Paper 5.1

The Oil & Gas Industry Can Now Benefit From Digital Plan Architecture

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1 Executive Summary

In the past few years, Digital Plant Architectures have proven their value by providing improved plant operations, increasing throughput, availability and reducing maintenance costs in process plant installations worldwide.

On the whole, the Upstream Oil and Gas industry has not benefited from these advancements, due largely to the logistical challenges posed in implementing the architecture over large and remote geographical areas. Among these challenges are utility availability, communications infrastructures, availability of local expertise leading to prohibitive costs.

It can be shown that the breakeven costs for the instrumentation and automation of a wellhead or pipeline installation are much lower today than even a few years ago. Utilising Electronic Flow Measurement (EFM) to measure flows at each wellhead is important for accurately reporting the production of a well in real-time. And, Supervisory Control and Data Acquisition (SCADA) software allows high visibility for managing and optimizing wellhead or pipeline data in real-time. This real-time visibility would be almost impossible to achieve with paper charts and such instrumentation alone.

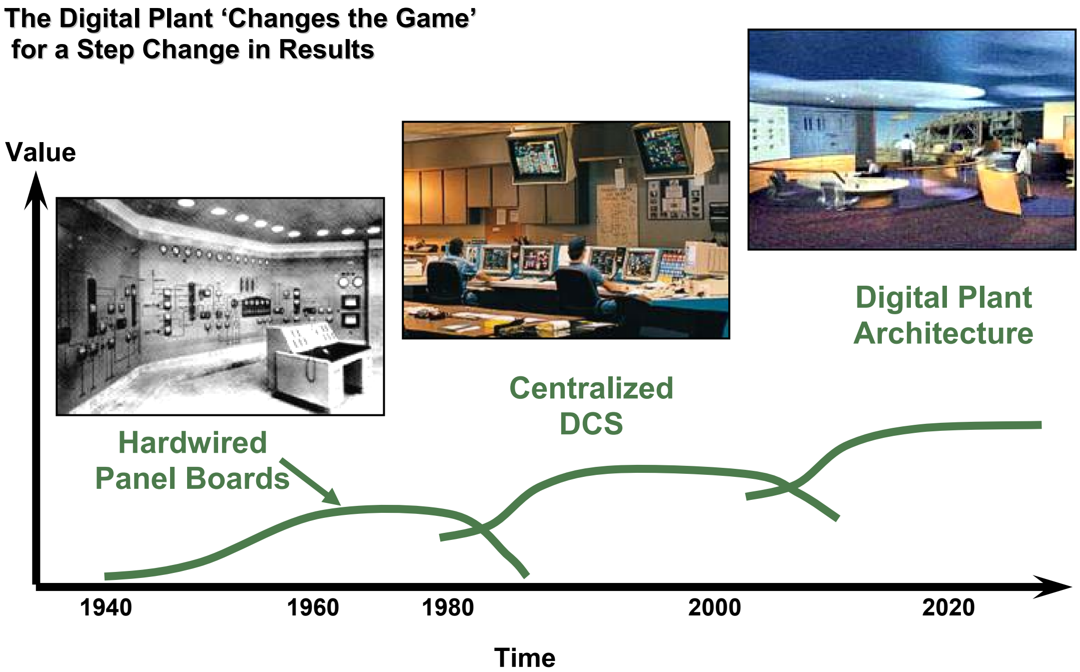
Advancements in technology now make it possible to integrate remote sites into a Digital Field Architecture, or virtual plant, occupying hundreds or thousands of square miles.

This Digital Field Architecture goes beyond the limited capabilities of traditional SCADA architectures by integrating real-time, historical and asset data from field instrumentation and associated equipment. This architecture can provide unprecedented capabilities to improve system level visibility, quality, throughput and availability. In addition, operations, maintenance, safety compliance, and environmental costs can be lowered while reducing waste.

Another important benefit of Digital Plant Architecture is the possibility of wellhead-based and field-based optimization to provide increased production. As the field can now be managed in real-time, and instrument health can be trusted, advanced techniques can be used to improve current production using the data provided.

