How To Pre-Qualify and Select DDC Systems and Vendors

Viktor Boed, CEM
Manager, Plant Engineering
Department of Facilities & Services
Yale University

Evaluating and pre-selecting a DDC system uses criteria based on three items related to long-term systems performance: System selection, system implementation, and system support. The selection process is based on clearly defined objectives, and a six-step selection process which is described in this article.

GENERAL

Building Automation Systems (BAS) are closely associated with the hi-tech and computer industry. Hi-tech industries by their nature are undergoing rapid changes, and are competitive. Evolution and a highly competitive market results in never ending changes to systems hardware and software, and changes of vendors' organizations (and sometimes of their owners) that are marketing and supporting such systems.

DDC manufacturers introduce new products, on average, every five years and product upgrades annually. DDC systems provide a reliable hardware platform, sophisticated application programs, and are "user friendly" for operators and maintenance.

Building owners—and users of BAS systems—benefit from the situation through competitive pricing. At the same time, they feel the pressure originating from frequent introduction of new systems and instability of the companies bringing them on the market.

Vulnerability is further enhanced by owners' needs for long-term system support.

Many centralized BAS were upgraded to distributed DDC systems over the past decade. Distributed DDC systems became synonymous with HVAC control systems, providing environmental control for buildings. DDC systems have completely changed the controls industry—from systems development, through implementation, support and maintenance.

Long-term performance of installed DDC systems depend on three components:

- selection DDC system
- system implementation
- system support

DDC SYSTEM SELECTION

Selection of DDC systems for any given project should be in compliance with long-term development goals related to the facility's automation. The task is challenging, considering budgeting criteria, funding policies related to individual projects, and DDC systems selection based on the lowest initial cost in the design-bid process. Considering the cost of installed systems and their life span, which is 10 to 15 years or longer, owners should protect this substantial investment by selecting systems in accordance with their long-term automation goals.

Due to complexity of DDC systems, the team involved in system selection should have a thorough understanding of DDC systems, their features and communications options. The team should focus on the following key items:

DDC System Architecture

Selection of the most appropriate architecture is probably the best protection of the owner's investment. Properly chosen hardware, software and communications assures future expansions of DDC systems, their upgrades, interfaces to third-party systems and software, and interoperability of DDC systems via facilities networks.

To protect their investments, owners should be looking for "popular" elements in systems. For example, DOS operating system, Windows, Lotus or Excel became so popular that they are standards on their own merits. Among the specialty software items, one should look for dBase for date base management, AutoCAD and AutoSketch for graphic software, Dynamic Data Exchange (DDE) for sharing information between individual programs, etc. Many automation vendors base their automation software on the above pieces of software, or are using them in their systems.

It is equally important to choose "industry standard" hardware platforms (i.e. PCs), processors (i.e. Intel, Motorola), external data storage media (i.e. diskettes, tapes, CDs), communications modes (i.e. RS-232, 485, Ethernet, ARCNET). Layered systems architecture, based on "levels" of computing (i.e. building, system, equipment levels) provides an economical solution to hardware and wiring cost optimization, systems compartmentalization, and a platform for future expansions.

Systems connectivity and interoperability is becoming more and more an issue for facilities. Many BAS systems manufacturers changed their systems architecture (and their attitudes) from proprietary to so called "open" systems.

Having an open system means that DDC vendors made their interface protocols available to other system vendors, who can write interface protocols to these systems, if they desire to do so. The same approach applies to communication drivers. Popularity of open systems and communication drivers is a positive sign leading to future support of popular protocols by vendors and systems houses. Many open systems and drivers will fade away over time.

However, some of them will become "industry standards," used and supported by systems vendors, independent systems houses or systems integrators. There are numerous attempts to standardize communications protocols for the automation industry. In the past few years, there were two so-called standard protocols (approved by related agencies) introduced for building automation systems: the Canadian Automated Building (CAB) protocol, approved and released for public use by Public Works Canada in 1992, and the BACNet, approved and released by ASHRAE in 1995. Their success will be determined by their popularity among DDC vendors, and their acceptance by the users.

DDC Hardware Architecture

Trends in automation systems are toward distributed processing. The most popular architectures are using controllers dedicated to control single equipment (i.e. a VAV box, fan coil unit), larger, more complex mechanical systems (i.e. air handling units, roof top units), or concentration of such equipment (i.e. in building mechanical rooms, power plants). Selecting appropriate hardware architecture for the site is important for (a) future expandability of the DDC system, (b) cost optimization for controllers, installation and wiring.

DDC Software Architecture

Software architecture follows the hardware platform. Since it would not be economical or necessary to provide full software capabilities at each level of the system's architecture, full understanding of software features at each level of systems architecture is important. Allocation of software features at each level will determine (a) the system's distributed processing capabilities, (b) stand-alone controls capabilities, and (c) systems end-to-end reliability in case of communications failures.

