HOW CAN INDUSTRY TAKE ADVANTAGE OF FIELDBUS SYSTEMS IN PROCESS CONTROL, MAINTENANCE AND ASSET MANAGEMENT

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Abstract:

Traditional process control technologies cause a dilemma for designers and operators of modern processing facilities due to their limitation when it comes to planning, operation and service efficiencies. In particular the remoteness of Australia's resources centric industries requires effective ways to apply consistent process control technologies that are locally supported by skilled resources, knowledge development programs and product support infrastructures.

"In typical process industries, fieldbuses can contribute significantly to the achievement of operational excellence by enabling the sharing of critical information about the condition of devices. The problem-free and consistent availability of all necessary data is an important prerequisite for optimized processes (O'Brien, 2005)."

Technologies such as Profibus and Foundation Fieldbus offer comprehensive solutions including actual communication, application profiles, system integration and engineering.

In 2007 the ARC has identified plant asset management as an emerging area where the traditional definition of process automation does not apply. The plant assets in a typical control system include mechanical equipment, computers, networking, drives, motors, and process instrumentation. Through the use of Fieldbus technology, process control systems today have the capability to act as the centre point to gather, store, and manage health information about these plant assets. Asset management means the most beneficial operation of these assets from the time a piece of equipment is commissioned to when they are finally replaced or decommissioned.

With more around 40 million devices installed globally, Profibus is regarded as the most successful fieldbus system on the market (PI, 2011). This paper argues the customer benefits and solution competence of Profibus through an approach encompassing technological innovativeness, knowledge resource development, skills availability, open vendor strategy and a unique relationship *based "Profibus Community" approach.*

1. Benefits derived from Fieldbus Communication Technologies

A simple definition describes a fieldbus as an all-digital, serial two-way, multi-drop communication System. In process engineering, ideal process control should support monitoring and controlling of a process in the most cost-effective way given the requirements of the process and system. This requires extensive information about the process and the system. Today, this information is made available by intelligent field devices and communicated via fieldbuses replacing traditionally used 4-20mA analogue systems. The problem-free and consistent availability of all necessary data is an important prerequisite for optimized processes (Fieldbus Foundation, 2006).

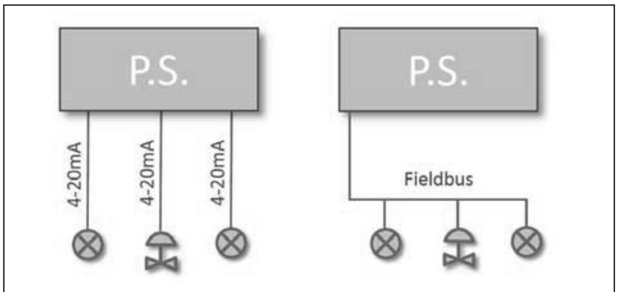

Figure 1: 4-20mA vs. Fieldbus

Major operations in the Australian Alumina industry have opted to install fieldbus devices in the expanded plant as opposed to the previously used 4-20 mA devices (Batista R, 2010) aiming at:

- Reduction in complexity of the control system in terms of hardware outlay, PLC and DCS hardware requirements and other hardware such as control cabinets.
- Elimination of large cabling runs
- Reduction in installation times and man power
- Efficient and easy commissioning of devices
- Superior diagnostic and fault finding procedures of fieldbus instruments

However, the potential benefits from the utilisation of fieldbus systems appear far more comprehensive than actually aimed for in many installations (O'Brien L, 2005). Fieldbus technology is gaining traction in the process industries not only due to perceived advantages such as low installation costs, but also through other benefits such as enabling sophisticated tools like predictive maintenance for intelligent asset management.

Fieldbus technology in Process Automation

Process automation is characterized by a number of specific features which determine the use of automation technology to a significant extent: the service life of systems is frequently more than 20 years; such systems often feature high risk potential and, therefore, demand that specific safety requirements are met; the use of proven-in-use devices and systems is preferred; old and new technologies must coexist in such a way that they are functionally compatible. This coexistence of old and new technologies is a particularly relevant requirement where communication between field devices, in-process components and control systems is concerned. The most frequently used standard for transferring measured values or manipulated variables is consistently the 4-20 mA signal (PNO, 2010).

