DEVELOPING IN THE IOT SPACE

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ReDev B0st0n 2017
A LITTLE ABOUT ME

• Over 35 years with PTC (via Prime Computer / Computervision)

• Pre-sales; R&D; Product Management; Office of the CTO

• I’m a prototype guy

• I’m a tools guy

• I’m a process guy

• I’m a mentor

• It’s only software
OVERVIEW OF THE IOT SPACE

• Where does IoT Apply?
  – To the Things you make
  – To the Things you use to make your Things
OVERVIEW OF THE IOT SPACE

• Segments of IoT
  – Industrial
  – Fleet
  – Consumer
• Keep your production line running
  – Monitor sensor data for “troublesome” readings – schedule replacement according to risk acceptance of the customer
  – Analyze sensor data leading up to device failure – use to improve the search for “troublesome” readings
  – Replace components prior to failure. Adjust for just how much shutdown risk you are willing to take
USE CASES

- Keep your Things running
  - Notify user of potential issues, service procedures needed
  - Use AR/VR to guide through maintenance, repair procedures
USE CASES

- Make better Things
  - Analyze your sensor data to improve future versions of your Things
USE CASES

– Give your Thing an HMI (Human Machine Interface)
  • Ecobee Thermostats
  • Rachio Sprinkler systems
SO MANY DEVICES, SO LITTLE TIME...

- Data Capture – lots of ways (more later)
- Device Control – changing the device’s state
- SECURITY! (remember the webcam cyberattack?)
DATA, DATA AND MORE DATA

- Where to put it
  - At my place
  - In the cloud

- Where to process it
  - At the edge
  - At the server
WHAT TO DO WITH THE DATA

• Analyze the Raw Data

• Anomaly Detection – statistically speaking, I don’t like this latest sensor value

• Machine Learning – statistically speaking, I don’t like the way all this data looks for this device based on all the other instances of this device in the field

• Feedback into Product Design

• Taking action via integrations to other systems
LIVEWORX KEYNOTE DEMO
• A walk through several different departments within a company heavily invested in IoT technology
  – Engineering – Reviewing IoT data and improving product design
  – IT – Building applications that include IoT data
  – Sales – reconciling device use with specific customers
  – Operations / Service – keep it running
• Problem: some customers are running the device at too high a temperature, but there is no obvious solution based on existing models
  – PLM supplies Design of the device
  – Digital mockups of CAD models to validate design
  – Analysis of performance data from the devices
    • Historical IoT data
    • Machine Learning prediction of performance to evaluate changes in the design
    • Integration to physics-based Simulations of design parameters
  – Digital twin to analyze current usage, create new design to improve market coverage
• Part 1 - CAD / PLM functionality
  – Retrieve a product structure and it’s visualization files from PLM
  – Use Creo View to inspect the models
  – Use Creo data in the finite element analysis
  – Use Creo to redesign the part
Part 2: Analysis of the data:
- Historical IoT data captured in Thingworx
- A machine learning model created from an analysis of the historical data
- A Simulink simulation, wrapped with Visual Basic and the Thingworx .NET SDK to make it appear as a remote device
ENGINEERING: HOW IT WAS DONE

• Solution: Make the cooling plate more efficient
• Use Additive Manufacturing (3D printing) to get a better cooling path
• For Sales: Integrate sales data and IoT data to identify up-sell or cross-sell opportunities
• For Marketing: Use VR/AR to provide brochures
• For Service: Use VR/AR for service procedures
• For IT: Deploy apps quickly
• Sales: Combine business systems data with IOT performance data plus machine learning in creative ways
  – Predict upsell situations and which customers to focus on based on historical interactions
  – Use Tablet / Phone / Hololens based virtual brochure with VR/AR data
• A Machine learning model was run against SalesForce data to predict customers likely to respond to an upgrade campaign.

• Historical IoT data showing specific devices at the top of their performance range was then cross-referenced against the identified customers.
• For the Virtual Brochure, a Thingworx Studio Experience was created, showing:
  – The 3D model for the device
  – The various animation sequences created with Creo Illustrate showing options and the internal impact on the design
  – Menus and command buttons were used to activate the various sequences to show off the features and options of the device.
For IT: Thingworx Composer was used to wire together UI widgets and Thingworx Services to let you rapidly create apps.
• Connect all critical assets
  – Use products with existing sensors
  – Optionally add new sensors
  – Use Digital Twin
    • CAD + IoT data + positioning of components based on sensor readings
OPERATIONS AND SERVICE

• Monitor devices
  – Trigger alarms

• Use AR to invoke service procedures
  – Barcode style identification labels
  – CAD recognition
• Kepware was used to access the sensors built into the Cytropac via OPC-UA protocols

• A National Instruments cRIO controller was added with thermocouples to monitor temperature at key points on the device. Kepware also accessed this data via OPC-UA protocols

• Kepware used a direct Thingworx websocket interface to deliver the data
• REST calls were made to an ABB website that collected the robot arm data into Thingworx

• A graphics widget was created to show the CAD model and the position of the hydraulic cylinder arm in near-real time using Thingworx Composer
• Thingworx configured to monitor several sensor values

• When the Thingworx server detects changes, events get fired, services run to determine if the change merits an alert. If so, other services run to perform whatever appropriate action is needed.
• For the AR experience, Creo Illustrate is used to show the sequence of steps needed to remove and replace the filter. Thingworx Studio is used to package the steps together so the tech (or the customer) could perform the maintenance.

