



# I(oT) in Process Networks

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14 October 2016

# What is IoT?



# IoT World Forum – Reference Model for IoT

## Levels

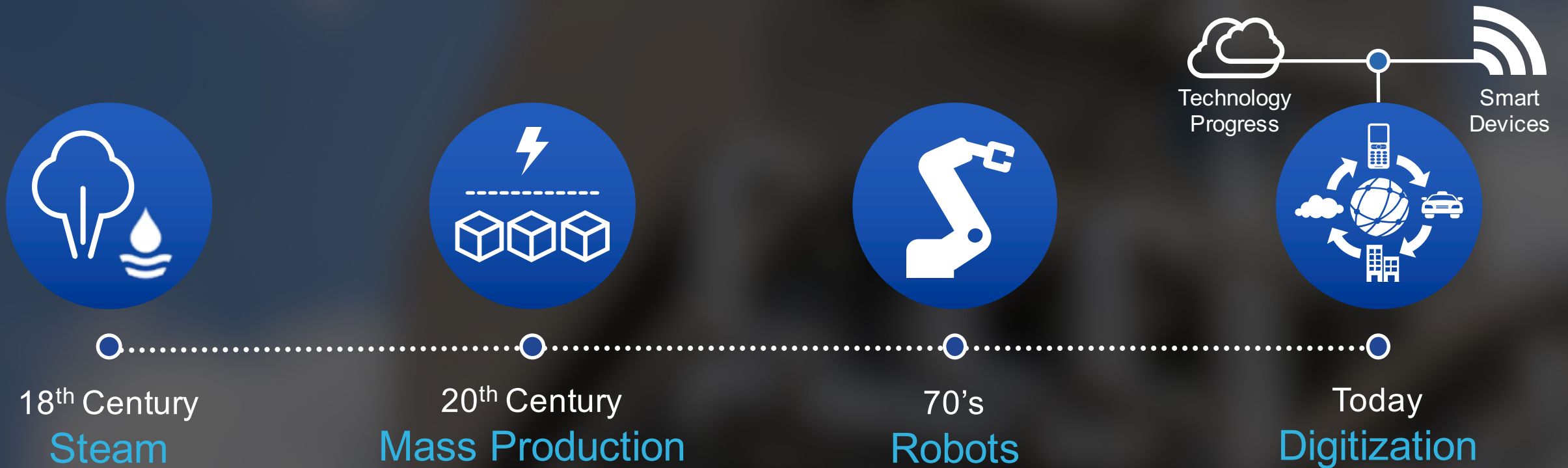
- 7 Collaboration & Processes**  
(Involving People & Business Processes)
- 6 Application**  
(Reporting, Analytics, Control)
- 5 Data Abstraction**  
(Virtualization, Federation, Caching)
- 4 Data Accumulation**  
(Storage)
- 3 Edge Computing**  
(Data Element Analytics & Transformation)
- 2 Connectivity + Fog Computing**  
(Communication & Processing Units)
- 1 Physical Devices & Controllers**  
(The “Things” in IoT)





# A New Industrial Revolution

Digitizing Manufacturing to Capture the Value of the Internet of Everything



Digital Manufacturing Priority Investments #1 Analytics | #2 Connectivity | #3 Automation | #4 Mobility

Source: SCM World/Cisco "Smart Manufacturing & the Internet of Things 2015" survey of 400 Manufacturing Business Line Executives and Plant Managers across 17 vertical industries.