Where newer systems or system expansions are being installed, the use of 4-20 mA technology has given way to fieldbuses such as PROFIBUS PA or FF (Foundation Fieldbus). In order for these technologies to run side-by-side in a single system, integrated communication concepts are required.

Fieldbus technology is able to generate significant cost reductions throughout the life cycle of a system: during planning, installation, operation and maintenance, as well as in the context of system expansions or upgrades. The provision of additional information such as diagnostics data or supplementary measured values increases system availability and productivity.

Project Cost Comparisons

A cost comparison between a conventional installation based on 4-20mA technology and a Profibus fieldbus installation at a chemical process plant reveals that despite the 15% higher cost for system devices, reduction in cabling and wiring costs as well as significantly shortened engineering times resulted in an overall saving of 31% (O'Brien L, 2005).

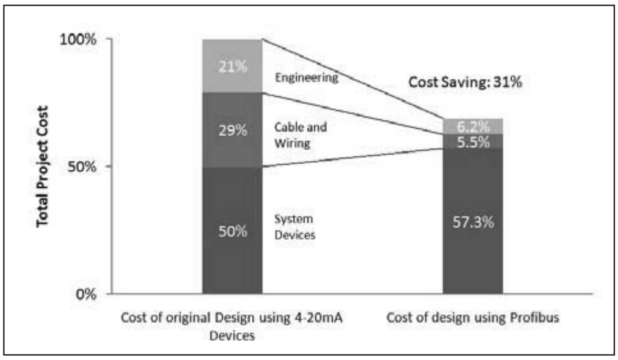

Figure 2: Cost Comparison between conventional installation and Profibus

The simple, transparent topology of PROFIBUS PA pays off as early as the planning phase. The scope of documentation can be reduced by up to 90% when compared with a 4-20 mA installation. During the commissioning phase, functional checks can be completed much more quickly, significantly reducing the total time line from planning to commissioning. Therefore, PROFIBUS is able to reduce the time to market. The flexibility of the PROFIBUS installation also makes the addition of devices, retrofitting or device replacement easier once operation is underway. Where add-ons or expansions affecting older systems are concerned, 4-20 mA devices can be integrated into PROFIBUS installations with ease (PNO, 2007).

Asset Management Features

PROFIBUS application profiles are specified for standard data exchange between field devices on the user level. The use of such profiles guarantees interoperability in the data exchange between field devices from different manufacturers. Field devices with different application profiles can be operated in the same automation system (PNO, 2010).

The Profibus PA profile describes how process devices communicate with the controller. The specifications of the profiles ensure the interoperability of devices from many manufacturers within a single system.

The PA profile defines the functions and parameters for process control devices, such as transmitters, actuators, valves and analysers (PNO, 2010). These functions and parameters are used to adapt the devices to the respective application and process conditions.

