A STRATEGY PAPER FROM

CENTER FOR DIGITAL EDUCATION

Wireless Connectivity in Education:

New Tools to Scale Wi-Fi Infrastructure for 21st-Century Learning

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Good Morning, Class — Please Connect

The bring-your-own-device (BYOD) trend sweeping through K-12 and higher education is changing the face of teaching and learning as more students use their own devices at home and in school. A Project Tomorrow survey of more than 360,000 K-12 students revealed that "80 percent of students in grades 9-12, 65 percent of students in grades 6-8, and 45 percent of students in grades 3-5 use smartphones."[1] An Ed Tech survey conducted by Australia's Charles Sturt University found that 87 percent of university students want to revisit lecture material on their mobile devices.[2]

At Baruch College in New York City (see Baruch College sidebar on page 6), students and faculty are using mobile learning devices such as smartphones, tablets and laptops to enhance engagement, facilitate collaboration, increase productivity, receive individualized tutoring and much more. Coupled with a powerful wireless network providing fast and reliable connectivity to college resources, students can use their devices to view pre-recorded events and lectures, take class notes directly on electronic "handouts," roam around campus to conduct research, check on the availability of meeting rooms and other resources, and make any location — indoors or outdoors — an instant learning environment.

Baruch College is not an isolated example. Technological progress is allowing the education market to rely on wireless infrastructure and mobile learning devices to meet the vision of 21st-century learning, as well as logistical and funding challenges. In Colorado's St. Vrain Valley School District (see St. Vrain Valley School District sidebar on page 7), which spreads across 411 square miles, geographically dispersed administrators will soon be able to convene monthly leadership meetings via web conferencing instead of driving hours to meet in person. In the same district, students can use a wireless network to take online credit recovery classes during lunch instead of going to summer school. As a result, student retention and graduation rates have increased, along with per-pupil revenue.

A reliable Wi-Fi infrastructure is essential to adapting to these groundbreaking changes and successfully harnessing the potential of mobile learning devices and instructional technology to create a dynamic learning environment. Teachers spend hours preparing lesson plans and must maximize every minute of classroom time to cover course material. They simply can't risk adopting tools and pedagogy that rely on the network unless they can be sure it will perform predictably when needed. Reliable, high-capacity and fast Wi-Fi is quickly becoming an indispensable component of this network infrastructure — as essential as electricity and hard-wired broadband cabling — in the day-to-day operation of school districts, college campuses and university systems.

This Center for Digital Education white paper provides an overview of the network issues that education institutions grapple with as they introduce thousands of student and faculty mobile devices into the learning environment, and discusses new wireless network technologies that help schools harness the power of BYOD.

The Connectivity Condundrum

As K-12 and higher education institutions embrace mobile learning devices and instructional technology to implement their vision for a 21st-century learning environment, they are discovering that their networks aren't quite ready for prime time. A recent study among IT professionals revealed that 87 percent would need to upgrade their infrastructure — including wireless networks — in order to incorporate more instructional technology into the learning environment.[3]

General Network Challenges: Too Much, Too Far, Too Old

Whether the network is wired, wireless or a hybrid of the two, network specialists face unique demands in today's rapidly evolving learning environment.

- **Density of users, devices and data-rich applications.** The sheer number of users, devices and applications in today's network-enabled learning environment creates challenges that didn't exist a few years ago. Among other things, IT departments must be sure that myriad devices — on heterogeneous operating systems, in hundreds of models and using multiple carriers — can all concurrently access

the network. They must also provide adequate bandwidth to accommodate exponential growth in devices and data; deliver low bit error rates to support streaming multimedia applications that demand continuous connectivity; push the right applications to the right people; and provision, remediate and manage user and device credentials for a huge, diverse population.

- **Geographic distribution and physical coverage.** Some school districts and higher education systems are geographically distributed across hundreds of miles. Others have to provide network coverage for millions of square feet of real estate — including traditional classrooms, administrative offices, portable buildings, gymnasiums, labs, playing fields and off-campus, community-based access points.
- **Antiquated buildings.** Older buildings often have very basic problems, such as too few electrical outlets to accommodate everything from security cameras to interactive whiteboards and other instructional technology, inadequate HVAC systems for properly housing servers and other network equipment, and insufficient or non-existent Ethernet cabling.