# Connected Machines Deliver Business Outcomes



Reduced  
Downtime

48%

Unplanned  
downtime down  
from 11%  
to 5.8%



Reduction in  
Defects

49%

Defect rate  
down from  
4.9%  
to 2.5%



New Product  
Introduction

23%

New product  
introduction cycle  
time reduced from  
15 to 11



OEE  
Improvement

16%

Average OEE  
improved  
from  
74% to 86%



Improved  
Inventory

35%

Inventory  
turns increased  
from  
14 to 19



Reduction in  
Energy Use

18%

Annual energy  
cost down from  
\$8.4M  
to \$6.9M

## The Real Economic Value is Immense

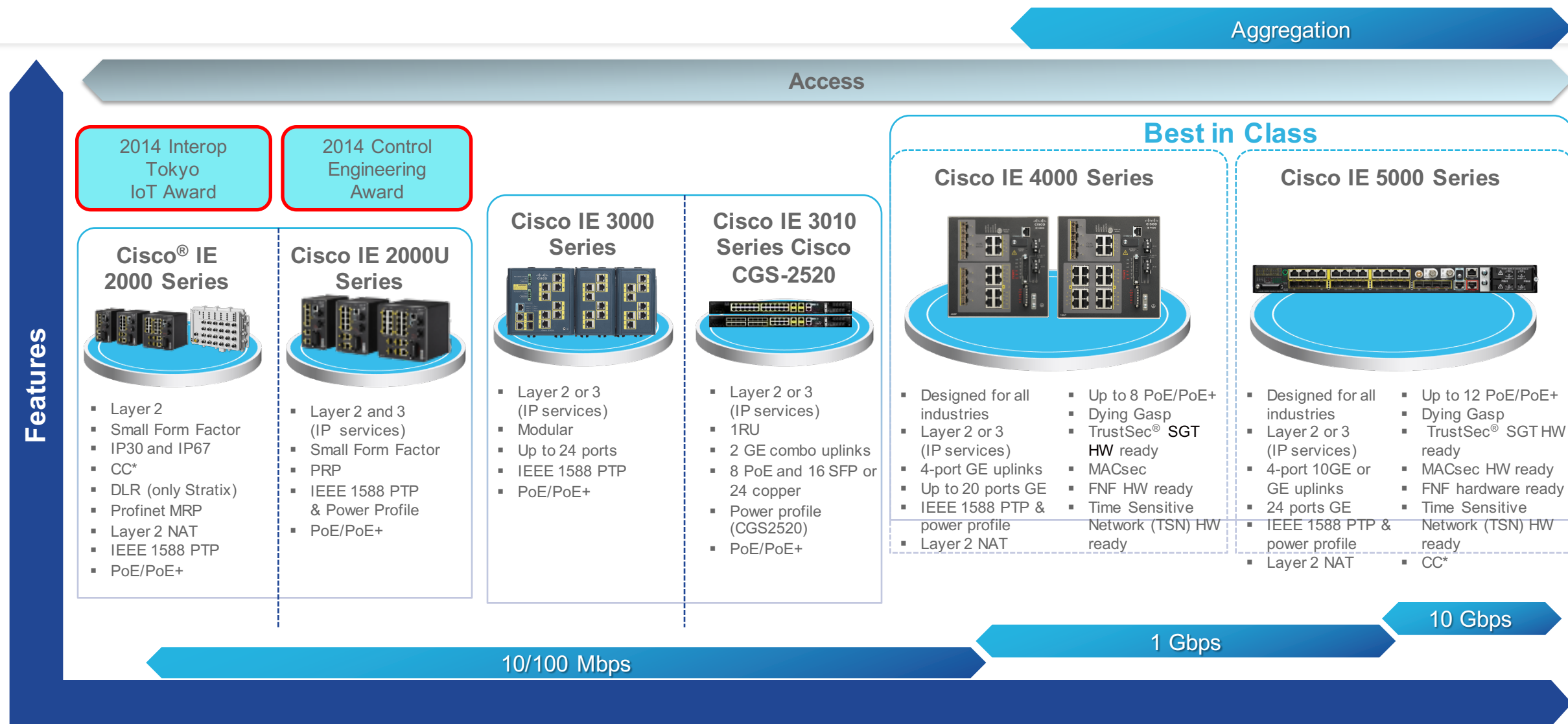
# Industry 3.0 to Industry 4.0

- Step 1: Connect the plant floor
- Step 2: Figure out how to gather the data from machines (protocol)
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# Cisco IE Switches Product Overview



# Introducing the new IE1000

Target FCS Q4FY16

EFT Q3FY16

SKU	IE1K-copper	IE1K-PoE
Downlinks	4 10/100M RJ45 6 10/100M RJ45	4 10/100M RJ45 (w/POE) 8 10/100M RJ45 (w/POE)
Uplinks	(5port) 1 FE Copper (8port) 2 FE copper	2 GigE Fiber
PoE	N	PoE/PoE+
Total Ports	5 or 8	8 or 10
Power Input	24 VDC nominal (9 – 36)	48/54 VDC nominal (44 – 57)
Size (cm)	(5port) W3.81 x H12.7 x D11.5 (8port) W4.5 x H12.7 x D11.5	W4.5 x H12.7 x D13.3
Console port	None	
Alarm input/output	No	Yes
Temperature range	-20-60C	-40-70C
Ingress Protection	IP30	





# IE Switching Cauvery 15.2(4)EA Release



## One Combined Release

- IE-4000 combined with IE-2000, IE-2000U IE-3000, IE3010, CGS2520



## Certifications

- PROFINET MRP from PI (Profinet International) IE2000
- Profinet Stack V2.31
- FIPS & CC compliance



