra Best, executive director of BETA[7], to help secure legislative approval. Best met with the major state committees that were working on technology. Her aim was to communicate BETA's vision and gather support. "We had to identify the right champions. It made no sense to do things separately," she said. "We knew everyone with a stake in technology needed to be in the loop from the outset."

Perdue's and Best's efforts were successful. During the July 1, 2005 legislative session, the General Assembly agreed to the study. It directed Perdue's team to use the allocation for two purposes: to (i) evaluate the statewide status and adequacy of existing broadband connectivity and education technology, and (ii) recommend

[6] Perdue was elected governor of North Carolina in 2008.

[7] In 2009 Governor Purdue named Myra Best as special advisor to the governor on education and education innovation.

ways to maximize the use of existing public and private network resources to support services for K–20 schools.[8]

Purdue used a collaborative strategy to accomplish this mission by assembling a team that included representatives from the e-NC Authority (e-NC);[9] the Friday Institute for Educational Innovation; DPI; the state-run Office of Information Technology Services; MCNC, the nonprofit that ran NCREN; the University of North Carolina system; the North Carolina Community College system; the K–12 sector; network service providers; and other telecommunications companies. "Bringing the various players to the table right from the start was, in hindsight, the best way to approach this," Best said. "Everyone could then see there was no hidden agenda. We helped educate everyone along the way. It meant we could have substantive conversations about goals right from the outset. It put the issues on the table from the beginning and provided a public forum to address them."

The study recommended leveraging existing resources, such as the NCREN network and E-Rate funds.

Jane Patterson, director of e-NC, led the team during this phase. The team collected data, reviewed current infrastructure, and developed designs for upgrading infrastructure. In May 2006 it published a full report titled "Developing Regional Networks," which included the following recommendations:

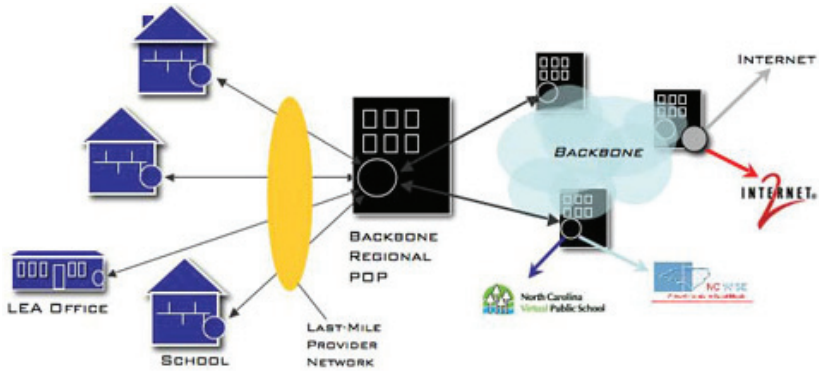
1. Extend broadband to all schools.
2. Leverage statewide resources (e.g., NCREN, state government, UNC, Community Colleges, North Carolina Independent Colleges and Universities, K–12, and e-NC).
3. Promote cooperative regionalism, inviting regional networks and resources to contribute capacity for the good of the whole.
4. Leverage best practices to optimize E-Rate.
5. Provide state funding to extend the statewide backbone structure, cover connectivity costs, and provide support services.[10]

[8] See http://www.e-nc.org/public/beta, accessed October 2010.

[9] Governor Easley established the e-NC Authority in 2003 as a government agency charged with improving rural Internet access.

[10] "Developing Regional Education Networks," Report to the North Carolina General Assembly by the e-NC Authority Per Session Law 2005-276, May 2006, http://www.e-nc.org/documents/0000/0005/beta_report.pdf.

Figure 1 *Blueprint for connectivity—NC EdNet*



Developing a scalable model

Pursuant to the report's recommendations, in 2006 the General Assembly passed Senate Bill 1741, which allocated $6 million non-recurring as an initial investment in a North Carolina School Connectivity Initiative. It directed the School Connectivity project team[11] to use this money to begin to expand broadband at schools, selectively build out networks to rural and underperforming schools, and develop a statewide model for scalable implementation.[12] Perdue, Patterson, and Best appointed Emer of the Friday Institute to serve as the lead planner.

