City of Boston

Boston Optical Network Assessment (BoNET)

Table of Contents

INTRODUCTION AND EXECUTIVE SUMMARY

The City of Boston, Department of Innovation & Technology, ("DoIT"), has observed continued growth in network traffic on the Boston Optical Network, ("BoNET"), and increasing demand and opportunity to connect new sites and services. These factors, coupled with the 6 year old age of the network, justify a detailed review of BoNET with regard to upgrades, expansion and/or replacement. The Department of Innovation and Technology commissioned a study to review and confirm the network growth drivers, to evaluate the options for addressing these requirements, and to make recommendations about the upgrade implementation.

This report concludes that BoNET is a technically and operationally sound Metropolitan Area Network, s ("MAN"), structured on carrier class equipment and best-in-class design principals, providing enterprise level network services across numerous diverse agencies with varied requirements. The logical, cost effective, upgrade and expansion path is to build upon the existing network, upgrading the network cores and re-purposing the existing core equipment out to the next network layer.

As a city-wide network, BoNET provides agnostic network services to user groups that vary from typical office environments to 24 x 7 public safety operations. It provides critical, cost effective infrastructure to the operations of the city, and is a technically proven platform upon which to build the new capacities required to meet the growing demands of a connected city.

STUDY PROCESS AND APPROACH

The BoNET assessment process consisted of a detailed review of the existing equipment, systems, and configuration. Interviews with the DoIT representatives and network management team were conducted to identify and quantify the network traffic growth drivers. The team then reviewed similar projects and industry examples to explore options for upgrading and/or expanding BoNET. The information generated by these activities was evaluated and refined by the assessment team.

BoNET CURRENT CONFIGURATION AND STATUS

Current Network Topology

Since its inception, 6 years ago, BoNET has grown to support a wide array of users and systems across the City of Boston. The network provides connectivity to approximately 20% of the public schools, many municipal buildings and numerous city agencies. Through an initial agreement with Comcast, and the incorporation of one RCN/Lighttower fiber run, the system now connects approximately 150 buildings. The network leverages a fiber optic link installed by the Boston Fire Department in the early 1990s. This link connects City Hall to the Fenway, connecting seven agencies along the path. Typical connections to the network consist of 6 strands of single mode fiber optic cables, with a limited number of additional wired and wireless connections to some outlying buildings. Within the Summer Street meet-me room, there is a fiber connection from BoNET to the MCCA convention center which is used to share surveillance information and to support network traffic shaping. The significant investment in the development and deployment of this technology infrastructure has improved the quality of network connectivity and internet services to the users while reducing operating costs for the city.

Internet service connections consist of one Lightower connection at the Prudential building and two connections at the Summer Street collocation site, CenturyLink and TowardEX. Each connection provides a 1Gbps standard connection with bursting capacity up to 10 Gbps. The connections include access to Internet peering with capacity of up to 10Gbps.

The existing network consists of 17 core nodes, each equipped with optical dense wavelength division multiplexing, ("DWDM"), equipment, manufactured by Nortel/Ciena. Three additional key locations, Allston, Charlestown and East Boston are optically connected via diverse paths to the core network. The optical multiplexers are each equipped with two active channels providing 2.5GHz links to the City Hall and Schroeder Plaza super nodes. Each channel supports 2 Gbps Ethernet connections.

At the center of BoNET, three super nodes, City Hall, Schroeder Plaza, and 1 Summer Street provide redundant services to support the overall network. Each of the optical multiplexers has expansion capacity to support the addition of multiple channels of the same or higher capacity. The DWDM environment consists of a "north" and "south" linear architecture. The north DWDM environment does not have any optical amplifiers and the south ring has two optical amplifiers. Optical amplification equipment requires power and associated cooling and introduces additional potential points of failure into the network. The minimal number of optical amplifiers in BoNET simplifies its installation, maintenance and operation. The fiber optic cabling connecting the optical multiplexers and amplifiers is built on the 6 strand single mode fiber optic cables provided through the Comcast agreement. The implementation of the DWDM environment required six months of extensive testing, re-termination, and commissioning of fibers within these cables, prior to connecting the network hardware.

The BoNET nodes and endpoints are frequently located in fire houses and police stations. These locations do not have dedicated data equipment rooms with dedicated power and cooling. The initial BoNET installation included dedicated sealed cabinets to house the electronics, cooling, DC rectifier and battery support. The cabinets are configured in floor and wall mounted variations. The wall mounted cabinets are typically located and network endpoints such as schools, where the cabinet houses a Juniper EX 3200 switch as the network hand-off point to the local user network. The selection of local DC

power with battery backup simplifies the installation, reduces maintenance and failure potential as well as locally generated heat.

The client organizations and agencies that are supported by BoNET range from community centers to public safety emergency management. The network provides enterprise standard functionality including virtual local area networks, MPLS routing, and redundancy. A number of the supported agencies have mission critical applications including emergency communications and dispatch. The network supports video, radio communications, surveillance, monitoring and applications such as the "Where's My Bus" for the public schools. The BoNET equipment and configuration meet this demanding and constant connectivity requirement.

Connectivity

At each of the connected municipal buildings, BoNET provides connectivity to the common network resources, and to the Internet. In some cases, building management and monitoring systems are connected, allowing central management of building conditions and alarms. BoNET also supports Voice over Internet Protocol, ("VoIP"), phone systems, which are being deployed across the city. Converting traditional phone lines to VoIP connections not only improves the quality of connection, but also provides additional cost savings for the city, by eliminating separate telephone systems and analog connections. For the Boston public schools, BoNET acts as a neutral Internet provider serving more than 100 schools. The school system provides management of the internal networks within schools.

BoNET provides connectivity for portions of the surveillance cameras across the city. There is a growing requirement for the modernization, expansion, and integration of surveillance throughout the city. Surveillance cameras and equipment are being connected to BoNET, allowing the recording and management to be redundantly supported by the City Hall, Summer Street, and Police HQ central network cores.

BoNET is configured to provide a "best effort" network capacity at each handoff point. The actual realized throughput may vary depending upon the equipment and network configuration of the connected facility or agency. For example, a school's firewall may be configured in a way that causes a reduction in the potential throughput. The maintenance and configuration of the connected facility or agency is the responsibility of that group, and not DoIT.

The radio systems for the Boston Police and Fire Department are connected to BoNET nodes, allowing better communications and coverage throughout the city. The Boston Transportation Department uses BoNET to provide real time access and control of the stoplights and traffic systems around town.

