

Ask Tom! Column

Distributed Control Systems Primer

by Dan Capano, DTS, Inc

As water and wastewater treatment plants grow in both size and complexity, so does the need to control equipment that make up the unit-operations of that plant. Distributed Control System (DCS) is a control system method that is spread, or distributed, among several different unit processes. These processes may be related, as in a water treatment facility, or unrelated, as in a manufacturing plant where many different products are fabricated.

The DCS is typically a hard-wired system and exists within finite boundaries, such as a process plant or within a factory. Wired systems are reliable and are well suited for the typical process environment where flexibility is not an issue. Wireless systems are starting to become popular and hold the promise of improved flexibility in both physical and logical layout of the facility. An entire process may be retooled to the extent that several parts of the process will be physically moved or removed. Using wireless, system reconfiguration is as simple as disabling the station address or downloading the suitable database.

Whether wired or wireless, distributed control systems offer the advantage of centralized control, while retaining the capability of distributed, or local control. True distributed control systems use localized control, which is in turn controlled by the operator located at a central location. Distributed Control Systems consist of the following:

- Remote control panel
- Communications medium
- Central control panel or facility
- Control, interface and database software

If the system is performing both monitoring and control of a process or facility, it is referred to as a SCADA system, or Supervisory Control And Data Acquisition system. Most systems will transfer data and commands using communication protocols such as Ethernet, or some other open standard, depending upon the DCS vendor. An effort should be made to avoid so-called "proprietary" protocols. These protocols require specialized equipment to perform their functions; the equipment is usually only available from a single vendor, at a premium. Also, vendors who rely solely upon this form of business development have the annoying tendency to go out of business. Open protocols allow the use of "off the shelf" equipment at a considerably reduced cost.

A DCS may be as simple as one PLC (Programmable Logic Controller) remotely connected to a computer located in a field office. Larger systems may be PLC based, but will most likely consist of specially designed cabinets containing all of the equipment necessary to provide I/O and communication. One point to consider during the design and specification of a control system is the level of autonomy each node will have in the event of a network or system failure. A true distributed system will allow most remote nodes to operate independently of the central control facility should the facility go off line or lose communication capability. Each remote node should be able to store the minimum process data required to operate in the event of such a failure. In this manner, costly and potentially disastrous process upsets can be avoided.

Remote Control Panel

The remote panel is variously referred to as a Remote Transmission Unit (RTU) or a Digital Communication Unit (DCU) or any number of different names, depending on the vendor. For this discussion, I will refer to remote panels as DCUs. A typical DCU contains terminal blocks, input/output modules (both analog and digital),

a computer or proprietary processor, and a communications interface. A DCU, depending upon where it is located in the world, can perform both monitoring and control of a given process or processes.

A DCU on a true SCADA system contains both input and output modules, or I/O. While great strides have been made in both wired and wireless networking, the majority of process monitoring and control is still hard-wired to the DCU terminal blocks. A DCU is sized by determining the amount of inputs and outputs required to monitor and control each process or piece of equipment. A pump, for instance, will require a minimum of 4 I/O: Start command, Stop command, and status for Run and Stop. The Start and Stop commands are DCU outputs, while the Status indications are inputs. These remote I/O are usually relay coils and contact or switch closures that are hard wired into and out of the I/O modules. Analog I/O is handled similarly.



Photo: An example of a DCU

Courtesy: Westinghouse Process Control

An analog signal may be output from a DCU in order to position a slide gate valve or to control the speed of a pump motor. A DCU may accept an analog signal from a pressure or flow transmitter for monitoring or control purposes. The combinations of control and monitoring needs are extensive, and unique to every facility. The on-board computer scans the inputs and controls the outputs of the DCU. It interprets the digital signals from the Input modules, which convert either analog or digital data into coded signals on the DCU's internal bus or backplane. Signals are transmitted over the network medium to the central control facility via the DCU's communications interface. Signals received at the DCU are converted into coded signals addressed to a specific output module and output. An internal relay can be

tripped or a power source may be switched into a connected device.

