

PM469347

IoT Manufacturing Demo: Optimizing CNC Toolpaths Using Fusion 360 and Forge

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Learning Objectives

- Understand the problem space
- Understand the solution space
- Build a MQTT broker
- Build a IoT Sensor Device
- Build IoT Sensor Firmware
- Understand how to easily upload models to Forge account
- Customize a Forge Viewer Sample Project

Description

In this class demo, we will walk through a simplified example of capturing real-time manufacturing data (cutting temperatures) from a hobby-class computer numerical control (CNC) router as it machines aluminum, visualizing that data on the visual model of the part being manufactured. Cutting tool and workpiece temperatures are direct indications of cutting efficiency and tool health.

Mapping temperatures can help validate and suggest adjustments to feeds, speeds, and depth of cut to achieve the nominal chip load. While this is far from an industrial solution, this demo will show the power of IoT manufacturing within a simplified context to explore the utility and promise of cloud-based manufacturing solutions, built with Forge.

Speaker(s)



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!

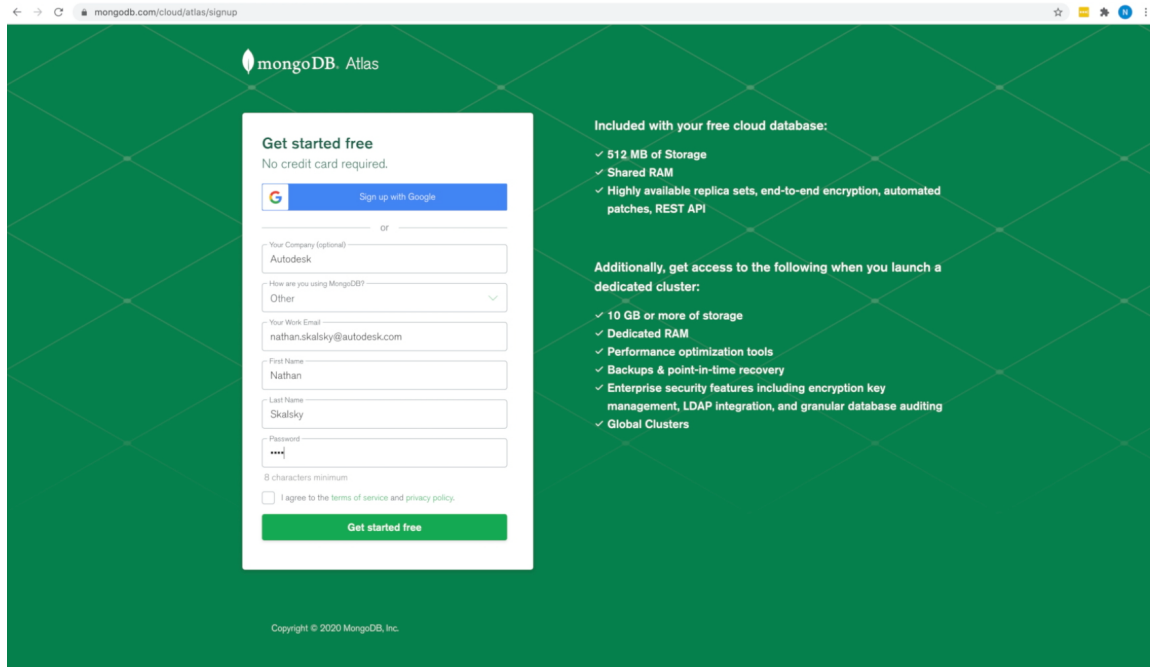


About the speaker

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.

Deploy the Database



mongoDB. Atlas

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How are you using MongoDB?
Other

Your Work Email
nathan.skalsky@autodesk.com

First Name
Nathan

Last Name
Skalsky

Password
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8 characters minimum

