Evolution of Industrial Networks - IoT and BIG Data

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Georgia Tech Manufacturing Institute

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What is this presentation about?

1. Industrial networks past and present, and what's going to happen to industrial networking in the age of IoT.
2. Big Data and why it will be a key driver for IoT adoption in Manufacturing.
3. How to adapt and thrive in the IoT and Big Data Industrial Automation landscape.

Presentation Outline

- **Introduction**
  - What is this presentation about?
  - Who is this guy?
  - What does he know?
- **Industrial Networks**
  - Before Ethernet
  - Adoption of Ethernet
  - Consequences of Industrial Ethernet
- **IoT**
  - What is it?
  - Characteristics of IoT devices
  - How will IoT change industrial networking?
- **BIG Data**
  - What is it?
  - What can we do with it?
  - Relationship between IoT and Big Data
- **Conclusions**
  - How to adapt and thrive with IoT and Big Data

Who is this Guy?

Philip Barkes

- Born in Montreal, Canada
- Immigrated to the United States in 1986
- Attended High School in Clayton County, Georgia
- Completed my Electrical Engineering degree here at **Georgia Tech** in 1999
  - Co-op'd 7 quarters at **Factory Automation Systems**
- 1999-2005, Project Engineer at **Factory Automation Systems**
- 2005-2010, Project Engineer at **Printpack**
- 2010-2015, Corporate Electrical and Controls Manager at **Printpack**
- 2015-Present, Electrical and Controls Manager, **Nestle Purina**, Atlanta Plant

What does he know?

Automation Engineering

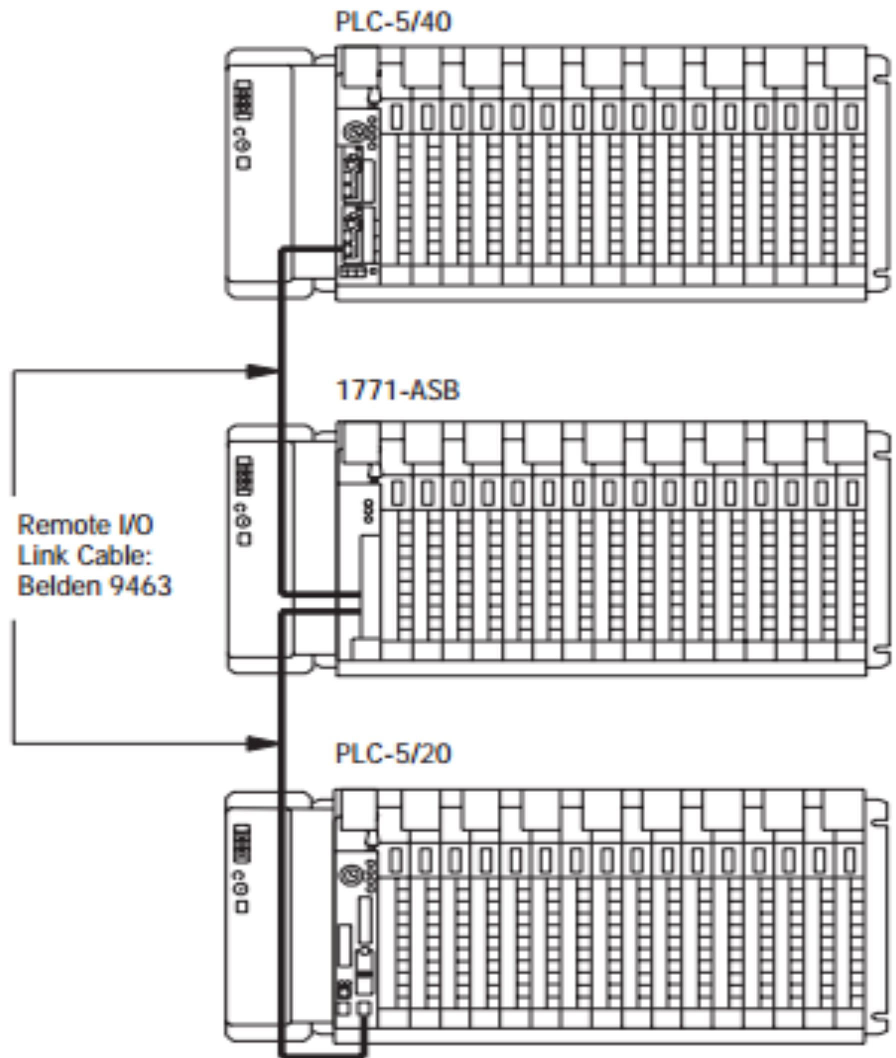
- **Industrial Control System Design**
  - Gathering system requirements
  - Developing functional specifications
  - Selection of components
  - Designing control panels and field wiring
  - Developing machine control and HMI software
  - System installation and commissioning
- **Industry Experience**
  - Material handling & conveying, web handling, auto assembly, food and beverage
- **Automation Platform Experience**
  - Rockwell (Allen-Bradley) – Native Language
  - Modicon and GE – Designed a few systems
  - Siemens and B&R – Basic knowledge

