

The Future Control System Environment,

As envisioned by the a member of the ExxonMobil Next Generation Control System Pilot

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Abstract -

The LCCC Process Control Workshop

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- ▶ There has been a lot of media discussion about the ExxonMobil Next Generation Control System initiative
- ▶ It's not common for a large company to say to industry something like:

‘We don't like what you are selling us,
we want better,
not just incrementally better,
but a whole lot better.’

- ▶ This session will help to clear the air and explain the positive and negative consequences of changing existing DCS and PLC architectures

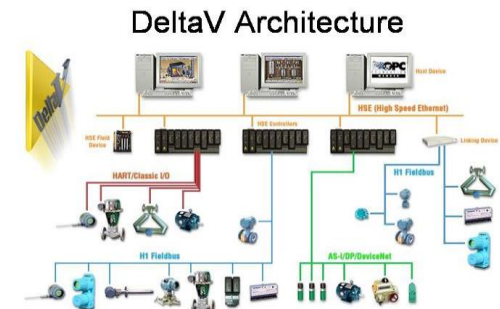


KEEP
CALM
AND
JUST SAY
NO



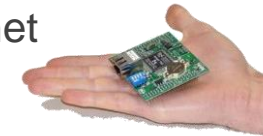
Why Now?

- ▶ The current architectures have not changed significantly since the 1980's.
 - ▶ They are still based on the concept of one or more computers in a hardened box, what connects to tens to thousands of I/O points, connected to dumb devices.
- ▶ There have been incremental advances in functionality, and decreases in size and cost, but the basic architecture has remained the same.
- ▶ The advances that are shaking up the world through connected smart devices in homes, stores, health care, transportation, and energy have not penetrated the barrier of obsolete industrial system architectures.



What is Possible Today

- ▶ Raspberry Pi, Android MK808B , Adrenio, SmartTILE...
- ▶ Massive computing systems, in tiny inexpensive boxes
 - ▶ Dual Core Cortex-A9, Android 4.2 Jelly Bean With Bluetooth HDMI, 1GB RAM, 8GB ROM, 3.4" x 1.1" x 0.5 inches and 1.3 ounces, - \$43.99
 - ▶ 700MHz ARM processor with FPU and Videocore 4 GPU (24GFLOPs) HDMI, 10/100 BaseT, 512MB RAM, 3.4" x 2.2" x 0.8 inches, - \$27.98
 - ▶ 32 Bit CPU, 256 DIOs 12 AIOs, High level language programming, Ethernet built in, 2.6" x 2.5" x 0.95" - ~ \$100.00



LCCC Process Control Workshop

	Circa 1980's	Today	Change
Memory	1 Mega Byte	1,000 Mega Byte	1,000X
CPU	1 MIP	10,000 MIPs	10,000X
Network	1 MB	1,000 MB	1,000X
Size	40 ft ³	0.04 ft ³	1,000X
Cost	\$1,000,000	< \$100	1,000 X

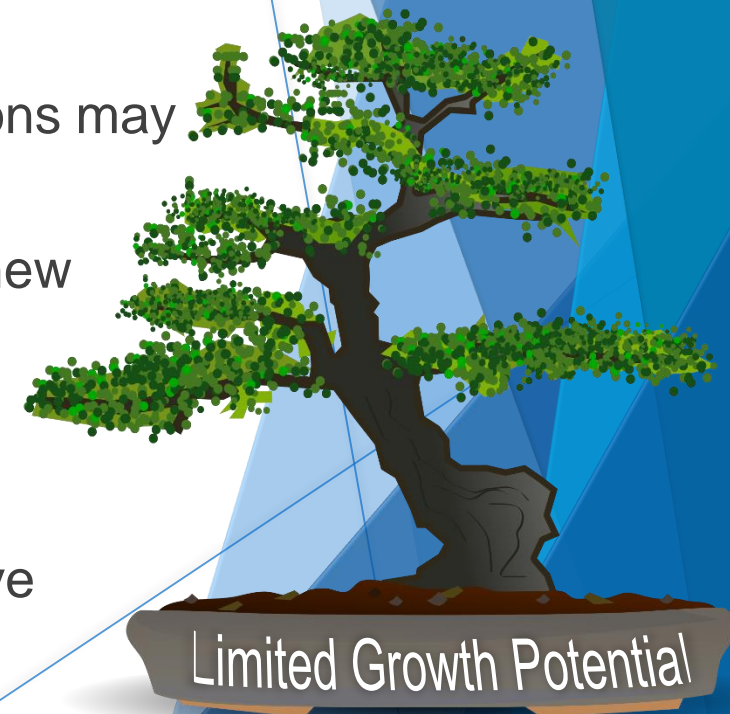
Monolithic Proprietary Systems

If it ain't broke ...

- ▶ Today's monolithic, single-vendor control systems boast an impressive 99.999+% system availability
- ▶ What design characteristics have contributed to this impressive reliability performance?
 - ▶ Simple, deterministic system functionality (e.g. proprietary function block and custom programming etc.)
 - ▶ Physical coupling of a field I/O sub-network to one and only one controller creating a self-contained regulatory control appliance
- ▶ Single system designer and integrator
 - ▶ Issues a standard product release and ensures compatibility
 - ▶ Provides a single point of contact for all system performance issues; no opportunity to "pass the buck."
- ▶ Early proprietary control systems comprised entirely of running proprietary operating systems connected via proprietary networks offered some level of "security through obscurity"

Well It Is Broke, In Several Ways

- ▶ The architecture complicates and constrains growth
 - ▶ An I/O sub-network is normally physically connected to one and only one controller so any new application using that I/O must fit into the single connected controller
 - ▶ If the controller becomes loaded, I/O and associated applications may have to be moved to another controller
 - ▶ If the I/O sub-network becomes loaded, adding I/O requires a new controller, even if the existing controller has spare capacity
 - ▶ You are limited to whatever control programming language and built-in capabilities provided by the vendor
 - ▶ No “Best of Breed” solutions allowed, or they are very expensive