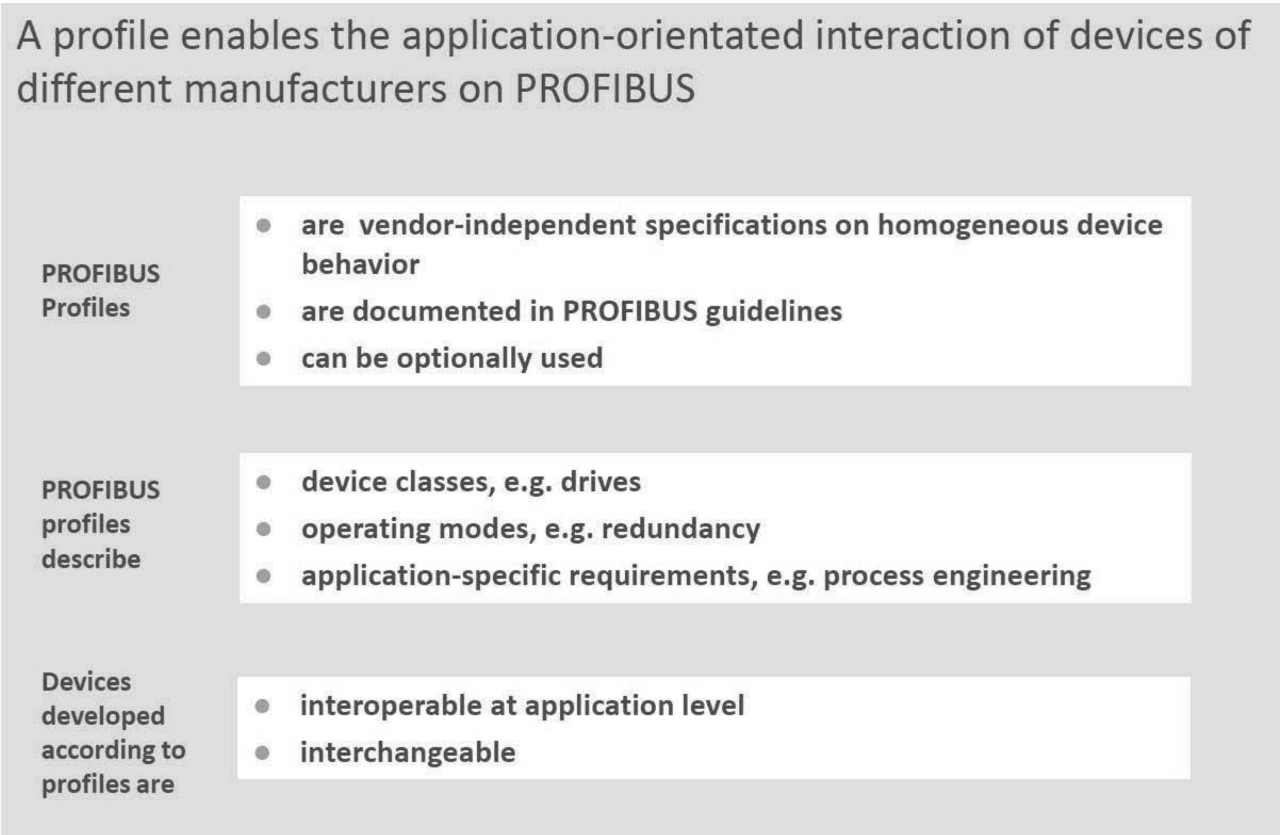

Figure 4: Profibus Device Profiles

The diagnostics concept defined in the PA profile paves the way for comprehensive asset management and for a shift from preventive or reactive maintenance to proactive maintenance or condition monitoring. PROFIBUS PA can, therefore, tap into enormous potential for cutting costs, since field devices susceptible to wear, e.g., actuators or ph value analysers, can be virtually fully utilized and necessary service operations can be scheduled in line with the production schedule and/or regular downtimes.

Industrial Ethernet – The end of the Fieldbus?

Industrial Ethernet technology has emerged as a technology that is being embraced by multiple organisations and vendors, including the Industrial Ethernet Association (IEA), Fieldbus Foundation, and Profinet and Profibus International (PI). Adoption of Industrial Ethernet by end users has also been significantly increasing over the last few years. However, put into context the total number of market leading Profinet installations is still below the number Profibus nodes added per year. This indicates the continuous relevance of conventional fieldbus technology for the foreseeable future (PI, 2011).

Plant operators in the process industry demand industrial communication that is uniform and consistent over the entire production chain, including for continuous and batch processes and in hazardous areas, has a high level of availability and reliability, is flexible when it comes to modifications and expansions, and is economical to use throughout all phases, from planning to operation (Wenzel, 2011).

