IoT 4 MFG

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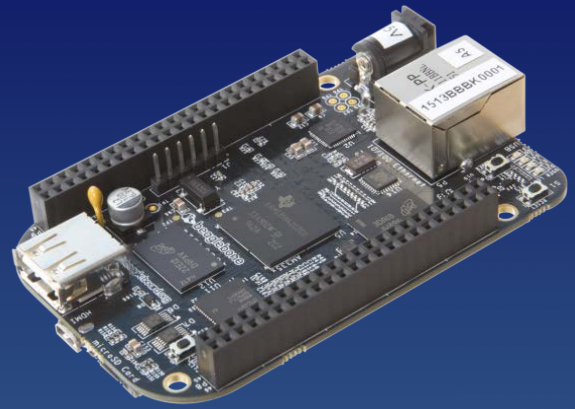
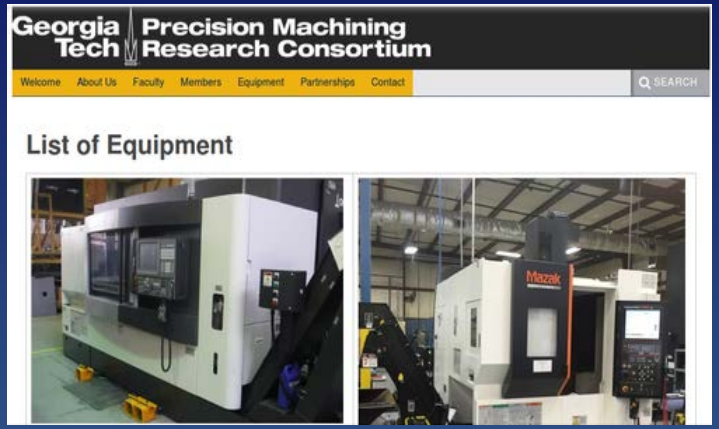
Edge / Fog / Cloud Computing

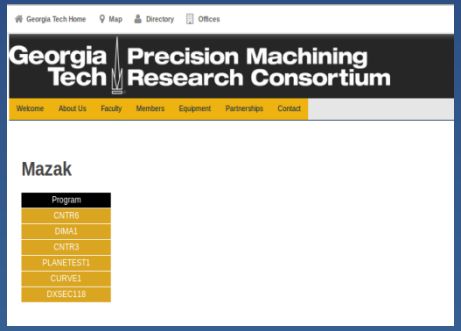
- High frequency data acquisition
  - Analog, digital, serial
- Embedded computing platforms
  - Arduino
  - Beaglebone
  - Raspberry Pi
- Computation performed on embedded device
  - Transmit data in MTConnect format to agent
  - Interface directly with database

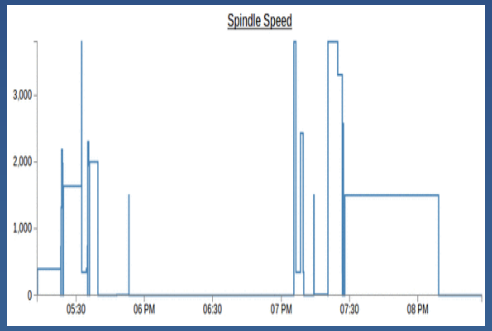


Big Data Generation – On Board Sensors

- 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

MTConnect Agent

Smart Box

MTConnect

PC

INTERNET

The Cloud

amazon web services

Other sensors (Accelerometers, fluid levels)

BeagleBone MTConnect Adapter (Working on an Agent)

XML (MTConnect Compatible)

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Product and Process Tracking Example

Upload materials and tools

Collect Spindle speed, power and variation of tool offset

MTConnect

Register final piece

Operations in the cloud
Big Data
Predictive models

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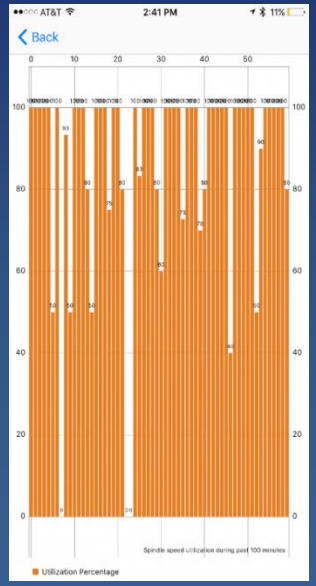
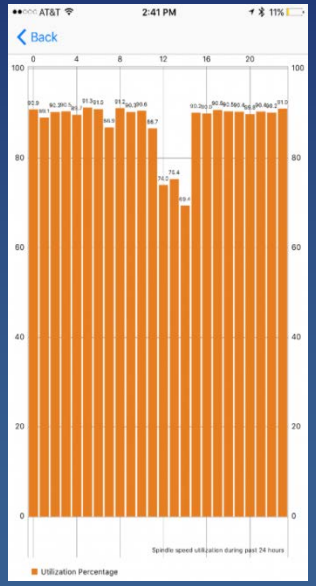
Mobile Device Integration

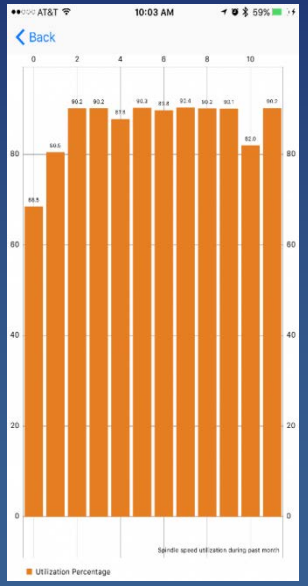
- Data visualization on smartphones
  - Using cloud database (Google Sheets)



