IoT Manufacturing Demo: Optimizing CNC Toolpaths

Nathan C. Skalsky
Senior Product Manager, Autodesk Forge | @speedbirdpdx

Varun Patil
Developer Technical Consultant, Autodesk Forge
About the speaker

Nathan Skalsky

I’m a senior product manager for Autodesk Forge and a ‘maker-of-things’ at heart. I enjoy enabling workflows and capabilities that enable more efficient expression of human creativity through automation and simplification.

I started my career at IBM designing small parts of big systems, a software development manager for Fusion 360, a couple startups, and happy to be back at Autodesk as a Forge product manager!
Varun Patil

I'm full stack developer, working in Autodesk for more than two and half years as part of Forge development team. I create sample projects using Forge APIs and help our customers along the way.
The problem space
Making Better Things with Fusion 360, Forge, and CNC Machines!

Fusion 360, 3D CAD, CAM and More!  
CNC Router (Benchtop PRO 2’x2’)

A Maker’s Dilemma

Design-to-Manufacturing workflows (CNC, 3DP, Laser) are often primarily a one-way process. How to we ensure we learn from our outcomes?

• **Close the loop**, aka ‘light’ Process Control with Forge APIs
• **Learn from outcomes**, capture meaningful results
• **Make better stuff!** The better our workflows become, the better our outcomes will get.
Connecting Results back to CAD/CAM Inputs
Feedback brainstorm for simplified Process Control

Automated Feedback:
• Machine Vision
• Sound
• **Temperature**
  • Servo/PLC/CMM feedback

Manual Analysis:
• Visual inspection of surface finish
• Machine operator notes
• Engineering functional feedback
• Customer feedback

Other ideas?
IOT Devices
CNC PLC
Results DB
CAD
CAM
CNC
Data Visualizer
Process Control
Results DB
CNC PLC
IOT Devices
GCODE
IOT Device

Results DB

Data Visualizer

mongodb+srv

Cloud

Edge(ish)

Temp Sensor

SPI

MQTT Broker / DB Bridge

IOT Device

mongodb+srv

Cloud

Edge(ish)
simplify, then add lightness

Colin Chapman
Compute Solution Matrix

- Microcontroller
- Single Board Microcontroller
- Processor CPU
- Single Board PC

Axes:
- Complexity (Balance)
- Capability (Weight)
NodeMCU ESP12E (WiFi with Limited-IO)
## Our Solution Recipe

<table>
<thead>
<tr>
<th>Visualization Engine</th>
<th>Forge Viewer</th>
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<tbody>
<tr>
<td>Database</td>
<td>MongoDB</td>
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<td>DB Protocol</td>
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<td>IoT Device</td>
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<tr>
<td>Temperature Sensor</td>
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Our Plan

- Deploy database
- Build the MQTT broker
- Build the IoT sensor
- Build the IoT firmware
- Test MQTT → Database
- Translate our Fusion 360 model
- Build Forge visualization service
- Put it all Together
- Wrap things up
Deploy the database
Get started free
No credit card required.

Sign up with Google

Your Company (optional):
Autodesk

How are you using MongoDB?
Other

Your Work Email:
nathan.skalsky@autodesk.com

First Name:
Nathan

Last Name:
Skalsky

Password:

8 characters minimum

I agree to the terms of service and privacy policy.

Get started free

Included with your free cloud database:

- 512 MB of Storage
- Shared RAM
- Highly available replica sets, end-to-end encryption, automated patches, REST API

Additionally, get access to the following when you launch a dedicated cluster:

- 10 GB or more of storage
- Dedicated RAM
- Performance optimization tools
- Backups & point-in-time recovery
- Enterprise security features including encryption key management, LDAP integration, and granular database auditing
- Global Clusters

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Build the MQTT broker
Building a Simple MQTT Broker (+MongoDB Bridge)

- **Libraries Used**: mongodb, mosca (MQTT)
- **Description**: Listens to port 1888, receives MQTT messages, inserts them into the results database using a simple sensor schema
Testing a Simple MQTT Broker

- **Libraries Used:** mongodb, mosca (MQTT)
- **Description:**
  - `MQTTPublish.js` – Will send MQTT messages when the user passes in Topic/subtopic string and the sensor value
  - `MQTTSubscribe.js` – Will subscribe to receive MQTT messages using the specified topic/subtopic string.
Build the IoT device
Building IoT device

- See class video and handout for details

- **BOM:**
  - ESP8266 NodeMCU ESP-12E
  - DS18B20 Digital Thermometer
  - 4.7k Resister

- **Connections:**
  - Temp Sensor.VCC = Vin on ESP board
  - Temp Sensor.GND = GND on ESP Board
  - Temp Sensor.Data = GPIO 5
  - 4.7k resister connected to GPIO 5 and Vin
Build the IoT firmware
Build the IoT Firmware

- See class video and handout for details
- Nathan’s Four Essential IoT Device Features
  1. WiFi client to connect to access point
  2. Ability to act as WiFi access point to receive WiFi credentials from user
  3. Feature to allow user to reset controller to an unconfigured state (double reset)
  4. MQTT Client to publish and subscribe to MQTT events
Test MQTT > Database
Unit testing MQTT to database

- See class video and handout for details
Upload Fusion 360 model
Upload Fusion 360 model to Forge

- See class video and handout for details
- Upload model to models.autodesk.io using forge API credentials
Build the Visualization Service
Build the visualization web experience

- See class video and handout for details
Put it all together
Unit testing MQTT to database

- See class video and handout for details
- Watch the video as we put the demo in action!
Wrap-up
We Discussed

• Deploy database
• Build the MQTT broker
• Build the IoT sensor
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Digital Resources and References

- Download this Sample Project > https://github.com/Autodesk-Forge/forge-iot-cnc
- Forge API Documentation > https://forge.autodesk.com/developer/documentation
- MongoDB Atlas > https://docs.atlas.mongodb.com/
- MQTT > https://mqtt.org/mqtt-specification/