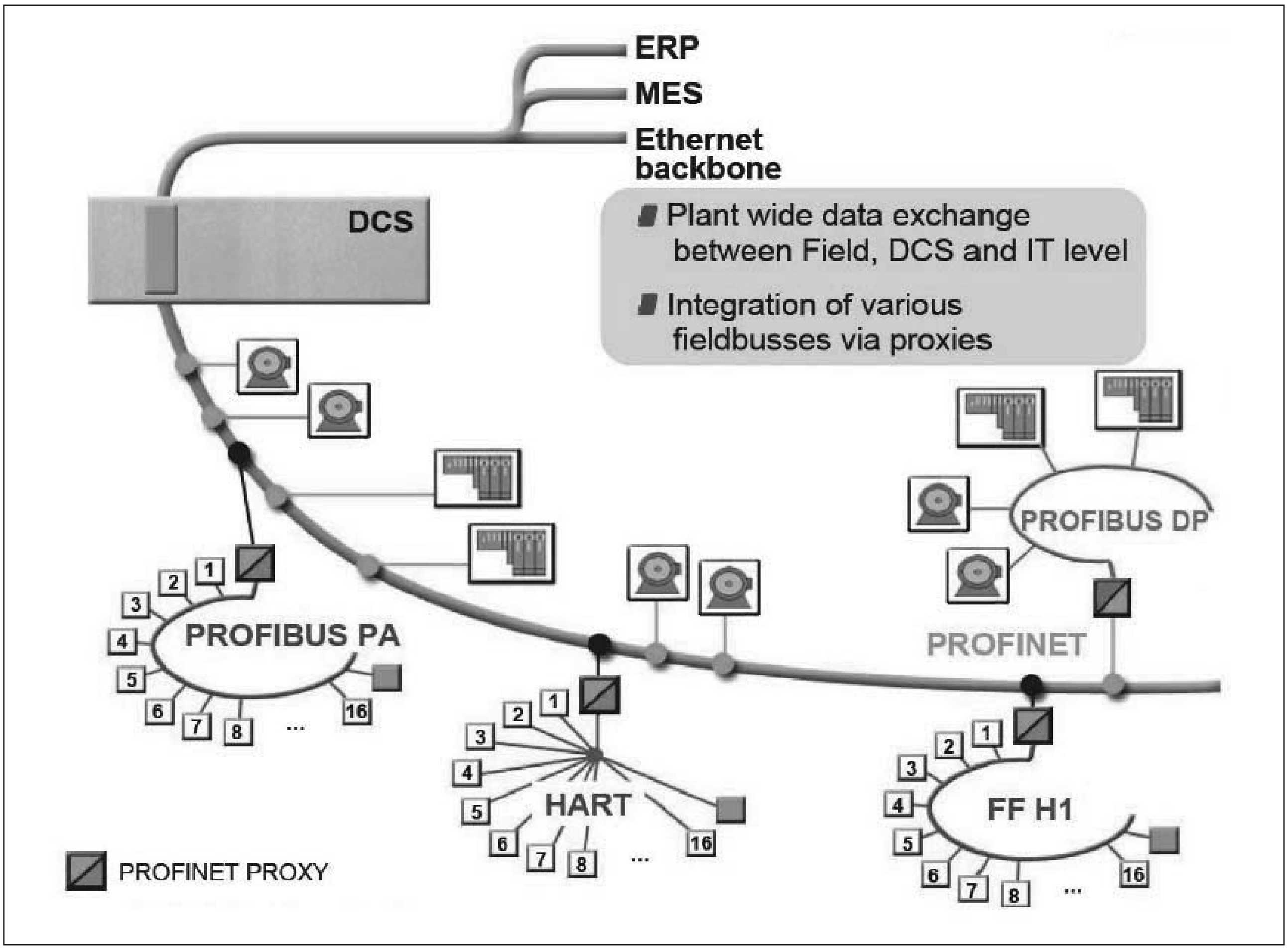

Figure 5: Profinet technology integration

The technologies of PI (PROFIBUS & PROFINET International) fully meet these requirements. The basis for this is the time-tested industrial communication system PROFIBUS. Specifics of the process industry sector are ideally covered by the proven PA Device application profile. For plants that use Ethernet, PI provides the PROFINET solution, which utilizes existing protocols from the IT world such as TCP/IP or DHCP and defines supplemental protocols in order to satisfy the more stringent requirements of industrial environments for availability, real-time capability, etc (Wenzel, 2011) .

