CITY OF SCOTTSDALE

BUILDING AUTOMATION SYSTEM GUIDELINE SPECIFICATION

April 5, 2007

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1.0 INTRODUCTION

The purpose of this Building Automation System (BAS) Guideline Specification is to educate the design community working on City of Scottsdale (City) projects with respect to an interoperable Wide Area Network (WAN) control system the City has chosen to develop. The overall goal is to develop and maintain a common platform for a Web based Graphic User Interface (GUI) for all new buildings. As such, this Guideline Specification is meant to convey the concept of interoperability, as well as define the ground rules for all new control systems integrated into the BAS Wide Area Network.

The architecture that has been chosen is based on the Niagara Framework (or "Niagara"), a Java-based framework developed by Tridium. Niagara provides a software infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time over the Internet using a standard Web browser.

Appendix A provides a schematic diagram of the system, whereas Appendices B and C provide Division 15 and Division 17 specification language in CSI format. Those specifications need to be referenced or included in the contract documents of every new project developed by the City. Division 15 is meant to cover the minimum requirements of the HVAC Control System and Division 17 (BAS Integration) is meant to cover the work and materials of the System Integrator. The System Integrator will need to be involved in every project and it will be important to maintain a strong relationship with a single contractor for that work to maintain consistency within the system. A long-term contract will likely be established between the Owner and the System Integrator that will include pricing agreements. On the other hand, in an effort to maintain competition with the larger portion of the work, the Division 15 contractor for HVAC controls will likely vary from one project to the next as new buildings are constructed or old systems are renovated.

Over the years, the City has done a great job of maintaining a strong relationship with a single control vendor (Pro Services). Pro Services handles the Invensys product line and the majority of the City's larger buildings have Invensys control systems. The current Invensys product line is based on Niagara, and therefore, this Guideline Specification will help to ensure that the system does not become fragmented as additional control vendors are allowed to bid on new City projects.

The City may have a few existing (or "legacy") systems that do not meet this Guideline Specification. At some point they may choose to start integrating those systems into the WAN. Legacy systems are sometimes much more difficult to integrate because they are often based on a propriety communications protocol for which an appropriate translation device may not yet have been developed. While there is some language within this document regarding the integration of legacy systems, they will need to be considered and appropriate specifications may need to be developed on a project by project basis.

The design team may also choose to integrate additional systems such as lighting, access and security, or vertical transportation for a given project. The Division 15 specifications can easily be adapted to those systems by simply replacing the HVAC Control System (HCS) designation with something that more appropriately describes the system being integrated. It goes without saying that the specification and Division and Section numbers should also be appropriately changed.

Finally, it is extremely important to note that this is a "guideline" specification only. While Division 17 does contain a full set of specifications for the System Integrator's scope of work, Division 15 is meant to convey only the minimum requirements for that Division and to show the interdependencies with the work of Division 17. Details concerning sensors, actuators, wiring, piping, sequences of operation, etc., are outside the scope of this document. It is intended that the design team of each new project will develop a full set of specifications for Division 15, Division 16, or any other Division providing controls that will be integrated into the WAN.

2.0 BACKGROUND AND HISTORY

The personal computer (PC) industry has made enormous advances in the last two decades; since the early 1980's sales of PCs have exploded, with faster processors, expanded and enhanced peripherals and updated software being introduced every few months. The building automation system (BAS) industry has undoubtedly benefited from this trend. The man-machine BAS interfaces that were formerly text-based have been replaced ubiquitously by Graphic User Interfaces (GUI) that are faster and much easier to use, while the devices and communications protocols have become vastly more complex. The BAS industry has also benefited from consensus and development of network communications standards, allowing higher data transfer speeds and superior equipment performance.

Besides keeping pace with the PC industry, the most important recent change in BAS has been a move away from "proprietary" protocols toward more "interoperable" solutions. While control theory has not changed much in the last two decades - control routines that were originally designed for pneumatic control systems are still being utilized in direct digital controls (DDC) installations today - the move towards "interoperability" has been both technology and cost driven. The low cost of microprocessors has allowed more "distributed intelligence" within the BAS network, relying less on central processing and communication to "dumb" field devices. Industry groups and facility managers see opportunities for product and service cost savings as more competition and better, faster solutions infiltrate the marketplace.

Other recent PC-driven impacts on the BAS industry are the more common utilization of a facility's Ethernet backbone as a communication medium for the BAS, development of software frameworks, integration of wireless technologies for data transfer, and web-enabling capabilities. As the Internet and its applications continue to expand, new BAS technologies will most certainly continue to develop in these and other areas.

2.1 Interoperability

Interoperability in BAS can be best defined by the following benefits it potentially helps to facilitate.

1. The ability to have a single-seat interface to connect BAS systems of different manufacturers together in a single building or multiple facilities.
2. The ability to integrate HVAC, lighting, access control, security, fire protection, elevators and energy monitoring.
3. The ability to provide more choices, (competitive bidding = potential for lower costs), both now and in the future, for the selection of both primary control vendors and packaged unitary controls. This is especially true for BAS expansions, retrofits and service contracts.

Of the three benefits described above, single-seat interface is probably the most important, allowing the tasks listed below to be performed in a common format. The first three tasks can be performed by any interoperable system, while the remaining tasks have proven to be more challenging, as described later in this report.

1. Data collection and viewing from the GUI
2. Modification of setpoints
3. Sharing of data between controllers
4. Alarm management
5. Modification of schedules
6. Trend logging
7. Network management

BACnet™ and LonWorks®

Among the several interoperable communication protocols in the BAS industry today, the two that hold the largest market share are BACnet™ and LonWorks. Development of BACnet™ was sponsored by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) in 1987, when it formed a Special Project Committee (SPC-135P) to develop an "open" communication protocol that could be utilized as a standard for building automation. This work has since been adopted as ANSI/ASHRAE Standard 135: "A Data Communication Protocol for Building Automation and Control Networks (2001)", which has been adopted as a worldwide ISO standard. BACnet™ has shown great promise in the integration of BAS at the systems level, where high-speed data transfer is critical. Most BAS vendors are now designing their product lines to include BACnet™ protocols and its development continues on many levels.

"LonWorks" is an encompassing term that includes the "LonTalk" communications protocol, devices that use the LonTalk protocol (LonMark devices), and the network on which the devices reside. Developed by the Echelon Corporation, LonWorks defines the set of protocol rules and practices that have been developed and approved by a group of manufacturers that use the "Neuron" processor chip developed by Echelon. The LonTalk communication protocol resides on the Neuron chip within each LonMark compatible device. In a real sense, LonWorks is based on the concept of device-level control (a "bottom-up approach"), compared with BACnet™ which is more of a "top-level down" approach that does not emphasize communication below than the unitary controller level.

Other Useful Protocols

Modbus® is a common protocol often utilized within the power monitoring industry and OPC (Ole for Process Control) is a common protocol utilized by industrial process control systems. While these are not often utilized in a typical BAS, it may be important to not eliminate their utilization as potential integration possibilities of disparate systems.

Software Frameworks

Software frameworks can be thought of as a set of object-oriented software components that operate together to establish a common platform upon which other applications can be developed. The main components of the framework include the majority of the functions needed to design and implement other software applications. This process thereby helps to streamline product development and reduce the time to market for new products. Frameworks are quite common in the IT industry and have become more prevalent in the BAS industry in the last several years.

Probably the most widely utilized software framework in the BAS industry is the Niagara Framework ("Niagara") originally developed by Tridium in 1996. Niagara is a JAVA-based framework developed in yet another attempt to solve the dilemma of interoperability in the BAS industry. Tridium's idea was to design a software framework that would be able to integrate diverse systems and devices, (regardless of manufacturer, communication standard or software) into a single seat user interface capable of being managed across the Internet with a standard Web browser. To this day, Tridium claims that their business model has never been to enter into the controls market selling the end-use control devices. Instead, they choose to focus on integration of control systems that already have good penetration in the marketplace.

The Tridium product line includes both software and hardware. The hardware can be thought of as a more traditional gateway coupled with additional IT functionality. Their hardware device is typically referred to as JACE (Java Application Control Engine). A more generic term for this device as used in the specifications that follow is Network Application Controller (NAC). Control vendors such as Invensys, Honeywell, and Staefa that base their product lines on the Niagara Framework each have their own brand names for these devices. No matter what label you place on this device, its purpose is to translate a standard protocol,

such as BACnet or LonWorks, or a proprietary protocol into a common JAVA software object model. It is these objects that create the common platform upon which all of the various vendor's data and functionality is "morphed" to allow equal treatment of all devices and applications.

When connected over an Ethernet network, several NACs can communicate with one another on a peer-to-peer basis in what they refer to as "distributed server" architecture. While this may be acceptable in smaller systems, in a large Wide Area Network it is important that a true server will be utilized to provide network management functions and provide a more robust means of managing and storing data.

While the Tridium solution does indeed utilize a "gateway" approach to integration, they have developed a software framework that appears to follow the trend in the IT industry for product development. The gateways that they have developed translate from a particular protocol into the JAVA object model and appear to be much more cost effective and more robust than early generation gateways that were implemented in system integrations of proprietary manufacturers.

In November of 2005 Honeywell, Inc. purchased Tridium. That led many in the industry to worry about the changes in that might occur. Was Honeywell purchasing the company in an effort to stall a small but growing company in the marketplace? Would Honeywell change the product line or direction of their newly acquired company? Since that time, it appears that Honeywell has allowed Tridium continue on its previous course and not interfere much in product development. It seems as though the early fears were unwarranted, and Honeywell has provided a much larger capital base under which Tridium will continue to grow and thrive in the industry. Early on, it was clear that because other vendors, such as Invensys, had previously acquired the rights to manufacture their own JACE panels; the product concept was likely here to stay for the near future.

2.2 Web-based Control

Nearly all manufacturers currently offer web-based enabling for interfacing with their BAS. The majority of these systems are "thin" client interfaces, meaning that they do not require any specific application software other than a standard Internet Explorer Web browser in order to achieve this functionality. In contrast, a "thick" client interface would require some type of additional application software to be loaded on the client in order to achieve some specific function. The manner in which most manufacturers accomplish this task is with an application server located on the system level LAN.

It is important to note that while many manufacturers claim to have true "thin" client functionality; most require some type of software applet to be downloaded to the client upon the first entry into the system. While this may not be a huge issue, it may limit the ability to access the system via the Web from a public interface like a library where it may be impossible to modify the client configuration.

2.3 Web Services

The integration of multiple BAS into one controls interface to manage multiple facilities has been a recent positive development in the industry. While there has been a resistance to integrating fire and/or security with HVAC controls, it is becoming more common to integrate HVAC and lighting in larger facilities. Interoperable communications protocols like BACnet™ and LonWorks offer a means to integrate disparate systems and networks, however there are parallel developments in information technology (IT) industry that are being incorporated by the BAS industry.

Web services is a term used to describe machine-to-machine data exchange, much in the way that the Internet provides a machine-to-person information exchange. Web services are intended to facilitate the exchange of information between intelligent buildings and enable enterprise application integration. Potential uses of the technology include simplifying access to building energy and performance data for inclusion in spreadsheets and other management reports; accessing equipment run-time data for use by

maintenance management systems; coupling of room scheduling with ventilation and comfort control; and many more. A technical committee known as oBIX (Open Building Information Xchange) was recently organized to develop a standard Web services protocol for the data acquisition and control industry.

Web services utilize common Internet communication technologies such as XML (Extensible Markup Language) and SOAP (Simple Object Access Protocol). These applications are being driven more by the IT community than the BAS industry, but it is safe to say that the majority of the recent changes in the BAS industry have been IT driven and this will likely continue into the near future. Though there are technical challenges such as security and speed, the possibilities in this field appear endless.

While Web services are intended to improve operational effectiveness, it is our opinion that the industry may be moving ahead of the users in this arena. Our experience is that most existing Building Automation Systems are not currently being utilized to their full potential. Many are not installed or commissioned properly, while others seem to fall into some level of disrepair over time. Until the BAS is providing consistent and reliable information, passing that data to another system will be of little value. While we can envision specific instances where Web services could be useful, we feel that opportunities for Web services in the BAS industry will be limited for the near future.

2.4 IP Enabled Devices

Most manufacturers appear to be moving their product lines in the direction of Internet enabled devices. Similar to an Internet enabled webcam, these IP enabled devices provide direct connectivity to the Internet, making it easier to develop Wide Area Networks and more cost effective to provide connectivity to smaller facilities. In some instances, these devices are merely IP enabled controllers, whereas other times, these are IP enabled distributed servers. Most manufacturers currently offer these technologies, which should continue to evolve over time.

2.5 Wireless Devices

The promise of a wireless world seems to have been in the shadows for the last couple of decades. While progress is being made (we have wireless keyboards, wireless phones, etc.) a completely wireless BAS has its own unique challenges.