Emer and his team conducted site surveys at over 40 districts to assess their needs, talked with peer states about the possibility of setting up an E-Rate consortium, interviewed representatives from existing K–12 statewide networks, and conducted four connectivity pilot tests at select districts. These activities led to the release of a detailed School Connectivity Implementation and Operating Plan,[13] which outlined a roadmap for building new network architecture to support North Carolina's schools. Figure 1 depicts this new architecture, which the project team called "NC EdNet."[14]

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[11] The project team at this point included representatives from the Friday Institute and other experts from North Carolina State University, MCNC, DPI, and the e-NC Authority.

[12] See http://www.connectivity.fi.ncsu.edu/overview/, accessed October 2010.

[13] A summary of the plan is available at http://www.connectivity.fi.ncsu.edu/status/, accessed October 2010.

[14] See http://www.connectivity.fi.ncsu.edu/overview/, accessed October 2010.

The NC EdNet architecture featured the following design elements:

- A shared education backbone that made use of existing core networks—primarily NCREN, but also others, such as the state government's network
- Fiber-based WAN solutions at the district level wherever possible
- Local (last mile) service providers and regional Internet service providers connected to the shared education backbone
- Common service agreements with last-mile providers, negotiated by the state
- All 2,400 school buildings in the system equipped with remote measurement and monitoring
- An E-Rate service bureau to help districts obtain funding
- A network engineering services bureau to provide schools with ongoing technical consulting
- An opt-in model, allowing districts to participate voluntarily

MCNC had to bid for each district's business against third-party Internet service providers.

One of the advantages that the team leveraged was North Carolina's proliferation of robust local networks, which could be linked to create a stronger shared network. For example, WinstonNet was a robust local network built in the Winston-Salem region under the auspices mostly of Wake Forest University and already a node on the NCREN backbone. But WinstonNet only supported higher-education entities, not K–12. WinstonNet had essentially done the hard work of digging the holes in the ground and laying fiber. But it lacked the expertise to operate the network once in place, so it kept about a half-dozen strands of fiber for its own use and offered the rest back to the local service provider (Duke Net) to sell, in return for permanent access to the Internet and support. The arrangement was a win-win. The Connectivity team seized upon such networks to provide connection possibilities without requiring new construction.

NCREN itself presented a huge opportunity for the project. It already covered a significant portion of the state's districts. Additionally, MCNC, the nonprofit that owned and maintained NCREN, had leverage with commercial providers, such as Emarq, now CenturyLink, AT&T, and Time Warner. "Our experience was that the private service providers would gain business in the connectivity initiatives MCNC undertakes," said Joe Freddoso, Chief Executive Officer of MCNC. "We want to create private sector opportunity with school and university connectivity. As the districts use more and more bandwidth, we knew the size and value of these local circuits would increase."

MCNC offered a remarkable cost advantage compared to third-party Internet service providers. Because of its $40 million endowment, MCNC could lease its

The project depended on high-profiled leadership to generate legislative and private-enterprise support.

bandwidth at cost. "But it wasn't a given," Freddoso said. "MCNC had to bid for it against commercial providers, many of whom had existing service contracts with the districts." MCNC had a strong advantage, however. "MCNC had run the university network for years," Freddoso said. "This was a valuable sales tool... to win the hearts and minds of the districts. It was much easier to make them understand our capabilities." A counterpoint to this advantage was that universities had had exclusive use of the network and considered it their property. "Anything that risked compromising their service wasn't worth going down in their minds," said J.B. Buxton, deputy superintendant of the DPI. "But Joe Freddoso had a real vision for MCNC and the role it could play. He also had credibility, knowledge, and trust of the backbone's constituents, which allowed him to persuade the universities it could work."

MCNC's big endowment could help it build out the remaining network, and such generosity would generate significant goodwill with the legislature. "MCNC gave us a partner with something to gain, but also something to give," Buxton said. Freddoso and his organization saw the project as an opportunity to do something valuable for the state. "The state was at risk of losing this asset if we didn't show we knew how to use it across all of education," Buxton added.

