User Perspective:

ODVA 2014
Industry Conference and 16th Annual Meeting

Single hop inter-VLAN routing

– a capability that EtherNet/IP I/O can take advantage of
– a feature that suppliers of advanced, managed, industrial Ethernet switches should consider implementing.

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Technical Track

Outline

GM's Current EtherNet/IP Network Architecture

- EtherNet/IP Network Size Discussion

Switching vs. Routing EtherNet/IP I/O Traffic

Single Hop Inter-VLAN Routing Proposal

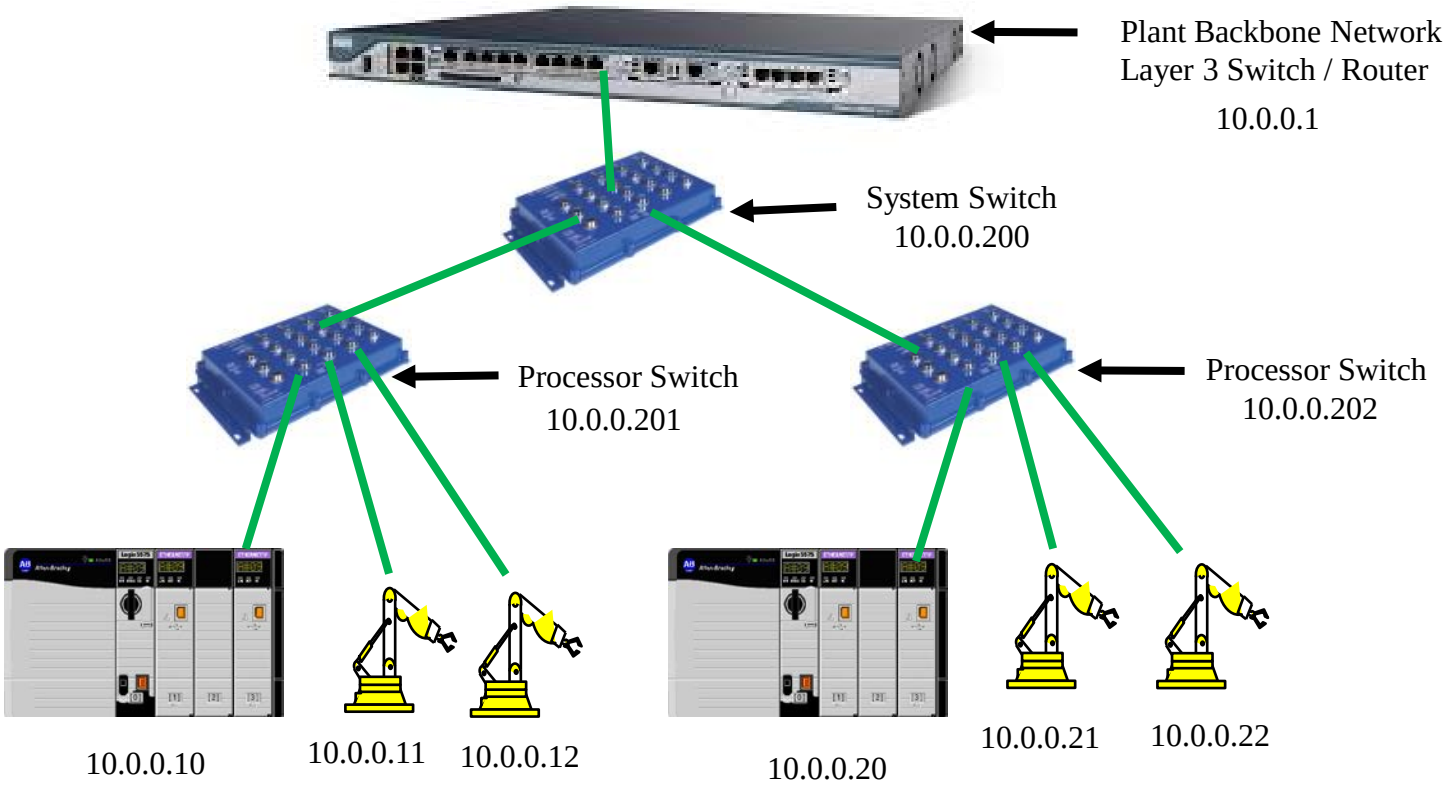
- Description
- Advantages / Limitations
- Alternatives

I/O Device Communication Needs

GM's EtherNet/IP I/O Network Architecture

Summary / Acknowledgements

GM's Current EtherNet / IP Network Architecture



How Large Can a Logical EtherNet/IP Network Be ?

