Advantages of Embedded Linux in Industrial Automation and IIoT

Benson Hougland – Opto 22
Topics I’ll Cover

- Who is this guy and what is Opto 22?
- What is Industrial Automation? What about IIoT?
- What problems are we trying to solve here?
- How do we solve these problems?
- A case study application – Tale of Two Turbines
- How *groov* EPIC solved the problem
- Live Demonstration
About me and my company

Benson Hougland, VP Marketing & Product Strategy
Opto 22, Temecula, CA USA – www.opto22.com

♦ 44 year technology innovator, from SSRs to I/O, control systems, software, mobile, & IoT

♦ Market leader of intelligent, distributed I/O systems: 100M I/O at over 10K global customers

♦ Reputation for quality and reliability backed by lifetime warranty on solid-state I/O

♦ Unique in industry to combine capabilities in OT
  - ruggedness, reliability, flexibility – with IT
  - networking, protocols, accessibility

♦ Responsible for many firsts in our industry
Many Firsts

- Plug-in I/O
- Ethernet I/O
- M2M
- EPICs
- Founding Member
- PACs
Industries Served

- Manufacturing
- Retail Outlets
- Pharmaceutical
- Petrochemical
- Food & Beverage
- Commercial buildings
- Government buildings
- Pulp & Paper
- Telecom
- Semiconductor
- Utilities
- Packaging and conveyance
- Mining
- Discrete manufacturing
- Telecommunications and data centers
- Retail stores
- Power generation
- Process plants
- Building management
- OEM
- Energy use
- Telecom and data centers
Entertainment
Transportation
Oil & Gas
Buildings & Facilities
Special Projects
Special Projects

Dive Time: 05:42:12
Depth: 10100 m
Vision 1: 18.2°C
Vision 2: 15.9°C
CO2: 0.2%
Batt.: 72.6%

Auto Altitude

Depth: 10100 m
Altitude from sonar: 50 m

Vertical speed: 3.6 m/s

Thrusters: 4

Internal temp: 27.4°C
External temp: 2.4°C

Internal pressure: 1024 mbar
External pressure: 1130 bar

Spot: 100%
Store Heading and Reciprocal: 358°

Heading: 2

Reciprocal: 358°

Date: 03/14/12
Time: 14:27
What is Industrial Automation and the IIoT?
What is Industrial Automation?

- Industrial automation deals primarily with the automation of manufacturing, process control, and material handling processes.

Industrial automation is to replace the decision making of humans and manual command-response activities with the use of mechanized equipment and logical programming commands.

*Wikipedia, 2019*
Automation Tools of the trade

- PLC – programmable logic controller
- PAC – programmable automation controller
- IPC – industrial PC
What is the Internet of Things (IoT)?

- The internetworking of physical devices, vehicles, buildings and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data
  
  Wikipedia, 2016

- The ability of “things” to sense, communicate, and control.

  Benson Hougland, TEDx Temecula, 2014
The Internet of Things

What is it, and should you care?
What is the Industrial IoT (IoT)?

- The industrial internet of things (IIoT) refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management.

- This connectivity allows for data collection, exchange, and analysis, potentially facilitating improvements in productivity and efficiency as well as other economic benefits.

Wikipedia, 2019
The IIoT Modular Architecture

<table>
<thead>
<tr>
<th>Layered modular architecture IIoT</th>
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<td><strong>Content layer</strong></td>
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<td><strong>Service layer</strong></td>
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<td>Hardware: CPS, machines, sensors</td>
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*Courtesy of Industrial Internet of Things, Wikipedia, 2019*
Industrial IoT Tools of the Trade

- Gateways, sensor systems
- Ignition by Inductive Automation
- Node-RED by IBM Emerging Labs
- Cloud Platforms
  - AWS IoT
  - IBM Watson
  - Microsoft Azure IoT
  - PTC Thingworx
What’s the problem?

