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Comparative Analysis of Industrial Control Communication Network Protocols

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***Abstract*— Industrial Communication Network Protocols are used to exchange the information between an industrial control system and field instruments. These Communication Network Protocols are different from domestic and commercial networks because they have different internal and operational requirements. Although the operation and functional characteristics of industrial and conventional networks are different, but there exist a strong relationship between them. There is a great similarity between the development of standards of industrial and conventional network protocols. The upper level hierarchy of both industrial and conventional network is same that's why the engineer involved to develop the best industrial network communication protocols by researching the conventional network and their architecture. This document emphasis characteristics differences between conventional and industrial network protocols like Profibus, Industrial Ethernet, Modbus RTU/ASCII CAN open, Device Net, Control Net, Foundation Field bus and ASI etc. The main goal of the paper is to give comparative analysis of architecture and development standards commonly used industrial communication network protocols.**

***Index Terms*— Communication Industrial Network, Communication Protocol, Industrial Automation, PROFIBUS DP/PA, Industrial Ethernet ControlNet, Device Net, PLC, DCS and Control System**

I. INTRODUCTION

IN the previous decades, the expanding force and cost-adequacy of electronic frameworks has impacted all regions of human attempt. This is additionally valid for modern control frameworks. At first, control of assembling and process plants was done mechanically - either physically or utilizing pressure driven controllers. As discrete hardware got to be distinctly well known, the mechanical control frameworks were supplanted by electronic control circles utilizing transducers, transfers and hard-wired control circuits. These frameworks were huge and space expending, regularly requiring numerous kilometers of wiring, both to the field and to interconnect the control hardware. With the development of coordinated hardware and microchips, the usefulness of various simple control circles could be imitated by a solitary advanced controller. Advanced controllers started to relentlessly supplant simple control, although correspondence to the field was still performed utilizing simple signs. The development toward advanced frameworks brought about the requirement for new correspondences conventions to the field and in addition between controllers. These correspondences conventions are generally alluded to as fieldbus conventions.

The rest of the paper is organized as follows: In Section II, we introduce an industrial network communication protocols basics, and formally define the problem. An overview of related work is presented in Section III. We describe our system modeling in Section IV and general architecture design & implementation in Section V. The results are described in Section VI and Section VII concludes the paper.

II. INDUSTRIAL NETWORK BASICS

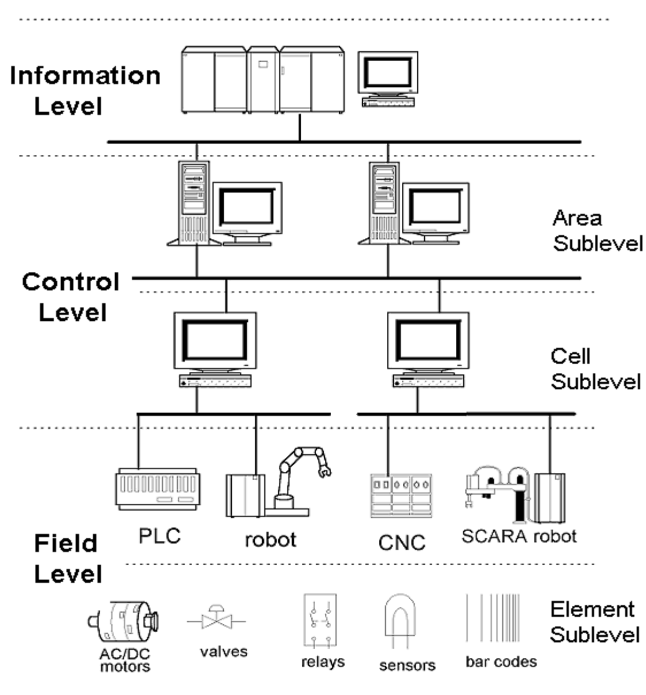

Fig. 1: Different hierarchical level decomposition of Industrial network communication

A) Different Level of Industrial Communication Network

Industrial communication network is divided into 3 levels, first information level it includes the Panels and Engineering Stations. Then 2nd control level which includes PLC, Robot, CNC, SCARA robot etc. and other control Elements. Third is the field level includes all field instrument like AC/DC motors, Valves, Relays, Bar codes etc. and all other field controlling sensors and instruments. A typical comparison of industrial and conventional networks is given blow in Table I.