DDC Network Architecture

Network topography should be determined by volume and speed of transmitted data, utilized communications protocols, and site conditions. For example, communications among application specific or unitary controllers, controlling individual equipment, with low data exchange rate, can utilize RS 232 or 485 lower layer communication protocols. High volume, high speed data communication (i.e. Ethernet, ARCNET) should be implemented for data exchange on the facilities network.

Standard methods of information access are equally important. Many facility networks are standardized, and support standard protocol packet methods such as Transmission Control Protocol/Internet Protocol (TCP/IP), information access utilizing multiple networking software, such as NetWare (by Novell), LAN Manager (by IBM), or DECnet (by DEC).

There are numerous options for systems architecture available from DDC vendors. The owner or system integrators should design the most suitable options for the facility.

DDC Controllers

Selection of individual DDC controllers should be based on individual HVAC applications for a given project. Distributed processing allows selection of controllers with point capacity to match the application requirements, and location of the controllers in the highest concentration of points.

DDC Application Software

DDC application software is the brain of building environmental control systems. The selection team should look for the following basic features:

- **point definition**—Each vendor specific software differs in point definition. Attributes of each point, ease of access and on-line modification is important for future DDC software maintenance.

- **alarm reporting** is one of the most important features of DDC systems. The number of analog alarm limits per point and their differentials (Hi/Lo, HHi/LLo, +/- of the defined values), return to normal, definition of binary alarms, scan rates for alarm reporting, associated alarm messages, alarm acknowledgment, inhibition and lockout, and other alarm handling characteristics of DDC systems should be individually evaluated.

- **time scheduling**—of building equipment and systems on hourly, daily, weekly, monthly, yearly basis. Time scheduling is one of the most common features offered by DDC systems. The team should look for ease of entering new schedules, modification of existing ones, holiday scheduling, providing temporary schedules for special events, global changes and modifications of equipment or groups of equipment schedules, disabling schedules, creating temporary schedules and other features important for building operation.

- **application programming**—use of line codes, common programming languages (i.e. Basic, C+), graphic programming languages, and ease of program modifications, code compilation, program down and upload to controllers, data exchange (i.e. DDE), interface to other common popular data processing, graphic and communications programs are important criteria for DDC systems selection.

- **operator interface**—alarm and data presentation on OWS, graphic displays, dynamic screen updates, representation of points in alarm, off-line, ease of moving from one screen to another, alarm acknowledgment, time schedule modification, set point modifications, control loop tuning from the graphic screens, and other features are important for systems operators.

- **operator access** from OWS, remote terminals, hand-held terminals, password protection, levels of passwords related to individual points, geographical areas, group of points, systems functions, network access, network nodes, etc., are important for systems integrity.

- **report generation**—data compilation into reports, spread sheets, graphs, and other common software is important for facilities management. Alarm or management reports are utilized by the systems manager, as well as facilities management, to evaluate building and systems performance. Reports should be compiled into customary report formats, such as text, spreadsheets or graphs. Dynamic data transfer of actual analog point readings into spreadsheet and other common statistical media should be evaluated.

- **history data**—data storage (file size), validation by data filtering, statistical data compilation, interpolation of missing data, are among features of most DDC systems. Compilation of data into reports and graphical presentation of history data should be evaluated.

- **DDC systems reporting**—self-diagnostics of DDC systems, reporting of error rates per communication channel, on line/off line status of controllers and network devices, and other systems-related reporting is important for systems managers.

- **energy management**—Many DDC systems are implemented to automatically control building HVAC systems and to contain energy cost. The so-called energy management programs were developed in the seventies, and improved through the years. The most common energy management programs are:

  — Night setback—lowering building temperatures and ventilation rates

— Free cooling—using outside air for cooling, when available

— Optimal start—optimization of equipment start time demand limiting—to avoid peak charges for electricity

— Duty cycling—on/off cycling of controlled equipment central plant optimization—chiller, boiler optimization

DDC System Performance

Performance of DDC systems depends on the system architecture, loading, software features, and other site specific items. The evaluation team should get a feel for systems performance from the provided literature, demonstrations and site visits.

The clues to look for are: dynamic screen update, scan rate, response to changes of state, response to alarm, PID loop control, automatic tuning (continuous or on-demand), time required for software up/down load, time delay for restart after power failure, access time to points, programs, files, ease of moving from screen to screen, ease of making modifications from the color graphic screens, such as change of point definition, set point, alarm limit, alarm message, enable/disable point, etc.

DDC system selection should always be done with long-term objectives in mind.