2 The Role of Digital Plant Architecture Today

In the process world, it is quite typical for a Distributed Control System, or DCS, to run all processes in a process plant. In recent years, “digital” instrumentation has become main stream replacing older instrument technology i.e. pneumatic and analogue. Through the use of digital instrumentation, a Digital Plant Architecture has emerged to capitalize on the benefits of **improved diagnostics** and **predictive intelligence** bringing value to the user.



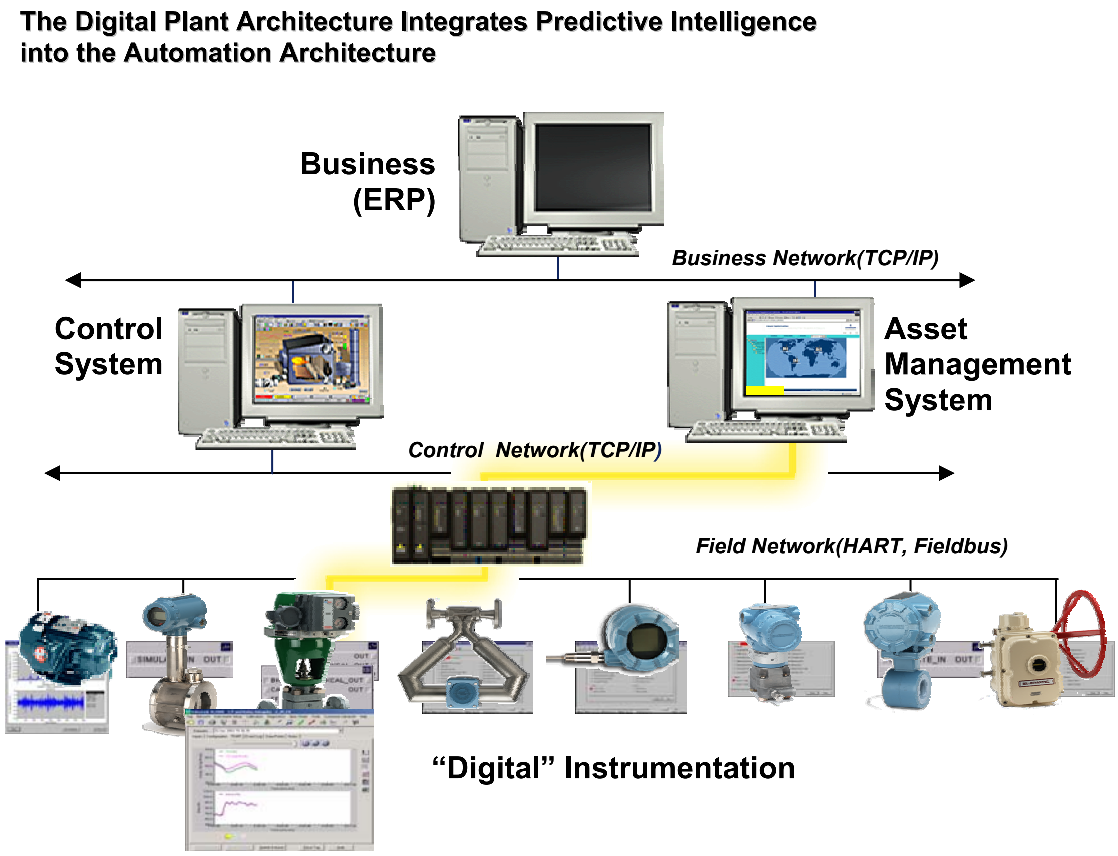
Key components of a Digital Plant Architecture include **"Digital" Instrumentation**, a **Control System**, and an **Asset Management System**.

2.1 "Digital" Instrumentation

"Digital" instrumentation refers to instrumentation in which a microprocessor handles the conversion of a field signal (that is to say, pressure, temperature, etc) to an industry standard transmission format, for example 4-20 mA, HART or FOUNDATION™ fieldbus. The use of the microprocessor brings tha additional benefit of allowing additional valuable configuration information to be stored in the unit.