B) Industrial Networks

Industrial network controlling elements: PLC, SCADA and DCS. Industrial control networks are including of special devices and operations, such as Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA) systems and Distributed Control Systems (DCS). It is the communication within and between these devices and systems application that industrial networks are primarily importance with.

C) Commercial Networks

Commercial networks are simple domestically used networks like Wi-Fi, Local Area network, Telephone network etc. The hierarchy of such network is that wide area network relates to sub network called site backbone which are connected to the local subnetworks.

Fig. 2 shows a network topology comparison between industrial and commercial networks.

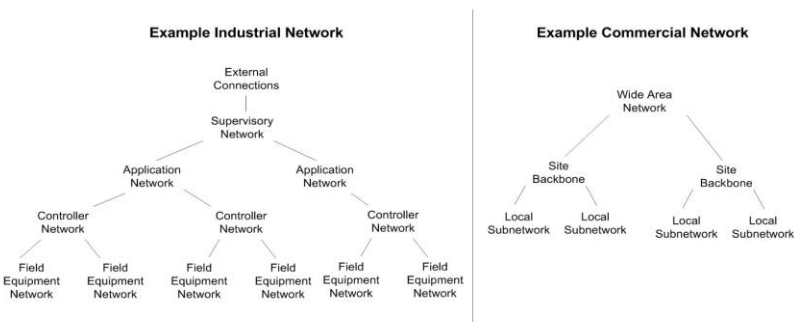

Fig. 2: Network Topology Comparison between Industrial and Commercial Networks

III. ORIGINS AND DEVELOPMENT

The center of industrial systems administration comprises of fieldbus proto-cols, which are characterized in the IEC standard 61158 as "a computerized, serial, multidrop, information transport for correspondence with modern control and instrumentation gadgets, for example, - yet not constrained to - transducers, actuators and nearby controllers". Although fieldbus was initially imagined to be a swap for the conventional two-wire flagging strategies, for example, 4-20 Mama and 0-10 V utilized at the most minimal level of a mechanical control framework, the innovation has extended and now displays usefulness that can be utilized at a wide range of levels of a control establishment.

As indicated by [12], industrial control systems can be brother ken up into three eras with differing levels of similarity. The main comprises of customary serial-based fieldbus conventions, the second of Ethernet-based conventions and the most recent era, which has started to consolidate remote correspondences advances. The joining of Ethernet innovation has brought about a developing closeness between the once unmistakable fieldbus and Web advancements. This has offered ascend to new terms, for example, industrial control organizing, which includes not just the capacities and necessities of traditional fieldbus, additionally the extra capacities and prerequisites that Ethernet-based frameworks introduce.

Many articles have been composed about the long and a few- what disputable improvement of fieldbus frameworks, frequently by individuals personally included in the advancement or institutionalization forms. These incorporate [3], [13], [7] and [12]. This segment will cover the primary focuses in the advancement of modern control systems, yet the peruse is urged to allude to the referred to writings for a more point by point history. Table II underneath shows finish points of interest of foundation data of all mechanical system conventions.

Table II: Mechanical system conventions

Network Specification	Technology Developer	Year Introduced	Governing Standards	Openness
PROFIBUS DP/PA	PNO/PTO	DP-1994, PA-1995	EN50170	ASICs from Siemens and Profichip, Products from over 300 vendors
INTERBUS- S	Phoenix Contact	1984	DIN 19258 EN 50.254	Products from over 400 manufacturers
Device Net	Rockwell Allen-Bradley	March 1994	ISO 11898 ISO 11519	17 chip vendors, 300+ products, Open specification
ARCNET	Data point/ SMC	1977	ANSI/ATA 878.1	Chips, boards, ANSI docs
Foundation Fieldbus H1	Fieldbus Foundation	1995	ISAS50 IEC TC65	Chips/software/products from multiple vendors
Foundation Fieldbus High Speed Ethernet (HSE)	Fieldbus Foundation	In development, Preliminary	IEEE 802.3u RFC for IP, TCP and UDP	Chips/software/products from multiple vendors that supply Ethernet products
IEC/ISA SP50 Fieldbus	ISA & Fieldbus Foundation	1992 - 1996	IEC 1158 ANSI 850	Multiple chip vendors
SDS	Honeywell	Jan., 1994	Honeywell IEC, ISO11989	Submitted to 17 chip vendors,200+ Products
ControlNet	Rockwell Allen-Bradley	1996	ControlNet International	Open Specification,2 chip vendors
CAN Open	CAN in Automation	1995	CiA	17 chip vendors, 300 products