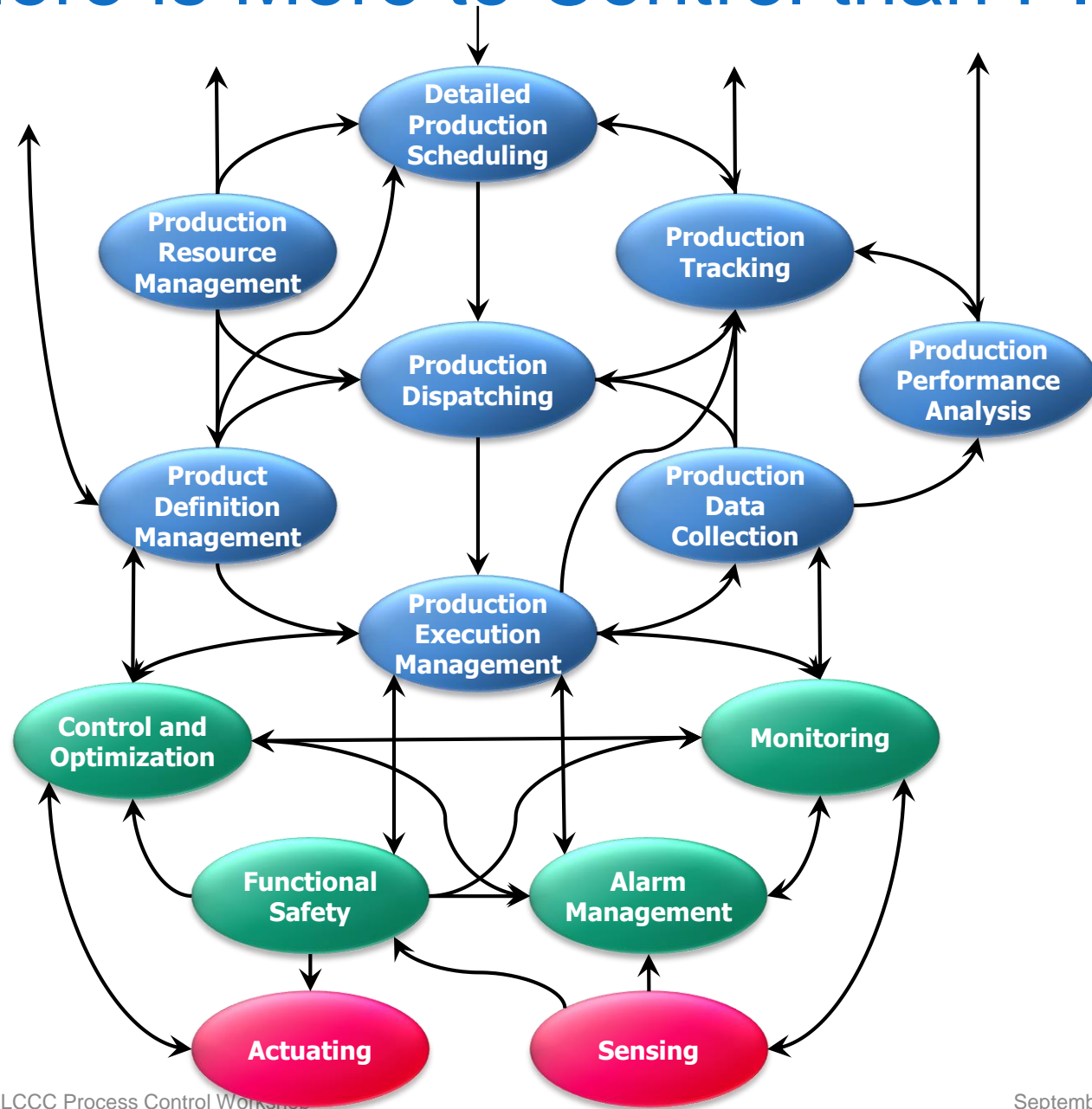


Well It Is Broke, In Several Ways

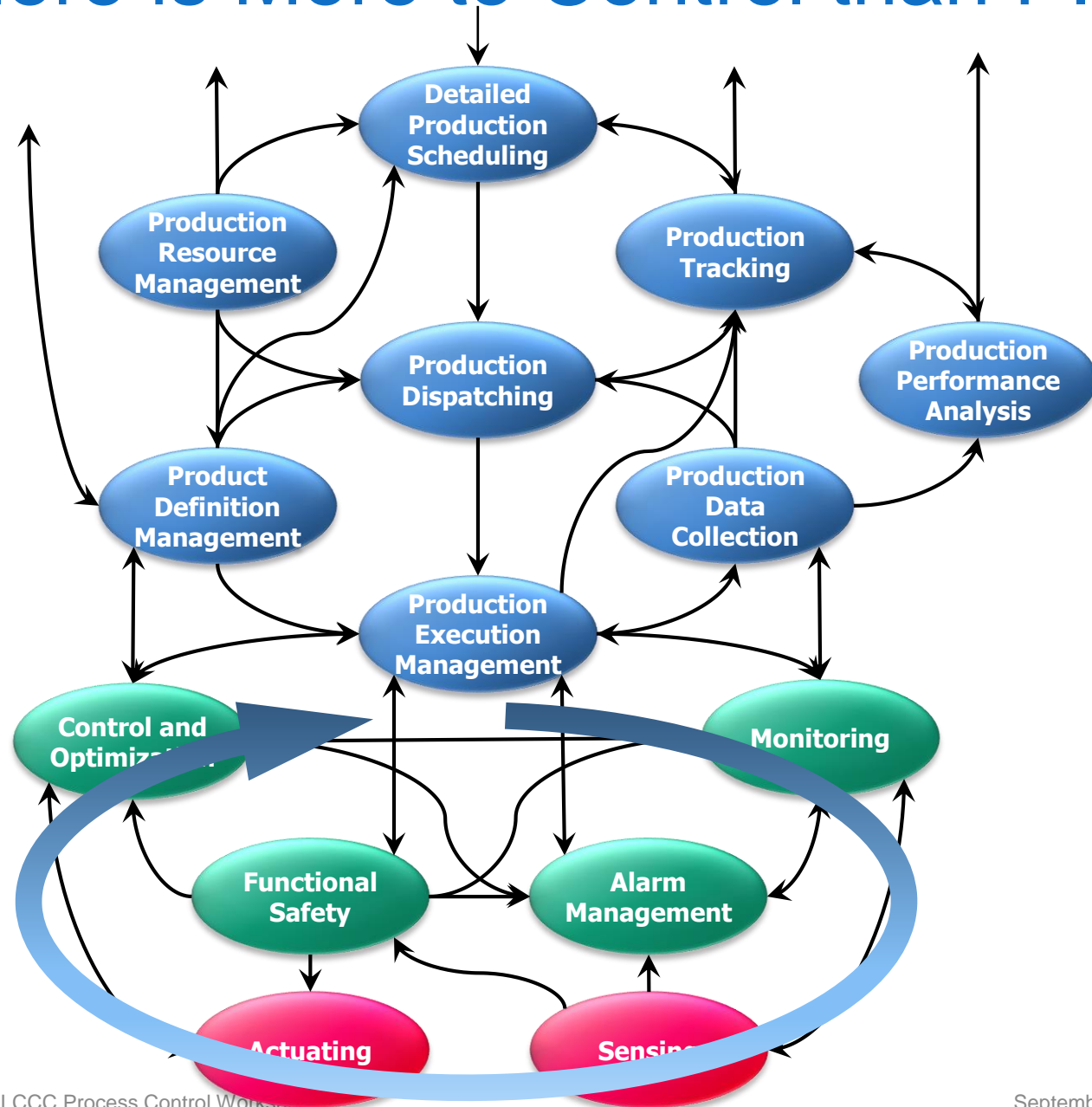
- ▶ Controllers cannot be upgraded to exploit new & more sophisticated functionality due to the cost and risk associated with replacement
 - ▶ Stagnant controller capability do not allow facilities to exploit the competitive advantage derived from new technologies
- ▶ Migrating hierarchical systems usually requires concurrent controllers and I/O replacement driving up project cost, complexity, duration and risk
 - ▶ The result is that few replacements are done, and systems are decades old