## Industry Leading Redundancy

- Media Redundancy Protocol (MRP) support on IE-2000 series



## Usability Features

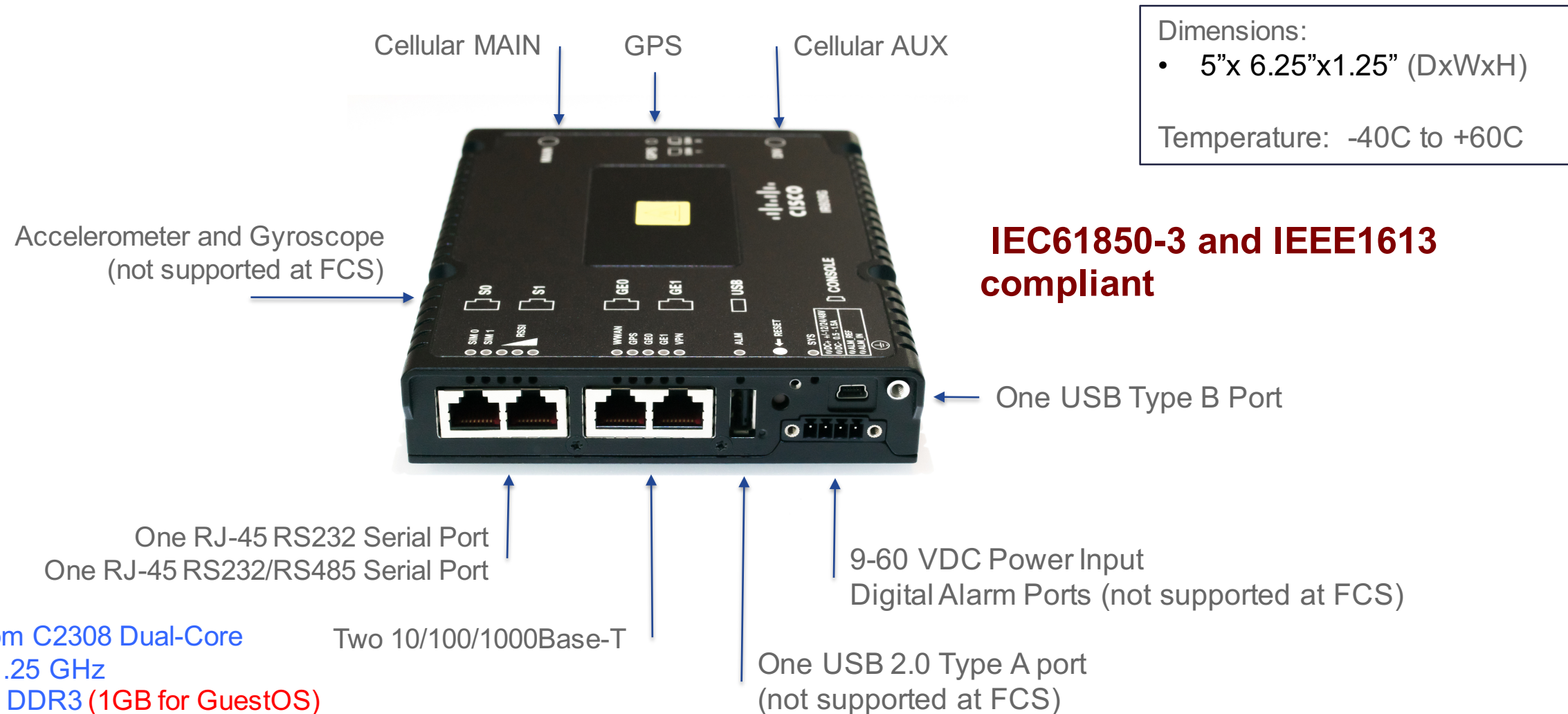
- NTP to PTP flywheel
- Identify/ Locate switch LED
- MODBUS TCP Server
- Express Setup enhancements



## Additional features

- PTP – PDV filtering
- PTP – feedforward boundary clock
- MIB: LLDP-EXT-PNO-MIB
- MACSEC: IE-4000

# Cisco 809 Industrial Integrated Services Routers



CPU: Intel Atom C2308 Dual-Core  
Rangeley @ 1.25 GHz  
Memory: 2GB DDR3 (1GB for GuestOS)  
Storage: 8GB eMMC flash (2-3 GB for GuestOS)



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# Machine Anatomy – Mazak i-400ST

## Identify machine components to collect data



### General Motion Controller (GMC)

- GMC is considered as the brain of the machine
- Off the shelf motion controller from suppliers
- Usually perform single motion control at a time
- Typically consist of motion controller/drive amplifier/sensor
- A machine will only have GMC or CNC but not both
- 1 to 1 ratios between GMC/CNC and machine

### Computer Numerical Controller (CNC)

- CNC is a special type of GMC – customized motion controller
- CNC are different from GMC that CNC also provide coordinated motion control and meet the special requirements of machine tool industry
- In a CNC based machine, the precision of motion control determines the overall system performance
- Typically consist of controller/servo drivers/spindle drives/HMI

### Programmable Logic Controller (PLC)

- PLC functionalities include logic/drives/process control
- Work with GMC and CNC
- Pass G code to GMC/CNC to execute
- Many to 1 ratio between PLC and machine



# Mazak SmartBox Use Case



## Factory

Historian

Tool Health

Memex Merlin



OEE & Analytics

Quality

Maintenance

### Machine / Cell Package

Cameras



Analytics



Sensors



IoT FOG Node  
MTConnect



Cell

## Main Menu

Exit

## Monitoring Screen Menus

Efficiency  
Down/Reject  
Machine Detail  
Data Tables  
Floor Layout Monitoring  
Event Monitoring

## Job Menu

Job Queue Editor  
Visual Job Queue

## Report Menu

Report Generator  
Auto Report Scheduler

## Slide Show

Setup  
Start  
Stop

## RT Analytic Charts

Down/Reject Pie Chart  
Down/Reject Bar Chart  
Run Time Chart

## Data Base Connection

Server sqlsrv01

Status CONNECTED

Date/Time

14/08/22 - 01:15



OEE



Availability



Quality



Performance



## Efficiency Screen

Machine ID	OEE	Availability	Quality	Performance	Group
> 300:MTC SIM 1	80.32	80.32	100	100	lane1
110:Husky IMM 1	71.87	75.2	100	95.58	turret
105:Twin Turret Lath	60.92	74.91	94.12	86.41	lathe
104:Tnacci Lathe 22F	60.71	60.71	100	100	lathe
113:Gantry Mill M21	59.88	74.94	83.33	95.88	mill
112:Doosan Mill 99	59.88	74.94	83.33	95.88	mill
101:Olympia Vert Mil	53.88	75.04	69.23	103.72	mill
116:Cincinnati Gantr	46.31	75.01	76.32	80.91	mill
120:Gun Drill	43.63	64.98	79.45	84.52	drill
103:Mori Seiki Lathe	42.38	74.25	66.67	85.62	lathe
119:Gap Lathe GL54	42.17	64.94	84.21	77.12	lathe
114:Doosan Mill 98	41.93	74.93	58.33	95.91	mill
121:Haas Mill 11	24.32	74.3	76.81	42.61	mill
124:Vert Mill VM34	15.53	74.93	58.33	35.54	mill
100:Auto Chop Saw	14.13	72.19	57.14	34.26	saw
303:OPC SIM 1	10.86	49.95	100	21.75	
500:ROYAL-MACHINE	2.23	28.75	100	7.76	
302:MAZAK SIM	0	0	100	0	
301:MTC WEB AGENT	0	0	100	100	