Digital communications further increases the benefits, as additional information may also be stored in the "digital" instrument regarding the type of asset it may be. Tag number, serial number, or construction materials are examples of this ***asset data***, which is typically entered only once, and then resides in the unit for future reference.

In addition, most vendors can include device level ***diagnostics*** which can provide detailed troubleshooting of their instrument. Using HART or Foundation Fieldbus to communicate this data from the instrument provides a powerful new tool for improving reliability and predicting failure.



2.2 Control System

A control system monitors process variables and controls final elements in the process, in order to achieve an objective. In some systems, the Asset Management System and the Control System are combined. Most controls systems interface with the process with at least one of the following techniques.

Analogue
Initially replacing pneumatic instrumentation, analogue signals consisted of the transmission of a single variable from an instrument using a current loop, in which the variable is scaled in the range of 4-20 mA, 1-5v, etc.

HART
Designed as the first step towards the digital architecture, HART is a communications protocol which rides on the 4-20 mA current loop, and allows additional data to be communicated. (For more info see www.thehartbook.com)

FOUNDATION™ fieldbus
FOUNDATION™ fieldbus is a standard for all digital communications from an instrument to a control system. It facilitates interoperability between devices. And FOUNDATION™ fieldbus makes it possible for control algorithms to reside in the instrument, as opposed to the DCS. (For more info see www.fieldbusworld.com)

2.3 Asset Management System

The Asset Management System is a software database for collecting and interpreting all of the asset data. It is intended to be a powerful tool for improvement of reliability and prediction of failure. Instrument data is provided in a structured format for ease of organization, documentation, and troubleshooting. Alarms are presented in plain English when they happen for immediate action.

3 Types of Data Found in a Digital Plant Architecture

Real-Time Data is data that is updated as quickly as possible, typically 1 second in a process plant DCS, and 1 minute or more in a production field or pipeline network. This data is time critical, and it is used to make decisions at the operator level. It has the highest priority in the communications network. If, for example, communications fail and the operator is not able to view this data, the operator is blind to what is happening in their process at that moment in time. Many cases would require instant action to rectify the situation. One solution could be intelligent remote telemetry which monitors the local process and under healthy conditions limits communications back to a HOST system, only under fault or predetermined conditions will the Remote Telemetry Unit (RTU) in the field “call” the HOST to alert it to a problem, i.e. report by exception. This reduces bandwidth and also reduces reliance on communications to remain intact for long periods of time.

Historical data is sampled Real-time data that has been archived for future analysis and reference. In a process plant this is typically done by the DCS, which stores, displays and may provide an element of analyses. Some systems may even feed back to the control system optimized settings based on historical trends. In the RTU world, it is a requirement to log all relevant data so that if, for example, communications go down, all of the data for the corresponding period of data flow interruption can be applied retrospectively later for analysis. In some instances the RTU may be required to execute local control of the wellhead or station for safety reasons, for example, overpressure.

Asset data is data stored in a digital instrument, and used for configuration, diagnostics or to physically describe attributes of the asset (instrument). This would include calibrated range, last calibration date, current status, and construction. This data can be collected by the Asset Management system in parallel to the SCADA system. The diagnostic functions of many of the instruments provide a very powerful capability to predict a failure before it affects a process or site. This would also provide remote troubleshooting and decrease the number of visits to remote sites required to resolve the issue.

4 The Challenges of the Oil and Gas Industry

Digital Plant Architectures can be found in the oil and gas industry today in refineries, processing facilities, and terminals. These facilities are very similar to the chemical process industry, in operations and design considerations.

Large process industries have seen the results of using a Digital Plant Architecture.
They are:

1) Improved Quality
2) Improved Throughput
3) Reduced Downtime
4) Reduced Operations and Maintenance Costs
5) Reduced Utilities Usage
6) Improved Safety
7) Reduced Waste

In contrast, the Oil and Gas production and transmission industry offers distinct challenges due to remoteness of well sites and pipeline stations.

In a typical natural gas production wellhead application, the minimum data needed would be gas pressure, gas temperature, and flow rate (typically differential pressure, or dP). Options for the collection of this data range from pneumatic chart recorders, to purpose-built integrated electronic flow computers and Remote Telemetry Units (RTUs) using field transmitters to measure the data points.