Consumer-Grade Wi-Fi: The Weakest Link

With these networking issues, education institutions are also encountering additional challenges as traditional, consumer-grade Wi-Fi technology is pushed to its limits.

Wi-Fi today is a shared medium operating at what's known as "half duplex." This allows only one user to transmit at any given time. As a result, ensuring that users can get on and off a wireless network as fast as possible so others can do the same is a fundamental tenant of building a reliable Wi-Fi network.

As mobile learning devices proliferate, education institutions are facing the following challenges with their traditional, consumer-grade Wi-Fi implementations.

- **Poor reliability and performance.** The wireless signals coming from traditional, omni-directional Wi-Fi antennas (see Traditional Wi-Fi sidebar on page 4) are unfocused, transmitting and receiving signals in all directions at all times. This creates interference in the radio frequency spectrum and limits the ability to optimize signals to enhance performance, effectively diminishing the strength of the signal reaching a client device at any given time. As a result, data not only moves more slowly through the "air," but also is lost (or dropped) frequently, as obstacles and interference crop up — further delaying data transmission.

Reliable, high-capacity and fast Wi-Fi is quickly becoming an indispensable component of educational network infrastructure.

Adding more users and devices on the network compounds these problems. While these issues may be minimally acceptable when casually surfing the Internet, they become untenable when using media-rich applications such as streaming video or interactive whiteboards for instructional purposes.

- **Spotty coverage.** Wireless signals don't penetrate well through metal, concrete, glass and other materials that typically make up a higher education or K-12 campus. This impermeability creates blind spots in coverage. In turn, students and faculty either cannot access a signal in certain locations, or lose the signal when they move from one location to another.
- **Single-plane spatial orientation.** Because conventional Wi-Fi uses dipole (or basic) antennas that only broadcast on a single plane or polarization (see Traditional Wi-Fi sidebar on page 4), smartphones and other devices that have a different or more fluid spatial orientation may not be able to pick up or maintain a signal. As the device orientation changes, users can experience wild fluctuations in performance as the Wi-Fi network struggles to talk and listen to the device.
- **Complex device discovery.** Network resources such as printers and TVs were once fixed in one location with a network cable attached. With wireless technology, these resources can now be moved to wherever they're

Traditional Wi-Fi

Most of us are familiar with the traditional Wi-Fi access points that enable us to get a wireless signal in our homes. These access points typically have one or more antennas that broadcast signals in all directions on a single (usually horizontal) plane. That is, they are omni-directional. This omni-directional approach has inherent weaknesses that are especially problematic in environments with multiple access points and multiple devices.

Akin to tossing a rock into a calm pool, causing waves to emanate everywhere, wireless signals coming from an omni-directional Wi-Fi antenna are unfocused. In an environment with hundreds of Wi-Fi access points, this type of antenna can easily create "co-channel interference" with other devices — causing some of the data in a transmission to be lost. This, in turn, requires the dropped data to be re-transmitted, which further holds up traffic. Adding to the problem, omni-directional Wi-Fi diffuses the strength of the signal that reaches the client, which causes a delay in throughput (the rate at which data can travel through the system). Interference and poor throughput rates cause packets of data to be dropped and transmissions to be delayed.

needed. In order for users' mobile learning devices to "find" them, these resources broadcast messages to client devices advertising their location. The problem is an absence of specificity: An instructor, for example, usually needs to access a specific printer or TV, not all of them. Additionally, the instructor's device may have access to one virtual local area network (VLAN), but the resource resides on a different VLAN.

- **Centralized management.** Conventional, consumer-grade and even enterprise-grade Wi-Fi systems also lack more sophisticated capabilities for centrally managing hundreds or thousands of Wi-Fi access points. While centralized management isn't new, features such as band-steering, airtime fairness and smart wireless meshing are, and must be, simple to access and enable across a vast wireless infrastructure.
- **Lack of IT experience.** Although IT specialists have strong technical competency in many areas, they are not usually trained on how radio frequencies work to carry traffic through the air, or on how to plan, implement and manage wireless networks. If a problem arises and staff cannot fix the issue, students, teachers and administrators may not be able to use the network. In the long run, this impedes adoption of the network as an enabler of teaching and learning.

Smart Wi-Fi Technology Meets BYOD

To address the increasing scale of simultaneous users, devices, applications and locations that their networks must serve, institutions are adopting new technologies that are improving wireless services, simplifying management of the myriad devices now being brought onto campuses and, in many cases, saving money.