Past 60 minutes



Past 24 hours



Past 12 days

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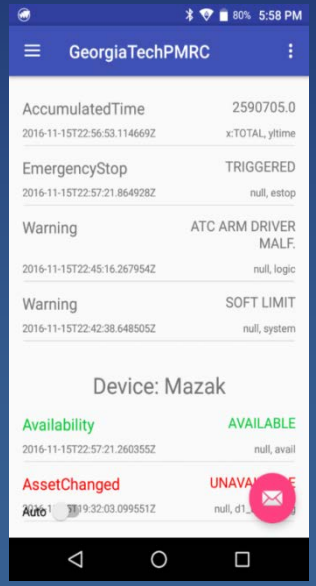
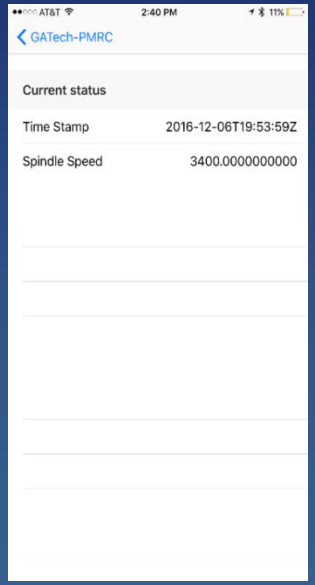
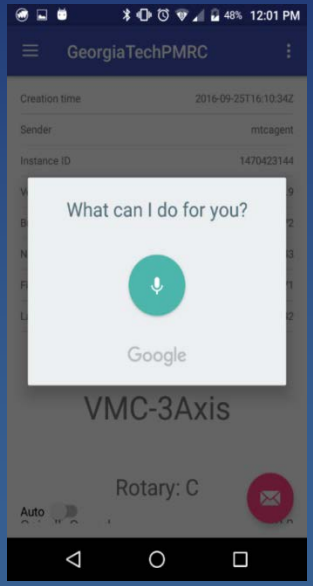
Mobile Device Integration – Smartphones / Tablets

