Peer-to-Peer Distributed I/O Systems Solve Signal Interface Problems

Consider the expansion of a facility requiring the addition of two dozen field transmitters and control devices: Before the devices are mounted, wiring decisions have to be made. Do you try and find existing spare wires? Not a probable scenario. Do you pull new wires? This is often a prohibitively expensive proposition.

All new and legacy control systems are able to accommodate new 4-20mA or discrete signals with additional analog and discrete I/O boards. But how are we going to connect our two dozen loops to the control system's I/O boards?

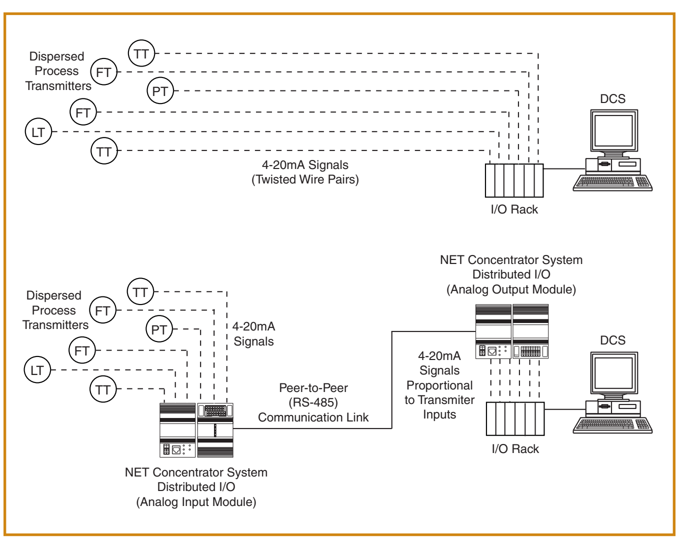
A sometimes overlooked solution is a Peer-to-Peer distributed I/O system. Not only is this choice an economically attractive one, but it can often be implemented by resident instrumentation personnel without involving specialist technology staff.

Wiring Woes

According to some estimates, the cost of wiring pairs is over $8,000 per pair. In this case our 24-loop project needs a budget of $192K just for the wiring! Some plants estimate the cost of running wires by the foot, which run $40 to $100 per foot, depending on the electrical classification of the area.

In essence, you can easily expand a legacy system if you can afford to run additional wire pairs. If running new wire is going to be too expensive, you must seek another solution.

Figure 1. *A peer-to-peer distributed I/O system eliminates the need to run multiple twisted pairs (top) for new instruments. Instead, the instruments are wired into an input module in the field, which connects via a single twisted pair to a peer module in the control room. The control room module outputs 4-20mA signals, which are wired into the control system's I/O.*



In many such cases, a peer-to-peer distributed I/O system is the answer. In a basic peer-to-peer system (Figure 1), field instruments are connected to an input module at the field location. The input module communicates with a matching output module in the control room. The two locations are connected via a single twisted wire pair, wireless, Ethernet or fiber-optic communication link.

Analog and discrete field inputs are converted to digital signals at the input module and converted back to the original analog and discrete signals at the output module, and then wired into the control system's I/O boards. A peer-to-peer I/O system is bidirectional; thus, signals originating in the control room are wired into a module and sent out to the field over the same communication medium. Once in the field, those signals are wired from the field module to control and indication devices.

Figure 2. *Moore Industries NET Concentrator System® (NCS)*

Essentially, the peer-to-peer system acts as a two-way concentrator that eliminates the need to run individual loop wiring.

NOTE: Peer-to-peer systems are available from several manufacturers; in this white paper, we will discuss systems based on the Moore Industries NCS (NET Concentrator System®, Figure 2). Other peer-to-peer systems can be based on PCs, RTUs or PLCs, and must be programmed to perform the peer-to-peer function, but the basic principle remains the same; that is, "concentrating" field data, transmitting it over a single wire or communication medium, and presenting it to the legacy control system.

The NCS consists of input and output modules that can accept most process control signals. Various styles of modules in an NCS can accept signal types such as current (4-20mA, 0-20mA), voltage (0-5V, 1-5V, -10 to 10V), sensor (RTD and thermocouple), direct millivolt (-50 to 1000mV), direct Ohm (0-4000 Ohms),

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potentiometer and discrete inputs. Output modules provide current, voltage and discrete relay outputs. A significant advantage of the NCS is that each input and output signal is allocated a separate channel, isolated from each other, and individually configured; thus, channel 1 can be a 100 Ohm Pt RTD, and channel 2 a J-Type thermocouple. It also means that because the channels do not share a multiplexing A/D processor, there is no single point of failure.

