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Executive Summary

This Wireless Infrastructure Plan is one part of the Friday Institute for Educational Innovation’s work for the North Carolina Digital Learning Plan. The full plan, due in the summer of 2015, will address content, pedagogy, human capacity, professional learning, policy, funding, as well as technology infrastructure and devices.

The plan presented in this report builds upon the success of the prior School Connectivity Initiative (SCI), established in 2007, which has provided high-speed Internet access to every K-12 public school in the state. SCI is designed to increase Internet capacity to each school as demand grows, to ensure adequate connectivity for all students to benefit from digital learning. However, many schools lack the internal network infrastructure (commonly referred to as “Wi-Fi”) required to fully leverage the provided Internet connectivity. So while adequate Internet access may reach the school building, it does not reach each student or even each classroom. The goal of this Wireless Infrastructure Plan is to provide a roadmap that outfits every school with the internal network required to support the full use of digital tools and resources within all classrooms and other spaces in which teaching and learning takes place.

Through SCI, schools benefit greatly from the FCC E-Rate program, which has supported Internet connections to schools and libraries for the past 18 years. Beginning in 2015, E-Rate will support inside-the-school wireless networks and the necessary supporting infrastructures for all school buildings in a sustainable way. This is an important change for North Carolina schools, and this plan outlines how the State can maximize the benefit from the $2 billion1 that FCC has committed to funding internal connections during the initial two years this new program.

This plan provides a technical update about relevant networking technology trends. This is important to guide the planning and purchasing of equipment, so that new systems will remain up-to-date, can be expanded as needed over time, and can be managed by service providers in the future. One of the most important recommendations is to ensure that every classroom is equipped with a wireless access point: the device that allow wireless laptops and tablets to connect to the school internal network. In looking at future technological advancements, this will be necessary to support digital learning at scale.

The E-Rate Modernization Order allows schools to request E-Rate support for internal networks of up to $150 per student (pre-discount) over a five-year period. Based on the $150 per-student allocation, which the Friday Institute considers sufficient, the five-year cost for the approximately 1.5 million students in North Carolina would be $225,000,000. Analysis shows

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1 This cap was raised to $3.9 billion after the initial version of this report was released. See http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db1212/DOC-330986A1.pdf for most recent details from the FCC.
that the E-rate program could provide about 75% of this funding, if the State proceeds in a coordinated and efficient manner.

If the State and LEAs were able to fund about $10 million per year for the next 5 years, North Carolina would receive over $150,000,000 in federal E-Rate Category Two funds. This amount would provide every K-12 public school in NC with an up-to-date internal network that supports all digital learning needs. These funds for internal wireless networks would be in addition to the more than $100,000,000 in Category One E-Rate funding that North Carolina districts are already on track to receive for external connectivity through the existing SCI over the next 5 years.

The FCC regulations allow for a single application on behalf of a statewide consortium, with a central agency developing the application and ensuring appropriate use of the funds. This report proposes a consortium approach, with the State providing the required funding of about $10 million per year, as was done in SCI. North Carolina has obtained approval from the U.S. Department of Education to apply approximately $4.5 million of funds remaining in the NC Education Cloud Race to the Top grant, to help cover the cost in 2015.

North Carolina policy makers and educators will need to move quickly to optimize return on investment and be among the first consortium applications approved. It is possible that E-Rate funds will run out, so a coordinated and well-executed plan it required. This is an essential step toward providing equitable, modern, personalized digital-learning to North Carolina’s students, preparing them for college and careers.
Introduction

North Carolina is committed to providing the personalized digital education K-12 students need to be successful in college, in their careers, and as productive citizens in the 21st century. North Carolina has already made significant progress with statewide efforts, and many districts have digital learning initiatives well underway. However, much remains to be done to ensure that all students throughout the state have equitable access to high quality digital learning. Recent legislative actions that address preparing educators for digital learning, providing digital resources, and ensuring technology access across all schools, as well as the goals of the State Board of Education Strategic Plan, are important steps in moving forward.

The Friday Institute for Educational Innovation at NC State University, working in collaboration with policymakers, educators, business leaders and other partners from throughout the state, has been asked to develop the North Carolina Digital Learning Plan (NCDLP) to continue and accelerate North Carolina’s progress. This report, which focuses on the Wireless Infrastructure component of the North Carolina Digital Learning Plan, is the third in the series of deliverables in the Friday Institute’s contract to develop the NCDLP, pursuant to Section 6.11(g) of S.L. 2013-3601 and the scope of work approved by the North Carolina State Board of Education in April 2014. It builds upon the prior two deliverables:

- The Digital Learning Plan Policy Brief, submitted on June 1, 2014, sets the stage for the overall planning effort. The Policy Brief summarizes the rationale for the plan, North Carolina’s progress on the transition to digital learning, relevant recent Legislative and State Board of Education actions and the key elements of the K-12 digital learning transition.

- The Digital Learning Work Plan, submitted July 1, 2014, describes the organization, governance, and major tasks planned to develop the NCDLP. It describes our plans to ensure input from all stakeholder groups and to apply a data driven approach to developing recommendations.

As described in the prior deliverables, work is divided into the four major components required for the transition to personalized, digital learning in K-12 schools:

1. Content and Pedagogy
2. Technology Infrastructure and Devices
3. Human Capacity
4. Funding and Policy
More specifically, the following nine major questions to be addressed in the NCDLP:

Content and Pedagogy
1. How will North Carolina transition from funding for textbooks to funding for digital materials that are aligned with curriculum, remain current, and are effective for all learners?
2. How will existing systems, such as Home Base and the North Carolina Virtual Public School, support the transition to digital resources and digital learning?

Technology Infrastructure and Devices
3. How will North Carolina ensure that every public school has the technology, service, and support infrastructure needed to sustain robust digital learning?

Human Capacity
4. How will North Carolina build or enhance the capacity of all its teachers, school leaders, and district leaders, to fully utilize digital resources and meet the new digital learning standards?
5. How will North Carolina ensure that there will be a sustained pipeline of teachers and administrators prepared to support the K-12 digital learning transition?

Funding and Policy
6. How do State and local education policies and processes need to be updated and revised to further digital learning?
7. How does the digital learning transition impact school budgets and how can the digital learning transition be funded?

Cross-cutting
8. What exemplary approaches and lessons learned from local school districts’ digital learning initiatives should North Carolina build upon?
9. How can North Carolina best support current and future local digital learning transitions in districts throughout the State?

This plan addresses question #3 related to Technology Infrastructure and Devices, focusing on the critical and timely (due to the E-Rate application schedule) need to provide well-designed and up-to-date wireless infrastructure to bring effective Internet access into every instructional space in all K-12 public schools throughout North Carolina. This report incorporates the most recent changes in the “modernization” of the FCC E-Rate program; changes that will provide substantial benefit to North Carolina schools by now provide federal funding for wireless networks within every school building.