x [Group] In ("', 'drill', 'lane1', 'lathe', 'mill', 'saw', 'turret') -

Edit Filter



# Industry 3.0 to Industry 4.0

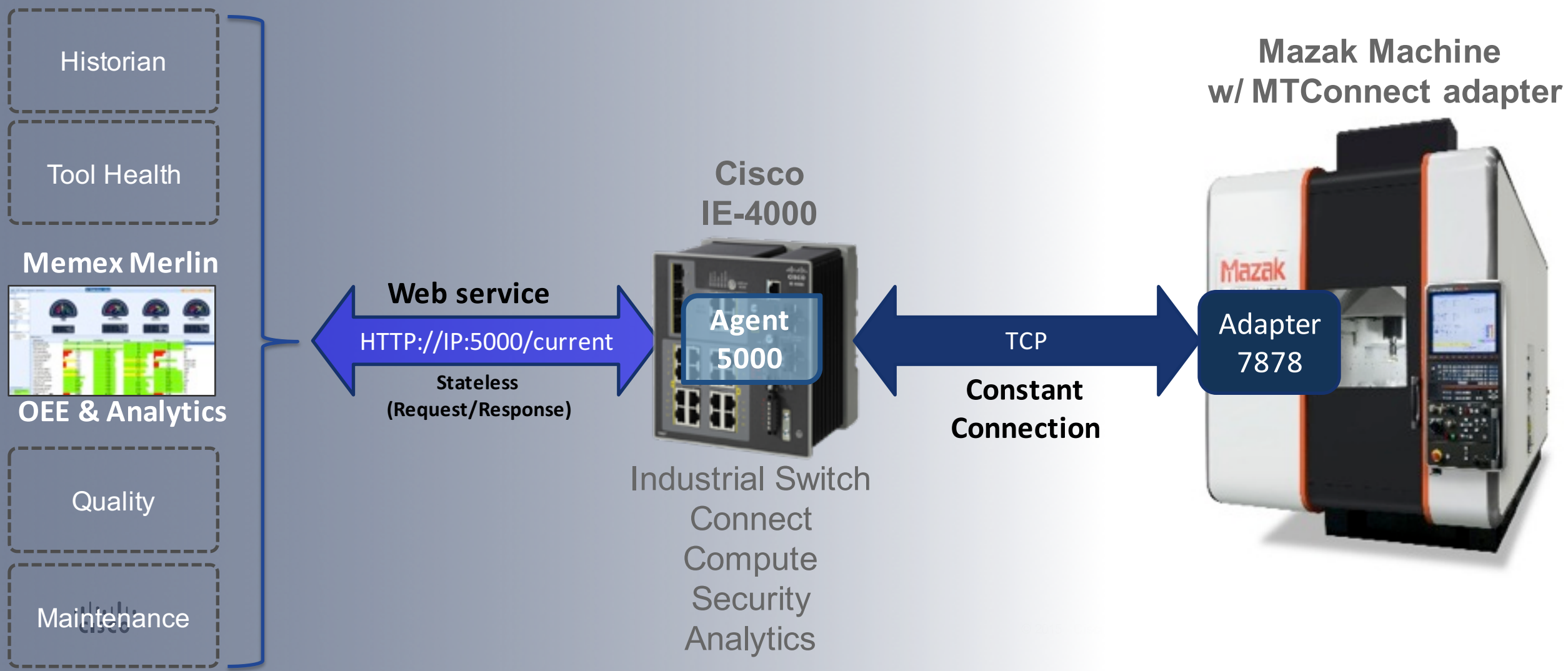
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# Why MTConnect ?