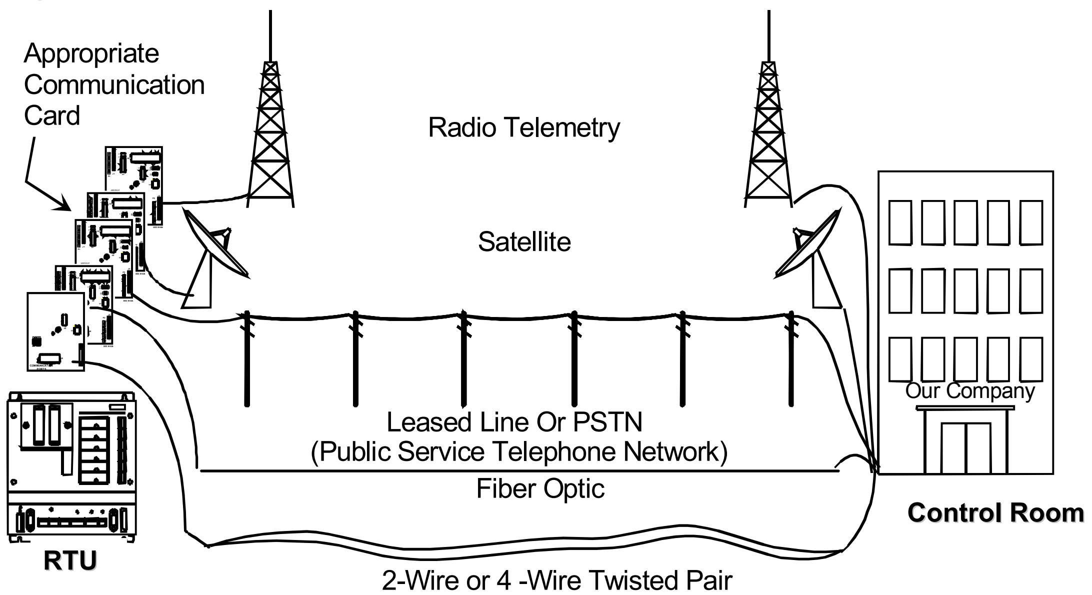
Electronic data gathering devices are typically higher accuracy than the more traditional chart recorders. By utilising electronic data acquisition operators can make decisions based on real-time data, as opposed to data that can take weeks, sometimes months to collate. In most cases, this improved visibility would lead to improved production from increases in availability of the wellhead and better accuracy of the process measurement.

Payout Period (days) on an improvement value of $3000 and a 2% increase in Production

	Gas Price						
Mcf/day	$4.00	$4.25	$4.50	$4.75	$5.00	$5.25	$5.50
50	750	706	667	632	600	571	545
100	375	353	333	316	300	286	273
150	250	235	222	211	200	190	182
200	188	176	167	158	150	143	136
250	150	141	133	126	120	114	109
300	125	118	111	105	100	95	91
350	107	101	95	90	86	82	78
400	94	88	83	79	75	71	68
450	83	78	74	70	67	63	61

Some companies may wonder if they really need a Digital architecture. Using the table above as an example. Assuming a typical wellhead EFM package costing $3000.00, and a payback requirement of 120 days, the ability to achieve a 2% increase in wellhead production by instrumentation should be a justification to instrument all of our wells producing 300 Mcf/day unless the gas prices drops below $4.25/Mcf.

Typical SCADA Monitors Real-Time and Historical Data



While the use of SCADA systems fulfil the need for a control system, the additional requirement to communicate to "digital" instrumentation from the Asset Management System can complicate the issue, as typical communications protocols supported by SCADA systems may not support passing asset data. Without the correct method of communications to the devices, it is not possible for the Asset Management System to manage them.