While the BAS has historically been relegated to its own separate network infrastructure, every year we see more and more IT departments recognizing the cost-effectiveness of utilizing the IT backbone for BAS network traffic as well. The majority of those IT network topologies and protocols in use around the world today utilize a TCP/IP protocol in both wired and wireless combinations. With TCP/IP, many applications like BACnet/IP can be readily supported using the IT backbone. Protocols like BACnet/MSTP and LonWorks can also be encapsulated in IP packets and transported over the same network. Many wireless devices are currently utilized in the network infrastructure and that will not likely change.

Wireless network components offer several advantages including the ability to deal with areas difficult to wire and flexibility when systems need to be reconfigured. Wireless devices continue to be introduced in the BAS industry and prices are anticipated to drop as additional products come to market. Wireless challenges include noisy environments, reliability of communications, and security. We envision that the BAS industry will continue to evolve in this direction and wireless devices will become more prevalent in the years to come. Similar to the IT industry, we feel that the BAS industry will continue to utilize wired networks for the majority of their infrastructure and only rely on wireless technology where it is more cost-effective to do so.

3.0 BAS WIDE AREA NETWORK SPECIFICATIONS

3.1 Overall BAS Functionality

Based upon the current offerings in the BAS industry, the City has chosen to develop their Building Automation System WAN upon the Niagara Framework model for the system level LAN. This strategy is based on the following key ideals:

The Niagara Framework is an IT Based Approach
The Niagara Framework developed by Tridium is an IT based, system integrator approach. We have already seen that developments in the IT industry are permeating the BAS industry and will likely continue to do so into the future. It is clear that the Niagara Framework is based in this approach.

The Niagara Framework can be Provided by Multiple Vendors
The Niagara Framework has been integrated into standard offerings of several vendors including Invensys, Staefa, and Honeywell. While the products are marketed under their own brand names, the products are identical to the Tridium devices in terms of integration capabilities. Tridium also offers their product line through traditional BAS vendors and system integrators under the Tridium name. The ability to have multiple vendors, available to provide multiple support paths, can maintain one of the key elements of interoperability that was discussed earlier; the ability to provide choice and prevent an owner from being locked-in to a single vendor. Should the owner become dissatisfied with his Tridium vendor he has some negotiating leverage or the ability to change vendors.

The Niagara Framework was Developed Solely for the Purpose of System Integration
While the BAS industry has been forced into the world of interoperability and standard communication protocols, Tridium was founded and products were designed with that particular function in mind. While native BACnet vendors would lead you to believe that their systems will speak with one another without gateways or other integration devices required by the Tridium solution, the reality is that system integration is still a challenge even for native BACnet systems. Although system integration is becoming easier all the time, it will likely be a challenge for some time to come and will continue to be constantly evolving.

The Niagara Framework is a Complementary Solution to Standard Protocols
By no means are we suggesting that the Niagara Framework should replace or overshadow the developments that are currently taking place in the world of standard interoperable protocols such as BACnet and LonWorks. Instead, we feel as though the two complement one another. We have already seen this in the way that the Tridium product line has evolved along with the BACnet standard to include support for recent changes in the standard such as BACnet/IP and BBMD routing. As more and more vendors begin to adopt these changes, the integration paths will likely become fewer and more simplified.

Appendix A provides a network architecture diagram of the system as it is currently envisioned. The system will include access to the Graphical User Interface (GUI) via the Internet from any Web browser with a person supplying appropriate logon credentials. Day to day functions of the facilities operators such as changing setpoints, modifying schedules, and general system maintenance and control functions will be accessed through the common Niagara Framework GUI no matter what integrated control system is being accessed. The system will also include a central file server. The server will provide network administration activities, storage of long-term data, and provide access into the system from the Web.

BACnet shall be the communication protocol of choice for the system. All new integrated control systems should communicate on this protocol. In the event that the BACnet protocol is not available for a particular piece of equipment, the City may consider the use of LonWorks. In the case of legacy systems, there are several other options for integration that are briefly discussed in the specification.

The City's existing Ethernet "backbone" shall be utilized for connecting workstations, Web servers and system controllers. The City will be responsible for providing all connections to the backbone and for day to day maintenance and operation. In addition, the Owner will provide LAN components that are not control components provided by the vendors including computers, servers, routers, hubs, bridges, switches, etc. If necessary, specifications for these devices will need to be provided to the Owner but the intent is for the City's IT department to maintain full control of the LAN. Ethernet drops will be provided by the Owner for any control equipment that needs to be connected to the backbone. Minimum requirements for the computers and servers of the Niagara Framework have been provided in Appendix C. These should be reviewed for every project and updated as necessary due to the rapid changes that take place in the personal computer industry.

Only the vendor specific technician tools and a basic text based control interface are required for any new integrated system. Development of the Graphic User Interface is the role of the Division 17 Systems Integrator. To provide that same functionality within the vendor specific control system would be an added expense that is not likely necessary. The technician tools are required because controller programming tools are generally proprietary per vendor. A text based control interface should also be required to assist the vendor in the checkout and acceptance of his system since he will likely be unfamiliar with the Niagara Framework GUI. The text based control interface can also serve as a good backup means of control should the Niagara Framework system have a temporary malfunction.

The technician tools and text based control interface should be provided as part of a desktop workstation or a laptop computer. The laptop computer has the added advantage of being able to travel around the building as diagnostics or maintenance is necessary on the system. No matter whether a desktop or laptop computer is chosen, the system should include some means of archiving programming and database structures such as a Compact Disk Read-Write (CD-RW) drive or Digital Video Disk Read-Write (DVD-RW) drive.

3.2 Division 15 Specifications

Appendix B provides Division 15 specifications that should be referenced or included in any new controls installation where the design intent is to integrate that system into the BAS Wide Area Network. There may be an occasional HVAC controls project that is small enough that integration would be cost prohibitive or not desired, however, it is anticipated that nearly every new HVAC project should follow these Guideline Specifications so the system will be designed and constructed in a manner that will facilitate its integration into the Building Automation System WAN. It will be the Owner's sole decision to designate which projects should be integrated.

While the Division 15 Specifications are written to describe the minimum requirements of an HVAC Control System (HCS), they could just as easily be utilized for a lighting control system, card access control system, etc. The specification is not intended to be a complete specification for the system inclusive of all devices, installation requirements, etc. Instead, the specification has been assembled in a CSI format to establish the ***minimum*** requirements for the system integration with the Niagara Framework infrastructure being installed by the System Integrator of Division 17. It is up the design team of each project to develop the overall specifications for the project and ensure that the minimum requirements as stated in Appendix B are included.

3.3 Division 17 Specifications

Appendix C provides Division 17 specifications that should also be referenced or included in any new controls installation where the design intent is to integrate that system into the BAS Wide Area Network. The work of the System Integrator defined in Division 17 is intended to be ongoing as the system expands. The file server and the basic system infrastructure will be established on the first integration project

undertaken by the City, however, the system will continue to evolve and expand. It is intended that the System Integrator will be a single entity responsible for making changes to the overall system each time a new control system is integrated into the WAN.

The Division 17 specifications also follow the CSI format and include sections titled General, Products, and Execution. The Division 17 specification is intended to contain enough information that the whole section could be integrated nearly "as is" into a project. The work of the Division 17 System Integrator relies heavily on the control system I/O Summary tables and other information specified under Division 15 or elsewhere within the project specifications. For this reason, the design team needs to fully review the Division 17 specifications and ensure that all information required of the System Integrator has been specified somewhere within the contract documents. Once again the design team of each project shall be responsible to develop the overall specifications for the project and ensure that the minimum requirements as stated in the Guide Specification are included.

4.0 PROCUREMENT RECOMMENDATIONS

Whether the project is being developed as a Design/Build project or as the more traditional Design/Bid/Build project, this Guide Specification must be incorporated or referenced in the contract documents. Failure to do so will jeopardize the ability of the control system to be cost-effectively integrated - if integration is even possible. Questions should be addressed to the City where function or intent is unclear.

There will be multiple vendors who can meet both the Division 15 and the Division 17 specifications. It is the intention to allow open competition among a pre-qualified short-list of vendors for every new control system that is to be integrated. However, we would advise against it for the work of the Division 17 System Integrator. The System Integrator should be chosen on the first integration project with the intent to continue this relationship on a long term basis. That entity may initially be a control vendor but that role may later be taken on by facilities personnel as they become more familiar with the system.

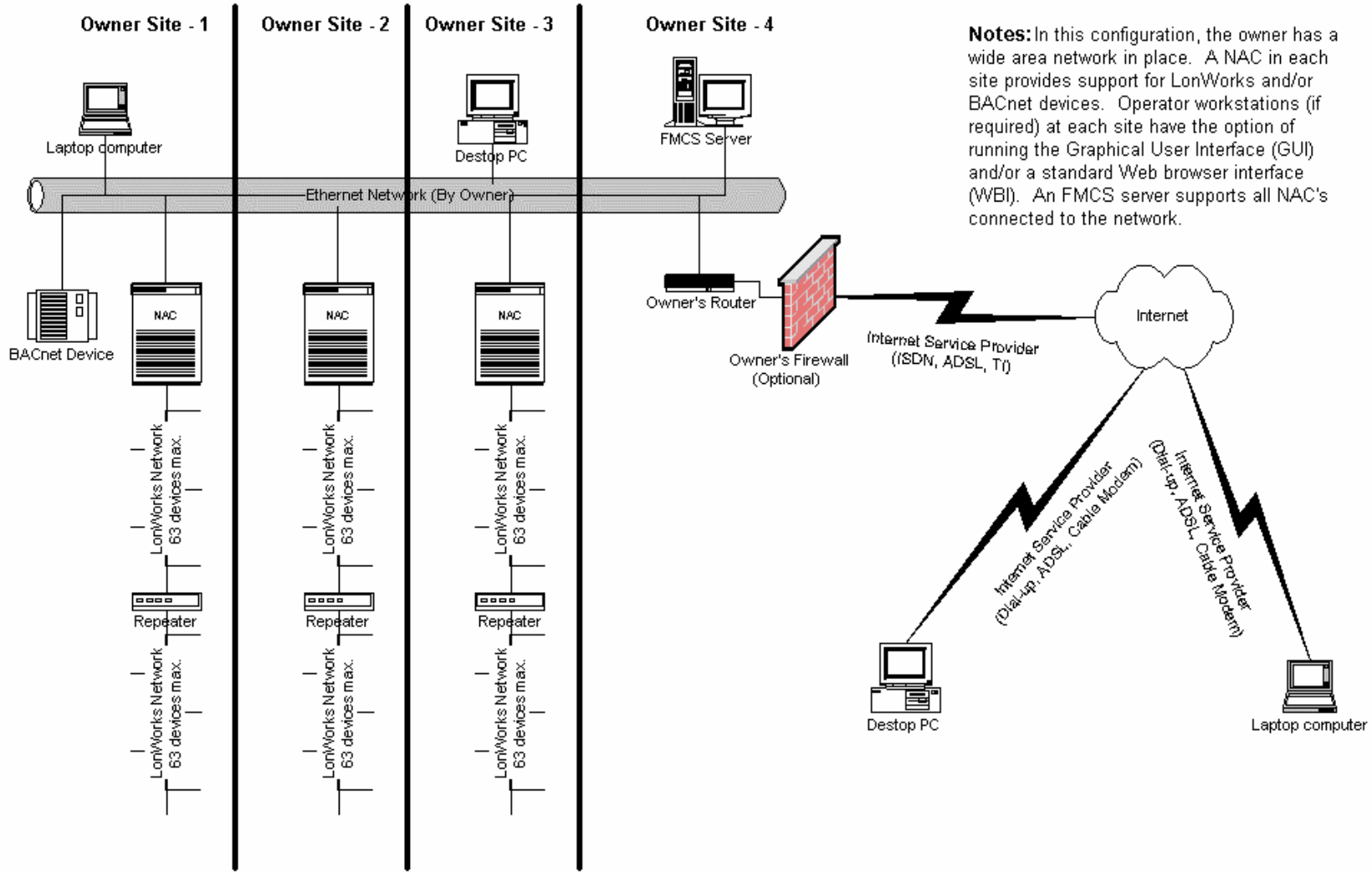
The System Integrator is providing very little product and a lot of integration expertise. For this reason, it is important to choose a firm that has a strong background in system integration with the Niagara Framework product line and one who also has a strong reputation for quality service in the local region. The relationship with the System Integrator will be ongoing with every new integration project as they will be responsible for developing the Graphic User Interface. Standards for graphic images, naming conventions, etc., should be developed along the way. While it will be possible to change System Integrators, it would not be recommended to have more than one System Integrator for the system at any given time.

