



# I(oT) in Process Networks

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# 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



18<sup>th</sup> Century  
Steam



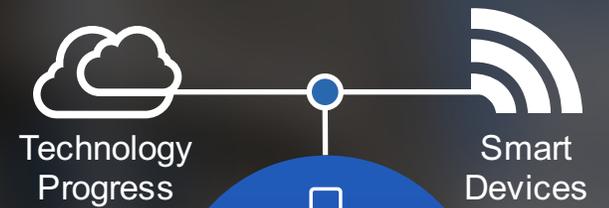
20<sup>th</sup> Century  
Mass Production



70's  
Robots



Today  
Digitization



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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- Step 5: Have a very simple way to integrate (REST API)



# Cisco IE Switches Product Overview

Aggregation

Access

Features

2014 Interop  
Tokyo  
IoT Award

2014 Control  
Engineering  
Award

## Cisco® IE 2000 Series



- Layer 2
- Small Form Factor
- IP30 and IP67
- CC\*
- DLR (only Stratix)
- Profinet MRP
- Layer 2 NAT
- IEEE 1588 PTP
- PoE/PoE+

## Cisco IE 2000U Series



- Layer 2 and 3 (IP services)
- Small Form Factor
- PRP
- IEEE 1588 PTP & Power Profile
- PoE/PoE+

## Cisco IE 3000 Series



- Layer 2 or 3 (IP services)
- Modular
- Up to 24 ports
- IEEE 1588 PTP
- PoE/PoE+

## Cisco IE 3010 Series Cisco CGS-2520



- Layer 2 or 3 (IP services)
- 1RU
- 2 GE combo uplinks
- 8 PoE and 16 SFP or 24 copper
- Power profile (CGS2520)
- PoE/PoE+

## Best in Class

### Cisco IE 4000 Series



- Designed for all industries
- Layer 2 or 3 (IP services)
- 4-port GE uplinks
- Up to 20 ports GE
- IEEE 1588 PTP & power profile
- Layer 2 NAT
- Up to 8 PoE/PoE+
- Dying Gasp
- TrustSec® SGT HW ready
- MACsec
- FNF HW ready
- Time Sensitive Network (TSN) HW ready

### Cisco IE 5000 Series



- Designed for all industries
- Layer 2 or 3 (IP services)
- 4-port 10GE or GE uplinks
- 24 ports GE
- IEEE 1588 PTP & power profile
- Layer 2 NAT
- Up to 12 PoE/PoE+
- Dying Gasp
- TrustSec® SGT HW ready
- MACsec HW ready
- FNF hardware ready
- Time Sensitive Network (TSN) HW ready
- CC\*