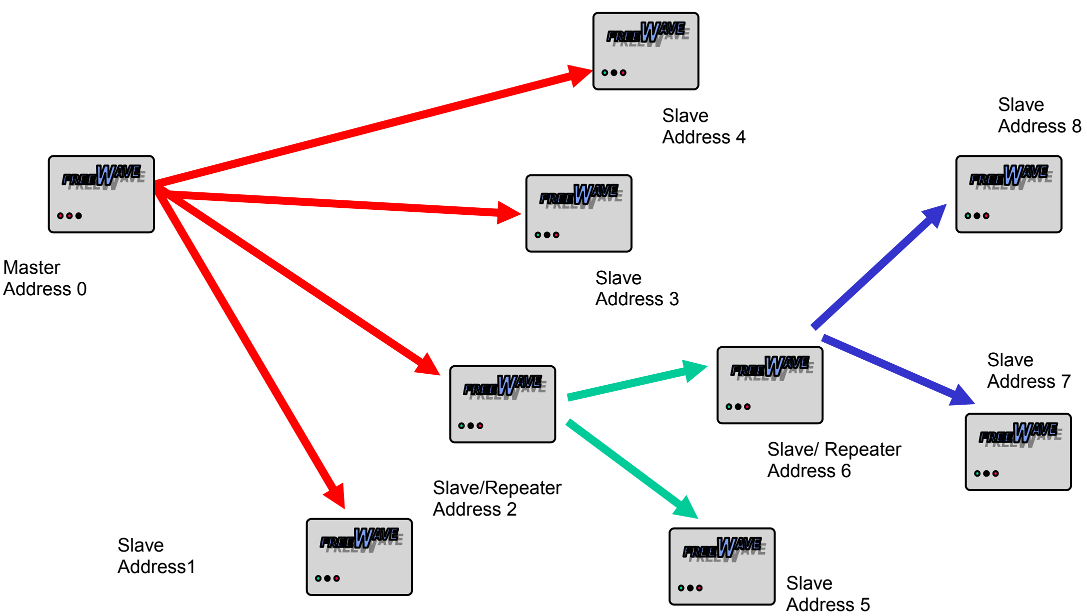
When addressing the remoteness of production and transmission sites, most networks are limited to *real-time* data gathering only, with little focus on bandwidth reduction, or additional data gathering. In general, it has been too hard or expensive to integrate an Asset Management System and a SCADA system seamlessly in one network. The needs of the production and transmission segment have made this type of Asset Management System impractical.

When considering the communications network for a remote site, most people would consider the lowest cost option capable of providing the communications required. If a hard-wired telephone or an optic fibre network option is not available, then the situation may require mobile telephone, radio, or satellite technology to provide communications.

- Radios are typically limited to line-of-sight (LOS), typically with an unlicensed range of 3-5 miles, and a licensed range of 10-15 miles. However, increased range means increased power consumption and possibly slower data rates.
- Mobile phone networks are very good at coverage in populated areas, but are typically poor or non-existent in the more remote areas.
- Satellite networks generally offer the best coverage. Satellite modems are now available that can provide a static IP address on the internet, for direct communications to site.