Adaptive Antenna Array Technology — Reliability, Performance, Ubiquity

One of the most promising Wi-Fi solutions for K-12 and higher education institutions is the innovation of miniaturized adaptive antenna array technology. Unlike consumer-grade Wi-Fi, adaptive antenna array technology uses software that allows antenna elements to self-focus the Wi-Fi signals to each client, creating stronger and more controllable transmissions. It is analogous to shining a spotlight on a specific place versus turning on an overhead light. As the word "adaptive" implies, this technology automatically adapts to — and learns from — the environment to find the best combination of antenna elements to transmit a signal. An adaptive antenna array system "listens" and "learns" from the response of data traffic from user devices. It uses these responses or packet acknowledgements as fuel for algorithms that determine the best combination of antennas to use at any given moment. If the software detects a drop in transmission speed, for example, it automatically seeks another antenna combination to minimize interference and maximize throughput. By working together, these arrays help ensure that wireless signals are strong, reliable and ubiquitous — even in buildings that are not Wi-Fi friendly.

Adaptive antenna array technology offers the following advantages over traditional, consumer-grade Wi-Fi solutions.

- **Helps ensure reliability and optimize performance.** By controlling the direction and strength of the wireless signal, adaptive array antenna technology helps data move

through the system more quickly and reliably, enabling high-capacity connectivity for high volumes of concurrent users. By minimizing packet loss and mitigating inference, this capability is essential as learning organizations incorporate streaming video and other media-rich applications into teaching and learning.

- **Adapts in real time to mobile devices' changing orientation.** This capability is especially important in an environment where students and faculty are using mobile learning devices such as smartphones and tablets.
- **Frees up IT and help desk staff.** Adaptive antenna arrays automatically tune each access point, obviating the need for manual tuning by IT staff. In addition, the technology's reliability and high performance mean that help desk calls for dropped or slow signals are virtually eliminated.
- **Enables instant network connectivity without cumbersome cabling.** Many schools simply don't have Ethernet cabling everywhere that Wi-Fi services are desired. Adaptive array antenna technology uniquely supports reliable wireless meshing. This allows an access point to simply be plugged into an electrical outlet rather than a hard-wired connection — using the radio frequencies themselves to establish a network connection to a nearby access point. Meshing is ideal for an auditorium, gymnasium, playing field or portable classroom that must be set up quickly to offer wireless connectivity.
- **Lowers cost of connecting geographically dispersed facilities.** Long range point-to-multipoint Wi-Fi bridges that use the channel-rich 5GHz Wi-Fi band can help education institutions extend their reach and connect to distant facilities without the need to contract for expensive and recurring broadband connections at every site.

Mobile Device Management (MDM)

Once a reliable network is in place, education institutions must find a way to systematically introduce thousands of unmanaged mobile learning devices and users to the network, directing those devices and users to the right network partitions and resources. Onboarding, securing and managing student devices not under the control of IT staff has become a major concern as wireless network computing explodes.

IT administrators must also manage the lifecycle of these devices and users in a way that prevents security compromises, restricts content as needed, detects and eliminates viruses, and complies with internal and external policies such as the Children's Internet Protection Act (CIPA) and federal privacy laws. Some of these requirements are to protect students on the network. Others are to ensure that the network operates optimally — for example, by preventing unlimited access to YouTube and other resources that consume large amounts of bandwidth.

Mobile device management (MDM) software helps learning organizations enroll, manage, secure, monitor and support students, faculty and devices on the network. Although many learning organizations are still focused on using MDM to meet basic requirements, MDM also offers sophisticated capabilities that can help take K-12 and higher education institutions to a whole new level of network integration into learning and teaching.

The following list outlines some of the things that state-of-the-art MDM technology allows IT administrators to do.