The field-located NCS analog input module (AIM) is wired to a "peer" NCS analog output module (AOM) installed in the control room I/O cabinet. The control room NCS output modules are a mirror image of the input modules; that is, for every AIM in the field, there is a corresponding AOM in the control room module (and vice versa).

At the control room end, the output module decodes the incoming signals and outputs 4-20mA and discrete signals that are then wired into the control system's analog and digital input cards. As far as the DCS or similar control system is concerned, it sees new process signals coming in via its own I/O system, and can process them.

Sophisticated programming knowledge is not necessary. The NCS modules can be configured with a simple PC program, similar to the way you would configure a transmitter. Therefore, adding new I/O to a legacy control system with a peer-to-peer I/O system is a simple, uncomplicated solution and, as we all know, simple is best. Because you start with analog and discrete signals and end with analog and discrete signals, fewer resources are needed to implement this solution.

Picking a Wire Pair

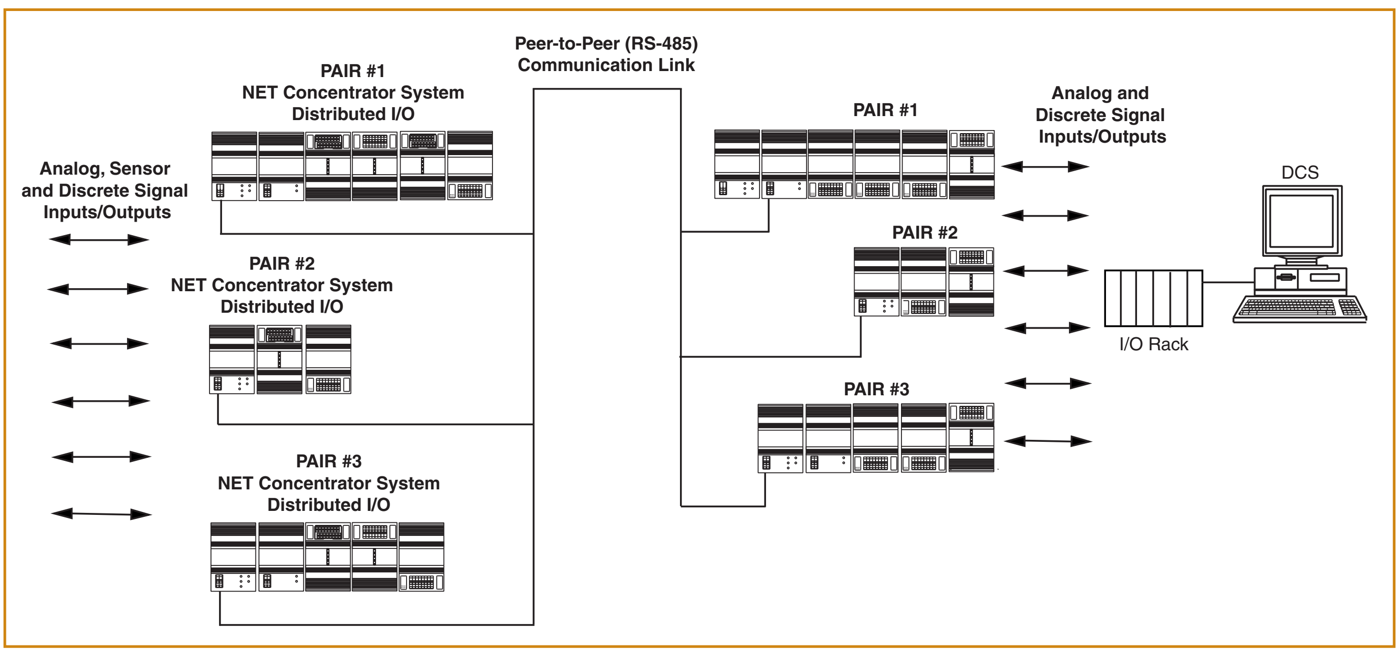
Ideally, a peer-to-peer system uses an existing spare wire pair in the conduit. If there are no spare pairs in the conduit, an easy solution is to disconnect one of the older instruments, wire it into the NCS instead, and use its wire pair for the communication link.

If it is not possible to find a free wire pair, there are other options available to still use this simple peer-to-peer solution. If an Ethernet infrastructure is in place, this can be used to connect the modules. Fiber optic cable can also be used if available. If neither of the above is an option, line of sight, spread-spectrum radios can be used to transmit the signals from the field to the control room. The wireless system is transparent to the DCS, which—once again—does not know or care how the field signals get to its input cards.