DDC SYSTEM IMPLEMENTATION

The implementation of a DDC system is a process of customizing an off-the-shelf DDC system to meet site requirements and to control the connected building (HVAC) systems within design parameters. The process includes:

- systems engineering which should fully complement the HVAC design;
- applications software development, to provide fully automated operation of controlled building systems;

- installation of DDC hardware and software;

- DDC commissioning, including calibration of analog points, validation of end-to-end accuracies, tuning of PID loops, working with the air balancer to provide desired building pressures, flows, temperatures and relative humidity, verification of application programs, verification of reporting and operator interfaces, and other features of the DDC system;

- training of operators and controls technicians, and;

- final systems turnover to the O&M department and end users.

While DDC systems development is at the same level as the hi-tech industry, there is a lot to be done in systems implementation and long-term systems support.

One step to improving the current situation is standardization. Site standardization should be related to the following areas:

- development of long-range plans which include facilities automation
- development of methods of budgeting, justifying, and funding environmental controls related projects
- development of site design standards
- development of site DDC performance standards
- standardization on hardware and software
- development of energy conservation policies
- development of O&M procedures
- development of HVAC and DDC systems
- procurement procedures
- training of in-house O&M personnel
- establishment of long-term systems support by system vendors

A facilities automation master plan should include:

- systems interoperability
- site DDC standards

- systems selection criteria
- training criteria
- funding and budgeting criteria
- systems evaluation criteria

DDC VENDOR SUPPORT

DDC vendor support is important for systems upgrades, training, service and maintenance. Very few sites, if any, can exist without some form of vendor support. In the past, support was limited to service and repair of the installed hardware. That is rapidly changing because of the complexity of computers, controls operating software and ongoing need for systems upgrades. DDC systems support is important for the design and implementation phases of the project as well as follow-up support.

Most DDC systems in the United States are:

(a) developed, produced, marketed, sold, engineered, installed and supported by their manufacturers or vendors;

(b) developed, produced, marketed by a DDC vendor; sold, engineered, installed and supported by others, such as dealers or manufacturer representatives; or

(c) some combination of the above.

Multinational, large controls companies have established company owned local branch offices to cover their customer base. Local offices are staffed to provide full support for their customers. Branch offices are fully dedicated to sales and support of their own product lines in the respective geographical areas.

The home office is responsible for product development, manufacturing, marketing, sales and technical support of the branch offices, training of the staff as well as their customers. The home office and the branch share legal responsibilities and contractual obligations to the end users for products and services rendered.

Independent local dealers, franchises or contractors provide another way for DDC vendors to market and sell products. DDC vendors provide product development, manufacturing, marketing and training of the network of independent dealers and contractors. Local dealers or contractors buy the systems from the DDC vendor. Most DDC vendors have no financial obligations to support the dealers or contractors. End users deal with the local authorized dealers or contractors, and have no legal connection or contractual obligations with the DDC vendor.

Independent dealers or contractors may carry one vendor's product line, or some carry different products from noncompeting vendors. Some dealers or contractors carry a certain DDC system complementary to their main business interests such as mechanical, or HVAC contracting. Many DDC dealers and contractors develop loyalty to their vendors and display continuous commitment to support the systems they sell. Probably an equal number of dealers or contractors have changed product lines in response to market demands and/or their own financial needs.

As a result of the market evolution, some owners end up with discontinued products, failed vendor's systems, or systems which cannot be migrated into a newer generation of DDC systems. Business interests and local market conditions may force independent dealers and contractors to abandon existing product lines and pick up other more profitable products.

Background checking of potential suppliers during the selection process is not only prudent, but essential. While either of the above arrangements may provide adequate systems support to the owner/end user at any given time, long-term contractual relationship or partnership for support of DDC systems must evaluate the advantages and disadvantages of working with each potential supplier.

OBJECTIVES FOR DDC SELECTION

1. Pre-select DDC systems which comply with site long-range development objectives for facilities automation, operations and maintenance. Pre-selected systems should also comply with site design criteria, standards and site interoperability requirements.

2. Pre-select DDC vendors who can provide DDC systems in compliance with the facility's long-range goals; have a proven track record for long-term DDC systems development and their migrations; development and support of standard or open protocols for third-party inter-

faces; have a track record for long-term systems and customer support; and have local representation with adequate engineering, installation and service support capacity.

REQUIREMENTS AND MEASURES

Pre-selection requirements

1. Pre-selected DDC systems should comply with the requirements specified in the site performance and material specification.

2. Pre-selected DDC systems should be in production for over one year, and be installed and operational on job sites similar to the owner's site for one year.

3. All proposed communications and interface protocols should be operational on at least one job site similar to the owner's site, for the minimum duration of one year. In absence of such site, the DDC vendor should be required to set up communications testing at the owner's site free of charge for minimum of two weeks. The DDC communication should be tested on the longest available communication wiring.