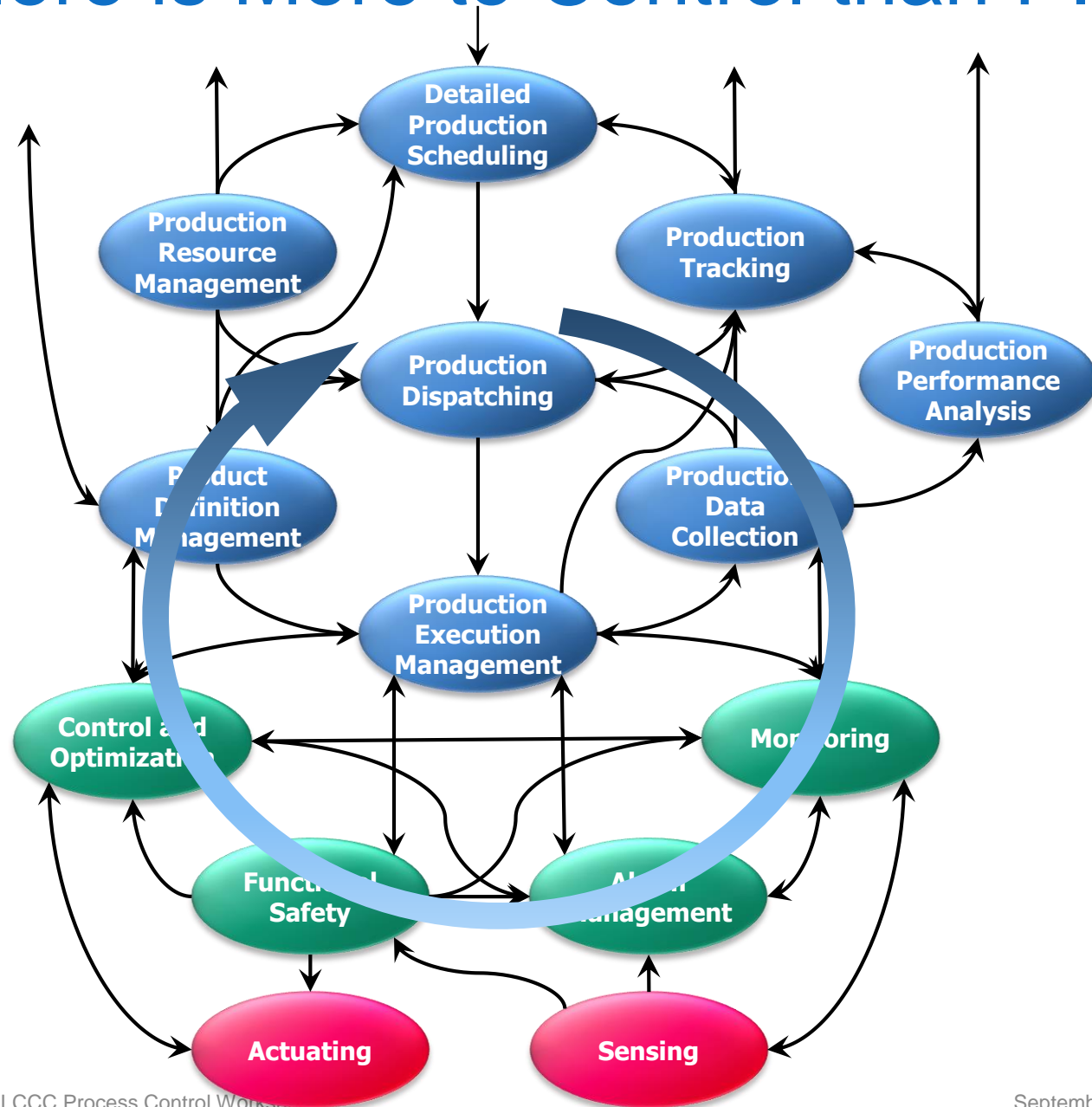
There is More to Control than PID Loops



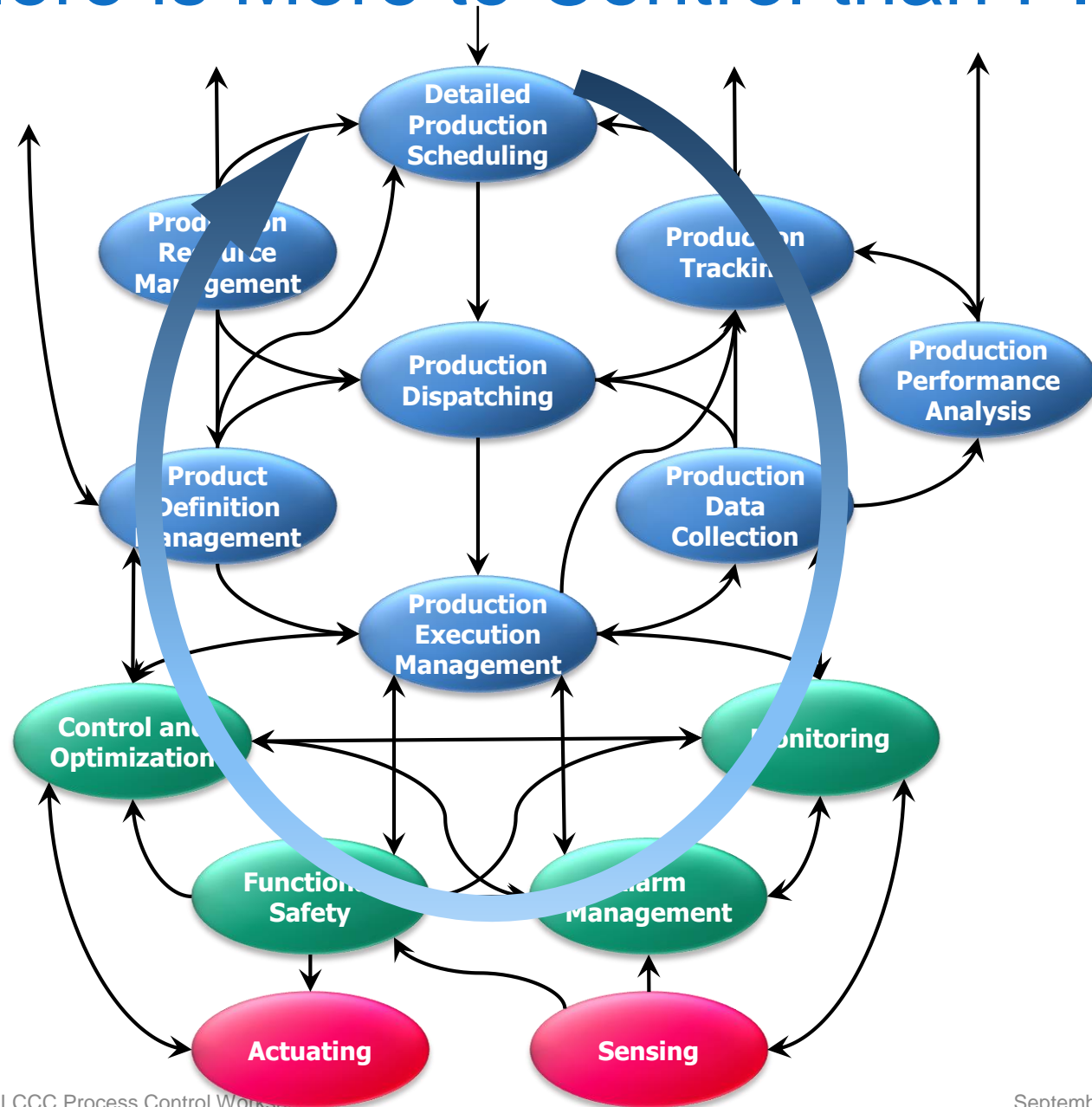
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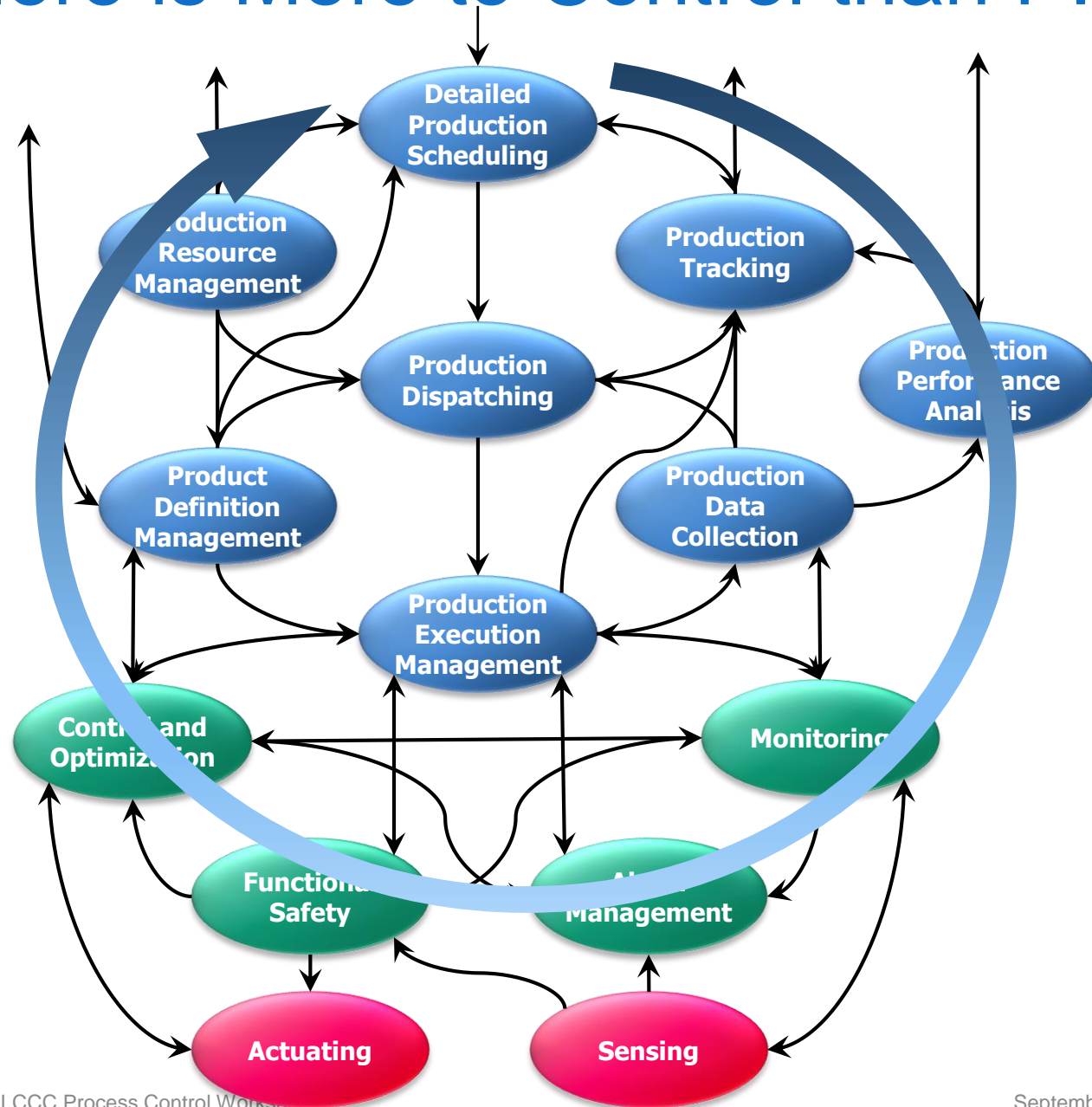
There is More to Control than PID Loops