BONET GROWTH DRIVERS

There are three main drivers for the realized and anticipated growth in BoNET traffic, specifically, student on-line assessment (PARCC), surveillance cameras (city, schools, housing), and the increasing number of connected devices. The successful support of the growth on these three fronts requires that enhanced network capacity and reach be implemented in the near term so that it is positioned to support and not react to these demands. Traditionally, data network traffic consisted of period of low activity and bursts of higher traffic levels. Additionally, network traffic varied by time of day. For example, the network traffic at a community center would be low during school hours and then higher after school, when the program was active. Correspondingly, the traffic at schools would be higher during the school hours and low when the school was not occupied.

There are a number of newer technologies that generate network traffic at constant levels such as surveillance cameras and Internet Protocol radio systems. Radio over the network, "TDM over IP", traffic remains constant regardless of radio use, typically requiring 8Mbps. Fire alarm communications and surveillance cameras also produce constant levels of network traffic. Critical systems often have network capacity reserved for their use, ensuring availability when needed. Current Boston Traffic Department intersection cameras generate 1Mbps of constant traffic per camera. The growth of these newer, constant traffic loads, technologies requires more immediate and larger increases in network capacity than traditional growth models would have predicted.

The Partnership for the Assessment of Readiness for College and Careers (PARCC) is in the process of field-testing the new assessment systems at a sample of schools during the Spring 2014 semester.[1] Full test administration will be implemented in during the 2014-2015 school year. Achievements levels and subsequent recommendations will be determined by summer of 2015. Please see the PARCC website for more details.[2] Massachusetts, one of the states on the governing board of PARCC is already at the forefront of integrating these assessment into the school systems.[3] The state has already made a strong commitment to seeing the improvement school assessment systems and the new online format will be an essential part of its success.

Cisco (IBSG) defines connected devices as the 'Internet of Things' ("IoT"), and identifies the point when there were more devices connected to the Internet than people as occurring in 2008.[4] In 2015, Cisco estimates that 50 billion devices connected to the Internet.[5] Emerging technologies continue to promote the growth of the IoT, as IP capable computers and devices become smaller, cheaper, and more power efficient. IP capable systems can be placed in remote locations, harvest vibrational energy, and communicate directly with other network resources. In metropolitan area networks, water meters, gas pumps, generators, and other critical services are all connected to the Internet. BoNET currently carries information generated by gas pumps, access control systems and building management systems. This type of traffic is expected to grow significantly. The connection of devices to BoNET slows for a reduction in the number of phone lines used to carry alarms and monitoring information, lowering ongoing communication costs for the city.

Certain network nodes traffic demands have grown through increasing user levels and associated services and functions. The Boston Public Library Copley location is currently connected with 2Gbps links. This location supports a number of branch locations and has significant bandwidth requirements for storage replication, virtualized server management and similar services. This is an example of how anticipated growth has led to network constriction. The Roslindale core supports 32 additional sites and

the corresponding radio systems. Roslindale is another example of how the rapid adoption of BoNET leads to the requirement for expanded network capacity.
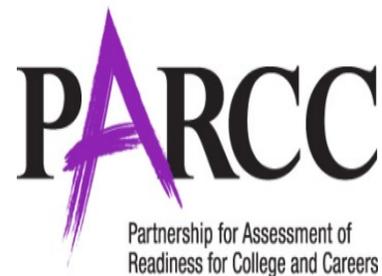
Most of the devices, large and small, that are connected to the IoT require limited overhead (network traffic) and will impose light demands on bandwidth or capacity. Door alarms and gas pumps often send periodic status updates at low data rates. However, the quantity of new devices and systems that will be connected to BoNET will create significant cumulative network traffic. Live connection to these systems not only improves maintenance, diagnostics and security, but also offers the ability to control them in real time.

Boston Public Schools

BoNET provides Internet access to approximately 20% of the Boston Public Schools, via 1Gbps connections. The school handoff occurs at each BoNET endpoint switch. The internal school network is separate from BoNET and is maintained and managed by the schools. The remaining schools receive Internet access through 100Mbps Verizon Metro Ethernet circuits. The Verizon circuits are aggregated and the combined traffic is connected to the Internet service provider. This configuration is not ideal due to circuit over-subscription and limited redundancy. BoNET is able to provide higher capacity Internet access and redundancy at a lower cost than the Verizon solution. Over time, the Verizon circuits will be replaced with BoNET connections, increasing the network traffic and demand.

The PARCC February 2014 Version 4.0, "Technology Guidelines Update" identified the following network bandwidth requirements for an on-line student assessment:

- External connection to the Internet recommended capacity of 100 Kbps per student, or faster.

- Internal school network, recommended capacity of 1000 Kbps per student or faster.

While Revision 4.0 recognizes the potential role of caching servers as a way to manage external bandwidth requirements, in a medium or large school, it is easy to see that these requirements call for significant network bandwidth. Please see Tables 1 and 2 for additional information, and network impact estimates. Ideally, the BoNET team and the public schools technology group should establish an evaluation model that simulates the anticipated testing environment at a large school and monitor the internal and external network traffic. This hard data would support the development of a more accurate long term capacity model.

Usage during assessment periods is modeled around specific time of the day during the multi-day testing period. It is likely that multiple schools will be conducting the assessments at the same time, driving the overall network requirements up. Given the duration of the assessments and number of students in the district, we may reasonably predict that a significant percentage of the 55,000 students in the City of Boston area might be online at the same time. Using the PARCC recommended external connection rate, the required bandwidth will be many Gigabit per second. See Table 3 for more details. Currently, the network has been able to accommodate the traffic and avoid congestion, but oversubscription will create choke points, as the schools implement on-line assessments, and other demanding applications.

The growing dependence of teachers and students on wireless networking to support collaborative learning will necessitate upgrades of the school wireless networks. The emerging wireless standard, 802.11ac, has significant additional bandwidth requirements based on its configuration and capacity. As the neutral Internet connectivity provider to the schools, BoNET will need to support this demand. The 802.11ac wireless access points currently support 1.3Gbps per unit. This capacity, coupled with the

increased use of video, cloud based, and collaborative tools will drive these new demands. Each of the BoNET connections to schools will require an upgrade.

Security Systems

Security systems across the city continue to expand, and need to become more available to authorities for central monitoring, dispatch, and response. Trends in security technology have led to improved systems that offer centralized recording, monitoring, and live data streaming in the capacities required Redundant image storage and retrieval provide local and central copies of information ensure appropriate backup and security measures. Camera imaging technology continues to improve quality, resolution and image processing techniques. Therefore, the expanding CCTV network will be one of the primary consumers of bandwidth on the network, while supporting the goal of creating a unified camera system throughout the city of Boston.