Launching the implementation

By September 2007 the request for a recurring allocation to fund the full implementation was on the state's legislative agenda as one of then Lieutenant Governor Perdue's top priorities. From the outset, the high profiles of the project's leadership were critical in making headway. Best led the team of public and private organization leaders. "She was really the hammer that drove the project and kept everything on track, helping to run interference for some of us technology folks who did not have a lot of state politicking experience," Emer said.

Buxton added, "Myra dealt with the constant policy questions a project such as this ignited at the legislator level, but she also brought together the service providers and other private enterprise who, up until then, had not been very cooperative." The initiative benefitted immensely from key legislative support, both from Perdue and Rep. Joe Tolson (D-Edgecombe), co-chair of the Joint Legislative Information Oversight Committee. Perdue and Tolson made sure that the project was part of legislative conversations at the committee and leadership levels.

The Connectivity team proposed a three-year implementation period, funded with a $24 million recurring line item. Table 3 shows the proposed budget.[15]

By 2008, the General Assembly pledged a recurring line item of $12 million annually to fund the three-year implementation. In 2009, the General Assembly allotted an additional $10 million per year, which brought the total to $22 million annually. "Of course we asked for more....But we were able to move forward and make it work," Emer said.

Among the first priorities during the implementation phase was garnering the support of districts. While Best lobbied the Assembly for funding, Buxton and his team at DPI focused on winning over the districts. "Initially the project was not received warmly at all in the remote districts," Emer said. There were a number of reasons for this, including entrenched skepticism toward representatives from the state's information technology group, concern about outside decision makers in local matters, and a lack of understanding about the technology itself. Technology directors from some districts were among the most vocal critics, and many lobbied against the team and the project.

Emer was especially aware of this challenge and designed the implementation plan with cultural issues in mind. For example, he suggested that districts opt in to the program, rather than requiring mandatory participation. The state-led program had to compete in terms of rates and services against third-party providers. Emer then worked tirelessly to sell the program to district tech directors.

The team further mitigated district resistance by offering a number of olive branches. Among the most important was the establishment of an E-Rate service bureau in year one of implementation (FY2007–08) to help districts obtain federal funding. As Table 3 indicates, the Connectivity team planned for E-Rate monies to comprise close to half of the public revenue for the project. The E-Rate program offered huge discounts, enough to reimburse some of the network build out, pay ongoing fees in re-negotiated, lower-rate structures with local providers, and cover the costs of individual districts' diverse range of technology needs. As stated earlier, districts faced roadblocks in capturing these funds and left significant money unclaimed.

The team set up an E-Rate service bureau to help districts obtain federal funding.

[15] School Connectivity Team, "School Connectivity Initiative Implementation and Operating Plan," June 2007, courtesy of Philip Emer.

Table 3 *Proposed pro forma implementation budget*

Funding	FY2006–07	FY2007–08	FY2008–09	FY2009–10
E-Rate Reimbursements		$19,309,246	$23,355,752	$30,289,291
Golden Leaf Grant		$400,000	$400,000	$400,000
School Connectivity Carryover		$4,600,073		
Cisco Fellow Grant	$200,000	$200,000		
Non-Recurring Appropriation	$6,000,000			
Recurring Appropriation		$24,000,000	$24,000,000	$24,000,000
TOTAL FUNDING	**$6,200,000**	**$48,515,319**	**$47,755,752**	**$54,689,291**

Operating Expenses	FY2006–07	FY2007–08	FY2008–09	FY2009–10
Project Leader		$(221,400)	$(221,400)	$(221,400)
Administrative Assistant		$(61,500)	$(64,575)	$(61,500)
E-Rate Staff (up to 7 FTEs)		$(477,978)	$(713,400)	$(713,400)
Engineering Staff (up to 7 FTEs)		$(619,920)	$(885,600)	$(885,600)
Connectivity Planning	$(430,927)			
Project Management	$(200,000)	$(200,000)		
General and Administrative		$(400,000)		
State Technology Plan		$(400,000)	$(600,000)	$(600,000)
Network Health Check		$(1,000,000)		
NC EdNET Operations Support		$(1,100,000)	$(2,200,000	$(2,200,000)
Backbone Operations		$(1,000,000)	$(1,500,000)	$(2,000,000)
Staff Computing Equipment		$(60,800)		
Miscellaneous		$(15,000)	$(15,000)	$(15,000)
Travel		$(125,000)	$(125,000)	$(125,000)
Existing Connectivity		$(16,155,997)	$(8,077,999)	
New Connectivity		$(16,667,123)	$(33,334,246)	$(47,837,849)
TOTAL OPERATING EXPENSES	**$(630,927)**	**$(38,504,719)**	**$(47,737,220)**	**$(54,659,749)**