- 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

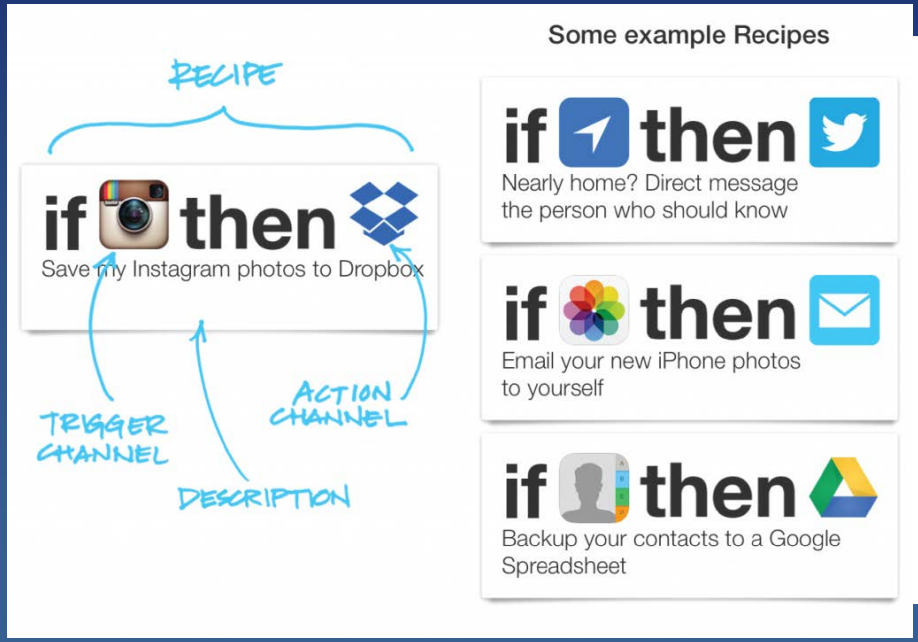


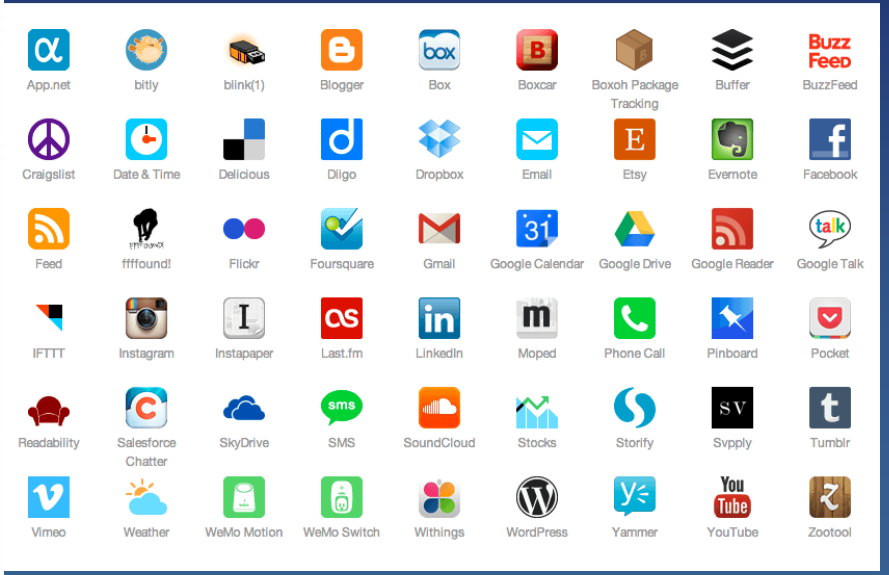




IFTTT

- 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

twilio

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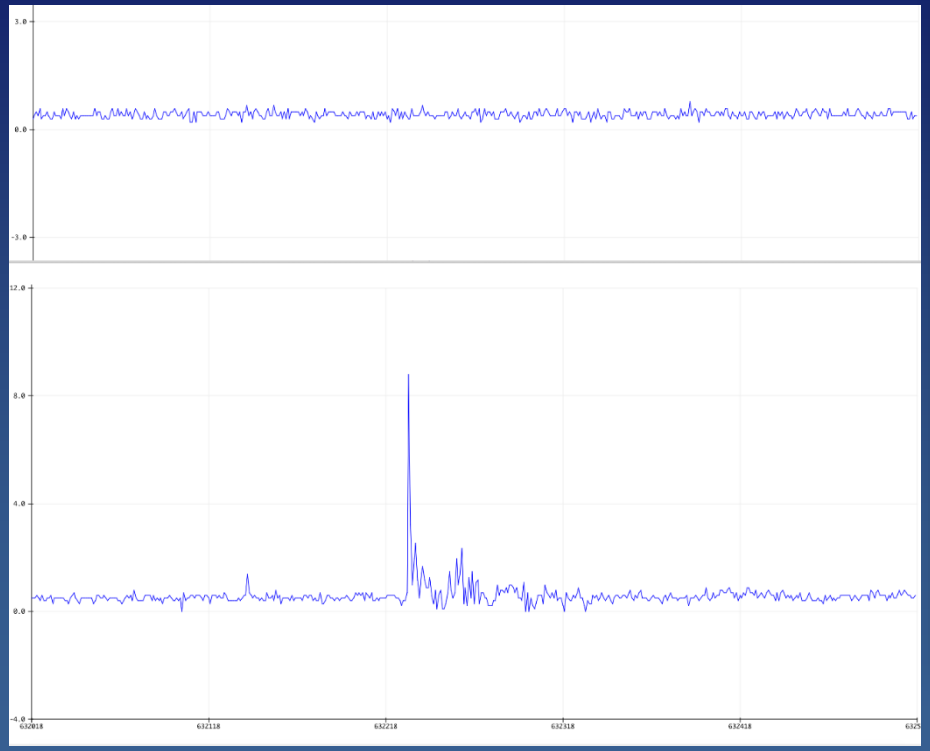
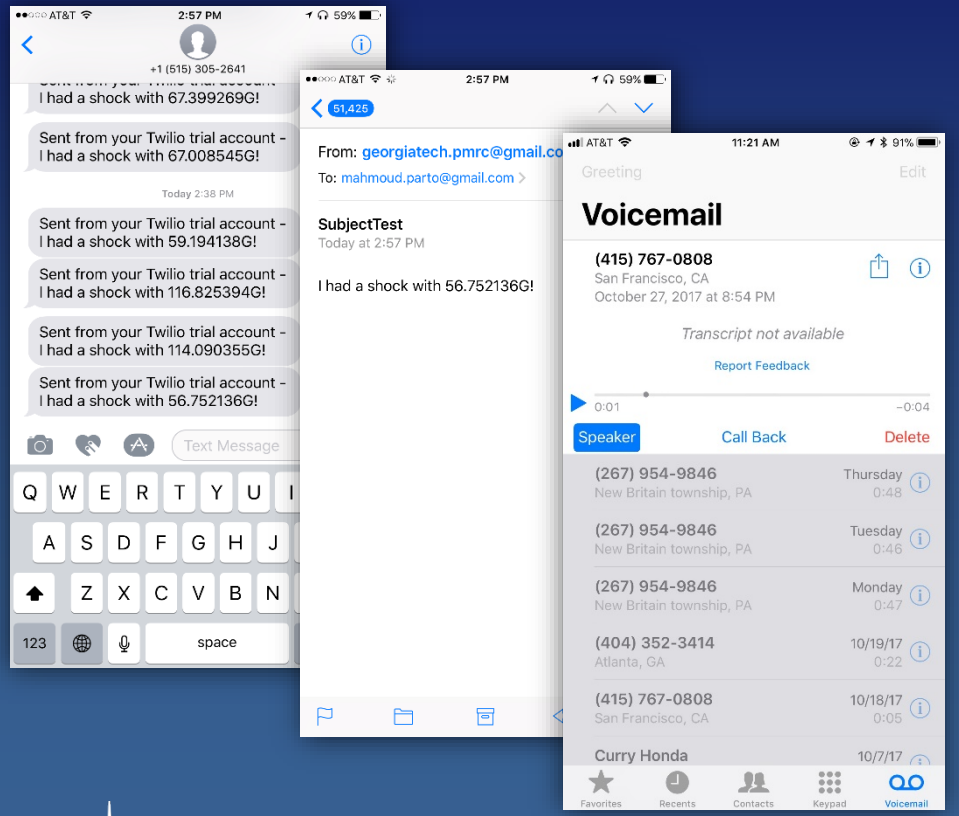
Amazon Lambda

- 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

Amazon Echo Dot

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."

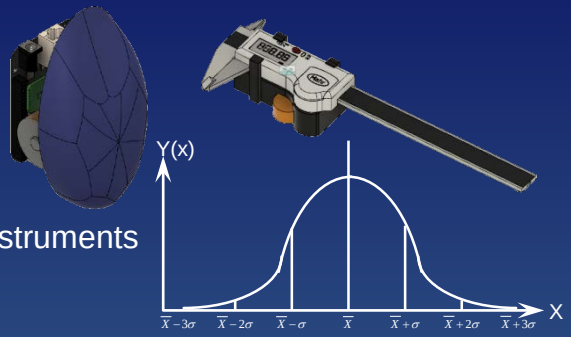
Alexa – I have sent the following message to ME 2110, "Will the person who is shown in this picture cutting steel with a hardness of 40-50 Rockwell C on the ME 2110 wood band saw, please see Professor Kurfess in his office immediately. Also, please turn off the saw before coming to his office."

Research / Education / Workforce Development

Wireless Machine Monitoring System

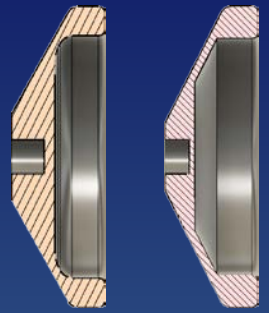
Low-cost sensors:
- Vibration based PM
- OEE
- Coolant health

Wireless calipers and instruments



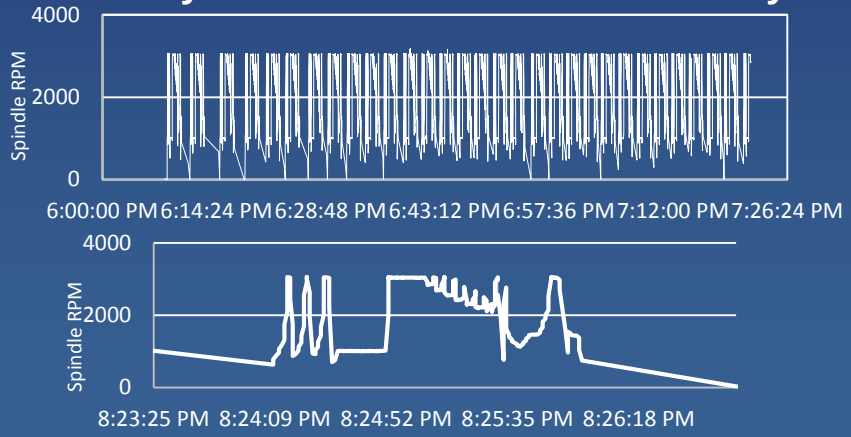
Yo-yo Production Process

<u>Version 1 – Fall 2017</u>
More mass
Thick center
Complex inner profile



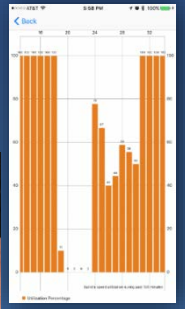
<u>Version 2 – Spring 2018</u>
Less mass
Thin center
Simple inner profile

Yo-yo Production Process Data Analytics



Mobile App / Cloud / Deep Learning

- Surface finish
- Machine monitoring, material, and tool usage analytics
- Live run charts and notifications