There is More to Control than PID Loops



There is More to Control than PID Loops



- There is “control” everywhere
- The next big gains will come not at the PID level, but through control and optimization of the higher level activities.

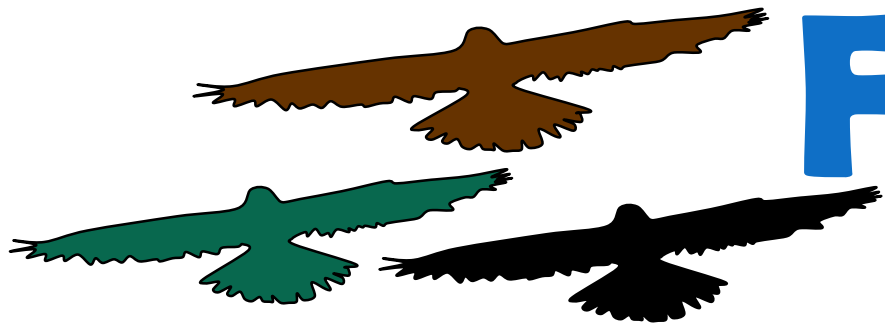
New Architecture, Functional Characteristics

- ▶ A system which does not require replacement of existing instruments.
- ▶ A system which is adaptable to future changes without requiring wholesale replacement.
- ▶ Inherent security that is designed and built-in, not bolted on after the fact.
- ▶ The preservation of intellectual property in the form of control strategies, configurations, representations, and reports, with online replacement of system components over a very long 20-40 year period.
- ▶ A system designed to improve operational situation awareness enabling broader scope of control and better automated response to normal situations.
- ▶ A system that is not limited to the control capability provided by the vendor's supplied function blocks and gives the Owner the freedom to use *best-of-breed* components at all levels of the control strategy hierarchy, when it is justified.

Automation Industry Challenges

The “want” list

- ▶ A flexible, modular, scalable and extendable system architecture
 - ▶ Conformant with existing field device standards and communication protocols
 - ▶ The flexibility to assign any I/O to any networked device
 - ▶ Simple, online addition/replacement of any networked device as a maintenance activity
- ▶ Distributed, portable and interoperable automation
 - ▶ Ability to execute an application on all compliant platforms (portability)
 - ▶ Deployment of interactive applications on different platforms with no modification (interoperability)
 - ▶ Standard exchange of both structure and unstructured data between adjacent system levels
- ▶ Intrinsic Security
 - ▶ Embedded security layers that can evolve with emerging threats
 - ▶ Verification of message authenticity and integrity with a simple key management system
 - ▶ Authentication of new network devices
 - ▶ Authentication of all new executable code
 - ▶ Automated intrusion detection & prevention
- ▶ Productivity Improvements
 - ▶ “Plug-and-play” field device technologies
 - ▶ Intrinsic system notification tools (e.g. alarms, alerts, advisories, etc.)
 - ▶ Lower the costs associated with patch management, software updates, etc.



Falcons

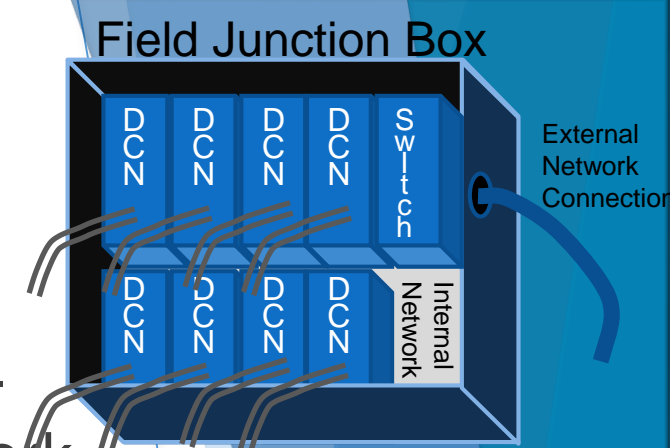
Federated Automation Logic Control on Open Network Systems