10/100 Mbps

1 Gbps

10 Gbps

# 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



## 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



## Certifications

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

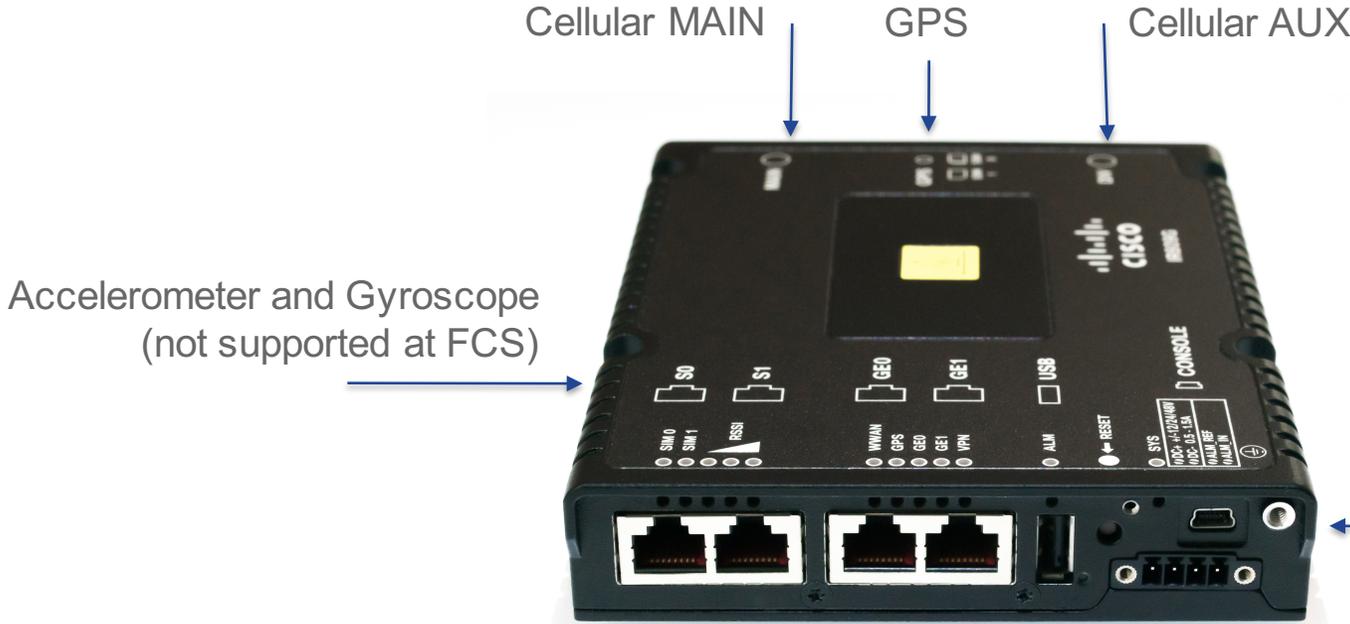


## Additional features

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

# Cisco 809 Industrial Integrated Services Routers

Dimensions:  
• 5"x 6.25"x1.25" (DxWxH)  
Temperature: -40C to +60C



**IEC61850-3 and IEEE1613 compliant**

One USB Type B Port

One RJ-45 RS232 Serial Port  
One RJ-45 RS232/RS485 Serial Port

9-60 VDC Power Input  
Digital Alarm Ports (not supported at FCS)

Two 10/100/1000Base-T

One USB 2.0 Type A port  
(not supported at FCS)

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



SECURITY



MONITORING



ANALYTICS

Factory

Historian

Tool Health

Memex Merlin



OEE & Analytics

Quality

Maintenance

Machine / Cell Package

Cameras



Analytics



Sensors

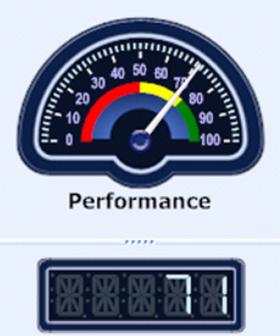
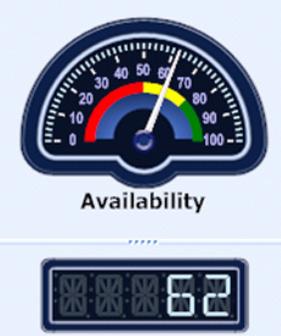


IoT FOG Node  
MTConnect



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



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	

Data Base Connection

Server sqlsrv01

Status CONNECTED

Date/Time 14/08/22 - 01:15

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# Why MTConnect ?