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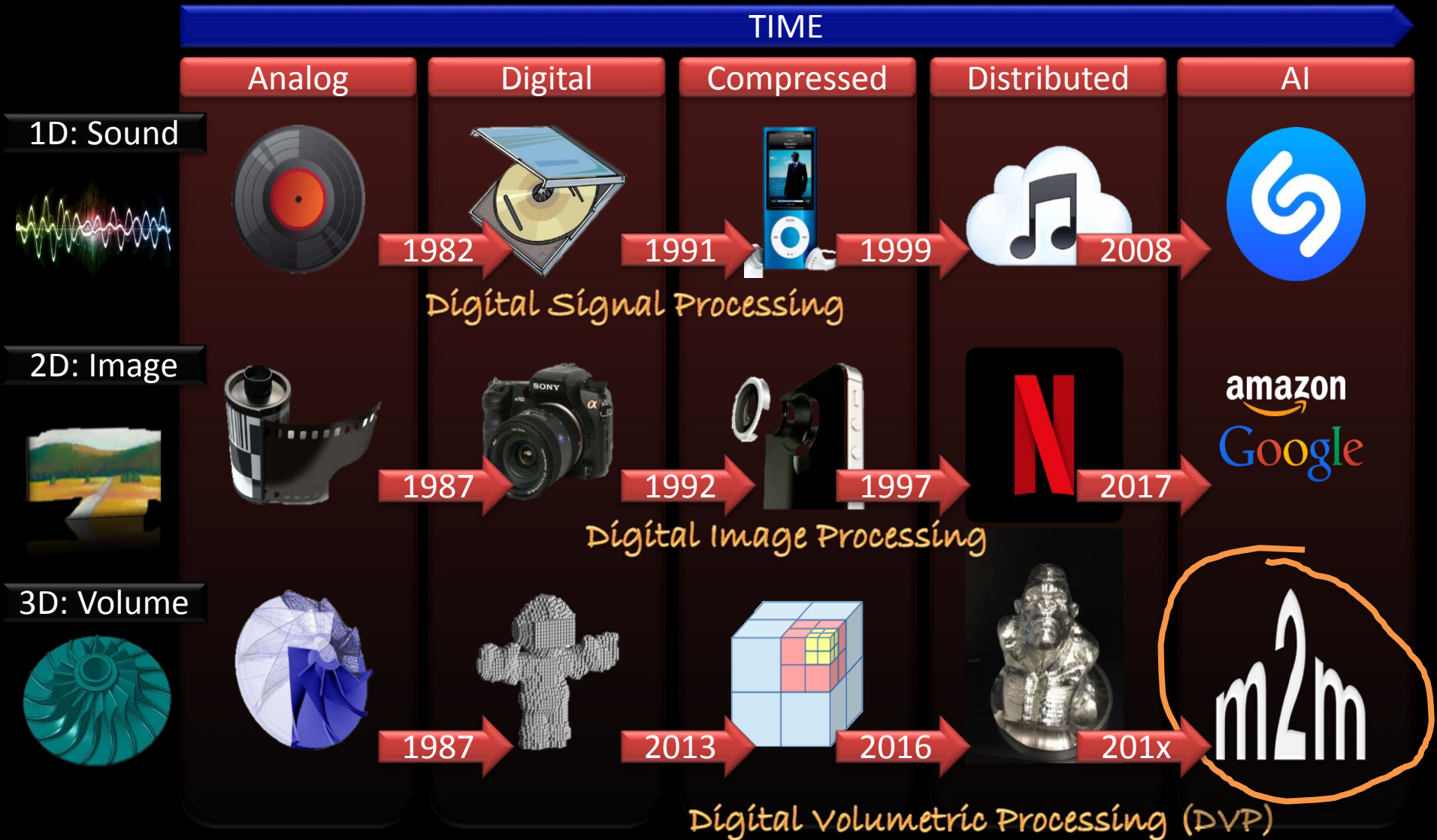
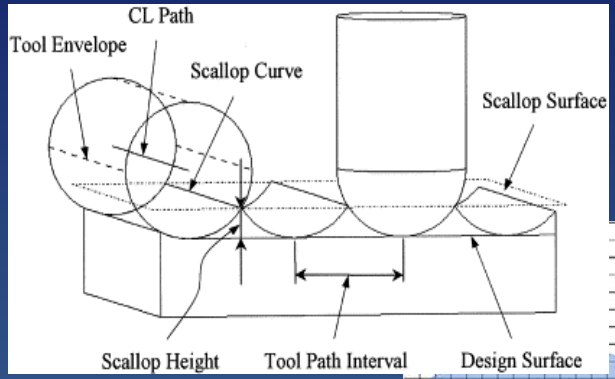
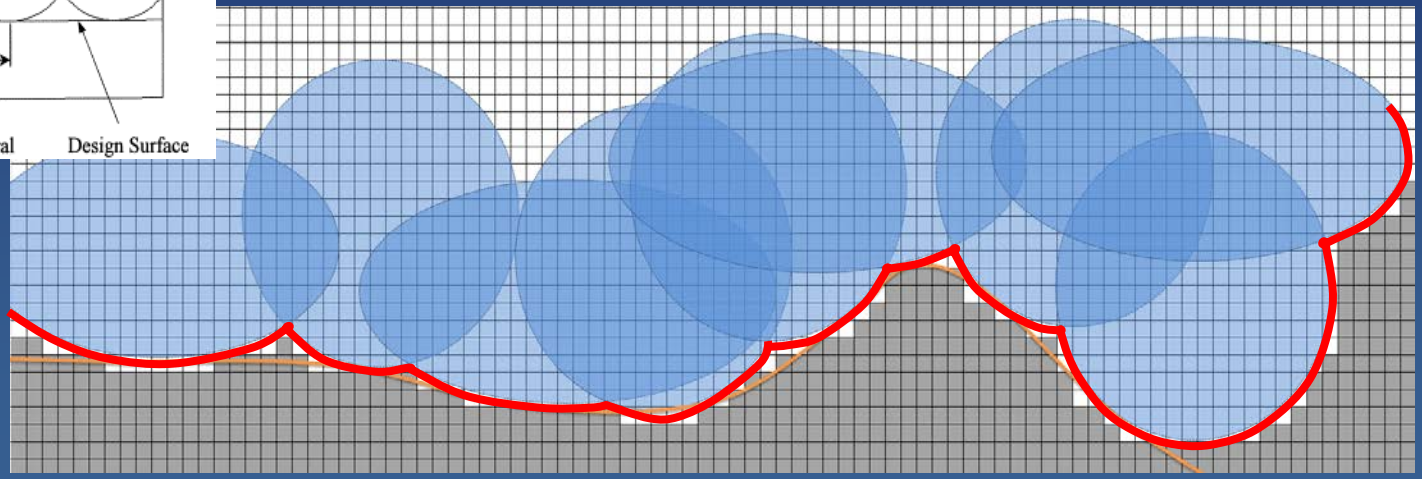