When possible, we would recommend a "qualifications" based selection of contractors rather than lowest bid. System integration requires an extreme amount of cooperation among all of the control vendors that are to be involved. Limiting yourself to the low bid rather than the most qualified at a fair and reasonable price can create additional work for all parties involved, usually during the period of checkout and acceptance when construction budgets have become tight.

Appendix A

BAS Wide Area Network Schematic Diagrams

Sample Configurations - Wide Area Network Configuration - Owner Supplied WAN



Notes: In this configuration, the owner has a wide area network in place. A NAC in each site provides support for LonWorks and/or BACnet devices. Operator workstations (if required) at each site have the option of running the Graphical User Interface (GUI) and/or a standard Web browser interface (WBI). An FMCS server supports all NAC's connected to the network.

Appendix B

Division 15 (HVAC Control System)

SECTION 15XXX
HVAC CONTROL SYSTEM (HCS)

Note to Specifiers: This section is intended to provide a means to delineate the scope of work between the Division 15 contractor, typically the HVAC Controls Contractor and other divisions supplying products and services that will become part of the overall BAS. This section must be closely coordinated with Divisions 17 and 16. A similar set of specifications should be developed for any other equipment or controls that require integration to the BAS specified in Division 17. It is anticipated that these requirements be included or referenced in the specific project specifications.

PART 1 GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, equipment, and service necessary for a complete and operating HVAC Control System (HCS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only.

B. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.

1.2 SYSTEM DESCRIPTION

A. It is the Owner's express goal to implement an open, Wide Area Networked (WAN) Building Automation System (BAS) system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. The Graphic User Interface (GUI) shall be Web based and shall provide a common operating platform for all integrated control systems. The work and products provided by the System Integrator are defined in Division 17 and are based on the Niagara Framework (or "Niagara"), a Java-based framework developed by Tridium. The work of the Division 15 contractor as it pertains to the HVAC Control System (HCS) and integration with the Division 17 BAS is further defined herein.

B. The entire HVAC Control System (HCS) shall be comprised of a network of interoperable, stand-alone digital controllers communicating via BACnet communication protocols provided under this Division to a Network Area Controller (NAC), provided under Division 17.

1.3 APPROVED CONTROL SYSTEM CONTRACTORS AND MANUFACTURERS

A. The following are the approved HVAC Control System Contractors and manufacturers:

COMPANY NAME	MANUFACTURER	PRODUCT LINE	ADDRESS/LOCATION	CONTACT

Note:

1. The above Contractors are listed alphabetically and do not display a preference.
2. The Contractor shall use only products from the corresponding manufacturer and product line listed.
3. The above list of manufacturers applies to operator workstation software, controller software, the custom application programming language, Building Controllers, Custom Application Controllers, and Application Specific Controllers. All other products specified herein (e.g., sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.4 SUBMITTAL

A. Prior to the start of system installation, six copies of the following shall be submitted and approved:

1. Shop drawings of the entire control system that shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

2. A complete written Sequence of Operation for all systems.

3. A complete point list of all connected points to the DDC system.

4. Control system Checkout and Testing and Demonstration forms developed in a format that fully documents the requirements as stated in the Division 17 specification sections titled “Checkout and Testing” and “Demonstration”. The forms shall include sections for any global or application programming performed by the Network Area Controllers provided by Division 17.

5. A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface included in the submittal. PICS to include for each product, as a minimum, a list of BACnet functional groups supported, BACnet services supported, BACnet data link options available and BACnet objects provided.

6. Graphics are not typically intended to be developed as part of the Division 15 work for either the Operator Workstation or Portable Operators Terminal. Instead, the typical Graphic User Interface for day-to-day operations is intended to be developed by the BAS System Integrator as part of the Division 17 work. However, should this project require local system graphics, the submittal shall also include a copy of each of the graphics developed for the local Graphic User Interface including a flowchart (site map) indicating how the graphics are intended to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or Owner.

B. The Division 15 contractor supplying products and systems, as part of their submittal packages shall also provide one additional copy of their submittal package directly to the Division 17 contractor for proper coordination of work.

C. Upon completion of the work, provide a complete set of ‘as-built’ drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ compatible files. Six copies of the ‘as-built’ drawings shall be provided in addition to the documents on compact disk.

1.5 DIVISION OF WORK

A. The Division 15 contractor shall be responsible for all controllers (ILC and IBC), control devices, control panels, controller programming, controller programming software, controller input/output and power wiring, controller network wiring and Portable Operator's Terminals.

B. The Division 17 contractor shall be responsible for the Network Area Controller(s) (NAC), software and programming of the NAC, graphical user interface software (GUI), development of all graphical screens, setup of schedules, logs and alarms, LonWorks network management, global supervisory control applications, system integration and coordination and connection of the NAC to the local or Wide Area Network.

C. The Owner shall be responsible for providing and maintaining the Ethernet backbone and all necessary connectors, repeaters, bridges, hubs, and routers The Owner will provide Ethernet drops within five feet of the equipment provided by Division 17 that requires network connection as defined on diagrams developed specifically for this project. It is anticipated that there will be one open RJ-45 jack located in each mechanical room to facilitate the connection of a Portable Operator's Terminal to the Ethernet backbone for purposes of troubleshooting and maintenance of the mechanical room equipment.

1.6 RELATED WORK SPECIFIED ELSEWHERE

A. Division 17, System Integration:

1. Providing Network Area Controllers, connection to local or Wide Area Network.
2. LonWorks network management
3. Integration of BACnet devices
4. Graphical user interface software
5. Global supervisory control sequences
6. Integration of Owner's existing control system

B. Division 16, Electrical:

1. Providing motor starters and disconnect switches (unless otherwise noted).
2. Power wiring and conduit (unless otherwise noted).
3. Provision, installation and wiring of smoke detectors (unless otherwise noted).
4. Providing control devices and systems including but not limited to:
   a. Interoperable BACnet Controllers and programming
   b. Control panels, devices and wiring
   c. Local controller and control device networks
   d. Independent system Portable Operator Terminals

1.7 CODES AND STANDARDS

A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids of the following codes. Systems or products not currently offering the following approvals are not acceptable.

1. Underwriters Laboratories UL-916; Energy Management Systems (Canada and the U.S.)
2. Occupational Safety and Health Act (OSHA)
3. National Fire Protection Association (NFPA) Standards
4. National Electric Code (NEC)
5. Uniform Building Code (UBC)
6. Uniform Mechanical Code (UMC)
7. Uniform Plumbing Code
8. Institute of Electrical and Electronic Engineers (IEEE)
9. ANSI/ASHRAE Standard 135 – BACnet (where specified)
10. LonMark Interoperability Association's "LonMark" Certification (where specified)
11. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices

1.8 SOFTWARE LICENSE AGREEMENT

A. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

1.9 OWNERSHIP OF MATERIAL

A. The Owner shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use within Network Area Controllers, Web server(s), and any related LAN/WAN/Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the Owner. In addition to the installed copy, a backup copy of the aforementioned documentation, data and software shall be provided in CD format.

1.10 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.11 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features. In locating equipment, ease of maintenance and serviceability shall have priority. The Contract Administrator shall be consulted on all hardware, valve, and controller locations to ensure serviceability.

1.12 QUALITY ASSURANCE

A. The manufacturer of the HCS digital controllers shall provide documentation supporting compliance with ISO-9001 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing). Product literature provided by the HCS digital controller manufacturer shall contain the ISO-9001 Certification Mark from the applicable registrar.

1.13 SPECIFICATION NOMENCLATURE

A. Acronyms and other terms used in this specification are defined as follows:

AI: Analog Input

AO: Analog Output

ASCII: American Standard Code for Information Interchange

BACnet®: A data communication protocol for building automation and control networks. The rules governing this protocol are defined in ASHRAE/ANSI Standard 135.

BAS: Building Automation System

BI: Binary Input

BMP: The standard bit-mapped graphics format used in the Windows environment. By convention, graphics files in the BMP format end with a ".BMP" extension.

BO: Binary Output

Bridge: A device that connects two local-area networks (LANs), or two segments of the same LAN that use the same protocol, such as Ethernet or Token-Ring.

Client: The client part of a client-server architecture. Typically, a client is an application that runs on a personal computer or workstation and relies on a server to perform some operations. Clients rely on servers for resources, such as files, devices, and even processing power.

Client/Server Architecture: A network architecture in which each computer or process on the network is either a client or a server. Servers are powerful computers or processes dedicated to managing disk drives (file servers), printers (print servers), or network traffic (network servers). Clients are personal computers or workstations on which users run applications. Client-server architectures are sometimes called two-tier architectures.

DDC: Direct Digital Control. The digital algorithms and pre-defined arrangements included in the control system software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

DDE: Dynamic Data Exchange

Ethernet: A local area network (LAN) technology that is probably the most prevalent in the world today due to its common usage in standard office networks. Due to its transmission speeds (10 Mbps) or Fast Ethernet (100 Mbps), most BAS control manufacturers offer Ethernet as an option for connecting their workstations and system controllers on the LAN. Ethernet can be implemented over several different types of network media including

unshielded twisted-pair (UTP), coaxial cable, and fiber optic cable. (Ethernet is also known as ISO8802-3).

Firewall: A system designed to prevent unauthorized access to or from a private network. Firewalls can be implemented in both hardware and software, or a combination of both. Firewalls are frequently used to prevent unauthorized Internet users from accessing private networks connected to the Internet, especially intranets. All messages entering or leaving the intranet pass through the firewall, which examines each message and blocks those that do not meet the specified security criteria.

Furnish: The term “Furnish” and its derivatives when used in this Division shall mean supply at the Contractor’s cost to the designated third party trade contractor for installation. The Contractor shall connect furnished items to the system, calibrate, test, verify, warrant and document.

GIF: Graphics Interchange Format. A bit-mapped graphics file format. GIF supports color and various resolutions. It also includes data compression, but because it is limited to 256 colors, it is more effective for scanned images such as illustrations rather than color photos. By convention, graphics files in the GIF format end with a “.GIF” extension.

GUI: Graphical User Interface

HCS: HVAC Control System

Hub: A common connection point for devices in a network. Hubs are commonly used to connect segments of a LAN. A hub contains multiple ports. When a packet arrives at one port, it is copied to the other ports so that all segments of the LAN can see all packets.

HTML: HyperText Markup Language. An internet programming language that defines the internet pages we look at and provides a common model for data representation.

HTTP: HyperText Transfer Protocol, the underlying protocol used by the World Wide Web. HTTP defines how messages are formatted and transmitted, and what actions Web servers and browsers should take in response to various commands.

IBC: Interoperable BACnet Controller

ILC: Interoperable LonWorks Controller

Install: The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.

Integration: The ability to link disparate control system devices into a cohesive Building Automation System.

Interoperability: The ability of disparate control system devices to work together toward a common objective through the exchange of information.

Intranet: A network based on TCP/IP protocols (an internet) belonging to an organization, accessible only by the organization's members, employees, or others with authorization. An intranet's Web sites look and act just like any other Web sites, but the firewall surrounding an intranet fends off unauthorized access.

IP: Internet Protocol. IP specifies the format of packets, also called datagrams, and the addressing scheme. Most networks combine IP with a higher-level protocol called Transmission Control Protocol (TCP), which establishes a virtual connection between a destination and a source.

Java: A high-level programming language developed by Sun Microsystems. Compiled Java code can run on most computers because Java interpreters and runtime environments, known as Java Virtual Machines (VMs), exist for most operating systems, including UNIX, the Macintosh OS, and Windows. Java is a general purpose programming language with a number of features that make the language well suited for use on the World Wide Web.

Java Applet: Small Java applications that are typically downloaded from a Web server and run on your computer by a Java-compatible Web browser, such as Netscape Navigator or Microsoft Internet Explorer.

JPEG: Joint Photographic Experts Group. JPEG is a glossy compression technique for color images. Although it can reduce files sizes to about 5% of their normal size, some detail is lost in the compression. By convention, graphics files in the JPEG format end with a ".JPG" extension.

LAN: Local Area Network. A computer network that spans a relatively small area. Most LANs are confined to a single building or group of buildings. However, one LAN can be connected to other LANs over any distance via the Internet, telephone lines, and radio waves. A system of LANs connected in this way is called a wide-area network (WAN).

LonMark™: A set of protocol rules and practices that has been developed and approved by a group of manufacturers that use the "Neuron" processor chip developed by the Echelon Corporation. LonMark is also the mark awarded to devices which implement the profile for their specific device type.

LonTalk®: A local area network (LAN) technology created by the Echelon Corporation. Its speed is scaleable (32Kbps to 1.25Mbps) and is comparable to MS/TP on the low end and ARCNET on the high end. LonTalk will typically be used for application specific controller networks. LonTalk can be implemented over several different types of network media including unshielded twisted-pair (UTP) or Free Topology (FTT-10a), coaxial cable, fiber optic cable, radio frequency (RF), and infrared (IR). (LonTalk is also known as EIA-709.1)

LonWorks®: An encompassing term that includes the LonTalk communications protocol, devices that use the LonTalk protocol (LonMark devices) and the network on which the devices reside.