A New Model for Control Systems

The New Architecture

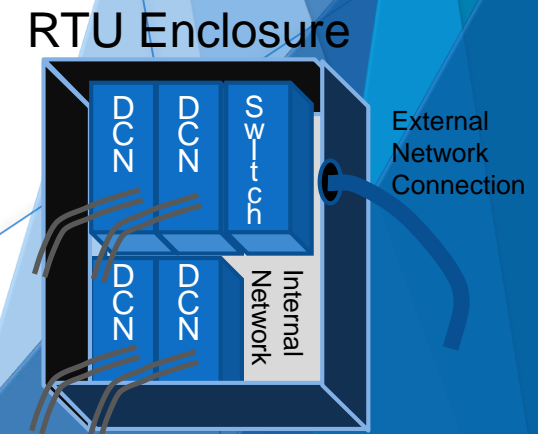
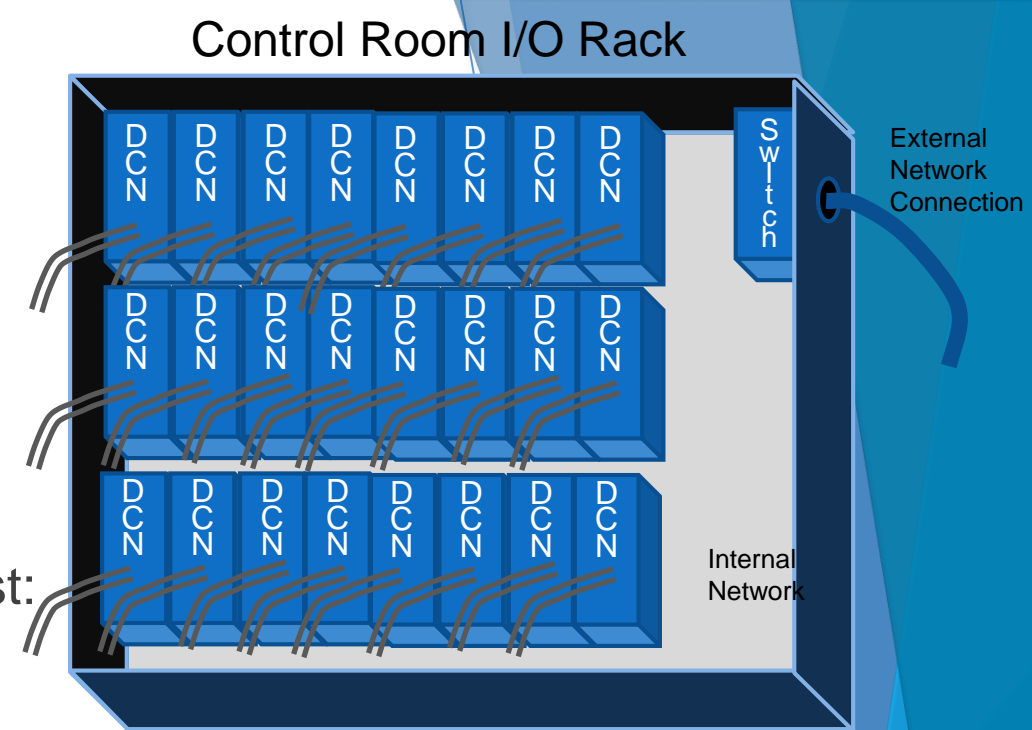
DCN – Distributed Control Nodes

- ▶ DCN is a single-channel I/O module that support both real-time application processing and interfaces with other network protocols
- ▶ A system is a collection of DCNs with I/O and without I/O, a DCN-cloud
- ▶ A DCN-cloud for centralized applications ranging from high-end data-center host servers to redundant embedded computers hardened for harsh field environments
- ▶ A high-speed IP-based Ethernet (wired or wireless) switch fabric that support layer 3 switching, VLANs and QoS to allow for the greatest network flexibility and segmentation