The DCU is essentially a translation device that directly interfaces with the process or equipment on one side, while interfacing with the control system on the other. Network data is addressed to that particular DCU and acted upon by the DCU, either performing the desired task or returning the requested data.

Communications Medium

The medium is a cable or wireless link that serves to connect the DCU to the Central control facility. A network is a collection of computers and similar devices, which are connected so resources, such as computers, printers and modems can be shared; also data can be transmitted between computers, or nodes for use in various applications.

There are several methods of doing this; a full discussion of the technology is outside of the scope of this article. Briefly, a cable, either a coaxial or twisted pair, is connected between the central control computer and the remote unit, or DCU. It is considered prudent to run two cables, on different routes, between the two in order to increase the reliability of the system. A network operates by taking data from the sending station, or node, and packaging and routing the information to the proper receiving station.

This is no small task in a process environment. Electrical noise, physical abuse and software bugs conspire to make the implementation of a DCS a tedious affair. When dealing with wireless links, the challenges can be daunting, particularly in an electrically noisy environment. Care must be taken, when installing wired systems, to protect cabling from such hazards as the "backhoe syndrome", where cabling is torn up or out by an uninformed equipment operator; or from excessive electrical noise from lighting or motors. Without reliable communications between components, the system can be rendered useless.

Central Control

Every water treatment facility has a control room from which the plant manager, supervisor or operator monitors and controls the process. When using a DCS, the control room is the center of activity and provides the means for effectively monitoring and controlling the process or facility. The control room contains the HMI or Human-Machine Interface, a computer that runs specialized software designed for that purpose.

There may be multiple consoles, with varying degrees of access to data. In most cases, each operator or manager is given specific rights to allow more or less access and control of the system. The plant superintendent, for instance, may have complete control over his facility, while a technician may only have access to specific data on a particular process. This is done to avoid accidents and process upsets. This scheme also affords a degree of security, ensuring that only properly trained and authorized personnel can operate the various parts of the facility.

The HMI varies by vendor. Each presents the operator with a graphical version of the remote process. Depending upon the skill of the operator and the level of sophistication of the interface, the process may be represented by anything from simple static graphics and displays to animation and voice alerts. Most packages afford the operator wide latitude on the design of the interface.



Photo: An HMI Screen

Courtesy: Westinghouse Process Control

The common thread to each system is the I/O database. The database contains all of I/O defined for that DCS. This does not mean that all process data will be monitored and controlled; it means that only the data defined by the designers to be monitored and controlled will be available to the DCS. This database is a product of detailed evaluation of the process by the designer who typically has the responsibility, with operator input, to design the most effective control schemes for a particular facility. The database is the reference the control software uses to correctly address each remote I/O point. Each database entry corre-

sponds to an entity on the system, whether it is a physical point or an internal, or “soft” point such as an alarm, timer or screen entity.

In designing a system, one has to consider cost as well as effectiveness and efficiency. It is important to understand that all data is not essential for proper control of the process. Much data is purely informational and can be reported by other means, rather than occupying valuable I/O points. Considerations for the selection of a vendor or system should be based upon the final point count broken down to a “cost per point” basis (total cost divided by point count). This will give the owner a means to compare the systems on a common basis. Another consideration is training, which is essential in order to get the most out of your system.

System Uptime

System uptime and signal latency are two parameters that are often overlooked. System up time is defined by the amount of time, in percentage per year, that the system can be expected to be in operation. This figure takes into consideration any required maintenance and is usually above 95%. A variant on this is called the MTBF, or Mean Time Between Failures, an indication of system reliability expressed in hours.

Again, comparative shopping is the best way to determine which system suits the facilities needs, though as a general rule, a higher number is indicative of a more reliable system. The final item to be considered is a service contract. Many different variations can be negotiated, including or excluding parts, technical support, travel costs, or loaner equipment. It is always a good idea to have some pre-arranged technical support, particularly after the warranties have expired.

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Welcome to Ask Tom!, a monthly column by our resident water treatment guru, Tom Keenan of National Environmental Services Agency (NESA). Tom addresses the issues that bug you the most. And Tom knows!! With 35 years experience in providing environmental support services to public and private sector clients on a wide range of environmental issues.

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