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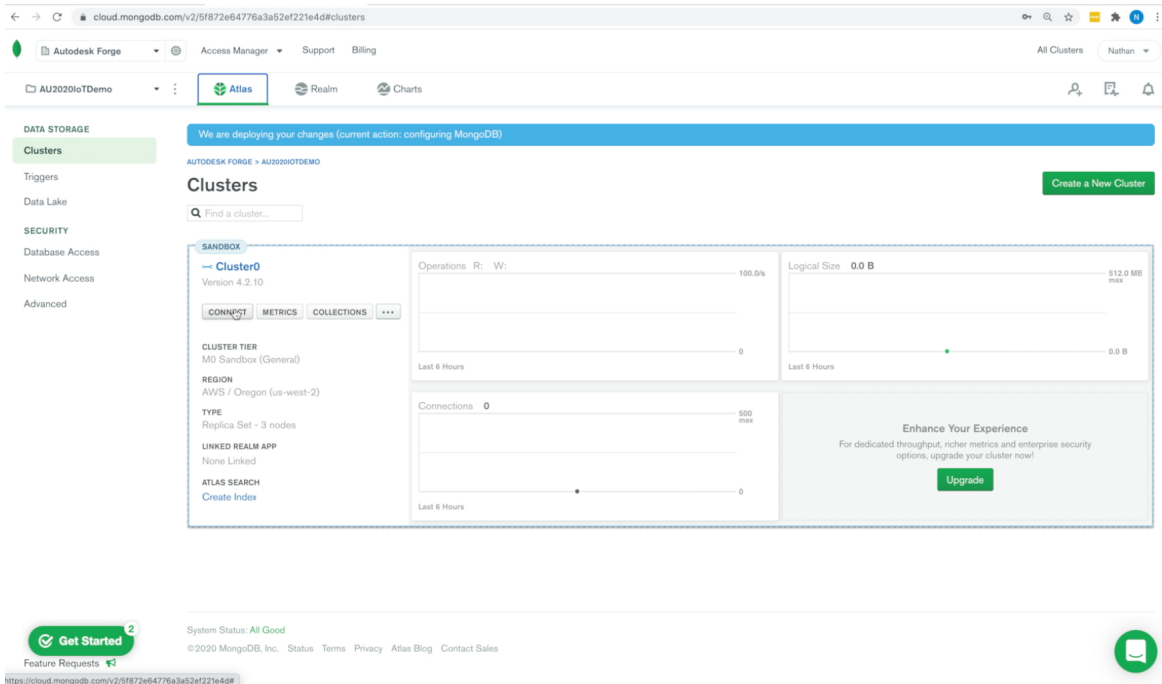
Included with your free cloud database:

- ✓ 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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cloud.mongodb.com/v2/5f872e64776a3a52ef221e4d#clusters

Autodesk Forge Access Manager Support Billing

AU2020IoTemo Atlas Realm Charts

DATA STORAGE

Clusters

Triggers

Data Lake

SECURITY

Database Access

Network Access

Advanced

We are deploying your changes (current action: configuring MongoDB)

AUTODESK FORGE > AU2020IOTDEMO

Clusters

Find a cluster...

SANDBOX

Cluster0

Version 4.2.10

CONNECTION METRICS COLLECTIONS

CLUSTER TIER
M0 Sandbox (General)

REGION
AWS / Oregon (us-west-2)

TYPE
Replica Set - 3 nodes

LINKED REALM APP
None Linked

ATLAS SEARCH
Create Index

Operations R: W: 100.0%

Logical Size 0.0 B 512.0 MB max

Connections 0 500 max

Enhance Your Experience
For dedicated throughput, richer metrics and enterprise security options, upgrade your cluster now!

Get Started

System Status: All Good

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Feature Requests

https://cloud.mongodb.com/v2/5f872e64776a3a52ef221e4d#

Building a Simple MQTT Broker (+MongoDB Bridge)