MTConnect Data Model is a Game Changer

Applications      MANY      IoT FoG Node      ONE      Machines & Assets



# What is Goal of MTConnect ?

## Translate Machines into Standard XML Semantics

```
<CuttingTool serialNumber="1" toolId="B732A08500HP" timestamp="2011-05-11T13:55:22" assetId="B732A08500HP.1" manufacturers="KMT">
```

```
<Description>
```

```
Step Drill KMT, B732A08500HP Grade KC7315
```

```
Adapter KMT CV50BHPVTT12M375
```

```
</Description>
```

```
<CuttingToolLifeCycle>
```

```
<CutterStatus><Status>NEW</Status></CutterStatus>
```

```
<ProcessSpindleSpeed nominal="5893">5893</ProcessSpindleSpeed>
```

```
<ProcessFeedRate nominal="2.5">2.5</ProcessFeedRate>
```

```
<ConnectionCodeMachineSide>CV50 Taper</ConnectionCodeMachineSide>
```

```
<Measurements>
```

```
<BodyDiameterMax code="BDX">3.16</BodyDiameterMax>
```

```
<BodyLengthMax code="LBX" nominal="120.825" maximum="126.325" minimum="115.325">120.825</BodyLengthMax>
```

```
<ProtrudingLength code="LPR" nominal="155.75" maximum="161.25" minimum="150.26">158.965</ProtrudingLength>
```

```
<FlangeDiameterMax code="DF" nominal="98.425">98.425</FlangeDiameterMax>
```

```
<OverallToolLength nominal="257.35" minimum="251.85" maximum="262.85" code="OAL">257.35</OverallToolLength>
```

```
</Measurements>
```

```
<CuttingItems count="2">
```

```
<CuttingItem indices="1" manufacturers="KMT" grade="KC7315">
```

```
<Measurements>
```

```
<CuttingDiameter code="DC1" nominal="8.5" maximum="8.521" minimum="8.506">8.513</CuttingDiameter>
```

```
<StepIncludedAngle code="STA1" nominal="90" maximum="91" minimum="89">89.8551</StepIncludedAngle>
```

```
<FunctionalLength code="LF1" nominal="154.286" minimum="148.786" maximum="159.786">157.259</FunctionalLength>
```

```
<StepDiameterLength code="SDL1" nominal="9">9</StepDiameterLength>
```

```
<PointAngle code="SIG" nominal="135" minimum="133" maximum="137">135.1540</PointAngle>
```

```
</Measurements>
```

```
</CuttingItem>
```

```
<CuttingItem indices="2" manufacturers="KMT" grade="KC7315">
```

```
<Measurements>
```

```
<CuttingDiameter code="DC2" nominal="12" maximum="12.011" minimum="12">11.999</CuttingDiameter>
```

```
<FunctionalLength code="LF2" nominal="122.493" maximum="127.993" minimum="116.993">125.500</FunctionalLength>
```

```
<StepDiameterLength code="SDL2" nominal="9">9</StepDiameterLength>
```

```
</Measurements>
```

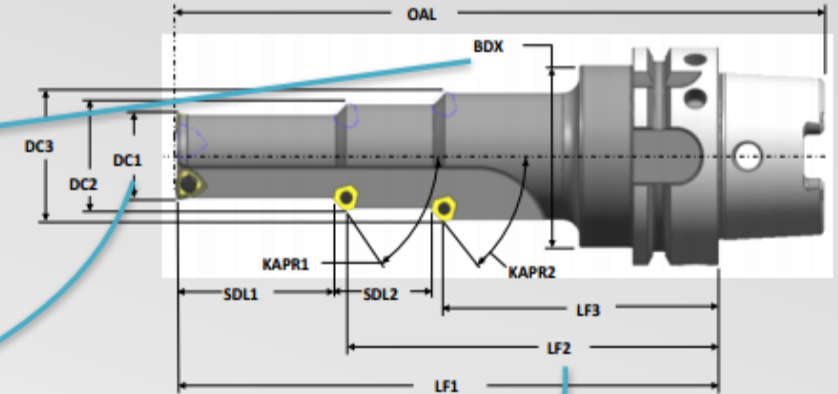
```
</CuttingItem>
```

```
</CuttingItems>
```

```
</CuttingToolLifeCycle>
```