				vendors, Open specification
Modbus Plus	AEG Modicon	1980's	None	Controlled by AEG Modicon many vendor support through mod connect program
Modbus RTU/ASCI I	AEG Modicon	1970's	EN 1434-3 (layer 7) IEC 870-5 (layer 2)	Open specification, uses UART (RS232,422/485), no special hardware required
Industrial Ethernet	Intel/DEC/Xe rox	Late 1970's	IEEE802. 2	The most open network worldwide thousands of vendors, hundreds of different chip suppliers.

IV. INDUST RIAL NE T WORK PROTOCOLS

A) Transmission Methods

Routine indicate point wiring utilizing discrete gadgets and simple instrumentation overwhelm today's PC based estimation and robotization frameworks. Curved combine wiring and 4-20 Mama simple instrumentation measures work with gadgets from most providers and give interoperability between other 4-20 Mama gadgets. Be that as it may, this is to a great degree restricted because it gives just a single bit of data from the assembling procedure. Verifiably, estimation systems and robotization frameworks have utilized a mix of restrictive and open computerized systems to give enhanced data accessibility and expanded throughput and execution. Incorporating gadgets from a few merchants is made troublesome by the requirement for custom programming and equipment interfaces. Restrictive systems offer constrained multi-merchant interoperability and openness between gadgets. With standard mechanical systems, then again, we choose which gadgets we need to utilize.

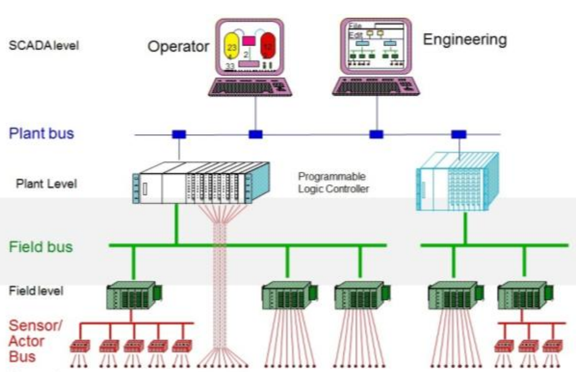

Fig. 3: Transmission Method

B) Industrial Network Components

In bigger mechanical and processing plant organizes, a solitary link is insufficient to interface all the system hubs together. We should characterize arrange topologies and configuration systems to give seclusion and meet execution prerequisites. Much of the time, since applications must impart crosswise over divergent systems, we require extra system hardware. The accompanying are different sorts of system parts and topologies:

- *Repeaters* - a repeater, or enhancer, is a gadget that upgrades electrical flags so they can travel more noteworthy separations between hubs. With this gadget, we can interface a bigger number of hubs to the system. What's more, we can adjust diverse physical media to each other, for example, coaxial link to an optical fiber.
- *Switch* - a switch switches the correspondence parcels between various system sections, characterizing the way.
- *Scaffold* - with an extension, the association between two diverse system segments can have distinctive electrical attributes and conventions. A scaffold can join two divergent systems and applications can circulate data crosswise over them.
- *Entryway* - a passage, like an extension, gives interoperability between transports of various sorts and conventions, and applications can impart through the door.

C) Network Topology

Industrial frameworks typically comprise of at least two components. As industrial frameworks get bigger, we should consider the topology of the system. The most widely recognized system topologies are the transport, star, or a cross breed arrange that consolidates both. Three chief topologies are utilized for modern correspondence systems: star, transport, and ring.

For most systems utilized for modern applications, we can utilize cross breed mixes of both the transport and star topologies to make bigger systems comprising of hundreds, even many gadgets. We can design numerous prominent modern systems, for example, Ethernet, Establishment Fieldbus, Gadget Net, Profibus, and CAN utilizing cross breed transport and star topologies relying upon application prerequisites. Half and half systems offer points of interest and detriments of both the transport and star topologies. We can arrange them so disappointment of one gadget does not put alternate gadgets out of administration. We can likewise add to the system without affecting different hubs in the system.