Against this backdrop it is evident that PROFIBUS und PROFINET are not competing solutions, but rather complementary. PROFIBUS is used in continuous processes and is ideally suited for use in hazardous areas. PROFINET can also play out its strengths in batch processes and is of primary interest when requirements exist for integration all the way to the corporate management level and for remote maintenance and diagnostic capabilities, and the like, via the Internet.

2. Are Human factors holding back technological progress?

The preceding sections of this article illustrate some of the technological capabilities and asset management features of fieldbus systems and in particular Profibus. However there appears to be a distinct gap between the technological capabilities and the extent these are exploited in actual installations.

In their research paper "Exploring the Human Factors Challenges of Automated Mining Equipment"; Lynas and Horberry, (2010) raise several issues that are equally relevant for other industries. An automation skills shortage where insufficient workers with the required technical knowledge, skills and abilities to support current and future workforce requirements is foreseen as a significant obstacle to the uptake of automation technologies.

Autonomous or remote operation systems will form part of the most important and transformational technology in the future of mining on a world wide scale. However, whilst large scale and rapid uptake of automation has often been pursued, the human factors and skilling of staff to support this automation has not progressed at the same pace as the technology. New operational or maintenance skills are required to support these technologies (Lynas and Horberry, 2010).

An analysis of the most commonly experienced faults diagnosed in Profibus installations somewhat confirms the link to skills and engineering capabilities. Line termination (device connection) issues top the list of most common causes for introducing signal reflections in Profibus networks accounting for more than 90% of all faults. This is followed by bent, squashed or wrong cables, connector problems and poor segregation and routing of wires. Faults such as device failures and peripheral sensor or actuator failure are the exception (Verwer, 2011).

Above findings illustrate that the majority of issues linked to Fieldbus and in this case Profibus problems relate to a lack of qualified engineering and operator/maintainer resources.

Quite often fundamental errors in system design and layout only come to light during commissioning. In most cases it costs no more to design a good layout and avoid common pitfalls. However, the consequences of a bad design can be very costly indeed.

Overcoming the Human Factors for Fieldbus Automation Technology

Considering Lynas' and Horberry's findings and the experience of the Profibus community it appears that the best possible exploitation of fieldbus automation technology benefits not only depends on the features of the product solutions but on surrounding aspects related to the availability of enabling technology, capable supply chain partners, skills and knowledge transfer and management. Core points to be addressed are:

- Remote Monitoring Solutions
- Global and Local Technology Support
- Knowledge and Skills Development

Human Factors (Lynas and Horberry, 2010)

Maintenance

The main Human Factors in maintenance issues with automation were thought to be both the high level, diagnosis issues (where no operator is present to be able to explain the problems to the maintenance staff) and lower level sorting out/interfacing with somebody controlling remotely. Maybe the lack of skill issue is for both operators and maintenance workers on sites; experts could be elsewhere to do higher level cognitive/fault finding when things are wrong.

Lack of Equipment Standardization

Interviewees commented that it would be difficult to standardize equipment across mine sites and companies, but inconsistencies would arise if displays were not consistent across different pieces of equipment; errors were more likely to occur. Comment was made regarding design and iterative testing with the relevant operator/maintainer population.

Inadequate Operator and Maintainer Training and Support

The main issue emerging was the need to ensure ease of operation and maintenance of equipment, and that risks associated with interacting with the equipment were designed out as far as possible. Interviewees indicated that with new automated equipment; the associated technologies would require different operator skills and different ways of working compared to current and past practices. Training for new equipment would be challenging in that there was uncertainty around the type of equipment that would be used and, therefore, uncertainty around the knowledge and cognitive skills that would be required to undertake problem solving, such as, fault diagnosis or the correct response in an emergency situation. Interviewees expressed concern regarding the level of basic and additional skilling operators and, in particular, maintainers required when considering the uncertainty of the type of equipment of the future automated mine. An area of particular concern was the method of delivery of training ("on the job" or virtual reality simulation) and the ongoing maintenance of training levels.