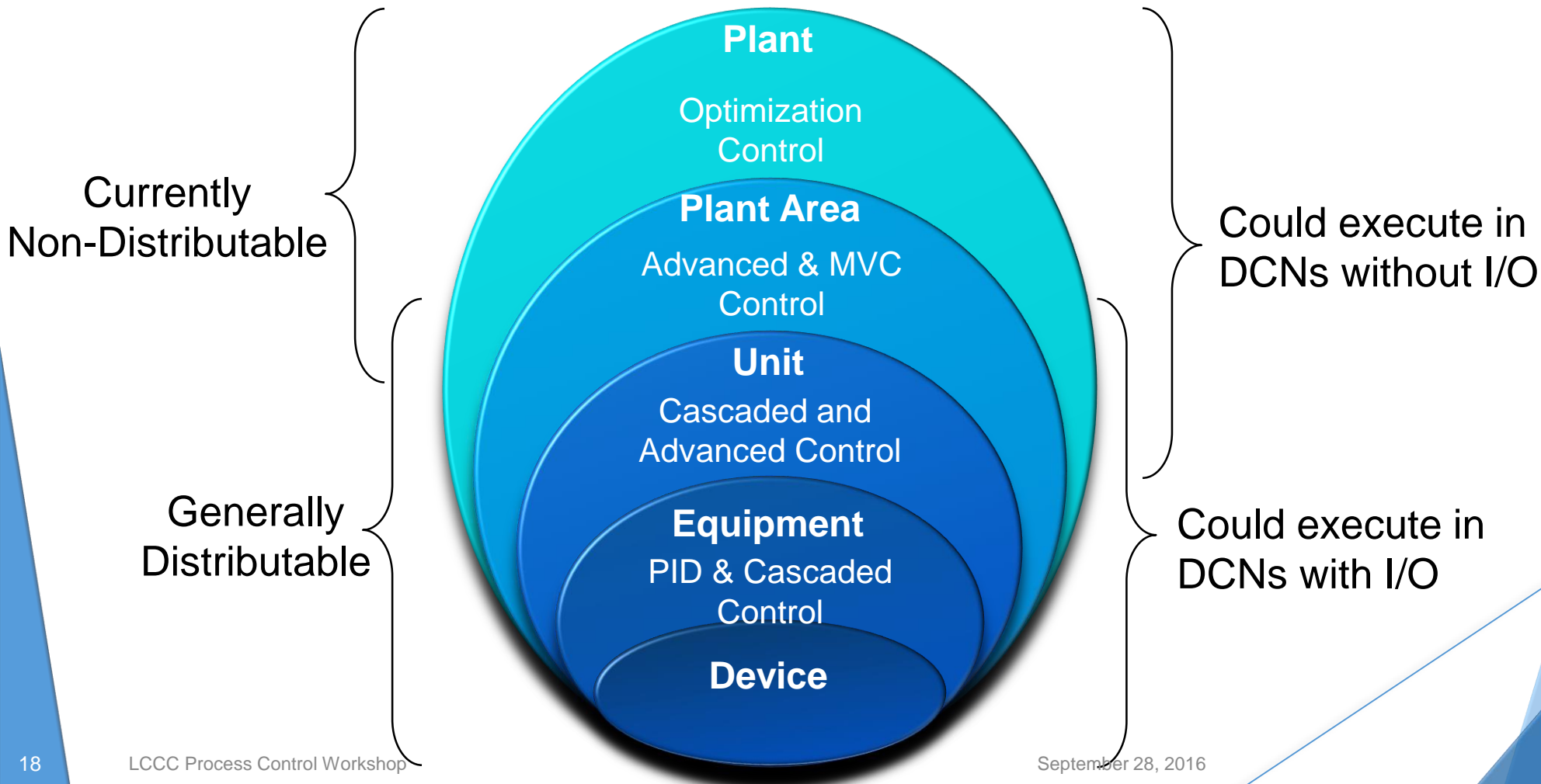


DCN-Cloud Smart I/O ++

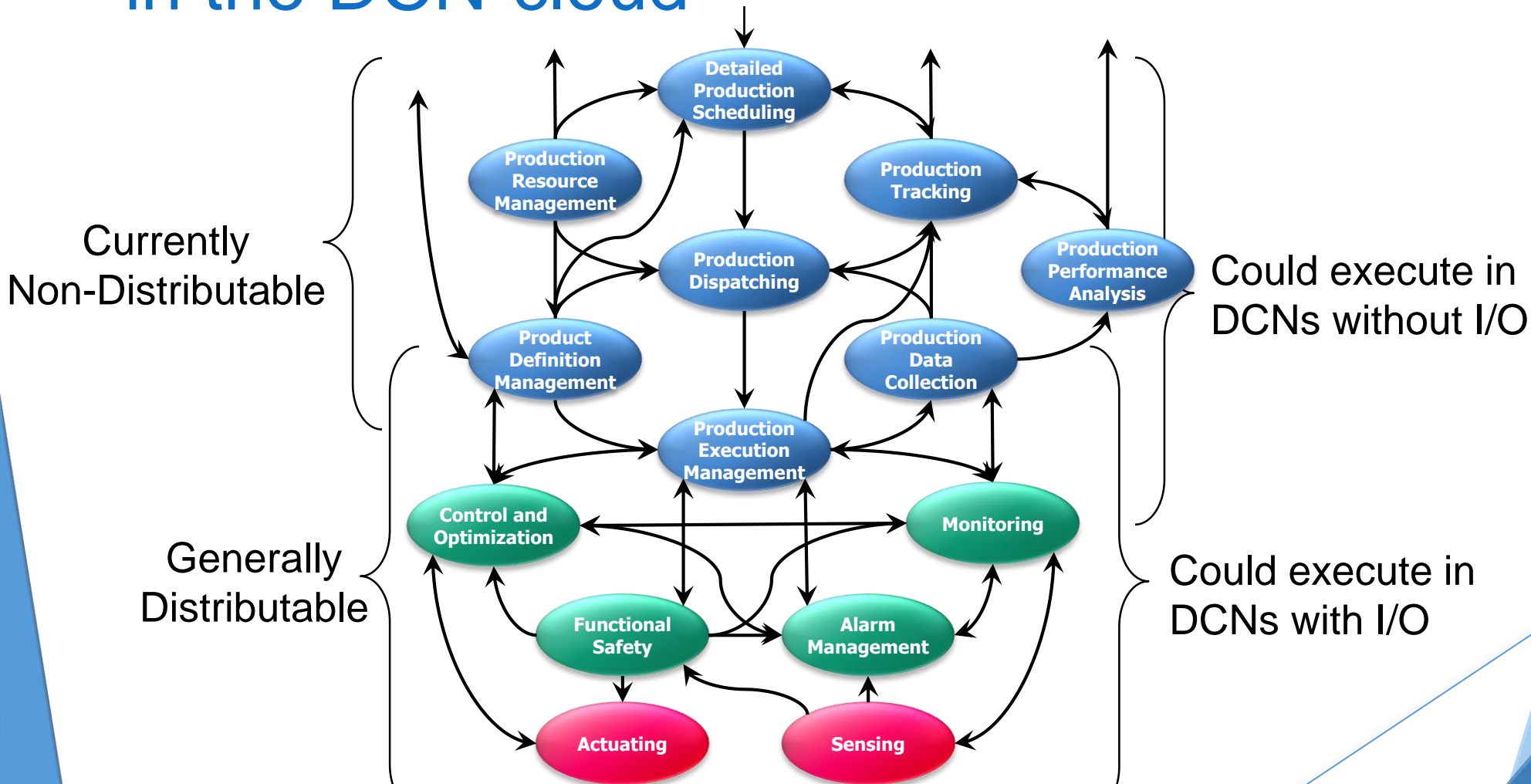
- ▶ Ethernet connected
 - ▶ So, lots of CPU power and memory
- ▶ Universal I/O
- ▶ Even the smallest, single point device will have at least:
 - ▶ 2 GHz multi-core processor
 - ▶ 1 GB of memory
 - ▶ 10 MByte, 100 MByte, 1 GByte, 10 GByte wireless & wired network support
 - ▶ Multiple protocol support
 - ▶ Real time Virtual Machine (VM) O/S
 - ▶ Think of a single point device with the power, memory, O/S, and network capability of a small cell phone
- ▶ This capability on every device:
 - ▶ I/O Point, or limit switch, proximity switch, motor, pump, valve, ...



Distributed & Non-Distributed Control in the DCN-cloud

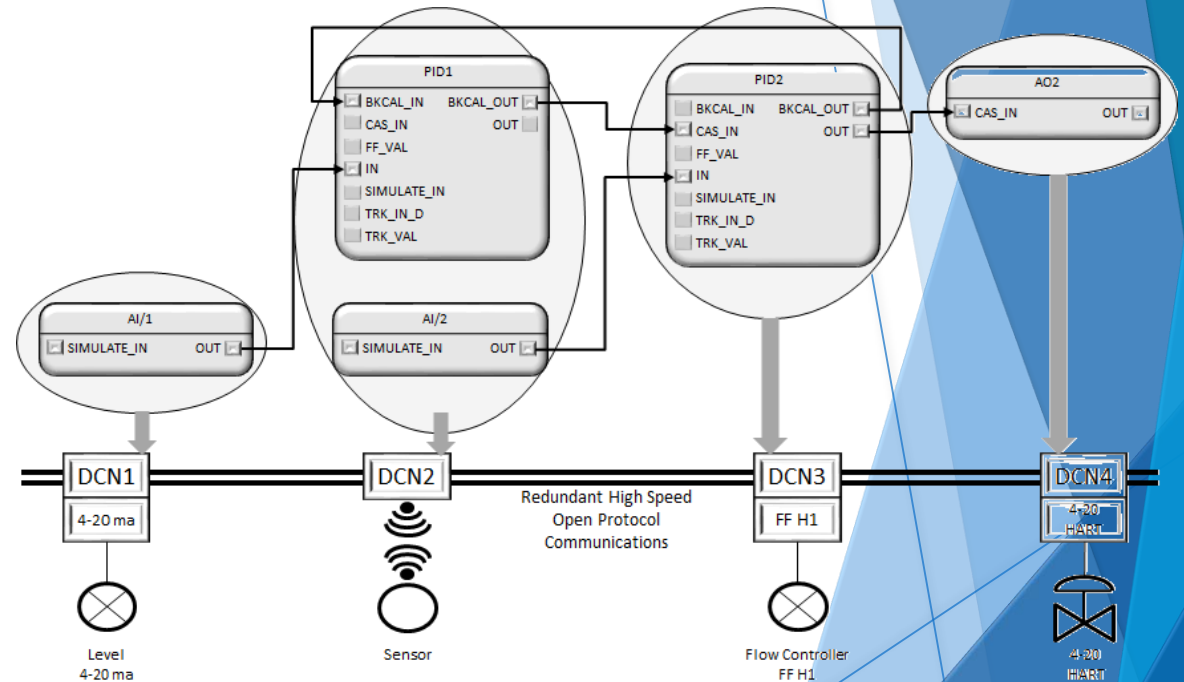


Distributed & Non-Distributed Control in the DCN-cloud



An Example Of A Distributed Algorithm

- ▶ Why must you program the communication layout?
- ▶ Let the “system” take care of it.
- ▶ “Control” functionality is cheap & small !
 - ▶ Compared to the computing power used for high speed communication
- ▶ Scope of failures can be minimized, down to a single loop
- ▶ Redundancy can be selected on as “as needed” basis



Networks Aren't Fast Enough! WRONG!

