All Aboard the SCADA Mothership

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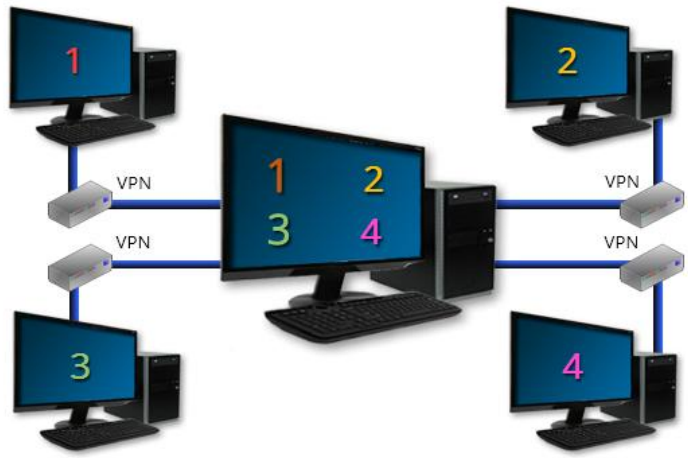


KEYWORDS

SCADA, Simple, Unified, Central, Big Data, Upgrade, Redundancy, Load Distribution

ABSTRACT

During the past two decades, there has been a dramatic evolution in terms of automation and communications. Twisted pair and co-axial cable have given way to fiber and wireless; serial exchanges have been replaced or augmented with Ethernet; processors are smaller, faster and less expensive; graphical displays are everywhere on the factory floor; increased data logging, storage and retrieval has evolved into big data. Perhaps the most significant change has been the adoption of "IP" or Internet Protocol for communications. This has facilitated multiple masters polling, FTP (File Transfer Protocol), remote configuration and SCADA systems which manage themselves at the local/enterprise levels. We can link with anyone, anywhere, anytime and rather than having to focus on getting connected, we actually need security to stop undesirables from accessing application data.

Yet, the typical SCADA system architecture has not really kept up with these changes. Specifications still call out a variety of independent or sub-applications and a completely separate SCADA central. This insular architecture requires significant design co-ordination between components as well as additional effort in terms of system configuration and commissioning. It usually involves a large number of both hardware and software suppliers. Multiple integrators and engineers must be kept in tune or else development may become a matter of trial and error.

This presentation will detail evolving system architecture options at the single and multi-plant levels made possible by emerging software technology that leverages these infrastructure enhancements.

MOTHERSHIP OVERVIEW

This application structure is referred to as the "Mothership" concept. Essentially, multiple workstations all run their own local applications as integrated parts of a larger system. As detailed later, benefits could include a significant reduction in hardware, configuration time and commissioning costs. Additionally, it lessens the long-term burden on maintenance, enhancements and upgrades while providing or increasing redundancy across drivers, historians, alarming and overall application management.

COMMUNICATIONS

Probably the biggest single impact to the system design is the flexibility and availability of so many communications options. We see this with the new focus on the dynamics of the Industrial Internet of Things (IIoT). Ethernet has become a standard for high speed data transfer because of relative ease of installation, price and data throughput. At the plant level, there is now extensive use of wireless communications and some manufacturers are even recommending replacing all hardwired connection throughout the plant. However, in the manufacturing environments, particular attention must be paid to obstructions, obstacles and RF interference that will negatively affect performance. While wireless throughput has lagged, the next generation standards contemplate speeds of up to 1,000 MB/s. Wireless will compete with Gigabit Ethernet.

Traditional LAN and WANs are being augmented by VPNs which provide secure point-to-point connectivity. These VPN connections can either be deployed and maintained by the utility IT department, or also now delivered seamlessly by many telephone service providers. Again, wireless Ethernet is providing “always on” monitoring over large geographic areas with multiple devices and exceptionally high data throughput. Cellular, fiber and satellite have become far more cost effective and have pushed the “last mile out” in most urban and rural areas - substantially farther than available 10 years ago and with megabit per second plus connectivity.