Networked Peer-to-Peer

The example in Figure 1 shows a simple peer-to-peer system, consisting of two NCS stations. More complex systems can be set up to allow process variables from different physical locations to be brought to the control system over the same wire pair, as shown in Figure 3. The principle is the same: the field NCS station talks to

Figure 3. *Multiple peer-to-peer modules can be set up to carry dozens, or even hundreds, of analog and discrete I/O points to a legacy system.*



its peer control room NCS station, and several stations share the same wire pair. Figure 3 illustrates three station pairs on a single network, but this configuration can be expanded to accommodate up to 32 NCS stations, or 16 pairs of NCS stations on a single twisted pair wire.

Because each NCS can accommodate up to sixteen I/O modules, and each I/O module can accept up to four analog I/O or eight discrete I/O, a single NCS station can handle up to 64 analog inputs or outputs, 128 discrete I/O, or any combination thereof. If a system has 16 NCS stations, then it can handle 1,024 analog I/O points, 2,048 discrete I/O, or a combination thereof on a single twisted pair to 16 matching peer output modules.

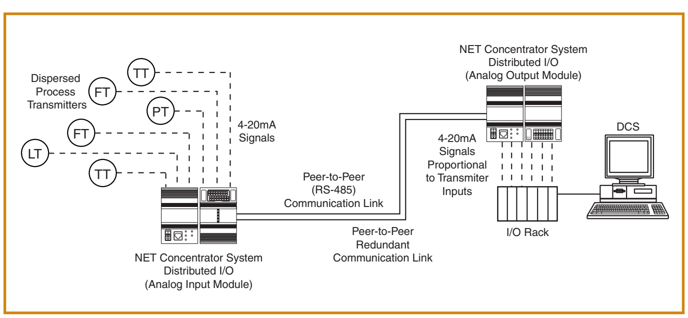
If a plant needs more than 1,024 analog signals, then additional NCS stations can be installed on another twisted pair. There is no limit to the number of I/O signals that can be handled by NCS-based peer-to-peer systems. The NCS concept works not only for adding new field I/O but could conceivably replace all existing “home run” wiring. Why replace existing wiring? Several reasons come to mind:

- Peer-to-peer can be set up with redundant networks, so that a break in any wire pair does not affect signal transmission. Making a hard-wired home-run system redundant requires running extra wire.
- Peer-to-peer systems can communicate via wireless, Ethernet, or fiber optic networks, making it easier to access data in remote locations.
- The NCS is easily expanded for future plant growth.

Two-Port Peer-to-Peer

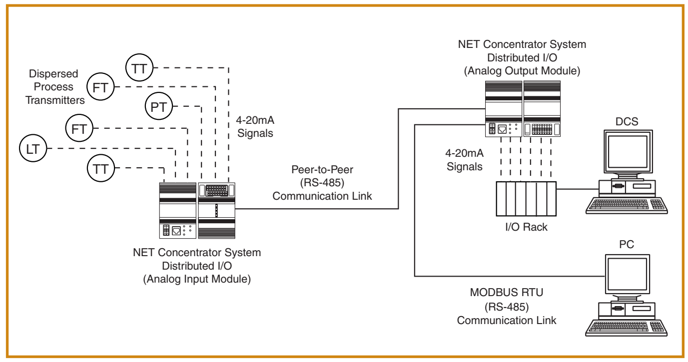
Setting up redundant I/O in a legacy plant can be extremely difficult and prohibitively expensive because the hard-wired “home run” twisted pairs have to be completely duplicated to provide full redundancy. However, because the NCS peer-to-peer system has two communications ports, setting up a redundant peer-to-peer network is relatively simple.

Figure 4. *The NCS has two communication ports, allowing for a redundant network or shared data.*



Just select a second twisted wire pair in the conduit for use as a second network, Figure 4. Ideally, the second wire pair should be run in different conduit so that whatever incident causes one network to fail does not affect the other network.

Figure 5. *The second port can also be used to communicate with a PC or HMI.*



The second communications port could also be used to connect to a DCS, PLC or any other device that wants access to the real-time data, Figure 5. MODBUS RTU protocol would be used for this application. In this case, one port is used for peer-to-peer communications, and the other port is used for peer-to-host communications.

Alternate Paths

As noted above, the peer-to-peer link can also be implemented with wireless, fiber optic and Ethernet communications.