Questions?

Industrial Networks before Ethernet

What is an Industrial Network?

- A network for transmitting data between devices such as Logic Controllers (PLCs), remote input and output "racks", and field devices.
- Early industrial networks included twisted pair networks such as Allen-Bradley "Remote IO", Modicon "Modbus", Siemens "Profibus".
- Twisted pair network speeds were typically less than 512kbps
- Later, faster networks using Coax cable such as Modicon RIO and Allen-Bradley ControlNet were introduced.



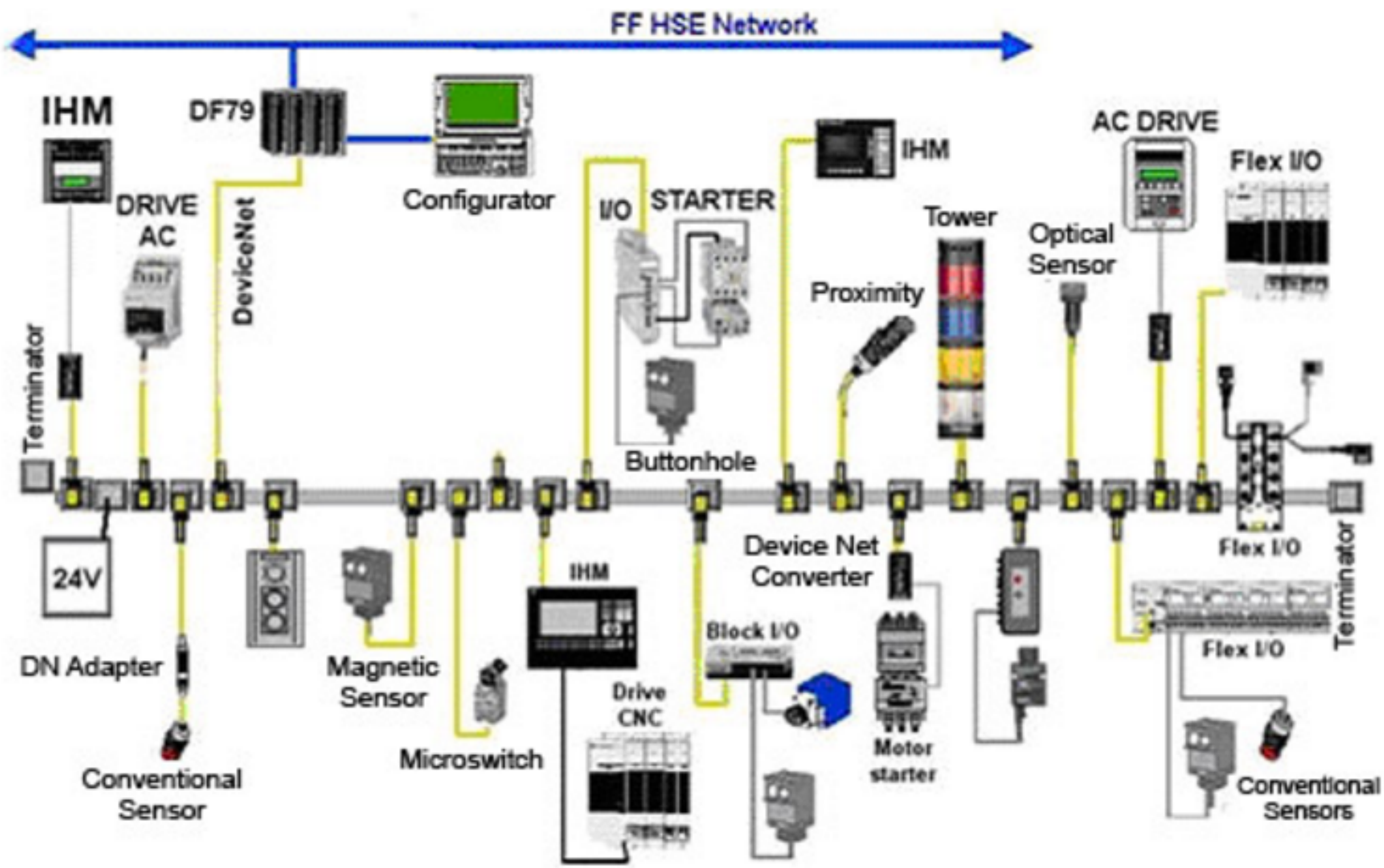
Source:
http://literature.rockwellautomation.com/idc/groups/literature/documents/um/1785-um012_-en-p.pdf