INDUSTRIAL PANEL PC

Many water and wastewater plant specifications identify a variety of independent sub-applications and a completely separate, but connected SCADA central. Operator Interface Terminals (OITs) running on a proprietary OS provide an on-site, single-purpose interface to various PLCs and RTUs. These are designated at multiple process locations.

In recent years, the Industrial Panel PC (IPC) has emerged as a cost effective alternative. In most cases, they are using a standard off-the-shelf OS which is familiar to plant personnel. With ever increasing use of compact flash and Solid State Drives (SSDs), moving parts have been eliminated and reliability enhanced. Fanless housings are increasingly popular, particularly in areas of high particulate or moisture contamination. Customizable versions of the embedded OS options can mitigate or eliminate specific processes that are disruptive or deemed to be detrimental to system security. Deploying an IPC with a familiar and widely used OS allows a whole new approach to SCADA server architecture including access to multiple third party expert systems and hardware.

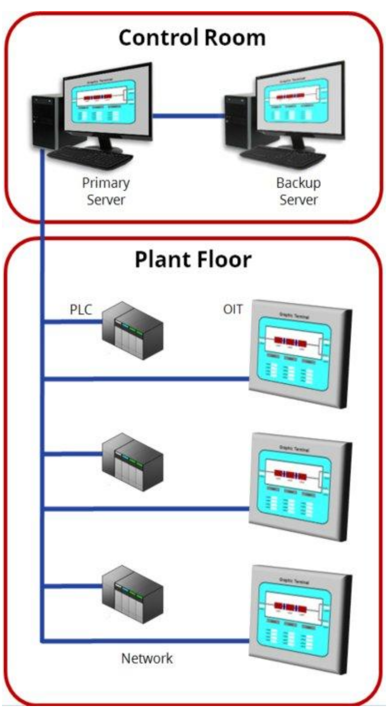


Diagram A

SINGLE PLANT ARCHITECTURE

Typically, a plant monitoring and control system includes SCADA software running on two or more computers (development and runtime) in the control room. They can also include one or more OITs, each one communicating directly with local I/O devices. This simple system is described in Diagram A – paired two SCADA workstations and three single-purpose OITs.

The “M cept, at the single plant level, is to deploy a standard SCADA software license in the main control room as the Operator Workstation (OWS). However, the same software product can now be deployed throughout the plant on IPCs, in lieu of the conventional OITs. Each field computer is designated as the Primary Application Server for all localized hardware, providing full graphics, alarm acknowledgement, trending, reports and acting as a local Historian for data – Diagram B.

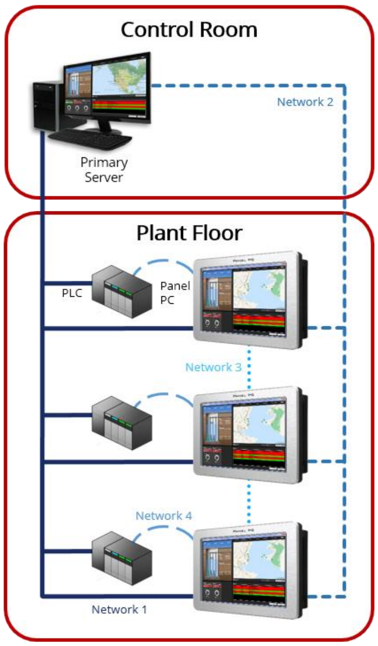


Diagram B

The OWS is essentially an Application Client to the multiple field Application Server nodes. It logs all data and provides all other standard SCADA features. The OWS is also a back-up Application Server to each field Server and a Centralized Historian. Operators can roam untethered around the facility while remaining directly connected to the OWS through support for mobile devices, tablet technology and web browsers.