Figure 6. *A WLM Wireless Link Module can be used in place of the twisted pair to acquire data from remote areas.*

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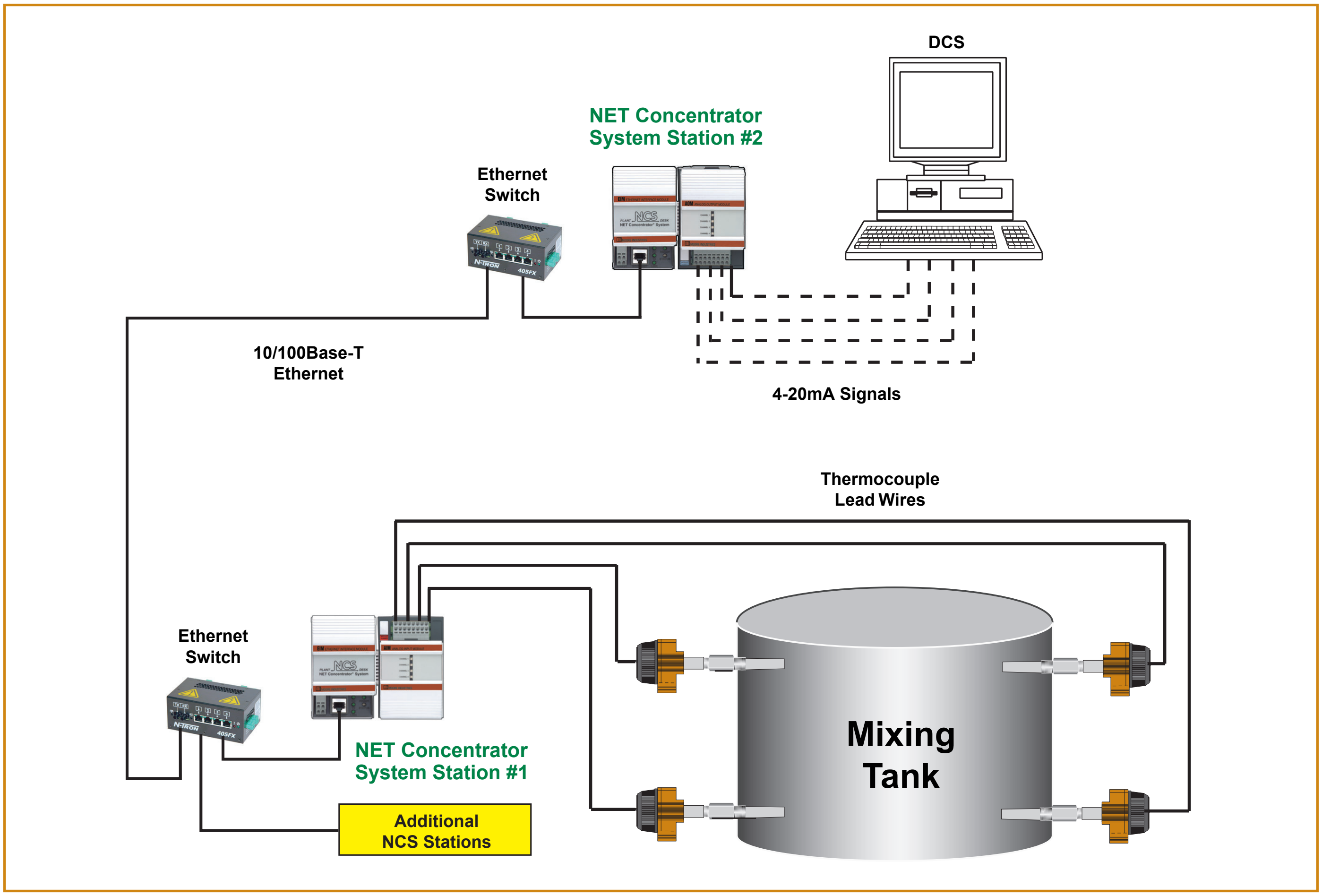
Figure 7. *An Ethernet network allows DCSes, PCs and PLCs to access an unlimited number of NCS stations.*



By using a Moore Industries Wireless Link Monitor (WLM, Figure 6), a wireless transmitter and receiver pair replace the single twisted-pair wire. This allows I/O signals to be sent and received from remote stations, or from sections of the plant that have no conduit laid.

Using the Ethernet Input Module (EIM) as the peer-to-peer physical layer provides two major advantages over twisted pairs: First, the limitation on the number of NCS pairs is based upon the number of IP addresses available on the subnet. A twisted pair system supports 16 pairs of NCS stations, but an Ethernet network can support an essentially unlimited number of stations, Figure 7. Also, the transmission speed over Ethernet is much higher than a RS-485 twisted-pair network, which typically operates at 2400 to 57000 baud. Ethernet supports speeds up to 100 MB/sec.

21st Century Control

Peer-to-peer systems are primarily designed to provide a low cost solution to plant expansions by not having to pull new wire, or to replace aging or inaccessible wiring. But as can be seen from these examples, the capabilities within a modern peer-to-peer distributed I/O system can take it beyond a simple wire concentrator if future plant upgrades require it.

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