Setting the Standard for Automation™

Process Control and Automation Network Selection

Simplifying the path for you

By:
Romel Bhullar P.E.

Standards
Certification
Education & Training
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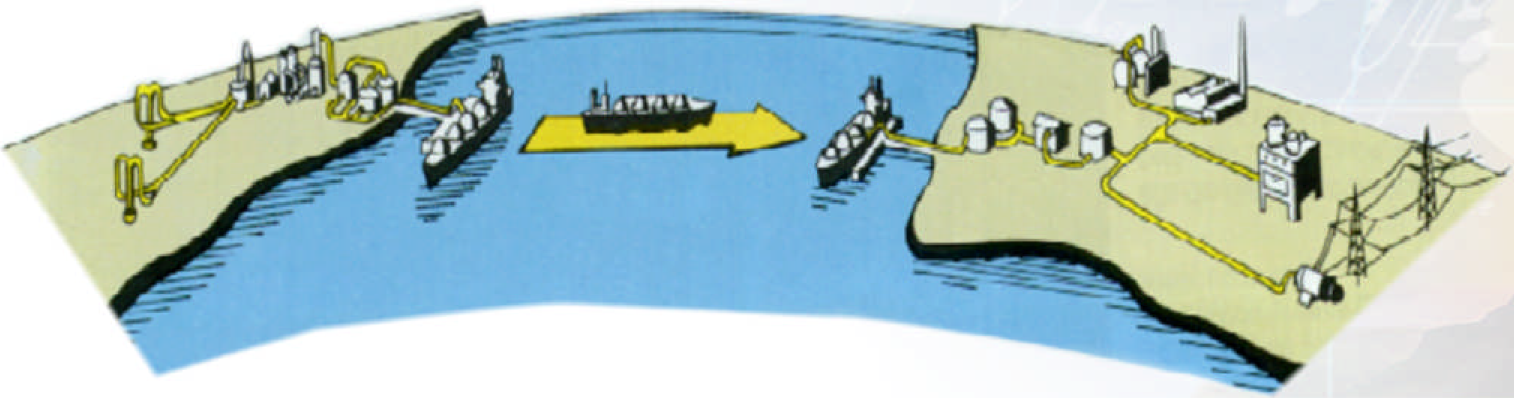
Gas Supply Chain



Modern LNG Plant Control Philosophy

- Totally Integrated Control System
- Comprised of “Stand Alone Sub-Systems”
- Best of the Breed Technologies
- Include Upstream and Downstream
- Suppliers and Customers
- Using Single Window of Operations

Ship Operation related Control System

- Ship Operations
- Berthing, Stabilization and Marine Monitoring
- Ship Board Systems

Single Control Room

- Single Window of Operation
- Manned by crew for Ship Control Functions
- LNG Processing and Handling Crew
- Functions/Duties may be shared
- No of Operators????
- As Needed Process Control Consoles

Integrated Controls In an Hierarchical Order

- Pyramid type Hierarchy Purdue Model
- Top layer for Management Information Systems and ERP
- Business Systems
- Basic Process and Safety Control Systems
- Field Devices
- Ancillary Systems
- Miscellaneous

LNG PROCESSING CONTROLS

- ONE MAIN CONTROL ROOM
- DCS AS HMI FOR THE ENTIRE SYSTEM AND SUBSYSTEMS
- SINGLE WINDOW OF OPERATIONS
- MAXIMUM USE OF AUTOMATION TECHNOLOGIES - No Local Panels/Control
- MINIMUM OPERATOR INVOLVEMENT AND OPERATION BY DEFAULT

MAIN CONTROL ROOM CONSOLE

- DCS AS HMI
- SINGLE INTEGRATED CONSOLE including CCTV
- ERGONOMICALLY DESIGNED TO ISO STANDARDS

HMI Main Control Console

MAJOR SYSTEMS AND SUBSYSTEMS

- DCS
- EMERGENCY SAFETY SHUTDOWN
- FIRE AND GAS DETECTION
- MACHINERY MONITORING
- INTELLIGENT MOTOR CONTROLS
- COMPRESSOR CONTROLS
- CUSTODY METERING
- LOADING ARMS

MAJOR CONTROL SUBSYSTEMS

- IMPORT LOADING ARMS
- SAAB CUSTODY SYSTEM (Tank Inventory)
- EXPORT CUSTODY METERING
- POWER GENERATION
- LOAD MANAGEMENT Using VSDs
- PIPE LINE LEAK DETECTION
- PIPE LINE SCADA
- CONTD.

SUBSYSTEMS

- CLOSED CIRCUIT TELEVISION
- COMMUNICATION SUBSTEMS
- ODS e.g OSI “PI”
- AMS OR ASSET MANAGEMENT SYSTEM

SAFEGUARDING SYSTEMS

- ESD TO BE DESIGNED TO ISA 84 OR IEC 65011 LATEST STANDARDS
- TUV Germany CERTIFIED
- SIL AND HAZOP TO BE IMPLEMENTED IN THE ESD SYSTEMS
- DOCUMENTATION
- MANAGEMENT OF CHANGE based on Life Cycle
- BYPASSES AND PERMISSIVES

FIRE AND GAS DETECTION

- LATEST STANDARDS
- NFPA INCLUDING STANDARDS IN REVISION
- Any Special Marine LNG carrier requirements??

ENTERPRISE BASED SYSTEMS

- INFORMATION (IT) FUNCTIONS
- BUSINESS FUNCTIONS
- MAINTENANCE AND SUPPORT SYSTEMS
- Who needs Information and where ON – Shore/Off shore, via Web….etc,

FIELD DEVICES

- FIELD DEVICES (SENSORS AND ACTUATORS)
- USE DIGITALLY SMART DEVICES
- NO FIELD BUS
- USE HART 6.0 OR BETTER
- USE WIRELESS HART
- USE WIRELESS FOR MONITORING WHERE PRACTICAL TO MINIMIZE WIRING

SYSTEM INTEGARTION

- USE OPEN INDUSTRY STANDARD PROTOCOLS AND COMMUNICATION MEDIA
- USE OPC., ETHERNET WITH TCP/IP
- Common systems and devices with ship side where possible

HMI AND CONSOLES

- DCS CONSOLE SINGLE WINDOW TO OPERATIONS AND SAFETY MANAGEMENT
- CCTV
- ENGINEERING WORKSTATIONS FOR SUBSYSTEMS

Helpful Strategies on Large Automation Projects

1. Needs Analysis
2. Develop Automation Philosophy and roadmap
3. Define Scope
4. Define Systems and Subsystems
5. Define Field Devices

Helpful Strategies on Large Automation Projects (Continued)

6. Define Interfaces
7. Define Automation Infrastructure
8. Execution Strategies
9. Monitoring and Control
10. Implementation, Testing and Commissioning

Automation System Integration Essentials

- Complete understanding of business
- Operational excellences
- Organizational structure
- Organizational boundaries & responsibilities

Automation System Integration Essentials (Continued)

- Information needs of stakeholders
- Interview sessions
- Key dialogues: CEO to operator
- Translate above to Automation Plan and Control Philosophy, and road map
- Evaluate automation assets and enable organization to stay competitive

System Integration

- Start with lowest level field devices and final control elements
- Integrate into higher level system
- Integrate into overall (Enterprise Resource Planning) ERP and Automation system
- Infrastructure: Security, throughputs, technologies, sharing of resources
- Execution strategy: Inside or Outside

System Integration Scope: Hardware, Software, Engineering

- Fiber optic Infrastructure
- Coax cabling
- Intrinsic safety or Explosion Proofing
- Auxiliaries such as: UPS or back-up power
- Special Requirements: telemetry, radio, wireless etc.

LNG Safety Automation (Continued)

- Use smart sensors to allow for proactive maintenance
- Use digital data and calibration, report generation, and logs
- Use Open or Proprietary protocols such as Foundation FieldBus (FF) , Profibus analog hardwiring

LNG Safety Automation (Continued)

- Take into account: Reliability, redundancy, back up systems
- Automatic validation, partial stroke testing, logging results
- System must be digitally integrated

Availability at what cost?

AT WHAT COST 9s?

AVAILABILITY	DOWNTIME PER YEAR	DOWNTIME PER MONTH	DOWNTIME PER WEEK
98%	7.30 days	14.4 hours	3.36 hours
99%	3.65 days	7.20 hours	1.68 hours
99.5%	1.83 days	3.60 hours	50.4 minutes
99.9%	8.76 hours	43.2 minutes	10.1 minutes
99.99%	52.6 minutes	4.32 minutes	1.01 minutes
99.999%	5.26 minutes	25.9 seconds	6.05 seconds
99.9999%	31.5 seconds	2.59 seconds	0.605 seconds

Source: Wikipedia

The technology used for disaster recovery and business continuity plans differs dramatically depending on the percentage of uptime that must be guaranteed. A two-9s guarantee (99 percent uptime), for example, would allow for a few days of downtime per year. Although this would be acceptable for low-priority corporate applications, few transaction-heavy applications can withstand this much downtime. To guarantee 99 percent uptime, an IT manager could get by using simple tape backup without having the added expense of warm standby servers. For three-9s systems, off-site redundant servers will be required; these servers should run data mirroring software to ensure that, in the event of a disaster, the backup servers will be able to restore services. Moving up to the five-9s range and beyond, distributed processing with load balancing becomes almost mandatory to meet uptime requirements. In this case, it would be common to see high-speed network connections running through powerful routers from companies such as Juniper Networks. Before deciding on a disaster recovery and business continuity plan, make sure you know how much uptime your business really needs because adding 9s can be an expensive proposition. —*Henry Balthazar*

Criteria for Sensors and Field Device Integration

- Who is interested in the sensor data?
- How will you get it to the users?
- Make a choice of bus technologies: HART, Foundation FieldBus (FF) Profibus, ModBus, DeviceNet
- Wireless
- EDDL and Ethernet

Communication Infrastructure: Define the bandwidth needs

- Media interfaces
- Cabling infrastructure
- Wireless
- Security
- Redundancy
- Availability

Define Subsystems

- Mechanical Package Interfaces : Loading Arms, Centrifugal Compressors, Marine Monitoring Systems

Advanced Process Control

- Opportunities to Optimize and enhance operations with xx$ barrel of oil
- Examples: Compressor stability, Plant Overhead pressure control, Minimize venting, Recondenser level and stability, Inventory monitoring, Resource allocation, Energy management and efficiency

Maintenance

- Proactive maintenance practice is necessary for survival; It not only minimizes downtime but assists with flexibility of operations when required

Control Room Design & Control Room Location

- No reason to locate within or close to process or hazardous area
- No need to be in resistant zone
- Provide safety, comfort and ergonomics and other Human Factors for peak operator performance during normal operation or emergencies

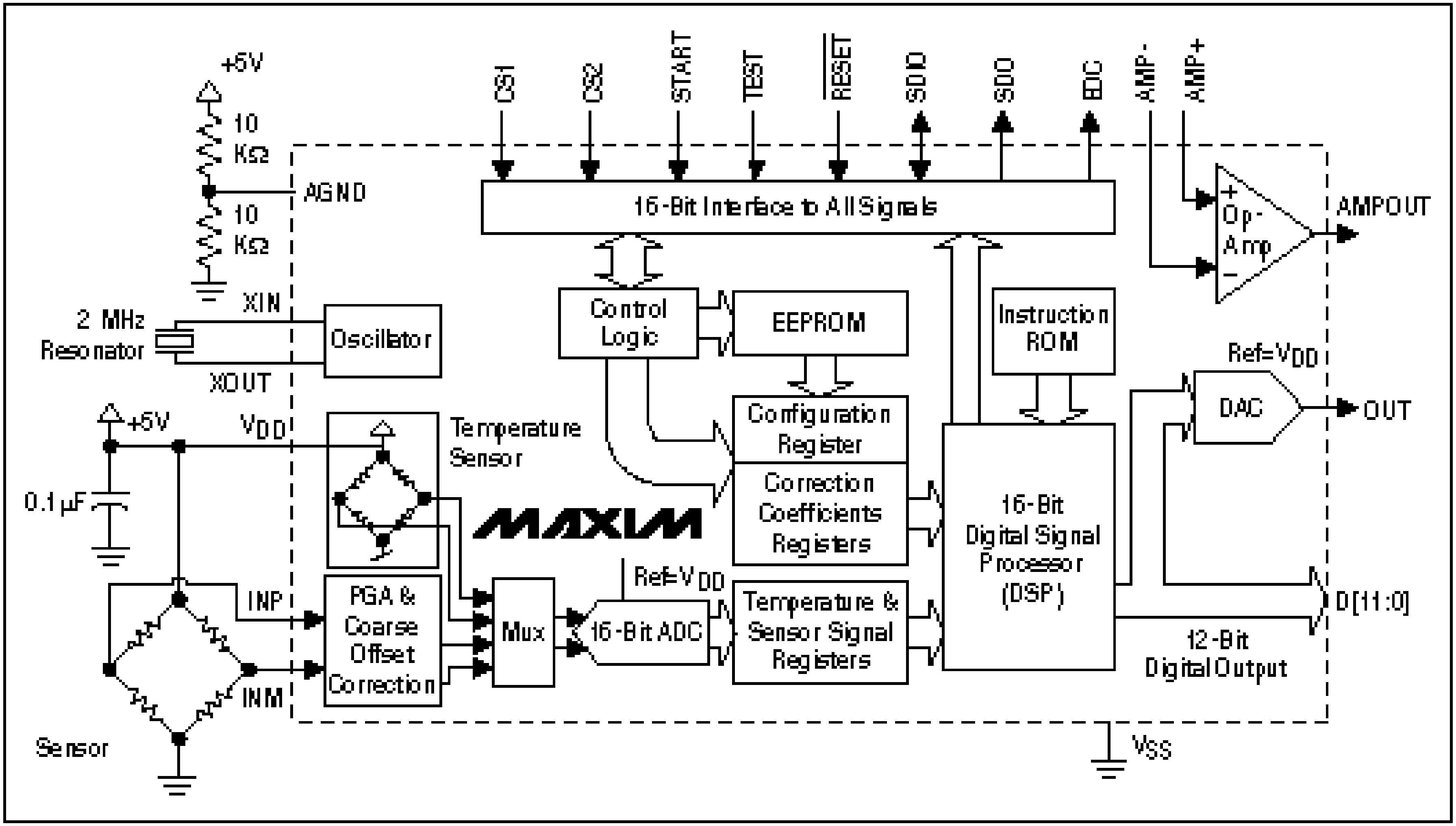
From Sensors to Systems What Information Is available

- Measured Parameters – Traditional role
- Current Role is as follows:
- Sensor Health Information
- Sensor Operating System and Architecture –by vendor
- Vendors proprietary Information - shhhh
- Vendor’s Technology Excellence

Sensors

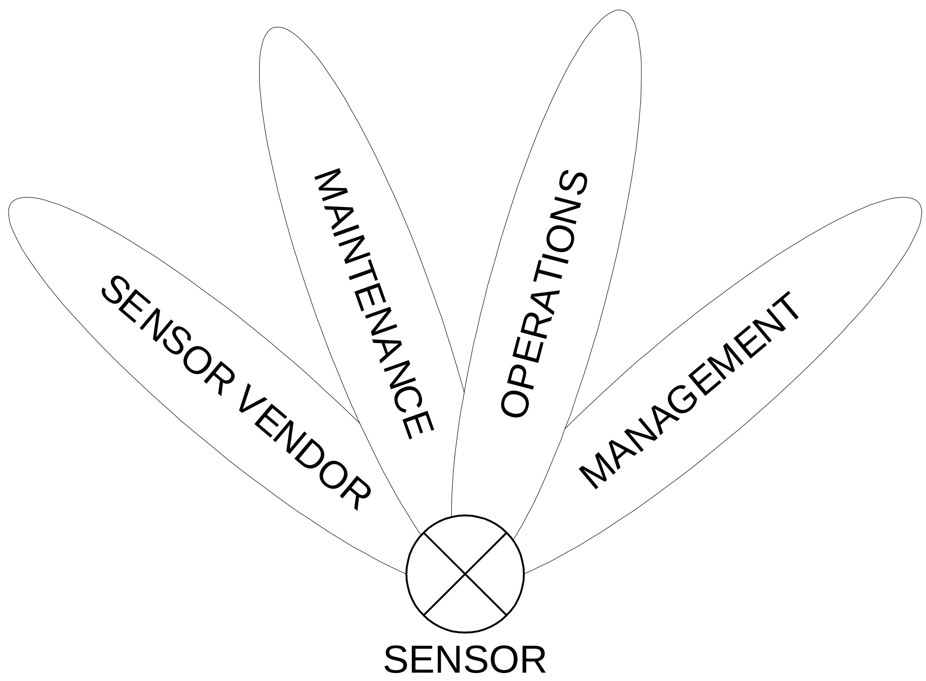
- Provide Information as follows
- Primary variables – what is being sensed
- The collected information is packaged to be sent to who needs it
- Remember modern digital smart sensors are microprocessor based and have many folders of information for different needs.
- Reality is "*ANALOG*", the world is not digital.