Industrial Networks before Ethernet - Fieldbus

An Industrial Network or "Fieldbus" generally has the following characteristics:

- Multiple devices can be connected to it with different network topologies supported depending on the network chosen.
- Topologies include "daisy chain", trunk/drop, star and ring.
- A single node serves as the bus controller.
- The key characteristic of a Fieldbus is that it is **Deterministic**, meaning that responses to messages are guaranteed within a certain amount of time. Some level of determinism is required in an industrial network in order to achieve repeatable control response.

Industrial Networks Before Ethernet - DeviceNet



Source: http://www.smar.com/en/devicenet

Industrial Networks – Arrival of Ethernet

First uses of Ethernet in industrial Automation:

1. Remote Programming
2. HMI to PLC communication
3. PLC to PLC messaging for non-time-critical data, such as setpoints and display data.

Problems with using "Standard Ethernet" in Industrial Automation

1. Standard Ethernet is not deterministic.
2. Order of delivery is not guaranteed because packets can take different paths to get to their destination.

Example: HMI "Sticky bits"

Typically when an HMI touchscreen buttons is pressed a packet is sent to the PLC to turn on a bit. A second message to turn off the bit is sent when the button is released. If the message to turn off the bit gets there first, or is not received, the bit is stuck on. Pressing the button again may fix the problem but the best solution is to program the PLC to set a separate bit for internal use and turn off the bit from the HMI after it is turned on.