MSTP: Master Slave Token Passing. A local area network (LAN) technology created by ASHRAE and unique to BACnet. Its speed (approximately 76Kbps) is slower than Ethernet and ARCNET, but it is the lowest cost LAN option for BACnet. The maximum delay before a device is able to transmit a message can be determined. Many BAS control manufacturers utilize MSTP for their application specific controller networks. MSTP is implemented using EIA-485 signaling and can be used in a master-slave mode, a peer-to-peer token passing mode, or a combination of the two.

Media: The physical network wiring that is used to transmit data. Typical media includes unshielded twisted-pair (UTP) wiring, coaxial cables, and fiber optic cables.

NAC: Network Area Controller

ODBC: Open DataBase Connectivity. A standard database access method developed by Microsoft Corporation. The goal of ODBC is to make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data. ODBC manages this by inserting a middle layer, called a database driver, between an application and the DBMS. The purpose of this layer is to translate the application's data

queries into commands that the DBMS understands. For this to work, both the application and the DBMS must be ODBC-compliant -- that is, the application must be capable of issuing ODBC commands and the DBMS must be capable of responding to them. Since version 2.0, the standard supports SAG SQL.

OLE: Object Linking and Embedding. OLE is a compound document standard developed by Microsoft Corporation. It enables you to create objects with one application and then link or embed them in a second application. Embedded objects retain their original format and links to the application that created them.

OOT: Object Oriented Technology

OPC: Object Linking and Embedding (OLE) for Process Control. This is a communication protocol utilizing Microsoft Windows NT client/server technology and Component Object Module (COM) and Distributed COM software architecture. It uses Ethernet TCP/IP message transportation.

Peer-to-Peer Architecture: A type of network in which each workstation has equivalent capabilities and responsibilities. This differs from client/server architectures, in which some computers are dedicated to serving the others. Peer-to-peer networks are generally simpler, but they usually do not offer the same performance under heavy loads.

PICS: Product Interoperability Compliance Statement

POT: Portable Operator's Terminal

Protocol: An agreed-upon format for transmitting data between two devices. The protocol determines; 1) the type of error checking to be used, 2) data compression method, if any, 3) how the sending device will indicate that it has finished sending a message, and 4) how the receiving device will indicate that it has received a message.

Provide: The term "Provide" and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, verify, warrant, document and supply the associated required services ready for operation.

Router: A device utilized to join two or more networks together. A router has the capability of joining together networks that use different Local Area Network (LAN) technologies such as a BACnet Ethernet LAN with a BACnet MSTP LAN. The router forwards data packets along networks and use headers and forwarding tables to determine the best path for forwarding the packets.

Server: A computer or device on a network that manages network resources. For example, a file server is a computer and storage device dedicated to storing files. Any user on the network can store files on the server. A print server is a computer that manages one or more printers, and a network server is a computer that manages network traffic. A database server is a computer system that processes database queries.

SQL: Structured Query Language. SQL is a standardized query language for requesting information from a database. Historically, SQL has been the favorite query language for database management systems running on minicomputers and mainframes. Increasingly, however, SQL is being supported by PC database systems because it supports distributed databases (databases that are spread out over several computer systems). This enables several users on a local-area network to access the same database simultaneously.

TCP: Transmission Control Protocol. TCP is one of the main protocols in TCP/IP networks. Whereas the IP protocol deals only with packets, TCP enables two hosts to establish a

connection and exchange streams of data. TCP guarantees delivery of data and also guarantees that packets will be delivered in the same order in which they were sent.

TCP/IP: Transmission Control Protocol/Internet Protocol. The suite of communications protocols used to connect hosts on the Internet. TCP/IP uses several protocols, the two main ones being TCP and IP. TCP/IP is used by the Internet, making it the de facto standard for transmitting data over networks.

Thick Client: In a "thick" client/server architecture, the client does the majority of the processing.

Thin Client: In a "thin" client/server architecture, most of the processing is handled by the server and all the browser has to do is process the display.

UPS: Uninterruptible Power Supply.

Virtual Point: A point of information that is generated as a software value rather than the value being generated by an actual hardware device.

WAN: Wide Area Network. A computer network that spans a relatively large geographical area. Typically, a WAN consists of two or more local-area networks (LANs).

WBI: Web Browser Interface

XIF File: The external interface file created in Neuron C defining the LonMark product's network variables, message tags, and hardware related parameters.

XML: Extensible Markup Language. A technology for moving structured data across the internet or a corporate network. Unlike HTML, XML documents include more than just raw data by including a definition of the data structure, so the receiving computer knows what information is contained in which fields.

PART 2 MATERIALS

2.1 GENERAL

A. The HVAC Control System (HCS) shall be comprised of a network of interoperable, stand-alone digital controllers and other devices as specified herein.

2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate the ANSI/ASHRAE Standard 135 BACnet communication protocol.

2.3 INTEROPERABLE BACnet CONTROLLER (IBC)

A. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with ANSI/ASHRAE Standard 135. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier must provide a PICS document showing the installed systems compliance level to ANSI/ASHRAE Standard 135, to the Division 17 contractor. Minimum compliance is Level 3.

B. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.

C. All IBCs shall support BACnet implementation and compliance as specified. All control sequences within or programmed into the IBC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

D. The Division 15 contractor supplying the IBC's shall provide documentation for each device, with the following information at a minimum:

1. BACnet Device; MAC address, name, type and instance number
2. BACnet Objects; name, type and instance number

E. It is the responsibility of the Division 15 contractor to ensure that the proper BACnet objects are provided in each IBC, as required by the point charts.

F. The application controller programming shall be object oriented block programming. Text based programming languages shall not be acceptable.

Note to specifiers: Specifications for computers change on a regular basis. The following specifications for the Portable Operator's Terminal should be reviewed and updated prior to each new project.

2.4 PORTABLE OPERATOR'S TERMINAL

A. The Division 15 Contractor shall provide one Portable Operator's Terminal (POT) for the HVAC Control System. The POT shall be complete with all vendor specific software necessary for programming and day to day operation of the system. The POT is intended to provide a text based interface only. The Graphical User Interface is specified as part of Division 17.

B. The POT hardware shall be based on currently available products at the time of bid and have the following minimum requirements:

1. An IBM compatible laptop computer with 15" (viewable) minimum screen size
2. Processing speed in the upper 50% of currently available products from Dell
3. 1 GB RAM
4. Hard drive size and speed in the upper 50% of currently available products from Dell
5. CD-RW combination drive
6. 2-parallel ports
7. 2-asynchronous serial ports
8. 2-USB ports
9. Standard keyboard with built-in mouse device
10. Connection to the BAS network shall be via an Ethernet network interface card, 10/100 Mbps.

Note to specifiers: Specifications for other control system devices, sensors, actuators, etc. can be inserted here.

2.5 OTHER CONTROL SYSTEM HARDWARE

Note to specifiers: Specifications for project execution can be inserted here. Items covered should include installation, training, documentation, warranty, acceptance testing and, if desired, system commissioning.

PART 3 EXECUTION

3.1 INSTALLATION

3.2 WIRING

A. All electrical control wiring and power wiring to the NAC and other equipment provided by the Division 17 contractor shall be provided by the Division 17 contractor.

B. providing and maintaining the Ethernet backbone and all necessary connectors, repeaters, bridges, hubs, and routers The Owner will provide Ethernet drops within five feet of the equipment provided by Division 17 that requires network connection as defined on diagrams developed specifically for this project. It is anticipated that there will be one open RJ-45 jack located in each mechanical room to facilitate the connection of a Portable Operator's Terminal to the Ethernet backbone for purposes of troubleshooting and maintenance of the mechanical room equipment.

C. All wiring shall be in accordance with the Project Electrical Specifications (Division 16), the National Electrical Code and any applicable local codes. All BAS wiring shall be installed in the conduit types specified in the Project Electrical Specifications (Division 16). Where BAS plenum rated cable wiring is allowed it shall be run parallel to or at right angles to the structure, properly supported and installed in a neat and workmanlike manner.

3.3 WARRANTY

A. Following acceptance testing, the Division 15 contractor shall be responsible for all initial troubleshooting when a system problem arises in the integrated control system. Upon initial checkout, if the problem cannot be determined and resolved, it may require temporary isolation of the HVAC Control System from the Network Area Controller. If temporary system isolation remedies the problem, then the Division 15 contractor will need to work together in harmony with the Division 17 System Integrator to diagnose and resolve the problem to ensure that the system is functioning in full accordance with these specifications.

B. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.

C. Within this period, upon notice by the Owner, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by the Division 15 contractor at no expense to the Owner

3.4 WARRANTY ACCESS

A. The Owner shall grant to the Division 15 contractor, reasonable access to the HCS during the warranty period.

3.5 CHECKOUT AND TESTING

A. See the Division 17 Section titled "Checkout and Testing" for the requirements of the Division 15 contractor during Checkout and Testing activities.

3.6 DEMONSTRATION

A. See the Division 17 Section titled “Demonstration” for the requirements of the Division 15 contractor during system Demonstration activities.

3.7 SYSTEM ACCEPTANCE

A. See the Division 17 Section titled “System Acceptance” for system acceptance requirements for the Division 15 contractor.

3.8 OPERATOR INSTRUCTION, TRAINING

A. Upon the first installation of the BAS GUI, the Division 17 contractor shall provide instruction to the Owner's designated personnel on the operation of the BAS and all system integration equipment provided by Division 17. Subsequent to that first installation, it is intended that the Owner’s operating personnel will be familiar enough with the system to assist with any training issues that may arise for the Division 15 contractor operating the Graphic User Interface with which they may have less familiarity.

B. During system commissioning and at such time acceptable performance of the BAS hardware and software has been established, the Division 15 contractor shall provide on-site operator instruction to the Owner's operating personnel. Division 15 training may utilize the Graphic User Interface as necessary but should focus mainly upon the equipment and systems provided as part of Division 15.

Note to specifiers: Project specific training requirements should be included here.

3.9 RECORD DOCUMENTATION

A. Three copies of the Operation & Maintenance manuals for work provided under this Division shall be provided to the Owner upon completion of the project. These manuals shall be updated each time changes are made to the system. The entire Operation & Maintenance manual shall be furnished in three-ring binders with adequate indexing and also on compact disc media, and shall include the following:

1. Table of contents.
2. As-built system record drawings. Record drawings in AutoCAD format shall represent the as-built condition of the system and incorporate all information supplied with the approved submittals. These shall include sequences of operation and a complete I/O point summary.
3. Manufacturer’s product data sheets for all products including software.
4. System operator’s manuals.
5. Complete network diagrams that also indicate connections to the BAS Wide Area Network.
6. Wiring termination schedules.
7. Copies of all completed forms for control system Checkout and Testing and Demonstration activities including hard copies of all trend log graphs.
8. Archive copy of all controller databases (on compact disk only).

Note to specifiers: Put the required sequences of operation in this part.

PART 4 SEQUENCES OF OPERATION

4.1 SUMMARY

A. For each system listed, provide the sequence of operation as stated.

Note to specifiers: I/O Summary tables must be developed to provide a clear understanding of what points are to be provided in the user interface and what they must be able to do. For each building system to be included, list the points that are to be accessible through the Network Area Controller and the actions the Graphical User Interface and/or the Web browser interface must support. An example table has been provided as a suggested format and to identify the minimum information that is required. Each table should represent a single system. In each table, enter the name of the system, the points desired, and place an "X" in the column indicating the required functionality.

PART 5 POINT LISTS

5.1 SUMMARY

A. The points in the following table shall be accessible from the Graphical User Interface (GUI) and/or the Web browser interface (WBI), supplied under Division 17. The supplier of the ILC and IBC devices shall ensure that the points listed in this table are accessible on their respective networks, by the Network Area Controller (NAC).