In this configuration, assuming all local hardware is directly available on the network, when any Application Server fails, the OWS will automatically move from Application Client mode to Primary Server role for the hardware associated with that particular node. In addition to standard SCADA functionality, it will act as a Server to any upper layer applications dependent on the data that are being stored. This role will be automatically relinquished when the IPC is restored and the entire system will rapidly synchronize back to its normal state with minimal data loss. The historian(s) will backfill bi-directionally if required.

By replacing the OITs with an IPC, the second computer in the control room can be eliminated and still have four fully-functional workstations. Note that in Diagram B, each IPC is on a multiple network with additional direct serial connections to local PLCs. Using standard OS network support, SCADA software capabilities, IPC hardware configuration and Ethernet and serial interfaces on the I/O, it may be possible to enhance communication redundancy by providing direct access to the PLCs/RTUs in case of limited network failures.

In a traditional system, configuration including graphic displays for both the SCADA application and the local OIT must be created using different tool sets. In the proposed system, displays only need to be created once and can be visible throughout the system. There is only one application installed everywhere, but running a subset at each node; i.e., one project install file for the whole plant. Not only does this provide much faster install/reinstall/switch-out, but all changes can be deployed to all nodes instantly through the high-speed network. The consistent displays also reduce training time and help to avoid operator confusion.

Modifications or enhancements would normally be made from the Operator Workstation rather than at the individual OITs. All configuration changes including displays, tags, and application properties are pushed to all workstations without needing to restart the system. In some cases, modifications can be allowed to run at the local OWS for testing and stability purposes prior to being universally deployed.

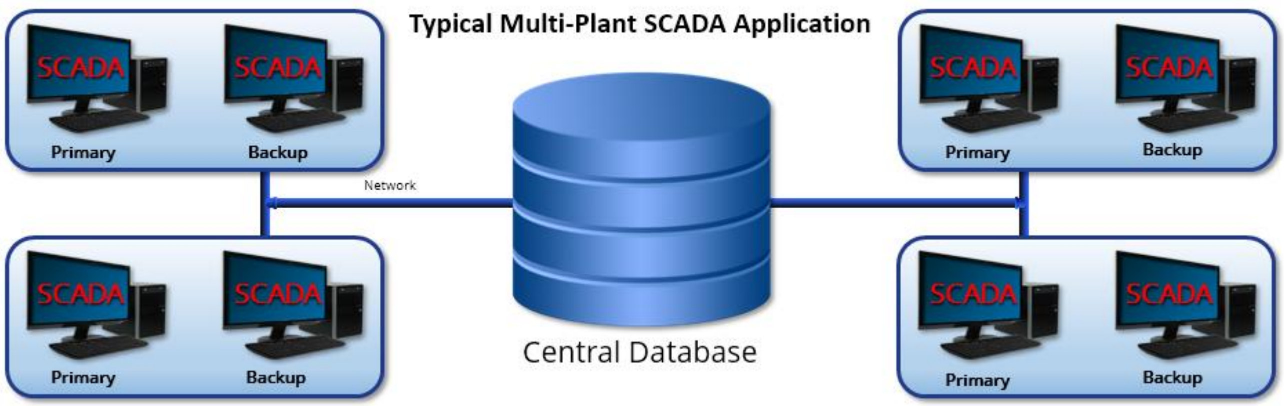
Additionally, this configuration allows for sharing of real-time data directly between OITs as well as ensuring application and configuration synchronization. With standardization of tags, pop-ups and screens, it is now possible to dramatically reduce the integration time while enforcing “best practices” at the facilities’ OITs.

To reduce the license tag count and cost on each IPC, it may be possible to filter locally loaded tags in order to activate only the elements required for that local I/O device. It should be noted that the entire plant-wide application will still be loaded. This still provides all the benefit of reducing configuration time and system maintenance and upgrades. However, tag limited IPCs will not be able to fill the roles of fully redundant Application Servers. Additionally, authorized users will not have full access to any part of the system from any workstation. However, the fact that the IPC is running a standard SCADA software product should provide access through the vendor's support for mobile client technology.