Remote Diagnostics and Monitoring

In a recent interview with the Profibus Association of Australia, Andy Verwer, former Principal Lecturer at Manchester Metropolitan University in the UK for automation and control stated that the most obvious advantage of modern fieldbus enabled devices is that they usually have extensive inbuilt diagnostics to report errors in a manufacturer independent way. This provides very rapid diagnosis of problems and consequently rapid repair. PROFIBUS supports standardised diagnostics that can indicate communications and peripheral errors. They can provide helpful information on identifying and locating errors down to the device, module and channel level (Verwer A, 2011).

Remote diagnostics has two main objectives, firstly collecting operational data from the connected peripheral network devices to evaluate their operability and condition, secondly to monitor the quality and reliability of the fieldbus network communication itself. Any high speed digital communication system is subject to errors that are not obvious. Further, these errors often give confusing symptoms. For example incorrectly installed or configured devices can in many cases generate errors in other devices on the network, event though they are working fine. In fact it is quite common for faulty communications to be caused by simple installation errors at the other end of the cable (Verwer A, 2011).

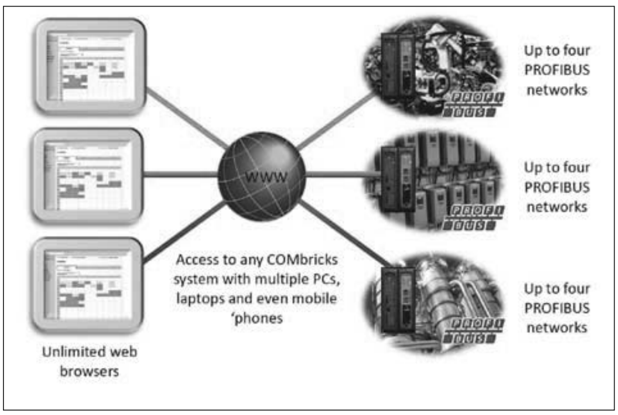

Figure 6: Profibus Remote Monitoring

A host of diagnostic tools to analyse and evaluate Profibus networks is available for the skilled professional. These tools have the ability to monitor and detect network problems long before they cause communication breakdowns and failures. However, up until recently these tools required the onsite presence of skilled experts which somewhat reduces the value proposition of fieldbus systems operating in remote locations in the first place.

Technical solutions that overcome the need for highly skilled onsite presence of Profibus experts are particular relevant for remote fieldbus installations. The requirements of the industry have resulted in the development and release of Profibus Network Management equipment that can be installed permanently and be accessed via an IP address over the Internet. The technology allows the permanent monitoring and health check of the Profibus Network. Operational status, live lists and statics can be accessed and used to trigger message alerts prompting the control centre to evaluate the need for preventative action long before actual breakdowns occur.

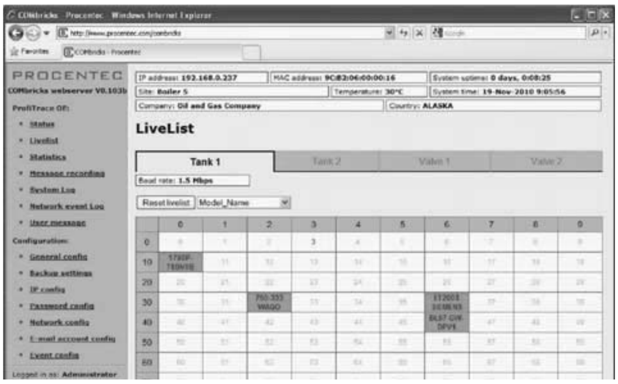

Figure 7: Web Browser Screen for Profibus Network Monitoring

Global and Local Technology Support

As a non-proprietary or open protocol technology Profibus combines in excess of 300 device manufacturers and a portfolio of more than 2500 certified Profibus compatible products. With around 36 Million installed devices worldwide by the end of 2010 the technology is seen as the clear market leader for Fieldbus systems (PI, 2011).