Capital Expenses	FY2006–07	FY2007–08	FY2008–09	FY2009–10
NCREN Backbon Upgrades		$(5,300,000)		
Connectivity Pilots (4)	$(963,000)			
Establish NCV		$(300,000)		
LEA Equipment and Wiring		$(4,406,073)		
TOTAL CAPITAL EXPENSES	**$(963,000)**	**$(10,006,073)**		

Figure 2 *Total number of requests for E-Rate funds across North Carolina by year*

The team appointed Ed Chase to lead the effort to help districts with E-Rate. Chase began by driving across the state to meet with even the most remote districts. "I put 40,000 miles on my car that first year," Chase said. "The interactions helped me get on the ground. And providing the services and guidance to individual districts that hadn't been provided before gave me some credibility." As Chase traveled, he met talented technology directors, some of whom he asked to join his team of E-Rate experts. Making these connections on the ground was a critical piece of the puzzle. "It's difficult to be client focused if you are at the central office each day," Chase said. "People really do pay attention to that. If they feel somebody is regional to them, they feel part ownership. They feel these people and the work they are doing are their resources, not Raleigh resources. That took some of our clients aback. They're used to a Raleigh-centric approach."

Chase set in place services to provide ongoing E-Rate support. The first service was simple and effective: "On September 1st, we call people at the districts, and we tell them 'You have this invoice to turn in, do you need help? If you're new, we'll be glad to walk you through it,'" Chase said. The E-Rate team held workshops and offered one-on-one consultations to shepherd districts through their applications. It also offered to review applications to help districts avoid or survive a federal audit.

The E-Rate service began to show modest improvements by 2009. Figure 2 shows that from 2008 to 2010, districts across North Carolina submitted fewer requests for funds than they had in previous years, despite an increase in total

Figure 3 *Percent of E-Rate funds that North Carolina districts received per each dollar they requested*

requested dollars.[16] This suggests that they had become moderately more efficient in streamlining their paperwork. Figure 3 shows the total E-Rate funds that districts received each year divided by the total E-Rate funds that they requested.[17] This trend line indicates a higher yield in recent years, although it is unknown whether the E-Rate service bureau caused this improvement.

In addition to the E-Rate service, the Connectivity team moved quickly in year one to set up a network engineering service bureau at MCNC to help district engineers troubleshoot, manage upgrades, and design systems within district area networks. Cisco volunteered three full-time engineers through their executive-on-loan program to join the small team, called the client network engineering team. This team was accessible to all districts at no charge and served as a significant incentive to connecting to NCREN. "Providing this engineering service was a raging success," Freddoso said. "The districts used them every day." As of May 2010, the client network engineering team had completed network assessments or undertaken troubleshooting assignments in over 100 of North Carolina's 115 school districts.

Other year one implementation activities included developing and executing a plan to interconnect local providers with the NC EdNet backbone, identifying

[16] School Connectivity Team, "School Connectivity Initiative Implementation and Operating Plan," June 2007, courtesy of Philip Emer.

[17] Ibid. 2010 data is not yet available.

districts to transition to using NC EdNet as their Internet service provider, and completing a master plan to prioritize network development across schools.

In year two (FY2008–09), the team continued to build out the NC EdNet backbone, focused on providing solutions for underserved districts, and continued to prioritize the build out of fiber connectivity. Year three (FY2009–10) centered around finalizing the NC EdNet backbone and upgrading backbone capacity to support load.

By the end of year one, the Connectivity team reported that all 115 public school districts now were connected to NCREN.

Results

By November 2009, the Connectivity team had made measurable progress in improving the speed and reliability of school connections to district WANs across the state. Table 4 documents this migration away from copper and unlicensed wireless connections in favor of optical fiber.[18] By November 2009, only 6.5 percent of the approximately 2,400 schools in the state did not have fiber connecting them to their district WAN.