Sensor Schematic



Who is Interested in Sensor Data

- Process Data for Digital Controls
- Data acquisition, OSI PI etc.
- Corporation Business needs –ERP, supply chain, Customer
- Maintenance
- Vendors
- Regulatory authorities



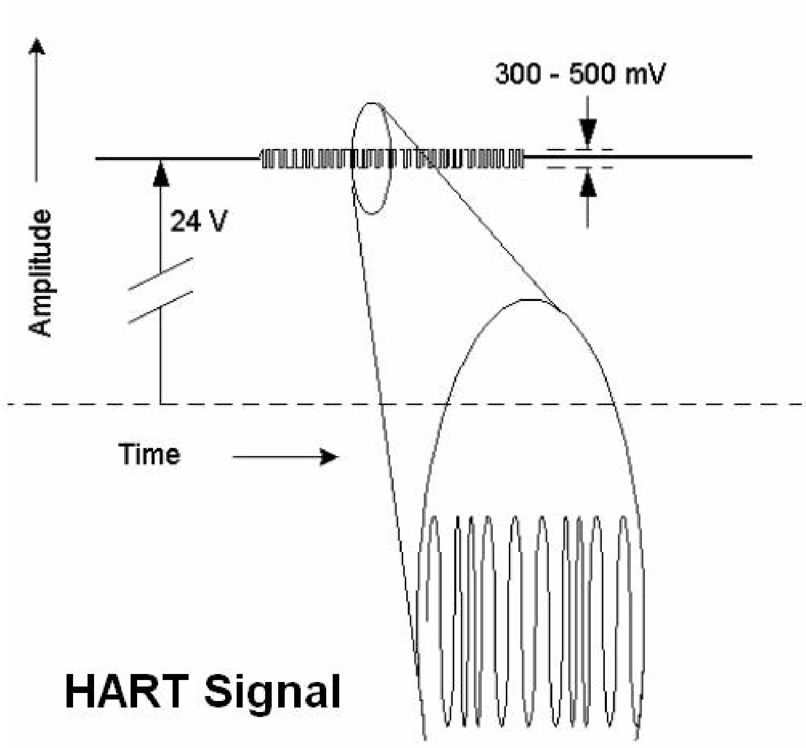
What are we really doing

- Taking one packet of information from one place to other
- Sensor to DCS/PLC or digital processors
- Process data/logic/algorithm/control action
- DCS to actuator
- DCS to DCS – implementation in other control strategy
- DCS to or from other third party subsystems or remote computers

Choice of field Device Integration

- Traditional 4-20 mA, analog
- Advent of digital technology
- We are going to discuss Inputs sensors and
- Final control elements – Valves, actuators
- *Primary Measurements like temp. flow, pressure, level are still analog in reality.*

HART SIGNAL



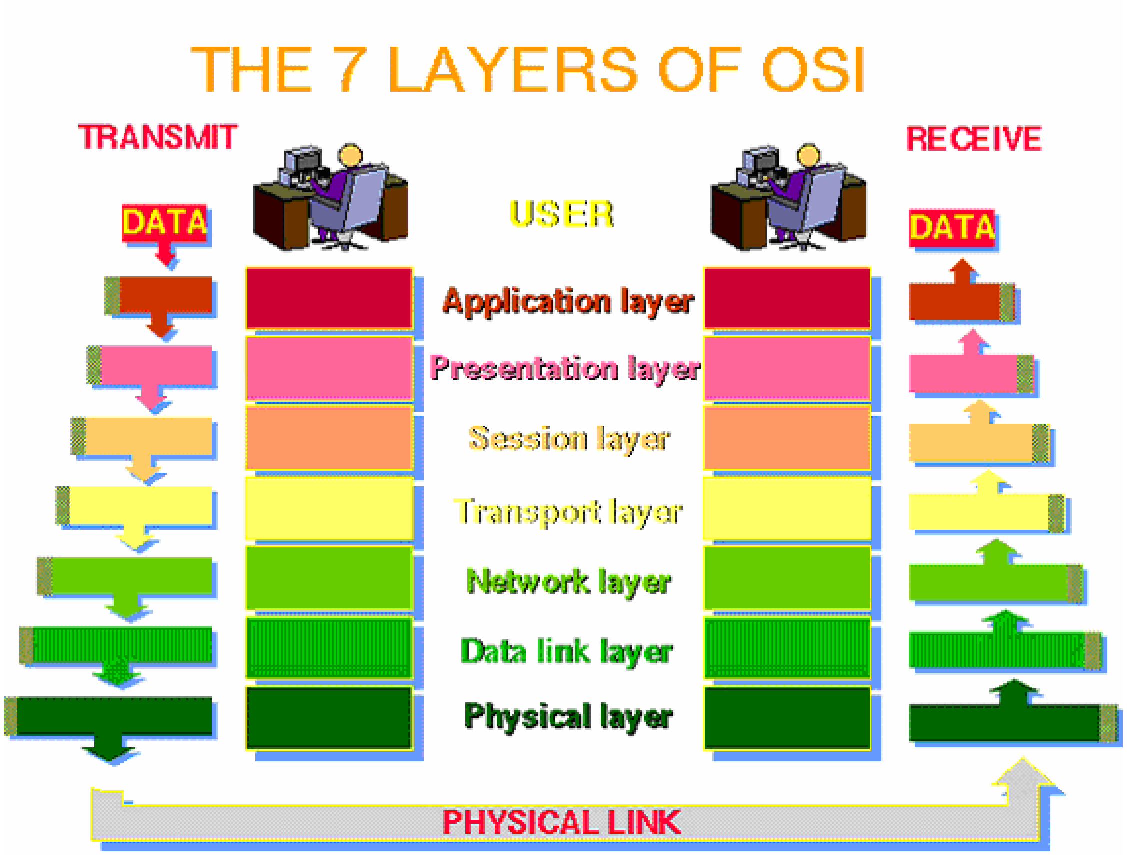
HART Signal

Media Choice

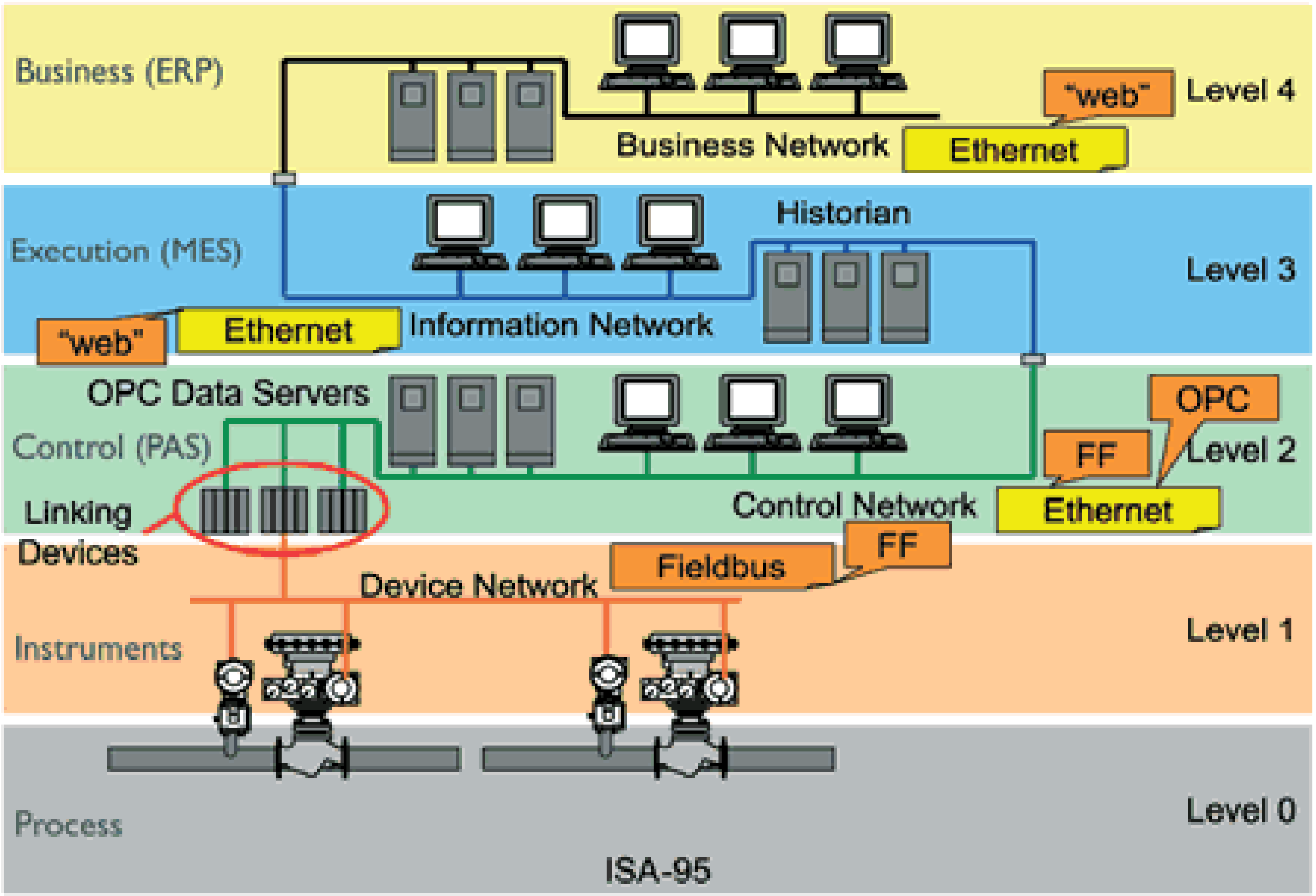
- Serial communication
- Twisted Pair
- Coax Cable
- Fiber Optics
- Wireless
- Infrared or Radio

What are we discussing here

- We are talking at the bottom layer of the OSI model
- Bus choices
- HART
- Profibus
- Fieldbus
- Devicenet
- Proprietary
- Ethernet

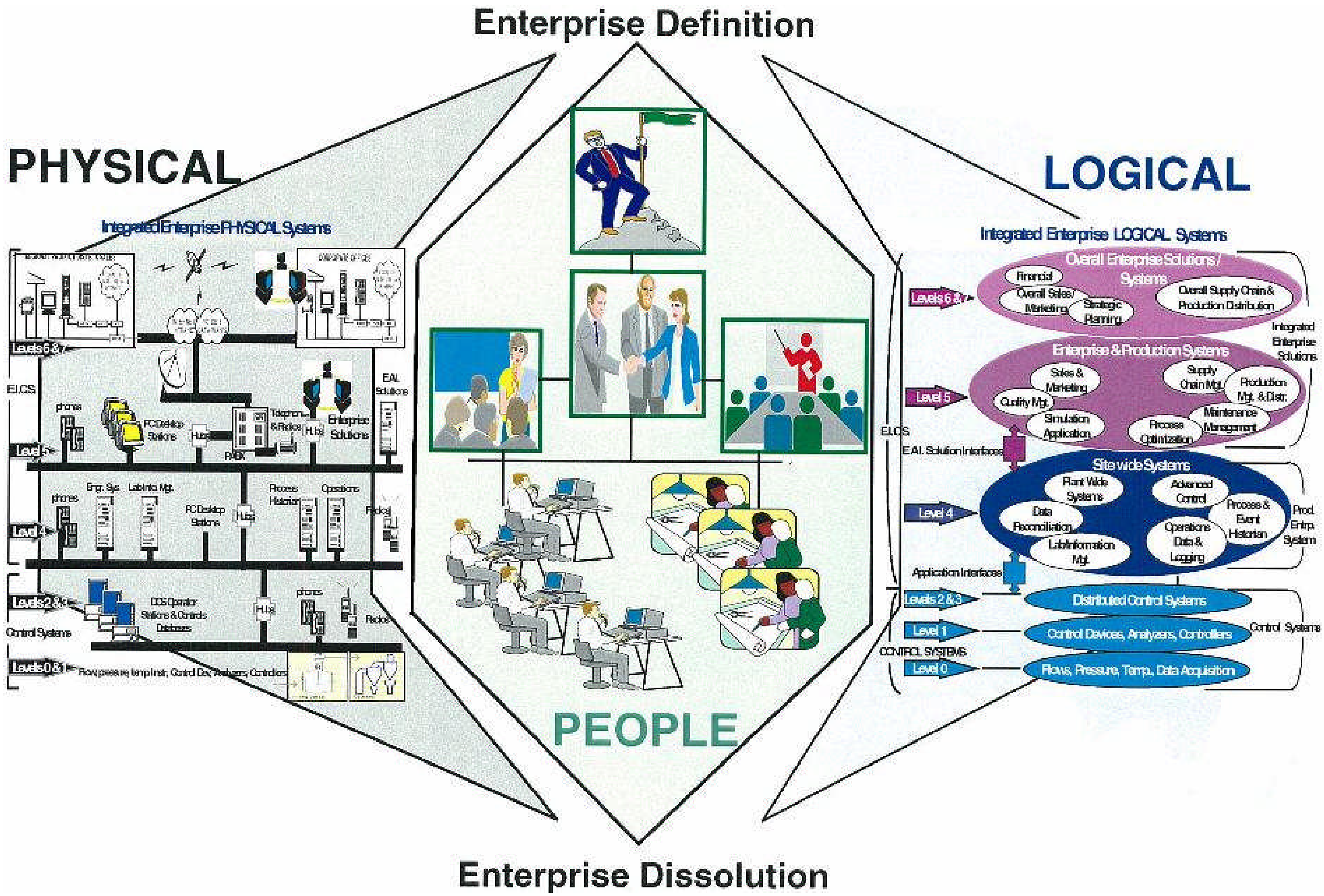


OSI Model



Business (ERP)
Business Network
"web"
Ethernet
Level 4
Execution (MES)
Historian
Information Network
"web"
Ethernet
Level 3
OPC Data Servers
Control (PAS)
Linking Devices
Control Network
OPC
FF
Ethernet
Level 2
Device Network
Fieldbus
FF
Instruments
Level 1
Process
Level 0
ISA-95

ENTERPRISE INTEGRATION



Ethernet

- Brief Overview
- Open
- Low cost
- Gigabytes bandwidth
- Not limited like others in throughput

INDUSTRIAL ETHERNET

- IEEE 802.3
- CSMA/CD
- NON DETERMINISTIC
- COMMUNICATION MODEL OSI LAYERS
- LAYERS/STACKS

Bus Topology

From Computer Desktop Encyclopedia
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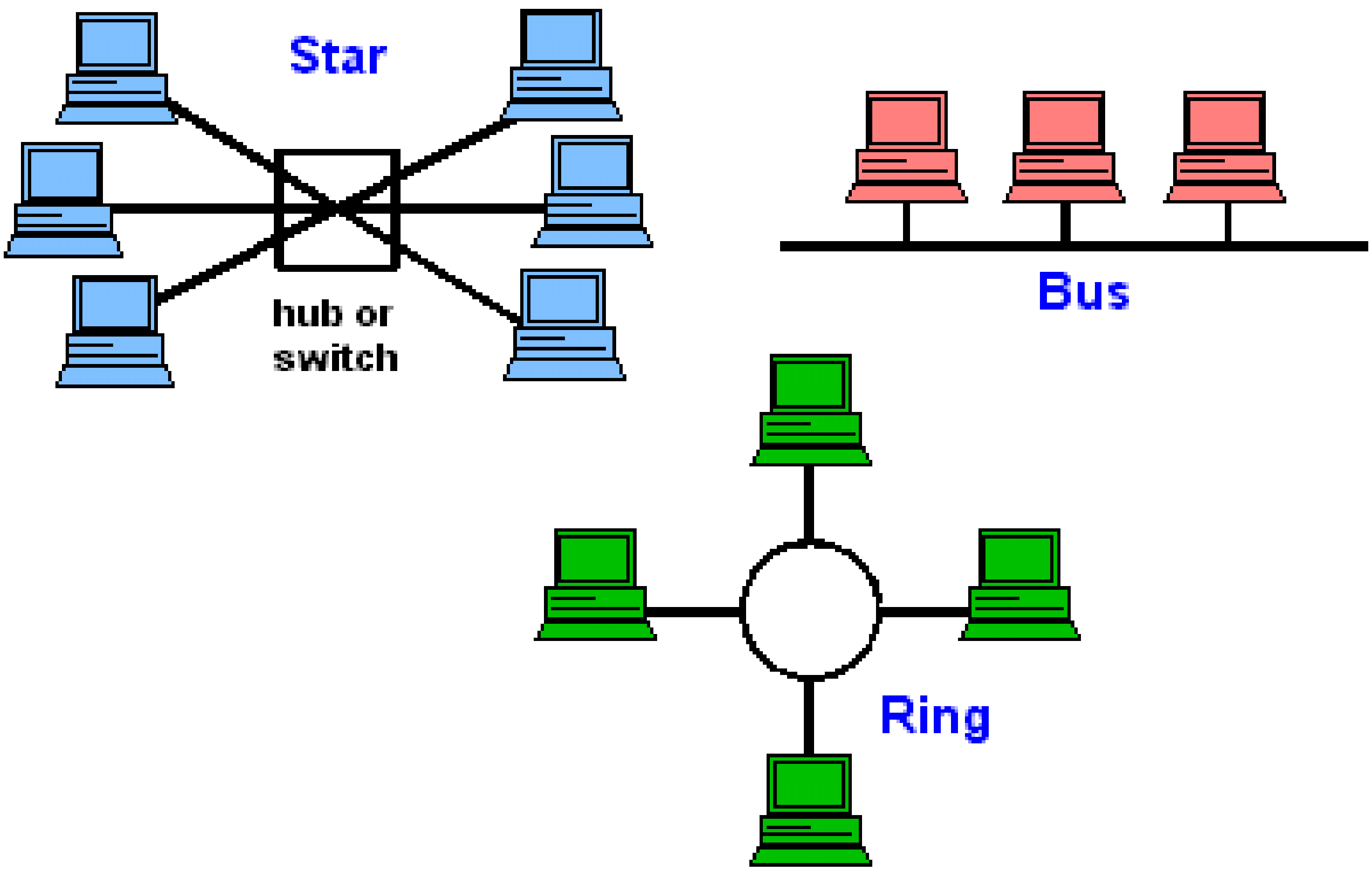

NETWORK DEVICES

- INDUSTRIAL CATEGORY
- ROUTERS
- MANAGED AND UNMANAGED SWITCHES
- MANAGED SWITCHS PROVIDE
- BETTER PERFORMANCE DUE TO MONITORING, REDUNDANCY, SECURITY, BETTER CONTROL AND PROACTIVE MAINTENANCE.

