Optimization of Process Integration:
Using EtherNet/IP for Integration of Field Devices with a Process Automation System

October 14, 2015  2:00 PM – 3:45 PM
Welcome, Background, and History

Shannon R. Foos, P.E.
ODVA Strategic Marketing Requirements Team, Leader
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Terry Minns
ODVA Strategic Marketing Requirements Team
Terry.Minns@Schneider-electric.com
2:00 – 2:10 Background and History of Optimization of Process Integration (OPI)

2:10 – 2:15 Reference Architecture for OPI

2:15 – 2:30 Developments by ODVA’s Special Interest Group for EtherNet/IP in the Process Industries

2:30 - 3:30 Adjacent Technical Developments Important to the Realization of OPI in Field Devices

   A New Perspective on Integration of Field Devices: Using the FDT Standard with EtherNet/IP

   Physical Layer – Overview and Demonstration of New Physical Layer Concepts for Industrial
   Ethernet and EtherNet/IP in Process Field Devices

3:30 – 3:45 Panel Session: Industry Perspectives on EtherNet/IP for the Process Industries
The Process Initiative

SMRt Participants
Cisco Systems  René Pluis
Endress+Hauser  Olivier Wolff
Rockwell Automation  *Shannon Foos*
Schneider Electric  Terry Minns
ODVA  Katherine Voss

White Paper
Optimization of Process Integration

Work Plan
Next steps: 12-18 months
- Finalizing EtherNet/IP Input Assembly structure including device diagnostics
- Finalizing HART mapping on EtherNet/IP
- Define PoE adaptation for EtherNet/IP
- Additional EtherNet/IP work plan topics

Achievements
- Defined EtherNet/IP Reference Architecture for Process Industries
- Draft of EtherNet/IP Input Assembly structure including Process Diagnostics
- Draft of HART mapping on EtherNet/IP

SIG - 19 members, 10 different vendors
Active Participants:
Cisco Systems (René Pluis)
Rosemount (Eric Rotvold)
Endress+Hauser (*Mirko Brcic*, Martin Hönicke)
Krohne (Christian Brehm, Christoph Spiegel)
Rockwell Automation (Carl Schumaker)
Schneider Electric (Stephane Hernu, Terry Minns, Mark Rossi)
Reference Architecture

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The Technical Working Group

Mirko Brcic

ODVA Special Interest Group, Leader

Mirko.Brcic@solutions.endress.com
Technical Working Group Overview

New ODVA Special Interest Group (SIG) Formed April 2015

– EtherNet/IP in the Process Industries SIG

– Accomplishments and Activities in Progress
  • Defined Reference Architecture for Process Industries
  • Draft of Input Assembly structure including Process Diagnostic
  • Initiated HART mapping on EtherNet/IP
  • Evaluation of PoE adaptation for EtherNet/IP

– Plans for next 12-18 Months
Accomplishments and Activities in Progress

- Defined Reference Architecture for Process Industries
  - The **logical architecture** gives an overview of the functionality and segmentation between the several Purdue levels including Process Networks (FOUNDATION Fieldbus, PROFIBUS, HART and Wireless Networks)

  - A physical implementation / realization of the logical architecture can ‘collapse’ Purdue levels in one physical devices, as long as the associated logical function(s) are realized.
Accomplishments and Activities in Progress

Draft of Input Assembly structure including Process Diagnostic
  • Standardized access to process data from EtherNet/IP devices
  • Self-monitoring and Device Diagnostics according to NAMUR NE107
  • Proposal was presented at the ODVA EtherNet/IP Roundtable in Raunheim, Germany on September 30, 2015

Communication Diagnostics
Focus of ODVA Diagnostics Working Group
  • Quick and effective identification and resolution of communication problems
  • Vision: Conduct regular analysis of the network using network statistics

Self-monitoring and Device Diagnostics
Focus of ODVA Process SIG
  • Quick and effective identification and resolution of problems
  • Vision: Conduct predictive maintenance to reduce downtime and to protect the investment
Accomplishments and Activities in Progress