Issues plaguing Industrial Automation & IIoT
The future is here.
Uh-oh.
**PROBLEM**

Existing systems are complex, costly, & difficult to maintain

<table>
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<tr>
<th>Sensors Actuators Devices</th>
<th>PLC RTU EFM</th>
<th>OPC Server</th>
<th>HMI PC</th>
<th>Firewall Gateway</th>
<th>Cloud &amp; On-Premises Applications</th>
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PROBLEM

Existing systems are complex, costly, & difficult to maintain

- Proprietary OSs & RTOSs
- Multi-domain expertise required
- Security nightmare
- Unable to scale
- Licensing costs and manageability
How do we solve these problems?
Embrace Embedded Linux.
The World’s First **Edge** Programmable **Industrial** Controller
Existing systems are complex, costly, & difficult to maintain

EPICs are simpler, more secure, & manageable

SOLUTION
Existing systems are complex, costly, & difficult to maintain

SOLUTION

EPICs can also secure legacy systems
**PROBLEM**

Applications Tightly Coupled to Devices

- Direct connections required
- Inefficient poll-response
- Multiple, insecure open ports
- Unencrypted traffic
- Difficult to manage & maintain
- Complex architecture
- Shifts responsibility to IT
Numerous security vulnerabilities and points of access to manage
SOLUTION

Applications Decoupled from Devices

♦ Efficient
  ◆ Publish-subscribe, bi-directional

♦ High performance
  ◆ Data transmit only on change

♦ Secure
  ◆ Only ONE secure open port
  ◆ Only ONE place to manage & maintain user and data access
Case Study

Wind Turbines
Case Study: Tale of Two Turbines

- Most turbines were commissioned decades ago.
- Most wind turbines have older, antiquated control systems.
- Operating data was siloed and difficult to retrieve.
- Generally speaking, when the wind blew, electricity was generated.
- Now, over-generation is problematic for turbine owner-operators.
California’s Renewable Energy

Legislated Energy Goal

- 33% of energy from renewable sources by 2020
  - Solar, Wind, Hydroelectric, Geothermal
- However...
  - Generation is variable and not always needed
  - Cannot store excess generation
  - Electricity must be produced and used at the same rate
CAISO attempts to predict the future:

- Available supply
- Expected demand
- Weather’s impact
- Renewables variability
- Then, determines which generating assets to dispatch
Finding Equilibrium

Supply & demand management tool

- Vary the *spot price* of electricity for generation producers in real time
- Price can fluctuate minute by minute
- Determined by CAISO
Typical Scenario

- Electricity supply exceeds demand
- Curtailment dispatched by CAISO market price, sometimes to below $0
- Legacy wind turbines have no communications or edge processing
- Owner-operators write a check if generating
What if they apply IA and the IIoT?

- Get physical inputs: generation, blade pitch, temperature
- Combine with data inputs: market price, weather forecast
- Set outputs: change turbine blade pitch, curtail turbine
- Report data to cloud IoT platforms for predictive maintenance
Tale of Two Turbines Results

- Autonomous turbines query energy spot price, weather forecast, and post operational data
- Turbines generate electricity to grid based on real-time spot price
- Local visualization for turbine operators
- Cloud visualization for turbine owners
- Legacy systems increase in value
How’d they do it?
The World’s First **Edge** Programmable **Industrial** Controller
System Architecture

Where does it fit?
System Architecture

On Premises  Corporate Network  In the Cloud  On Devices

IT

BT

OT

Control Networks

Analog, Digital, Serial

Allen-Bradley®, Siemens® S7, Modbus®/TCP
# The IIoT Modular Architecture

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*Courtesy of Industrial Internet of Things, Wikipedia, 2019*
groov EPIC Hardware

Overview of EPIC’s hardware
High Performance Controller

- Industrial Quad-core ARM Cortex A9
- Linux OS with PREEMPT-RT
- 2GB RAM
- 6GB useable SSD
- Power-fail safe file system
- Dual Gigabit Ethernet
- Dual USB
- Temperature rated -20 to 70°C
Integrated HDMI-based touch display

