IoT 4 MFG

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Edge / Fog / Cloud Computing

- High frequency data acquisition
  - Analog, digital, serial

- Embedded computing platforms
  - Arduino
  - Beaglebone
  - Raspberry Pi

- Computation performed on embedded device
  - Transmit data in MTConnect format to agent
  - Interface directly with database
Big Data Generation – On Board Sensors

- Website for accessibility
  - List of machines with images as links
  - Review machine programs
  - Graphs plotted from near real time data
Uploading to the Cloud

MTConnect Adapter

Smart Box

PC

INTERNET

The Cloud

MTConnect Agent

XML (MTConnect Compatible)

Other sensors (Accelerometers, fluid levels)

BeagleBone MTConnect Adapter (Working on an Agent)
Product and Process Tracking Example

Upload materials and tools

Collect Spindle speed, power and variation of tool offset

Register final piece

Operations in the cloud
Big Data
Predictive models
Mobile Device Integration

- Data visualization on smartphones
  - Using cloud database (Google Sheets)

Past 60 minutes

Past 24 hours

Past 12 days
Mobile Device Integration – Smartphones / Tablets

- **Local and Online Machines**
  - Direct access to machine data
  - Display the current status

- **Cloud for local machines**
  - Data transmits to a cloud database (AWS, Google Sheets)
  - Display current and historical data
IF This Then That (IFTTT): A free web-based service to create chains of simple conditional statements, called applets.
Twilio

Twilio allows software developers to programmatically make and receive phone calls and send and receive text messages using its web service APIs.

- Programmable SMS
- Programmable Voice
- Programmable Video
- Programmable Chat
- Programmable Fax
AWS Lambda is a serverless computing platform that runs code in response to events.
Shock monitoring – integration of Twilio, GS, IFTTT

ADXL377 - 200G analog accelerometer
Alexa integration – AWS Lambda, IFTTT

Alexa – Excuse me Professor Kurfess, some one is cutting steel with a hardness of 40-50 Rockwell C on the ME 2110 band saw.”

Tom – Alexa, send a note to ME 2110 s with the picture, and into asking the student to see me in my office immediately.”

Alexa – I have sent the following message to ME 2110, “Will the person who is shown in this picture cutting steel with a hardness of 40-50 Rockwell C on the ME 2110 wood band saw, please see Professor Kurfess in his office immediately. Also, please turn off the saw before coming to his office.”
Low-cost sensors:
- Vibration based PM
- OEE
- Coolant health

Wireless calipers and instruments

Yo-yo Production Process

Version 1 – Fall 2017
- More mass
- Thick center
- Complex inner profile

Version 2 – Spring 2018
- Less mass
- Thin center
- Simple inner profile

Mobile App / Cloud / Deep Learning
- Surface finish
- Machine monitoring, material, and tool usage analytics
- Live run charts and notifications

Yo-yo Production Process Data Analytics

Wireless Machine Monitoring System
Digital Signal Processing

1D: Sound

1982

2D: Image

1987

3D: Volume

1987

Digital Image Processing

1992

1997

Digital Volumetric Processing (DVP)

1991

1999

2008

2017

2018

Digital Volumetric Processing (DVP)

201x
DVP and Machining (aka Subtractive)

Analog Approach

Digital Approach
Hybrid Dynamic Tree (HDT)

- HDT: combination of two-level grid and octree

(16 \times 2^3 \times 16)^3 = 2,048^3 \text{ resolution}
DVP – Enabling WYSIWYG MFG

By the way, It works for Additive Manufacturing as well
Gravity – It’s not just a Recommendation, It’s the Law
Breaking the Law – Thinking Outside the Parallelepiped
Thinking Big
The Digital Twin – Simply Taking on Moore’s Law

Chen and Kurfess, 2017

https://www.linkedin.com/pulse/moores-law-heterogeneity-deep-learning-chien-ping-lu
Let’s Rent a Few Tens of Thousands of Cores

Available as of September 30, 2016
GPUs are 2 generations behind

Available as of November 10, 2010
GPUs are 4 generations behind
You Want it When?

1 GPU- $2.40  
2 hours 40 minutes  
7:29 pm Completion

8 GPU- $2.76  
23 minutes  
4:50 pm Completion

16 GPU- $2.88  
12 minutes  
4:39 pm Completion

2.66 hours X $0.9/hour  
(2.66 hours / 8) X $7.2/hour  
(2.66 hours / 16) X $14.4/hour
DVP & Education – Virtually There
Designing, Building and Thinking in New Ways
Beyond Manufacturing
IoT4MFG – Morphing Makers to Manufacturers

Chen and Kurfess, 2017

Bearing vibration signal & VMD

Voxel Transforming Agents
Advanced Materials

Elasticity & Strength

Chen and Kurfess, 2017

To view more parts online, please visit our website.
What is the Right Product Life Cycle Model?
Validation in the The Digital World
Validation: Can We Afford to Do it the Old Way?

1959 Chevrolet Bel Air vs. 2009 Chevrolet Malibu
How Do We Reconcile?
When am I Going to Lose my Job?
Lexus Automatic Parking
What do we Need to Do?

- Workforce development
- Policies
- Regulation / Deregulation
- Integration
- Metrics
- Validation
- Standards
  - New
  - Modifications

Do Not Underestimate the Human Factor