– Initiated HART mapping on EtherNet/IP

  • Update of internal Rockwell object review process
  • Presentation of technical aspects of object
  • Discussion of future work effort
Accomplishments and Activities in Progress

Evaluation of PoE adaptation for EtherNet/IP

– First evaluation of PoE adaptation for EtherNet/IP
  • The current standards for PoE (Power over Ethernet), being IEEE 802.af (for max 15W) and IEE 802.at (for max 30W), can be deployed for Ethernet/IP in Process environments
    – Using 4 or 8 wires CAT 5 or above cables
  • There are several developments to increase the total available power budgets to 60 – 90W or even above as well as integration with IEEE 802.3az (EEE – Energy-Efficient Ethernet)
  • For those industrial areas which need compliance to ‘intrinsically safe’ standards, the used maximum voltage of PoE needs to be lowered to 12V (instead of the standard used 48V)
Proposal for next 12-18 months

- Follow-up Reference Architecture for Process Industries
  - Provide implementation examples of the ‘X in the cloud’ or ‘as a service’ developments, e.g. SCADA implementation in the cloud (either public or private) based on the logical architecture.

- Finalizing EtherNet/IP Input Assembly structure including device diagnostics
  - Standardized access to process data from EtherNet/IP devices including device diagnostics
  - Definition of device diagnostics for native EtherNet/IP devices that are compliant with NAMUR NE-107

- Finalizing HART mapping on EtherNet/IP
  - Standardized CIP object structure to get access to HART

- Define PoE adaptation for EtherNet/IP
Logical reference architecture

- Standard Ethernet
- Industrial Ethernet (e.g. EtherNet/IP)
- Fieldbus (e.g. Profibus, Foundation Fieldbus)
- 4-20mA (and HART)
- Wireless (e.g. WirelessHART, ISA100)

Enterprise Zone
- MES
- ERP systems
- Web servers

DMZ
- Enterprise Firewall
- Terminal Services
- AV Servers
- Internet / WAN

Control Domain
- Engineering Station
- Operator Station
- Network Services
- Control Network
- Remote I/O
- Drive
- Fieldbus Gateway
- Safety Zone
- History

L5: Enterprise Zone
L4: DMZ
L3½: Control Domain
L3: Control Network
L2½: Safety Zone
L2: L1: L0:
Logical reference architecture – functional areas (ISA 95, 88)

Business Process Information Network
- Resource Management
- Production Execution
- Product Definition Management
- Detailed Scheduling
- Configuration Management
- Production Analysis
- Production Tracking
- Production Dispatching

Operations Information Network
- Alarm Management
- Operator Visibility
- Equipment Information Collection
- Operator Control
- Supervisory Control
- Recipe Control

Automation Network
- On/Off Control
- Programmed Control
- Continuous Control
- Interlock & Safety Control
- Phase Control

Discrete & Process Device Communication Networks
- Sense Events
- Manipulate Equipment
- Manipulate Process
- Sense Process
Observations and remarks Logical reference architecture

The logical architecture gives an overview of the functionality and segmentation between the several Purdue levels.

A physical implementation / realization of the logical architecture can ‘collapse’ Purdue levels in one physical devices, as long as the associated logical function(s) are realized.

A point of further study will be the incorporation of the ‘X in the cloud’ or ‘as a service’ developments, e.g. SCADA implementation in the cloud (either public or private) into this logical architecture.
HART Mapping on CIP

October 14, 2015
HART Mapping on CIP

- Update of internal Rockwell object review process
- Present technical aspects of object
- Discuss future work effort
The current standards for PoE (Power over Ethernet), being IEEE 802.af (for max 15W) and IEE 802.at (for max 30W), can be deployed for Ethernet/IP in Process environments (using 4 or 8 wires CAT 5 or above cables).

There are several developments to increase the total available power budgets to 60 – 90W or even above as well as integration with IEEE 802.3az (EEE – Energy-Efficient Ethernet).