**MTConnect** Data Model is a Game Changer

Applications

**MANY**

IoT FoG Node

**ONE**

Machines & Assets

Historian

Tool Health

Memex Merlin



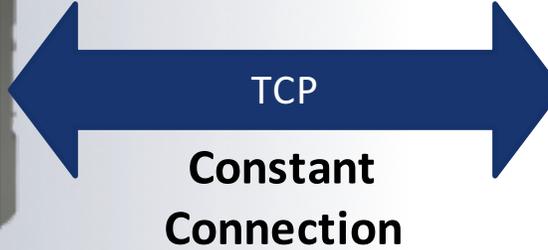
OEE & Analytics

Quality

Maintenance



Industrial Switch  
Connect  
Compute  
Security  
Analytics



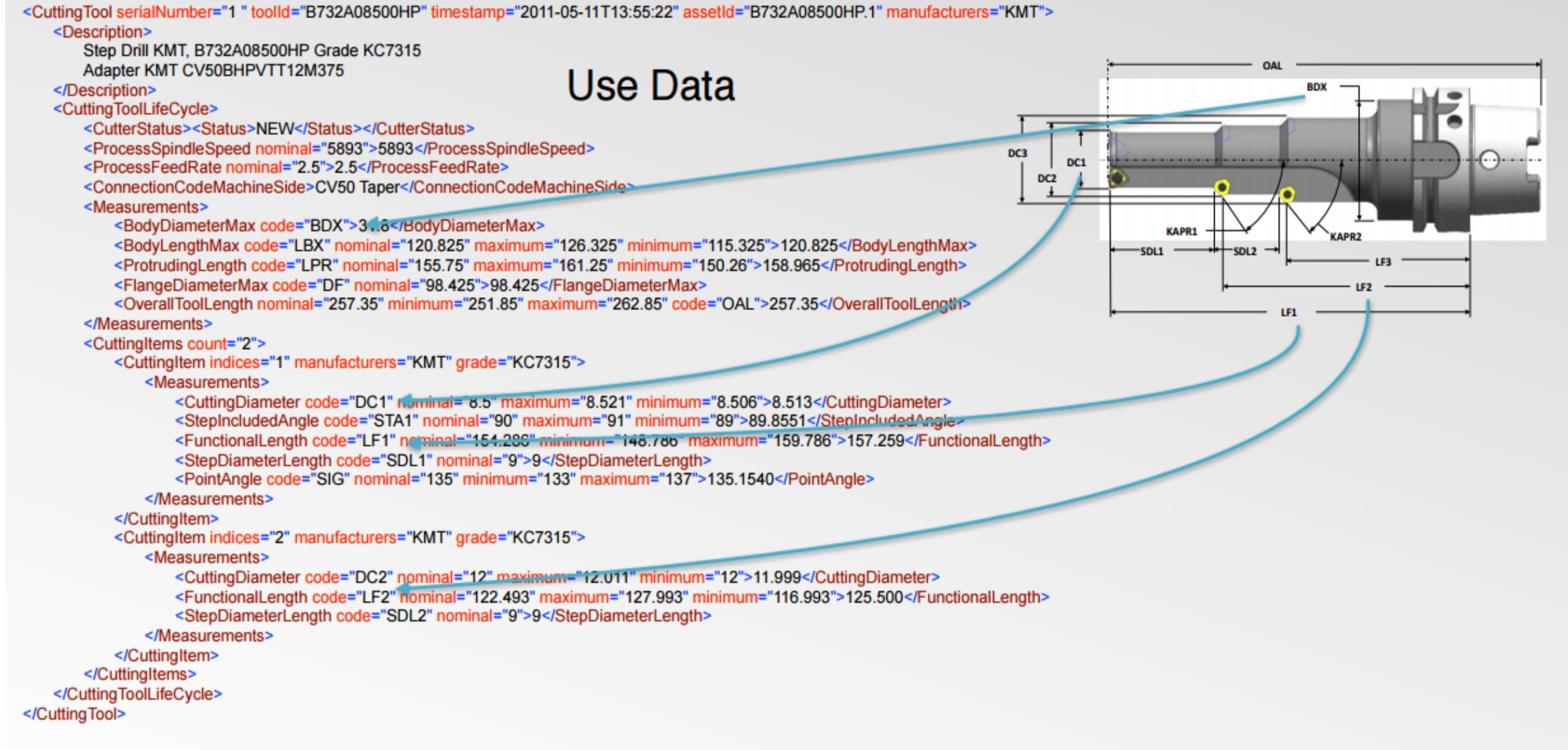
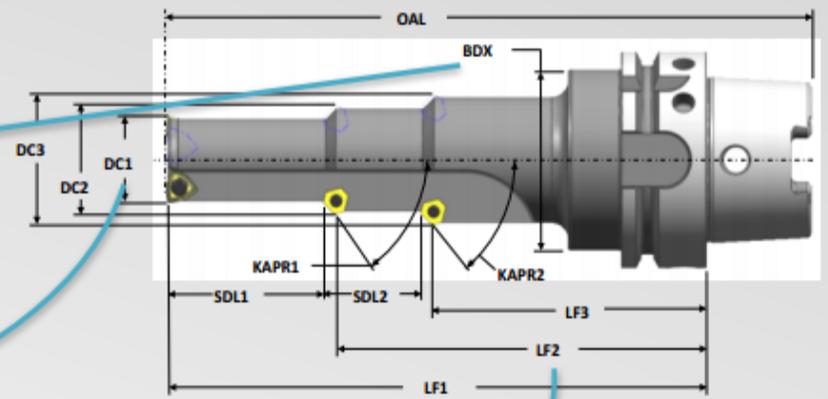
Mazak Machine  
w/ MTConnect adapter