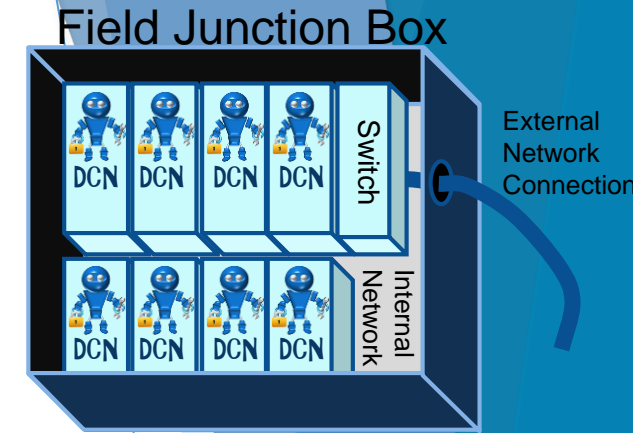
Whenever they say it can't be done,
remind them that they make a jellybean
that tastes exactly like popcorn.
-John Mayer

- ▶ Managed switches and high speed networks are today's "active backplanes"
 - ▶ As fast as previous backplanes
 - ▶ As resilient (with fail silent semiconductor logic)
 - ▶ A whole lot more extensible
 - ▶ A whole lot more open
- ▶ Switching Hub Technology
- ▶ Redundant Managed Gigabit Switches
- ▶ Message Authentication
- ▶ Class of service message priority
- ▶ Predefined message time slots



Why The DCN Approach

- ▶ Conformant with existing field device standards and communication protocols
- ▶ The flexibility to assign any I/O to any networked device
- ▶ Modular online addition/replacement of any networked device as a maintenance activity
- ▶ Why
 - ▶ A modular system allows paced, online, component-by-component migration towards any new platform whether driven by obsolescence, strategic or economic considerations
 - ▶ Coupled, online controller and I/O replacement projects are expensive, lengthy and risky
 - ▶ Purchasing only the I/O and control capacity one needs avoids pre-investment in large chunks of spare capacity and lowers the cost hurdle associated with new investment
 - ▶ Single channel I/O reduces the need for costly and complex redundancy schemes



DCN Within a Device

Secure Cyber Physical Device

- ▶ Distributed
 - ▶ Can participate in distributed information management
- ▶ Industrial
 - ▶ Follows the industrial standards for safety, security, control, device management, communication protocols, ...
- ▶ Control-enabled
 - ▶ Able to participate in distributed control strategies at all levels
- ▶ In the I/O or in every Device
 - ▶ Part of, or attached to, every device in your manufacturing facility, production line, warehouse, refinery, chemical plant, ...
 - ▶ Limit switches, motor, pumps, valves, proximity switches, actuators, level sensors, robots, conveyor sections, vision systems, ...
- ▶ Secure by Design
- ▶ Self Maintenance Enabled



Smart Assets

Auto-configured

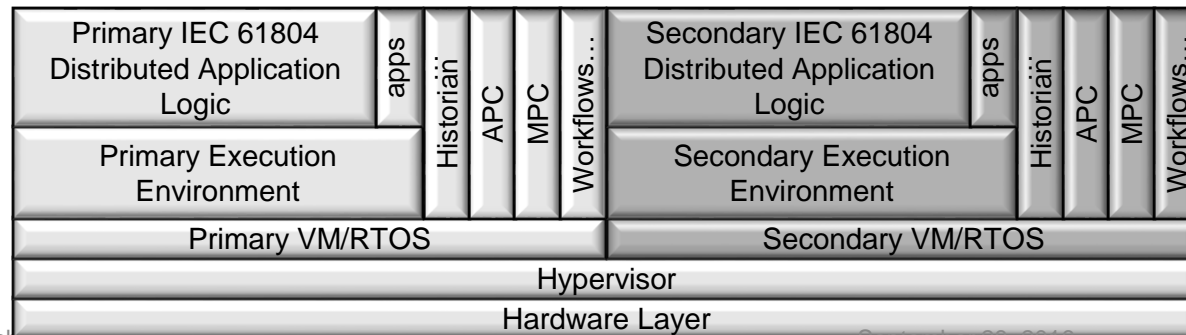
- ▶ Every device is configured based on the role it performs in the control strategy
- ▶ Picks up its configuration from neighbors on startup
- ▶ Send configuration to neighbor on their startup
- ▶ Can run a “fault mode” simulation of a failed neighbor
- ▶ No extensive manual configuration, just specify the “role” the DCN is to assume, which could even come from a smart attached device