Industrial Networks – Industrial Ethernet

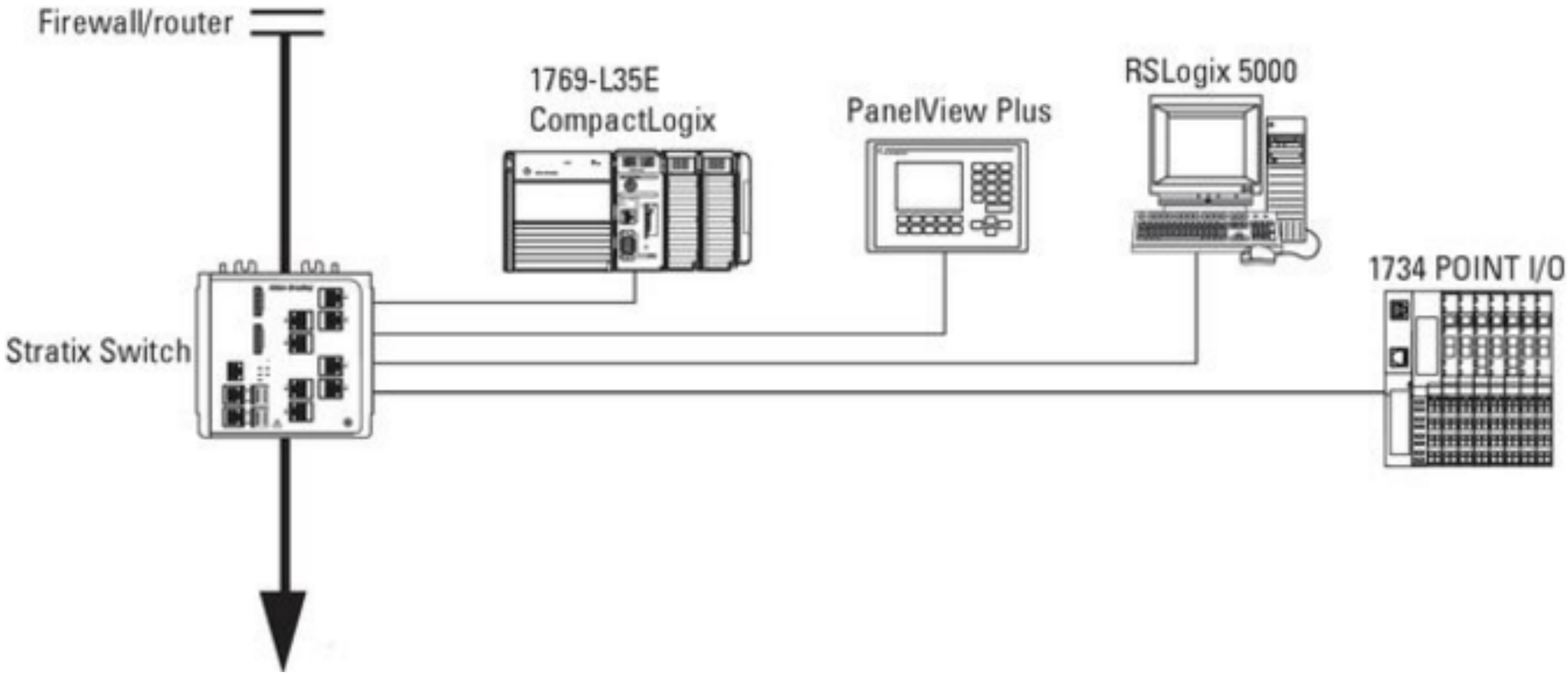
Ethernet media and hardware are ubiquitous and therefore inexpensive so it makes sense that automation vendors adopted the Ethernet standard and added their own tweaks to make Ethernet an Industrial Fieldbus.

Common Industrial Ethernet Protocols

1. Schneider Modbus TCP
2. Siemens Profinet RT (Real Time)
3. Rockwell Ethernet/IP (in this case "IP" stands for "Industrial Protocol," not Internet Protocol)