The anticipated expansion of CCTV coverage in public areas, municipal buildings and schools, will place growing demands on network capacity. For example, the police have expressed interest in accessing the surveillance systems of the Housing Authority buildings, covering their approximately 70 buildings. These 70 buildings have approximately 600 cameras in use. The traffic from these cameras will require an estimated 3.6Gbps of capacity. See Table 3 for an example increase on the system. These additional cameras will need to be integrated into the City standard Genetech image management system.

Across the City

The amount of data that the City generates, delivers, manages, and records will show continued growth with the expansion of the IoT. For BoNET, this means more nodes and more devices generating more data, and requiring more capacity.

The "Wireless Main Streets" and neighborhood wireless initiatives call for free wireless along many of the city's main streets. This initiative represents a very large wireless deployment that will leverage BoNET for the backhaul of network traffic, again adding to the overall network traffic.

BoNET has already provided significant long-term savings for the city, through the elimination of numerous telephone company phone and data lines. There are many other systems that can easily transition onto the fiber network. There are building and door alarms that are still connected to analog lines. These can be easily replaced with network capable systems at lower cost and improved quality.

ASSESSMENT

At the time that BoNET was conceived, the metropolitan area network equipment provider market key players included Cisco, Juniper, Nortel, and ProCurve. There were international equipment providers with similar capabilities, including Huawei, but geopolitical issues made the international providers unlikely participants. The Nortel MAN product line has been acquired by Avaya, but remains viable and fully supported. The existing Juniper network equipment is supported and will remain so for at least the upcoming 5 years. It is likely that the City will start to deploy the replacement model edge switch instead of the EX3200 units; however, the EX3200 switches will continue to operate and support the requirements of the network users.

Juniper offers several upgrades that aim to protect current investments in MX systems by using the same chassis, with modular expansion for internal routing and individual ports. New switching modules for the MX240, 480, and 960 can double the router capacity.

There are many Juniper/Nortel systems in use today supporting metropolitan area networks ("MAN") and wide area networks ("WAN"). Please see Appendix A for some examples of large MANs and WANs using Juniper Networks equipment.

The options for adding the required core capacity to the network include expansion of the existing network, introducing equipment from a different manufacturer at the specific locations where expansion is needed, or replacing the network with equipment from a different manufacturer.

The introduction of different equipment at the core expansion locations would create a multi-vendor environment and require significant efforts to integrate the two systems and ensure operational interoperability. This approach would also require the DoIT staff to engage in professional development, training them in the management and servicing of the new equipment. It is likely that an additional support vendor would be needed, providing outside support for the new equipment.

The replacement of the existing network equipment with equipment from a different vendor would require the commissioning of new fiber strands to support the connectivity, construction and configuration of the new network and a flash cutover. This approach is very expensive and carries inherent risks associated with cutting over an entire network while supporting the critical users and systems currently served by BoNET.

The recommended approach to upgrading the network capacity is to leverage the existing investment and introduce new Juniper 960 cores at the three super-core locations. The existing equipment can be migrated to the current locations where there are capacity issues. This approach is a non-disruptive phased approach that can be implemented without the concerns related to network outages and/or multi-vendor interoperability.

Redundancy

BoNET has connected fiber to approximately 150 city locations with redundant connections at 22 of the core nodes, especially those connecting schools, fire departments, and police departments. Please see Appendix B for a map of BoNET.[6] The 10G optical core connections from City Hall to Roxbury are supported by multiple redundant 2G links. This configuration has proven to be adequate in light of the current network demands. Growing demands on the system may benefit from additional redundancy and expansion of the fiber network in this same manner. Each of the cores is connected to two super-cores with redundant links. The network traffic is monitored in real-time and reported on monthly. The trigger point for upgrading the links will be when the traffic approaches 40% of link capacity. This approach

maintains the redundancy logic by ensuring that either link will be able to carry the full node's traffic in the event of the loss of one link.

OPERATIONS AND MAINTENANCE

Staffing

The current staff, with coordinated vendor support, has provided network design, management and support since its inception. Initially a homegrown initiative, BoNET has become a great source of pride for the city and has been supported by in-house capacity employing limited contracted outside support. With the addition of more critical systems and anticipated network growth, there is the need to develop a blended support model that addresses the new demands and 24x7 operation. The supplementary support function will include the following activities:

- Monitor and receive notifications regarding BoNET.
- Evaluate and determine the responsible party.
- Take action or dispatch a technician to the location.

BoNET has presence across much of the city of Boston. In order to effectively support the evolving metropolitan area network, we anticipate that the department will require a dedicated vehicle with tools and an inventory of replacement parts. Please see Appendix B for several maps showing the general geography of BoNET and the potential drive times necessary to reach some of the furthest nodes. To service the whole network, a technician would require approximate 30 minutes of driving to reach the outer nodes, while realistic traffic delays could easily double that time.

Network support staff will be responsible to lead the service response, assess the issues, go to the site and/or involve the 3rd party support vendor to resolve the issue. Technicians acting in this capacity will require ongoing professional development related to the specific systems and configurations within the network. The current network team configures, deploys, and maintains the remote EX3200 switches, and will oversee the migration to their replacement models as the 3200 product line reaches "end of support" in 2019.

In order to offer full troubleshooting and support after business hours, management will benefit from formalizing second and third shift coverage. This will ensure that a regular work cycle is maintained and that backup is available if necessary. In this case, staffing could take the form of 2 full time equivalents. These technicians will require a high level of expertise with specific equipment, so selective staffing will be needed to meet core requirements.

Vendor service contracts should also be developed in coordination with the expansion of internal staff, providing supplementary support on an as needed basis. Supplementary services include activities requiring specialty equipment and services such as bucket trucks and aerial construction. Using these services selectively in conjunction with the careful purchase of assets will help to save cost while minimizing downtime in the unlikely event of issues.

Cost Avoidance

BoNET provides comprehensive network connectivity that would otherwise have to be procured from vendors and/or carriers. The value of the BoNET core connectivity has been estimated to be $1,828,000.00, annually. This estimate was developed by quantifying each of the core connections, speed and capacity, and then identifying the cost from the ITT46 State of Massachusetts contract for network services. The lowest available state contract prices were selected for each option.

Additionally, the elimination of telephone company circuits connecting non-core locations to BoNET produces annual savings in excess of $600,000.00.

The savings to the City is approximately $2,428,000.00 per year.

Over the six years that BoNET has been in place, it has saved the City approximately $14,568,000.00, in total.

Maintenance and Management

As the camera and security systems continue to grow, there will be a corresponding increase in the amount of data storage systems required to accommodate the 30 days of image retention. These systems along with the routers and other systems in the core nodes will require installation and management services.