• Either a ThingMark or CAD recognition of the device can be used to invoke the Experience
• To see the full Keynote video (including the Laserman opening), go to
  – https://www.liveworx.com/blog/tag/keynote
  – Search for Liveworx 2017 keynote
    • Skip to 17:30 to bypass the opening introductions and laser show
    • Skip to 32:00 to see the demo portion
BEYOND THE KEYNOTE
IoT affects all companies that manufacture “things”
- Capturing data from the “things”
- Capturing data from the machines that make the “things”
• What does the company consider important?
  – Customer satisfaction (uptime, quick and accurate service, self-service for consumables)
  – Manufacturing performance (line stays up – maintenance scheduled ahead of failures to avoid downtime

• Use AR/VR to describe self-service procedures

• Use AR/VR for service techs – help increase first time fix rate, especially with newer techs
• Integrate with CRM – some sensor out of range could automatically open service ticket

• Schedule preventive maintenance for off-peak times to replace troublesome components – keep the device or production line running at peak times

• Collect and analyze sensor information leading up to failures – use to adjust indications of “troublesome” components
Capturing data from the “thing” is a wide spectrum
- Low level GPIO / I2C / SPI / RS485 / … connections
  - The smaller the “thing”, the less likely it is to be able to talk directly to the internet
  - You need aggregators to collect data from these things and send it up to the server
  - Operations network isolated from the internet – only the aggregators are on the IT network
  - Likely little or no security in this type of “thing”
Simple networking is available
- Device has just enough capabilities to contact an MQTT broker to deliver messages
- May or may not enable bi-directional communication for device control as well as monitoring

Full networking stack is available (embedded computer)
- Options now include all TCP-based software stacks but the primary methods seem to be:
  - Message brokers
  - REST
  - websockets
• Industrial Setting
  – Usually talking with PLCs only – hardwired to the PLC – some wireless
  – Usually two networks – IT and OT Operations Technology
  – Devices live on OT
    • Because they might not have any security capabilities
    • Isolate the traffic
  – Aggregators (like Kepware) provide the gateway between IT and OT and do it in a secure fashion
Fleet Setting – things that move around
  – Now we talk about the wire (or lack thereof):
    • WiFi
    • Cellular
    • Bluetooth
    • Satellite
  – Aggregators
    • Laptops
    • Cellular phones and tablets
  – Delayed reporting
    • Asset must capture data into storage
    • Aggregator captures data near the asset
    • Aggregator forwards data when back online
• Similar to fleet, except the wire is your ISP router or your cellular network
  – WiFi feeds
  – Bluetooth feeds
  – USB Connection

• Security is paramount (remember the webcam attack?)
  – Don’t have a default id/password on your device!
  – Make them change one or both on first use
  – Consumers won’t change it unless you force the issue
  – Insist upon use of HTTPS

• Ease of configuration

• Ease of use

• Opt In / Out for data collection
• In the Keynote, we looked at the specifics for a hydraulic pump.
  – Even if a huge success, it may still only be in the 10s of thousands of units to monitor and control
  – What happens when it is 100s of thousands of units (e.g., city light fixtures)?
  – What happens when it is millions of units (e.g., telemetry from an automobile or cell phone)
• Let it happen in the cloud
  – They can scale very quickly (for a price)
  – They can hold massive amounts of data

• Know when to hold ‘em, know when to fold ‘em
  – Decide how long to archive the history data
    • Last several days, full details in the server
    • Further back, data only available from a historian / data lake
    • Even further back, detailed data replaced with summary information
• Ingestion layer in front of primary server
  – Convert messages into standardized model data format (InfoTables in the Thingworx instance)
  – Only ever deliver the model data format to the server so it can focus on the Orchestration aspects and push the Contextualization to another layer
  – Do what you can / must at the edge; do the rest near but not in the primary server
KEYNOTE
DEVELOPER
SKILLSET

• Javascript for developing services in Thingworx
• JSON for data exchange
• Java for developing extensions to Thingworx
• Visual sequence generation (Creo Illustrate)
• REST development
• Creo / Windchill / Finite Element Analysis
• Factory PLC integrations
• Simulink
• Visual Basic to integrate Simulink
• Virtualization / Hypervisors
• System Administration
DEVELOPER SKILLS FOR BEYOND THE DEMO

• Message brokers
• C, C++, Java, Python, other scripting languages for HW integrations
• XML for data exchange
• Microprocessor programming
• Direct HW wire interfaces
• Communications programming
• SECURITY implementation
PTC TOOLSET

- Thingworx – IoT Application Enablement Platform
- Kepware – Factory Device Aggregation
- Thingworx Studio – AR/VR Experiences
- Thingworx Analytics – Machine Learning
- Creo (CAD), Windchill (PLM / SLM), Integrity (ALM), Creo Illustrate, Creo View
QUESTIONS?

• See more at https://www.ptc.com
• Explore IoT at https://developer.thingworx.com