(*The following table is presented as a suggested format and to indicate the minimum required information.)*

Network Area Controller (NAC) Global Control Functions and I/O Summary

	Application Programs							
System Description	**Demand Limiting**	**Optimum Start/Stop**	**Setback/ Setup**	**Night Purge**	**Duty Cycling**	**Custom?**		
AHU-1	X	X	X					
Point Description	**Point Type**	**Units**	**Default Value**	**Read**	**Write**	**Alarm**	**Trend Interval**	**Schedule**
Supply Fan Start/Stop	BO	On/Off	Off	X	X			X
Supply Fan Status	BI	On/Off		X		X		
Return Fan Start/Stop	BO	On/Off	Off	X	X			X
Return Fan Status	BI	On/Off		X		X		
Supply Fan Static Pressure Setpoint	AO	in. H_2O	1.0 in. H_2O	X	X			
Supply Fan Static Pressure	AI	in. H_2O		X		X	5 min	
Supply Fan VSD Speed	AO	% Speed	20%	X	X		5 min	
Supply Fan kW	AI	kW		X			15 min	
Supply Fan Runtime	VI	Hours		X		X		
Building Static Pressure Setpoint	AO	in. H_2O	0.1 in. H_2O	X	X			
Building Static Pressure	AI	in. H_2O		X		X	5 min	
Return Fan VSD Speed	AO	% Speed	20%	X	X		5 min	
Return Fan kW	AI	kW		X			15 min	
Return Fan Runtime	VI	Hours		X		X		
Return Air Temp	AI	deg F		X		X	15 min	
Return Air Relative Humidity	AI	% RH		X		X	15 min	
Return Air CO_2 Setpoint	AO	PPM	800 PPM	X	X			
Return Air CO_2	AI	PPM		X		X	15 min	
Return Air Smoke Detector	BI	Nrm/Alm		X		X		
Outside Air Damper Position	AO	% Open	0%	X	X		15 min	
Outside Air Flow	AI	CFM		X		X	15 min	
Air Filter Status	BI	Nrm/Alm		X		X		
Mixed Air Temp	AI	deg F		X		X	15 min	
Supply Air Temp Setpoint	AO	deg F	55 deg F	X	X			
Supply Air Temp	AI	deg F		X		X	15 min	
Supply Air Smoke Detector	BI	Nrm/Alm		X		X		
Cooling Valve Position	AO	% Open	100%	X	X		15 min	
Heating Valve Position	AO	% Open	0%	X	X		15 min	

END OF SECTION

Appendix C

Division 17 (BAS Integration)

SECTION 17XXX
BUILDING AUTOMATION SYSTEM (BAS) INTEGRATION

Note to Specifiers: This section is intended to provide a means to delineate the scope of work between the Division 17 contractor (System Integrator) and other divisions supplying products and services that will become part of the overall BAS. This section must be closely coordinated with Divisions 15 and 16. Typically Division 17 has been used to cover the integration of multiple systems within a facility such as HVAC, lighting, access, fire, etc.

This guide specification is setup to clearly divide the work between the HVAC Control System contractor (Division 15900) and the System Integrator (Division 17000). If other systems are planned for integration, such as lighting, access, fire, etc., please add the appropriate documentation in those sections.

PART 1 GENERAL

1.1 SUMMARY

A. This section describes the Systems Integration scope of work for the project. This section also coordinates the responsibilities of the Mechanical and Electrical trade contractors pertaining to control products or systems, furnished by each trade that will be integrated by this Division.

B. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.

1.2 SYSTEM DESCRIPTION

A. It is the Owner's express goal to implement an open, Wide Area Networked (WAN) Building Automation System (BAS) system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. The Graphic User Interface (GUI) shall be Web based and shall provide a common operating platform for all integrated control systems. The work and products provided by the System Integrator are defined in Division 17 and are based on the Niagara AX Framework (or "Niagara"), a Java-based framework developed by Tridium. Niagara provides a software infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time over the Internet using a standard Web browser. Systems not developed on the Niagara AX Framework platform are unacceptable.

B. The Building Automation System (BAS) shall be comprised of Network Area Controllers (NAC) within each facility. The NAC shall connect to the Owner's local or Wide Area Network, depending on configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each NAC shall communicate to LonMark/LonTalk (ILC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices provided under Division 15 or Division 16.

1.3 SUBMITTAL

A. Six copies of shop drawings of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate

that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings. A complete written Sequence of Operation shall also be included with the submittal package. Division 15 and 16 contractors shall provide shop drawings for their portions of work. Division 15 and 16 contractors supplying products and systems, as part of their packages shall provide catalog data sheets, wiring diagrams and point lists to the Division 17 contractor for proper coordination of work.

B. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol. Though the Division 15 and 16 contractors shall provide these diagrams for their portions of work, the Systems Integrator shall be responsible for integrating those diagrams into the overall trunk cable schematic diagrams for the entire Wide Area Network (WAN).

C. Submittal shall also include a complete point list of all points to be connected to the BAS by the System Integrator. Division 15 and 16 contractors shall provide a point list of their portions of the work. The Division 17 submittal should focus on the integration of those points into the BAS including any point mapping, addressing, or database configuration information.

D. Submittal shall also include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are intended to be linked to one another for both the standard tree navigation structure and any “hot spot” or directly links from one graphic to another. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or Owner.

E. Upon completion of the work, provide a complete set of ‘as-built’ drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ compatible files. Six copies of the ‘as-built’ drawings shall be provided in addition to the documents on compact disk. Division 15 and 16 contractors shall provide as-builts for their portions of work. The Division 17 contractor shall be responsible for as-builts pertaining to overall BAS architecture and network diagrams.

1.4 SPECIFICATION NOMENCLATURE

A. Acronyms and other terms used in this specification are defined as follows:

AI: Analog Input

AO: Analog Output

ASCII: American Standard Code for Information Interchange

BACnet®: A data communication protocol for building automation and control networks. The rules governing this protocol are defined in ASHRAE/ANSI Standard 135.

BAS: Building Automation System

BI: Binary Input

BMP: The standard bit-mapped graphics format used in the Windows environment. By convention, graphics files in the BMP format end with a “.BMP” extension.

BO: Binary Output

Bridge: A device that connects two local-area networks (LANs), or two segments of the same LAN that use the same protocol, such as Ethernet or Token-Ring.

Client: The client part of a client-server architecture. Typically, a client is an application that runs on a personal computer or workstation and relies on a server to perform some operations. Clients rely on servers for resources, such as files, devices, and even processing power.

Client/Server Architecture: A network architecture in which each computer or process on the network is either a client or a server. Servers are powerful computers or processes dedicated to managing disk drives (file servers), printers (print servers), or network traffic (network servers). Clients are personal computers or workstations on which users run applications. Client-server architectures are sometimes called two-tier architectures.

DDC: Direct Digital Control. The digital algorithms and pre-defined arrangements included in the control system software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

DDE: Dynamic Data Exchange

Ethernet: A local area network (LAN) technology that is probably the most prevalent in the world today due to its common usage in standard office networks. Due to its transmission speeds (10 Mbps) or Fast Ethernet (100 Mbps), most BAS control manufacturers offer Ethernet as an option for connecting their workstations and system controllers on the LAN. Ethernet can be implemented over several different types of network media including unshielded twisted-pair (UTP), coaxial cable, and fiber optic cable. (Ethernet is also known as ISO8802-3).

Firewall: A system designed to prevent unauthorized access to or from a private network. Firewalls can be implemented in both hardware and software, or a combination of both. Firewalls are frequently used to prevent unauthorized Internet users from accessing private networks connected to the Internet, especially intranets. All messages entering or leaving the intranet pass through the firewall, which examines each message and blocks those that do not meet the specified security criteria.

Furnish: The term “Furnish” and its derivatives when used in this Division shall mean supply at the Contractor’s cost to the designated third party trade contractor for installation. The Contractor shall connect furnished items to the system, calibrate, test, verify, warrant and document.

GIF: Graphics Interchange Format. A bit-mapped graphics file format. GIF supports color and various resolutions. It also includes data compression, but because it is limited to 256 colors, it is more effective for scanned images such as illustrations rather than color photos. By convention, graphics files in the GIF format end with a “.GIF” extension.

GUI: Graphical User Interface

HCS: HVAC Control System

Hub: A common connection point for devices in a network. Hubs are commonly used to connect segments of a LAN. A hub contains multiple ports. When a packet arrives at one port, it is copied to the other ports so that all segments of the LAN can see all packets.

HTML: HyperText Markup Language. An internet programming language that defines the internet pages we look at and provides a common model for data representation.

HTTP: HyperText Transfer Protocol, the underlying protocol used by the World Wide Web. HTTP defines how messages are formatted and transmitted, and what actions Web servers and browsers should take in response to various commands.

IBC: Interoperable BACnet Controller

ILC: Interoperable LonWorks Controller

Install: The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.

Integration: The ability to link disparate control system devices into a cohesive Building Automation System.

Interoperability: The ability of disparate control system devices to work together toward a common objective through the exchange of information.

Intranet: A network based on TCP/IP protocols (an internet) belonging to an organization, accessible only by the organization's members, employees, or others with authorization. An intranet's Web sites look and act just like any other Web sites, but the firewall surrounding an intranet fends off unauthorized access.

IP: Internet Protocol. IP specifies the format of packets, also called datagrams, and the addressing scheme. Most networks combine IP with a higher-level protocol called Transmission Control Protocol (TCP), which establishes a virtual connection between a destination and a source.

Java: A high-level programming language developed by Sun Microsystems. Compiled Java code can run on most computers because Java interpreters and runtime environments, known as Java Virtual Machines (VMs), exist for most operating systems, including UNIX, the Macintosh OS, and Windows. Java is a general purpose programming language with a number of features that make the language well suited for use on the World Wide Web.

Java Applet: Small Java applications that are typically downloaded from a Web server and run on your computer by a Java-compatible Web browser, such as Netscape Navigator or Microsoft Internet Explorer.

JPEG: Joint Photographic Experts Group. JPEG is a glossy compression technique for color images. Although it can reduce files sizes to about 5% of their normal size, some detail is lost in the compression. By convention, graphics files in the JPEG format end with a “.JPG” extension.

LAN: Local Area Network. A computer network that spans a relatively small area. Most LANs are confined to a single building or group of buildings. However, one LAN can be connected to other LANs over any distance via the Internet, telephone lines, and radio waves. A system of LANs connected in this way is called a wide-area network (WAN).

LonMark™: A set of protocol rules and practices that has been developed and approved by a group of manufacturers that use the “Neuron” processor chip developed by the Echelon Corporation. LonMark is also the mark awarded to devices which implement the profile for their specific device type.

LonTalk®: A local area network (LAN) technology created by the Echelon Corporation. Its speed is scaleable (32Kbps to 1.25Mbps) and is comparable to MS/TP on the low end and

ARCNET on the high end. LonTalk will typically be used for application specific controller networks. LonTalk can be implemented over several different types of network media including unshielded twisted-pair (UTP) or Free Topology (FTT-10a), coaxial cable, fiber optic cable, radio frequency (RF), and infrared (IR). (LonTalk is also known as EIA-709.1)

LonWorks®: An encompassing term that includes the LonTalk communications protocol, devices that use the LonTalk protocol (LonMark devices) and the network on which the devices reside.

MSTP: Master Slave Token Passing. A local area network (LAN) technology created by ASHRAE and unique to BACnet. Its speed (approximately 76Kbps) is slower than Ethernet and ARCNET, but it is the lowest cost LAN option for BACnet. The maximum delay before a device is able to transmit a message can be determined. Many BAS control manufacturers utilize MSTP for their application specific controller networks. MSTP is implemented using EIA-485 signaling and can be used in a master-slave mode, a peer-to-peer token passing mode, or a combination of the two.

Media: The physical network wiring that is used to transmit data. Typical media includes unshielded twisted-pair (UTP) wiring, coaxial cables, and fiber optic cables.

NAC: Network Area Controller

ODBC: Open DataBase Connectivity. A standard database access method developed by Microsoft Corporation. The goal of ODBC is to make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data. ODBC manages this by inserting a middle layer, called a database driver, between an application and the DBMS. The purpose of this layer is to translate the application's data queries into commands that the DBMS understands. For this to work, both the application and the DBMS must be ODBC-compliant -- that is, the application must be capable of issuing ODBC commands and the DBMS must be capable of responding to them. Since version 2.0, the standard supports SAG SQL.

OLE: Object Linking and Embedding. OLE is a compound document standard developed by Microsoft Corporation. It enables you to create objects with one application and then link or embed them in a second application. Embedded objects retain their original format and links to the application that created them.

OOT: Object Oriented Technology

OPC: Object Linking and Embedding (OLE) for Process Control. This is a communication protocol utilizing Microsoft Windows NT client/server technology and Component Object Module (COM) and Distributed COM software architecture. It uses Ethernet TCP/IP message transportation.

Peer-to-Peer Architecture: A type of network in which each workstation has equivalent capabilities and responsibilities. This differs from client/server architectures, in which some computers are dedicated to serving the others. Peer-to-peer networks are generally simpler, but they usually do not offer the same performance under heavy loads.

PICS: Product Interoperability Compliance Statement

POT: Portable Operator’s Terminal

Protocol: An agreed-upon format for transmitting data between two devices. The protocol determines; 1) the type of error checking to be used, 2) data compression method, if any, 3)

how the sending device will indicate that it has finished sending a message, and 4) how the receiving device will indicate that it has received a message.

Provide: The term “Provide” and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, verify, warrant, document and supply the associated required services ready for operation.