CONCLUSIONS AND RECOMMENDATIONS

The Boston optical network is a technically sound, highly redundant enterprise-class network, providing best-in-class services across multiple locations and agencies. The design of the physical and logical portions of the network, including the IP address scheme and naming conventions is excellent. BoNET is a solid platform for expansion in core capacity and in connections to additional agencies, buildings, users and devices.

The current and anticipated growth in network traffic and connections substantiates a phased upgrade to the three super-cores and specific high traffic cores such as Copley and Roslindale. The implementation of Juniper 960 series equipment at the core of the network and the upgrade of specific additional network cores is the most prudent approach. The existing network equipment is carrier class and well suited for supporting the BoNET role of providing city-wide network connectivity. The enhancement of the cores, coupled with the ability to upgrade the optical portion of the network to 40Gbps, in place, ensure that future capacity demands can be met. The introduction of other manufacturer's equipment would require additional cost, coordination, and would complicate network management and maintenance.

The DoIT staffing, dedicated to the ongoing development and maintenance of BoNET, requires two additional full time employees and the supporting service vehicle, tools, and spare equipment. The annual cost savings to the City more than justifies these positions and the critical nature of the systems supported by the network require an expanded level of support coverage. The outside contractors, who provide specialized services such as bucket truck based installation, should remain contracted for these on-call services.

The BoNET Internet access provided to the schools is not currently being reimbursed under the federal E-Rate school funding program. The ability to capture this funding exists and should be pursued.

PROJECT TEAM

The project team consists of the following participants:

City of Boston (alphabetical)

Dan Rothman, Chief Technology Officer
Murray Shafiroff, Infrastructure Project Manager
Jerry Turner, Network Manager

R. G. Vanderweil Engineers (alphabetical)

James Kerwin, Electrical Engineer
Michael Kerwin, Principal
Ernest Schirmer, Senior Engineer

The Vanderweil team has significant experience in the assessment and design of large networks serving multiple buildings distributed over large campuses, cities, and broader areas.

RESUMES

Education
- B.S., University of Massachusetts, 1978

Registrations
- BICSI - Registered Communications Distribution Designer & Wireless Designer RCDD & RCDD/WD
- CSI- CCS - Certified Construction Specifier
- DCCA Data Center Certified Associate
- AT&T, Systemax Engineer ND3300, ND3310, ND3321 Certified
- State of Connecticut Telecommunications Layout License #24

Professional Activities
- Construction Specification Institute (CSI)
- BICSI: Advancing Information Technology Systems

Publications
- "Enhancing Access Control for Existing Campuses", High Profile Monthly, November 2013
- "New Networks, Less Energy", High Profile Monthly, February 2013

Overview

Mike is a Principal with over 32 years of experience in technology infrastructure, audiovisual and security systems design. He oversees the Technology Services Group within Vanderweil Engineers. Prior to Vanderweil, Mike served as President and Technical Director of CCR Pyramid, Inc. His professional focus is centered on the effective integration of relevant technology. He works with the client, owners, and design teams to address the impact technology issues have on each project.

Related Project Experience

- **Acadian Asset Management, Multiple Locations**
  Project included the renovations and expansions of over 93,500 sf of office space, conference rooms and cafeterias.

- **Analysis Group, *Boston, MA***
  This 118,000 sf expansion and renovation project was completed in two phases. Phase one consisted of a tenant improvement initiative to expand the 7th and 8th floor. Phase two mostly focused on the renovations of selected spaces within the occupied 9 through 11 floors. The main focus on phase two was the expansion of the existing server room and upgrades to the security systems.

- **Arrowstreet Capital, John Hancock Tower, *Boston, MA***
  Audiovisual, security and voice/data designs were designed for the relocation of 30,300 sf of office space. The audiovisual main focus was the four conference rooms which required projectors, projection screens, white boards and video-conferencing capabilities. Security requirements included card access control to office spaces, server rooms and front lobby doors.

- **Bingham McCutchen LLP, *Boston, MA***
  The project involved a full build-out and relocation to a 12 floor, 295,000 sf rented space located in the heart of the Financial District. The firm required the highest level of security along with supporting technology infrastructure systems. Audiovisual designs were prepared for conference rooms, offices and reception areas.

- **C Change Management, *Boston, MA***
  This new 57,800 sf office space included audiovisual designs for conference/lecture rooms, reception areas trading rooms and kitchen. Security involved card readers, CCTV cameras and video/audio intercom systems.

- **Liberty Mutual Investment Group, *Multiple Locations***
  Projects included renovations and new constructions to spaces up to 30,000 sf. Audiovisual control systems were updated with new plasma screen and individual volume controls. Spaces included conference rooms, trading desks, front desk spaces and customer service spaces.

- **LogMeIn, Corporate Headquarters, *Boston, MA***
  Relocation of office space includes 100,000 sf fit-out in the greater Boston area. The initial phase of the project involved due diligence evaluations of several potential sites. The design includes collaborative work spaces and offices, kitchenettes, conference and multipurpose areas and associated support spaces.

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- **MetLife,** *Multiple locations*
  Provided design, construction management, testing, documentation, certification and acceptance services for numerous technology infrastructure installations, including MetLife Utica, NY, and a project with 1,800 locations of voice and data installation spanning two buildings. The entire cable delivery system for the project was designed into a raised floor system. Numerous projects throughout the United States have included design, site coordination, construction management, installation, and system documentation.

- **MPM Capital Investments, The John Hancock Tower,** *Boston, MA*
  Renovations to the 15,700 sf space included audiovisual and technology infrastructure designs for three conference rooms within the office. Audio conference speakerphone system, LCD projectors and table top speakerphone with remote speaker and technology infrastructure was install to support these devises.

- **State Street Bank,** *Boston, MA*
  This 1.8 million sf, 14-story multi-phased renovation included the oversight of equipment relocations, integration procedures for swing space and permanent space and provided design and project management implementation services to the bank's headquarters and locations in Boston and Quincy, MA.

- **Stonehill College, Merkert Tracy Building,** *Easton, MA*
  A renovation of 36,000 sf of existing science laboratory spaces and classrooms to accommodate the need for more office and administrative spaces.

- **Sullivan and Worcester LLP,** *Boston, MA*
  The office occupies 4 floors in the modern high rise building with office space spanning approximately 86,500 sf. Renovations included the preparation of swing space and the redesign of the current computer room. Consulting and design services were provided for the structured cabling system as well as audiovisual design for the conference rooms and common areas.