TIME
Analog
Digital
Compressed
Distributed
AI
1D: Sound
1982
1991
1999
2008
Digital Signal Processing
2D: Image
SONY
1987
1992
1997
2017
amazon
Google
Digital Image Processing
3D: Volume
1987
2013
2016
201x
m2m
Digital Volumetric Processing (DVP)

DVP and Machining (aka Subtractive)

Analog Approach

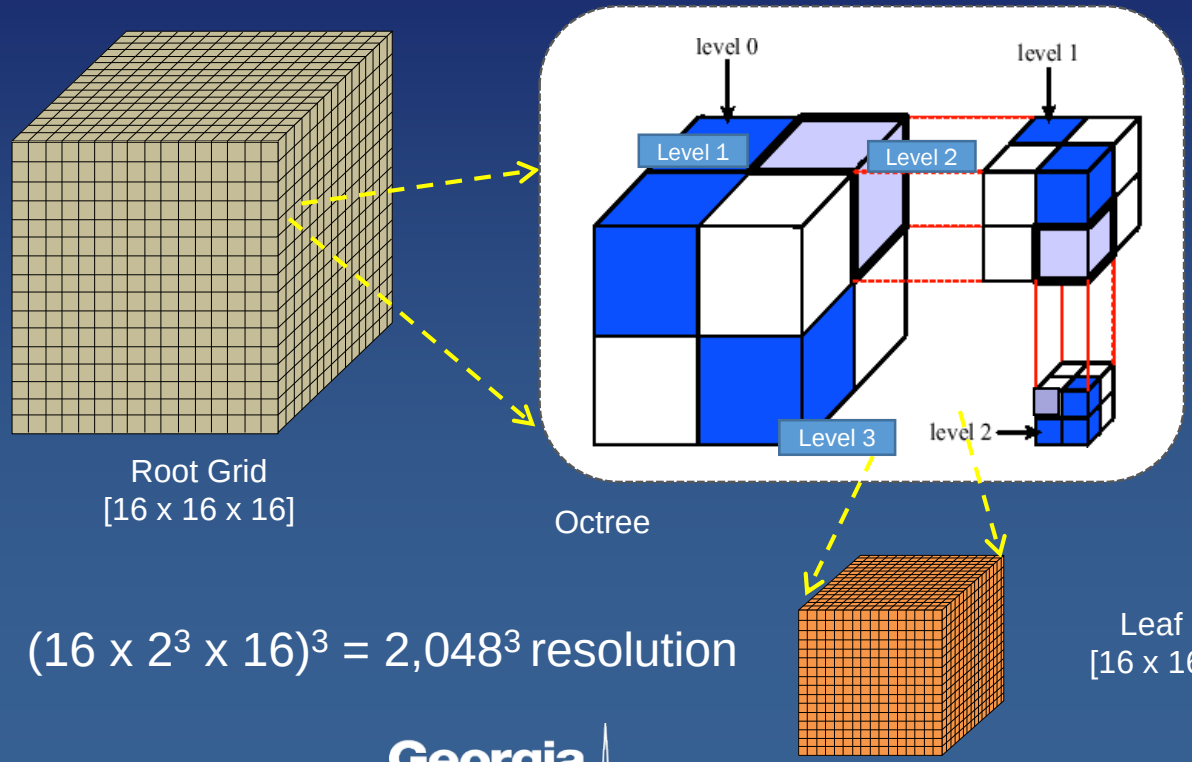


Digital Approach



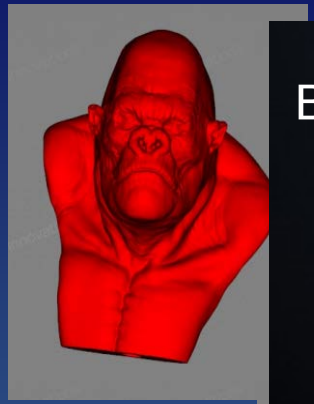
Hybrid Dynamic Tree (HDT)

- HDT: combination of two-level grid and octree

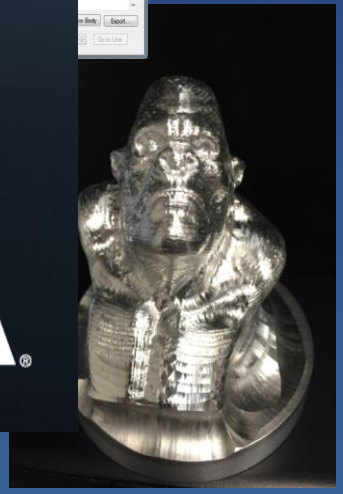


$(16 \times 2^3 \times 16)^3 = 2{,}048^3$ resolution

DVP – Enabling WYSIWYG MFG



By the way, It works for Additive Manufacturing as well



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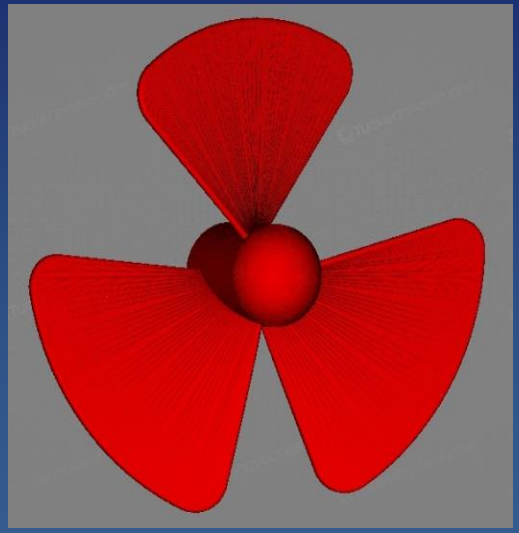
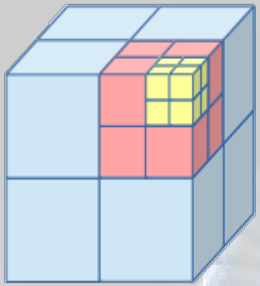
Gravity – It’s not just a Recommendation, It’s the Law