MANAGED SWITCHES

STACKABLE MANAGED SWITCHES

CABLING INFRASTRUCTURE

- COPPER
- FIBER
- CONNECTORS
- POWER - FIELD BUS/ETHERNET
- INTRINSIC SAFETY/CLASSIFIED

REMOTE I/O

- Can be located within processing area or adjacent to it.
- May require special handling depending on environmental requirements (hazardous area).
- Can be used in place of field junction boxes.
- Reduces “Home-run” wiring costs.

FOUNDATION FIELDBUS

- Open, non-priority, star topology.
- Distance limitations seldom a limiting factor.
- Communications at 31 kBPS.
- Typically no more than 15 devices per segment.
- Number of control valves per segment limited by application.

Setting the Standard for Automation™

Intergraph Houston I&E LTUF

February 15, 2005

Foundation™ Fieldbus Forward

By David Hobart

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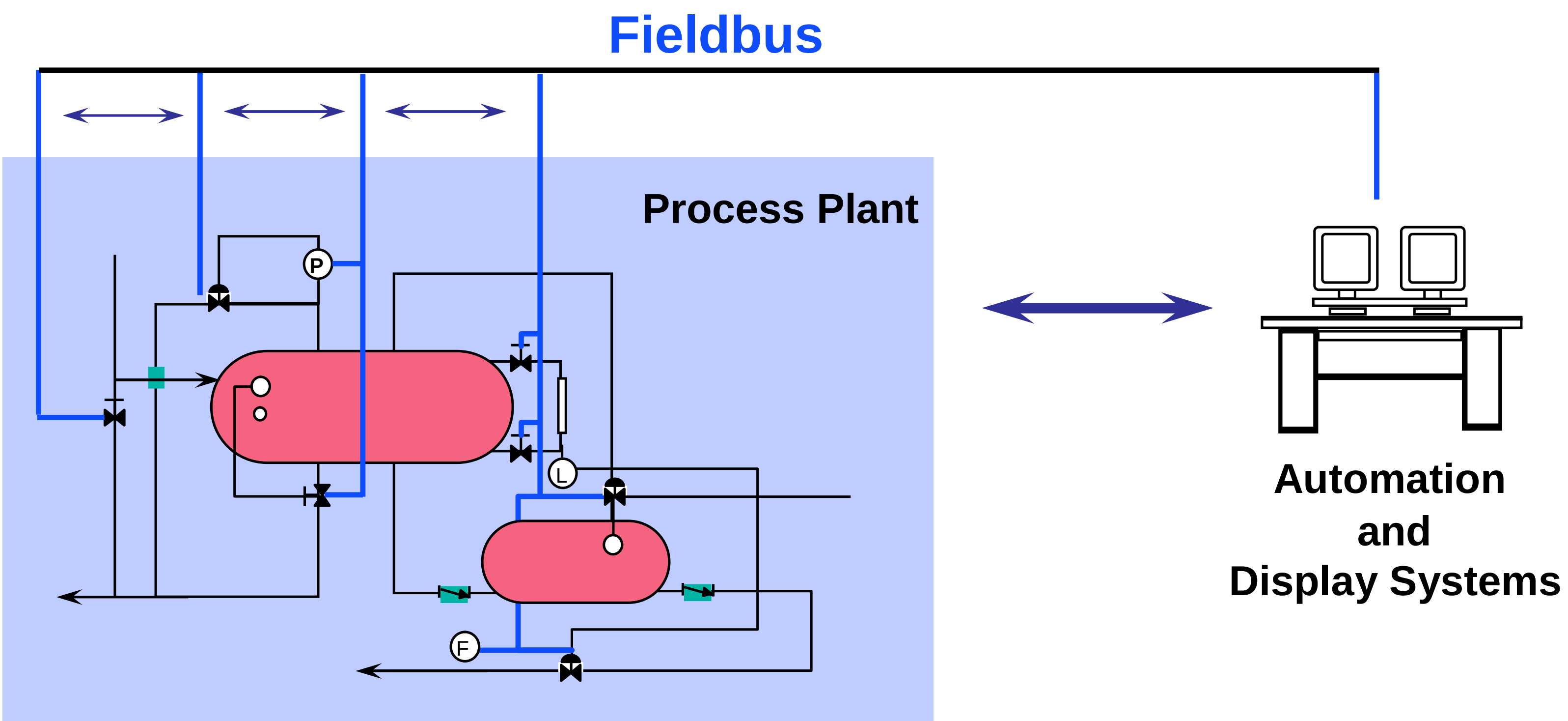
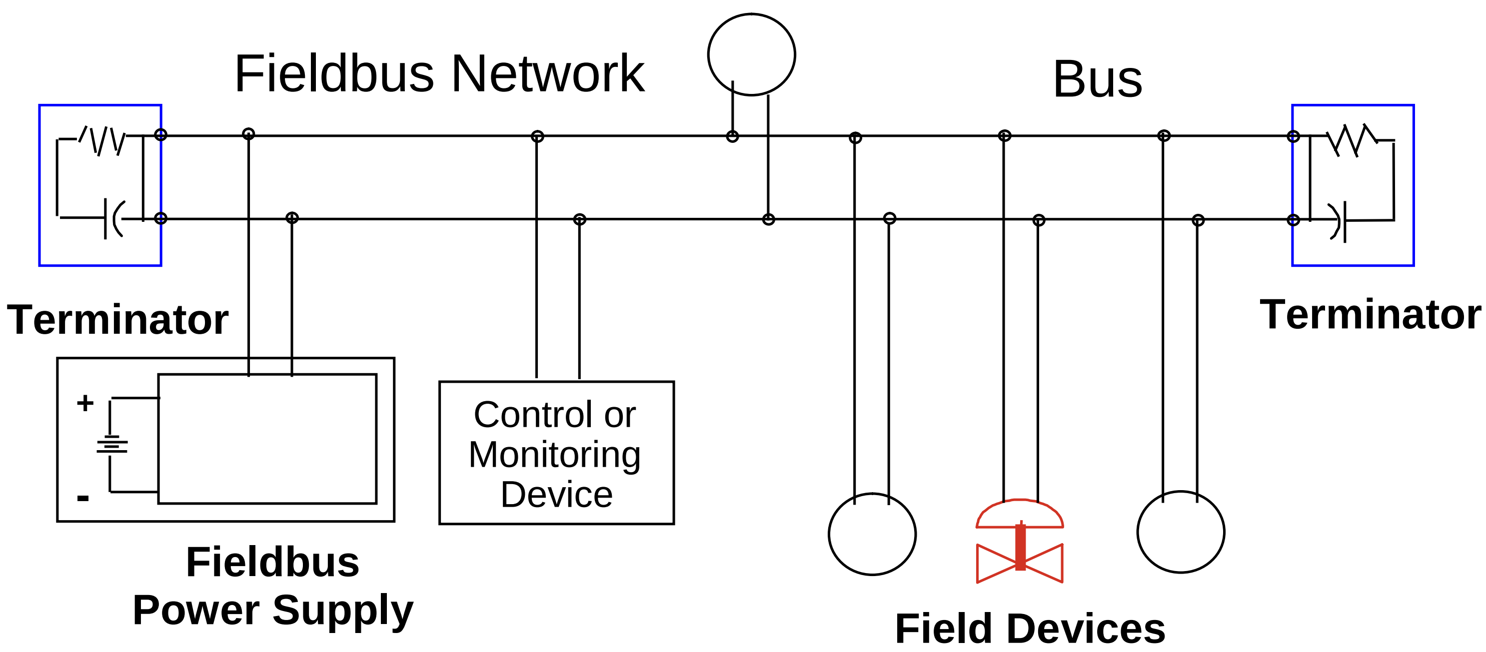
What is a Fieldbus?

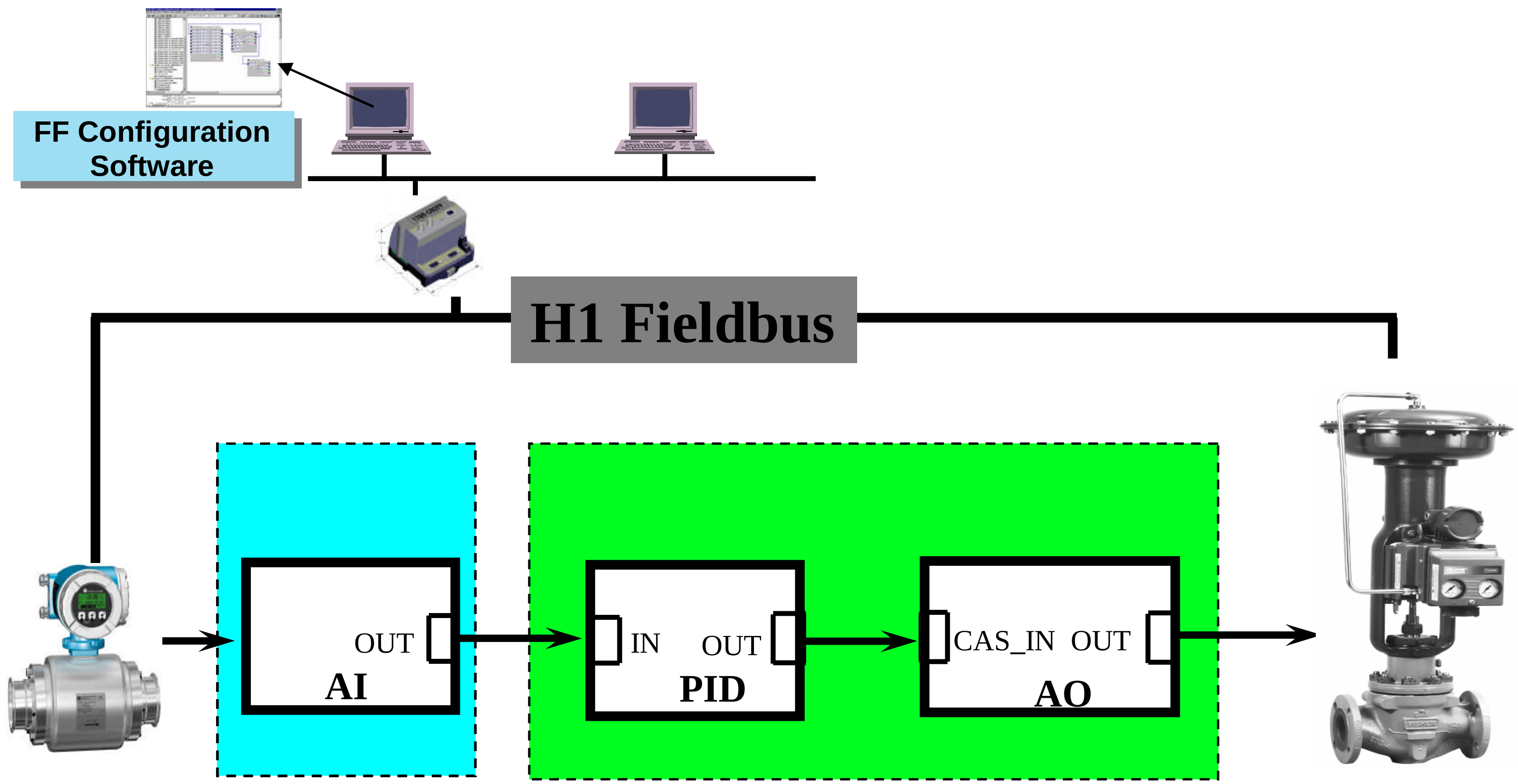


What is a Foundation fieldbus?

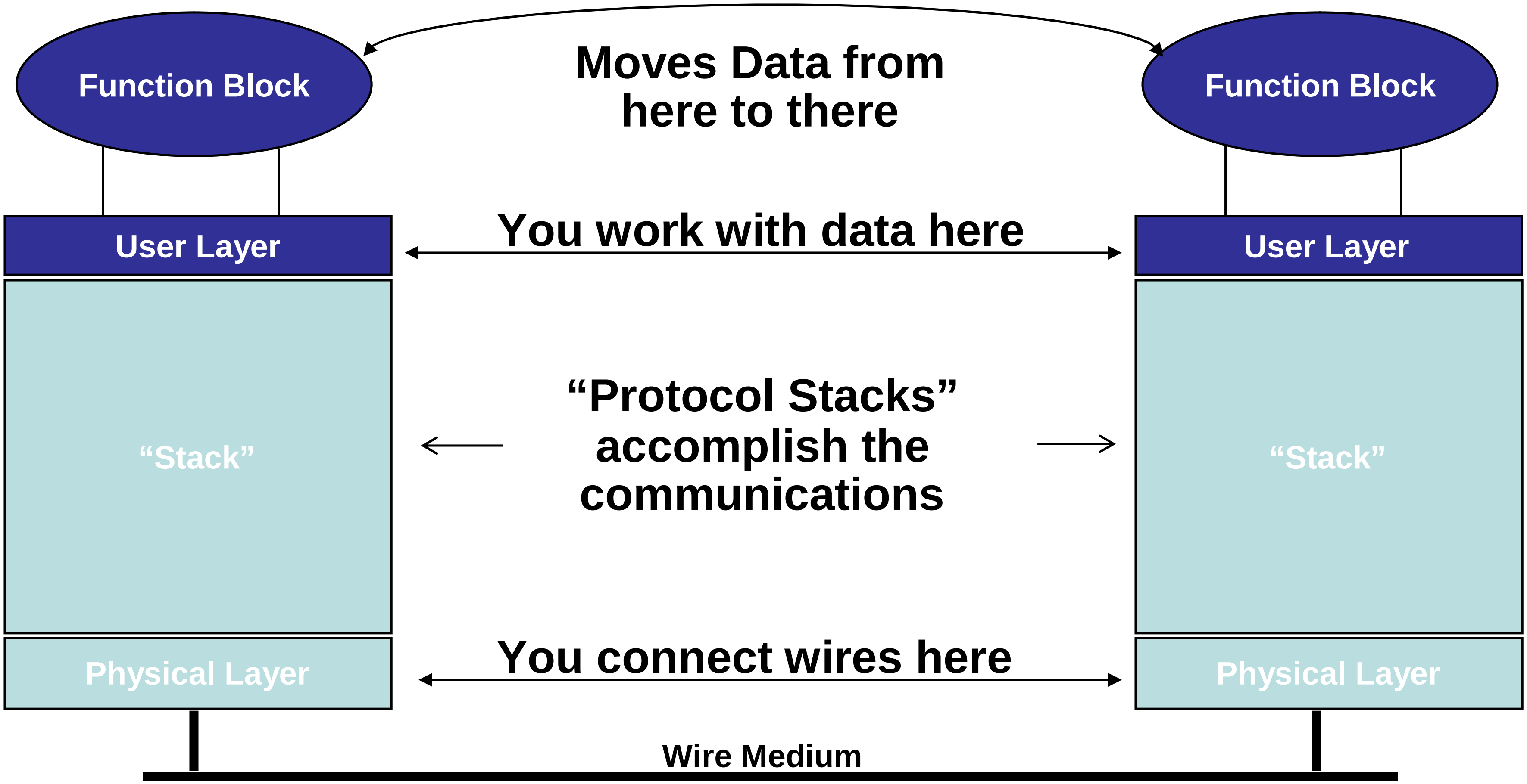
- Foundation Fieldbus - a digital, two-way multi-drop communication link among intelligent measurement and control devices, and automation and display systems.