- **Textron Defense Systems, 201 Lowell Road,** *Wilmington, MA*
  Construction of a new building. Project size of approximately 275,000 sf office and research & development space. Program requirements include: approximatley 85 office, 610 workstations, 30,000 sf pf lab space, 50 conference rooms including two large presentations rooms and a computer training room, cafeteria and other shared, collaborative spaces.

- **Virgin Money,** *Waltham, MA*
  A renovation of 28,000 sf of office space including board and conference rooms, office and work spaces and a bar/lounge area. Telecommunications, audiovisual and security designs were provided.

- **The World Trade Center,** *Boston, MA*
  The project included a 30,350 sf relocation, featuring a data center and trading environment. Security and technology infrastructure designs were provided. Additional services include multiple audiovisual and technology projects in other areas of the building.

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Ernest J. Schirmer, RCDD/NTS, CTS

Senior Engineer

Education

- M.B.A., Information Systems, SUNY Binghamton, 1987
- B.S., Economics, SUNY Oneonta, 1986
- A.A.S. Business Administration, SUNY Stone Ridge, 1986
- A.A.S., Electrical Engineering Technology, CUNY Queensborough College, 1966

Registrations

- Registered Cable Distribution Designer (RCDD)
- Network Transport Specialist (NTS)

Professional Activities

- Institute of Electrical and Electronics Engineers (IEEE)
- Vice-President of Education for the Association of Information Technologies
- Former Chairman of the Continental Automated Buildings Association (CABA) Task Force Integrated Intelligent Building Systems
- Higher Education and Building Information Modeling (BIM) Standard Committees
- InfoComm; Certified Technology Specialist and NSCA Faculty Member
- Building Owners and Managers Institute (BOMI); Technology for Facilities Managers Course Instructor
- International Facility Management Association (IFMA); Education Committee Member

Overview

Ernest is a Project Manager with Vanderweil's Technology Services Group. He has more than 25 years of experience in technology evaluation and design in the areas of building technology and integrated intelligent building systems; voice, data and multimedia networking; and telecommunications cabling infrastructure in the pharmaceutical, aviation, healthcare, education, research, corporate headquarters, and hospitality markets. A specialist in telecommunications and IT infrastructure, Ernest's project experience includes the specification, bid preparation, and implementation supervision.

Related Project Experience

- **New Jersey City University, Data Network and Instructional Technology Assessment & Plans, J***ersey City, NJ***
  In preparation for submitting an application for a New Jersey Higher Education Technology Infrastructure (HETI) grant, Vanderweil assessed the existing campus data network infrastructure and systems for the main campus and satellite locations. As a result of the documentation produced, NJCU received the full $3.58 million of its grant application.

- **NYC DOMHM & OMB, Proposed Renovations of Public Health Laboratory,** *New York, NY*
  Feasibility study for a multi-phased renovation of approximately 310,000 sf in an existing 14-story plus cellar, 375,000 sf public health laboratory. The building includes spaces for environmental science, microbiology and vector borne disease surveillance, vivarium, BioWatch, bioterrorism, BSL-2 labs, and a 25,000 sf high containment BSL-3 facility.

- **Rutgers University, Life Sciences Center - Phase Two,** *Newark, NJ*
  Technology infrastructure engineering services for this new six-story, 95,000 gsf Life Sciences Center addition with modern STEM learning spaces including new teaching laboratories.

- **Rutgers University, Newark 2012 Housing Project at 15 Washington Street,** *Newark, NJ*
  Renovation and addition to a 21-story historical high-rise structure with approximately 350 beds and associated retail space. The upper levels provide single and multi-bedroom apartments. The lower levels provide common spaces for graduate residents, as well as uses by various other University department functions. The project includes a new welcome center and admissions office for the campus, college store, a cafe, a large seating capacity auditorium and a lecture hall.

- **AstraZeneca, Wilmington, DE**

  Corporate headquarters complex 1.2 million sf.

- **Jeffries-Avlon, Tampa, FL**

  Hillsborough River Complex, 1 million sf.

- **Jeffries-Avlon, New York, NY**

  Class "B" office building infrastructure upgrade

- **New York State Controller's Office, New York, NY**

  20,000 sf relocation.

- **New York State Governor's Office, New York, NY**

  Secure voice and data network.

Jonas R. Bielkevicius, EE, MBA

Senior Engineer

Education

- MBA, Master of Business Administration, Northeastern University, 1986
- B.S., Electrical Engineering, Northeastern University, 1975

Professional Certifications

- Massachusetts Board of Electrical Examiners 1178 and 449D
- MA Division of Public Safety, 275S

Awards

- US Patent Award, X25 DataLink Error Detection Algorithm, Pat #4554541

Overview

Jonas is an Electrical Engineering professional with over 30 years of experience in security systems, closed circuit television (CCTV), access control, fire alarms, computer networks, communications and intelligent transportation systems. His experience includes technical design, system integration, testing, client training and support, product requirements analysis, procurement, construction, operations management and marketing/sales. Jonas has developed and utilized his skills in the commercial, military and nuclear power industries and is skillful at working with customer and engineering design teams as liaison and as a solution creation catalyst.

Relevant Project Experience

- **U.S. Air Force DDN, Washington, DC**
  Developed a suite of US Air Force Defense Data Network (DDN) standard node equipment products with subsequent planning and installation of over 300 new X.25 Packet Switch node sites and upgrades of other sites. Responsibilities included transition of old to new systems, customer field service support, training of Air Force personnel, development of maintenance and trouble-shooting techniques and subcontractor coordination. Provided engineering support for the installation and operation of an analog telephone switching system, at the National Military Command Center (NMCC), The Pentagon, Washington, D.C.

- **Boston's Central Artery Project, Boston, MA**
  Managed system design, engineering resources, quality assurance to ISO 9000, standards, business development, customer support, and proposal management. As Senior Systems Engineer for the Central Artery (Big Dig project), designed and managed security, fire alarms, CCTV and Intelligent Transportation Systems (ITS) projects. Identified new business possibilities including Gillette Stadium in Foxboro. Designed and developed the access control system at Joslin Clinic & Titleist Golf factory. Worked with local and municipal Fire and Life Safety authorities to establish compliance to requirements.

- **CCTV Fire Alarm Access Control, Life Inc. Adults with Disabilities Community, Plymouth County, MA**
  Installation, maintenance, testing and monitoring of all fire, access control, and CCTV systems.

- **Closed Circuit Television, Boston, MA**
  Provided engineering services for a 28 camera Closed Circuit Television (CCTV) System, I-93 central artery, downtown Boston, which included Control Center monitors, recorders, remote pan-tilt, zoom and focus telemetry systems.