MDM Purchase Considerations

When choosing MDM software, education institutions should consider the following:

- Ease of software integration with existing network segmentation, security architectures, authentication protocols and directory services
- Features to streamline enrollment of users, devices and guests on the network
- Features to allow students, faculty and administrators to manage their own data usage, password resets and other user-specific administrative tasks
- Security features to enable secure authentication and single sign-on
- Encryption or other security features to protect student information, assessment data and other sensitive content as it travels across the network
- Flexibility to apply unique authorization profiles for specific users, roles and device types
- Features to simplify policy enforcement and to notify users regarding viruses, usage violations or other policy compliance issues
- Solution scalability and stability
- Training and support

Baruch COLLEGE

Increasing Productivity by Bringing Learning and Services to Students

Before Baruch College upgraded its wireless network to an adaptive antenna array solution, students had given up on the wireless network. Wireless coverage on the campus was spotty, slow and unreliable. Even with more than 150 Wi-Fi access points, Baruch could not provide consistent coverage as students and faculty moved around campus. "We had gotten by offering Wi-Fi service that wasn't very good because there had not been demand. But as students started bringing their own devices, demand shot up. It was important that we have ubiquitous services and also service that would support a growing use of multimedia on the campus, most of it stemming from the curriculum," explains Dr. Arthur Downing, CIO at Baruch.[4]

The new network was fully funded by student technology fees, and students had a key role in the planning process. Since implementing the new solution, students have enthusiastically returned to the wireless network. Forty percent of Baruch students are the first in their family to attend college, and many of them work full-time jobs. Time is precious, and students need fast, reliable connectivity throughout campus to do their work. "Our students have to be very economical when they're on campus. If they have a free moment, they want to know what they can get done right now," says Downing.

The wireless network meets a range of needs and enables learning to occur anytime, anywhere. "Students don't have to wait anymore," explains Downing. "Before, they had to go to a fixed facility or a designated space to do things, so they would go to a computer lab, a faculty member's office or a tutoring lab. Between their devices and our Wi-Fi network, these activities can now take place at any given space on campus because everybody can carry around the equipment they need." To further address the needs of its student population, Baruch has developed applications that help students maximize their time — for example, by using their smartphone to locate and reserve campus resources such as laptops, study rooms and video equipment.

Baruch is also using the new network to extend services and learning outdoors. It recently embarked on a project to build a plaza between two buildings. As soon as the plaza was approved by New York City, and in spite of severe winter weather, "I had to have Wi-Fi there," says Downing. "People couldn't understand, because it was so cold outside, but within two hours of activating the access points, and without any announcement, we already had 33 users. This is such a part of people's lives."

- Enroll and manage user/device identities and authorizations
- Tailor resource usage to specific user groups — e.g., allowing a specific user group to access YouTube or Facebook during a specific time, or allowing only teachers to access printers
- Push content to a device or erase content from a device
- Push content to a specific user at a specific location — e.g., pushing books, assignments or other content to a location-sensitive (i.e., GPS-enabled) device when the student enters a specific area
- Quarantine devices to specific networks or network locations (VLANs)
- Control which user-downloaded applications are available while the user is on campus
- Limit the amount of capacity a certain type of traffic or application (eg., YouTube, Netflix) can consume on the network
- Distinguish between a sanctioned device and an unsanctioned device and decide whether the authorized user can use the unsanctioned device to access resources — e.g., when a student's tablet is authorized but the student's smartphone has not yet been authorized

Finding the Money

K-12 school districts and institutions of higher learning are relying on tried-and-true methods, as well as more innovative approaches, to fund their wireless network implementations and upgrades. In some cases, they're even building on their wireless network success to gain funding and awards for additional education initiatives.

Education institutions can consider these and other approaches when seeking ways to implement an advanced Wi-Fi network.

St. Vrain Valley School District

Reaping Dividends from a Successful Wireless Network

When St. Vrain Valley School District in Colorado started testing vendor solutions for its wireless network upgrade, it took a "no holds barred" approach, doing everything it could to bring down the system being tested. "Our main objective was to break the product and see where and when those breaks occurred," says Joseph McBreen, St. Vrain's CIO.[5] But when it came to testing an adaptive array antenna solution, the evaluation team encountered a problem: they were never able to get the solution to fail.

"We had 60 concurrent devices streaming video from two classrooms and couldn't break this [access point], so we began pulling out iPhones, iPads, anything we could get a hold of to make it fail," explains McBreen. "Ultimately we had 78 devices pulling traffic off a single access point, and it wouldn't fail." At that point, the team was convinced that the adaptive array antenna technology was the right solution for the district, and have since installed over 1,000 access points across their school district.