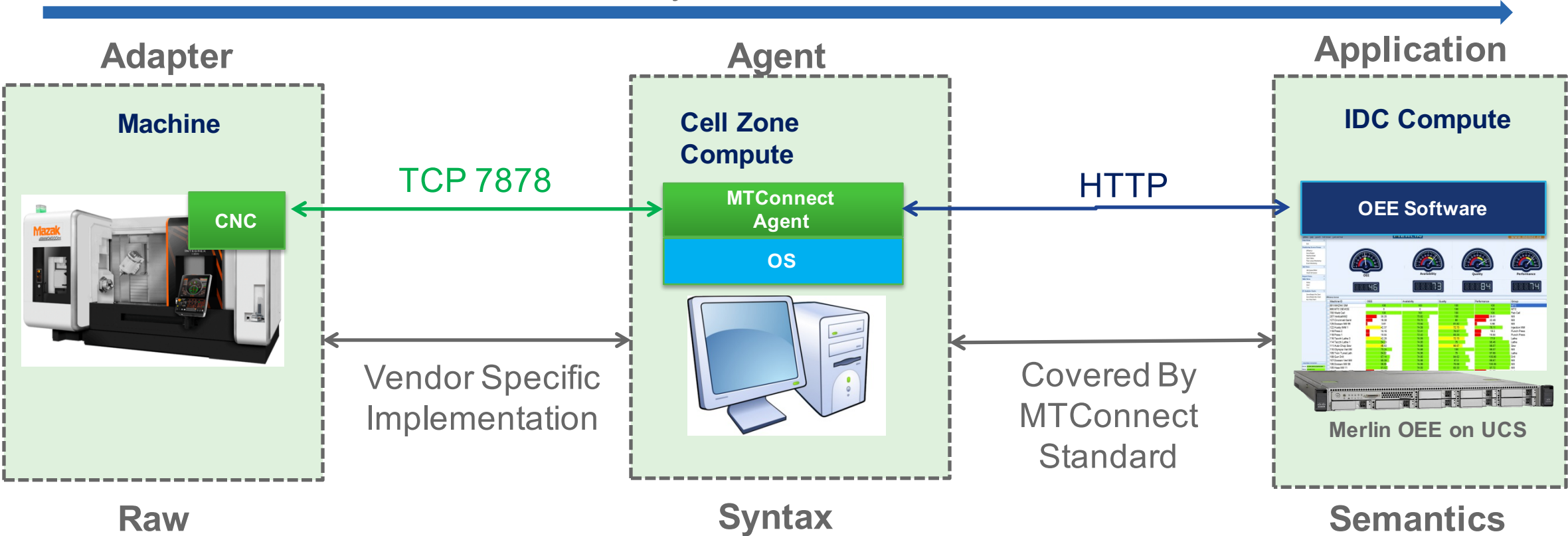
```
</CuttingTool>
```

Use Data



# MTConnect Architecture

Read-Only Data from Machines



01010011010  
10001010010



a = 196.54  
b = 12.43  
c = 87.22  
d = 2



Device  
Linear X  
Position 196.54 mm  
Load 12.43%  
Rotatory C  
Rotary Velocity: 87.22 RPM

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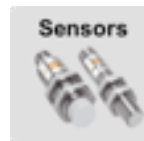
# Cisco Parstream

- Sensor Inputs:
  - **Coolant Level**
  - **Temperature**
  - **PH**
  - **Vibration**
- Digital I/O Sensors look like MTConnect Adapter.
- Feeds Data to MTConnect Agent IoT Platform(ie-4000)
- Cisco Streaming Analytics can be tuned to be process specific
  - Pattern Matching
  - Predictive Analytics
  - Compound Signatures

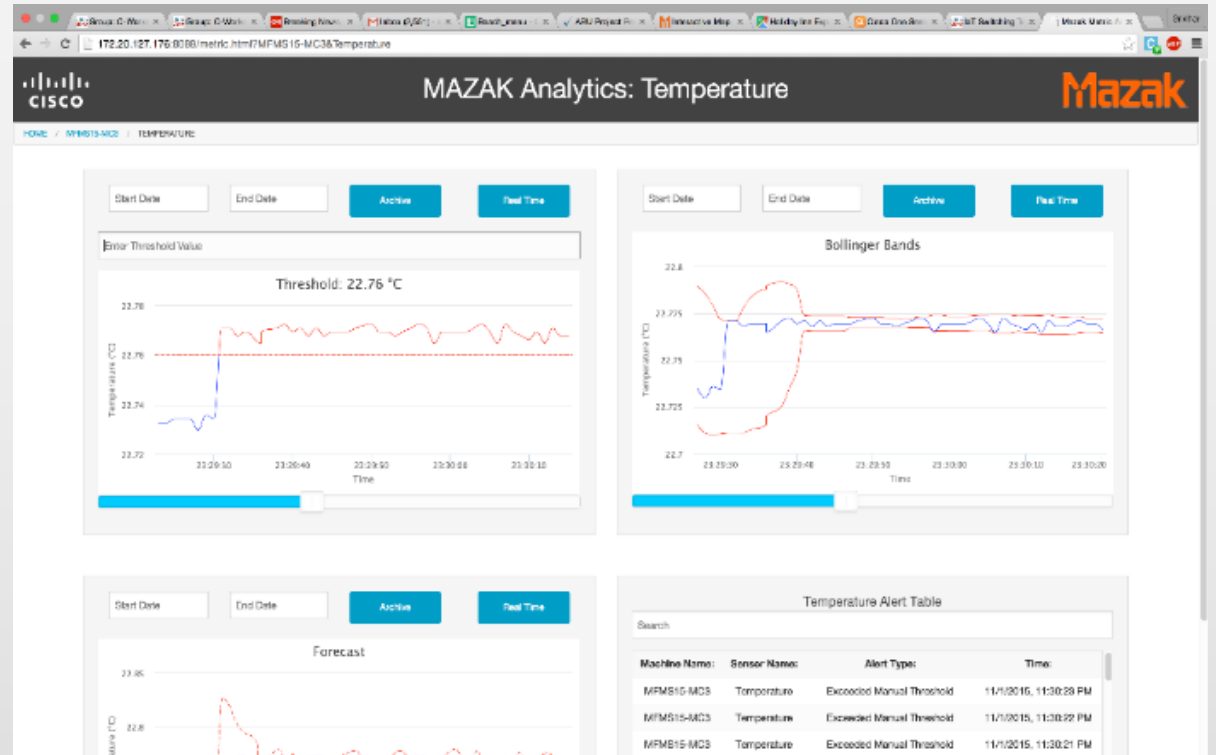
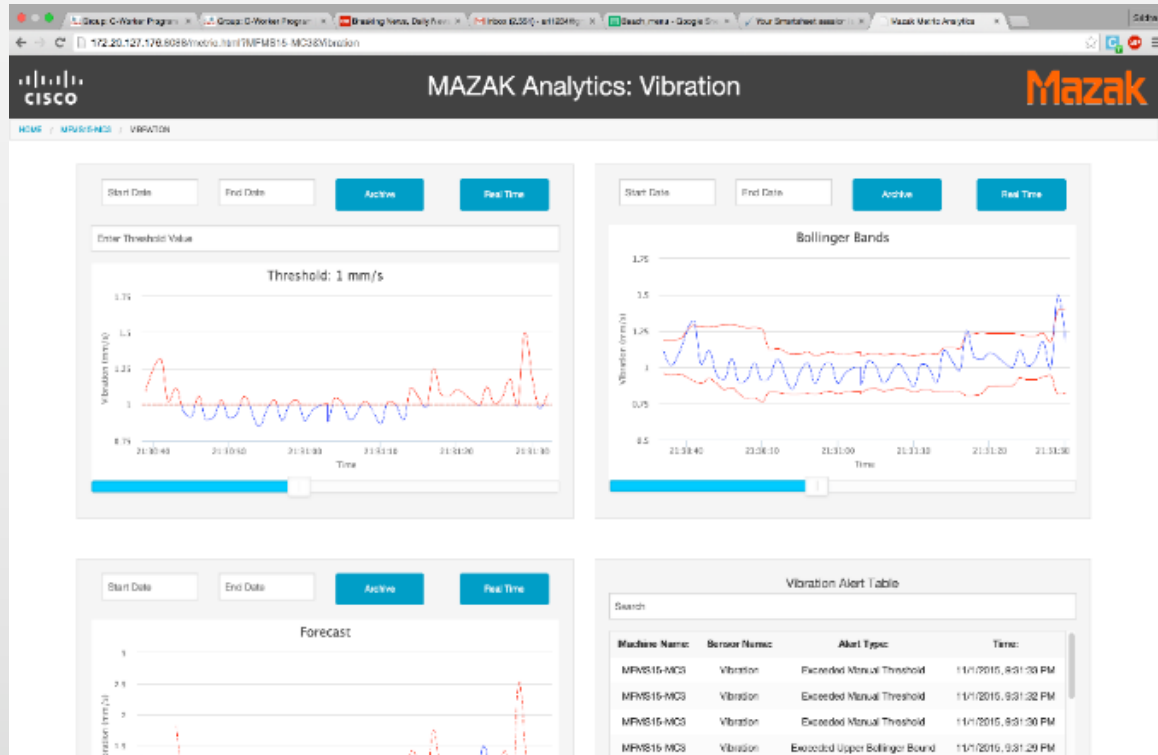