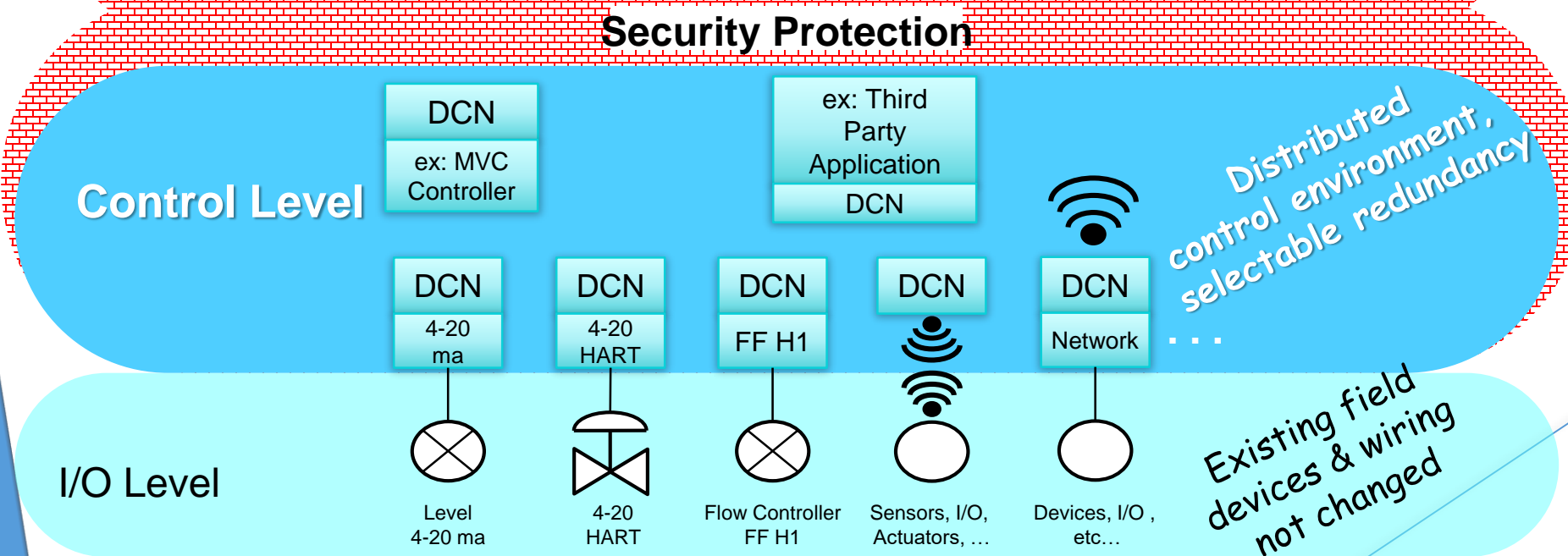
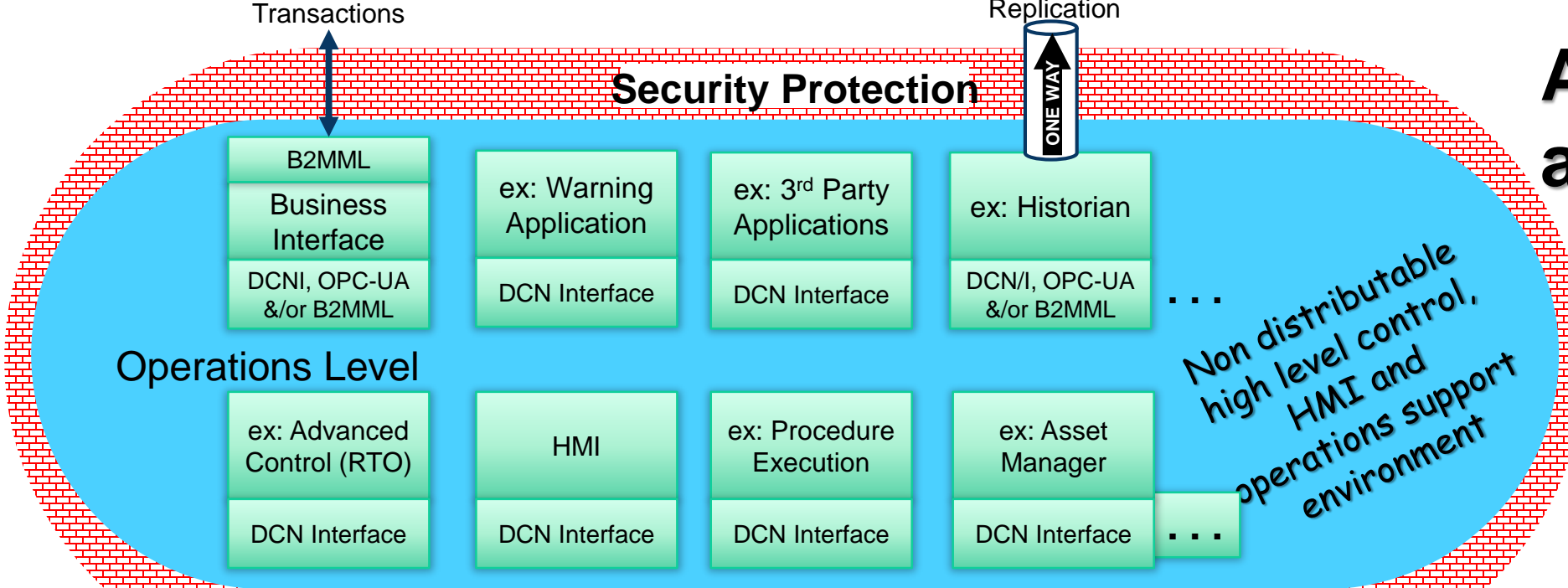
Security and Patch Support - Built In



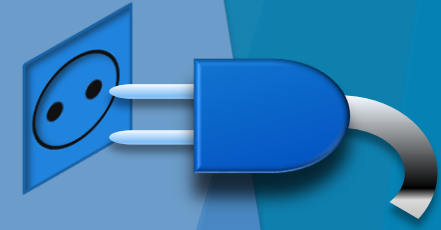
- ▶ DCNs must have built in security, controlled network access, application right management, and patch management
- ▶ Each device contains a virtual machine O/S
 - ▶ One or more VMs to run the control strategies
 - ▶ One or more VMs running in shadow/standby
 - ▶ Used for updated strategy definition, security and other software patches, downloaded without affecting primary VM
 - ▶ Shadow mode checks that the changes do not “break the system” before it becomes the active VM
- ▶ **ZERO DOWNTIME PATCHING & UPDATING!**



Applications in a DCN Cloud



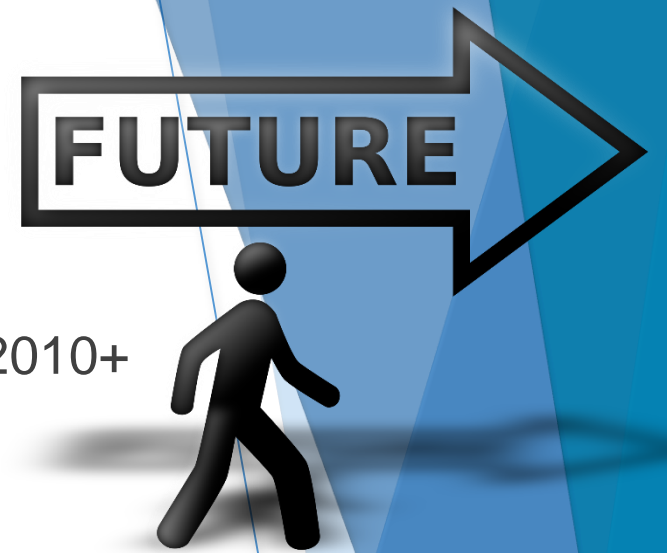
Value of fully distributed plug and play control



- ▶ Affordable access to more granular improvements (no big box replacement steps)
 - ▶ Earlier improvement in quality, throughput, energy use, reliability
 - ▶ Better use of capital
 - ▶ Point by point incremental addition of I/O
 - ▶ Upgrade I/O and devices on case by case basis
- ▶ Minimal scope of hardware failure
- ▶ Selected redundancy, where it is critical and adds value
- ▶ Keep existing instrumentation & wiring (and get HART/FF capability)
 - ▶ Reduced project cost
 - ▶ Reduced capital cost
- ▶ Incremental evolution (apply best state of the art at each expansion & replacement)
 - ▶ Improved reliability through additional asset information
- ▶ Improved control (MPC/DMC) at any level, much faster cycle times
 - ▶ Improvement in quality, throughput, energy use
 - ▶ Reduction in cost to deliver the solution
 - ▶ Improves security (less general purpose computing (Windows©) environments)
 - ▶ Increment computing power, where you want it, when you want it (at incremental cost) (Level 1 Controller Cloud)
- ▶ Auto detection, auto configuration and auto documentation of all I/O devices
 - ▶ Eliminate need for engineering support
 - ▶ Eliminate need for loop drawings

Where We Can Go

- ▶ Move to replacement systems that will last 20-30 years, based on 2010+ technologies
- ▶ Move to systems that grow organically in scale and in functionality
- ▶ Move to systems that have information from any source, all with history, from any device, at any place, optimized for “situational awareness”
- ▶ Move to systems that provide the capability to do things we have not yet imagined
- ▶ Move to systems not constrained by 30 year old technology solutions and architectures



What it Will Take

- ▶ One more turn of Moore's law (18 months) to get the cost affordable
- ▶ Combining already existing different technologies into a system
 - ▶ The first PC was a system, combining existing technologies to create enormous new capabilities
 - ▶ The first smart phone was a systems, combining existing technologies to create new markets and possibilities
 - ▶ Truly distributed control can combine existing technologies to provide systems that can grow organically in scale and in functionality
- ▶ To build it, you first have to dream it

Assertion

“a confident and forceful statement of fact or belief”

- ▶ We have the opportunity for a quantum change in capability, functionality, usability, extensibility and reliability in control systems
- ▶ The old way of doing things won't get us where we need to go
- ▶ The new realities of computing power, networks, and Human Engineered HMIs give us the capability to improve production in ways we can not yet image!
- ▶ It's up to you to help create and use this new capability

Questions & Discussions