For those industrial areas which need compliance to ‘intrinsically safe’ standards, the used maximum voltage of PoE needs to be lowered to 12V (instead of the standard used 48V).
Diagnostics – Status Quo

October 14, 2015
Types of Diagnostic

Communication Diagnostics - Focus of ODVA Diagnostics Working Group

Self-monitoring and Device Diagnostics - Focus of ODVA Process SIG
How diagnostics can be used

**Communication Diagnostics**
- Short term: Quick and effective identification and resolution of communication problems
- Mid term: Conduct regular analysis of the network using network statistics

**Self monitoring and Device Diagnostics**
- Mid-term: Conduct predictive maintenance to reduce downtime and to protect the investment
- Short term: Quick and effective identification and resolution of problems
Device Diagnostics

- Modern sensors and actuators are able to do self-monitoring and provide diagnostic information.
- In addition to the “Big 12”, this can also be used to prevent downtime.
- Therefore Device diagnostics were regarded in the Process SIG work plan.

“In particular, the SIG will seek to define device diagnostics for native EtherNet/IP devices that are compliant with **NAMUR NE-107**”
NAMUR

- NAMUR is an international association of process automation end users
- NEs are recommendations to help end users and to guide suppliers as well as industry foundations on future technology and product development
- ~300 active members in ~40 working groups
- Members: e.g. Novartis, BASF, Bayer, Evonik, Shell, Clariant, …
Possible sources of error

- E.g. electronics, sensor or actuator element, installation, putting into operation, non-compliance with specified operating conditions, connecting to the process
NE107 – Information Flow

Categorization of the diagnostic event according NAMUR NE107:
- Failure (F)
- Function check (C)
- Out of specification (S)
- Maintenance required (M)

Displays the diagnostic event to the end user

Creates Diagnostic events by utilizing measurement- and self monitoring signal(s)
### Accessing Device Diagnostics with EIP

#### PLC/Tool
- Input Assembly (work in progress)

#### NE107-Device

<table>
<thead>
<tr>
<th>Status</th>
<th>Diagnostic Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE 107 status signal channel</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data(i)</th>
<th>Value</th>
<th>Status</th>
<th>(Padding)?</th>
<th>Engineering unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data(i+1)</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Source of status signal (for multichannel devices)
- Grouping by source (sensor, electronics,...)
- Good, bad, (uncertain)?
- +simulation flag?
- +active flag?

### Grouping by source (sensor, electronics,...)
Adjacent Technology Developments

Three Use Cases in Optimization of Process Integration:

Field Device to Industrial Control System Integration
Field Device to Plant Asset Management
Holistic Field to Enterprise Architecture
Adjacent Technology Developments

Automation Domains

Factory Automation

• Strong heritage in Factory Automation applications
• Desire to grow in Process Automation

ODVA

Process Automation

• Strong heritage in Process Automation applications
• Desire to grow in Factory Automation

FDT Group
A NEW PERSPECTIVE ON INTEGRATION OF FIELD DEVICES:
USING THE FDT STANDARD WITH ETHERNET/IP

GLENN B. SCHULZ
MANAGING DIRECTOR
Glenn.Schulz@fdtgroup.org
The FDT standard is the standard for the Process Industry
- Commissioning applications
- Asset Management applications

Most large HART and FF installations use the FDT standard
- Including HART Plant of the Year winners
- Written into procurement requirements

10+ year track record
- Millions of devices shipped
- Tens of thousands of hosts installed
- Supported by more than 90 companies

There is no charge to use the FDT standard
- Truly open and free

A large FDT EcoSystem to support vendors
- Services, toolkits, consulting
The FDT Standard

Allows any compliant device to be integrated into a host system (Frame)

Device vendor supplies a DTM (Device Type Manager)
- A software representation of the device
  - Configuration (wizards, smart guides, etc.)
  - Diagnostics
  - Troubleshooting
  - Manuals