# What is Goal of MTConnect ?

## Translate Machines into Standard XML Semantics

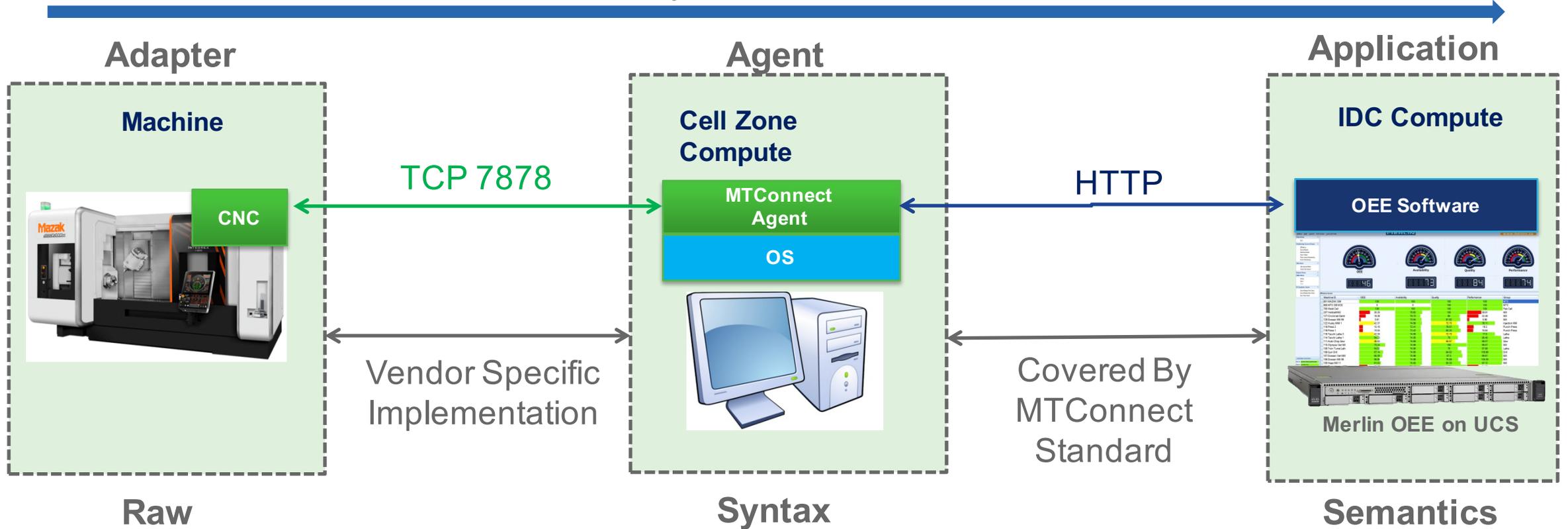
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<CuttingTool serialNumber="1" toolId="B732A08500HP" timestamp="2011-05-11T13:55:22" assetId="B732A08500HP.1" manufacturers="KMT">
  <Description>
    Step Drill KMT, B732A08500HP Grade KC7315
    Adapter KMT CV50BHPVTT12M375
  </Description>
  <CuttingToolLifeCycle>
    <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">31.6</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">
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          <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>
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        <Measurements>
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          <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

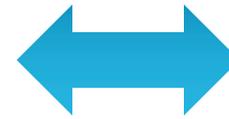
Read-Only Data from Machines



01010011010  
10001010010



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



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

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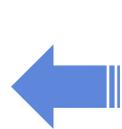


# Cisco Parstream

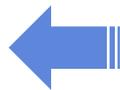
- Sensor Inputs:
  - **Coolant Level**
  - **Temperature**
  - **PH**
  - **Vibration**
- Digital I/O Sensors look like MTConnect Adapter.
- Feeds Data to MTConnect Agent IoT Platform(ie-4000)
- Cisco Streaming Analytics can be tuned to be process specific
  - Pattern Matching
  - Predictive Analytics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