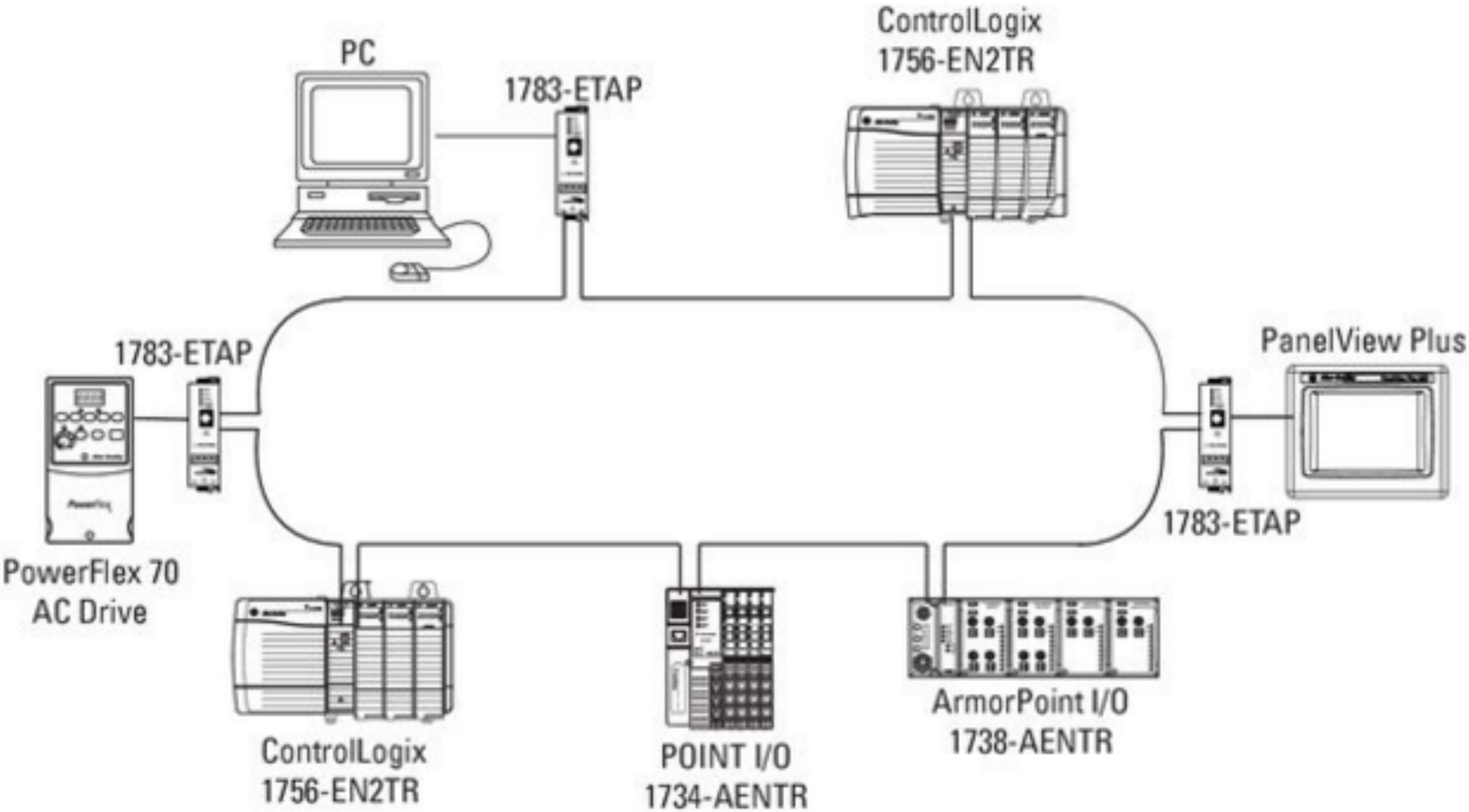
These protocols are built on standard Ethernet with determinism and other features added to support real time control. Therefore you can specify the update rate for specific nodes and subnodes on the network.

Industrial Networks – Ethernet Star Network



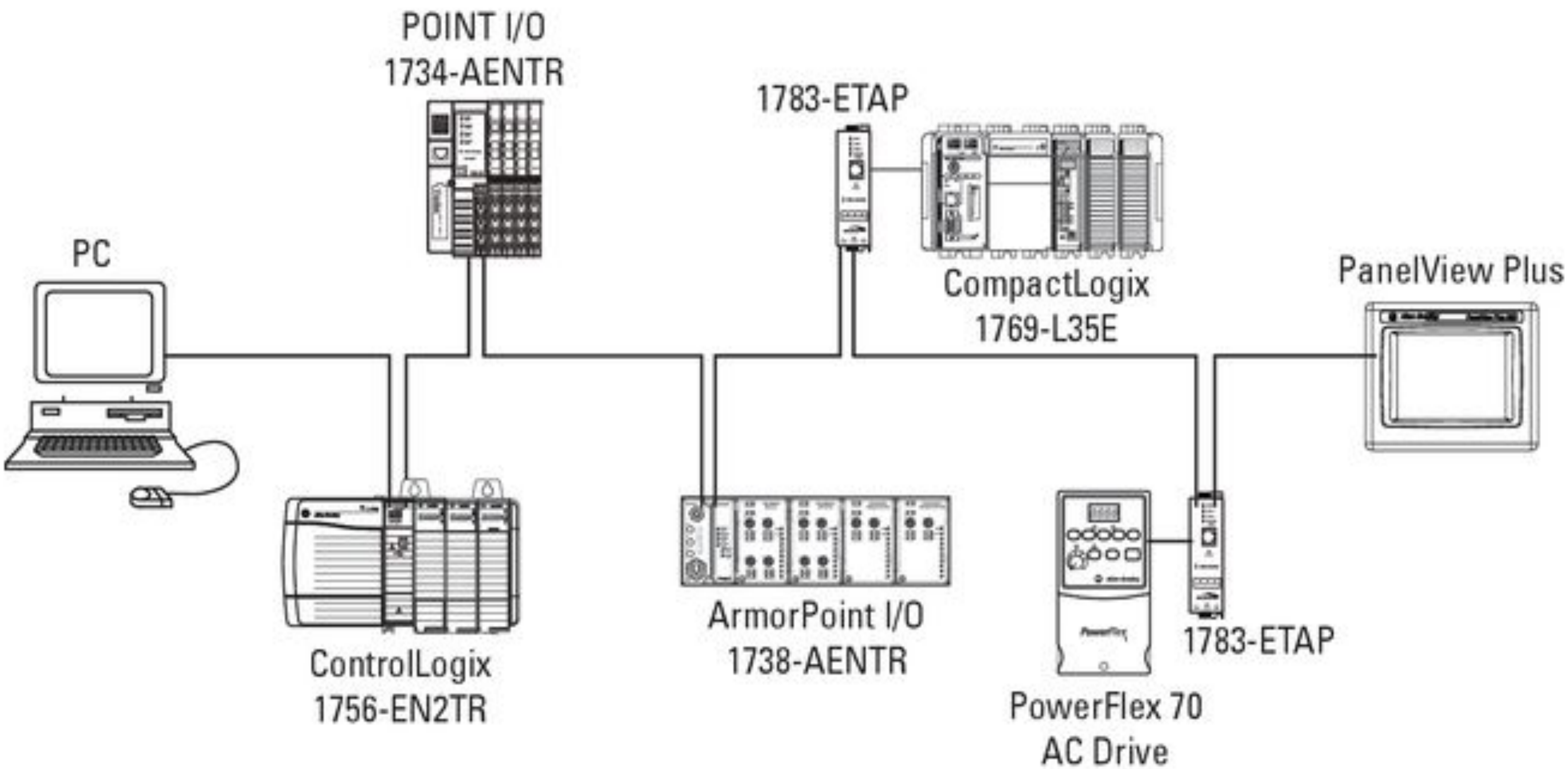
Source: http://www.ab.com/en/epub/catalogs/12762/2181376/214372/1810894/3404056/print.html