Future deliverables include an updated Policy Brief that will provide recommendations for consideration during the 2015 legislative session, a Digital Learning Feasibility Study and Assessment Report, and a Final Report; the schedule for each is shown in Figure 1.
This document provides a brief history of the highly successful School Connectivity Initiative, discusses changes to the FCC’s E-Rate program, explains school networks and emerging wireless technology trends, and finally provides technology and policy guidance for the next year. A goal of this document is to inform stakeholders of significant changes in technology and policy which, with proper planning and forethought, can be leveraged to North Carolina’s benefit in 2015.

**Background on School Connectivity Initiative**

The *School Connectivity Initiative* (SCI) was established and funded in Session Law 2007-323 §7.28(d), ultimately providing $22M in recurring funds to support high speed Internet connectivity to all North Carolina public schools. Today, state funding for SCI is $19.9M annually and is leveraged against more than $50M in disbursed E-Rate funding\(^2\). This program is the culmination of years of vision surrounding the 21st century classroom, and developing a North Carolina workforce poised to meet the challenges of the global economy.

Due to the success of the SCI, virtually every public school in the state is connected to the North Carolina Research and Education Network (NCREN) with a connection of 100 Mbps or better. NCREN then connects to the public Internet and provides access to a wealth of global educational resources. However, many schools lack internal network infrastructure to fully leverage this connectivity. Providing robust networking from the school building’s NCREN connection to the student’s desk must be a priority for digital learning to be successful.

In 2006, the e-NC Authority and the Business Education and Technology Alliance presented their "Developing Regional Networks" report to the General Assembly recommending the expansion of the North Carolina Research Education Network (NCREN) to the K-12

\(^2\) NC received $52.1M in priority one E-Rate disbursements in 2011, $56.7M in 2012, and is on track for $51M in 2013; source: Funds for Learning.
community and the development of a plan to provide scalable fiber-based Internet connectivity to all K-12 schools. As a result in the 2006 session, the General Assembly passed Senate Bill 1741\(^3\) allocating $6M non-recurring to expand the number of schools with broadband, to selectively build out networks to rural and underperforming schools, and to develop a scalable model for statewide implementation. Since the funding was non-recurring, projects were selected to provide the greatest impact on student achievement and to highlight practices that would serve as the model for a sustained and funded program.

In 2007, the Connectivity Implementation Plan was approved by the State Board of Education. Bills in the House and Senate, and the Governor's biennial budget, all recommended recurring funds for connectivity. The 2007 budget bill included a $12M recurring line item for the program. With additional funding, the Friday Institute and MCNC worked to finalize implementation plans, and begin the process of site and health assessments for LEA networks. This funding also provided a partial reimbursement for LEA Wide Area Network costs for the first time.

The goal of the SCI was to provide equity of access to broadband connectivity to all 2500+ schools in the state, while at the same time controlling cost and leveraging statewide purchasing consortia. The initial years of the program demonstrated that the state could achieve economies of scale, and as a result, the 2008 budget increased recurring funding to $22M for the initiative. The realization of this full funding allowed all schools in North Carolina to be connected to the statewide education backbone, NCREN, at adequate speeds to support 21\(^{st}\) Century Digital Teaching and Learning. The SCI appropriation provides funding to districts to cover the non-E-Rate share of Wide Area Network and Internet costs, pays for consortium-procured access to the NCREN backbone for all districts and Charters, as well as central support to LEAs for Client Network Engineering and E-Rate support services. The NC appropriation for SCI is $19.9M annually as of September 2014.

The SCI has effectively leveraged E-Rate under the legacy rule structure, and dramatically increased access while controlling cost. For example, in the Mooresville Graded School District, WAN capacity is 100 times greater than in 2006, with every school now attaching to the WAN with a 1 Gbps fiber connection. Additionally, upstream Internet capacity for the district has increased by a factor of 16 over the same time period. The Mooresville Graded School District has the highest consumption of Internet capacity per student in the state, yet through effective consortia management, costs have only increased by a factor of 5. It is also worthy to note, these increases were completed without changing the telecommunications provider; throughout this time period; Windstream Communications has been the exclusive provider of circuits to the district.

The School Connectivity Initiative continues to be a national exemplar for providing equitable access to Internet-based digital learning resources to all North Carolina students. The 2006 recommendation included provisions to increase funding incrementally to extend the program from beyond just the WAN connection, all the way down to the classroom. It was envisioned that these increases would be done in concert with rule changes to the federal E-Rate program.

While the program continues to fully fund WAN connections, student growth and the increased number of charter schools are putting stress on the program. Additionally, the expansion of digital learning to more students has further exposed the need to provide the same level of support and equity in school internal networks.

In the summer of 2014, the FCC released new rule changes to the E-Rate program that can greatly benefit North Carolina. These changes extend the E-Rate discount to equipment and services related to wireless networks inside schools. Expanding funding for the School Connectivity Initiative in 2015 will guarantee that North Carolina can fully leverage these rule changes, and ensure that every student has equitable access to broadband and digital learning regardless of their location in the state. The next section of this report focuses on the history of E-Rate, how it is changing and how SCI in light of the modernized E-Rate program, North Carolina can provide every student in every classroom with wireless Internet access.

**E-Rate**

In order to understand the impact and the importance of the 2015 changes to the E-Rate program, it is important to first understand what E-Rate is, and how it benefits North Carolina today.

**History of E-Rate in North Carolina**

E-Rate, as summarized by the FCC, prior to the 2014 modernization, is defined below:

“The schools and libraries universal service support program, commonly known as the E-Rate program, helps schools and libraries to obtain affordable telecommunications services, broadband Internet access and internal network connections.

Eligible schools, school districts and libraries may apply individually or as part of a consortium. Funding may be requested under five categories of service: telecommunications, telecommunications services, Internet access, internal connections, and basic maintenance of internal connections. Discounts for support depend on the level of poverty and whether the school or library is located in an urban or rural area. The discounts range from 20 percent to 90 percent of the costs of eligible services. E-rate

program funding is based on demand up to an annual Commission-established cap of about $2.3 billion.

The E-rate program is administered by the Universal Service Administrative Company under the direction of the FCC. Specifically, USAC is responsible for processing the applications for support, confirming eligibility, and reimbursing service providers and eligible schools and libraries for the discounted services. USAC also ensures that the applicants and service providers comply with the E-rate rules and procedures established by the Commission.”

Between 2008 and 2013, North Carolina received approximately $300M in E-Rate Priority One discounts, based on approximately $120M in state funding being applied to the purchase of qualified broadband connectivity services. During the same time frame, approximately $75M of E-Rate Priority Two discounts for internal networks and maintenance were dispersed throughout the state. However, due to nationwide increases in request for Priority One funds, virtually no Priority Two funds have been available for the last two years.

In North Carolina, Priority One funds were mainly focused on providing Internet and WAN connectivity to schools. SCI enabled these funds to be expended in a highly efficient and results-driven process. Priority Two funds were generally requested for all sorts of projects at the LEA or school level, with little or no coordination of effort at the State level. As a result, the utilization rate of Priority Two funds dropped to a record low of 48% in 2012, the last year in which North Carolina received any Priority Two discounts⁵.