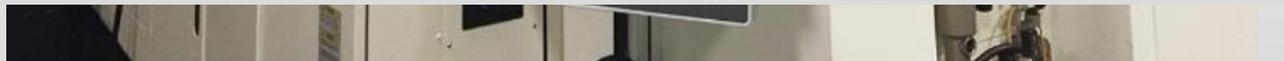
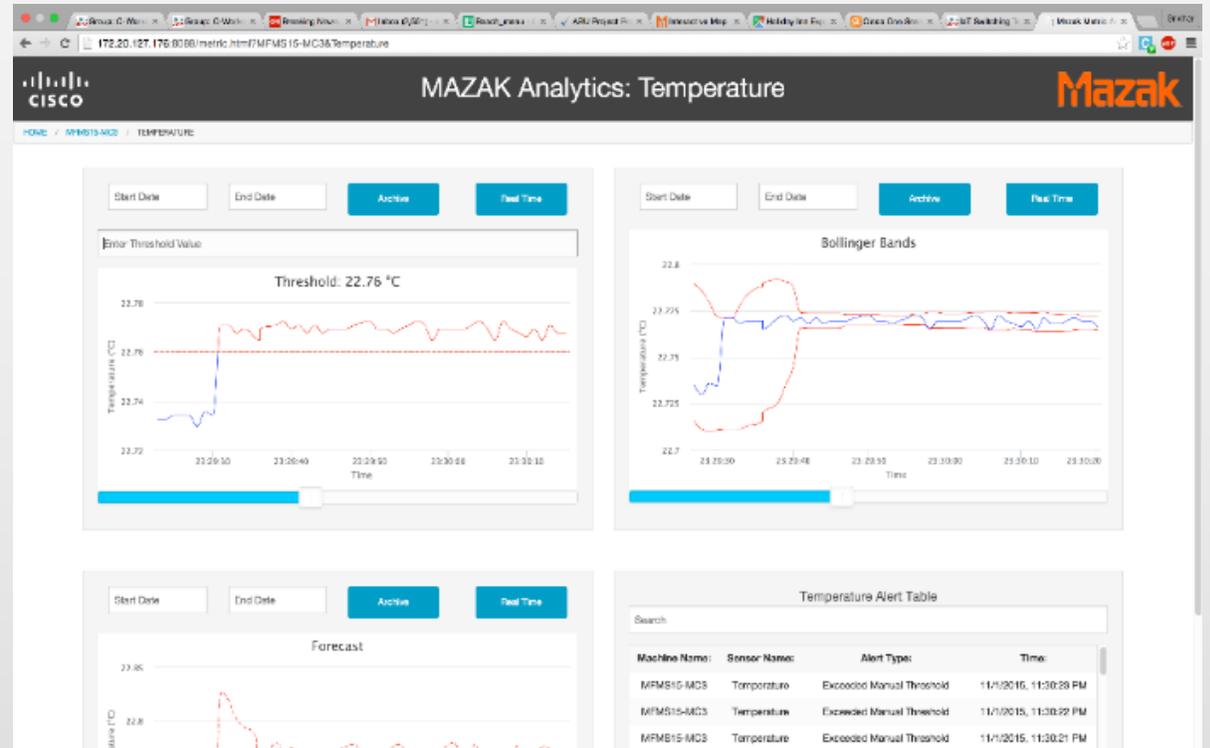
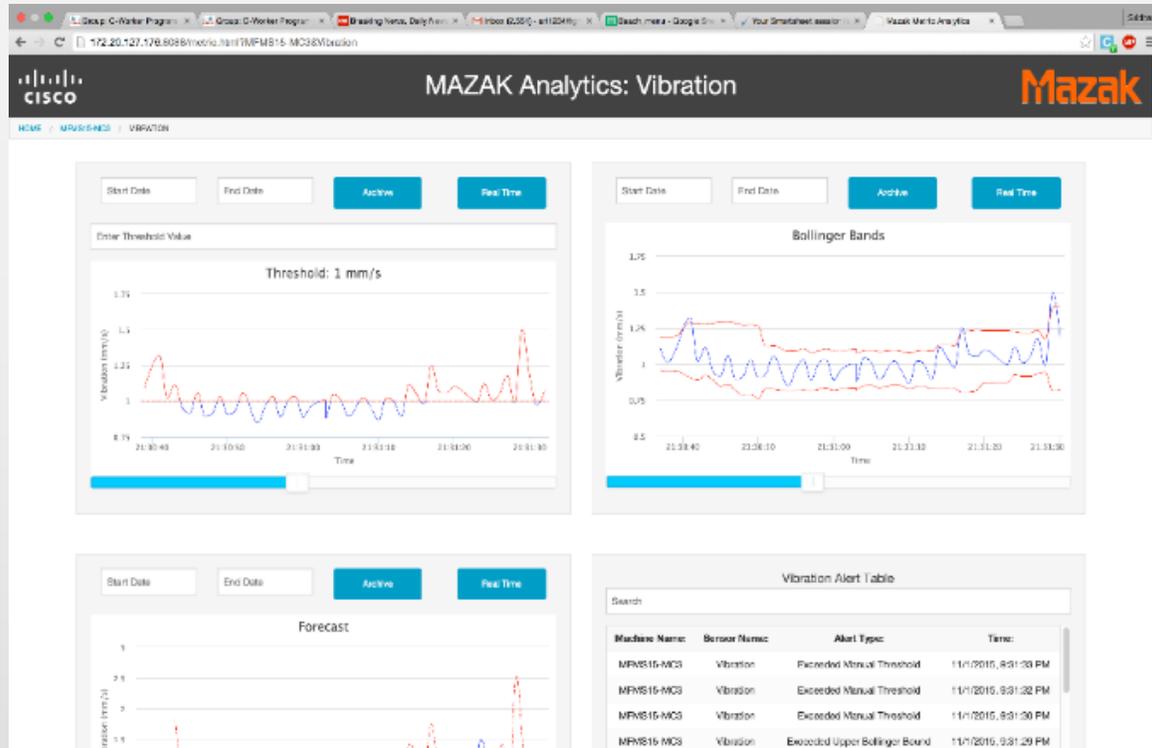
Cisco CSA