Cisco CSA

MTConnect  
Agent 5000



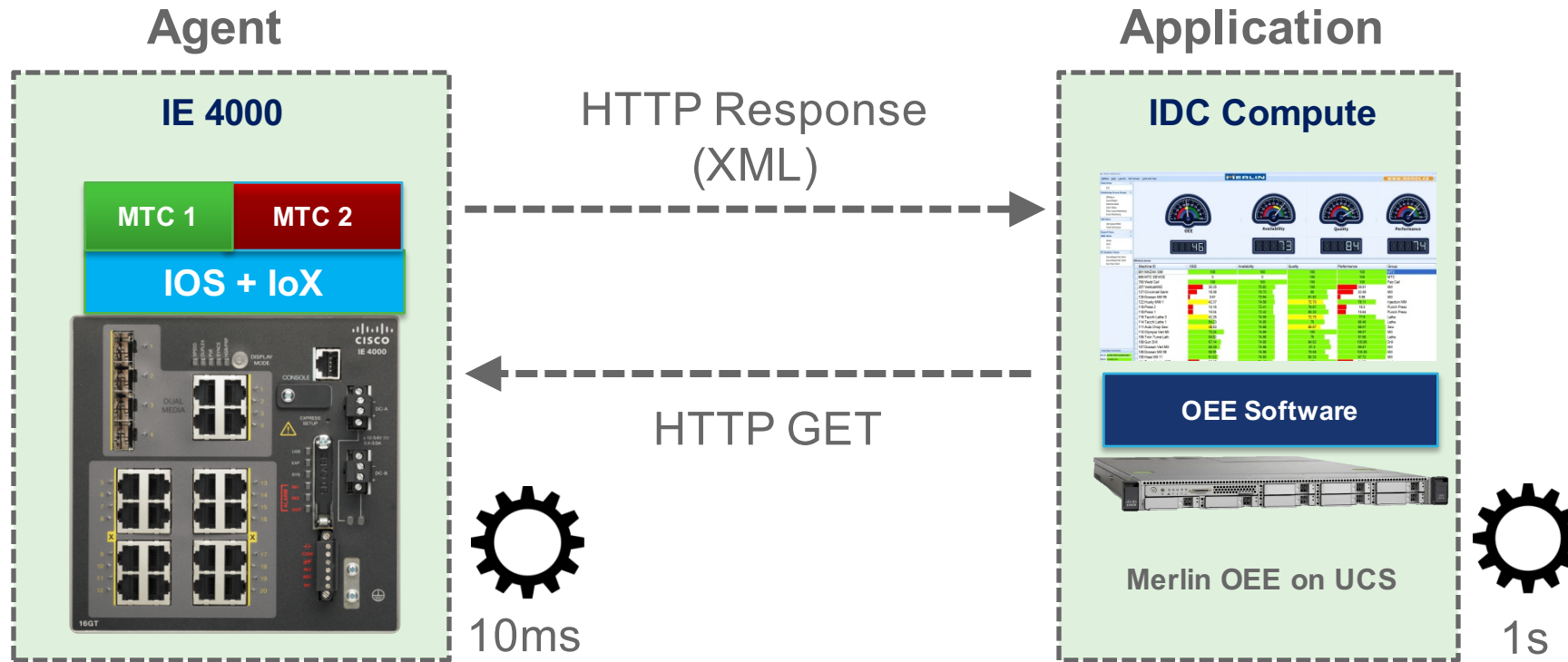
# Streaming Analytics on Mazak's Smart Box