The recent lack of Priority Two funding has caused the FCC to redesign the entire E-Rate program, with changes taking effect in 2015.

**Significant E-Rate Changes for 2015**

The changes announced in the summer of 2014 by the FCC represent the first extensive overhaul to the E-Rate program since its inception 18 years ago⁶.

Some of the more impactful changes to the program are:

- Discounts for voice, e-mail, web hosting, and other legacy services will be phased out over the next several years
- New method for determining the Urban/Rural status of a school and district
- District-wide Free/Reduced lunch calculations, rather than per-school
- New forms and processes used by USAC and the FCC

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• Termination of the Priority One and Priority Two designations, with new eligible services and products being placed in groups known as Category One and Category Two
• Broader eligibility for Category Two; in the past only the schools with the very highest NSLP participation were eligible for Priority Two funds
• A target to fund Category Two at a rate of $1B in 2015 and 2016 and hopefully beyond

In the past, the FCC E-Rate program focused on providing equitable Internet access to all schools based on the percentage of students in the National School Lunch Program (NSLP), with additional funds provided for schools that were considered rural.

Each year, if additional funds were available, Priority Two funds would be released to only the schools with the highest E-Rate discounts. These additional funds were used for a much broader variety of networking products such as switches and wireless access points. Under the new rules, Category Two funds will be available to a much larger percentage of schools in North Carolina, and with an expectation that nationally, $1B per year will be dedicated to Category Two above and beyond Category One funding. The list of eligible services and products under Category Two is significantly different than under the Priority Two rules.

The rule changes will allow North Carolina schools to leverage Category Two funds to build wireless networks inside schools, including the supporting wired infrastructure necessary to build these networks. Under the new rules, every LEA and most charter schools in North Carolina will qualify for Category Two funds at a discount rate of, on average, over 78%, if a statewide consortium application is used.

The 2015 changes also phase out items that were previously allowed under the Priority Two rules. For example, voice circuits, e-mail, and pagers will no longer be discountable under E-Rate. This policy change demonstrates the FCC’s focus on providing access to resources that directly reach students, rather than the overall IT infrastructure of a school.

To put the new Category Two program into perspective, it is estimated that, if North Carolina expends $49M in state and local funds within the next 5 years, E-Rate discounts would amount to $173M7. These funds, if spent in a coordinated and thoughtful way, would provide a wireless access point to every classroom in the state, as well as the infrastructure to connect the wireless network to the global Internet. The current State appropriation of $19.9M funding for SCI is still required for WAN connectivity, and will result in an additional $100M+ in Category One E-Rate discounts for related WAN services over the same 5 year period.

Together, Category One and Category Two funding sources would provide the infrastructure required for every student in the state to have equal network access to digital learning resources located anywhere on the globe.

7 Assuming statewide consortium discount rate of 78% and $150/ADM/5 year limit.
Overview of School Networks in North Carolina LEAs

There are four major components to the “network” used by North Carolina public schools. In reality, each of these components use different technologies, and is supported by different organizations, but ultimately each component transports data using a format called IP, or Internet Protocol. Together, these networks move data from student devices, through the school, then through the state, and on to the global Internet.

The four component networks are:
1. Internal school network (Local Area Network)
2. LEA Wide Area Network (WAN)
3. NCREN
4. The public Internet

Internal Networks in Schools

The networks inside the school building are called LANs, or Local Area Networks. Today these networks are built using Ethernet and Wi-Fi technology. The data rates to each classroom vary, but in the future every classroom should have a wireless access point, connected via at least one gigabit Ethernet cable. Fiber is generally only required in the school building when the distance between the network switch and the end device is greater than 100 meters, such as the connections between two wings of a large school building, or when speeds of 10 Gbps or more are required. Since fiber is much more expensive to deploy, its use inside schools should be limited to where absolutely necessary.

The industry standard for wireless LAN is commonly called Wi-Fi, or formally IEEE 802.11. The most popular standards in use in schools are 802.11g and 802.11n. Products based on these standards allow throughput on the order of 50 to 100 Mbps per access point. Most schools that have 1:1 programs or high numbers of student devices have one AP installed per every two classrooms. Other schools with smaller numbers of student devices may only have APs in a few classrooms where digital learning takes place. In the future, as more and more educational content is accessed via the Internet, each classroom will require an AP.

Work at the IEEE to develop higher speed networks is always underway, as technology is constantly progressing. The equipment used to build the wired portion of the school network has become largely commoditized, with the differentiating factors being the management systems rather than the switching features of the devices. Wireless products are less commoditized, as there is more engineering and product differentiation in the areas of radio design, spectrum management, device management, security, and capacity. Generally, wireless products are managed by proprietary systems, meaning that only one vendor’s wireless products should be used in any given school.

In the past, only E-Rate Priority Two funds could be applied to the internal school network, which limited the schools receiving E-Rate funds for internal networks to only those with the
highest percentages of students participating in NSLP. This has resulted in insufficient wireless capabilities in many schools across the state.

Research has shown that virtually every public school in the State is connected to the WAN at 100 Mbps or better. However, many schools lack internal network infrastructures to fully leverage this connectivity. Providing robust networking from the school building’s WAN connection to the student’s desk must be a priority for digital learning to be successful. The use of Category Two funds is an integral part of the solution to this challenge.

**Wide Area Network (WAN)**
Each school is connected to a central point in the school district, known as the LEA Hub. Inside each school is a device (typically a router or switch) that connects the internal school network (LAN) to a service provider network (WAN). Except in a handful of remote locations these connections are provided by the local telephone or cable TV operators. In North Carolina, the minimum data rate from a school to an LEA Hub is 100 Mbps.

The service providers own the wires and infrastructure of these networks, located in huts, along telephone poles and buried in the ground. Additionally, the service provider may own premises equipment at each school, which is the demarcation point of the Wide Area Network. The school’s wired LAN plugs into this premise equipment and from that point a service level agreement (SLA) ensures the school’s data arrives at the LEA Hub within specific parameters for delay and latency, and at a specific and agreed upon data rate.

These WAN connections are funded using E-Rate Priority One funds today, with each LEA filing separately at the district level. In the future, the way this portion of the network is architected will need to be improved, and the concept of the LEA Hub drastically changed as the current design does not scale efficiently to the data rates that will be required to support digital learning in the future.

For the foreseeable future, LEAs will continue to file for E-Rate Category One funds, individually to recoup the costs of these connections. This may be an area where improved efficiency in terms of E-Rate process could be found, but that is beyond of the scope of this report.

**NC Research and Education Network (NCREN)**
At the LEA Hub, every school in the district connects to a router which also has a connection to NCREN. In most districts, the LEA Hub is either located at the LEA Administrative Office or at a school with a large student population and sufficient wiring closet space to house networking equipment. The LEA Hub is a central point of failure in the current architecture; meaning that if the LEA Hub were to lose power, the entire LEA would lose connectivity to NCREN, and thus the Internet.
MCNC maintains NCREN, and in about half the LEAs, MCNC owns the fiber from the LEA Hub to the NCREN Regional Point of Presence (RPoP), where multiple LEAs, Community Colleges, UNC System Universities and other educational institutions also connect. The NCREN RPoPs are connected together across the state on MCNC-owned fiber to create a massive mesh network which allows every school, community college and university to interconnect to each other without using the public Internet. This same network also allows all of these institutions to connect to the public Internet in a highly efficient architecture, discussed in the next section.