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

```

MQTTBroker.js
1 //Mongo DB Connection
2 const MongoClient = require('mongodb').MongoClient
3 const dbConnectionString = MongoDB = "mongodb+srv://MQTTBroker:formez2no@cluster0.cnyhr.mongodb.net/"
4 <dbname?retryWrites=true&w=majority"
5 const client = new MongoClient(dbConnectionString, {useNewUrlParser: true, useUnifiedTopology: true})
6 client.connect() // create persistent connection
7
8 //MQTT Broker
9 var mosca = require('mosca')
10 var config = {port: 1888}
11 var MQTTBroker = new mosca.Server(config)
12
13 MQTTBroker.on('ready', ()=>{
14   console.log('MQTT Broker Service Started!')
15 })
16
17 MQTTBroker.on('published', (packet)=>{
18   message = packet.payload.toString()
19
20   if(!isNaN(message)){
21     console.log('Publishing Topic: '+packet.topic.toString()+ ' Value: '+message)
22     var activeCollection = client.db('AIU2020IoTDemo').collection('test_ESP12') //TODD: map collection
23     // name to CNC job name dynamically
24     activeCollection.insertOne({
25       when: new Date(),
26       temperature: message, // Sensor value, in this case (Temp), it will be degrees celsius (float)
27       sensor_type: packet.topic.toString().slice(0,4), // sensor type is only 'Temp' presently
28       sensor_name: packet.topic.toString().slice(5,25) // sensor name can be 'StockMaterial', 'Tool',
29       'Spindle', 'StepperX', etc.
30     })
31   }
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```

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.

```

MQTTPublish.js
1 //MQTT client
2 var mqtt = require('mqtt')
3 var client = mqtt.connect('mqtt://localhost:1888')
4
5 //what topic?
6 var topic = 'Temp/Default'
7 var sensorValue = 0
8
9 client.on('connect', ()=>{
10   process.argv.forEach(function (val, index, array){
11     if (index == 2){
12       topic = val
13     }
14     if (index == 3){
15       sensorValue = val
16     }
17   })
18   client.publish(topic, sensorValue.toString())
19   console.log('Sending Topic: '+topic.toString()+ ' Value: '+sensorValue.toString())
20   return process.exit(22)
21 })
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MQTTSubscribe.js
1 //MQTT client
2 var mqtt = require('mqtt')
3 var client = mqtt.connect('mqtt://localhost:1888')
4
5 //what topic?
6 var topic = process.argv.slice(2);
7
8 client.on('message', (topic, message)=>{
9   message = message.toString()
10   console.log(message)
11 })
12
13 client.on('connect', ()=>{
14   client.subscribe(topic)
15 })
16 }
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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



```

Arduino File Edit Sketch Tools Help
CNC-IoT-TempSensor-ESP12 / AiB
CNC-IoT-TempSensor-ESP12.g
}

void checkTempSensors(){
  // get the temps
  // update MQTT data with temp (info = sensor type and name (MQTT topic/subtopic))
}

void updateMQTTData(float temp){
  char mqtt_payload[100] = "";
  sprintf(mqtt_payload, "100", "%2f", temp);
  Serial.print("Publish Message: ");
  Serial.println(mqtt_payload);
  client.publish(MQTT_Topic, mqtt_payload, true);
  Serial.println("> MQTT data pub");
}

void mqttCallback(char* topic, byte* payload, unsigned int length){
  Serial.print("MQTT Message arrived [");
  Serial.print(topic);
  Serial.print("] ");
  for (int i=0; i < length; i++){
    Serial.print((char)payload[i]);
  }
  Serial.println();
}

void connectMQTTClient(){
  while (!client.connect()){ //loop until connected
    Serial.print("***** Re-Attempting MQTT connection...");
    if (client.connect(MQTTClientName, mqtt_username, "")){
      Serial.println(" -> MQTT client connected");
    } else {
      Serial.print("failed, rc=");
    }
  }
}

Done compiling.

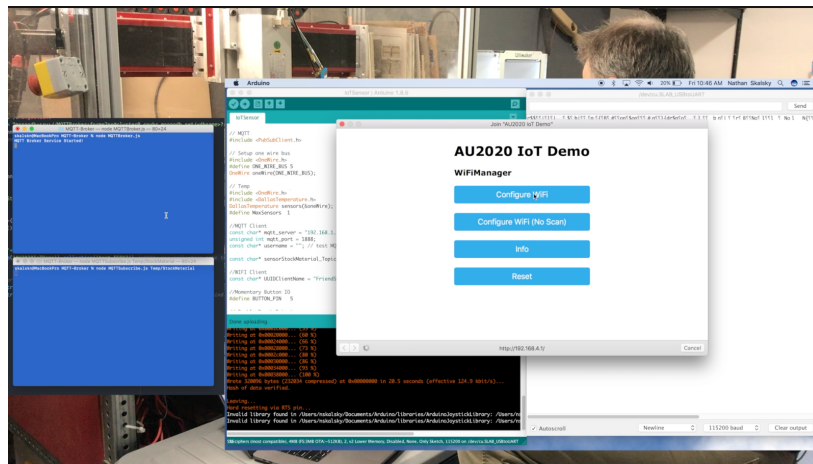
Executable segment sizes:
FROM : 281280 -> code in flash (default or ICACHE_FLASH_ATTR)
DATA : 1276 -> code in RAM (ICACHE_RAM_ATTR, IRAM_ATTR)
DATA : 1276 -> initialized variables (global, static) in RAM/HEAP
CONST : 1544 -> constants (global, static) in RAM/HEAP
BSS : 2044 -> zeroed variables (global, static) in RAM/HEAP
Sketch uses 311420 bytes (29%) of program storage space. Maximum is 1044464 bytes.
NodeMCU 1.0 ESP-12E Module, 80 MHz, Flash, Legacy dev can return nullpin, All pins output level compatible, 4000 pins