Industrial Networks – Ethernet Ring Network



Source: http://www.ab.com/en/epub/catalogs/12762/2181376/214372/1810894/3404056/print.html

Industrial Networks – Ethernet Linear Network



Source: http://www.ab.com/en/epub/catalogs/12762/2181376/214372/1810894/3404056/print.html

Consequences of Industrial Ethernet

1. **Automation Engineers no longer "own" the Fieldbus network:** Before industrial Ethernet the IT controlled Ethernet network ended at the controller. All the networks below that were isolated and managed by Automation Engineers. Now with the Fieldbus using Ethernet, IT departments are asserting control in order to maintain network security and standards compliance.
2. ***Since they are built on standard Ethernet, data from Industrial Ethernet Fieldbus networks and devices can be transmitted through standard Ethernet switches to anywhere on the network.***

Questions?

Internet of Things – What is it?

"...one day, your fridge will send spam to your microwave, and together [they'll] DDoS the coffeemaker."
[Eugene Kaspersky. https://eugene.kaspersky.com/2016/10/28/the-internet-of-harmful-things/]

IoT Definitions:

1. "The Internet of Things is the concept of everyday objects – from industrial machines to wearable devices – using built-in sensors to gather data and take action on that data across a network." [http://www.sas.com/en_us/insights/big-data/internet-of-things.html]

2. "Machines or systems talking to each other." [Andy Dugenske]

Internet of Things – Characteristics of IoT Devices

1. Ability to send and receive data across a wide area network without the use of a bridge device (directly connected)
2. Intelligent, have on-board processing and Firmware
3. Remotely Programmable or Configurable
4. Take action based on their own programming
5. May include wireless connectivity including cellular wireless

Internet of Things – Challenges

1. **Ability to send and receive data across a wide area network without the use of a bridge device (directly connected)**
   A. More data entering and leaving factory floor networks
   B. Firewall/security challenges, bottle necks
2. **Intelligent, have on-board processing and firmware**
   A. Network security risks / Mandate for more IT control
3. **Remotely Programmable or Configurable**
   A. Stronger security will be required to prevent unauthorized access and malware infections
4. **Take action based on their own programming**
   A. Internal security threat
5. **Wireless connectivity including cellular wireless**
   A. Security issues, clogged wireless networks.