The connection from the LEA Hub to NCREN is covered by E-Rate Priority One funds and the filing to USAC is completed by staff at DPI.

The larger LEAs currently connect to NCREN at multi-gigabit per second data rates, while smaller LEAs generally connect at 100 Mbps to 250 Mbps. MCNC monitors each LEA’s connection and as average sustained consumption surpasses a threshold, the circuit is automatically upgraded. This ensures that an LEA never becomes limited in its capacity to reach educational resources on the Internet. This monitoring and management is a key feature of NCREN, allowing schools to be freed from the fear of not having capacity to move forward with digital learning programs. In fact, the key network inhibitor to digital learning is the LAN, discussed above.

**Public Internet**

The Public Internet includes the resources most readers are familiar with, like Google, Live.com, PowerSchool, Facebook, and the like. These resources are located on public Internet connections. Through various agreements, Internet service providers agree to connect by exchanging traffic over connections. This interconnection of a multitude of service providers creates a mesh network which is colloquially called “the Internet”, but which in reality is not a single entity.

At the Charlotte and RTP NCREN Regional Points of Presence (RPoP), there are massive connections to commercial Internet service providers. In 2014 there is an aggregate capacity of well over 150 Gbps. In other words, NCREN is connected to large international networks like Level 3, AT&T, Time Warner and CenturyLink at massive scale and with substantial capacity. This connectivity ensures that students can access educational materials anywhere on the globe with ease. By consolidating purchasing power of the entire educational system in North Carolina, each LEA receives far more access to the public Internet than would be affordable if each LEA purchased the service independently. In fact some of the NCREN connections are “peering” arrangements, also known as Settlement-Free Interconnection, in which no fees are paid, but traffic is exchanged in a mutually beneficial arrangement. Other service providers charge NCREN for access to their networks. By consolidating traffic and increasing the settlement-free peering connections, NCREN will be able to continue to provide increased capacity while controlling costs.
The Internet connections with charges associated to them are covered by E-Rate Priority One funds and filed by DPI as part of the NCREN connection, thus making the Internet service virtually free to all LEAs.

**Important Networking Technology Topics and Trends**

As the state prepares for digital learning, it is important that technology decisions be informed, and that leaders understand the trends in the networking industry and how that will affect the delivery of digital content to students. The following section provides some insight into the more significant changes happening in the networking industry today.

Two forces are simultaneously at work in the transformation to digital learning. First, the concept of personalized learning drives content delivery to a model whereby each student interacts with educational content providers in a one-to-one paradigm, requiring a unique stream of data for each student. Secondly, more and more content over time will be accessed in the cloud rather than hosted on school or LEA servers. Furthermore, as the population of the state continues to grow, so too will the total number of students. These factors will greatly drive the need for increased wireless capacity as well as increased WAN capacity.

Historically, Wi-Fi vendors have promoted the concept of site surveys, where Radio Frequency (RF) analysis and mapping are performed at each location that requires wireless access. It is estimated that site surveys at all 2500+ public schools in North Carolina would cost upwards of $20,000,000. This amount of money could buy tens of thousands of APs. In the near future, in order to provide higher data rates, APs will be using signalling algorithms and frequencies that are known to be incapable of penetrating walls made of cinder block or drywall. Thus it is apparent that every classroom will require its own AP, and public spaces and other learning areas will also require additional APs. Rather than performing wireless surveys, LEAs are encouraged to assume an AP is needed in every single classroom and wire accordingly.

**Network Capacity**
While the FCC has a stated target for schools to provide 1Mbps/ADM, a more pragmatic approach is to provide an AP in every classroom and enough WAN throughput to ensure the 85 percentile peak rate remains below 60% of the WAN link’s total capacity. Other metrics such as latency and jitter are important, but to a lesser extent.

Any network implementation should be extensible to allow for a graceful migration to capacities from 1 to 10 Mbps per ADM over the next decade. The best way to accomplish this is to plan for a 5 to 7 year refresh cycle on access points and aggregation switches and purchase enterprise class access points that implement the latest standard.

**Spectrum**
The 2.4GHz spectrum has become increasingly crowded over recent years. Other protocols, just as Bluetooth, Zigbee (IEEE 802.15.4), and proprietary voice and camera systems also
use these frequencies. The IEEE 802.11 committee has not formally declared that 2.4GHz is “dead”, but no future development is occurring in this frequency band. Currently, all the advanced protocol development is focused on the 5GHz, as well as other new frequencies. Due to this fact, it is recommended that all future student devices and access points purchased include 5GHz radios.

**Content Filtering**
In order to receive E-Rate funds, the FCC requires LEAs to be compliant with the Children’s Internet Protection Act (CIPA). There are four key components to CIPA compliance:

- Develop an online safety policy
- Filter unsavory and harmful content
- Educate students on safe Internet behavior
- Monitor online activity by minors

Of these components the filtering of content is the most difficult in terms of technical challenge. As data rates of Internet and WAN connections increase each year, this task becomes even more challenging, since the processing power required to provide filtering is considerable, and it increases linearly with the speed of the link being filtered. Highly specialized, and expensive hardware and software is often utilized to filter high capacity links. The products and services used to filter WAN traffic are not covered by the E-Rate program, meaning that local funds are used to purchase this functionality. NCREN currently provides an option to filter LEA Internet connections with a product called Zscaler, for an additional charge to the LEA.

Most LEAs perform filtering at the LEA Hub, rather than at each school. This is a factor of how filtering technology is frequently sold by vendors. Some LEAs may choose to filter content differently for teachers versus students; for example, allowing access to YouTube by teachers, but not students. These are local decisions which any statewide filtering technology procurement needs to be able to address.

There is ongoing development and innovation in filtering technology and over time it is expected that a massive, statewide, configurable and adaptable filtering service could be economically provided by NCREN near the Internet peering points. More research is needed in this area, but it is recommended that the State investigate the options, possibly leveraging the combined buying power of LEAs and State agencies.

**Authorization**
One of the more important functions of the wireless infrastructure is to prevent unauthorized access to the network. This is a considerable challenge in the educational environment where each student may own several devices which they will attempt (with or without permission) to use on the school’s network.
Most vendors promote the use of IEEE 802.1X authentication along with RADIUS, LDAP and Active Directory integration. The use of site-wide Pre-Shared Keys in the K-12 environment is highly discouraged as it unlikely the PSK will remain a “secret” for long. The NC Education Cloud Identity and Access Management (IAM) Service could be leveraged for Wi-Fi authentication. This would enable users to securely access wireless networks using the same credentials (i.e. username and password) as other applications in the school. This will require integration work, but offers the best opportunity for protecting school networks and could provide excellent auditing and management capabilities.