One limit to the logical size of an Ethernet network is the ability of devices on that network to tolerate extraneous broadcast Ethernet traffic.

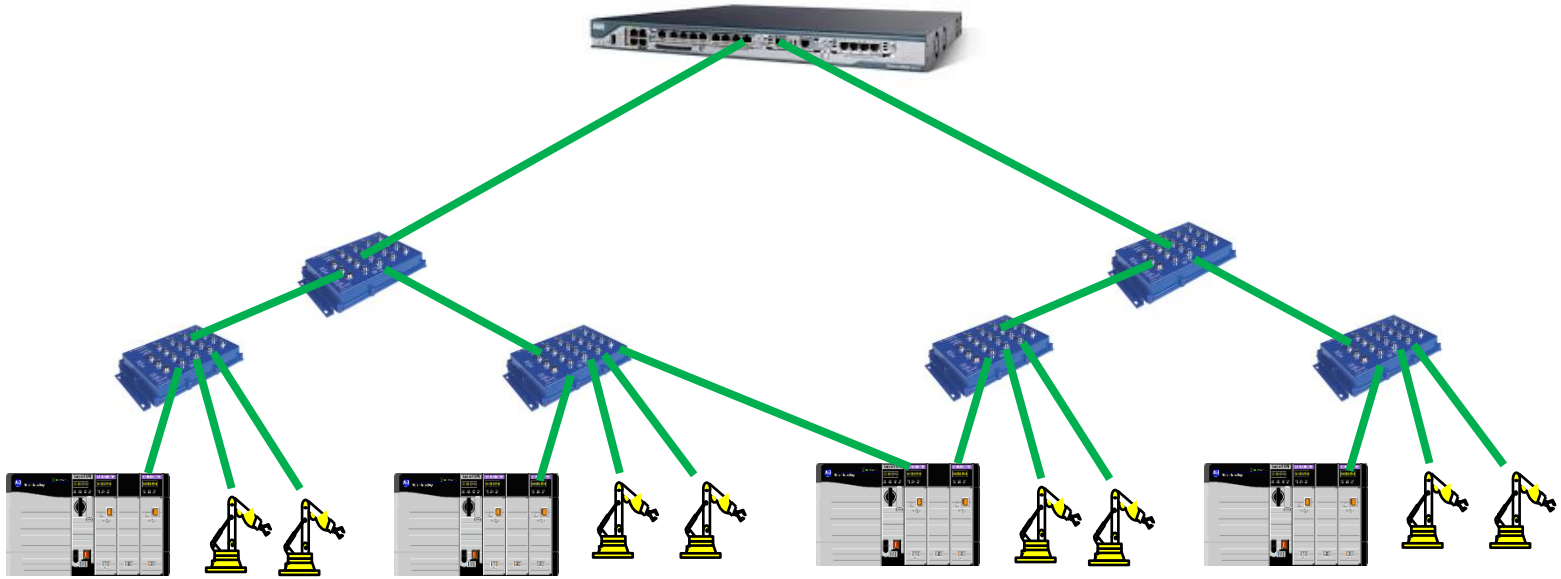
Operational problems occurred on early installations of EtherNet/IP networks with 300+ nodes due to ARP broadcast traffic. Two situations caused device failures:

1) A broadcast EtherNet/IP "Who's there?" message from a newly activated diagnostic computer.
2) An IT asset inventory application running on a high performance server searching for in use IP addresses.