V. GENERAL ARCHITECTURE AND IMPLEMENTATION

Benefits of industry-standard networks: Present day control and business frameworks require open, advanced interchanges. Mechanical systems supplant routine indicate point RS-232, RS-485, and 4-20 Mama wiring between existing estimation gadgets and mechanization frameworks with an all-computerized, 2-way correspondence arrange. Modern systems administration innovation offers a few noteworthy changes over existing frameworks. With industry-standard systems, we can choose the correct instrument and framework for the employment paying little respect to the control framework maker. Different advantages include:

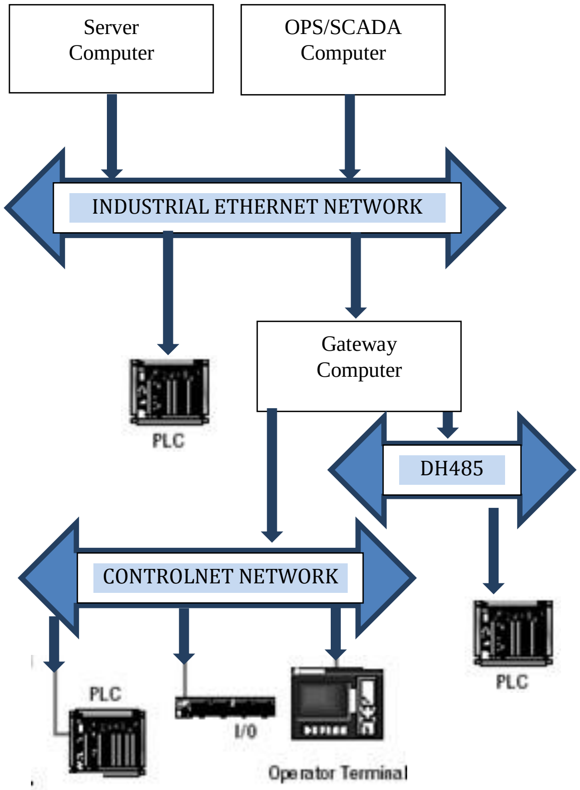

Fig. 4: General Architecture Design

- Lessened wiring - bringing about lower general establishment and upkeep costs
- Smart gadgets - prompting to higher execution and expanded usefulness, for example, propelled diagnostics
- Circulated control - with smart gadgets giving the adaptability to apply control either halfway or dispersed for enhanced execution and dependability
- Rearranged wiring of another establishment, bringing about less, less difficult drawings and general decreased control framework designing expenses
- Lower establishment costs for wiring, marshaling, and intersection boxes

Standard Industrial control systems offer the capacity to meet the growing needs of assembling operations of all sizes. As our estimation and robotization framework needs develop, mechanical systems give an industry-standard, open foundation to add new capacities to meet expanding assembling and creation needs. For generally low introductory ventures, we can introduce little PC based estimation and computerization frameworks that are perfect with huge scale and long haul plant control and business frameworks.

VI. RESULTS

The Table III, IV, V shows complete comparison of physical characteristics, transport mechanism, performance of different Industrial Control Communication Network Protocols.

Table III: Physical Characteristics

Network	Network Topology	Physical Media	Max.Devices(Nodes)	Max.Distance
PROFIBUS DP/PA	Line, star & ring	Twisted-pair or fiber	127 nodes (124 slaves, 4 segments, 3 repeaters) up to 3 masters	100m between segments @ 12Mbaud; 24 Km (fiber) baud rate and media dependent
INTERBUS- S	Segmented with "T" drops	Twisted-pair, fiber, and slip-ring	256 nodes	400 m/segment, 12.8 Km total
Device Net	Trunk line/dropline	Twisted-pair for	64 nodes	500m (baud rate dependent) 6Km
ARCNET	Star, Bus, distributed star	Twisted-pair, coax, fiber	255 nodes	Coax 2000 feet; Twisted pair 400 feet; Fiber 6000 Feet
Foundation Fieldbus H1	Star or bus	Twisted-pair,	240/segment, 65,000	1900m @ 31.25K
Foundation Fieldbus High Speed Ethernet (HSE)	Star	Twisted-pair, fiber	IP addressing - unlimited nodes	100m @ 100Mbaud 2000m @ 100Mbaud fiber full duplex
IEC/ISA SP50 Fieldbus	Star or bus	Twisted-pair fiber, and radio	IS 3-7 non-IS 128	1700m @ 31.25K 500M @ 5Mbps
SDS	Trunk line/Dropline	Twisted-pair for Signal Power	64 nodes 126 addresses	500m (baud rate dependent)
ControlNet	Linear, Tree, Star, Coax, fiber or Combination	Twisted Pair + optional signal & power	99 nodes	1000m (coax) 2 nodes 250m with 48 nodes 3km fiber, 30km fiber w/repeaters
CAN Open	Trunk line/Dropline	Twisted-pair for Signal Power	127 nodes	25-1000m (baud rate dependent)
Modbus Plus	linear	Twisted Pair	32, 64 max. per segment	500m per segment
Modbus RTU/ASCII	Line, star, tree, network w/segments	Twisted Pair	250 nodes per segment	350m
Industrial Ethernet	STAR, BUS	1OBASE-T, 10-Base-FL (FIBER) 100 Base TX	48-bit address	