Ideally, a statewide identity system would exist to provide centralized control of user’s access rights. This is an area that requires more exploration but could enable an LEA to control who and/or which devices have access to the guest network or the actual network used to provide instructional content.

**Power over Ethernet**

There are currently two standards for Power of Ethernet (PoE), which allow aggregation switches to provide either 15 Watts (IEEE 802.3af) or 30 Watts (IEEE 802.3at) of power to each access point. By using the same twisted pair cable for both data (Ethernet) and power, schools can realize significant cost savings for installation of APs as no high-voltage (110V) power is required to be run to each AP. Given the significant amount of processing power required to implement the new Wi-Fi protocols like IEEE 802.3ac, it is advisable that LEAs only purchase PoE+ switches with the higher capacity that IEEE 802.3at provides.

**Wireless Controller Design Point**

When originally conceived in the 1990’s, IEEE 802.11 wireless LANs were thought to augment the wired LAN, providing convenience for a small percentage of devices and users. With that design point, vendors developed *wireless controllers* to consolidate the management of the additional and unique functions required for robust enterprise-grade wireless networking. In this network model, all Wi-Fi access points are connected to one or more wireless controllers which provide centralized management of the RF spectrum, wireless parameters, and handling of all user data traffic in the controller. This centralized controller architecture simplified the design (and lowered the cost) of APs, allowing complex functions such as roaming, IP address assignment, and spectrum management to be removed from the APs and aggregated in the controller.

The centralized controller architecture worked well for a decade, but today it faces challenges in light of the pervasiveness of Wi-Fi connected clients. In the modern LAN of many enterprises, including many schools, the wired infrastructure now exists solely to connect the wireless access points to a core network. In light of this paradigm shift in the access network, coupled with the ever progressing pace of technology improvements, network equipment vendors have responded by developing *controllerless wireless access points*. In this network architecture, each AP has enough processing power and intelligence to cooperate with all the other APs in the LAN to provide the various networking functions such as roaming
and authentication. In this model, there still exists a management platform, often located remotely in the cloud, which provides non-realtime specific management functions such as RF spectrum optimization, log analysis and centralized control of the entire wireless network.

In a well-designed controllerless network model, there is no central point of failure, as each AP is able to continue to operate even in the absence of a connection to the remote management console. Instead of all user data traffic being funneled to a centralized controller, in the controllerless network architecture, each AP cooperatively handles the chores of handoffs and roaming, allowing traffic to be expeditiously routed to the core network and on to its final destination, usually the Internet.

In the K-12 environment, controllerless wireless networks have been very popular for a number of reasons. Generally, the APs are not significantly more expensive than the APs used in controller-based networks. Not having a controller, means there is one less device for school IT staff to be concerned with maintaining. Eliminating wireless controllers also eliminates a single point of failure in the network architecture. And, finally, as educational content becomes more and more cloud based, the idea of funneling all traffic to a central location within the LEA makes less and less sense.

Some LEAs do have significant controller-based wireless infrastructure installed. For example, one large LEA in NC has over 13,000 access points and over 30 controllers. But very few of these APs support the latest IEEE 802.11ac standard. LEAs are encouraged to consider strategies of migrating to controllerless network environments, not by discarding their fairly new controllers, but rather by migrating, on a school-by-school basis, to controllerless networks. This type of migration will enable a graceful transition and prevent the waste created by prematurely discarding APs. Some vendors that have historically sold controller-based networks now offer software or feature upgrades that allow their existing APs to be used in the controllerless network architecture. These new licensing fees and “transition architectures” must be evaluated closely. More than likely, it will be more cost effective for an LEA to migrate to a controllerless architecture on a school-by-school basis, rather than trying to retrofit previously installed APs. LEAs with limited installed base of wireless networking gear should consider a greenfield deployment of controllerless Wi-Fi.

It should be noted that controllerless architectures still require some of the functions provided by controllers, but rather than require a physical device to provide these functions, many vendors now provide this functionality in the cloud or in virtualized servers that an LEA can host. Two very important management features of any Wi-Fi management platform are the RF spectrum management and network authentication management.

RF spectrum management is the thoughtful design and placement of APs in a building, coupled with the selection of frequency and power levels that each AP will use. The management consoles provided by enterprise-grade Wi-Fi vendors enable IT staff to intelligently assign frequencies, power levels and other parameters, in a way that minimizes
interference between APs. The best vendors provide tools which do this automatically, often
times responding to changes in the RF environment without any human intervention.

Authentication and authorization of users on the wireless network is another critical function
for Wi-Fi management. In most K-12 deployments, the Wi-Fi equipment will use an industry
standard, such as RADIUS and IEEE 802.1X, coupled with an LEA directory, such as MS
Active Directory. It is important that LEAs select Wi-Fi gear that interoperates with the existing
directory infrastructure as it will be imperative to limit access to the school wireless network in
a fashion that ensures data related to the education of students is not impacted by guests and
other network traffic. The use of pre-shared keys for authentication is highly discouraged as it
provides no real protections since students can easily share the keys with unauthorized users
or use the network from unauthorized devices.

Bring Your Own Device (BYOD)
The term “BYOD” is often used to describe the use of any personally-owned device on a
school (or enterprise) network. The device could be the primary computation device, such as
a Windows laptop, iPad, or Chromebook, or it could be a secondary device, such as a smart
phone.

As the cost of technology declines over time, it may be possible to rely on a BYOD policy for
student devices, much like students provide calculators and other school supplies. However,
the wide scale availability of sub $100 computing devices is still a few years away, and it is
unlikely that an LEA could require students to supply their own computational devices while
remaining compliant with letter, and the spirit of “free public schools” as defined by the State.

While BYOD cannot be relied on as a solution, it can be a component of a solution, allowing
families with means to purchase devices, thus reserving public funds to provide computational
devices to those based on need. Regardless of how BYOD is viewed by the LEA, allowing
students to bring their own devices to class raises several questions that must be addressed
locally. There is no easy answer to any of these questions, and rarely can these questions be
answered in a vacuum, irrespective of the overall technology strategy in use in any given
LEA. This report serves as a discussion guide, rather than a solution on this topic.

LEAs should carefully consider these questions when considering policy related to BYOD:

- Considering the level of NSLP participation in your district, how likely are families
  willing and able to supply their own devices?
- How difficult will it be to support a heterogeneous computing environment? For
  example, if an LEA purchases content that only executes on a Windows platform, how
  will students that own Apple laptops or Chromebooks complete assignments related to
  that content?

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8 http://www.ncleg.net/Legislation/constitution/article9.html
● Who is responsible for supporting BYOD devices when configuration changes in the school network inhibit or disrupt student owned device functionality?
● Should the LEA require students to install and run various security applications, such as anti-virus, web monitoring, and mobile device management tools? And, if these tools are not loaded should the device be prevented from accessing the school network?
● Can BYOD devices be used for end of grade or end of class assessments? Will the use of student owned devices enable new vectors for cheating and skew test results?
● Should mobile devices, like smartphones, which are inherently BYOD in nature be given access to the instructional network, or only a guest network with limited throughput and a high level of filtering?
● Should LEA filtering rules be enforced on BYOD devices, even while the student is away from school or at home?