In summary, replacing traditional OITs enhances the SCADA system instead of duplicating it and substantially reduces costs in deployment, integration, maintenance, and allows for a significant amount of standardization corporately for tags, screens and alarms. Benefits include simplicity and additional redundancy.

MULTI-PLANT APPLICATIONS

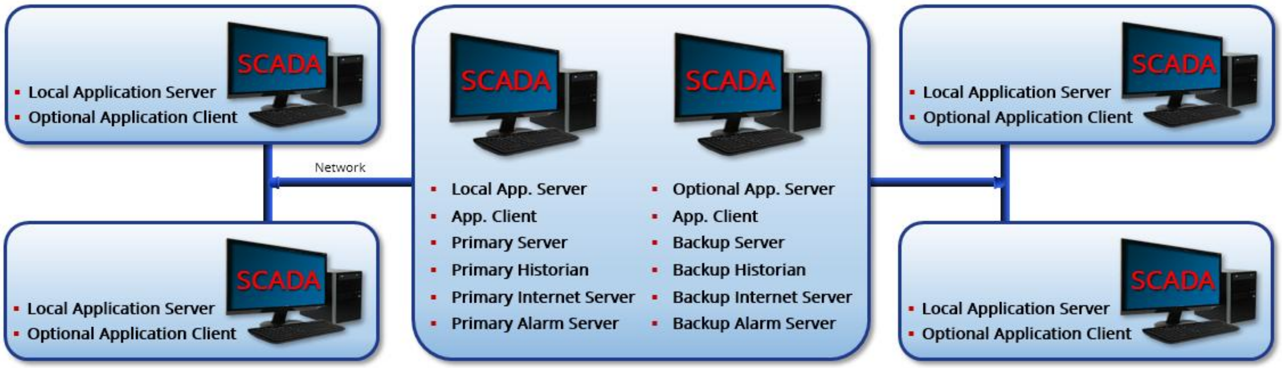
The standard architecture for an enterprise system consists of multiple separate applications running at individual sites. Typically, there are at least two computers at each location to provide redundancy. The sharing of information is typically handled through a centralized database which is also tasked with providing report and trending.



The "Mothership" concept which leverages newer communications technology at the individual plant level facilitates a similar style of architecture at the multi-plant level. The availability of high speed communications between disparate locations at a reasonable cost is critical to ensure a smooth operation. Additionally, the ability of newer OS's to support more RAM allow for significantly higher I/O counts in a single application.

In this enterprise architecture, all plants and distribution/collection systems are part of a single unified application. Computers at each individual location are designated as Primary Servers for that specific site. The local computer is tasked for all communication and control as it relates to immediately adjacent hardware and I/O. One location, either a plant or administrative office, is designated as the SCADA central. It may be a single computer or paired for redundancy or load sharing purposes. In addition to being an Application Server for all local I/O, it is also an Application Client to all other Application Servers on the network.

Any and all other computers on the network can readily be configured to act not only as Application Servers for local control but also as Application Clients for any or all other Application Servers. These nodes become redundant servers at either the individual, multi-plant or system-wide level. They have full SCADA capabilities including logging, mobile client and alarm synchronization and notification capabilities. Obviously, all hardware needs to be accessible on the network. Additionally, the software licenses may support all applicable hardware protocols in addition to supporting multiple asynchronous communication capabilities. As mentioned earlier, SCADA software support for redundant networks and both serial and Ethernet drivers can provide enhanced communications redundancy.



An additional benefit of the "Mothership" system architecture is the potential for handling system scaling by dynamically reallocating services across any combination of servers. For instance, one server can be dedicated to handling Internet connections, another for communications, another pair for logging. Some adjustments to running various services can be made by the SCADA program itself.

Obviously, the SCADA central requires a license to handle all tags. Again, in the interest of cost, the active tag count at each plant can be limited to local I/O or local hardware plus an adjacent facility. As mentioned earlier, if not all tags are loaded to a workstation, full system visualization may require other tools for mobile access.