- **Fire Installation, Access Control, CCTV, Plymouth County, MA**
  Maintained the firm alarm, access controls, intrusion, and CCTV system for all of the buildings located within Plymouth County.

- **Nuclear Power Plant, China**
  Development of IP Based CCTV, Security, Fire and Communications systems for two Nuclear Power Plants in China. Provided technical training of customer personnel, developed access control, alarm system, security lighting and security power systems specifications. Participation in establishing security program for control of nuclear documentation and safeguards information control systems. Responsible for Customer Response and Support for project security and communications systems requirements.

VANDERWEIL

ATTACHMENTS

APPENDIX A - JUNIPER NETWORKS EQUIPMENT - JANET NETWORK, UK

APPENDIX B - BONET GEOGRAPHY

APPENDIX C - TABLES 1, 2 & 3

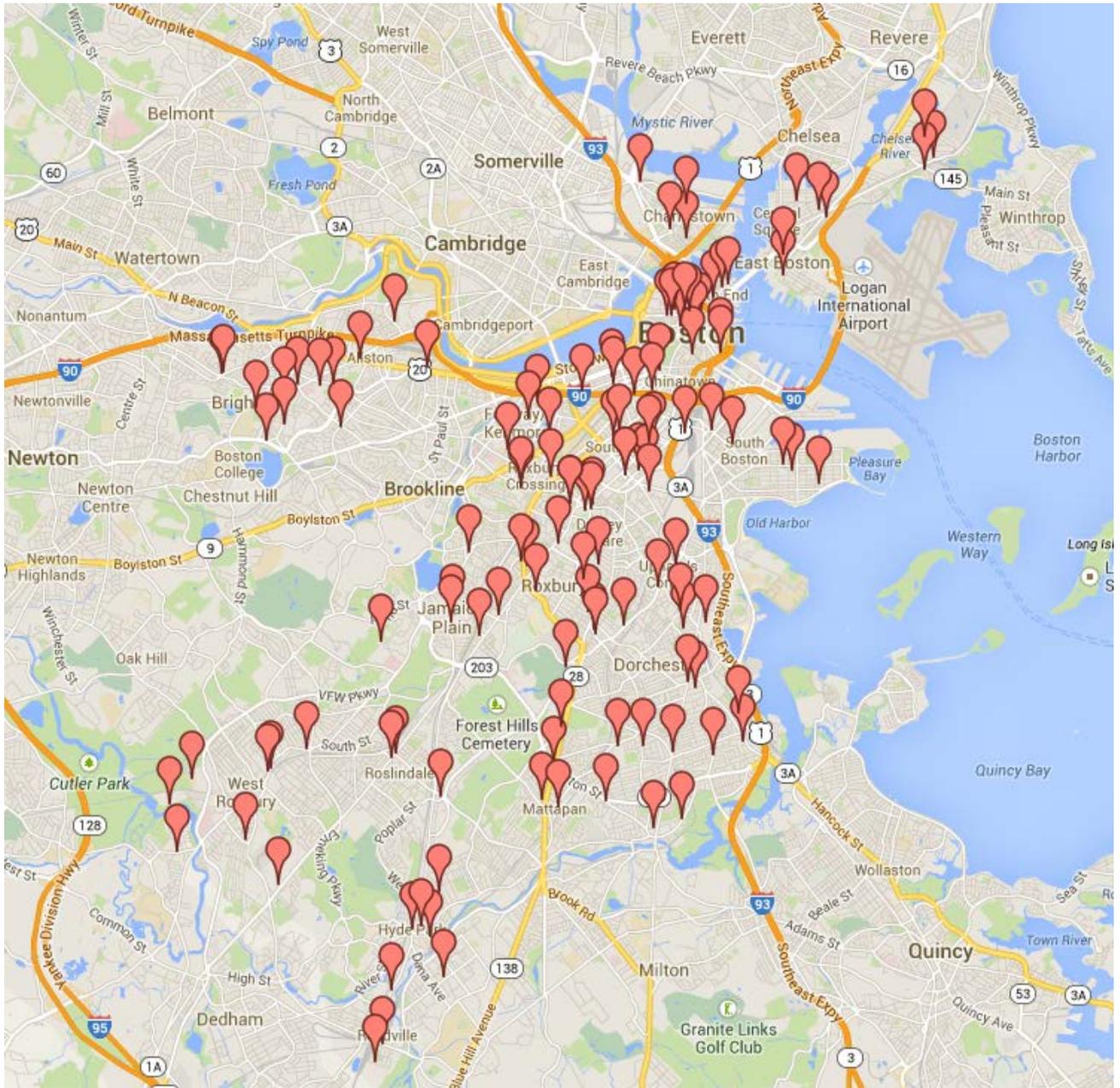**APPENDIX A - JUNIPER NETWORKS EQUIPMENT - JANET NETWORK, UK**

One example is "JANET", a government funded service provider in the United Kingdom built on Juniper Networks equipment. JANET primarily caters to research groups across the country, connecting 20 metropolitan area networks (MAN).[7] The newest system, JANET6, offers 2Tbps capacity on its primary connection services JANET IP and JANET Light path. These services use the JANET backbone, which is supported by Juniper MX and T series routers and has been designed for continued improvement with each iteration.[8]