MTConnect Agent 5000



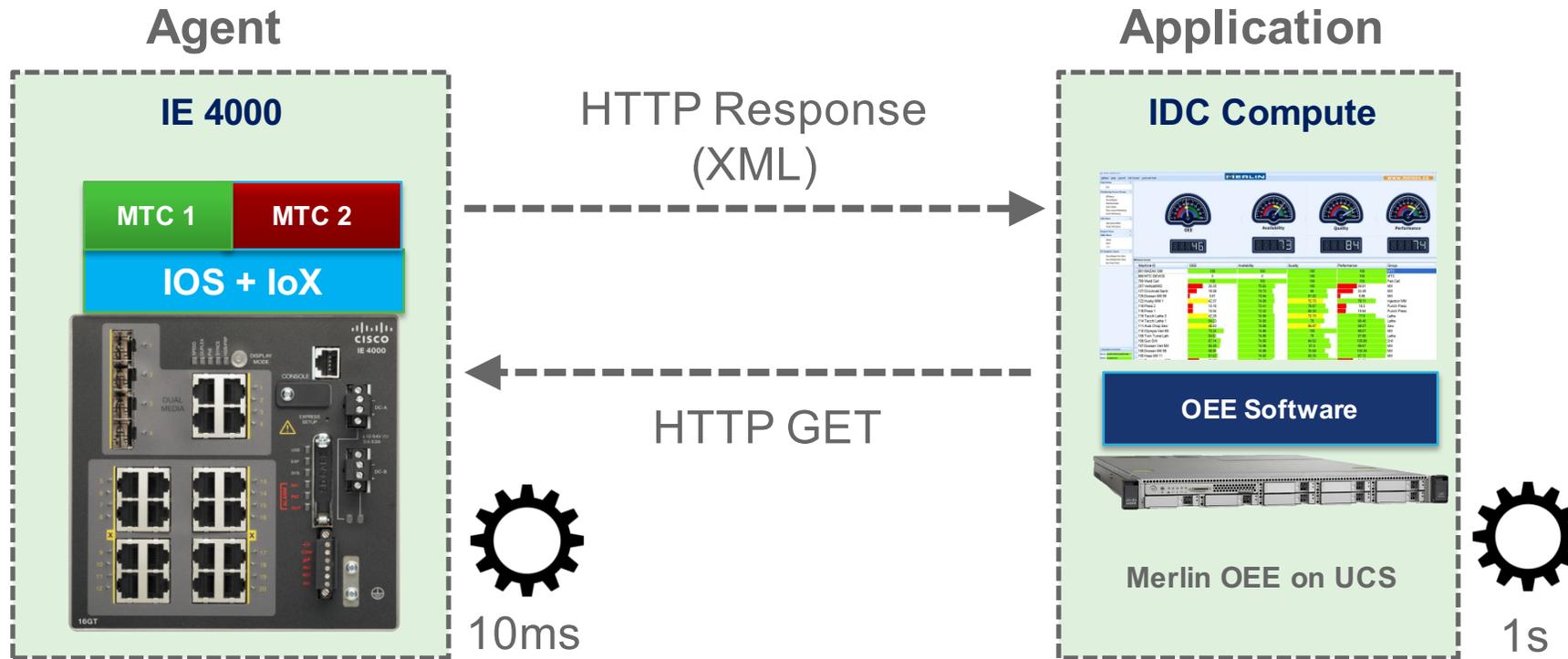
# Streaming Analytics on Mazak's Smart Box



