The Internet of Manufacturing Things

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The Internet of Things

“interconnection of sensors, devices, and other things”
The Hype Cycle
Why Manufacturing?

- Manufacturing is Big: $2 Trillion sector
- Discrete Manufacturing: Products for consumers and the supply chain
- High potential for productivity improvement
- Manufacturing generates a very large amount of data – most of it falls on the floor
Manufacturing Today

- Global
- Fragmented
- Heterogeneous
Improving the Transformation

• Focus:
  • Productivity? Profitability? Return on asset?
  • Part quality? Employee safety?
  • Sustainability? Energy usage?
  • How about a more holistic view?
Grand Challenge: Process Traceability
Track flow of resources and intelligence across manufacturing process

Manufacturing

Foundry  Forging  Roughing  Finishing  Sub-Assembly  Warehouse  Final Assembly  Shipping

Time

unique part

Design Impacts

Usage Impacts

Process Improvement
Design Integration
Usage Analytics
Enabling Technology

Internet of Manufacturing Things

Standards  Sensors  Software

Internet of Things
Standards

How Standards Proliferate:
(See: A/C chargers, character encodings, instant messaging, etc.)

Situation: There are 14 competing standards.

14?! Ridiculous! We need to develop one universal standard that covers everyone’s use cases.

Yeah!

Soon:

Situation: There are 15 competing standards.
Why no Standards?

• Manufacturing data highly complex

• High barriers to entry

• Specialized technical knowledge deterrent to innovation
Why Standards!

What do you prefer?
MTConnect

• Open royalty-free standard providing data from devices using a common unambiguous vocabulary

• Uses XML and HTTP – Internet ready

• Simple, free, and extensible

• Design Goals
  • Capture manufacturing domain model
  • Read-only – inherently secure
  • Borrow when you can
Differentiation

• How is MTConnect different than OPC, Ethernet/IP?

  • OPC is a transport – it gets data from one location to another

  • Same with the field-buses

  • OPC and Ethernet/IP do not have a domain model – nothing specific for manufacturing

• Tags are different for every implementation
Example: “Current Postion”

• OPC
  • Siemens Controller: /Channel/MachineAxis/actToolBasePos[u1,1] – returns a single value
  • Bosch Controller NC.Chan.AxisPosMcs,1 – returns a vector of values that needs to be decoded

• MTConnect
  • Devices
    <Axes id="a" name="axes">
      <Linear id="x1" name="X">
        <DataItems>
          <DataItem category="SAMPLE" id="x2" name="Xact" subType="ACTUAL" type="POSITION" units="MILLIMETER"/>
        </DataItem></Linear></Axes>

  • Stream of data
    <ComponentStream component="Linear" name="X" componentId="x1"><Samples><Position dataItemId="x2" timestamp="2014-02-18T23:32:11.133634" name="Xact" sequence="2810505090" subType="ACTUAL">2.0019900000</Position></Samples>
IoMT Requirements

• Security
  • MTConnect is read-only and inherently secure

• Reliability
  • MTConnect provides a reliable messaging platform

• Performance
  • MTConnect can run on embedded platforms
  • One agent can support multiple devices

• Sensor data
  • The most complete standardized sensor vocabulary and extensible for new sensors
  • Support for real-time time-series data
IOT Standards

- MQTT Protocol
  - Lightweight IP-based M2M communication protocol
  - Pub/sub model – highly scalable
  - Large community, supported by Eclipse

- MQTT + MTConnect
  - Take domain model of MTConnect and apply in MQTT
  - MTConnect can sit below/above MQTT layer based on the application
The Digital Thread

Integrating manufacturing with the design phase
Standards along the way

Idea → Initial Model → Design Refinement → Solid Model

Design

Manufacturing Planning → Manufacturing Process → Metrology → Product

Manufacturing

STL, STEP, IGES

STEP-NC ▶ MTConnect ▶ QIF/DMSC
But can we do better?

• We have standards for the boxes – what about the arrows?

• How do we standardize analysis across the digital thread?

• We need cross-standard interoperability
Sensors
Sensors

• Enable decision-making and automation

• Sensors at every level:
  • Manufacturing process —> Supply Chain

• What we need:
  • Minimally Invasive
  • Physics based

• Open question: Where do you put the intelligence?
Sensor Intelligence

- Traditional Approach: Self-contained local command-and-control loops
- Is centralized intelligence possible?
- Challenges: data load, bandwidth, latency
- Solution:
  - Distributed decentralized systems
  - Split decisions between local and central controllers
Software
Software

• Data Management:
  • High data volumes
  • Structured and unstructured data

• Decision-making:
  • Event-based decision making
  • Multi-dimensional reasoning
  • Multiple temporal scales
Data Volumes

Small Shop: 2~10 TB/year
Medium Shop: 5 ~ 25 TB/year
Large Shop: 16 ~ 80 TB/year
Enterprise: 80 ~ 5000 TB/year
US Machining Sector: 200 PB ~ 1XB/year
Data Types

- **Structured**
  - Sensor
  - Machine Telemetrics

- **Unstructured**
  - Alarms, Faults
  - Quality Control
  - Performance + Test

- **Tribal Knowledge**
  - Annotations
  - Over-rides
  - Interruptions

So what do we do with all of this data?
Event Reasoning

Event: Something that happened at a point in time

The Manufacturing Event Cloud

- spindle speed
- position
- tribal knowledge
- alarms
- feedrate overrides
- notification
- static data

Event Processing
- fusion
- filter
- aggregate
- identify relationships

Complex Event Processing

Temporal
- Overlap
- Before/After
- Contains

Spatial
- Clustering
- Shapes
- Trending
Temporal Decision Scales

Temporal scales can vary from µ-seconds to days:

- **Anytime**: process management
- **Neartime**: process improvement
- **Realtime**: process control

Manufacturing Analysis Scale:
- Manufacturing Supply Chain
- Manufacturing Enterprise
- Manufacturing Equipment
- Sub-Components
- Process Interface

Temporal Decision Scale:
- m-Seconds
- Seconds
- Hours
- Days
Multidimensional Reasoning

Multi-dimensional reasoning allows us to slice data across any plane, including: time, machine organization, parts.
IoMT: Enabling Technology

- High speed data from heterogeneous sources
- Integration across software and hardware platforms
- Decision-making across spatial and temporal resolutions
IoMT vs. IoT

• Enterprise focused vs. Consumer Focused
• Islands of Excellence vs. New Ecosystems
• Mature markets vs. New Markets
• “the internet of what?” vs. “take my money!”
Closing Thoughts

- Terrific potential
- Being domain specific helps – a lot
- Don’t reinvent the wheel
- Boxes ok, Arrows need work