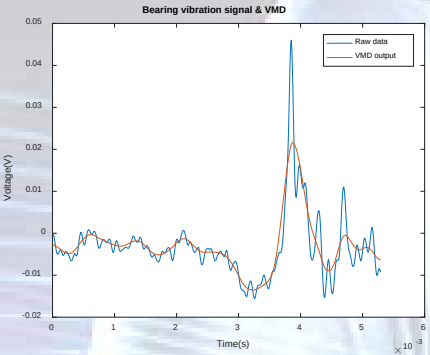
Breaking the Law – Thinking Outside the Parallelepiped



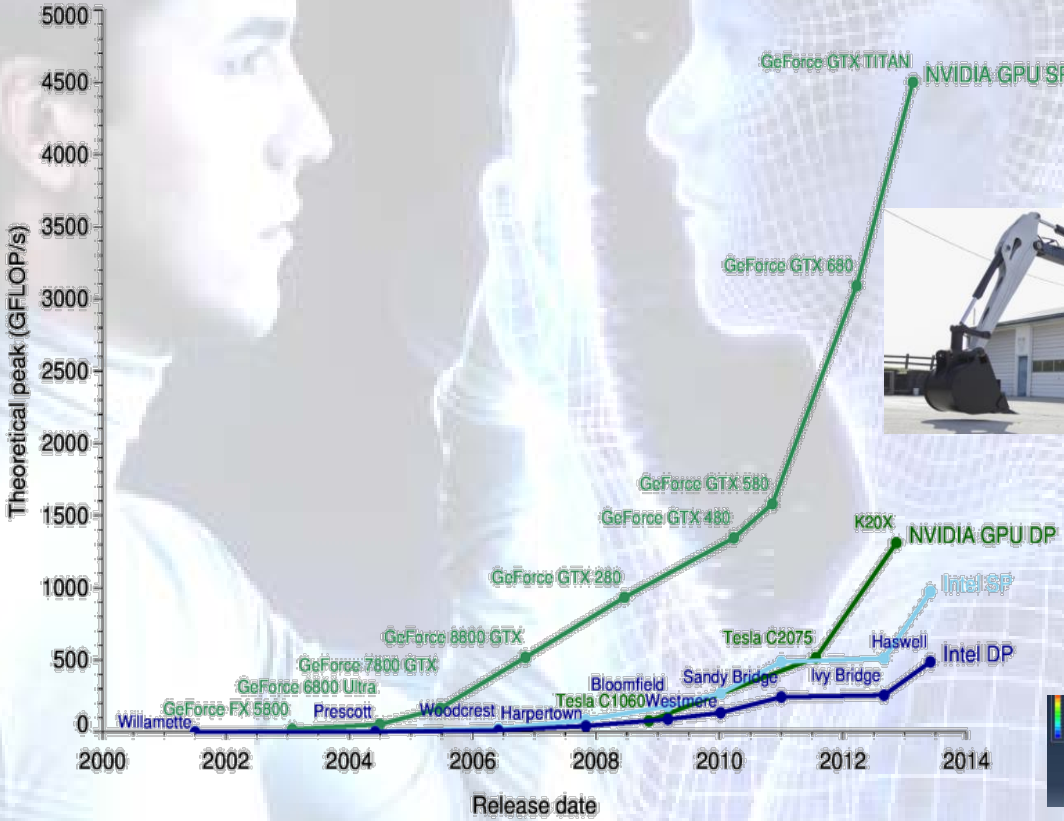
Thinking Big

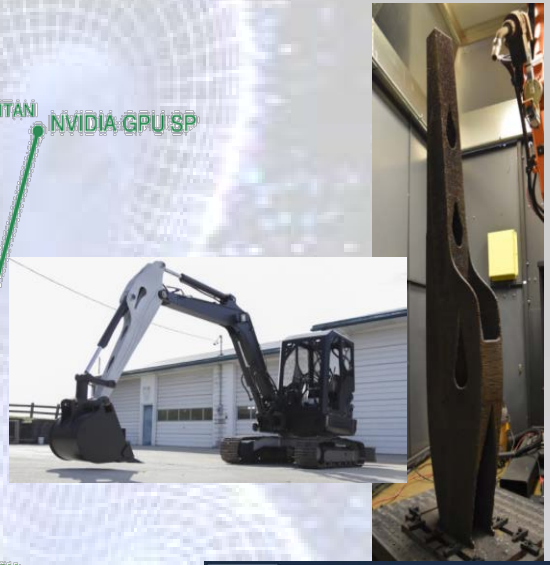
The Digital Twin – Simply Taking on Moore's Law

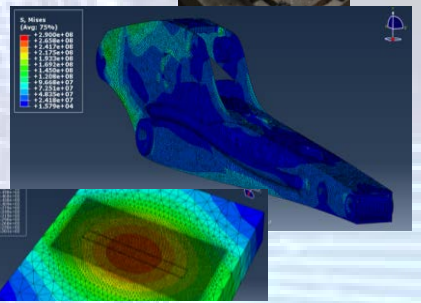




Chen and Kurfess, 2017







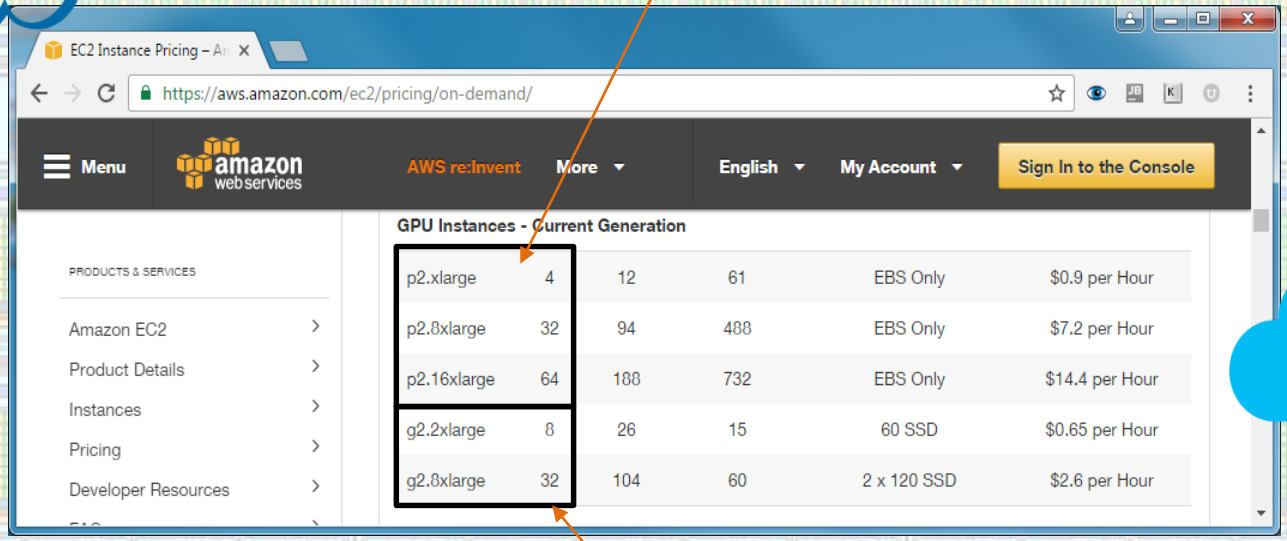
https://www.linkedin.com/pulse/moores-law-heterogeneity-deep-learning-chien-ping-lu