GM now limits EtherNet/IP networks to a maximum of 254 devices. Every device in a GM EtherNet/IP network now has a subnet mask of 255.255.255.0

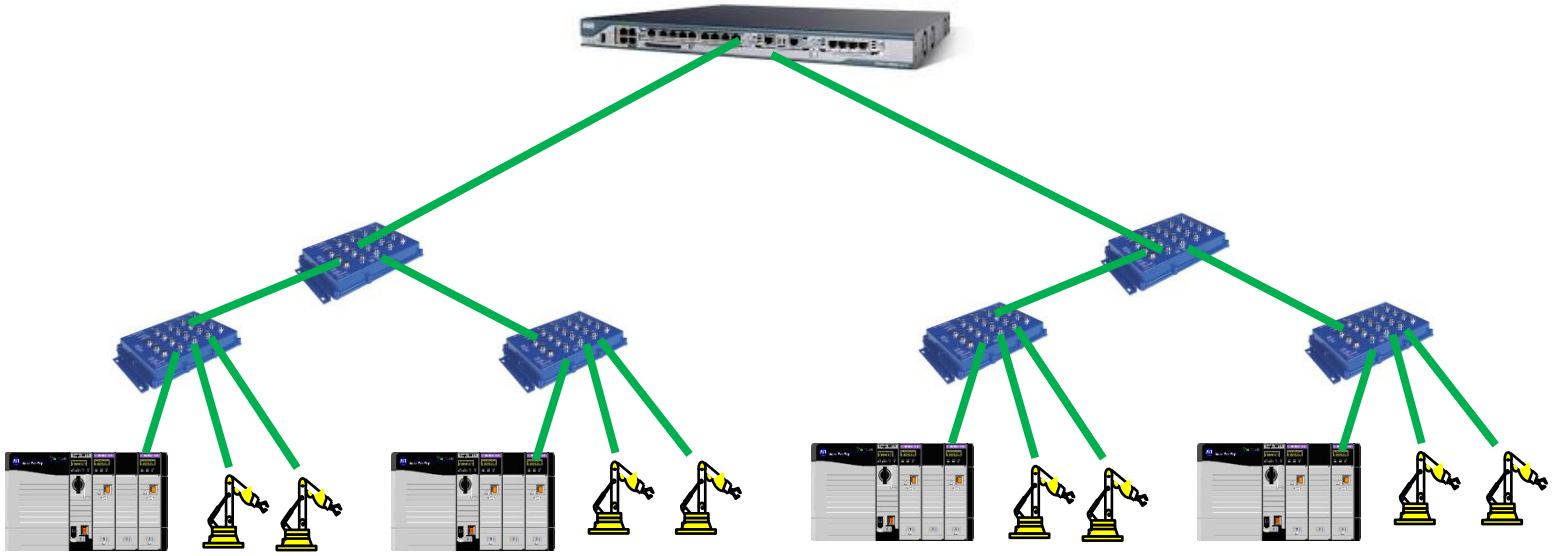
Communicating EtherNet/IP Implicit Message Traffic Between PLCs on Different EtherNet/IP Networks

Option 1: Make one PLC be a member of two EtherNet/IP networks



Communicating EtherNet/IP Implicit Message Traffic Between PLCs on Different EtherNet/IP Networks

Option 2: Route unicast EtherNet/IP traffic across the IT plant network.