```

Unit test the MQTT to Database Connection

Unit testing MQTT to database

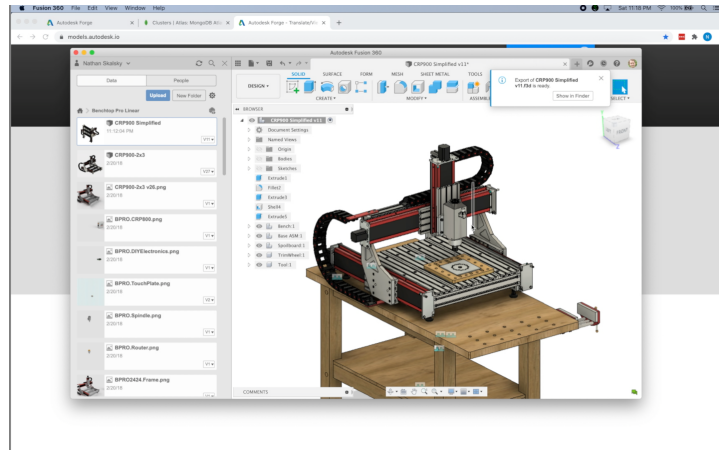
- See class video and handout for details



Upload a Fusion 360 model to Forge developer account

Upload Fusion 360 model to Forge

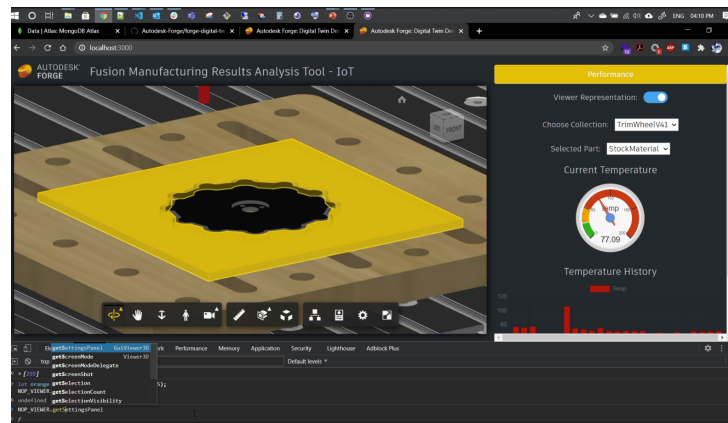
- See class video and handout for details
- Upload model to models.autodesk.io using forge API credentials



Configure and Extend the Forge Viewer to represent our CNC data

Build the visualization web experience

- See class video and handout for details



We Discussed

- 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



Digital Resource and Links

- Download this Sample Project > <https://github.com/Autodesk-Forge/forge-iot-cnc>
- Forge API Documentation > <https://forge.autodesk.com/developer/documentation>
- Forge Viewer > <https://forge.autodesk.com/en/docs/viewer/v7/overview/>
- MongoDB Atlas > <https://docs.atlas.mongodb.com/>
- NodeMCU ESP8266 > <https://www.instructables.com/NodeMCU-ESP8266-Details-and-Pinout/>
- MQTT > <https://mqtt.org/mqtt-specification/>
- Digital Thermometer (DS18B20) > <https://datasheets.maximintegrated.com/en/ds/DS18B20.pdf>