Internet of Things – How will IoT change Industrial Networking

1. Ethernet cable will increasingly replace discrete wiring for devices and interlocks.
2. Use of POE: Sensors and other low power devices will get their data and power over Ethernet
3. Typical discrete devices such as photoeyes and proximity sensors will increasingly be networked and offer analog data and other configurable options.
4. Less need for centralized discrete and analog IO cards in control panel “racks”, more field located Ethernet modular IO and POE switches.
5. Increased use of **Distributed** control: Control ***and safety*** logic solving moving to output devices such as Variable frequency drives, Pneumatic valve banks, and field located output modules.
6. Reduced need for centralized PLC control.
7. Increased use of wireless communication in industrial networks (mobile applications)

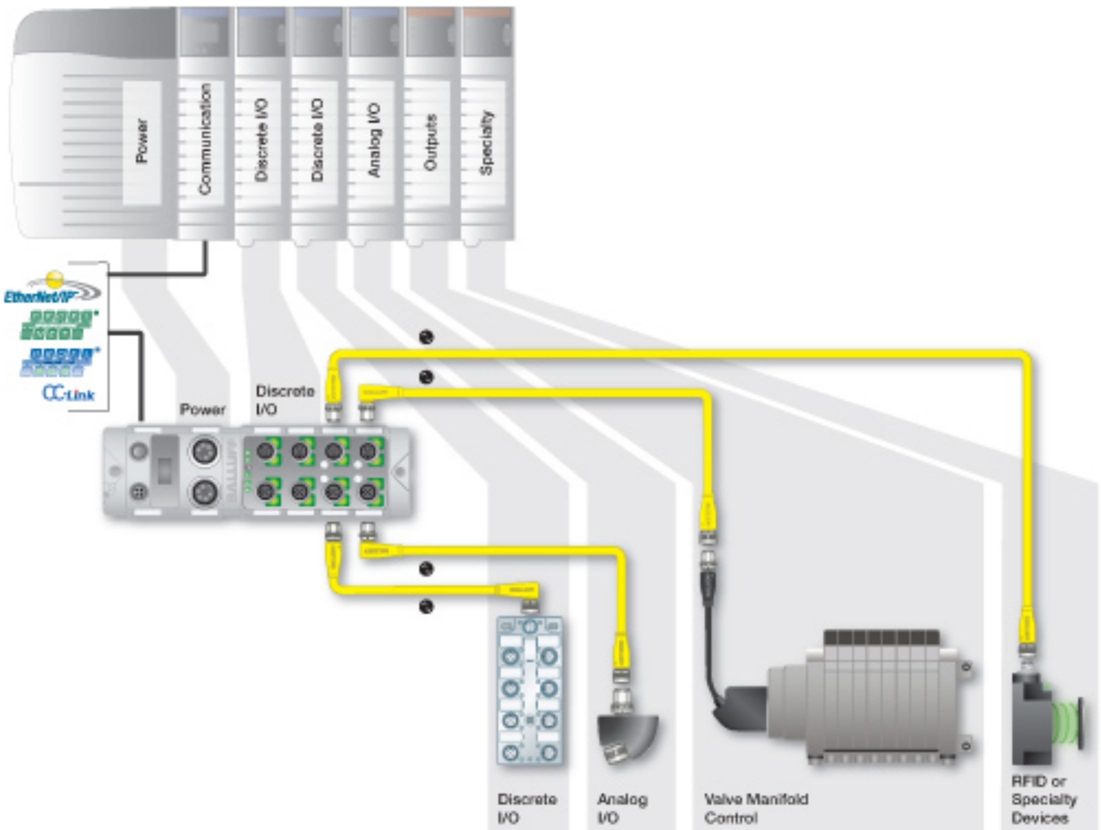
Prediction: The automation system of the future will consist of POE managed switches and field located intelligent input and output devices.

Why use IoT?

1. ***Get more data, with less effort***

2. ***Leverage that data to control the process better and rely less on operator intervention.***

Internet of Things – Distributed Modular I/0, Ruggedized Switch



[Source http://www.balluff.com/balluff/MUS/en/products/overview-io-link.jsp]

Cisco IE-2000 IP67 w/ M12 connectors, POE available

Questions?