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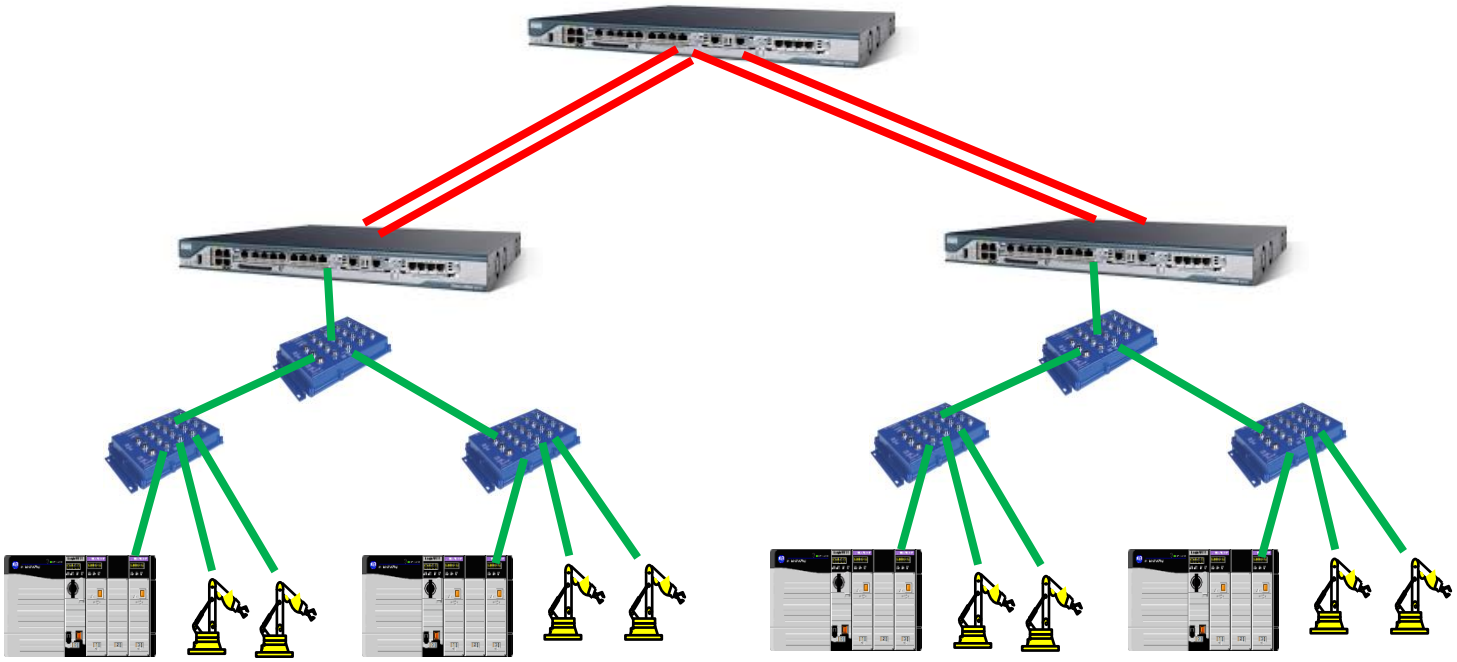
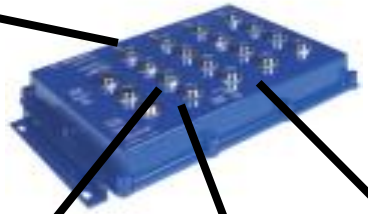


Switching vs. Routing EtherNet/IP I/O Traffic

Note the device IP addresses

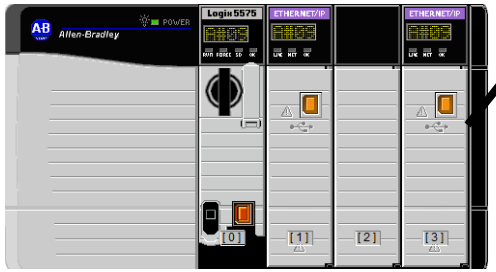
Commercial Grade Router /
Layer 3 Switch