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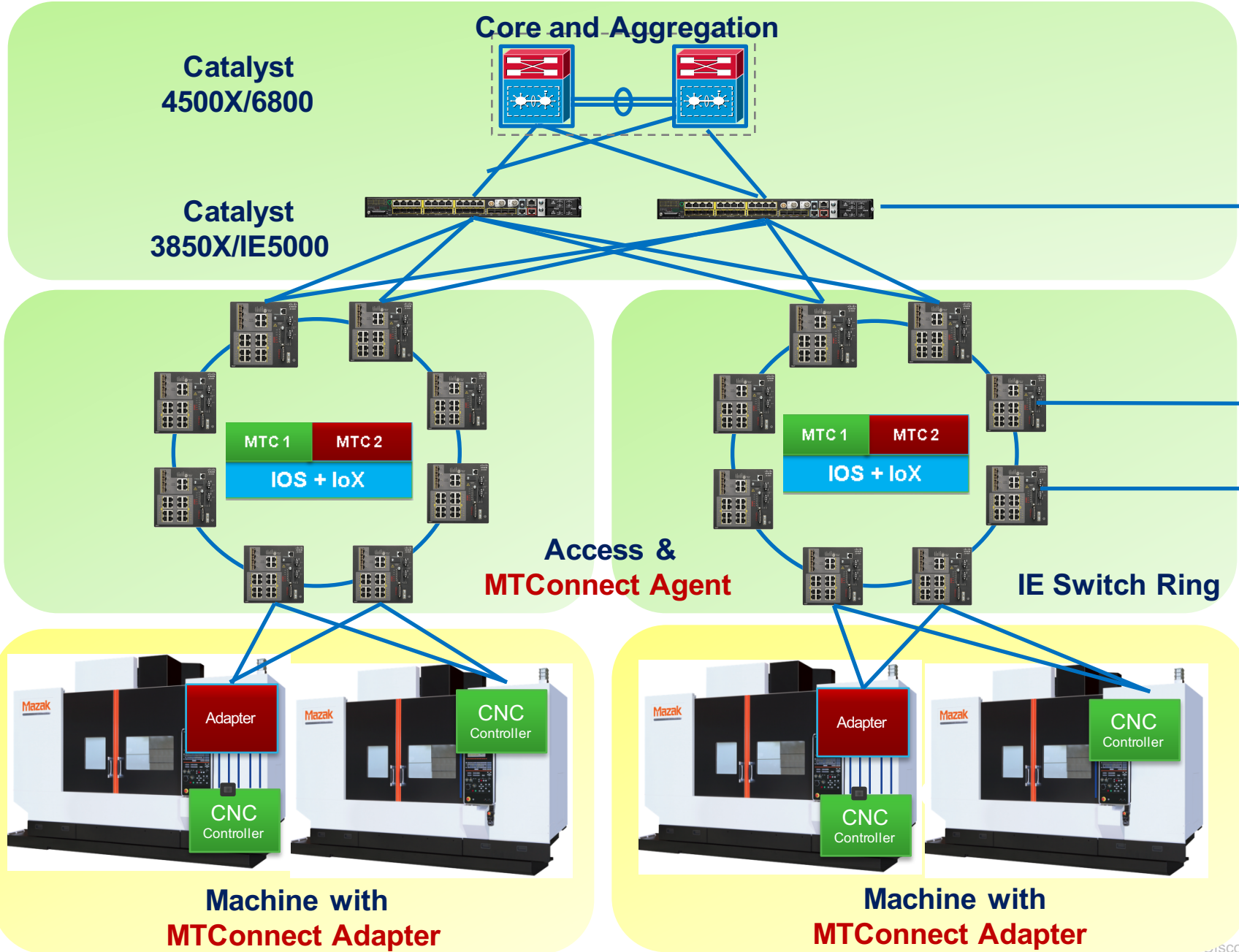
# MTConnect Agent - Application Communication



- Application makes an HTTP request -> Agent responses
- Communication use REST (Representational State Transfer)
- Agent is a special purpose HTTP server (open source available)
- Response in XML
- Store and forward with publish / subscribe semantics
  - Adapter collect machine data rapidly – in the range of 10ms
  - Application collect data less frequently – in the range of 1s
  - MTConnect agent need support data buffering



# Concluding?



**Industrial Data Center**

**MTConnect Application**

**Cell Level Compute Platform**

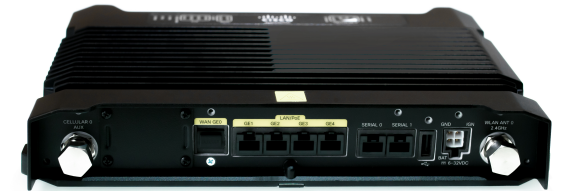
IR 809/829      UCS E Series

ICA 3000 (Roadmap)      CGR 1000 (Roadmap)

- Data Abstraction
- Data Processing
- Data Acquisition

# Big Stars

- (For now) you just want to connect: IE2000 ->
- You want your network to be Industry4.0 ready: IE4000 ->
- You want to start gathering Machine Data NOW: IR829 ->
- You want to start doing Analytics, fast, safe and at the edge -> Cisco CSA



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The Outcome will be immense