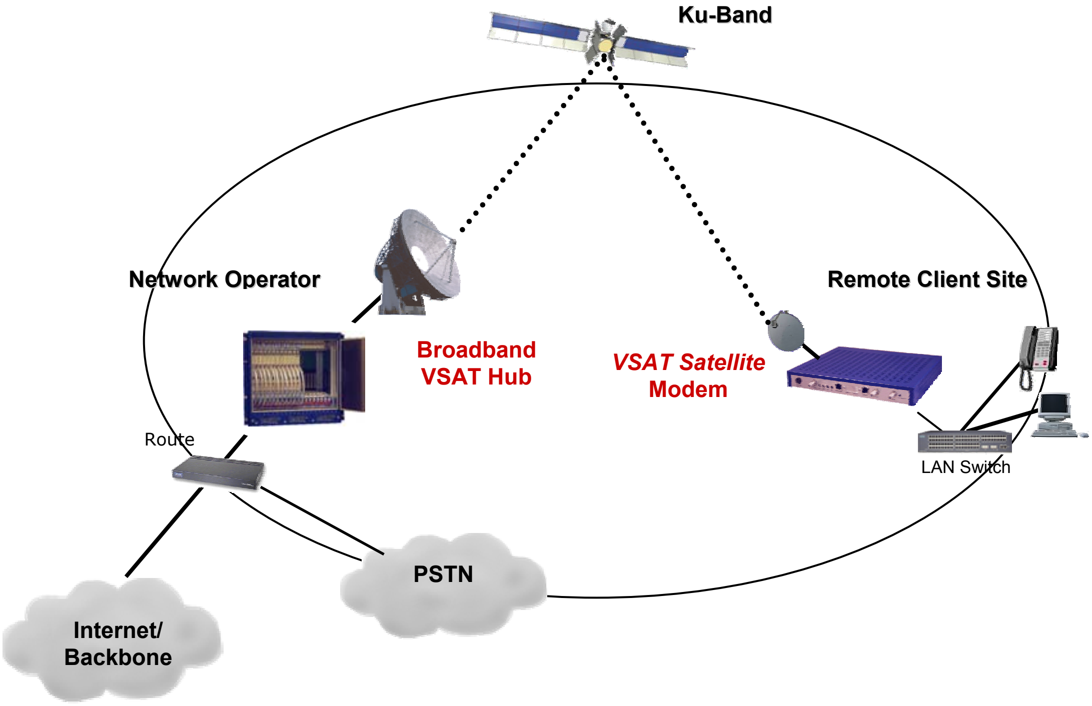
GSM technology is found in mobile phone networks. In these networks, the GSM modem would act just like a normal phone modem. GSM communications speed and bandwidth are typically slow at 9600 bits per second in a Generation 2 network. Recently, telephone companies have developed GPRS technology to provide direct access to the Internet from a remote terminal at higher speeds of around 56,000 bits per second. However, most network companies provide dynamically allocated internet IP addresses, and are reluctant to provide the static IP addresses required for communicating to SCADA type equipment. Mobile phone technology is by far the most economical if coverage is available and bandwidth is sufficient.

Typical Ethernet Radio Network



If more bandwidth is required, then Ethernet Radio Technology should be considered. It has really improved in recent years, with several companies offering spread spectrum radios that are Ethernet capable and have throughput rates of 100,000 bits per second or more. When using radio on site, the network infrastructure is completely controlled by the owner. This option has the highest bandwidth next to fibre optic, and is normally very competitive if Line Of Sight is not severely limited, increasing the costs of the network.

Typical VSAT Internet Network



Recent improvements in satellite data terminals have reduced size, power requirements and the cost using Very Small Aperture Terminal (VSAT) technology. A VSAT terminal can provide communications at data rates up to 5,000 bits per second, in a very small, low powered footprint. However, ongoing charges will be incurred based on data sent through the terminal. This option is suitable for those unable to use mobile phone or radio networks, or those wanting a static IP address on the internet. Due to its use of the internet, network latency and security considerations must also be taken into account.

Key Network Considerations

Method	*Power*	*Coverage*	*Speed*	*Cost*
PABX	Low	Poor	Slow	Low
Fibre Optic	Low	Dedicated	Fast	High
GSM/GPRS	Low	Moderate	Moderate	Low
SS Radio	Medium	Dedicated	Fast	Moderate
Satellite	Medium	Very Good	Moderate	Moderate

Another consideration in design of the communications network is the ease of troubleshooting network issues, and the diagnostics available from the equipment selected. Some vendors provide very detailed diagnostics in their Radio or Satellite equipment, while others provide little or no diagnostics at all. It is a major factor in effective troubleshooting to know whether it is the network or the remote device/asset that is at fault. An example of effective diagnostics is the provision by some radio companies of fade margin measurements, packet loss, and other statistics that can help improve the installation and maintenance of the radio network.

5 Bandwidth Management and Methodology

As all of the above network methodologies are limited on the effective bandwidth available, it is of utmost importance to use communications protocols and network devices that reduce bandwidth. It is feasible to design a network without giving due consideration to minimizing bandwidth, but a correctly designed network with bandwidth management will effectively handle a much larger amount of data.