4. The DDC systems architecture should comply with site conditions.

5. Operator interfaces should meet site-specific requirements.

Pre-selection requirements for DDC vendors and/or contractors

1. DDC vendors should be required to demonstrate their commitment to long-term systems development by demonstrating past systems development and their migration paths.

2. DDC vendors should demonstrate their commitment to open systems architecture by demonstrating adherence to major communications standards, industry and open protocols, and drivers. The above items are to protect the owner's investment for the selected automation systems, as well as to assure optimum life cycle cost for the installed systems.

3. DDC vendors should demonstrate commitment to systems and customer support from their headquarters as well as the local office.

4. DDC vendors should maintain a local office with sales, systems engineering, installation and service support.

5. Independent franchises of Building Automation Systems should

be required to disclose what other products or services are carried or provided by the office, and which products or business interests are the backbone of their business.

6. DDC vendors or contractors should provide the owner with a copy of their statement of financial situation, annual sales and service contracts, and other pertinent financial information.

7. DDC vendors and contractors should provide business references related to their customer base, suppliers, and other services as requested by the owner.

8. DDC vendors and contractors should provide the owner with a list containing the number and qualifications of engineers, technicians and support personnel in the local office, and their capabilities to respond to emergency situations.

9. DDC vendors must disclose how long the proposed product line (DDC system) will be sold and supported by the local office. Also, what other controls and DDC systems were sold and supported by the office prior to the current product line?

10. DDC vendors should provide a letter of commitment from the main office or the DDC manufacturer for technical support and training of the end-user.

THE PRE-SELECTION PROCESS

The process should be set up to meet site specific-conditions. The following steps are to aid engineers and commissioning agents in conducting a DDC pre-selection process:

Step 1: Request for DDC Documentation

Formal requests should be mailed out to DDC vendors and/or contractors for sales literature and other systems documentation.

Step 2: Pre-qualification Questionnaire

Designed to obtain basic information about DDC systems, vendors and/or contractor, the questionnaire should be sent out to all suppliers pre-selected in step 1. The questioner should contain information related to:

- DDC vendor

- long term support
- system implementation
- communications and interfaces
- other systems-related descriptions

Step 3: DDC system demonstrations

Demonstrations can be set up at the owner's site or at the DDC vendor or contractor's office.

Step 4: Site visits

Site visits are the most important part of the pre-selection process. The team should learn from other engineers, operators and maintenance personnel about their experience with the installed DDC system.

Step 5: Home office visit

The visit can be combined with DDC systems presentation, or scheduled separately. The team members should have a chance to be exposed to the "corporate culture" of the home Office.

Step 6: DDC system evaluation and ranking

In the final phase of the pre-selection process, the team should conclude its work by evaluating each DDC system individually.

The owner's team responsible for the selection process should develop checklists for the above steps and site specific conditions and requirements.

The checklists should also reflect requirements related to:

- DDC system architecture
- front-end OWS
- building and application specific controllers
- DDC system application software
- Evaluation of DDC vendors and contractors

DDC system selection based on a structured approach tailored to site-specific conditions and conducted with participation of the owner's engineers and O&M personnel will result in selection of a most appropriate system for the site-specific conditions. Furthermore participation of in-house personnel in the process assures full accep-

tance of the system by the owner's personnel responsible for daily operation and maintenance of the installed systems.

ABOUT THE AUTHOR

Viktor Boed, CEM, has a graduate degree in electrical engineering from the Brno Technical University in the Czech Republic. As a consulting engineer he has designed building automation systems in Europe and the U.S. and taught courses in electrical engineering at the Brno Technical University as well as in Cairo, Egypt. Boed came to the U.S. in 1979 and worked as a product manager and a senior research engineer for Johnson Controls, Inc. in Milwaukee, WI. He joined Yale University in 1983 as manager of building automation and became manager of plant engineering in 1989, where he is involved today in design and implementation of automation systems for buildings, power plants, maintenance management systems, utility metering systems, and a facilities real-time communications network. The Plant Engineering Division also is involved in implementation of energy conservation projects, and review and approval of capital projects for the university.

Boed is an active member of the Association of Energy Engineers and started the Connecticut AEE chapter. He is the recipient of the Energy Manager of the Year and the regional Energy Engineer of the Year awards, and is a frequent speaker at World Energy Engineering Congresses and other professional conferences. He also is a member of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and was on the ASHRAE SPC 135 committee that developed the ANSI/ASHRAE Standard 135/1995, BACnet (a data committee protocol for building automation and controls network). Viktor has published numerous technical papers in various trade magazines. He has also written two books, *Efficient DDC Systems Implementation*, (Chilton, 1996), and *DDC Applications Engineering*, (CRC Press, 1998).