Host system can “host” any number of DTMs
- Any device type, any vendor, any mix of industry buses
Key Features of the FDT Standard

**Extensible to any new industry bus**
- Simple “annex” process - e.g. ISA-100 recently added

**Transperantly tunnel (route) through all networks to talk with end device**

**Client server or standalone architectures**

**Layered security model**

**Latest version fully .NET**
- Backward compatible

**Recognized world-wide**
- IEC 62453 / ANSI ISA 103 / China GBT 29618

**No licensing or royalties to use the standard**
DTM Examples – Configuration
DTM Examples – Diagnostics
Three Types of DTMs

Device DTM

 Represents an “end” device e.g. a drive, prox, etc.

Communications DTM

 Provide communication channels which provide the services to access the fieldbus

Gateway DTM

 DTM representing a device that connects different fieldbus segments
Protocol Annex

- Written by technical experts for the protocol
- Maps protocol specific requirements and features into the FDT standard
  - No changes to the FDT standard or the Frame applications
- Provides derived classes and extended base arguments for methods to support the protocol specific requirements
- Defines required device DTM behavior, for example:
  - IO signals provided by the DTM
  - Mapping protocol specific data types to FDT data types
  - Support of scanning method
  - Handling of communication anomalies
- Deliverables include test cases for FDT conformance testing
CIP Annex Status

- FDT 1.2.x annex released in 2008
- FDT2 annex under development
  - David Comeau is the project leader
  - First TRB review this week
  - Expected release 1st Qtr 2016
An off the shelf demo

- A free, downloaded FDT Frame
- An Ethernet/IP communications DTM
- An ATV9xx family device DTM
- A Schneider Electric Altivar Process ATV9 Ethernet/IP AC drive
Core process industries

What are the characteristics of a chemical plant?

• Big foot print
• Long term running (~20-30 years)
• No plant shut down “button”
• Continuous processes without downtime
• Hazardous areas
“Clear requirements for use of EtherNet/IP in the field have to be fulfilled in core process industries”

Core requirements to be fulfilled

• Information and energy on a single cable
• Employable in hazardous areas
• Long distances communication between assets
• Easy handling
• High availability
Physical Layer – Overview and Demonstration of New Physical Layer Concepts for Industrial Ethernet and EtherNet/IP in Process Field Devices

Jens Schmidt, Pepperl+Fuchs
Agenda

- Application area
- Requirements
- Technical concept
- Live demonstration
- Outlook
Application area

- Standard Ethernet
- Industrial Ethernet (e.g. EtherNet/IP)
- Fieldbus (e.g. PROFIBUS, FOUNDATION Fieldbus)
- 4-20mA (and HART)
- Wireless (e.g. WirelessHART, ISA100)

Control Domain

Control Network

Network services

Safety Zone
# Requirements 1

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
<th>Met?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable length Control Room - Field Junction Box (Trunk)</td>
<td>1000 m / 3280 feet</td>
<td>✗</td>
</tr>
<tr>
<td>Cable length Field Junction box - Field Device (Spur)</td>
<td>200 m / 565 feet</td>
<td>✗</td>
</tr>
<tr>
<td>Connection method (Trunk and spur)</td>
<td>Copper, 2-wire for power + data</td>
<td>✗</td>
</tr>
<tr>
<td>Increased EMC immunity</td>
<td>NA 21</td>
<td>✗</td>
</tr>
<tr>
<td>Intrinsically safe option</td>
<td>Required</td>
<td>✗</td>
</tr>
<tr>
<td>Cable</td>
<td>Today used cable</td>
<td>✗</td>
</tr>
<tr>
<td>Connectors</td>
<td>Robust industrial-grade connectors</td>
<td>✗</td>
</tr>
</tbody>
</table>
### Requirements 2

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Field Devices per Trunk</td>
<td>more than 40</td>
</tr>
<tr>
<td>IO data update time</td>
<td>100ms (50 Byte IO) for 32 field devices</td>
</tr>
<tr>
<td>Communication performance for webservice, DTM etc.</td>
<td>Fluent / adequate</td>
</tr>
<tr>
<td>Implementation</td>
<td>Open solution with long time support</td>
</tr>
<tr>
<td>Cost aspect</td>
<td>Same order of magnitude than today</td>
</tr>
<tr>
<td>Power requirements</td>
<td>Low power to simplify implementation and allow higher number of devices</td>
</tr>
</tbody>
</table>
Result of Evaluation

After evaluation of the technologies available today Pepperl+Fuchs realized that they don’t fulfill the requirements for process automation field installations.