Statewide policy should not discourage the use of BYOD; however, it cannot be relied upon by the State as a panacea for digital learning. Each student must be provided equal access to all instructional content. Generally speaking, BYOD could free LEA resources to be used for economically disadvantaged students, while providing affluent parents more control and alignment with their home computing devices, but no BYOD policy will work equally well in every LEA.

Away From School Access
As the State relies more and more on digital content for K-12 education, the need for Internet access at home for all students becomes apparent. When an LEA is selecting content, it is important to understand the device and network required to use the educational materials, and to set expectations as to how homework may be completed. Some educational content providers design products specifically to enable “offline” use, meaning that the entire product, or module, can be installed on the device and function without an Internet connection once downloaded. Other products may only work if connected to the Internet.

A very large percentage of the citizens of the state live in rural communities or small municipalities. There are over 500 municipalities in North Carolina, but very few large cities. This fact, and many other historical reasons, have created a substantial lack of competition with respect to affordable home Internet access in North Carolina. Additionally, over 60% of North Carolina’s students receive free or reduced lunch subsidies, indicating that many parents cannot afford home Internet access.

Thus, the two broad categories of challenges with respect to away from school Internet access are:
● Physical access to broadband
● Ability to afford Internet access
A 2012 report\(^9\) and an interactive map\(^10\) produced by the FCC show that 15% of North Carolinians living in rural areas do not have physical access to a fixed broadband connection. These citizen live in areas that are either remote, or simply not economically interesting enough to service providers to reach with modern networking technology. The same report shows that only 2.1% of urban North Carolinians do not have access to broadband. It should be noted that the FCC defines fixed broadband in this context as 3Mbps downstream (from Internet to home) and 0.7Mbps upstream (from home to Internet). These data rates are just barely what would be required to support digital learning today, and unlikely to be sufficient after 2020.

The same report also highlights the issue of affordability. Only 13.8% of the households in North Carolina subscribe to fixed broadband connections at 3 Mbps or greater. That percentage includes all households, not just those with school aged children. However, for comparison is should be noted that the bordering states of South Carolina and Virginia have adoption rates of 14.1% and 62.8% respectively. In fact North Carolina has the lowest broadband adoption rate in the United States, indicating that the ability to afford home Internet access may be the greater of the two challenges for most citizens.

The issue of home access goes well beyond the K-12 Digital Learning Plan, since it impacts all family members and access to many resources and functions beyond those related to schooling. As this issue is addressed in North Carolina, to enable these students to complete assignments in the near term, after school access at school buildings and Internet access at libraries and community centers will be vitally important.

**Minimizing Technological Risk to Digital Learning**

Wireless networking has become incredibly complex in the last decade. Few LEAs are equipped with the staff to provide the mission-critical reliability required in the network of the 21st century school. LEA staff should be focused on forward looking technology improvements, innovation and student success rather than the day to day toil of keeping a network “up”.

With the new E-Rate rules of 2014, it is likely that the number of network service providers willing to extend their reach into the classroom will rise drastically. Instead of discreetly being concerned with Wi-Fi signal strength, in school LAN, wide area network and Internet access, the modern IT manager should simply be concerned with providing each and every student “access” to the wealth of digital content available today.

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Case Study: Idaho
In 2013, Idaho Senate Bill 1200\(^\text{11}\) provided one-time funding for school internal networks for all High Schools in the Idaho Public School System:

“$2,250,000 shall be expended for the installation, repair, replacement and support of a wireless technology infrastructure, in each public school serving high school grades, of sufficient capacity to support utilization of mobile computing devices by all students in such grades.”

This funding amounted to approximately $21 per ADM. The goal of this effort was to have a single vendor provide wireless access in every high school in Idaho. However, some districts, for various reasons, chose not to participate and asked for flexibility in vendor selection. In the following year, 2014, additional appropriations were provided and more flexibility was given to schools that wished to opt-out of the Statewide contract, but receive funding for their internal networks. The Idaho State Department of Education (SDE) developed a set of standards or baseline requirements that districts must meet in order to obtain state funds for wireless networking in schools.

A sample of the baseline requirements is provided below. Additionally, Idaho’s SDE has hired full-time staff to ensure compliance with the Wireless Requirements Policy, both for schools opting out of the statewide contract and in districts which use the statewide contract, as a way to ensure contract compliance by the vendor.

State funding for wireless networks to schools is contingent upon meeting the Idaho Wireless Requirements Policy requirements, some of which are listed below:

- The newest ratified IEEE 802.11 standards are to be utilized at the time of hardware purchase with periodic upgrades to the most current standards on a rotational basis once every 60 months or sooner.
- Provide both 2.4 GHz and 5 GHz access.
- Provide a minimum of -70dbm as measured on the 2.4 GHz spectrum to all areas where service is required. Signal strength will be measured by an industry-standard Wi-Fi measurement tool, such as the Fluke AirCheck or similar device.
- The solution must allow a multitude of wireless devices for students and educators to roam with transparent connectivity from different areas of the school or building without losing connectivity and without needing to re-authenticate.
- Minimum wireless signal strength\(^\text{12}\) of -70 dBm will allow almost all modern wireless devices to negotiate a connection with sufficient network capacity to stream video,


\(^\text{12}\) Typical Wi-Fi access point radio output is 20 to 24 dBm, which is 100 to 250 mW; -70dBm is equivalent to 100 picowatts; industry analysts describe -70dBm as an attractive target receive signal power goal.
participate in Web 2.0 interactive applications and generally have an excellent online educational experience.

- Provide cabling that is rated no lower than Cat5e (preferred Cat6) to allow copper connectivity at 1 Gbps, with no copper run that is longer than 100 meters.
- Wireless access must be provided in every “instructional and administrative area of the school.”
- At a minimum, provide quarterly per district and per school wireless utilization reporting to the State Department of Education, including total connected users, users per spectrum, and users per SSID.
- The solution should provide and deploy Power Over Ethernet switches, sized for the school’s needs, based on site analysis approved by the State Department of Education. Districts must define all areas at each site that are designated as instructional and administrative areas, where student learning or student study is taking place as each of these areas must be covered with Wi-Fi.
- Internet content filtering, as required by the Children’s Internet Protection Act (CIPA), must be included as part of the solution.
- Suitable architecture must be provided to allow for growth in the wireless network infrastructure if additional grades in the school begin to utilize the infrastructure or the population of the school utilizing the infrastructure grows. The solution must provide for growth in the number of devices per user as well as the number of users.
- System must have 99% uptime during school hours and 95% uptime at all other times.
- The solution must allow access to authorized users only. The solution must work in conjunction with the district’s network security policies allowing access strictly to those that are authorized to use it. Security will be definable by the district, both at an individual user basis and/or by class of users (educators, students, parents, administrators, etc.). Identification of a user must be unique to each individual (i.e. no pre-shared keys shared by users).
- The solution will be subject to validation testing, conducted by the State Department of Education, to confirm the solution meets or exceeds the functional requirements and the performance and reliability specifications as required herein. This Validation Test will include connectivity, usability and reliability during the first year. The SDE reserves the right to require additional testing. Tests performed by the SDE will distinguish between the wireless solution’s operation and performance on the Internet connection and the WAN links where applicable.