Big Data – What is it?

Give us all your data…

How Big is BIG?
"..anything too big to deal with in an Excel spreadsheet." [Josh Dreller, https://www.entrepreneur.com/article/227957]

64 bit Excel supports up to Rows:**1,048,576**. Columns: **16,384.**

Big Data is more than just a big pile of data its about what you are doing with it.

Big Data Examples:

Google Real Time Traffic
"When we combine your speed with the speed of other phones on the road, across thousands of phones moving around a city at any given time, we can get a pretty good picture of live traffic conditions."
[Dave Barth https://googleblog.blogspot.ca/2009/08/bright-side-of-sitting-in-traffic.html]

Smart Water Meters
Automatic collection of usage data -> huge transportation and labor savings
Identify unusual water usage within hours -> better customer service, less waste
[http://www.sas.com/en_us/insights/articles/big-data/3-internet-of-things-examples.html#]

Big Data – Characteristics

1. Combining and correlating large data sets
    A. (location + speed) x multiple users + digital maps
    B. (Water usage data + location) x all users in a system
2. Multiple data sources, frequently IoT devices
    A. Smart Phones
    B. Smart Utility meters
3. Use of data analytics

Data Analytics

[Source http://www.ey.com/Publication/vwLUAssets/EY_-_Big_data:_changing_the_way_businesses_operate/%24FILE/EY-Insights-on-GRC-Big-data.pdf]

1. Descriptive Analytics: Using data to figure out what happened
2. Real Time Analytics: What is happening?
3. Predictive Analytics: What will happen?
4. Prescriptive Analytics: How can we make something happen?
    A. Find the fastest route from point A to point B
    B. Reduce waste, improve yield, improve quality

Big Data – How can Manufacturing use Big Data

Big Data Conditions Reality Check

1. **Need to have ROI** – Creating collecting, storing and analyzing massive quantities of data is not cheap and may not be the most efficient method to solve a problem.

2. **Need to have the data** – Data infrastructure must be installed and maintained

3. **Need to have the right data** – Production and quality data is great for solving production and quality problems but not so much for predictive maintenance. *Is your production data going to be able to tell you that a certain motor or gearbox is about to fail?*

4. **Need to have scale and uniformity in data sources** – Aggregating data from dissimilar processes, machines and products will be challenging and expensive.

Big Data – How can Manufacturing use Big Data

Big Data Conditions Reality Check

1. **Need to have ROI** – Creating collecting, storing and analyzing massive quantities of data is not cheap and may not be the most efficient method to solve a problem.
   A. Focus on biggest opportunities – likely waste and downtime reduction. If investing in predictive maintenance, focus on bottle neck equipment (compressors, large transformers, chillers).
2. **Need to have the data** – Data infrastructure must be installed and maintained
   A. Use the data you already have first – likely this is process, quality and production data
3. **Need to have the right data** – Production and quality data is great for solving production and quality problems but not so much for predictive maintenance. *Is your production data going to be able to tell you that a certain motor or gearbox is about to fail?*
   A. Don't expect data analysis miracles. Step one is to make sure that you are collecting the best possible data to solve your problem.
4. **Need to have scale and uniformity in data sources** – Aggregating data from dissimilar processes, machines and products will be challenging and expensive.
   A. Most Big Data success stories are about solving production problems not machine maintenance problems. Your operation produces lots product so it is easier to collect lots of data on those products. Machines on the other hand fail infrequently so it is harder to collect data on those failures and predict them in advance. Additionally your production machines are probably not uniform.

Big Data – Relationship between IoT and Big Data?

Big Data needs data, IoT devices can provide that data efficiently

Conclusions – How to adapt and thrive with IoT and Big Data

"The famous IT/OT convergence that has been discussed for many years must happen. Control engineers must upgrade their skills so that they in the very least understand networking and security. And IT engineers and architects must understand the difference between business processes and manufacturing processes." [Gary Mintchell, https://www.tripwire.com/state-of-security/featured/5-key-challenges-for-the-industrial-internet-of-things-iiot/]

Recommendations

1. Get educated about networking and network security.
2. Learn how to setup a managed switch.
3. Earn the trust of your IT colleagues.

The winners will be the companies and engineers that come up with new ways to use data.