Table IV: Transport Mechanism

Network	Communication Methods	Transmission Properties	Data Transfer Size	Arbitration Method	Error Checking	Diagnostics
PROFIBUS DP/PA	Master/slave peer to peer	DP: 9.6, 19.2, 93.75, 187.5, 500 Kbps	0-244 bytes	Token passing	HD4 CRC	Station, module & channel diagnostics
INTERBUS- S	Master/slave with total frame transfer	50 Kbps full duplex	1-64 bytes parameter, 512 bytes h.s., blocks unlimited blk	None	16-bit CRC	Segment location of CRC error and cable break
Device Net	Master/slave, multi-master, others	500 kbps, 250 kbps, 125 kbps	8-byte variable message	Carrier Sonac Multiple Access w/ non-destructive bitwise arbitration	CRC check	Bus monitoring
ARCNET	Peer to peer	19.53K to 10M	0-507 bytes	Token passing	16-bit CRC	Built in Acknowledgements at Data link layer
Foundation Fieldbus H1	Client/server publisher/ subscriber	31.25 kbps	128 octets	Scheduler, multiple backup	16-bit CRC	Remote diagnostics network monitors
Foundation Fieldbus High Speed Ethernet (HSE)	Client/server	100 Mbps	TCP/IP	CSMA/CD	CRC	
IEC/ISA SP50 Fieldbus	Client/server Publisher/ subscriber	31.25 kbps IS+1, 2.6, 5 Mbps	64 octets high & 256 low priority	Scheduler, tokens, or master	16-bit CRC	Configurable on network management
SDS	Master/slave, peer to peer, multi-cast, multi-master	1Mbps, 500 kbps, 250 kbps, 125 kbps	8-byte variable message	Carrier-Sonac Multiple Access	CRC check	Bus monitoring, Diagnostic slave
ControlNet	Producer/ Consumer Device object model	5 Mbps	0-510 Bytes Variable	CTDMA time Slice Multiple Access	Modified CCITT 16	Duplicate Node ID, Device, Slave Faults
CAN Open	Master/slave	10K, 20K 50K, 125K, 250K, 500K,	8-byte variable	Carrier-Sonac Multiple	CRC check	Error Control & Eng Massage
Modbus Plus	peer to peer, token passing	1 MBPS	256 bytes data + header	Token Passing	16-bit CRC	Local Chip and Software
Modbus RTU/ASCII		300 bps - 38.4K bps	0-254 bytes	Master/Slave		
Industrial Ethernet	Collision Detection	10MBPs, 100 MBPs	1500 Bytes Data.	CSMA/CD	32 bit CRC	CD, Network Management