In addition, by the end of year one, the Connectivity team reported that all 115 public school districts now were connected to NCREN and using NCREN to access content and administrative applications from the state. This was among the most important milestones for the project. Furthermore, a portion of districts also were using NCREN to access the public Internet. Table 5 shows notable progress toward connecting districts to the Internet by leveraging NCREN.[19]

Improving connectivity facilitated the state's rise to a national leadership position in providing K–12 online learning opportunities. Its NCVPS was one of the largest and fastest growing state virtual schools in the country, with 15,721 course enrollments in 2008–09 and 30,000 enrollments projected for 2009–2010.[20]

The future

Improved connectivity brought new challenges. Some schools had been comfortable with their access under the old connection rates, which often prevented multimedia

[18] Dave Furiness, Director of Network Consulting, MCNC, and Joe Freddoso, President and Chief Executive Officer, MCNC, contributed to this table.

[19] Ibid.

[20] "State Report Cards," *Quality Counts 2010,* January 2010, Vol. 29, Issue 17, http://www.edweek.org/ew/qc/2010/17src.h29.html?r=2018502993, accessed August 2010.

Table 4 *Change in connection types for district WANs*

Connection Type	% of Schools, May 2007	% of Schools, November 2009
Fiber	84.6%	93.5%
Wireless Licensed	5.3%	5.4%
Wireless Unlicensed	5.9%	0.9%
Copper	4.3%	0.2%

Table 5 *Change in method in accessing the public Internet*

Connection Provider	% of Schools, May 2007	% of Schools, November 2009
NCREN	8.7%	40.9%
Hybrid NCREN/Third-party solution	–	8.0%
Third-party provider	91.3%	51.0%

and streaming. While this limited many pedagogical tools, it also meant that schools did not have to worry about students accessing offensive or illegal content and other Children's Internet Protection Act (CIPA) concerns. As connectivity became a reality, the districts had to rethink their access policies and sought to improve their filtering configurations. The DPI's regional technology consultants helped, as well as technologists at NCVPS.

With increased connectivity, schools searched for ways to provide training and development for teachers to use new online technologies. In 2010, many classrooms were outfitted with digital technology—including SMARTboards—but some teachers reported that the new tools were not being used.

In 2010 the project began moving the state's 58 community colleges to the network. As of April 2010, 20 had been connected. The remaining 38 were scheduled for connection by June 2011.

The team also grappled with increasing bandwidth demand among districts, which was rising as fast as 20 percent per year or more. Districts that had adequate infrastructure at the time of the Connectivity Initiative are currently finding that their systems are under stress. "We're watching the load on all of the fiber connections, making sure there is always plenty of headroom," Emer said.

Reflections from project collaborators

Project leaders attributed the project's success to various factors. Best cited the collaborative nature of the team. "We were not a bureaucratic group," she said. "It was a true public-private partnership." Chase agreed: "The real secret to our success was, 'we' were trying to do this thing, rather than 'I.' That made all the difference." Buxton said, "There was no one throat to choke on this. Having a broad leadership team, with specific roles and a well-defined plan, had a strong impact on the project's success."

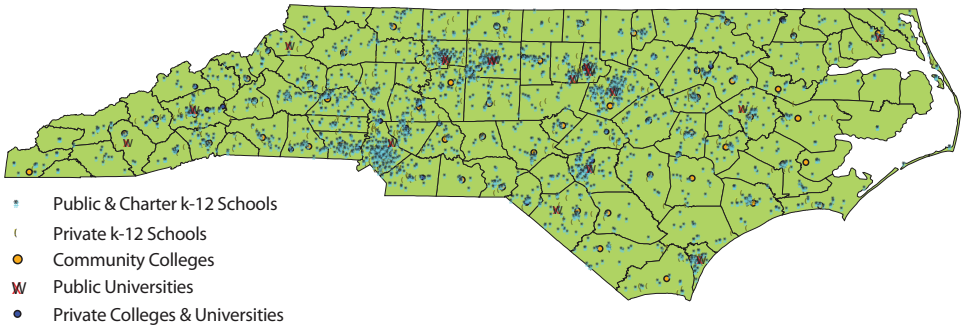
"Three years ago, we went through the gauntlet," Emer said. "How did we survive it? Key state leadership from Perdue and Tolson, some luck, a lot of communication and work. The order we did things in was important; we did it in the right order. First we got the $100,000 for the feasibility study. Then we got $6 million non-recurring funding for the pilot. And with the pilot's findings and a comprehensive plan, we were able to convince the state to fund the rest of the project. But it was a tenuous journey to get there. And we had to counter many skeptics who didn't think we'd get past the pilot stage."