Possible techniques that can be used would be data compression, and report by exception. In report by exception, an RTU may only reports changes in the real time data or alarm conditions. This RTU can then store all other data in history, until polled, at which point the data points can be sent in a complete (but compressed) format. Therefore, minimizing the total amount of bandwidth required.

In some cases a *Digital Gateway Device*, could be used to effectively **concentrate** the data requested from a high bandwidth network, and **manage** the data on a lower bandwidth network. These devices can also handle conversion of TCP/IP Ethernet traffic to serial data packets for forward transmission via the various communications mediums.

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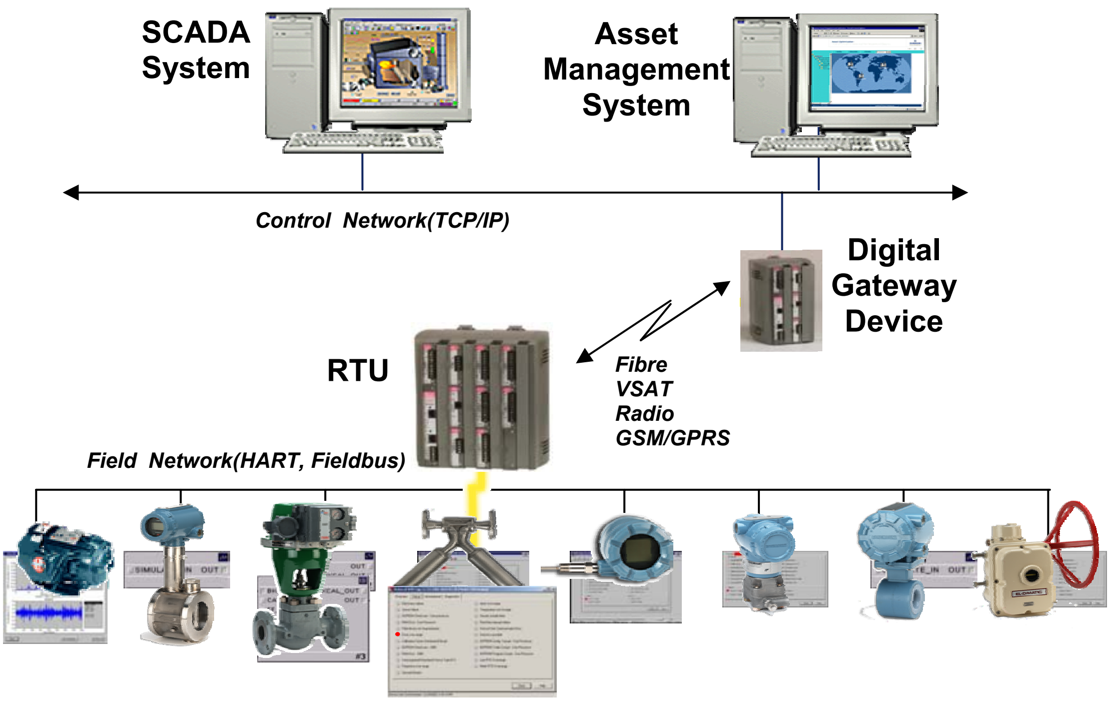
Bandwidth management with a Digital Gateway Device



6 Digital Plant Architecture for the Oil and Gas Field

Advances in networking and RTU technology now make it possible to pass *asset data* and *real-time data* within the same network simultaneously. This **Digital Field Architecture** would allow a maintenance crew to troubleshoot a problem remotely or **predict** a failure before it happens. This leads *to increases in production and availability*, and *decreases in maintenance and operations cost*.

Visibility of data at a site is further enhanced by knowing that the quality of the data is good. Coupled with predictive diagnostics available in most "digital" instrumentation, our wellhead is now ready for optimization.

6.1 Optimization

To further increase production, the Digital Field Architecture provides an opportunity for wellhead and field-wide optimization. Depending on your particular application, several processes can often benefit for the increased visibility the Digital Field Architecture can offer enabling process optimization. In natural gas production, these processes could include plunger lift, well cycling, and flow control. While in transmission, these could include pipeline modelling.
Field-wide optimization enables enhanced production through proper reservoir management.