- High-resolution color touchscreen display
- Displays *groov* Manage pages
  - Configure processor and modules
  - Troubleshoot I/O
  - Module specs and wiring diagrams
- Displays *groov* View screens
- HDMI port for external display
View on mobile, web browsers, and front display
groov I/O Modules

- 4-24 channels per module
- Isolated and non-isolated versions
- Hot swappable
- Many I/O variations
  - Analog in/out
    - flow, pressure, level, position
  - Discrete in/out
    - presence, status, on-off, start-stop
  - Serial
    - barcode, scale, RFID reader
  - Temperature
    - thermocouple, RTD, thermistor
Exploded View

- Easy to assemble
- Mount on SS chassis
  - 0, 4, 8, 16 module versions
- Industrial Approvals
  - UL Hazardous Locations
  - Class 1 Div 2
  - CE approved
  - ATEX Compliant
groov EPIC Software
What does the software do?

- Brings key capabilities to an industrial controller:
  - Manage, commission, and troubleshoot the system
  - Develop and run real-time control strategies
  - Create and view mobile and web operator interfaces
  - Build & deploy IoT applications quickly
  - Connect to legacy PLCs
  - Publish & subscribe data with MQTT/Sparkplug
  - Secure existing OT devices and infrastructure
Software Architecture

On Premises Applications

Web & Mobile Operator Interfaces

Cloud Applications
groov Manage
Software Architecture

On Premises Applications

Web & Mobile Operator Interfaces

Cloud Applications

 RESTful API

HTTPS

PAC Control

CODESYS

ssh

Java

python

I/O

Control

System

Security

Maintenance

Accounts

yocto PROJECT

Analogue

Digital

Field I/O devices

SNAP PAC Controllers

Modbus/TCP Devices

External OPC UA Servers

Opto Device

Modbus/TCP

Ethernet
Multiple Programming Options

- PAC Control
  - Flowchart-based control programming
  - Basic-like scripting engine

- CODESYS
  - IEC-61131 programming environment
  - Ladder logic, function block, etc.

- Secure Shell
  - Develop your own applications
  - C/C++, Java, JavaScript, Python, etc.
Software Architecture

On Premises Applications
- MQTT Broker
- RESTful API
- HTTPS

Web & Mobile Operator Interfaces
- groovView
- Internal Devices (groov Data Stores)
- External Devices (groov EPIC and SNAP PAC controllers, Modbus/TCP devices, OPC UA servers)
- HTTPS

Cloud Applications
- Amazon Web Services
- IBM Bluemix
- Microsoft Azure
- MQTT Broker
groov Manage – groov View
Software Architecture
groov Manage – Node-RED
Node-RED IIoT Development
Legacy PLC Connectivity

- Embedded drivers to PLCs
  - Allen-Bradley Logix, SLC, PLC5, and Micrologix
  - Siemens S7-300, -400, -1200, -1500
  - Modbus/TCP and Modbus/RTU over TCP
  - SNAP PAC S- and R-Series
  - groov EPIC PR-series
Live Demos

Get your smartphone ready...
Live Demo - local

- **groov EPIC** connected to **model turbine** and **stack light** for monitoring and control
- Connects to **CAISO API** via Node-RED to determine market spot price
- Connects to **Dark Sky weather API** for local weather data
- Publishes time-series data to **MS SQL** database on AWS RDS
- Publishes real-time operating data to **MQTT broker** for consumption by cloud-based SCADA (groov View/Ignition Gateway)
Live Demo - cloud

- View real-time live ELC Turbine data from your smartphone
- View time-series data from MSSQL database on AWS
- View live status updates on Twitter @OptoTurbineUS

Credentials:
- Username: trial
- Password: opto22
Thank you!

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