To fund the new network, voters passed a mill levy override on real estate valuation, and their investment is paying off. Today, St. Vrain uses the new wireless network to serve more than 26, 000 students and 4,000 staff spread across 45 schools in 13 communities. Coverage extends across 411 miles and 3.7 million square feet of space.

More than improving access and productivity, what excites McBreen is that the wireless network enables a whole different kind of learning. "When we went to school, the lion's share of learning was recall and memorization, but with Wi-Fi and therefore access to the Internet, forward-thinking teachers can shift to higher-order functions such as collaboration, synthesis and creation," he says.

For St. Vrain, the success of the wireless network is also yielding dividends in other, less expected ways. St. Vrain was recently awarded $16.59 million from the highly competitive federal Race to the Top program. "When we wrote the grant, we specifically wanted to leverage our investment in our wireless network," explains McBreen. "The grant is filled with technology such as laptops and tablets for students. We would not have gone after the grant in that way were it not for the wireless network. We would have written the grant differently and we wouldn't have gone for technology."

- **E-Rate funding.** Under the Education Rate (E-Rate) program, a K-12 school or library can receive federal subsidies of 20 to 90 percent on telecommunications services, Internet access and network equipment. The percentage is based on variables such as the percentage of students eligible for the National School Lunch Program and whether the school or library is located in an urban or rural area. Awards can be in the millions of dollars; however, the application process is complex and schools usually require professional assistance in completing the application forms.
- **State and local bonds and mills.** Many communities place bond measures on the ballot to raise funds for education projects.
- **Corporate programs, nonprofit organizations and civic foundation grants.** These sources may offer cash awards, technology grants and other support.
- **Tuition and student fees.** Some schools are turning to students themselves to fund their wireless networks. Baruch College, for example, fully funded its extensive Wi-Fi network by charging it against the students' annual technology fees. The students offered to use the fees for this purpose and were active participants in the planning process.
- **Smarter allocation of funds.** Schools have been able to save tens of thousands of dollars per year in carrier fees by replacing fixed-line broadband connections with long-range Wi-Fi connections. In many cases, these Wi-Fi solutions pay for themselves in less than a year, while fixed-line connections entail significant monthly carrier fees.
- **Standardization and centralized procurement.** By standardizing equipment across the network and centralizing procurement, education institutions can negotiate bulk pricing, minimize training on new equipment and create other economies of scale. They can also use this approach to establish long-term partnerships that prove to be beneficial over time.

What Next?

Wireless connectivity is no longer just a "nice-to-have" resource at schools. It is indispensable in modern education institutions, especially as BYOD strategies and technology-based lesson plans are integrated into teaching and learning. However, consumer-grade and even many enterprise-grade Wi-Fi systems are no longer adequate in this era of user-, device- and data-dense learning environments.

Education institutions are eager to address these challenges and bring their networks up to speed. In a recent MDR survey of district technology directors, 85 percent of respondents identified the development of wireless networking as their top priority, a significant jump from 71 percent just a year earlier.[6]

Advanced Wi-Fi technology, such as adaptive array antenna technology, scales flexibly to provide reliable, high-performance network access to thousands of concurrent users and devices while minimizing capital costs, maintenance and training. When used with MDM tools, this technology creates the foundation for delivering world-class education anywhere and anytime.

Endnotes

1. Project Tomorrow, "Do You Know? Ten Things Everyone Should Know about K-12 Students' Views on Digital Learning," 2013, www.tomorrow.org/speakup/DLD2013_top10.html
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Headquartered in Sunnyvale, CA, Ruckus Wireless, Inc. (NYSE: RKUS) is a global supplier of advanced wireless systems for the rapidly expanding mobile Internet infrastructure market. With 2012 revenues of $214.7 million, the company offers a wide range of indoor and outdoor "Smart Wi-Fi" products to mobile carriers, broadband service providers, and corporate enterprises, and has more than 21,700 end-customers worldwide. Ruckus technology addresses Wi-Fi capacity and coverage challenges caused by the ever-increasing amount of traffic on wireless networks due to accelerated adoption of mobile devices such as smartphones and tablets. Ruckus invented and has patented state-of-the-art wireless voice, video, and data technology innovations, such as adaptive antenna arrays that extend signal range, increase client data rates, and avoid interference, ensuring consistent and reliable distribution of delay-sensitive multimedia content and services over standard 802.11 Wi-Fi. For more information, visit http://www.ruckuswireless.com.

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