A vendor-neutral institution forms the working platform to maintain, advance and disseminate open Profibus technologies. For the PROFIBUS and PROFINET technologies, the PROFIBUS Nutzerorganisation e.V. (PNO) was established in 1989 as a non-profit group representing the interests of manufacturers, users and institutions. The PNO is a member of PI (PROFIBUS & PROFINET International), the international umbrella organization founded in 1995. With 25 regional PI associations (RPAs) and approximately 1,400 members, PI is represented on every continent and is the world's largest network for industrial communication (PNO, 2010).

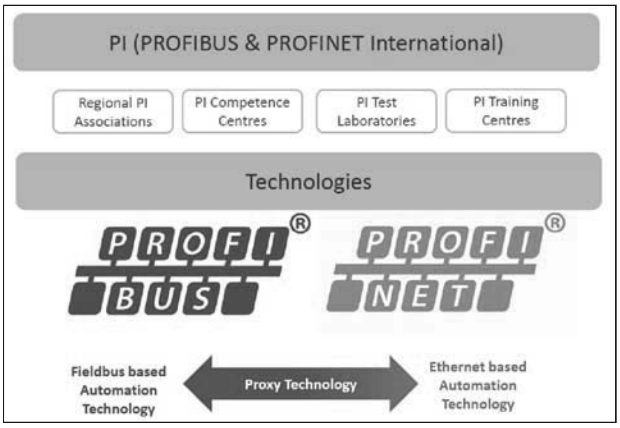

Figure 8: Profibus and Profinet International (PI)

Aim of PI's Australian set up is to create a technology community that combines capabilities from product vendors and manufacturers, specifiers and installers as well as end users.

The objective of the PAA is to function as an information and communication hub between users, vendors and installers. This allows the Australian Profibus community to tap into the body of knowledge created through the global PI Network.

The Profibus Competence Centre (PICC) provides vendor independent technical support. The centre can assist users with product compatibility issues, design support and onsite troubleshooting assistance.

The Australian competence centre is also accredited as a Profibus Training Centre (PITC). PI Training Centres have been set up to establish a uniform global training standard for engineers and technicians. Accreditation of the training centres and their experts ensures the quality of the training and thus of the engineering and installation services for PROFIBUS and PROFINET.

Figure 9: PI Structure in Australia

Standardised Training, a key to a qualified work force

Lynas and Horberry (2010) raise the point that one of the biggest obstacles to successful utilisation of automation is inadequate training for operators and maintainers of equipment. The role of Profinet and Profibus International training working groups is to define training outcomes or in other words what attendees are required to know to proficiently use the technology.

PROFIBUS International has been proactive in developing standardised training for PROFIBUS and PROFINET users. The Certified Installer courses provide a standardised basic level of understanding and competence in the basic problems that can occur. These courses have been put together by working groups from within the PROFIBUS International community and are based on many years of experience with real installations (Verwer A, 2011).

Commissioning and Maintenance training is also provided as a second level for those involved with commissioning and fault finding on systems. There are a wide range of excellent tools available, but some training in their use is always required. A common misconception is that control systems must be shut down for fault finding. In fact the opposite is true. The tools and techniques that are taught on these coursed are best applied when the system is fully operational and in production. The more devices that are switching on and off, the more likely it is that problems will be found. A systematic approach is essential for effective fault finding on fieldbus.

3. Conclusion

This paper shows that there is a clear connection between innovative technology, skills development and applied knowledge which are ultimately responsible for the successful adoption of fieldbus technology. The example of Profinet and Profibus illustrates some of the dilemmas the Australian process industries are facing. On a global scale, the knowledge and experiences that characterise the leading manufacturers of fieldbus equipment in their country of origin are not available to the same extent in Australia. Local issues such as the prevalent shortage of skilled engineering resources in process control and automation are problems that industry needs to overcome. Intelligent application of diagnostic and monitoring technology assists in the mitigation of risks; however a cure to the problem can only be achieved if skills development is addressed through a multi pronged approach. Profibus International and the Profibus Association of Australia regard human resources and technology related capability development as equally important to achieve optimum outcomes.

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