The Internet of Manufacturing Things

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The Internet of Things

“interconnection of sensors, devices, and other things”
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

- Productivity? Profitability? Return on asset?

- Part quality? Employee safety? Product reliability?

- Sustainability? Energy usage? Pollution?
Grand Challenge: Process Traceability
Track flow of resources and intelligence across manufacturing process

Manufacturing

- Foundry
- Forging
- Roughing
- Finishing
- Sub-Assembly
- Warehouse
- Final Assembly
- Shipping

Unique part

- Design Impacts
- Usage Impacts

Process Improvement
Design Integration
Usage Analytics
Manufacturing in the Frontiers

Solving the Grand Challenge

Standards
Sensors
Software
Standards

• Manufacturing data highly complex

• Specialized technical knowledge deterrent to innovation
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
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

- 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

Unstructured

Tribal Knowledge

Sensor Machine Telemetrics

Alarms, Faults Quality Control Performance + Test

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
- static data

Event Processing
- fusion
- filter
- aggregate
- identify relationships

Complex Event Processing

Temporal
- Overlap
- Before/After
- Contains

Spatial
- Clustering
- Shapes
- Trending
Multidimensional Reasoning

Multi-dimensional reasoning allows us to slice data across any plane, including: time, machine organization, parts.
Temporal Decision Scales

Temporal scales can vary from µ-seconds to days

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

Temporal Decision Scale

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

- Axes:
  - m-Seconds
  - Seconds
  - Hours
  - Days
The Internet of Manufacturing Things

Enabling technology for:

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

- Enterprise focused
- Islands of excellence – integration missing
- Mature markets
Closing Thoughts

- Terrific potential
- Being domain specific helps – a lot
- Don’t reinvent the wheel
- Everything is connected