Router: A device utilized to join two or more networks together. A router has the capability of joining together networks that use different Local Area Network (LAN) technologies such as a BACnet Ethernet LAN with a BACnet MSTP LAN. The router forwards data packets along networks and use headers and forwarding tables to determine the best path for forwarding the packets.

Server: A computer or device on a network that manages network resources. For example, a file server is a computer and storage device dedicated to storing files. Any user on the network can store files on the server. A print server is a computer that manages one or more printers, and a network server is a computer that manages network traffic. A database server is a computer system that processes database queries.

SQL: Structured Query Language. SQL is a standardized query language for requesting information from a database. Historically, SQL has been the favorite query language for database management systems running on minicomputers and mainframes. Increasingly, however, SQL is being supported by PC database systems because it supports distributed databases (databases that are spread out over several computer systems). This enables several users on a local-area network to access the same database simultaneously.

TCP: Transmission Control Protocol. TCP is one of the main protocols in TCP/IP networks. Whereas the IP protocol deals only with packets, TCP enables two hosts to establish a connection and exchange streams of data. TCP guarantees delivery of data and also guarantees that packets will be delivered in the same order in which they were sent.

TCP/IP: Transmission Control Protocol/Internet Protocol. The suite of communications protocols used to connect hosts on the Internet. TCP/IP uses several protocols, the two main ones being TCP and IP. TCP/IP is used by the Internet, making it the de facto standard for transmitting data over networks.

Thick Client: In a “thick” client/server architecture, the client does the majority of the processing.

Thin Client: In a “thin” client/server architecture, most of the processing is handled by the server and all the browser has to do is process the display.

UPS: Uninterruptible Power Supply.

Virtual Point: A point of information that is generated as a software value rather than the value being generated by an actual hardware device.

WAN: Wide Area Network. A computer network that spans a relatively large geographical area. Typically, a WAN consists of two or more local-area networks (LANs).

WBI: Web Browser Interface

XIF File: The external interface file created in Neuron C defining the LonMark product’s network variables, message tags, and hardware related parameters.

XML: Extensible Markup Language. A technology for moving structured data across the internet or a corporate network. Unlike HTML, XML documents include more than just raw

data by including a definition of the data structure, so the receiving computer knows what information is contained in which fields.

1.5 DIVISION OF WORK

A. The Division 15 and 16 contractors shall be responsible for all controllers (ILC and IBC), control devices, control panels, controller programming, controller programming software, controller input/output and power wiring and controller network wiring.

B. The Division 17 contractor shall be responsible for the Network Area Controllers (NAC), software and programming of the NAC, graphical user interface software (GUI), development of all graphical screens, Web browser pages, setup of schedules, logs and alarms, LonWorks network management, connection of the NAC to the local or Wide Area Network, and any licensing required to ensure connectivity to other NAC on the City's Wide Area Network.

C. The Owner shall be responsible for providing and maintaining the Ethernet backbone and all necessary connectors, repeaters, bridges, hubs, and routers as is standard practice within their facilities. The Owner will provide Ethernet drops within five feet of the equipment provided by Division 17 that requires network connection as defined on diagrams developed specifically for this project. It is anticipated that there will be one open RJ-45 jack located in each mechanical room to facilitate the connection of a Portable Operator's Terminal to the Ethernet backbone for purposes of troubleshooting and maintenance of the mechanical room equipment.

D. The Owner shall be responsible for providing and maintaining any desktop computers, laptop computers, and servers required as part of this system integration including operating system software. Any specifications for such equipment defined in this Division shall be considered minimum requirements. The Division 17 Contractor shall be responsible for providing and installing any application software necessary to meet the functional intent of this specification.

1.6 RELATED WORK SPECIFIED ELSEWHERE

A. Division 15, Mechanical:

1. Providing control devices and systems including but not limited to:

a. Interoperable BACnet Controllers and programming

b. Control panels, devices and wiring

c. Local controller and control device networks

d. Independent system Portable Operator Terminals

B. Division 16, Electrical:

1. Providing motor starters and disconnect switches (unless otherwise noted)

2. Power wiring and conduit (unless otherwise noted)

3. Provision, installation and wiring of smoke detectors (unless otherwise noted)

4. Providing control devices and systems including but not limited to:

a. Interoperable BACnet Controllers and programming

b. Control panels, devices and wiring

c. Local controller and control device networks

d. Independent system Portable Operator Terminals.

1.7 CODES AND STANDARDS

A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids of the following codes. Systems or products not currently offering the following approvals are not acceptable.

1. Underwriters Laboratories UL-916; Energy Management Systems (Canada and the U.S.)
2. Occupational Safety and Health Act (OSHA)
3. National Fire Protection Association (NFPA) Standards
4. National Electric Code (NEC)
5. Uniform Building Code (UBC)
6. Uniform Mechanical Code (UMC)
7. Uniform Plumbing Code
8. Institute of Electrical and Electronic Engineers (IEEE)
9. ANSI/ASHRAE Standard 135 – BACnet (where specified)
10. LonMark Interoperability Association's "LonMark" Certification (where specified)
11. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices

1.8 SOFTWARE LICENSE AGREEMENT

A. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

B. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). The Owner shall be named in the "orgid" of all software licenses. The Owner shall be free to direct the modification of the "orgid" in any software license, regardless of supplier, by Tridium, Inc. Any NACs provided shall be compatible with any and all vendors Niagara based tools.

1.9 OWNERSHIP OF MATERIAL

A. The Owner shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use within Network Area Controllers, Web server(s), and any related LAN/WAN/Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the Owner.

1.10 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.11 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.

1.12 QUALITY ASSURANCE

A. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices

PART 2 MATERIALS

2.1 GENERAL

A. The Building Automation System (BAS) shall be comprised of a network of interoperable, stand-alone digital controllers, a computer system, graphical user interface software, printers, network devices and other devices as specified herein.

B. The installed system shall provide secure password access to all features, functions and data contained in the overall BAS.

2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate the ANSI/ASHRAE Standard 135 BACnet communication protocol in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI/ASHRAE™ Standard 135, BACnet to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance shall include the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet or RS-485 MSTP

C. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

D. The supplied system must incorporate the ability to access all data using standard Microsoft® Internet Explorer Web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable. The

system shall support the archiving of historical data to optional databases including Oracle, MS SQL, and IBM DB2.

E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the Owner's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

F. Maximum acceptable response times for devices and Graphic User Interfaces connected directly to the BAS network shall be as shown in the following table:

Note to Specifiers: The response times specified are for a typical HVAC control system. These need to be thoroughly reviewed and possibly changed for more critical systems such as fire and security or others.

System Function	Point of Origin to NAC	NAC to Point of Display or Control	Point of Origin to Point of Display or Control
Graphic display with 20 dynamic points/object and current data	5 seconds	5 seconds	10 seconds
Graphic refresh with 20 dynamic points/object and current data	5 seconds	5 seconds	10 seconds
End use device reaction to object command	5 seconds	3 seconds	8 seconds
End use device change of value	5 seconds	1 second	6 seconds
Alarm response time	5 seconds	1 second	6 seconds

G. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.3 NETWORKS

A. The Local Area Network (LAN) shall be a 10/100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server. Coordinate with the Owner for connection to the LAN/WAN.

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE standard 802.3
2. Cable; 10 Base-T, UTP-8 wire, category 5
3. Minimum throughput; 10 Mbps, with ability to increase to 100 Mbps

2.4 NETWORK ACCESS

A. Remote Access.

1. For Local Area Network installations, provide access to the LAN from a remote location, via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the Owner's Intranet to a corporate server providing access to an Internet Service Provider (ISP). Owner agrees to pay monthly access charges for connection and ISP.

2.5 NETWORK AREA CONTROLLER (NAC)

A. The Division 17 contractor shall supply one or more Network Area Controllers (NAC) as part of this contract. The number of Network Area Controllers required is dependent on the type and quantity of devices provided under Divisions 15 and 16. It is the responsibility of the Division 17 contractor to coordinate with the Division 15 and 16 contractors to determine the quantity and type of devices.

B. The NAC shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:

1. Calendar functions
2. Scheduling
3. Trending
4. Alarm monitoring and routing
5. Time synchronization
6. Integration of LonWorks controller data and BACnet controller data
7. Network Management functions for all LonWorks based devices

C. The Network Area Controller must provide the following hardware features as a minimum:

1. One Ethernet Port 10/100 Mbps
2. One RS-232 port
3. One RS-485 port
4. One LonWorks Interface Port – 78KB FTT-10A
5. Battery Backup
6. Flash memory for long term data backup (Any NAC that utilizes a hard disk drive shall not be acceptable)
7. The NAC must be capable of operation over a temperature range of 0°C to 50°C (32°F to 122°F)
8. The NAC must be capable of withstanding storage temperatures of between 0°C and 70°C (32°F and 158°F)
9. The NAC must be capable of operation over a humidity range of 5% to 95% RH, non-condensing

D. The NAC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.

E. The NAC shall support standard Microsoft® Internet Explorer Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

F. Event Alarm Notification and actions

1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
    a. To alarm
    b. Return to normal
    c. To fault
4. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
5. Provide timed (schedule) routing of alarms by class, object, group, or node.
6. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Control equipment and network failures shall be treated as alarms and annunciated.

H. Alarms shall be annunciated in any of the following manners as defined by the user:

1. Screen message text
2. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
    a. Day of week
    b. Time of day
    c. Recipient
3. Pagers via paging services that initiate a page on receipt of email message
4. Graphic with flashing alarm object(s)
5. Printed message, routed directly to a dedicated alarm printer
6. Audio messages

I. The following shall be recorded by the NAC for each alarm (at a minimum):

1. Time and date
2. Location (building, floor, zone, office number, etc.)

3. Equipment (air handler #, accessway, etc.)
4. Acknowledge time, date, and user who issued acknowledgement.
5. Number of occurrences since last acknowledgement.

J. Alarm actions may be initiated by user defined programmable objects created for that purpose.

K. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.

L. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.

M. Provide a “query” feature to allow review of specific alarms by user defined parameters.

N. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

O. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

2.6 DATA COLLECTION AND STORAGE

A. The NAC shall have the ability to collect data for any property of any object and store this data for future use.

B. The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:

1. Designating the log as interval or deviation.
2. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
3. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

C. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web browser.

D. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

E. All log data shall be available to the user in the following data formats:

1. HTML
2. XML
3. Plain Text
4. Comma or tab separated values

F. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.

G. The NAC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties, at a minimum:

1. Archive on time of day
2. Archive on user-defined number of data stores in the log (buffer size)
3. Archive when log has reached it's user-defined capacity of data stores
4. Provide ability to clear logs once archived

2.7 AUDIT LOG

A. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:

1. Time and date
2. User ID
3. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

2.8 DATABASE BACKUP AND STORAGE

A. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.

B. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.

C. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

2.9 SQL DATABASE SUPPORT

A. In addition to the standard databases provided as part of the Niagara Framework, the BAS shall have the capability to archive all data (such as log data, alarms, alerts and audit histories) to a Microsoft SQL Server database. This will enable the Owner with an SQL Server to utilize this resource for data archive storage as well as for other applications to have access to energy use or other data that is captured by the Network Area Controllers.

2.10 GRAPHICAL USER INTERFACE SOFTWARE

A. Operating System:

1. The GUI shall run on Microsoft Windows 2000, or XP Professional.

B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not

limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

C. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
2. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.
3. Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
4. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
   a. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
   b. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
5. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
6. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.

D. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:

1. Create, delete or modify control strategies.
2. Add/delete objects to the system.
3. Tune control loops through the adjustment of control loop parameters.
4. Enable or disable control strategies.
5. Generate hard copy records or control strategies on a printer.
6. Select points to be capable of generating an alarm and define the alarm state.
7. Select points to be trended over a period of time and initiate the recording of values automatically.

E. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

F. Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

G. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

H. Alarm Console

1. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.

2. When the Alarm Console is enabled, a separate alarm notification window will supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

2.11 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Netscape Navigator™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.

B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BAS, shall not be acceptable.

C. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

D. The Web browser client shall support at a minimum, the following functions:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.

3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
4. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
5. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
   a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
      1. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
      2. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
   b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
   c. View logs and charts
   d. View and acknowledge alarms
   e. Setup and execute SQL queries on log and archive information
7. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.12 SERVER FUNCTIONS AND HARDWARE

A. A central server, located (in, at) _____, shall be provided and maintained by the Owner. The server shall support all Network Area Controllers (NAC) connected to the Owner's network whether local or remote.

B. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, ADSL, T1 or dial-up connection.

C. It shall be possible to provide access to all Network Area Controllers via a single connection to the server. In this configuration, each Network Area Controller can be accessed from a remote Graphical User Interface (GUI) or from a standard Web browser (WBI) by connecting to the server.