# Industry 3.0 to Industry 4.0

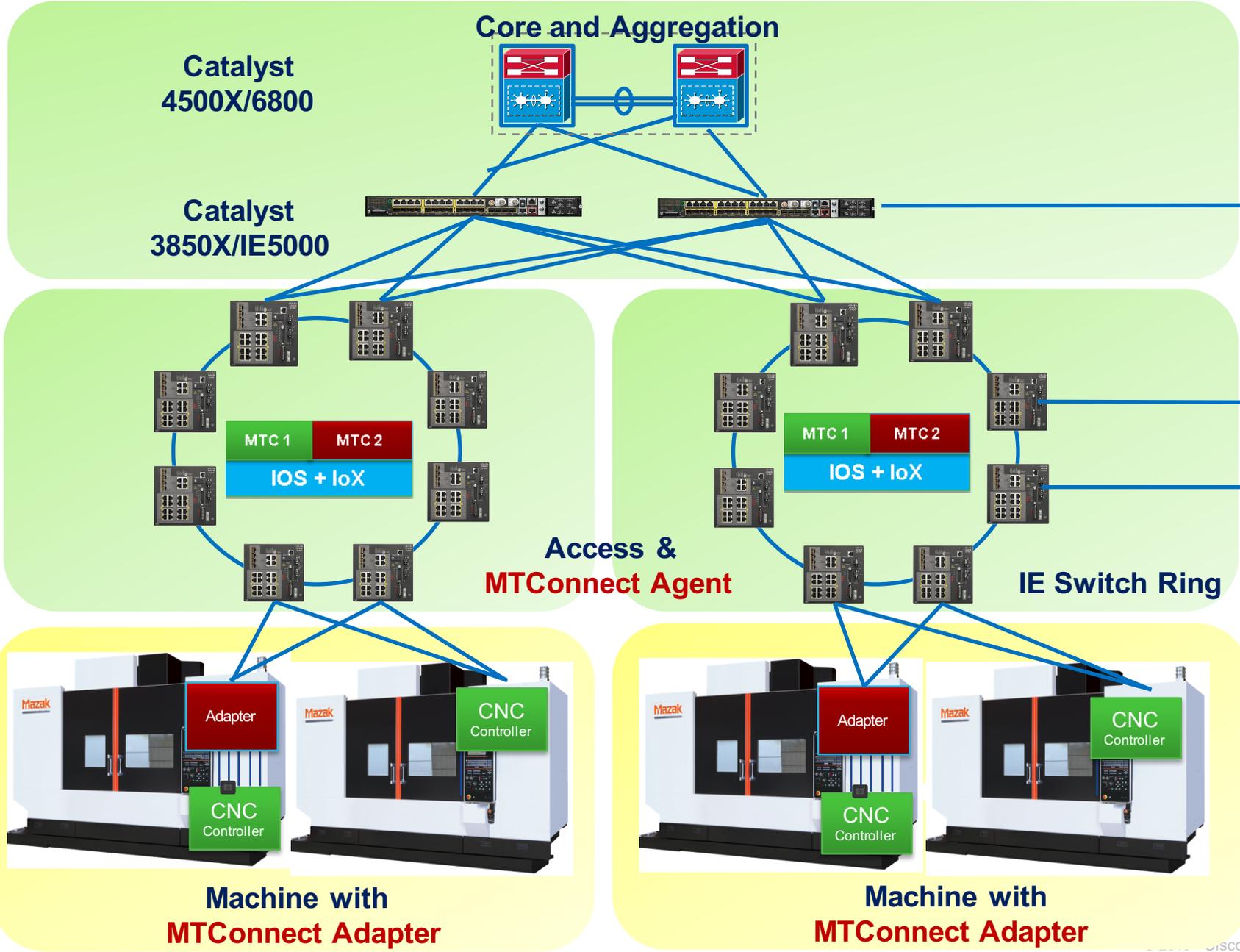
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# MTConnect Agent - Application Communication



- 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**

# Connected Machines Deliver Business Outcomes



Reduced  
Downtime

48%

Unplanned  
downtime down  
from 11%  
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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  
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\$8.4M  
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The Outcome will be immense