Let's Rent a Few Tens of Thousands of Cores

bluebox cloud

amazon web services™

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



Azure

Google Compute Engine

Available as of November 10, 2010
GPUs are 4 generations behind

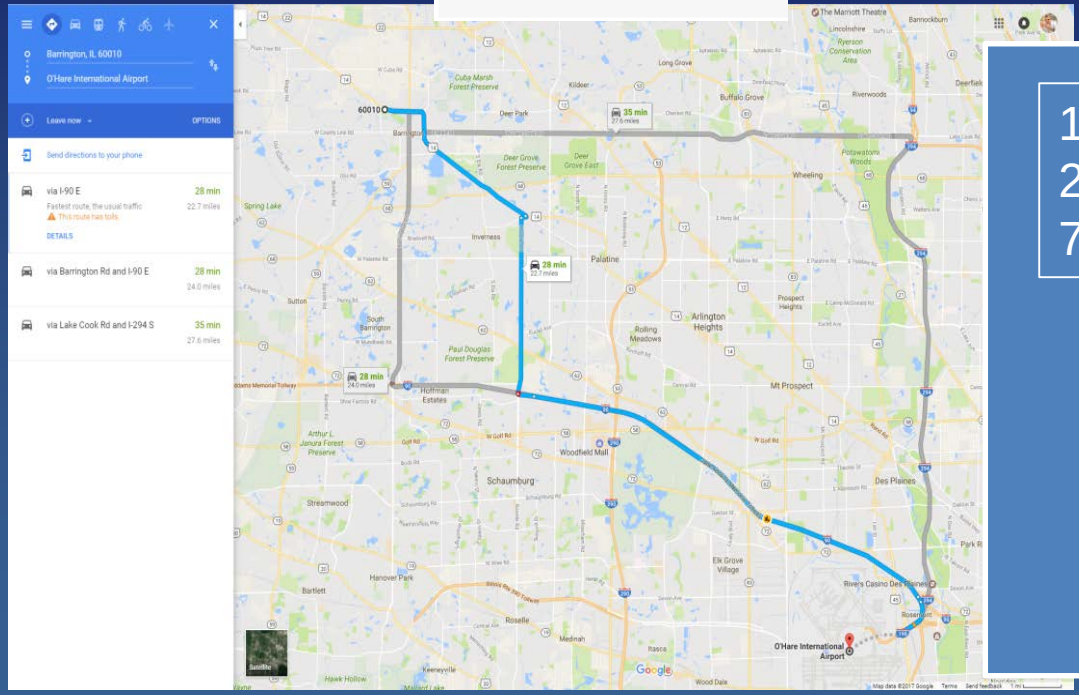
You Want it When?

GPU Instances	
p2.xlarge	$0.9 per Hour
p2.8xlarge	$7.2 per Hour
p2.16xlarge	$14.4 per Hour

2.66 hours X $0.9/hour

(2.66 hours / 8) X $7.2/hour

(2.66 hours / 16) X $14.4/hour

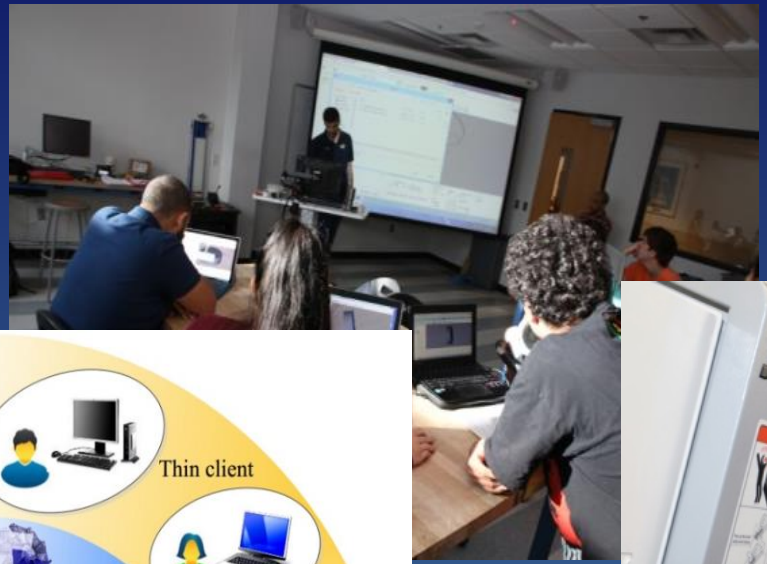


1 GPU- $2.40 Purchase
2 hours 40 minutes
7:29 pm Completion

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

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

DVP & Education – Virtually There



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Designing, Building and Thinking in New Ways

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Beyond Manufacturing

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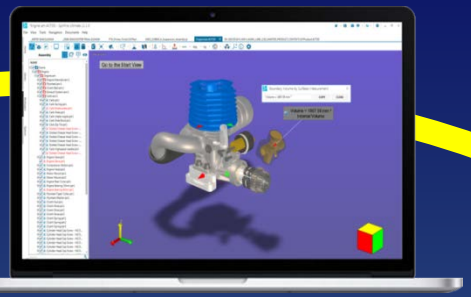
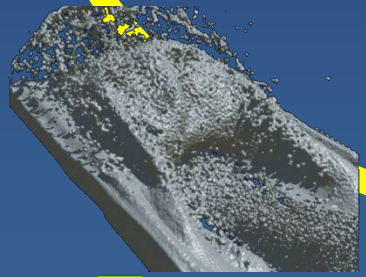
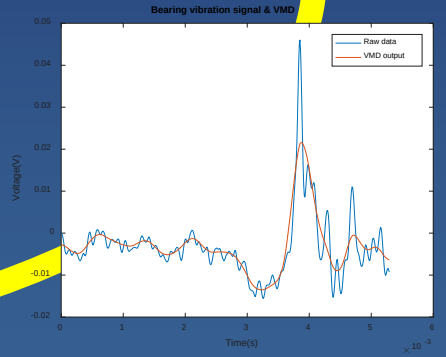
IoT4MFG – Morphing Makers to Manufacturers





NVIDIA



Chen and Kurfess, 2017

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What is the Right Product Life Cycle Model?