D. The server shall provide the following functions, at a minimum:

1. Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
2. Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.
3. The server shall include a master clock service for its subsystems and provide time synchronization for all Network Area Controllers (NAC).
4. The server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
5. The server shall provide scheduling for all Network Area Controllers and their underlying field control devices.
6. The server shall provide demand limiting that operates across all Network Area Controllers. The server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
7. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Network Area Controllers. Systems not employing this prioritization shall not be accepted.
8. Each Network Area Controller supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
9. The server shall provide central alarm management for all Network Area Controllers supported by the server. Alarm management shall include:
    a. Routing of alarms to display, printer, email and pagers
    b. View and acknowledge alarms
    c. Query alarm logs based on user-defined parameters
10. The server shall provide central management of log data for all Network Area Controllers supported by the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
    a. Viewing and printing log data
    b. Exporting log data to other software applications
    c. Query log data based on user-defined parameters

Note to Specifiers: The following system file server is intended to be installed along with the initial work provided by the Division 17 System Integrator. It is unlikely that a second server will be required, however, if a second server is required at some point in the future, the hardware specifications will need to be updated to reflect the current standards of that time.

E. Server Hardware Requirements: The server hardware platform shall have the following requirements:

1. The server shall be an IBM compatible, Pentium based computer with the following minimum configuration:
    a. 3.0 GHz processing speed

b. 2.0 GB RAM

c. 250-Gigabyte hard drive 7200 RPM

d. 48X DVD-CDRW combination drive

e. 1.44 MB 3.5 inch floppy drive

f. 2-parallel ports

g. 2-asynchronous serial ports

h. 2-USB ports

i. 17”flat panel color monitor, 1280 x 1024 optimal preset resolution, 25 ms response time

j. 104 key keyboard

k. optical or laser mouse with scroll wheel

2. Connection to the BAS network shall be via an Ethernet network interface card, 10/100 Mbps.

3. The server operating system shall be Microsoft Windows 2000 or XP Professional. Include Microsoft Internet Explorer 6.0 or later.

4. A system printer shall be provided by the Owner. Printer shall be inkjet or laser type with a minimum 1200 x 1200-dpi resolution and rated for 14 PPM print speed minimum. The printer shall be capable of printing wide format (11”x17”) paper.

5. For dedicated alarm printing, the Owner shall provide a dot matrix printer, either 80 or 132 column width. The printer shall have a parallel port interface.

2.13 SYSTEM PROGRAMMING

A. The Graphical User Interface software (GUI) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the GUI shall be through password access as assigned by the system administrator.

B. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

C. Programming Methods

1. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user’s application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link

identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.

2. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.

4. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.

5. The system shall support object duplication within an Owner's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.14 COLOR GRAPHICS

A. The Web browser GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated graphics controls shall be used to enhance usability. The GUI workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color. Graphics shall be navigated through a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the system. As a minimum, the following color graphics shall be developed:

WAN Graphic: System entry screen with links to all Building Graphics for buildings connected to the BAS Wide Area Network. WAN Graphic shall show locations of controlled buildings in relation to local landmarks. (Operator sign-on and password shall be required.)

Building Graphic: Building entry screen providing links to each Floor Plan Graphic and mechanical rooms. (Operator sign-on and password into each building may be required depending upon Owner security requirements and final system network architecture.)

HVAC Floor Plan Graphic: HVAC Floor Plan Graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints. Color floor plans shall utilize a contiguous band of colors, each corresponding to actual zone temperatures relative to the desired heating and cooling setpoints. The ideal temperature shall be shown as a green color band. Temperatures slightly warmer than ideal shall be shown in yellow, and even warmer temperature band shall be shown in orange. Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. All alarm colors shall be in red. The colors shall be updated dynamically as a zone's actual comfort condition changes or the setpoint is changed. The operator shall be able to select a zone on the graphic with the mouse and be automatically navigated to the HVAC Zone Graphic (Single) for that zone without the operator having to select the zone from the tree navigation structure.

HVAC System Graphic: The HVAC System Graphic shall show the system mechanical components through the use of a pictorial representation. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering

units. Animation shall be used for rotation or moving mechanical components to enhance usability.

HVAC Zone Graphic (Single): The HVAC Zone Graphic (Single) shall show the zone mechanical components through the use of a pictorial representation. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability. The HVAC Zone Graphic (Single) is intended to provide data on the final HVAC conditioning equipment for the zone whether that is a VAV box, or a piece of unitary HVAC equipment.

HVAC Zone Graphic (Multiple): The HVAC Zone Graphic (Multiple) shall show all of the zone I/O points being controlled or monitored for each zonal system being served by an HVAC system in a tabular format. (i.e., Data for each VAV box being served by a single air handler). The data shall be displayed with the appropriate engineering units.

Central Plant Graphics: Central Plant Graphics shall be provided for all central systems including chillers, boilers, cooling towers, etc. The Central Plant Graphics shall show the plant mechanical components through the use of a pictorial representation. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.

Lighting Floor Plan Graphic: Integrated lighting controls shall include Lighting Floor Plan Graphics. These shall show the current status of controlled lighting zones throughout the buildings in a range of colors, which provide a visual display of current status of the lighting in the zone. A lighting zone in which the lights are “On” shall be shown in yellow, whereas, as zone in which the lighting is “Off” shall be shown as black. Zones that do not have integrated controls through the BAS shall be shown as grey. The colors shall be updated dynamically as the lighting status or method of control changes. The operator shall be able to select a zone on the graphic with the mouse and be automatically navigated to the Lighting Zone Graphic for that zone without the operator having to select the zone from the tree navigation structure.

Lighting Zone Graphic: The Lighting Zone Graphic shall indicate the I/O points being controlled or monitored for each controlled lighting zone with the appropriate engineering units. The Lighting Zone Graphic is intended to provide the operator interface for control for the zone. The current status of the lighting in the zone shall be displayed along with the occupancy status if available. The entity or device providing the current control signal shall be indicated whether that is a time schedule, occupancy sensor, local manual override, remote operator override, etc. Depending upon the complexity of lighting control schemes, it may be acceptable to eliminate the Lighting Zone Graphic and provide these functions as part of the Lighting Floor Plan Graphic.

Tenant Access Interface Graphic: Tenant Access Interface Graphics shall be developed to allow an extremely simplified and limited interface into specific areas and features of the BAS with an appropriate sign-on and password. These graphics are intended to be a means of access by tenants for control and adjustment of a limited number of number of BAS features such as HVAC or lighting schedule adjustment, space temperature setpoint changes, etc. The Division 17 Contractor shall work with the Owner to define the specific features and functions of this interface. The graphic should rely heavily on the use of pictorial images of items, such as a standard thermostat, in order to make it easy for a non-standard BAS user to navigate.

B. All graphics, with the exception of the Tenant Access Interface Graphic, shall include a direct link to the programmed sequence of operations for that particular system. This link for the sequence of operations shall be selectable from the graphic without the operator having to select the sequence from the tree navigation structure. This sequence of operations shall be stated clearly and concisely through the use of words and shall be in addition to any graphic depiction or programming tool depiction of the programmed sequence.

2.15 LONWORKS® NETWORK MANAGEMENT

A. The Graphical User Interface software (GUI) shall provide a complete set of integrated LonWorks network management tools for working with LonWorks networks. These tools shall manage a database for all LonWorks devices by type and revision, and shall provide a software mechanism for identifying each device on the network. These tools shall also be capable of defining network data connections between LonWorks devices, known as “binding”. Systems requiring the use of third party LonWorks network management tools shall not be accepted.

B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

C. The network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.

D. These tools shall provide the ability to “learn” an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.

E. The network management database shall be resident in the Network Area Controller (NAC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times, within the control system, shall not be accepted.

2.16 OBJECT LIBRARIES

A. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.

B. The objects in this library shall be capable of being copied and pasted into the user’s database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.

C. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.

D. All control objects shall conform to the control objects specified in the BACnet specification.

E. The library shall include applications or objects for the following functions, at a minimum:

1. Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of on-off events.

2. Calendar Object. The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical “point-and-click” selection. This object must be “linkable” to any or all scheduling objects for effective event control.

3. Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals

4. Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.

5. Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled “occupied” time. Also, allow equipment to be stopped before the scheduled “unoccupied” time just far enough ahead to take advantage of the building’s “flywheel” effect for energy savings. Provide automatic tuning of all start/stop time object properties based on the previous day’s performance.

6. Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of equipment to be shed is not enough to reduce the demand to below the setpoint, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each object to be shed shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.

F. The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet specification.

1. Analog Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.

2. Analog Output Object - Minimum requirement is to comply with the BACnet standard for data sharing.

3. Binary Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an “on” condition. The user must be able to specify either input condition as the “on” condition.

4. Binary Output Object - Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.
5. PID Control Loop Object - Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.
6. Comparison Object - Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
7. Math Object - Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
8. Custom Programming Objects - Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including math and logic functions, string manipulation, and e-mail as a minimum. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for re-use.
9. Interlock Object - Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an air handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.
10. Temperature Override Object - Provide an object whose purpose is to provide the capability of overriding a binary output to an “On” state in the event a user specified high or low limit value is exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.
11. Composite Object - Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the “contained” application that are represented on the graphical shell of this container.

G. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). At a minimum, provide the following as part of the standard library included with the programming software:

1. LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. All network variables defined in the LonMark profile shall be supported. Information (type and function) regarding network variables not defined in the LonMark profile shall be provided by the device manufacturer.
2. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file and documentation for the device to facilitate device integration.
3. For BACnet devices, provide the following objects at a minimum:
   a. Analog In
   b. Analog Out
   c. Analog Value
   d. Binary
   e. Binary In
   f. Binary Out
   g. Binary Value
   h. Multi-State In
   i. Multi-State Out
   j. Multi-State Value
   k. Schedule Export
   l. Calendar Export
   m. Trend Export
   n. Device
4. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.
5. For BACnet devices, provide the following support at a minimum
   a. Segmentation
   b. Segmented Request
   c. Segmented Response
   d. Application Services
   e. Read Property
   f. Read Property Multiple

g. Write Property
h. Write Property Multiple
i. Confirmed Event Notification
j. Unconfirmed Event Notification
k. Acknowledge Alarm
l. Get Alarm Summary
m. Who-has
n. I-have
o. Who-is
p. I-am
q. Subscribe COV
r. Confirmed COV notification
s. Unconfirmed COV notification
t. Media Types
u. Ethernet
v. BACnet IP Annex J
w. MSTP
x. BACnet Broadcast Management Device (BBMD) function
y. Routing

2.17 LONWORKS® SYSTEM INTEGRATION

A. The preferred means of integrating data from a third-party product into the BAS will be a BACnet interface. In the event that this communication protocol is unavailable as an option for integration of new or existing legacy systems, integration of device data via LonWorks may be acceptable.

B. Controls shall be microprocessor based Interoperable LonMark or LonWorks Controllers (ILC). Where possible, all Interoperable LonWorks Controllers shall bear the applicable LonMark interoperability logo on each product delivered.

C. HVAC control shall be accomplished using LonMark based devices where the application has a LonMark profile defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device to the Division 17 contractor. Publicly available specifications for the Applications Programming Interface must be provided to the Division 17 contractor for each LonWorks / LonMark controller defining the programming or setup of each device. The Division 15 contractor shall provide all programming, documentation and programming tools necessary to set up and configure the supplied devices per the specified sequences of operation.

D. The Division 15 contractor shall run the LonWorks network trunk to the nearest Network Area Controller (NAC). Coordinate locations of the NAC with the Division 17 contractor to ensure

that maximum network wiring distances, as specified by the LonWorks wiring guidelines, are not exceeded. A maximum of 40 devices shall be connected to a NAC and must be installed using the appropriate trunk termination device. If more than one NAC is present on the project, the number of network devices shall be split equally among them. All LonWorks and LonMark devices must be supplied using FTT-10A LonWorks communications transceivers.

E. The Network Area Controller (NAC), supplied by the Division 17 contractor, will provide all scheduling, alarming, trending, and network management for the LonMark / LonWorks based devices.

F. The ILCs shall communicate with the NAC at a baud rate of not less than 78.8K baud. The ILC shall provide LED indication of communication and controller performance to the technician, without cover removal.

G. All ILCs shall be fully application programmable and shall at all times maintain their LonMark certification, if so certified. All control sequences within or programmed into the ILC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

H. The Division 15 contractor supplying the ILC's shall provide documentation for each device, with the following information at a minimum:

1. Network Variable Inputs (nvi's); name and type
2. Network Variable Outputs (nvo's); name and type
3. Network configuration parameters (nci, nco); name and type

I. It is the responsibility of the Division 15 contractor to ensure that the proper Network Variable Inputs and Outputs (nvi and nvo) are provided in each ILC, as required by the point charts.

J. The supplier of any programmable ILC shall provide one copy of the manufacturer's programming tool, with documentation, to the Owner.