Example:
In a gas lift application it is critical to manage your gas reservoir to ensure gas is available to feed the wells. If the gas supply you have is restricted it is important to ensure sufficient supply is available to the wells at all times to ensure production is not compromised. In the event of a gas supply disruption it is imperative that the highest producing wells be kept online whilst maybe choking back production on lower yield wells. In this scenario it is critical that the gas consumption data of the wells and well output data is available in order to make informed judgements as to where the remaining supplies should be directed. By maintaining real time visibility, it should be possible to avoid the unnecessary shutdown of wells. In addition the historical data provided by the electronic data gathering device in the field, RTU, could assist in developing optimized control algorithms to ensure lift gas is utilised as efficiently as possible.

Case Study

In their 56-well oil field, a Major Venezuelan producer operates one of the world's largest installations to separate oil from gas. A typical problem is a surge in liquid level from the wells, resulting in a gas pressure spike, which leads to the venting of gas. This has bad consequences both economically and environmentally. The producer selected a Digital Field Architecture to replace a traditional oil field automation system. This has led to good consequences and is making many jobs much easier.

One job that was made considerably easier and less expensive was installation. The producer selected the oldest of seven two-phase liquid-gas separator modules to upgrade from a Supervisory Control And Data Acquisition (SCADA) system to fieldbus. Installation was done using existing wiring. Complicating matters, the upgrade involved zones where processes could not be stopped. Based on prior experience with similar major instrument overhauls in the past that involved new technology, planners at the producer expected ***the installation to take five or six months***. That, however, wasn't the case. Everything was installed, calibrated and commissioned completely in ***fifteen days***. According to the producer, "Total installation labour for all these tasks was reduced by a factor of at least ten." These cost savings were attributed to ***plug-and-play intelligent field instruments*** that made installation much faster. Thus commissioning of the new system took place without tedious and drawn out point-to-point tests and loop-by-loop configuration and testing.

Beyond the initial savings, the producer also expects to reap other benefits from Latin America's first Digital Field installation. Their field covers 57 square kilometres and produces 15 percent of Venezuela's oil. For efficiency and to minimize impact on agricultural activities, the complex serves as a centralized processing point for the entire oil field. The daily processing capacity of the complex is **400,000 barrels** of 28 API oil mixed with **95,000 barrels** of water and **350 million standard cubic feet** of gas. During the separation process, sudden large slugs of liquid or gas cause surges in gas pressure. If these spikes are large enough, gas has to be vented and burned off through a flare system.

The natural variation from these spikes can be made even worse. When someone adjusts a controller incorrectly or walks away leaving it in manual operation, or if a valve became sluggish or stuck open or closed, the resulting upset can last a long time.

Using asset management software, when a valve or transmitter malfunctions, a maintenance crew can go directly to the problem source. Calibration of instruments can be done on an as needed basis, rather than according to an arbitrary schedule. “These and other uses of field intelligence should double the effectiveness of labour and field maintenance” says the producer.

Better process control also has reduced liquid level fluctuations. As a result, shutdowns of units or whole modules have decreased. There are other savings that should arise due to this improved better process control. Less gas is flared and more liquid is recovered, with savings in terms of recovered product and environmental compliance.

7 Conclusion

In summary, instrumentation technology in the process industry has lead to the development of a Digital Plant Architecture. This architecture has provided definite benefits in throughput, quality, and availability. And provided cost savings in operations, maintenance, safety compliance, and reduced waste.

When applied to the Oil and Gas industry, this Digital Plant Architecture has been challenged by the remoteness of sites, high implementation costs and limitations on power and communications.

Advances in technology have now provided the means for a new Digital Field Architecture, in which communications is minimised and managed, and *real-time* and *historical* data is merged with *asset* data, to provide the benefits of the process industry in the distributed operations of the Oil and Gas field.

Utilising this Digital Field Architecture provides high levels of visibility for managing and optimizing wellhead and pipeline facilities in real-time. Troubleshooting problems and predicting failures can now be carried out remotely without the need to travel to site. This would be almost impossible to achieve with a SCADA system, let alone in a open loop or paper charts environment.

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.