Inter-device Connectivity and Foundations of Industrial Internet

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Me

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- System Insights – Predictive Analytics 4 Mfg
- Chief Strategy Officer
- MTConnect Chief Architect and Chair of TSC
- Done lots of stuff for many industries
Agenda

• Inter-device connectivity
  – Demonstration of Part 3.1 Interfaces

• Industrial Internet
  – MTConnect as foundation of industrial internet
Inter-device connectivity using read-only communication
Observation Communication Pattern

MTCONNECT INTERFACES
Interfaces

MTConnect Agent

Control

Executive

h1p://…

Safety

By Design

Control

Executive

MTConnect

HTTP $Get$ $Read$ Only

h1p://…
Connectivity

Present - $$$$$

MTConnect - $
Distributed Intelligence

Present

Cell Controller

MTConnect
Wires

Haas Robot Ready Option - 2014
Communications

Present

States

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MTConnect

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Complexity

Traditional

Distributed

Cell Controller
Interfaces

- Chuck
- Door
- Material Handler
- Bar Feeder
Completing Task

Request

Response

Robot

READY → ACTIVE → COMPLETE

READY → ACTIVE

Machine Tool

Request

Response

Robot

READY → ACTIVE → COMPLETE

READY → ACTIVE

Machine Tool
Back to Ready

Request

Machine Tool

Robot

READY ➔ ACTIVE ➔ COMPLETE

Request

Machine Tool

Robot

READY ➔ ACTIVE ➔ COMPLETE
DEMONSTRATION
Door States
Door States
Success

Load

Given cnc MaterialLoad should be Active
When robot MaterialInterface MaterialLoad becomes Active
Then material load state should be processing
And cnc DoorState should be Open
And cnc Rotary ChuckState becomes Open
And cnc ChuckState should be Open
Then machine state should be loading
When robot ChuckInterface Close becomes Active
Then cnc CloseChuck should be Complete
Then after 1.2 seconds cnc CloseChuck should be Complete
And cnc ChuckState should be Closed
When robot DoorInterface Close becomes Ready
And robot DoorInterface Close becomes Active
Then cnc CloseDoor should be Active
Then after 1.2 seconds cnc CloseDoor should be Complete
And cnc DoorState should be Closed
When robot MaterialInterface MaterialLoad becomes Complete
And robot MaterialInterface MaterialLoad becomes Ready
Then machine state should be cycle_start
And cnc MaterialLoad should be Not_Ready
And robot MaterialInterface MaterialLoad becomes Ready

Unload

Scenario: Cnc asks Robot to Unload Material
Given machine state should be unloading
When robot MaterialInterface MaterialUnload becomes Active
Then material unload state should be processing
When robot DoorInterface Open becomes Active
Then cnc OpenDoor should be Active
And cnc DoorState should be Unlatched
And after 1.2 seconds cnc OpenDoor should be Complete
And cnc DoorState should be Open
When robot ChuckInterface Open becomes Active
Then cnc OpenChuck should be Active
And cnc ChuckState should be Unlatched
And after 1.2 seconds cnc OpenDoor should be Complete
And cnc ChuckState should be Open
When robot MaterialInterface MaterialUnload becomes Complete
Then cnc MaterialUnload should be Not_Ready
And cnc MaterialLoad should be Active
And machine state should be loading
Chuck Failure

Given robot MaterialHandlerInterface
MaterialLoad becomes Active
Then material load state should be processing

When robot ChuckInterface Close becomes Active
Then cnc CloseChuck should be Active
And cnc Rotary ChuckState becomes Unlatched

When cnc ChuckInterface Close becomes Failure
Then close chuck state should be fail
And cnc CloseChuck should be Fail
And cnc ChuckState should be Unlatched
And cnc should have fault
And machine state should be fault
And cnc fault should have code "Cnc::CloseChuck"

Out of Material

Given robot MaterialInterface MaterialLoad becomes Active
Then material load state should be processing
When robot faults Device FILL_LEVEL with "No Material"
And robot MaterialInterface MaterialLoad becomes Fail
Then cnc MaterialLoad should be Fail
And machine state should be loading
And material load state should be fail
When robot MaterialInterface MaterialLoad becomes Not_Ready
Then machine state should be idle
And cnc MaterialLoad should be Ready
When robot clears Device FILL_LEVEL
And robot MaterialInterface MaterialLoad becomes Ready
Then machine state should be loading
And cnc MaterialLoad should be Active
Next Steps
Foundation of Manufacturing Technology Information Model and Communications

INDUSTRIAL INTERNET
Types of Standards

Communications
• Ethernet/IP, ProfiNET/BUS
• Modbus
• Bacnet
• OPC/UA
• MQTT
• OpenDDS

Information Models
• STEP-NC/AP-238
• ISO 13399 (Tooling)
• MIMOSA
• ISA-95/B2MML
• PLC Open
• QIF/DMIS/I++
What MTConnect Provides

• Pub/Sub Protocol with Event History
• Store and Forward
• High Performance with Push
• Asset (doc) Storage w/ Information Models
• Two Tier Architecture for Security and Safety
Layers of Standards

- **ERP / MES**
  - Initial Plan
  - B2MML (ISA-95)
  - ISO 13999
  - Cutting Tools

- **Scheduling**
  - Initial Plan
  - MTConnect Part Archetype Model
  - MTConnect Part Model

- **Part Tracking and Analytics**
  - ISO 13374 – Open O&M
  - Executed
  - MTConnect Part Model

- **Real Time Data**
  - MTConnect
  - Cutting Tools
  - Process Plan

- **UPnP**
  - Discovery

- **OPC**
  - Ethernet/IP
  - MODBUS
  - FOCUS 2
  - LSV2

- **Device A**
- **Device B**
- **Device C**
- **Device D**
- **Device E**
- **Device F**
- **Device G**

Cradle to Gate
Collaborate & Appropriate

- Primary Focus: Information Model
- Never Invent If *Reasonable* Alternative Exists
- Find Standards to Provide Dependent services
- Harmonize
- Collaborate – example: OPC/UA
Security - CASSaVa

Communication
• Connection/Firewall
• On the Wire

Safety
• Human in the Loop

Access
• Authentication
• Authorization
  – Read
  – Write

Storage
• In Memory
• At Rest
• Derived

Verification
• Validity
• Provenance
• Authenticity
MTConnect Domain Security

• Agent Authentication – Use existing standards
• Access attached to Components, Data Items, and Assets
• Use the information model and “types”
• Example: PathPosition has more security risk than ControllerMode and Execution
Future Services

• Next Generation Products and Services
• Outcome based economies
• Economies of Scale
• Digital Thread and Distributed Manufacturing
Outcome Economies

Tools

Holes
Grand Challenges

• Art to Part
• Design for Manufacturing and Engineering Close Loop
• Dynamic Process Optimization
• Sustainability
• Full Automation – Systems of Systems...
Next Steps

• Complete MTConnect Technical Roadmap
• Harmonize with other standards groups
• Disseminate Benefits of Interoperability
• Create new Markets, Opportunities, and Capabilities
QUESTIONS

Thank you...
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