JANET has seen consistent upgrades for both its equipment and fiber lines. In 2002, SuperJanet4 upgraded from 2.5Gbps to 10Gbps. In 2006, SuperJanet5 was launched with an upgrade path to 40Gbps.[9] Janet6, launched in 2013, upgraded the system to 2Tbps through the implementation of Juniper MX and T series routers. JANET continues to work with Juniper Networks to support the expansion of core nodes to offer 100GbE at several locations around the London area.[10]
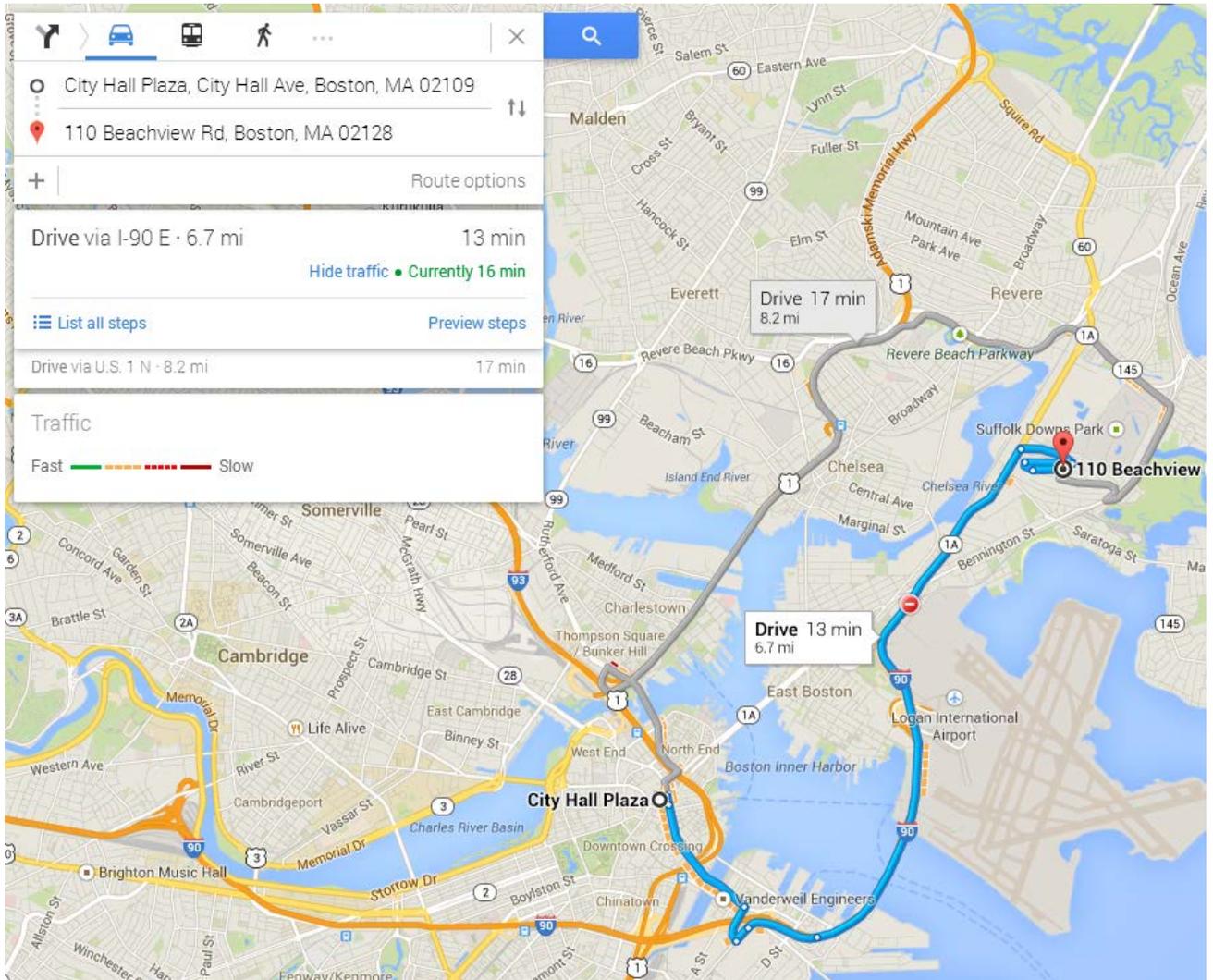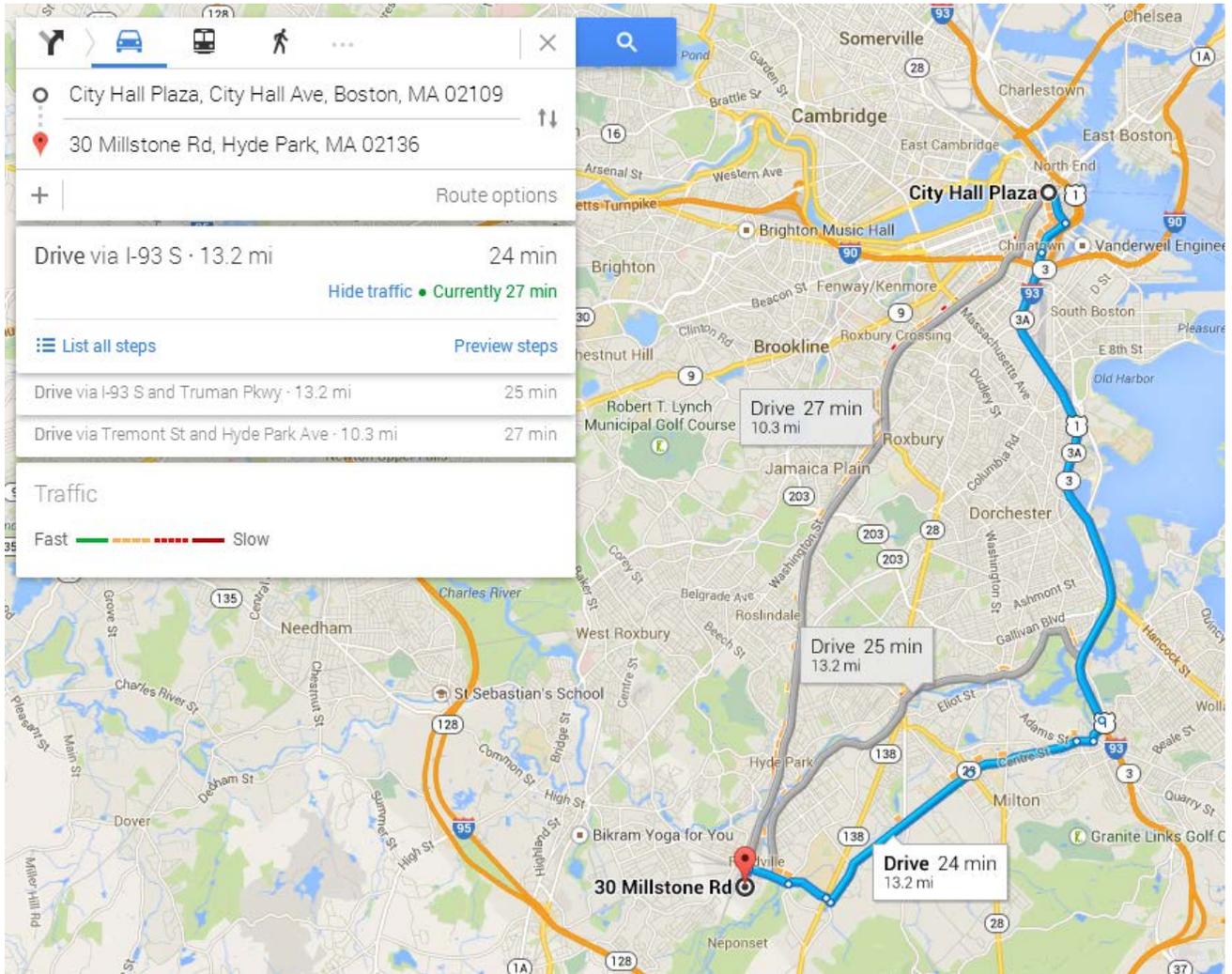
BoNET Principal Locations