The need for archived historical backup is no longer required due to geographic separation of historian redundancy and the availability of large scale and expandable long-term online storage. This will further reduce cost and provide a higher level of redundancy.

Software tools can be deployed on multi-plant installations to greatly reduce the overall complexity while providing a unified platform for acquiring and sharing data. In concert with new communications options, redundancy can again be increased with significantly less hardware, simpler system configuration and leveraging modern cloud based technologies.

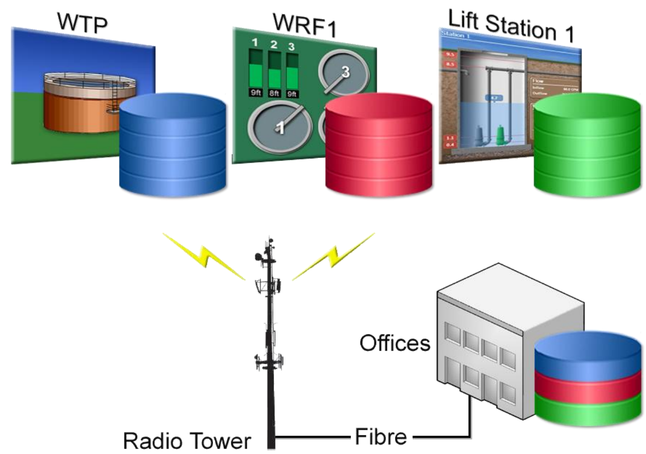
Geographically separated (or distributed) redundant servers, previously not possible, are now very cost effective and secure with advances in server technology and VPN technology (i.e., encrypted IP tunnel). In addition, the ability to track version control and undo changes made in the application, as well as the potential for version monitoring of the software deployed and router configurations, provides a substantial improvement over the traditional local back-up models or imaging.

PRACTICAL MULTI-PLANT APPLICATION

An example of this evolving type of system architecture can be found in Ocala, Florida. Twenty years ago, the City began a lengthy transformation to a unified SCADA application. The Water and Sewer Department operates a twenty-five million gpd lime softening plant, three water reclamation facilities with total capacity of thirteen million gpd, 125 lift stations, approximately two thousand acres of spray irrigation systems and fifteen other assorted water and wastewater sites.

The utility became increasingly concerned that they had personnel who were specialized in the water, wastewater or lift station systems. All three groups were responsible for their own automation side. None of the applications could see the whole system which created blind spots for critical alarms and made it difficult to respond to all issues in a timely fashion. Additionally, the lack of a single historical database complicated the process of generating reliable system-wide reports and trends.

Over a period of years, the utility replaced the three software packages with a single product. However, each location still relied on paired computers for redundancy, running only the local application. Seven applications required 14 computers. With a new city-wide, high-speed fiber network, they were able to modify the system architecture and keep only one server at each location. Each OWS could take over for any other in the system.



Each site also hosts its own local synchronized historical database with a central backup of all databases at the head office. This provides quick local access to live data with the benefits of a centralized database for reporting and analysis. While reducing the server count by fifty percent, there was an increase in the levels of server redundancy from two to six.

CONCLUSION

The standard insular architecture model requires significant design co-ordination between components as well as additional effort in terms of system configuration and commissioning. With the "Mothership" architecture, multiple computers can all run their own local applications as integrated parts of a larger system. Benefits include significant reduction in hardware, configuration time and commissioning costs. It lessens the long-term burden on maintenance, enhancements and upgrades while increasing redundancy dramatically. As we move forward, we need to address the concerns about growing system complexity and a shortage of trained personnel. The Mothership approach to application architecture has arrived.

ABOUT THE AUTHOR

Patrick Cooke *was born in South Africa and attended schools there as well as in England and Canada. After graduating from Dalhousie University in Nova Scotia with degrees in business and linguistics, he joined the Canadian diplomatic service. He has been at Trihedral for more than 23 years and is currently the Director of Marketing. Contact: pat.cooke@trihedral.com.*