Analysis of the Idaho Case Study and Impact of New FCC E-Rate Rules
Idaho should be commended for taking such a progressive and forward thinking approach to enable digital learning. Like North Carolina, Idaho is a geographically large and diverse state with many students in rural areas. The State of North Carolina could learn from the work already done in Idaho, and improve upon their process. Many rural locations simply do not have readily available access to network engineers, creating significant support challenges for LEAs. The Idaho approach of purchasing network as a service alleviates this issue and allows
a third party with pooled resources to significantly lower the cost of the services as opposed to each LEA purchasing or implementing, individually.

However, the $21 per ADM per year that the Idaho Legislature provided appears to be less than would be required for a full-scale, statewide deployment in North Carolina. In fact, the original procurement in Idaho provided for only high schools to be equipped with Wi-Fi and service. The vendor that provides the service in Idaho to high schools is unwilling to honor the same fixed price in middle and elementary schools in Idaho, implying that the service is not currently economically viable and the vendor is attempting to limit losses.

The new FCC E-Rate policy allows for the Category 2 funds to be used at a rate of $150/ADM every 5 years; or an annualized rate of $30/ADM. The FCC believes, and has signaled this in various documents, that internal networks should cost less than $150/ADM per 5 years to build and maintain. This figure includes both the LEA portion and the E-Rate discount portion, meaning that for the approximately 1.5 million public school students in North Carolina, the cost of providing Wi-Fi and internal networks over the next 5 years should cost upwards of $225,000,000 based on the FCC assumptions. The FCC has stated that any application for E-Rate funds that shows a per student cost of greater than $150 per 5 years will be highly scrutinized. In aggregate, at a statewide level, this cost seems containable; however, there are likely some schools which, due to various environmental issues, may not be able to meet this goal.

Under the new FCC rules, funds are determined on a per student basis, rather than by number of classrooms, number of access points, or other metric.\(^\text{13}\)

One of the next challenges of the Digital Learning Transition Plan team will be to determine the appropriate density of Wi-Fi access points and throughput rates for students. This work will be used as the baseline for statewide RFPs when procuring internal network connections. As stated elsewhere in this report, the move to higher frequencies and larger bandwidths will likely necessitate a one-AP-per-classroom design. Careful planning and determination as to “where teaching and learning take place” will be needed. The Idaho procurement is somewhat vague in the definition and thus is a possible area of contention when measuring the performance of the vendor with respect to meeting the SLA of the contract.

The level of service provided in a classroom of, for example, 28 students is fairly straightforward and auditable; however, corner cases such as auditoriums, cafeterias, courtyards, stadiums, athletic facilities and hallways may be debated by LEAs and service providers as to their relevance and applicability to a managed service contract SLA. For example, some students may use their lunch time to complete assignments, while some

\(^{13}\) Very small schools can use a calculation based on square feet, but this has minimal if any impact on NC.
schools may use the cafeteria facility to host group study sessions or other classes. Crisper
definition on the coverage area is recommended for North Carolina.

**Applicability to North Carolina**
Utilizing a skilled managed service provider for the internal school network appears to be one
way to limit the risks associated with the new teaching paradigm and increased dependence
on networking technology for the delivery of educational materials.

It is recommended that North Carolina follow the vision of the Idaho model, with appropriate
refinements, updates and adaptations for North Carolina. Any procurement of internal network
equipment, should include a requirement to be “managed service provider ready”. This will
prevent the purchase of equipment that cannot be utilized by a service provider. The team at
the Friday Institute is skilled in this area and will produce stringent definitions that keep the
State’s options for vendor selection as wide as possible, but limit the models and devices
purchased to those which have the ability to be managed at scale. This approach will reduce
the chance that the infrastructure will be an inhibiting factor in digital learning.

**Proposed Plan For North Carolina: SCI 2.0**
Over the last decade the School Connectivity Initiative has provided unparalleled Internet
access to every school in North Carolina. No other state has the number of schools and
districts connected as efficiently as North Carolina.

The Friday Institute recommends that the lessons learned over the last decade, in providing
E-Rate discounted Internet access at the statewide level, be applied to solving the internal
school network challenge in light of the new E-Rate rules. Using similar techniques,
consortium procurement, uniform statewide standards and coordination, the State could
receive as much as $160,000,000 or more in E-Rate Category Two discount funds over the
next five years. This is in addition to over $100,000,000 of Category One discount funds the
LEAs are already on track to receive through the existing SCI.

To kickstart the next generation of School Connectivity Initiative, the remaining “NC Education
Cloud” Race to the Top (RttT) grant funds could be applied to establish wireless access in
thousands of high school classrooms as early as May 2015. The US Department of Education
has already approved these RttT funds to be used to procure school wireless networks as
outlined in this report. In order to leverage these funds to the maximum extent possible, the
State must act quickly. The rules and processes to obtain E-Rate funds are non-trivial, but
North Carolina already has the foundation of a capable team and resources in place; namely
the team already responsible for the existing statewide consortium E-Rate processes.

**Execution Plan for SCI 2.0**
At a high level, the State, through the combined effort of the Department of Public Instruction,
the State Board of Education, the Office of the State CIO, MCNC and the Friday Institute can
leverage the existing E-Rate knowledge base and resources to develop a program by which the State files for E-Rate funds as a statewide consortium. Applying remaining Race to the Top grant funds in 2015 will likely yield E-Rate funds of between $3.50 and $5.66 for every $1.00 of State funds spent on eligible products and services. This program could cover wireless access points, aggregation Ethernet switches, cable installation, and WAN access/edge equipment upgrades.

The key principles of this approach include:

1. DPI leadership in filing with USAC, as a statewide consortium. This will require some resources at DPI to maintain paperwork and interface with USAC and FCC.
2. Developing minimal/baseline uniform standards for the network design, student devices and staff readiness, to which each school receiving funds must comply.
3. Allocating approximately $4.5M of remaining NC Education Cloud Race to the Top grant funds to fund the first year of this initiative.
4. Developing an opt-in method whereby LEAs may request support from the RttT funds, which will be distributed based on discount rate, need, anticipated return on investment and digital-learning readiness of the school.
5. Developing criteria for equity and maximum impact of federal E-Rate funds.
6. Developing an architecture that allows for LEA-wide and/or statewide managed network service providers to provide internal network management in future years, with the highest reliability and lowest cost possible.
7. Quantifying the gap in network resources between the installed base of 2014 and the needs for statewide digital learning, down to the school building level. This analysis will be dependent on surveys at each school building and cooperation of all LEAs and charter schools.
8. Identifying and securing sustainable funding sources to ensure continuity of network capabilities for the future.