Function Blocks



fieldbus Communications



Foundation Fieldbus Communications

Fieldbus Device Structure

Resource Block

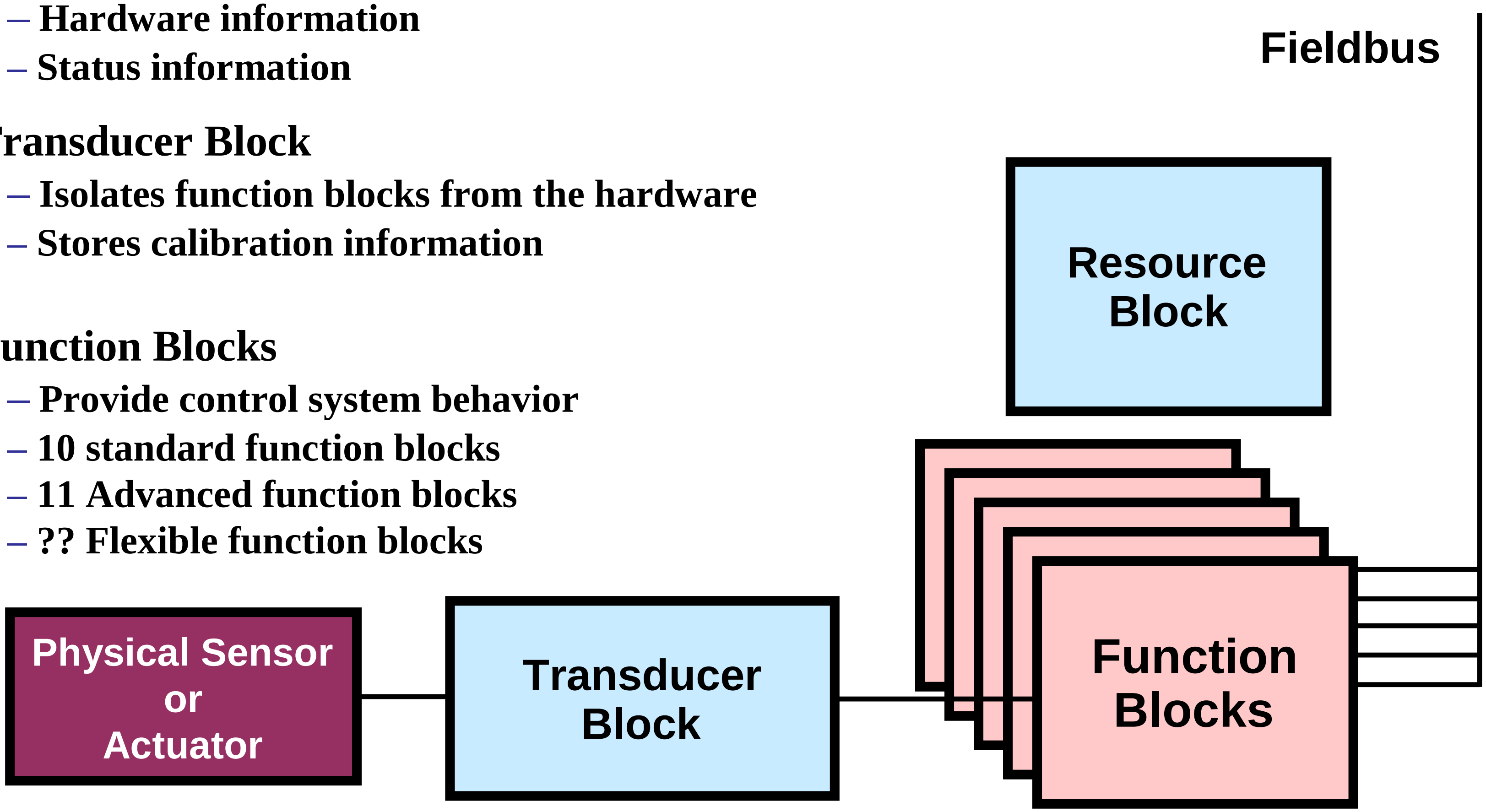
- Hardware information
- Status information

Transducer Block

- Isolates function blocks from the hardware
- Stores calibration information

Function Blocks

- Provide control system behavior
- 10 standard function blocks
- 11 Advanced function blocks
- ?? Flexible function blocks

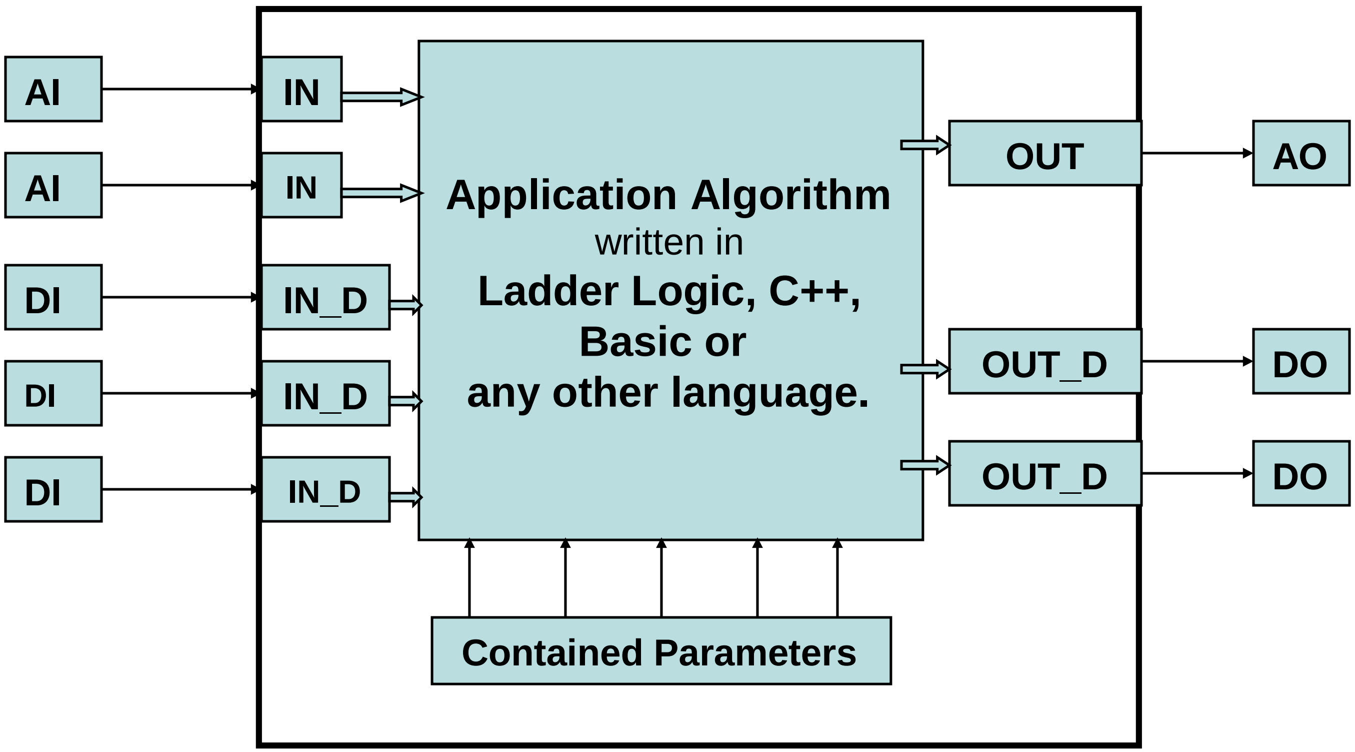


Standard Function Blocks

- **Ten Basic – Part 2**
  - Discrete Input
  - Discrete Output
  - Analog Input
  - Analog Output
  - PID/PI/I Controller
  - PD/P Controller
  - Manual loader
  - Bias/Gain
  - Ratio Station
  - Control Selector
- **Eleven Advanced – Part 3**
  - Device Control
  - Output Splitter
  - Signal Characterizer
  - Lead/Lag
  - Deadtime
  - Integrator
  - Setpoint Ramp Generator
  - Input Selector
  - Arithmetic
  - Timer
  - Analog Alarm

Flexible Function Blocks

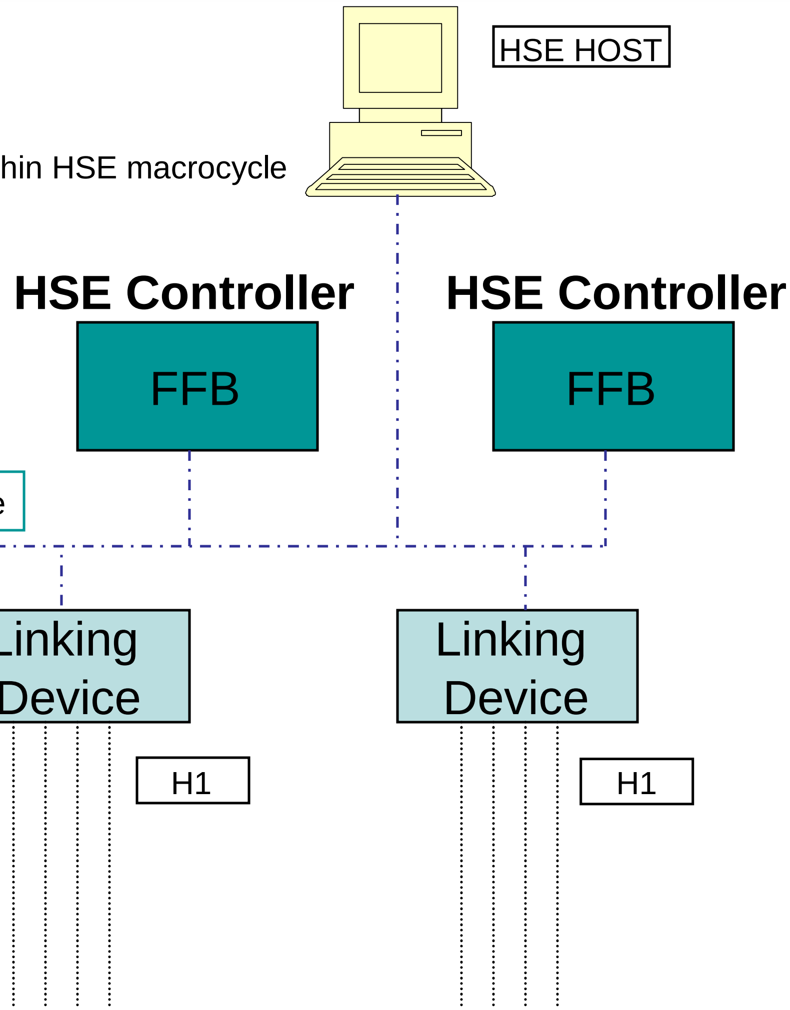
- Any Application in a fieldbus “Wrapper”



HSE Flexible Function Block

Characteristics

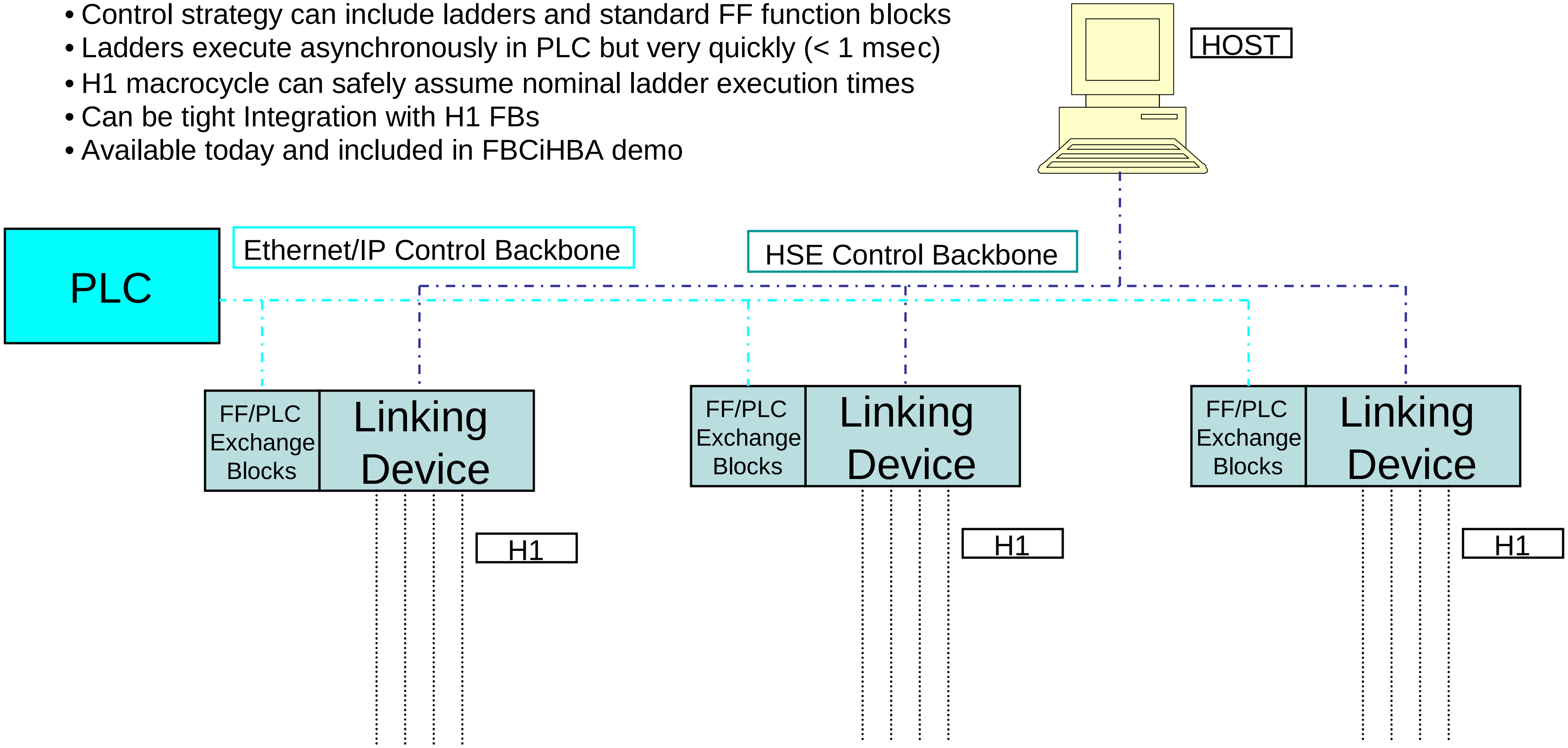
- 100% Foundation Fieldbus Solution
- Standard FB and IEC 61131-3 Ladder Logic
- H1 and HSE macrocycles can be synchronized
- FFBs and FBs can execute deterministically within HSE macrocycle
- Tight Integration with H1 FBs
- Prototype to be included in FBCiHBA demo