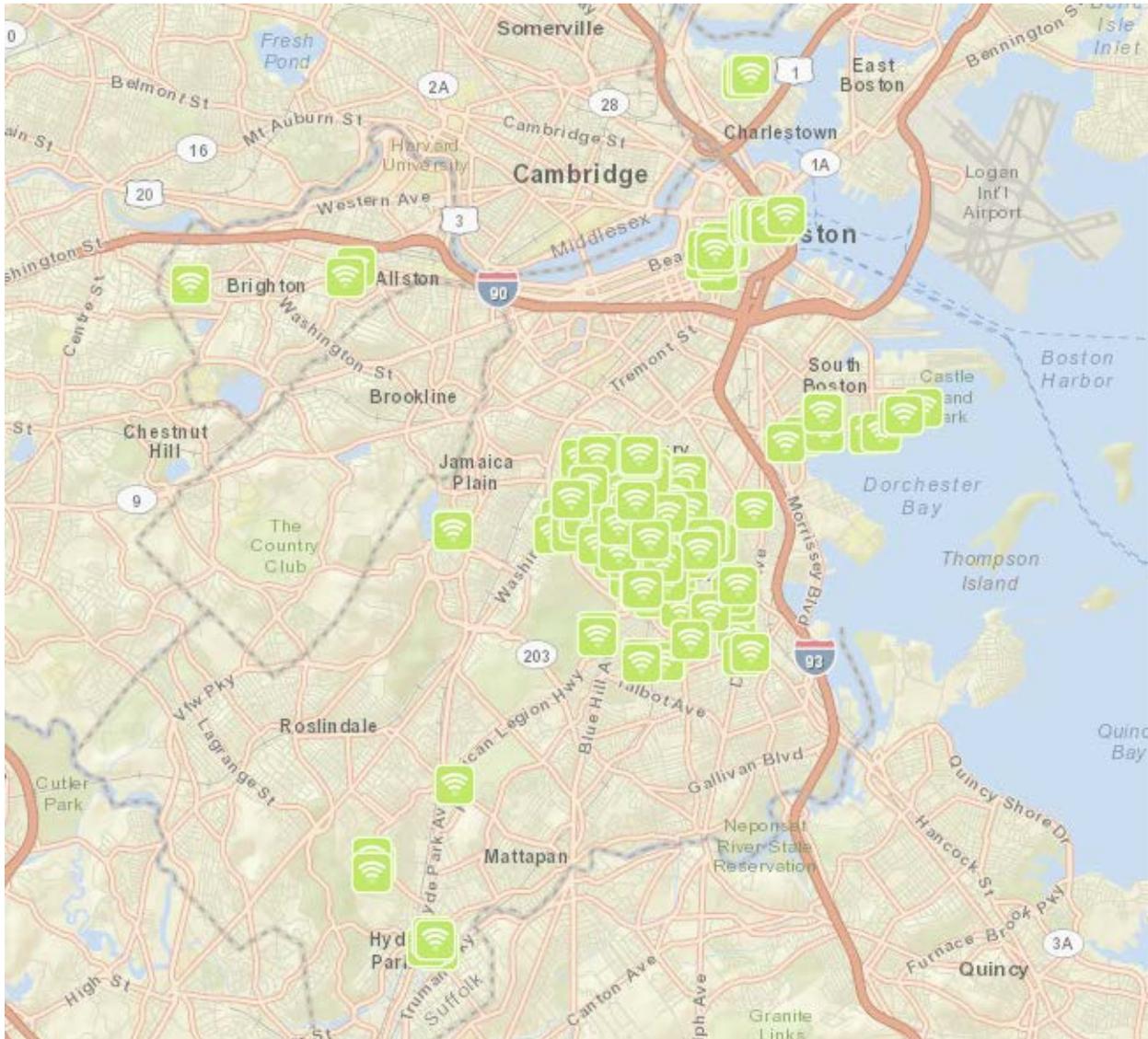**Driving Route and Time to Northernmost Node**

Driving Route and Time to Southernmost Node

Wicked Free Wi-Fi Hotspots

Table 1[11]

PARCC Student On-Line Assessment Connectivity Requirements

	Minimum Specifications	Recommended Specifications
External Connection to the Internet	To be Determined	100kbps per student or faster
Internal School Connection	To be Determined	1000kbps per student or faster

Table 2[12]

PARCC bandwidth estimation tool results for a school of 1,477 students over a 20 day assessment period

Internal Connection Speed (Mbps)	External Connection Speed (Mbps)
100	100

Table 3

Bandwidth for External Connection to the Internet

System	Location	Quantity	Approximate Bandwidth Per Unit	Total Bandwidth
CCTV	70 Buildings	600	6Mbps	3.6Gbps
VoIP	Municipal Buildings	100 per Building	100kbps	10Mbps
School Online Assessments	Distributed	55,000 Students	100kbps per student	5.5Gbps

[1] Partnership for the Assessment of Readiness for College and Careers, 2014. PARCC Field Test. http://www.parcconlnie.org/field-test.

[2] PARCC. 2014. About PARCC. http://www.parcconline.org/about-parcc.

[3] PARCC 2014. Massachusetts. https://www.parcconline.org/massachusetts

[4] Cisco. Dave Evans. April 2011. The Internet of Things How the Next Evolution of the Internet is Changing Everything. < https://www.cisco.com/web/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf.> 2 p.

[5] Cisco. Dave Evans. April 2011. The Internet of Things How the Next Evolution of the Internet is Changing Everything. < https://www.cisco.com/web/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf.> 3 p.

[6] Google Maps

[7] JANET. 2014. Regional Networks. <https://www.ja.net/products-services/janet-connect/janet-connections/janet-connected-sites/regional/>.

[8] JANET. 2014. JANET6 From Procurement to Design. <https://www.ja.net/sites/default/files/J5524%20Janet6%20Brochure%20with%20Diagram%20Amend%20201212MR.pdf>. 6p.

[9] Wikipedia. JANET. http://en.wikipedia.org/wiki/JANET.

[10] Juniper Networks. JANET, The UK's Research and Education Network, Scales to 100GbE. <http://www.juniper.net/us/en/local/pdf/case-studies/3520415-en.pdf>.

[11] PARCC. Technology Guidelines for PARCC assessments Version2.1 - February 2013 Update.

[12] PARCC. Assessment Capacity Planning Tool Release Version 1: March 5, 2013.