Table V: Performance Comparison

Network	Cycle Time: 256 Discrete 16 nodes with 16 I/Os	Cycle Time: 128 Discrete 8 nodes with 8 I/Os	Block transfer of 128 bytes 1 node
PROFIBUS DP/PA	Configuration dependent typical <2ms	Configuration dependent typical <2ms	not available
INTERBUS-S	1.8 msec	7.4 msec	140 msec
Device Net	2.0 msec Master-slave polling	10 msec Master-slave polling	4.2 msec
ARCNET	Application layer dependent	Application layer dependent	Application layer dependent
Foundation Fieldbus H1	<100 ms @ 31.25k Not Applicable;	<600 ms @ 31.25k Not Applicable;	36 ms @ 31.25k
Foundation Fieldbus High Speed Ethernet (HSE)	Latency <5ms	Latency <5ms	< 1 ms
IEC/ISA SP50 Fieldbus	Configuration dependent	Configuration dependent	0.2 ms @ 5 Mbps 1.0 ms @ 1 Mbps
SDS	<1 ms, event driven	<1 ms per event	2 ms @ 1 Mbps
ControlNet	<0.5 ms	0.5 ms	0.5 ms
CAN Open	<1 ms	<1 ms	<1 ms
WorldFIP	2ms @ 1Mbps	5 ms @ 1 Mbps	5 ms @ 1 Mbps
LonWorks	20 ms	5 ms @ 1 Mbps	5 ms @ 1 Mbps
Industrial Ethernet	Not Applicable; Latency <5ms	Not Applicable; Latency <5ms	< 1 ms

VII. CONCLUSION AND FUTURE WORK

The field of modern systems administration is of indispensable significance to the proceeded with operation of all types of industry in which physical hardware must be controlled. Since the approach of the principal fieldbus conventions, modern systems have turned out to be generally executed and are being utilized to a more noteworthy degree to satisfy a wide assortment of control, security and plant observing prerequisites. Mechanical systems offer an extensive variety of advantages that can be acknowledged through their establishment - lessening of cost and appointing time using low level fieldbuses, less demanding support and setup using brilliant instruments that can perform application level correspondence, elevated amounts of correspondence between controllers using abnormal state fieldbuses, and a more prominent general joining both inside a control framework and with outside systems. How-ever, it likewise has its drawbacks - more noteworthy levels of many-sided quality increment the trouble of investigating; a more noteworthy level of comprehension is required to arrange and keep up control organizes; the substantial assortment of measures could settle on plan decisions more troublesome and lower the level of interoperability between gadget merchants, and the more prominent level of joining opens control systems to assault by malignant gatherings. The reception of the Ether-net physical standard and the continuous appropriation of remote physical benchmarks have brought about a more prominent level of interconnection amongst modern and business systems. The utilization of models, for example, TCP/IP, HTTP and XML has brought about a further obscuring of the lines amongst customary and modern systems administration. Be that as it may, the two ought not be confounded - notwithstanding their developing similarity they each satisfy on a very basic level varying necessities. Because of this there is a developing requirement for designers and specialists who comprehend not just the operation of the basic business innovation additionally the strict and needs of the mechanical environment and the operation of industry-particular conventions and principles. This is particularly valid because system security where mechanical systems are turning out to be progressively helpless against dangers local to their adjusted innovative base. Such concerns have generally been the domain of data innovation experts, yet learning of both business best-rehearse and modern necessities is expected to amplify security without bargaining on the developing usefulness prerequisites.

REFERENCES

[1] K. Stoufer, J. Falco, and K. Scarfone, “Guide to industrial control systems (ICS) security,” National Institute of Standards and Technology, Final Public Draft, Sep 2008.

[2] J.-D. Decotignie, “A perspective on Ethernet-TCP/IP as a fieldbus,” in IFAC international conference on fieldbus systems and their application, Nov 2001, pp. 138–143.

[3] J.-P. Thomesse, “Fieldbus technology in industrial automation,” Pro- ceedings of the IEEE, vol. 93, no. 6, pp. 1073–1101, June 2005.

[4] P. Neumann, “Communication in industrial automation - what is going on?” in Control Engineering Practice. Elsevier Ltd, 2006, vol. 15, pp. 1332–1347.

[5] M. S. Branicky, S. M. Phillips, and W. Zhang, “Stability of networked control systems: Explicit analysis of delay,” in Proceedings of the American Control Conference. AACC, Jun 2000, pp. 2352–2357.

[6] F. li Lian, J. Moyne, and D. Tilbury, “Network design considerations for distributed control systems,” IEEE Transactions on Control Systems Technology, vol. 10, no. 2, pp. 297–307, Mar 2002.

[7] J. R. Moyne and D. M. Tilbury, “The emergence of industrial control networks for manufacturing control, diagnostics, and safety data,” Pro- ceedings of the IEEE, vol. 95, no. 1, pp. 29–47, Jan 2007.

[8] K. T. Erickson, “Programmable logic controllers,” IEEE Potentials, pp. 14–17, Feb/Mar 1996.