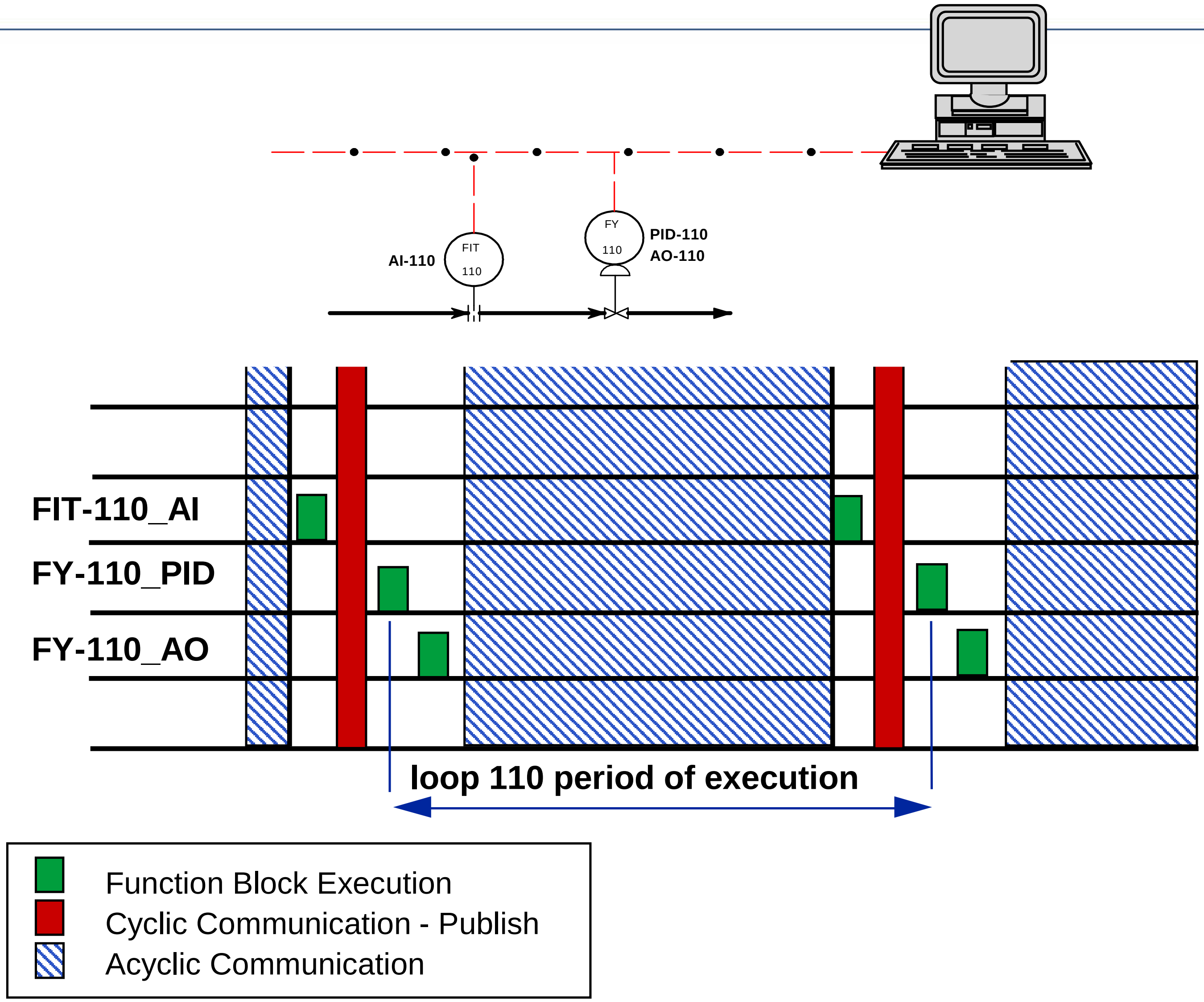
Integrated Standard PLC

Characteristics

- Hybrid Solution
- Includes an integrated standard PLC with all IEC 61131-3 languages
- Control strategy can include ladders and standard FF function blocks
- Ladders execute asynchronously in PLC but very quickly (< 1 msec)
- H1 macrocycle can safely assume nominal ladder execution times
- Can be tight Integration with H1 FBs
- Available today and included in FBCiHBA demo

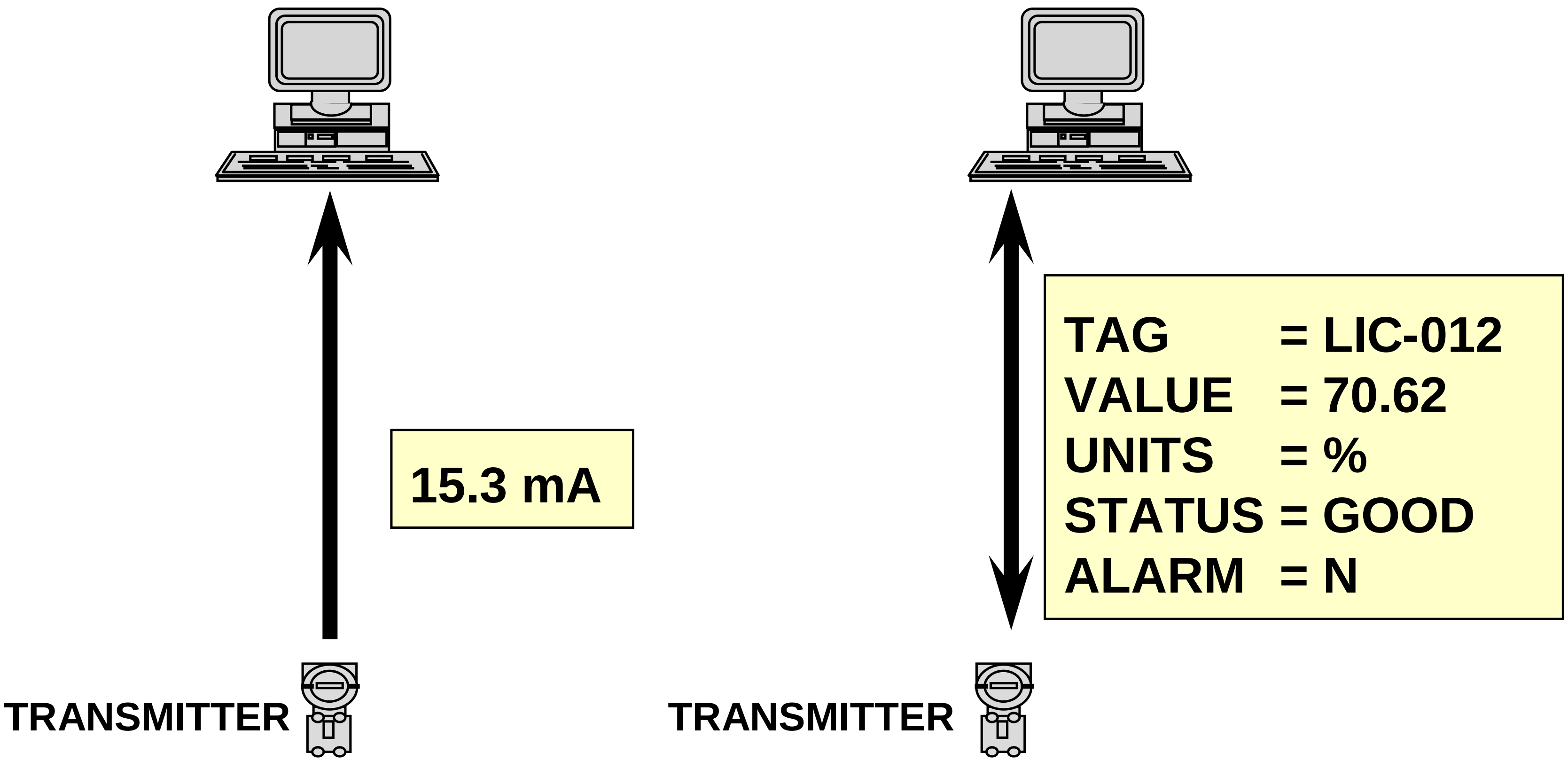


H1 Scheduling

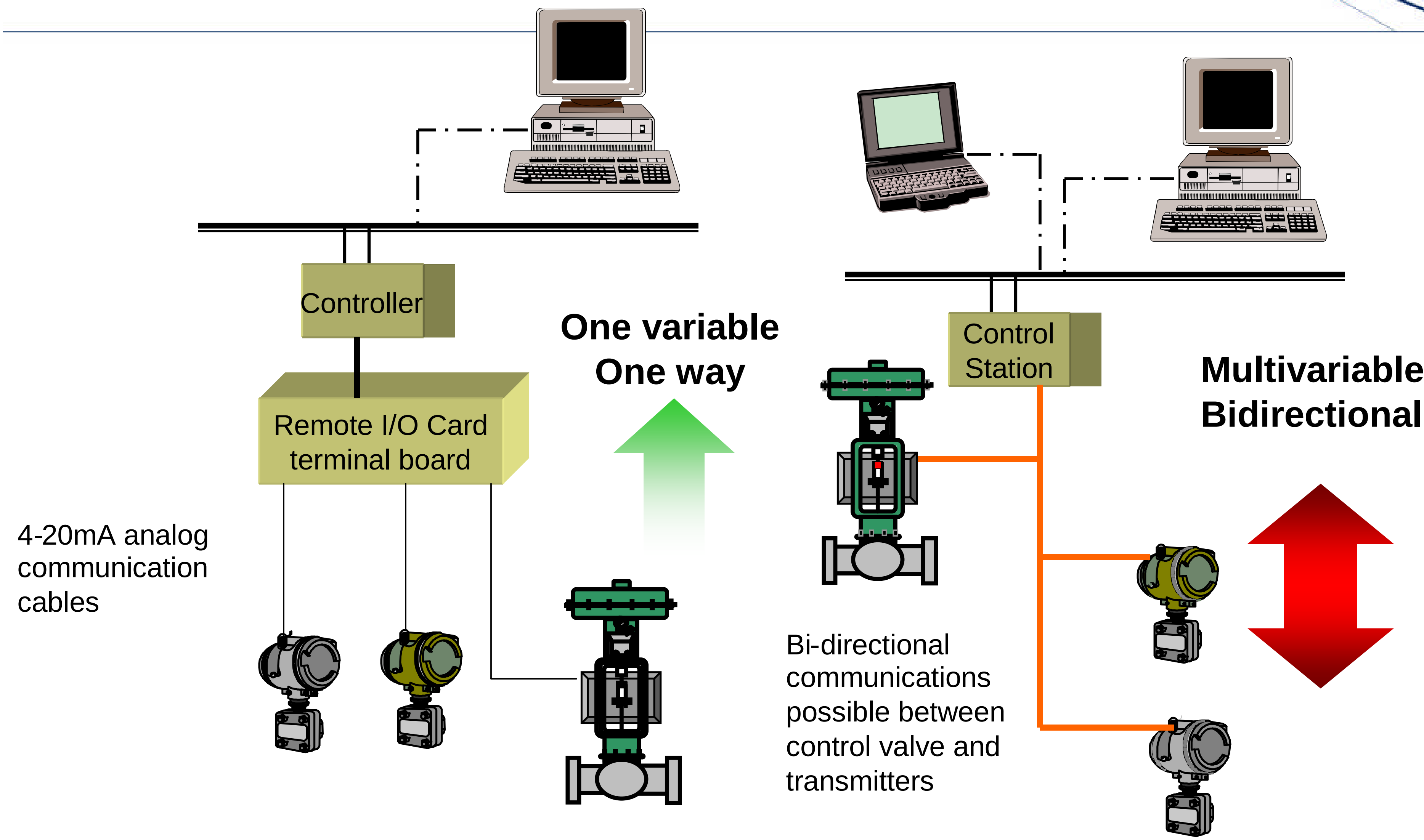


4-20ma vs. FF Data Quality

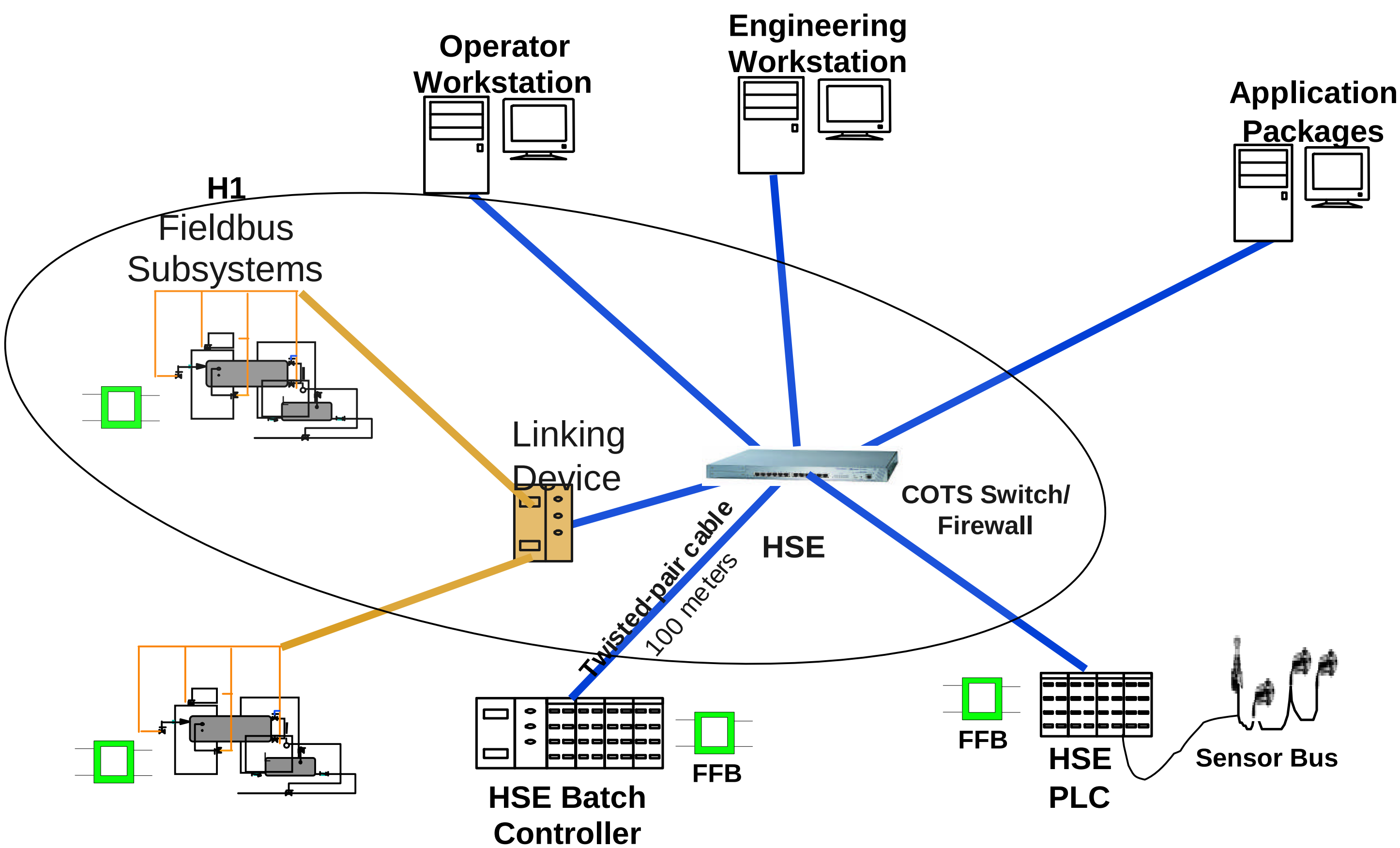
DCS | **Foundation Fieldbus**



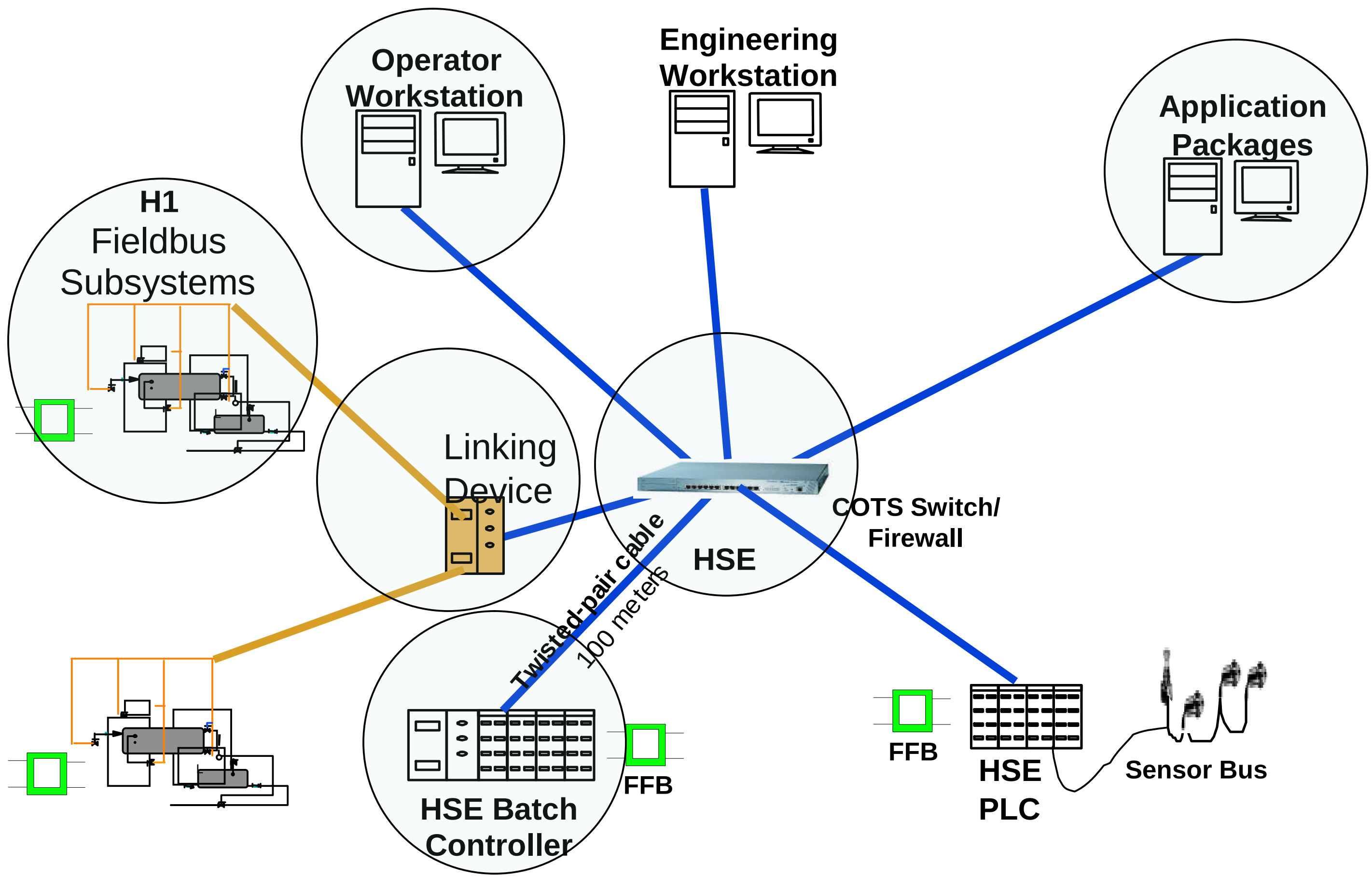
Expanded View of the Process



HSE Linking Devices And H1



HSE/H1 Integrated Architecture



BENEFITS OF FFBUS

- 1. Operating Benefits
  - Improved Integrity
    - Reduced Off Normal Operation
    - Reduced Down Time
  - Process Control Improvements
    - Operate Closer to Limits
- 2. Maintenance Benefits
  - Planned Maintenance
  - Plug and Play Devices
  - Improved Diagnostic Tools
- 3. Capital Expense Reduction
  - Reduced Engineering Costs
  - Lower Installation Costs
  - Quicker Start-ups

Some Considerations For Fieldbus

- Was developed for Layer 1 of the 7 Layer OSI model
- Drivers
- Does not meet complete needs of a modern refinery, petrochemical or power plant
- Limitations on data throughput
- Have not kept up with technological evolution – catching up mode
- Other technologies are leaping ahead rapidly
- Like a middle man, gate keeper role .. seeing work around it already.