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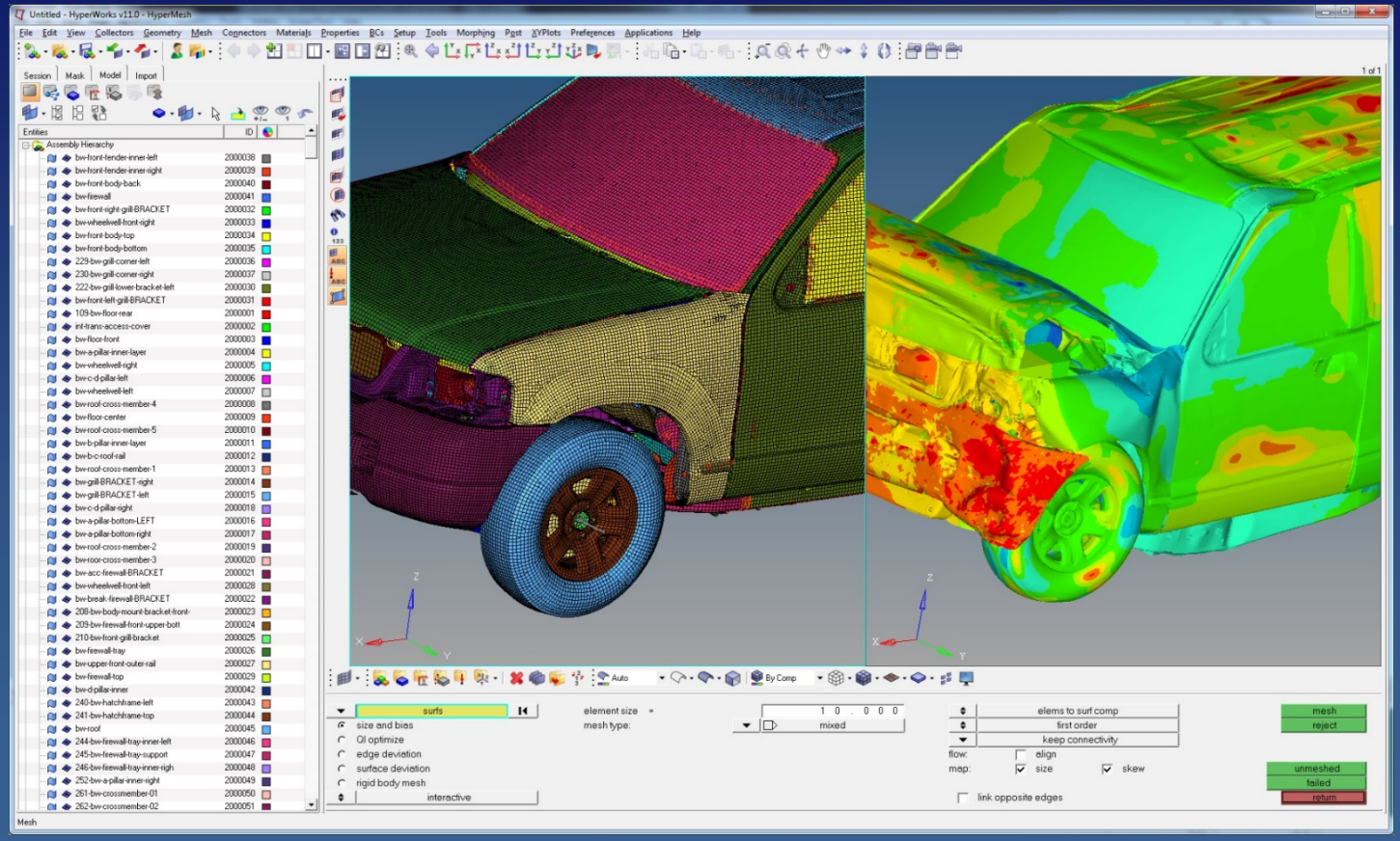
Validation in the The Digital World



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

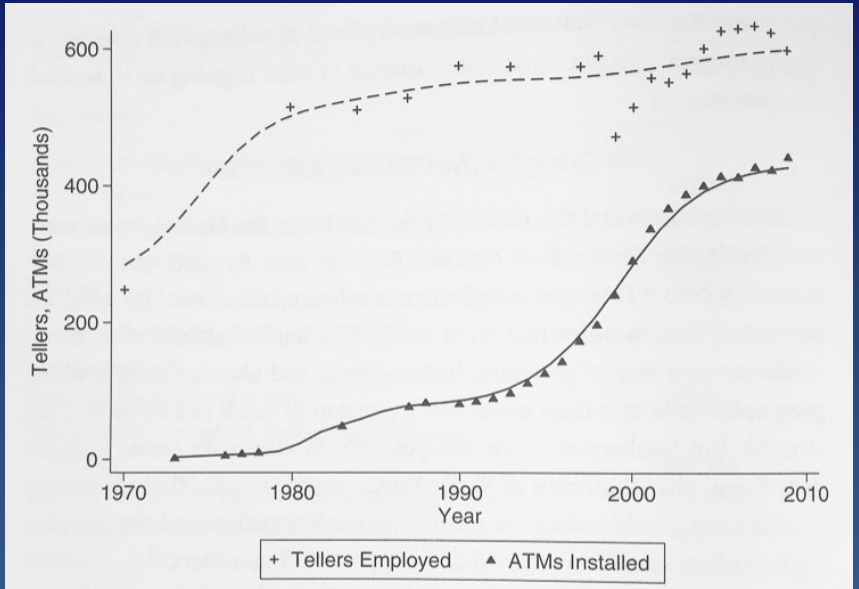


Figure 7.1. Adoption of automated teller machines did not reduce teller jobs. (Ruggles et al., Integrated Public Use Microdata Series: Version 5.0; Bureau of Labor Statistics, Occupational Employment Survey, http://www.bls.gov/oes/; Bank for International Settlements, Committee on Payment and Settlement Systems, various publications [see p. 243, note 9]).

Do Not Underestimate the Human Factor