2.18 MODBUS SYSTEM INTEGRATION

A. The preferred means of integrating data from a third-party product into the BAS will be a BACnet interface. In the event that this communication protocol is unavailable as an option for integration of existing legacy systems, integration of device data via Modbus may be acceptable.

B. The Network Area Controller shall support the integration of device data from Modbus RTU, ASCII, or TCP control system devices. The connection to the Modbus system shall be via an RS-232, RS-485, or Ethernet IP as required by the device.

C. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the Modbus system data into the BAS. Objects provided shall include at a minimum:

1. Read/Write Modbus AI Registers
2. Read/Write Modbus AO Registers
3. Read/Write Modbus BI Registers
4. Read/Write Modbus BO Registers

D. All scheduling, alarming, logging and global supervisory control functions, of the Modbus system devices, shall be performed by the Network Area Controller.

E. The equipment system vendor that provided the equipment utilizing Modbus shall ensure that the existing system's database is setup to make all data to be integrated into the BAS available at the interface. Any modifications to the existing system database to accomplish this shall be the responsibility of the equipment system vendor that provided the equipment utilizing Modbus.

F. The BAS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment utilizing Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning.

2.19 OPC SYSTEM INTEGRATION

A. The preferred means of integrating data from a third-party product into the BAS will be a BACnet interface. In the event thatthis communication protocol is unavailable as an option for integration of existing legacy systems, integration of device data via OPC may be acceptable.

B. The Network Area Controller shall act as an OPC client and shall support the integration of device data from OPC servers. The connection to the OPC server shall be Ethernet IP as required by the device. The OPC client shall support third party OPC servers compatible with the Data Access 1.0 and 2.0 specifications.

C. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the OPC system data into the BAS. Objects provided shall include at a minimum:

1. Read/Write OPC AI Object
2. Read/Write OPC AO Object
3. Read/Write OPC BI Object
4. Read/Write OPC BO Object
5. Read/Write OPC Date/Time Input Object
6. Read/Write OPC Date/Time Output Object
7. Read/Write OPC String Input Object
8. Read/Write OPC String Output Object

D. All scheduling, alarming, logging and global supervisory control functions, of the OPC system devices, shall be performed by the Network Area Controller.

E. The equipment system vendor that provided the equipment utilizing OPC shall ensure that the existing system's database is setup to make all data to be integrated into the BAS available at the interface. Any modifications to the existing system database to accomplish this shall be the responsibility of the equipment system vendor that provided the equipment utilizing OPC.

F. The BAS supplier shall provide an OPC client communications driver. The equipment system vendor that provided the equipment utilizing OPC shall provide documentation of the system's OPC server interface and shall provide factory support at no charge during system commissioning.

2.20 LEGACY SYSTEM INTEGRATION THROUGH CUSTOM DRIVER

A. The Network Area Controller shall support the integration of device data from the existing control system. The connection to the existing system shall be via an RS-232 connection between the Network Area Controller and the existing control system.

B. The Owner, and/or the existing control system representative shall ensure that the existing system's database is setup to make all data to be integrated into the BAS available at the RS-232 port. Any modifications to the existing system database to accomplish this shall be the responsibility of the Owner.

C. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the existing system data into the BAS. Objects provided shall include at a minimum:

1. LEGACY SYSTEM Generic AI Object
2. LEGACY SYSTEM Generic AO Object
3. LEGACY SYSTEM Generic BO Object
4. LEGACY SYSTEM Generic BI Object

D. All scheduling, alarming, logging and global supervisory control functions (demand limiting, etc.), of the existing system devices, shall be performed by the Network Area Controller. Integration of the existing system's schedules, alarms, logs, etc. is neither required nor desired.

E. The BAS supplier shall provide a legacy system communications driver. The Owner shall provide documentation of the existing system's protocol to facilitate the development of this driver. Costs for the development of the driver are to be arranged between the Owner and the BAS supplier and are not included as part of this contract.

PART 3 EXECUTION

3.1 INSTALLATION

A. All work described in this section shall be performed by system integrators or contractors that have a successful history in the design and installation of integrated control systems. The installing office shall have a minimum of five years of integration experience and shall provide documentation in the submittal package verifying the company's experience.

B. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Owner for resolution before rough-in work is started.

C. The Contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Owner for resolution before rough-in work is started.

D. Drawings of BAS network are diagrammatic only and any apparatus not shown, but required to make the system operative to the complete satisfaction of the Owner shall be furnished and installed without additional cost.

3.2 EQUIPMENT PROTECTION

A. The Contractor shall protect all work and material from damage by its work or employees, and shall be liable for all damage thus caused.

B. The Contractor shall be responsible for its work and equipment until finally inspected, tested, and accepted. The Contractor shall protect any material that is not immediately installed.

3.3 WIRING

A. All electrical control wiring and power wiring to the NAC and any other equipment or devices provided by the Division 17 Contractor shall be the responsibility of the Division 17 contractor. The Owner shall provide all power wiring to any computers, servers, routers, hubs, switches, and bridges provided by the Owner.

B. The Owner shall be responsible for providing and maintaining the Ethernet backbone as is standard practice within their facilities. The Owner will provide Ethernet drops within five feet of the equipment provided by Division 17 that requires network connection as defined on diagrams developed specifically for this project. It is anticipated that there will be one open RJ-45 jack located in each mechanical room to facilitate the connection of a Portable Operator's Terminal to the Ethernet backbone for purposes of troubleshooting and maintenance of the mechanical room equipment.

C. All wiring shall be in accordance with the Project Electrical Specifications (Division 16), the National Electrical Code and any applicable local codes. All BAS wiring shall be installed in the conduit types specified in the Project Electrical Specifications (Division 16). Where BAS plenum rated cable wiring is allowed it shall be run parallel to or at right angles to the structure, properly supported and installed in a neat and workmanlike manner.

3.4 WARRANTY

A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.

B. Within this period, upon notice by the Owner, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by the Division 17 contractor at no expense to the Owner

3.5 WARRANTY ACCESS

A. The Owner shall grant to the Division 17 contractor, reasonable access to the BAS during the warranty period.

3.6 CHECKOUT AND TESTING

A. The Division 15 and Division 16 contractors are to coordinate the Checkout and Testing of their systems with the Division 17 System Integrator such that each has a representative present during the activities.

B. The Checkout and Testing process shall utilize checklists and forms developed by the Division 15 and Division 16 contractors and previously defined under the section titled "Submittal" in Division 15 and Division 16 to document the testing results. The approved checklists and forms shall be completed for all points and systems during Checkout and Testing.

C. The Division 15 and Division 16 contractors and the Division 17 contractor shall perform tests to verify proper performance of components, routines, and points provided under their Division. Repeat tests until proper performance results. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

D. Division 15 and Division 16 Start-up Testing: All testing listed in this article shall be performed by the Division 15 and Division 16 contractors and shall make up part of the necessary

verification of an operating control system. This testing shall be completed before the Owner's Representative is notified of the system Demonstration. For all control devices and programming provided by the Division 15 and Division 16 contractors, the contractors shall:

1. Furnish all labor and test apparatus required to calibrate and prepare for service all instruments, controls, and accessory equipment furnished under this specification.
2. Verify that all control wiring is properly connected and free of all shorts and ground faults and verify that terminations are tight.
3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures per manufacturers' recommendations or as otherwise specified.
4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
5. Verify that all analog output devices (electric/pneumatic transducers, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The Division 15 contractor shall check all control valves and automatic dampers to ensure proper action and closure. The Division 15 contractor shall make any necessary adjustments to valve stem and damper blade travel.
6. Verify that the system adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules.
7. Tune all DDC loops.

E. Division 17 Start-up Testing: All testing listed in this article shall be performed by the Division 17 contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner's Representative is notified of the system Demonstration. For all control devices and programming provided under Division 17, the contractor shall:

1. Furnish all labor and test apparatus required to calibrate and prepare for service all instruments, controls, and accessory equipment furnished under this specification.
2. Verify that all control wiring is properly connected and free of all shorts and ground faults and verify that terminations are tight.
3. Verify that any global control strategies and application programs resident within the Network Area Controllers adhere to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules.
4. Alarms and Interlocks:
   a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.7 DEMONSTRATION

A. The Division 15 and Division 16 contractors and Division 17 contractor are to coordinate the Demonstration of the system such that each Division has a representative present during the activities.

B. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and demonstrate compliance with this specification. The Demonstration shall occur after the Division 15, Division 16, and Division 17 contractors have completed their tests as defined under “Checkout and Testing”. The Owner’s Representative shall be present to observe and review the Demonstration.

C. The Demonstration process shall utilize the forms and follow the processes previously defined as part of the Division 15 and Division 16 contractor submittals. The approved checklists and forms shall be completed for all systems as part of the Demonstration.

D. The Division 15 and Division 16 contractors shall provide at least two persons equipped with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including, but not limited to; day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point/object and system. Any test equipment required to prove the proper operation shall be provided by and operated by the Division 15, Division 16, and Division 17 contractors.

E. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.

F. Demonstrate compliance with sequences of operation through all modes of operation.

G. Additionally, the following items shall be demonstrated:

1. DDC Loop Response. The Division 17 contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in setpoint, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the setpoint, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the appropriate Division 15 or Division 16 contractor.

2. Demand Limiting. The Division 17 contractor shall supply a trend data output showing the action of any demand-limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting setpoint, and the status of sheddable equipment outputs.

3. Optimum Start/Stop. The Division 17 contractor shall supply a trend data output showing the capability of the algorithm. The hour-by-hour trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.

4. Operational logs for each system that indicate all setpoints, operating points, valve positions, mode, and equipment status shall be submitted to the engineer and Owner’s Representative. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in a printed graphical format.

H. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The Division 15, Division 16, and Division 17 contractors shall be responsible for any necessary repairs or revisions to the hardware or software they each have provided to successfully complete all tests.

3.8 SYSTEM ACCEPTANCE

A. All tests described in this specification shall be performed to the satisfaction of the Owner's Representative prior to the acceptance of the control system. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the Owner's Representative. Such tests shall then be performed as part of the warranty.

B. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved by the Owner's Representative.

3.9 OPERATOR INSTRUCTION, TRAINING

A. During system commissioning and at such time acceptable performance of the BAS hardware and software has been established, the Division 15 and 16 contractors shall provide on-site operator instruction to the Owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories. Operator instruction and training shall be as defined in the Division 15 and Division 16 project specifications.

B. Upon the first installation of the BAS GUI, the Division 17 contractor shall provide 40 hours of instruction to the Owner's designated personnel on the operation of the BAS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BAS shall include, but not be limited to; the overall operation program, equipment functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the system's operation.

C. The training shall be in three sessions as follows:

1. Initial Training: One day session (8 hours) after system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the Owners' personnel can start to familiarize themselves with the system before classroom instruction begins.

2. First Follow-Up Training: Two days (16 hours total) approximately two weeks after initial training, and before formal acceptance. These sessions will deal with more advanced topics and answer questions.

3. Warranty Follow-Up: Two days (16 hours total) in no less than 4 hour increments, to be scheduled at the request of the Owner during the one year warranty period. These sessions shall cover topics as requested by the Owner such as; how to add additional points, create and gather data for trends, graphic screen generation or modification of control routines.

3.10 RECORD DOCUMENTATION

A. Three copies of the Operation & Maintenance manuals for work provided under this Division shall be provided to the Owner upon completion of the project. These manuals shall be updated each time changes are made to the system. The entire Operation & Maintenance

manual shall be furnished in three-ring binders with adequate indexing and also on compact disc media, and shall include the following:

1. Table of contents.
2. As-built system record drawings. Record drawings in AutoCAD format shall represent the as-built condition of the system and incorporate all information supplied with the approved submittals. These shall include sequences of operation and a complete I/O point summary.
3. Manufacturer's product data sheets for all products including software.
4. System operator's manuals.
5. Complete network diagrams that also indicate connections to all control systems included in the BAS Wide Area Network.
6. Wiring termination schedules.
7. Archive copy of all controller databases (on compact disk only).

PART 4 SEQUENCES OF OPERATION

4.1 SUMMARY

A. The Division 17 contractor shall refer to this item under Division 15 or Division 16 to determine what level of control the Network Area Controller, must provide, which is the responsibility of this Division. It is the responsibility of the Division 17 contractor to coordinate control functions, such as scheduling and supervisory-level control with the Division 15 or Division 16 contractor. An example of supervisory-level control might be Demand Limiting or Optimum Start/Stop.

PART 5 POINT LISTS

5.1 SUMMARY

A. The Division 17 contractor shall refer to this item under Division 15 or Division 16 to determine what data in the local controllers must be integrated into the Network Area Controller, which is the responsibility of this Division. It is the responsibility of the Division 17 contractor to coordinate control functions, such as scheduling and supervisory-level global control with the Division 15 or Division 16 contractor.

END OF SECTION