PROFIBUS DP

- Open, non-priority, linear topology.
- Fastest and most widely implemented bus
- Communication speed inversely proportional to bus length (1.2 mBPS typical)
- 120 drops maximum

PROFIBUS PA

- Open, non-priority, linear topology.
- May operate on a Profibus DA segment
- Communications at 31 kBPS
- 10-20 drops depending on area classification

DEVICENET

- Open, non-priority, star topology.
- Communication speed inversely proportional to bus length (100-500 kBPS typical)
- Used typically for discrete devices such as starters, VFDs, relays, valve positions, etc.
- 60 drops maximum

Wireless

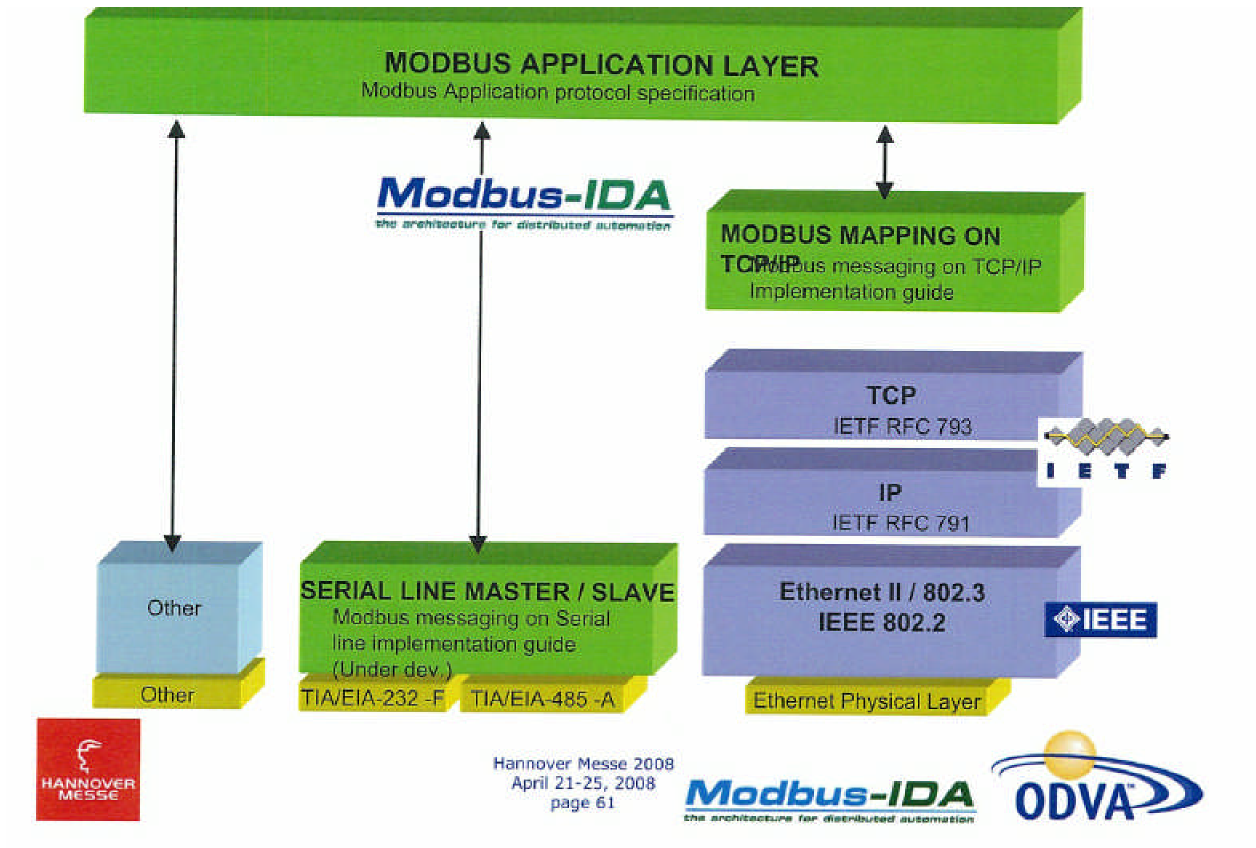
- Proprietary communications protocol between sender and receiver.
- Usually requires “line of sight” between devices

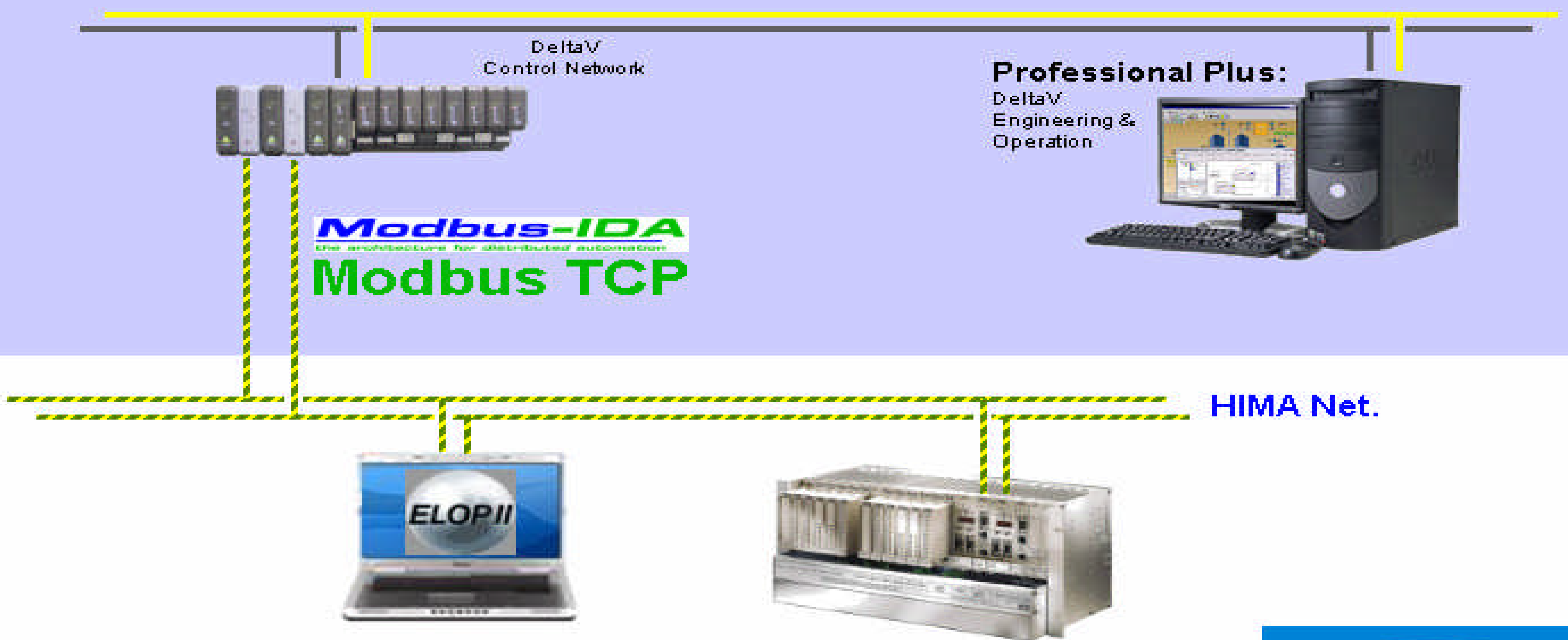
Modbus

- Brief overview
- In US , it is industry workhorse.

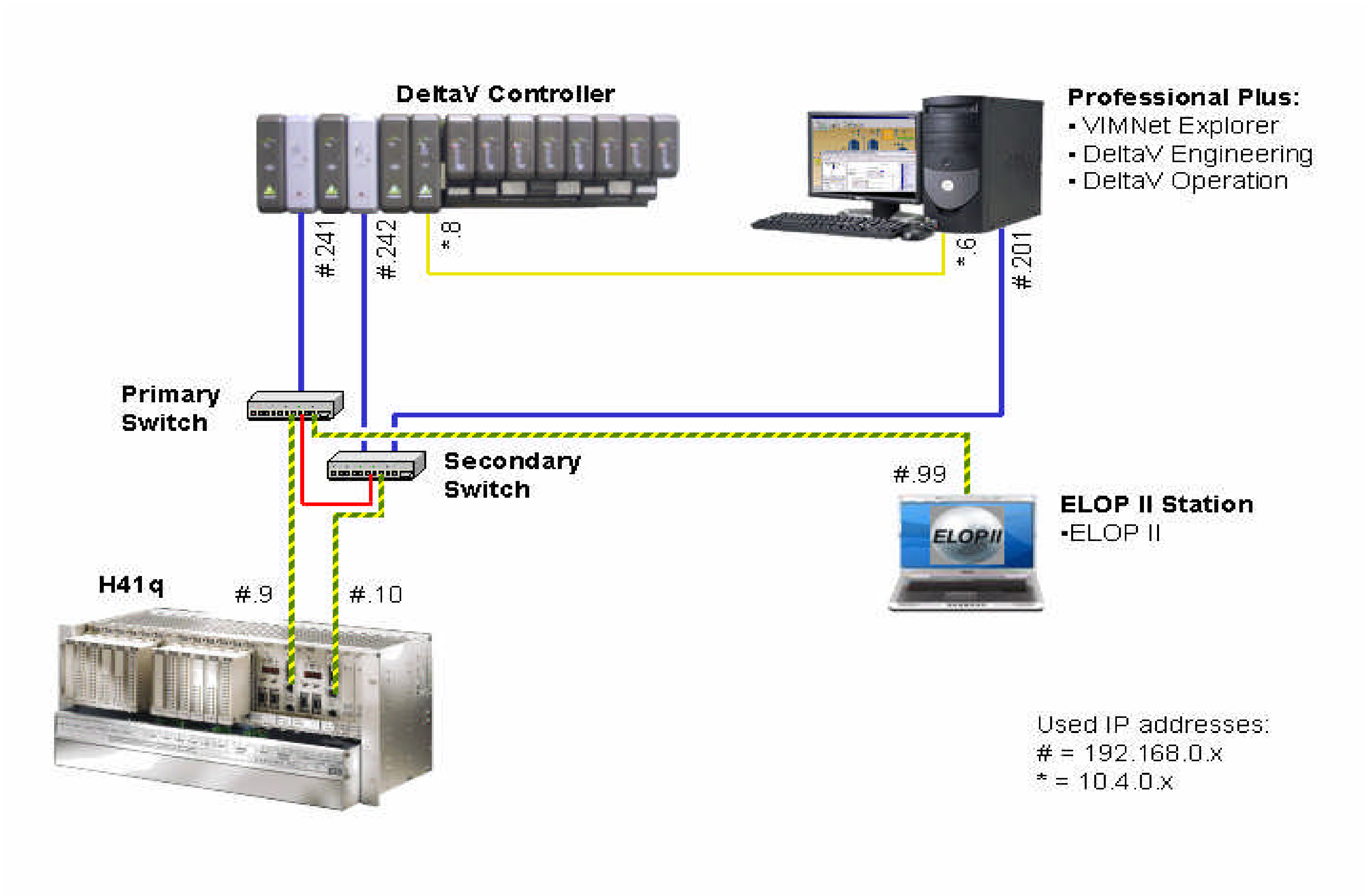
- There are others like Device net , Arcnet, cheapnet and so on.

MODBUS IMPLEMENTATION

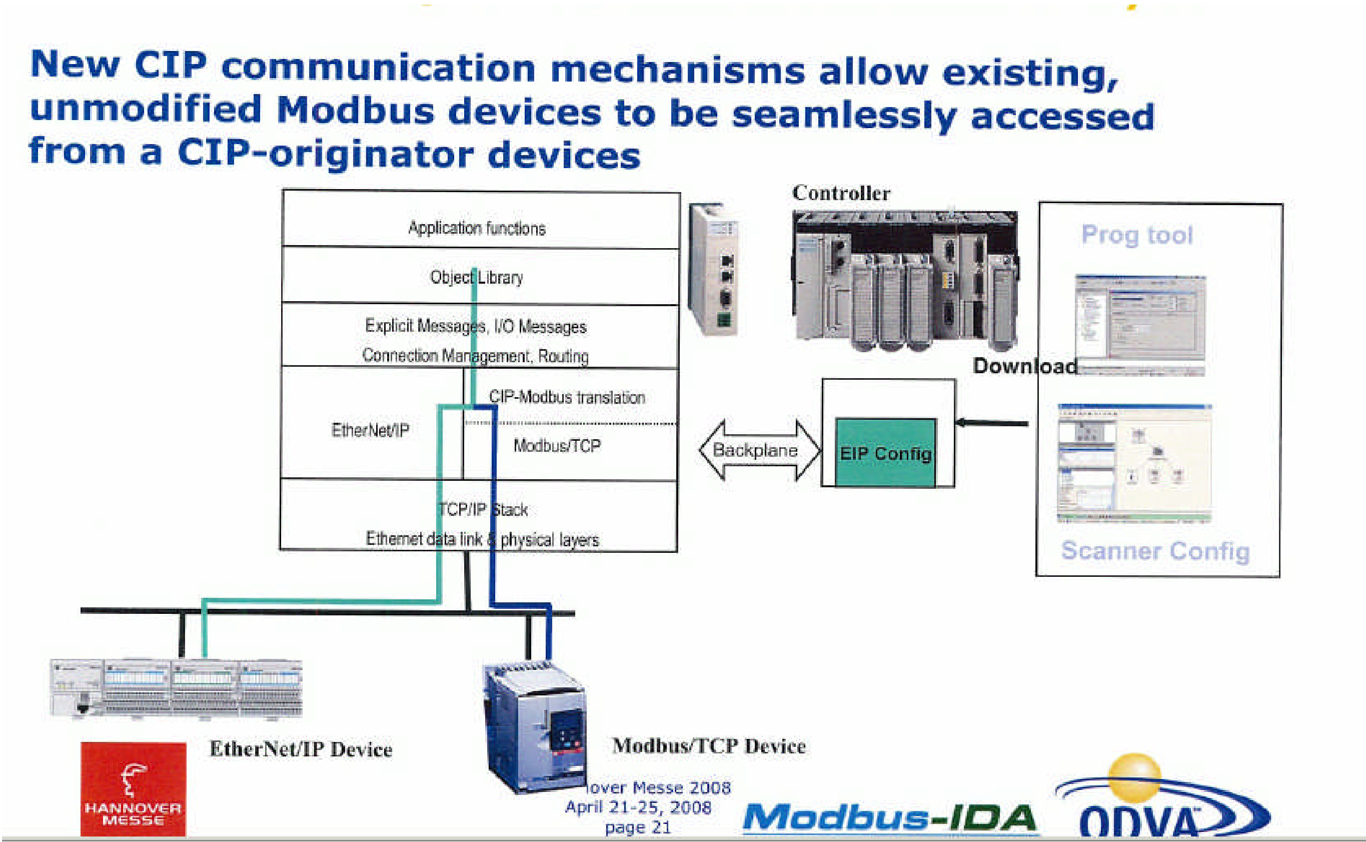



DeltaV
Control Network
Professional Plus:
DeltaV
Engineering &
Operation
Modbus-IDA
Modbus TCP
HIMA Net.
ELOP II