Commenting on the impact of the project overall, Best said, "[The Connectivity Initiative] was one of the most successful public-private partnerships in North Carolina, if not the most successful to date." Governor Perdue had high hopes for the project's impact. "Everyone, no matter their zip code, now has access to the best education in the world," she said.

"The order...was important....First we got the $100,000 for the...study. Then we got $6 million...for the pilot. And [then we convinced] the state to fund the rest."

—Phil Emer, Friday Institute technology director

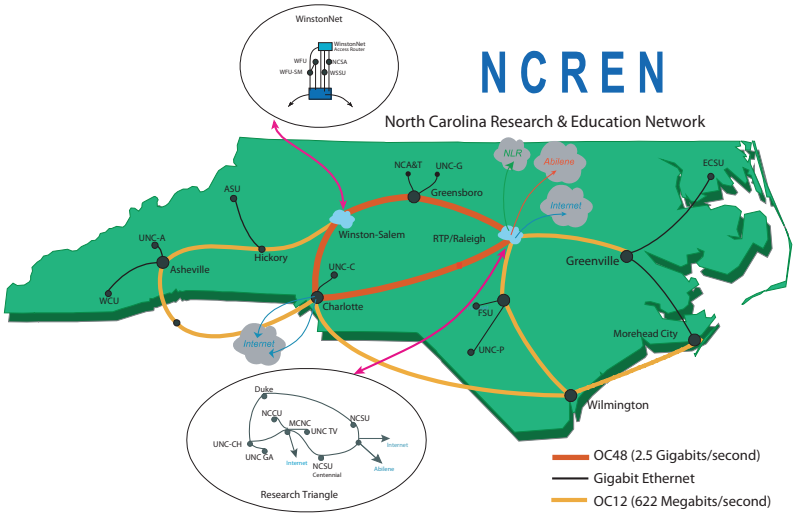
Appendix A *North Carolina's Schools*



Based on information provided by the NC Dept of Public Instruction, the University of North Carolina, the Association of Independent Colleges & Universities, and the NC Community College System.

Source: "Business and Technology Alliance Report," 2007, http://www.e-nc.org/pdf/BETA_Report.pdf, accessed May 2010.

Appendix B *North Carolina's Research and Education Network (NCREN)*



Source: "Business and Technology Alliance Report," 2007, http://www.e-nc.org/pdf/BETA_Report.pdf, accessed May 2010.

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Appendix C *E-Rate funding data, 2002–2010*

Year	Total Requests	Requested Amount	Dollars Per Request	Committed Amount	% Committed
2002	2,820	$75,279,755	$26,695	$54,535,810	72%
2003	2,970	$88,495,608	$29,797	$51,906,099	59%
2004	3,111	$67,164,040	$21,589	$43,343,832	65%
2005	3,084	$81,582,579	$26,453	$58,330,732	71%
2006	2,081	$92,899,050	$44,642	$52,641,136	57%
2007	2,408	$85,109,824	$35,345	$65,183,022	77%
2008	1,891	$78,574,179	$41,552	$63,457,498	81%
2009	1,822	$84,802,573	$46,544	$70,034,445	83%
2010	1,955	$96,666,823	$49,446	TBD	TBD
TOTAL	**22,142**	**$750,574,432**			

Source: North Carolina Department of Public Instruction, 2010.

About Innosight Institute

Innosight Institute, founded in May 2007, is a 501(c)(3) not-for-profit think tank whose mission is to apply Harvard Business School Professor Clayton Christensen's theories of disruptive innovation to develop and promote solutions to the most vexing problems in the social sector.

Acknowledgments

Innosight Institute thanks the Joyce Foundation for its sponsorship of this publication as well as its ongoing support of Innosight Institute's education case study and policy work.

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