As an outcome of the evaluation Pepperl+Fuchs decided to design a new physical layer for Ethernet communication fulfilling the requirements of Process Automation field installations.
Concept structure

Switch

PactWare
FDI-i-DTM, Plant PAx

Up to 1000 m

Controller

WLAN Router

iPad
Web-Browser

PEPPERL+FUCHS
Control room switch

- Separate powered
- Switched technology
- Converts Ethernet (e.g. 4-wire, 100 Mbit/s) to two wire powered Ethernet

Ethernet

Powered, 2-wire, Ethernet communication
Concept structure

Switch

PactWare
FDI-i-DTM, Plant PAx

Controller

WLAN Router

iPad
Web-Browser

Up to 1000 m

Field-Switch Zone 1
Field-Switch

- Switched connections for instruments
- Switch and instrument powered over data line
- Intrinsically safe instrument connection
- Robust industrial-grade connectors
Concept structure

PactWare
FDI-i-DTM, Plant PAx

Switch

Controller

Up to 1000 m

WLAN
Router

iPod
Web-Browser

Zone 0

Up to 200 m

Zone 1

Zone 2

Controller

Field-Switch
Key figures 1

- 2-wire system for power and data
- Number of devices per trunk: > 60
- Usage of IEC-61158 Type A fieldbus cable
- Provides all benefits of switch network according to IEEE 802.1
- Intrinsically safe option for use in hazardous area Zone 2/Div 2, Zone 1/Div 1 and Zone 0
- Low power consumption supports cost efficient Field Device implementation (below 100mW)
- More power for advanced device functions
- Open implementation based on mass market components (No ASICs)
- Redundancy for cable and infrastructure components supported
Communication speed

- 10 MBit/s up to 500m / 1640 feet
- 2 MBit/s up to 1000 m / 3280 feet

Auto negotiation and dynamic baud rate switching supported

Requirement: 100ms (50 Byte IO) for 32 field devices

Trunk bandwidth usage of this IO data:

- 2 MBit/s: 28%
- 10 MBit/s: 5%
Live demo - highlights

- Ethernet network fulfilling field installation requirements for process automation
- Multi vendor demo proves feasibility of concept
- Integration of complex and simple devices into one homogeneous network
- Major step in communication speed enables upcoming IIoT use cases
- Compatibility to existing technologies FF, PA and HART offers migration path
- First presentation of field device prototypes utilizing the new physical layer to provide EtherNet/IP communication
Outlook

- The concept shows what is possible today using available technology
- Switched technology and build in auto negotiation support future speed upgrades when technology evolves
- Basically it’s only a physical layer. The concept shows a reasonable utilization for process automation installations but other usage is also possible.

- Pepperl+Fuchs works with many process automation suppliers to create an international and open standard
The demo will be available for more detailed questions and presentation at the Magnolia room tomorrow and on request.
Industry Perspectives on EtherNet/IP for the Process Industries

- Mirko Brcic, ODVA Chairperson for Process SIG
- Shannon Foos, Rockwell Automation
- Terry Minns, Schneider Electric
- Rene Pluis, Cisco Systems
- Jens Schmidt, Pepperl+Fuchs
- Glenn Schulz, FDT Group
- Olivier Wolff, Endress+Hauser
THANK YOU
Links To Referenced Documents

White Paper Press Release

SIG Formation Press Release

White Paper

Work Plan (Accessible by ODVA Members)