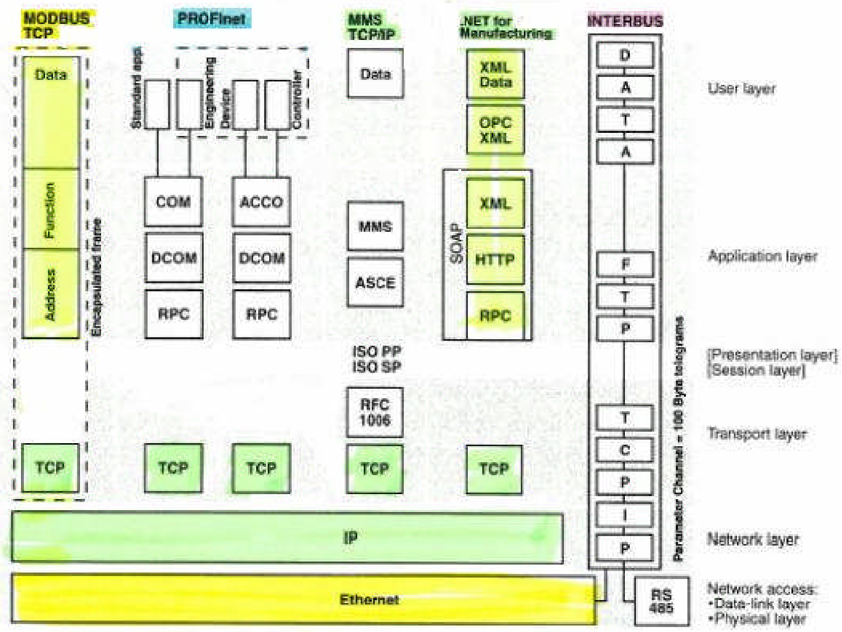
DELTA V MODBUS TCP COMMUNICATION



MODBUS IMPLEMENTATION



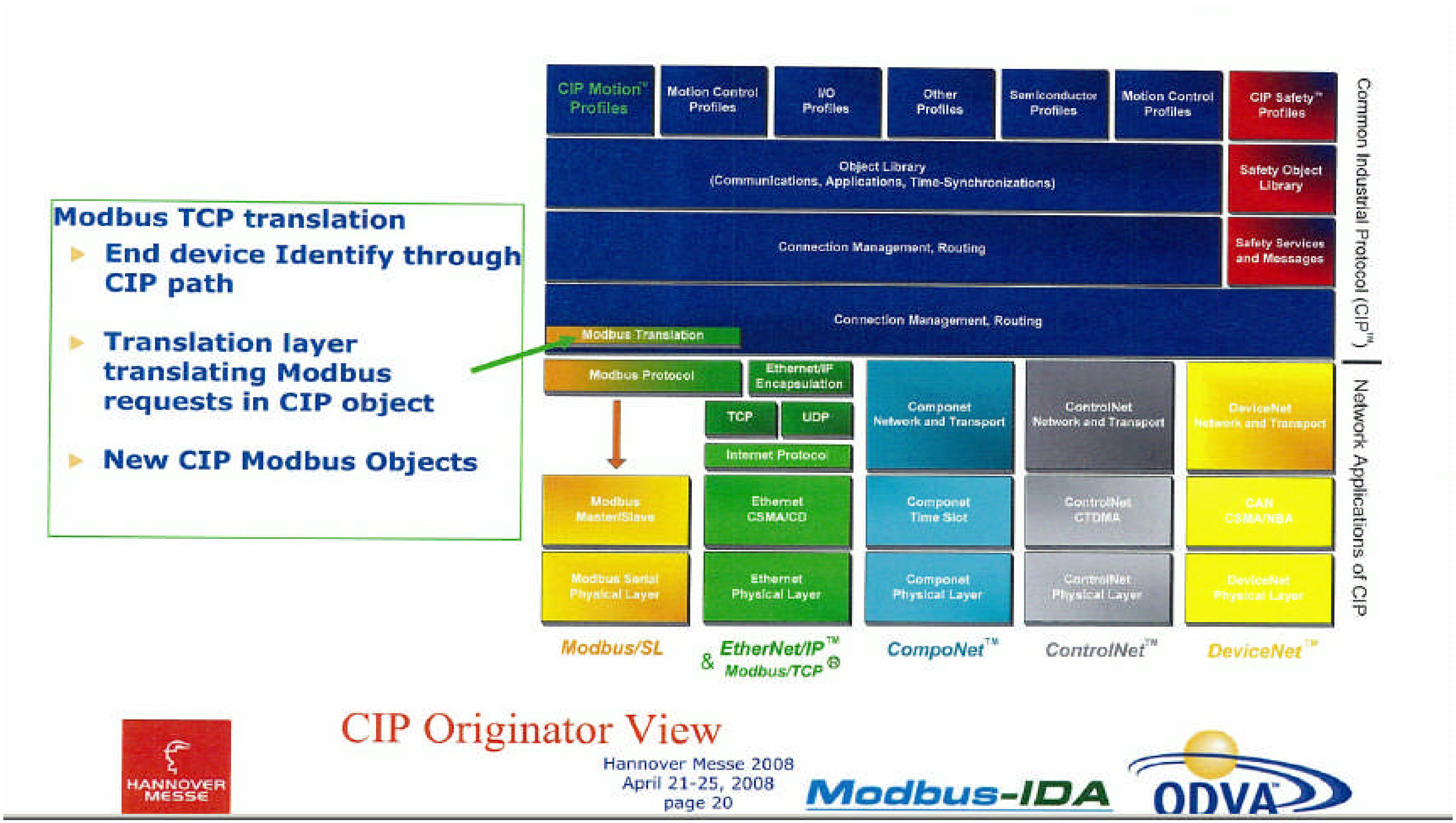
TCP/IP IE PROTOCOLS



ACCO: Active Control Connection Object
ASCE: Association Control Service Element
COM: Component Object Module
DCOM: Distributed Component Object Module
FTP: File Transfer Protocol
ISO PP: International Standards Organization Presentation Protocol
ISO SP: International Standards Organization Session Protocol
MMS: Manufacturing Message Service
OPC: OLE (Object Linking and Embedding) for Process Control
RPC: Remote Procedure Call
TCP: Transmission Control Protocol
UDP: User Datagram Protocol
XML: Extensible Markup Language

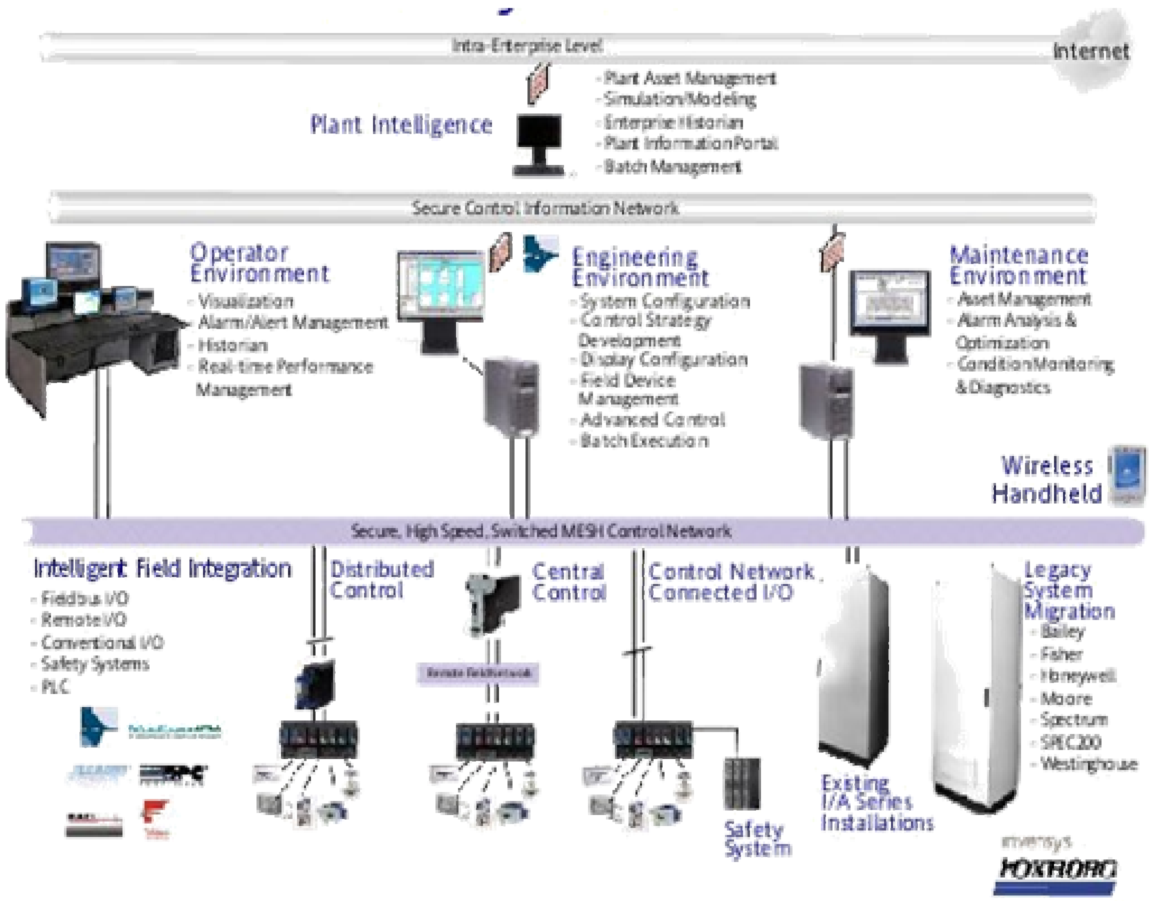
Comparison of TCP/IP-based iE protocols

IE PROTOCOL COMPARISON



Introduction

- Choice of field Device Integration
- I/O or system data integration



Need for Integration Into the Digital Control System

- Digital Systems
- Data needs - Information needs are immense
- Information hungry world

What an Integrator needs to do

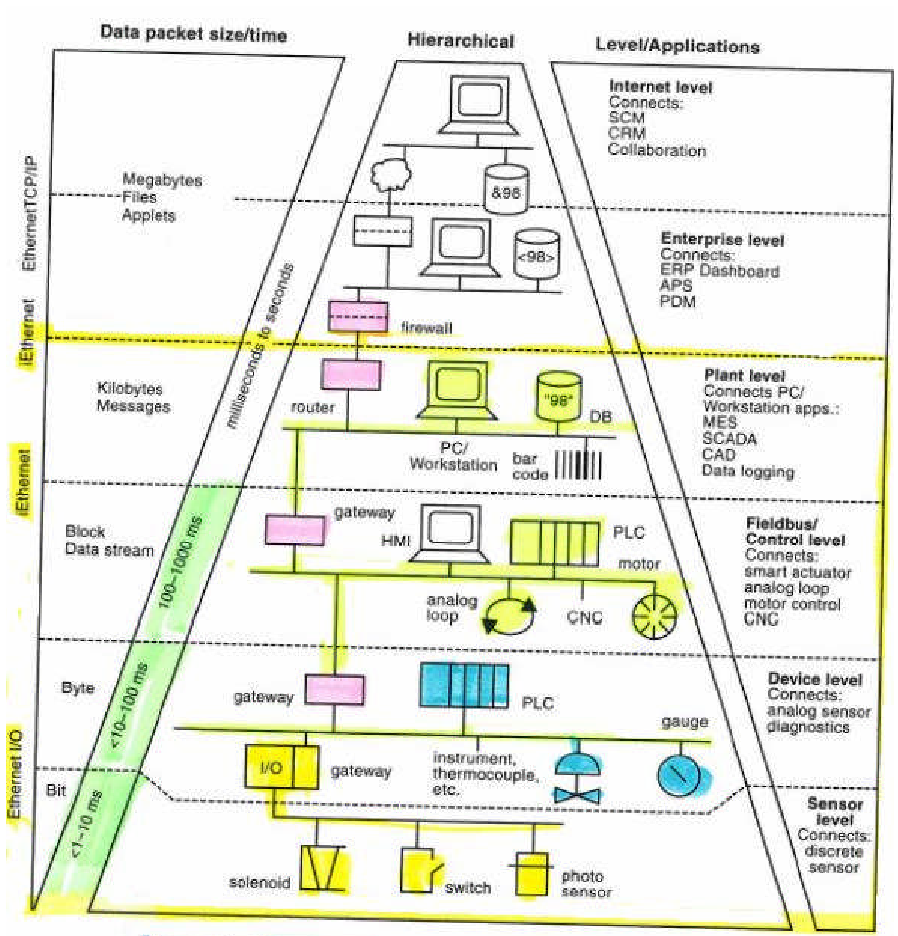
- Old Plants modernization
- New Plants
- Let’s look at needs of a new grass root LNG facility automation.

What are the available solutions

- There is no such thing as - “Perfect Tool”

- ONE SHOE FITS ALL – Does not work
- NO ONE BUS COVERS ALL THE NEEDS OF A MODERN PROCESS PLANT & Never will.
- Large, complex I/O based systems are difficult.
- In this information world “We need *additional* information to understand and process *more* information”

HIERACHICAL CONTROLS



Elements in a hierarchical factory automation and control infrastructure

What do I need to consider besides wiring costs

- Life Cycle Cost
- Technology Cost
- Technology life span before obsolescence
- Organizations road map
- Engineering, construction, commissioning and maintenance
- “Field bus was developed to replace wiring and promote inter-operability”

BUS SELECTION CONSIDERATIONS

- Bandwidth
- Area Classification
- Field Devices
- Control Strategy
- Distance, I/O Density
- Multiple Bus Requirements
- Installation Costs
- Region or Location of Plant/Project

BUS IMPLEMENTATION

- Field Instrument Segregation
- Number of Devices Per Bus
- Control Strategy
- Bus Hardware Requirements
- Capital Cost
- Operating and Maintenance
- Data Security

Fieldbus and Remote I/O comparisons

- From FuRIOS 2
- Study based upon a small pharmacy plant
- Sponsored by P&F
- Slight 3 to 5% cost advantage in wiring cost
- Other factors were ignored.
- P&F only supplier of Safety Barriers.

DESIGN CONSIDERATIONS

- Density of Devices
- Segment Segregation
- Operational Requirements
- Impact of Loss of Data
- Control Functions

Complications

- I/O mix
- I/O quantity
- Operating Systems
- Communication media and protocols
- Old Plant
- New Plant
- Technical issues
- Site location –Arctic, Saudi Desert, Rain forest
- Remote

PLANT SAFETY SYSTEM

- IPSS IS A CRITICAL COMPONENT FOR ANY LNG PLANT
- COMPLIED WITH ALL THE EXISTING STANDARDS, BEST INDUSTRIAL PRACTICES, AND REGULATORY AGENCY REQUIREMENTS
- USED BEST OF THE BREED AVAILABLE TECHNOLOGY.

PLANT SAFETY SYSTEMS

- MOST CRITICAL COMPONENT
- EXTREMELY HIGH AVAILABILITY
- EXTREMELY HIGH RELIABLITY
- TESTING/CERTIFICATION
- AUDITING TRAIL
- REGULATORY REQUIREMENTS

SAFETY STANDARDS FOR PROCESS INDUSTRIES

- ISA S-84   1996 HARD WIRES ONLY.
- ISA S84.00.01 ALSO IEC 61511-2003, ALLOWS A DIGITAL BUS COMMUNICATION.
- ISA SP84 WG 1 ON SUPPORT FOR FIELDBUS.