Note that prior to 2015, E-Rate rules did not allow for managed network services to be discounted through the E-Rate program. Changes in 2015 will allow for managed network services inside the school building to be discounted. It is imperative that purchases in 2015 are made in light of the fact that managed networks will likely provide the lowest cost and lowest risk path to digital learning infrastructure in K-12 schools.

Over the next several years, legacy network services such as pagers, e-mail and voice lines, which had previously been covered by E-Rate, will be phased out. It will be up to each LEA to determine which of the phased-out services, if any, need to be replaced using local funds. While the changes in the E-Rate program may cause changes in the way school staff communicate, work and fund networks in the near time, the FCC has set out new policy that will greatly improve student access to digital educational content across the nation.
Steps to Maximize FCC E-Rate Funding in North Carolina in 2015

This section outlines the steps which must be taken in the October 2014 to May 2015 timeframe. Additionally, similar actions will be required later in 2015 in order to maximize E-Rate funds for 2016.

The Friday Institute, in cooperation with DPI and with extensive LEA input, is developing a database on a per-school basis which quantifies the current installed base of networking equipment and student digital learning devices. From this data, the cost to build networks suitable to support digital learning will be developed. This database includes NSLP data and other inputs that will allow DPI and the SBE to predict E-Rate discount rate with fairly good accuracy, enabling maximum ROI from grant funds to be realized.

Over the next months, more data must be collected at the school building level in order to identify need, gaps, and staff readiness for digital learning. Also during this timeframe the Friday Institute will develop a baseline standard for the network and student devices. These standards will be vetted with industry experts and digital learning experts at LEAs, DPI and other education-focused organizations. These standards will then form the basis for identifying the gap at every school and prioritizing resources.

These baseline standards will include technical targets for items such as:
- Wiring (cable type and installation certifications)
- Number of APs per classroom or APs per ADM
- Minimal acceptable signal strength, RF characteristics and data rate
- Wi-Fi standards and design points, such as roaming and authentication
- Interfaces to enable remote management for managed services
- Guidelines for controller usage and migration to controllerless architecture
- Student device technology and features

Once each school’s current installed base is known, it will be possible to determine the technological deficit and develop the list of equipment and services necessary to meet the architectural standard. In 2015, we recommend that the distribution of RttT funds for internal networks be based on need, technical readiness, staff readiness and an algorithm to maximize E-Rate funds provided to the State as a whole. We also recommend that preference be given to high schools in 2015, with expansion to all schools in 2016.

It should also be noted that any LEA that has additional local funds to purchase internal network equipment is capable of also purchasing using the statewide E-Rate consortium. Cooperation between LEAs and DPI will be vitally important in these cases. The FCC has stated that any single school spending more than $150/ADM for internal networks in a 5 year period will likely trigger an inquiry by USAC to determine the necessity of the funds. This could delay or impact the receipt of E-Rate funds.
In October 2014, a survey was sent to each LEA asking for input as to current network installed base and other data that is required to assess need and readiness. It is imperative that any LEA or school seeking RtT funds for internal networks complete this survey with the highest level of accuracy possible.

The Friday Institute has completed a market survey of available wireless technology and will develop, in conjunction with DPI, the technical requirements for the consortium RFP. Simultaneously, DPI staff will complete the necessary filings with the USAC to build the consortium. The consortium will be opt-in and any LEA that seeks to participate will need to complete a Letter of Agency (LOA) in November 2014. This LOA will be provided with the school-level survey, but only one LOA per district is required.

In the coming months, in preparation for the 2015 legislative session, the Friday Institute will work to develop and refine policies and goals to articulate the business case for recurring funding from the General Assembly. This funding would ensure that a digital learning infrastructure is available to every student in just a few short years. The FCC has committed $1B in 2015 and $1B in 2016 and hopes to fund internal connections for at least an additional three years following 2016. Since E-Rate funds are only guaranteed for the first two years, it is imperative that the State move quickly to complete all the filings, needs analysis, funding prioritization and competitive bids as quickly as possible. Small delays in the approval processes for any of the items could lead to the loss of millions of E-Rate dollars.

Through 2015, staff will need to assess schools and LEAs in order to build a prioritized list for future internal network deployment based on need, ability to execute, digital content readiness, educator readiness, E-Rate discount, and other factors that may be determined after the initial deployment.

Finally, in 2015 it will likely be prudent to release an RFP for managed internal network services. The development of this RFP and the E-Rate rules around this are still being finalized, but there is expected to be significant work required in this area to ensure that once installed, the wireless network in every school works optimally, each and every school day and for each and every student. Managed network services will be key to this vision.

North Carolina is ideally positioned to capture a large amount of the E-Rate funds in 2015 and beyond due to existing E-Rate programs and resources already in use in the state. This can only happen with the full cooperation of LEAs, DPI, SBE and the Office of the State CIO. The benefits to the students and teachers in every public school throughout North Carolina, and the savings to the State, make it imperative that this be a high-priority task for all involved.
**Glossary / Acronyms**

**ADM** - Average Daily Membership; in general, the number of students in a school or LEA

**AP** - Access Point; the device that connects wireless clients to the Ethernet LAN; this is sometimes called a WAP or Wireless Access Point

**DPI** - Department of Public Instruction

**E-Rate** - a federal program managed by USAC and overseen by the FCC, which provides subsidies to schools, libraries and rural communities for Internet access and related products

**FCC** - Federal Communications Commission

**Gbps** - Gigabits Per Second, 1 billion bits per second; a metric for data transmission. At one gigabit per second the contents of a full hour of educational video can be transmitted in less than a minute.

**IEEE** - Institute of Electrical and Electronics Engineers; the standards organization responsible for developing the Ethernet and Wi-Fi protocol standards, also know as 802 standards

**IP** - Internet Protocol

**ISP** - Internet Service Provider

**LAN** - Local Area Network; e.g. the network inside of a school building for example

**LEA** - Local Education Authority; a school district or charter school

**Mbps** - Megabits Per Second, 1 million bits per second; a metric for data transmission

**MCNC** - The not-for-profit entity which manages NCREN

**NCREN** - North Carolina Research and Education Network

**RF** - Radio Frequency

**RPoP** - Regional Point of Presence; a communications facility where WAN circuits are aggregated to a larger

**SBE** - State Board of Education
**USAC** - Universal Service Administrative Company; the company that administers the E-Rate program

**WAN** - Wide Area Network; e.g. the network from the school building to the LEA Hub

**Wi-Fi** - technically this stands for Wireless Fidelity, and is a trade association trademark name used for products that are certified to be compliant with the IEEE 802.11 wireless standard

**1:1** - one to one; a learning methodology where there is one digital learning device for each and every student

**802.1** - the suite of IEEE standards concerned with interoperation between other IEEE standard protocols; 802.1X is the most relevant protocol with regards to wireless authentication

**802.3** - the suite of IEEE standards for wired (Ethernet) LAN communication protocols; the standard provides many options and data rates ranging from 10 Mbps to 10 Gbps

**802.11** - the suite of IEEE standards for wireless LAN communication protocols; the newest commonly deployed protocol is 802.11ac