[9] G. Frey and L. Litz, “Formal methods in PLC programming,” in IEEE International Conference on Systems, Man, and Cybernetics, vol. 4, 2000, pp. 2431–2436.

[10] A. Daneels and W. Salter, “What is SCADA?” in International Conference on Accelerator and Large Experimental Physics Control Systems, 1999, pp. 339–343.

[11] J. D. McDonald, “Developing and defining basic SCADA system concepts,” in Rural Electric Power Conference, 1993, pp. B31–B35.

[12] T. Sauter, “The three generations of field-level networks – evolution and compatibility issues,” IEEE Transactions on Industrial Electronics, vol. 57, no. 11, pp. 3585–3595, Nov 2010.

[13] M. Felser, “The fieldbus standard, history and structures,” October 2002, presented at Technology Leadership Day 2002, organised by MICROSWISS Network.

[14] R. Viégas, R. A. M. Valentim, D. G. Texira, and L. A. Guedes, “Analysis of protocols to ethernet automation networks,” in SICE-ICASE International joint Conference, 2006, pp. 4981 – 4985.

[15] R. A. Gupta and M.-Y. Chow, “Networked control system: Overview and research trends,” IEEE Transactions on Industrial Electronics, vol. 57, no. 7, pp. 2527–2535, Jul 2010.

[16] T. Novak and A. Gerstinger, “Safety- and security-critical services in building automation and control systems,” IEEE Transactions on Industrial Electronics, vol. 57, no. 11, pp. 3614–3621, Nov 2010.

[17] W. Granzer, F. Praus, and W. Kastner, “Security in building automation systems,” IEEE Transactions on Industrial Electronics, vol. 57, no. 11, pp. 3622–3630, Nov 2010.

[18] R. Lagner, “Cracking stuxnet - a 21st century cyberweapon,” http://www. ted.com/talks/ralph__langner__cracking__stuxnet a__21st__century__cyberweapon.html, Apr 2011.

[19] A. Matrosov, E. Rodionov, D. Harley, and J. Malcho, “Stuxnet under the microscope,” ESET, Tech. Rep., 2011, revision 1.31.

[20] A. A. Cárdenas, S. Amin, and S. Sastry, “Research challenges for the security of control systems,” in Proceedings of the 3rd conference on hot topics in security. Berkeley, CA, USA: USENIX Association, 2008, pp. 6:1–6:6.

[21] T. Zhong, M. Zhan, Z. Peng, and W. Hong, “Industrial wireless commu- nication protocol WIA-PA and its interoperation with foundation field- bus,” in Computer Design and Applications (ICCDA), 2010 International Conference on, vol. 4, June 2010, pp. 370–374.

[22] A. Kim, F. Hekland, S. Petersen, and P. Doyle, “When HART goes wireless: Understanding and implementing the wirelesshart standard,” in Emerging Technologies and Factory Automation, 2008. ETFA 2008. IEEE International Conference on, Sept 2008, pp. 899–907.

[23] PROFIBUS International, “PROFINET system description,” http://www. profibus.com/nc/downloads/downloads/profinet-technology-and-application-system-description/display/, 2009.

[24] J. Kjellsson, A. E. Vallestad, R. Steigmann, and D. Dzung, “Integration of a wireless I/O interface for PROFIBUS and PROFINET for factory automation,” IEEE Transactions on Industrial Electronics, vol. 56, no. 10, pp. 4279–4287, Oct 2009.

Table I: Comparison Overview of Industrial and Conventional Networks

Characteristics	Industrial	Conventional
Primary Function	Control of physical equipment	Data processing and transfer
Applicable Domain	Manufacturing, processing and utility distribution	Corporate and home environments
Hierarchy	Deep, functionally separated hierarchies with many protocols and physical standards	Shallow, integrated hierarchies with uniform protocol and physical standard utilization
Failure Severity	High	Low
Reliability Required	High	Moderate
Roundtrip Times	250 µs - 10 ms	50+ ms
Determinism	High	Low
Data Composition	Small packets of periodic and aperiodic traffic	Large, aperiodic packets
Temporal Consistency	Required	Not required
Operating Environment	Hostile conditions, often featuring high levels of dust, heat and vibration	Clean environments, often specifically intended for sensitive equipment