OBJECTIVES OF ISA S 84 WG1 ARE

- CERTIFIED SIL LEVEL OF SIS
- INTEROPERABILITY - NON PROPRIETARY
- COEXISTANCE OF SAFETY AND NON SAFETY RELATED DEVICES ON THE BUS
- DIAGNOSITIC REQUIREMENTS
- FAULT TOLERANCE
- SECURITY
- HOT REPLACEMENT
- TESTING
- FAST RESPONSE

SAFETY FIELDBUS (W2)

- TECHNOLOGY EXISTS TODAY
- STANDARDS ? – DRAFT MAY BE ACCEPTED BY NOW.
- PARTIAL STROKE TESTING CAPABILITIES ARE THERE.
- HAVE SIMILAR BENEFITS AS CLAIMED BY FIELDBUS

Implementation of complete system integration requires

- Technologies
- Engineering
- Project Execution
- Client/Project specific requirements
- Regulatory agencies

Technology factors

- Safety
- Availability
- Reliability
- System Integration
- Application Software
- Subsystem Integration
- Proprietary Technologies
- Special requirements

Engineering and Execution

- Work Processes
- Internal Interfaces
- External Interfaces
- Vendor Information exchange
- Organization
- Life Cycle Cost
- Cost Structure
- Pre-Investment
- Guarantees/ Warrantees

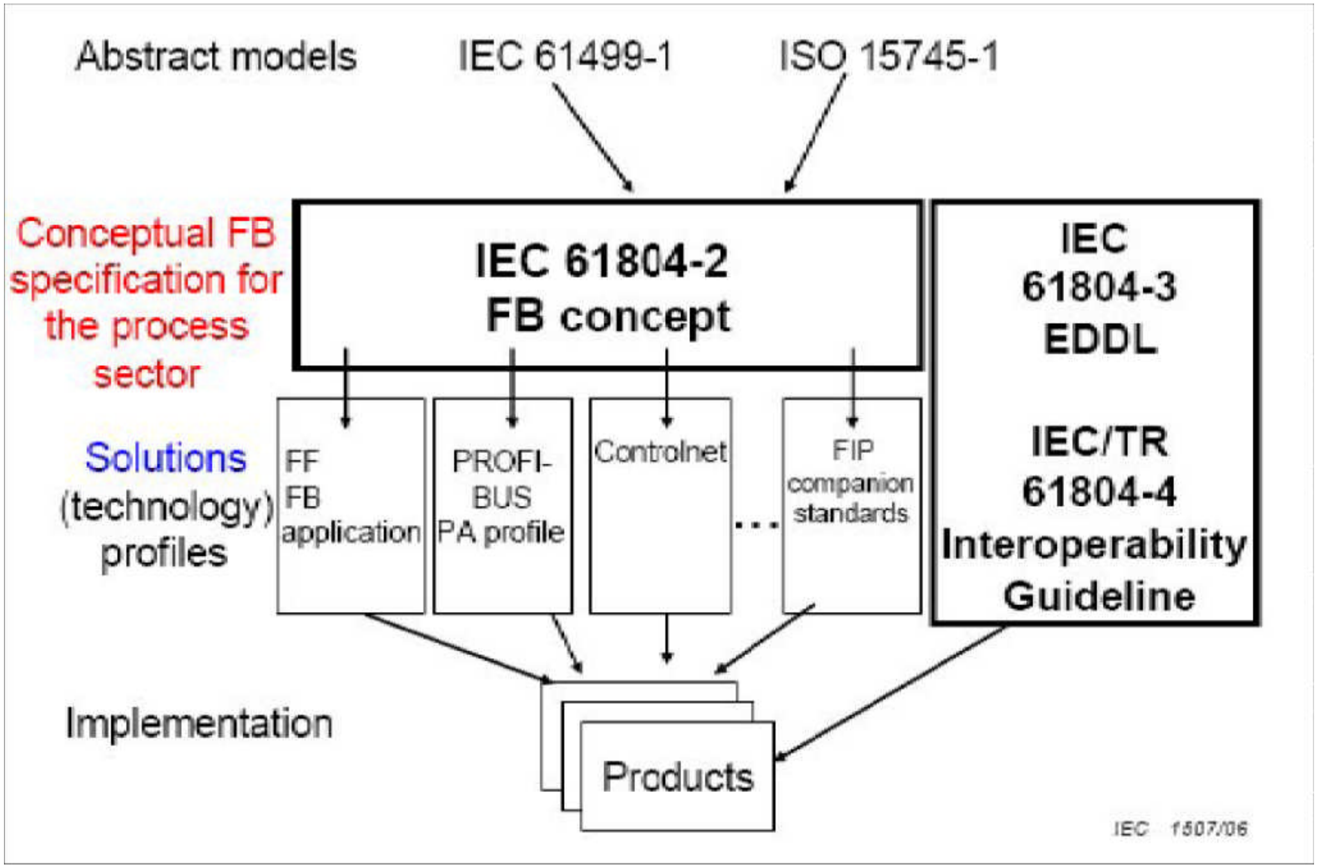
Emerging Technologies

- Lot of functional duplication – paying twice
- Watch out for EDDL
- Capabilities of Ethernet
- OPC model
- Traditional role of transmitter is disappearing
- From sensor to system – bus or no bus
- Wireless (Windows CE, Palm OS, Apple I-Pod)
- Security

EDDL

Electronic Device Description Language

Each field device has one



OPC OVERVIEW

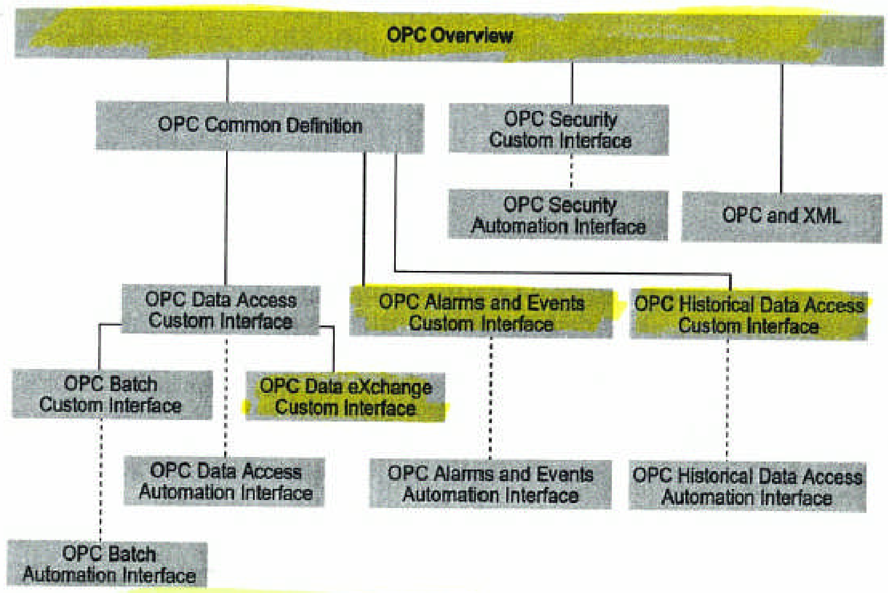


Figure 1.1: Available and in-progress specifications


DO NOT TRUST YOUR DATA TO
STROKE OF LUCK

INDUSTRIAL NETWORK SECURITY

- THREATS TO YOUR NETWORK
- BUILDING EFFECTIVE NETWORK SECURITY ON YOUR INDUSTRIAL NETWORK

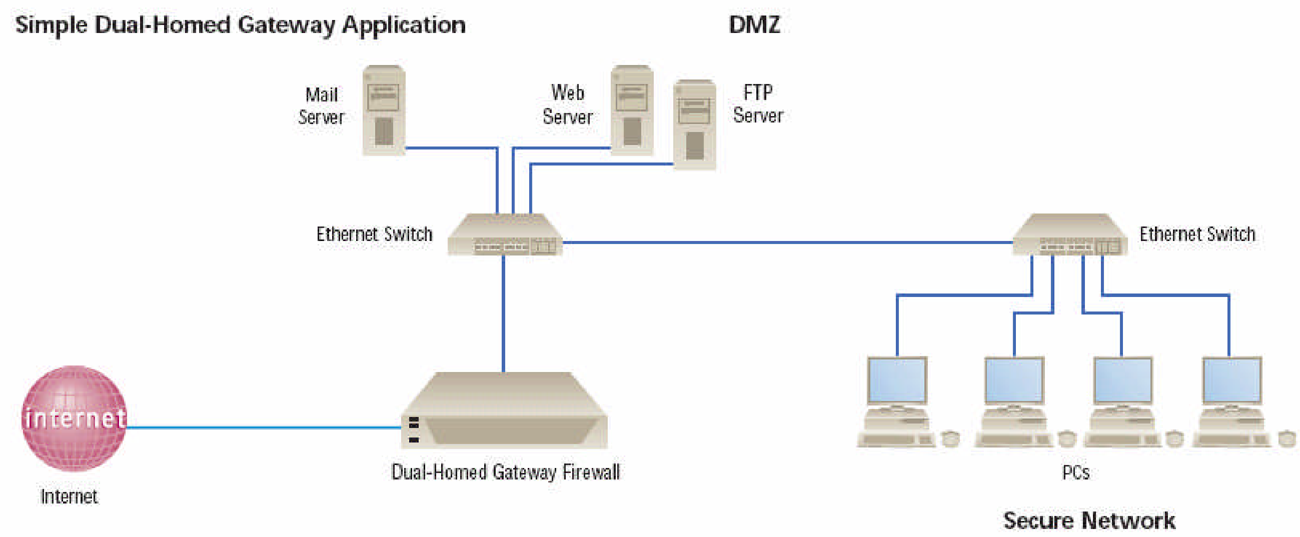
SECUIRTY THREATS

- MALWARE
- HACKERS
- NETWORK OVERLOAD
- PHYSICAL THREATS

BUILDING EFFECTIVE DEFENCE

- HAVE A PLAN
- EDUCATION
- COMPANY ACCESS POLICIES
- SECURITY SOFTWARE
- ROUTERS
- FIREWALLS
- DEMILITARIZED ZONES
- BACKUP AND RECOVERY

DEMILITARIZED ZONE -



Juniper Networks Solution.

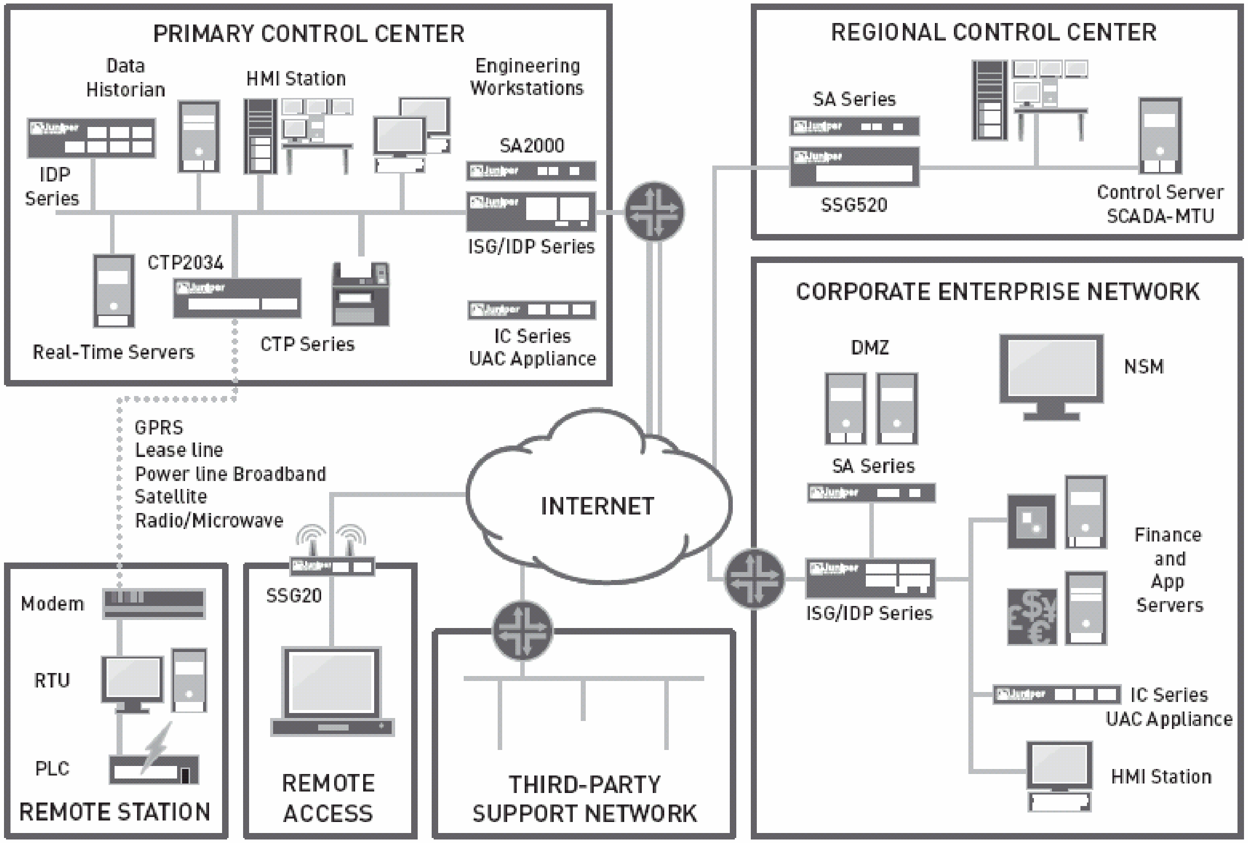
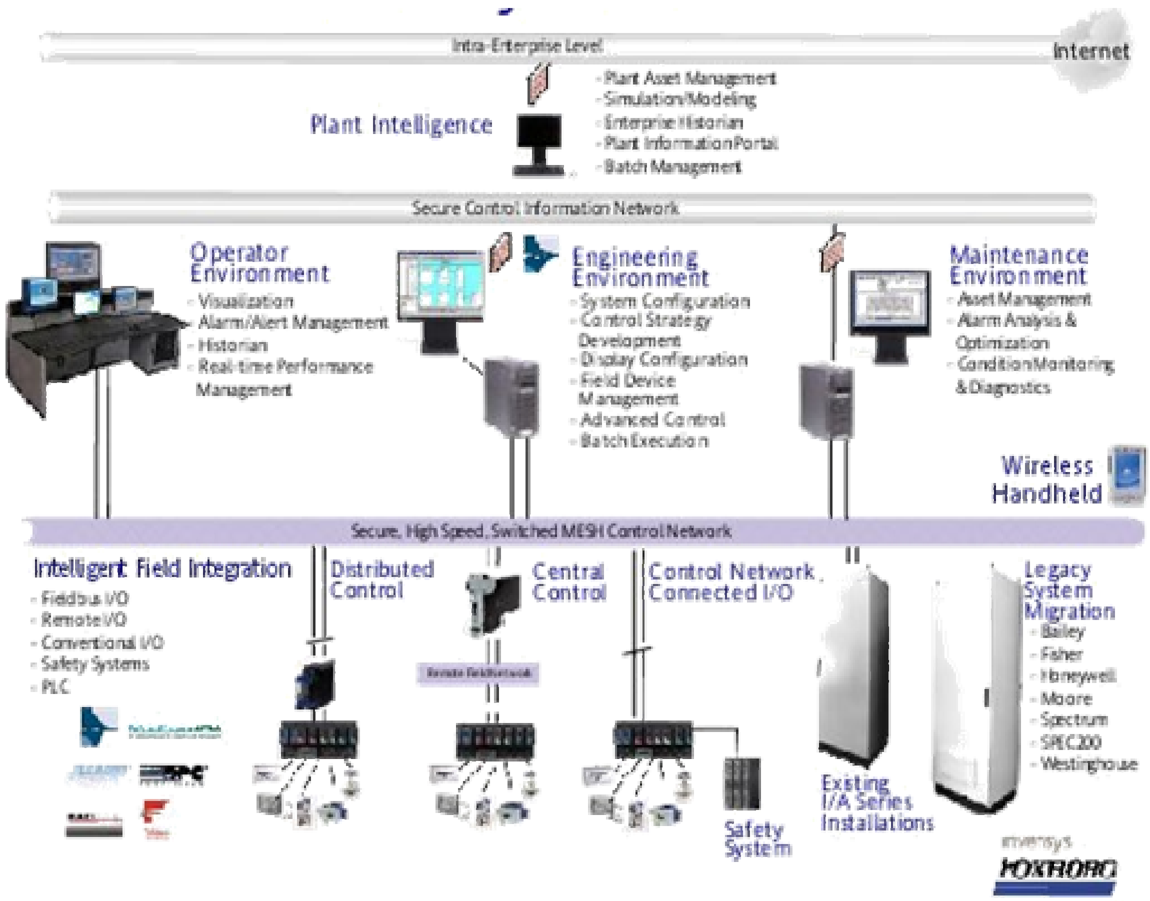


Figure 5: Comprehensive network-based security for control systems

Introduction

- Choice of field Device Integration
- I/O or system data integration



Conclusion

- Understand the business supply chain
- Understand your business Organization hierarchies and data requirements
- Have an all inclusive Automation road map
- Define your systems, sub-systems and interfaces
- Consider using the “best of a breed” technologies for Networks, Field buses,
- Deliver what is needed for current and future needs
- Use COTS components, connectors, cables, switches, servers, HMIs etc.

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- www.odva.org
- www.modbus.org

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- OPC Fundamentals, Implementation and Application by Fran Iwanitz and Jurgen Lange, Huthig Verlag Heidelberg
- The Industrial Ethernet Networking Guide by Sterling & Wissler, Thomson Publishing
- Automation Network Selection BY Dick Caro, ISA Publication