Industrial Ethernet
Switch



10.0.0.10

Programmable
Logic
Controller



Switched
Communication

10.0.0.1

Ethernet
Capable
I/O Block

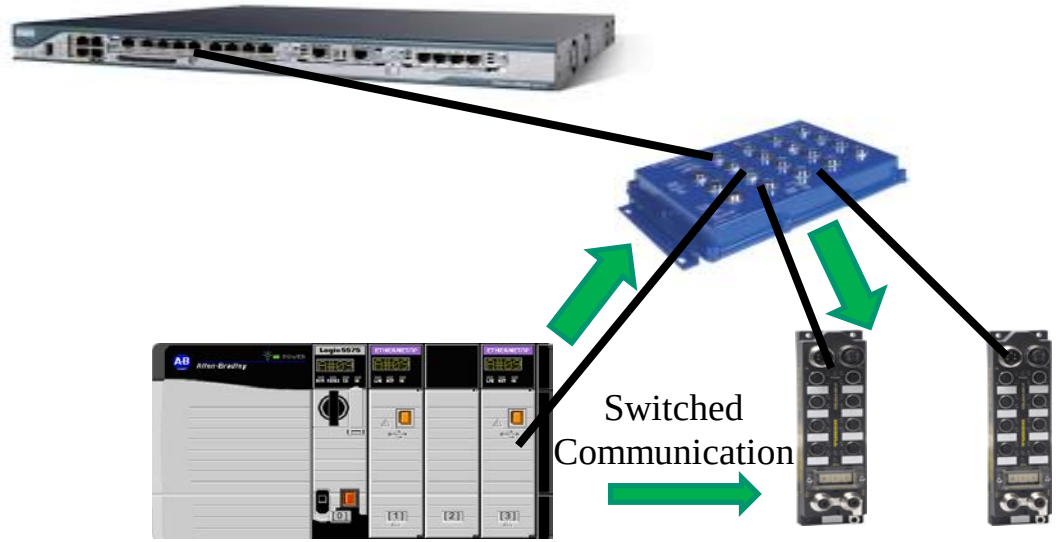
192.168.1.11

Ethernet
Capable
I/O Block

Routed Communication

Switched EtherNet/IP I/O Communication

Communicating devices belong to the same logical Ethernet network



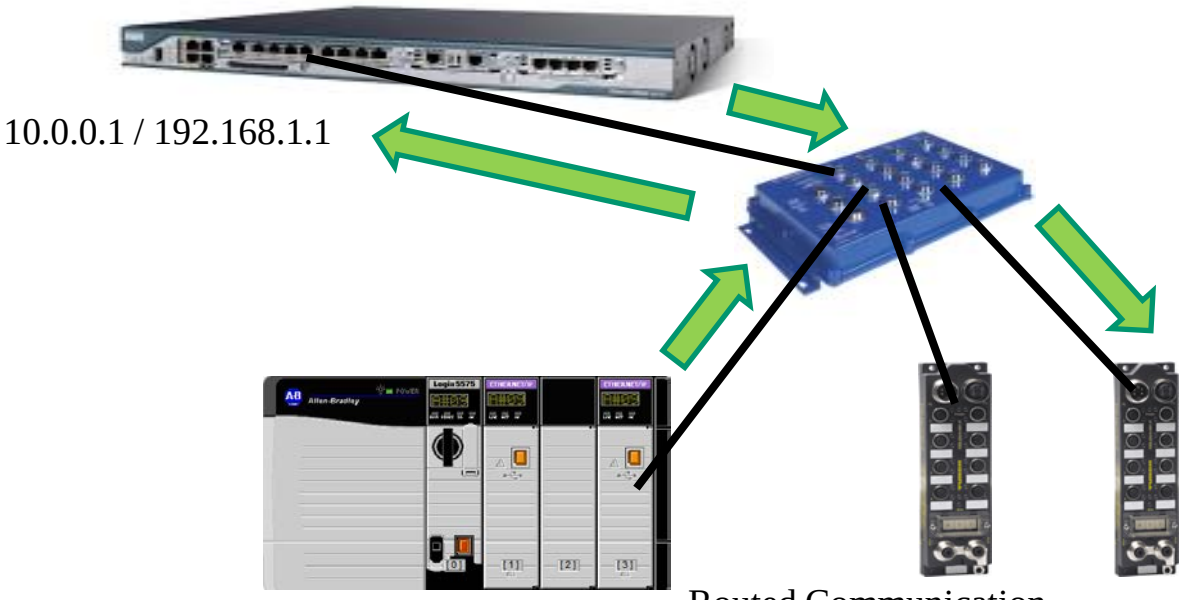
Encapsulated IP Packet

I/O BLOCK MAC ADDR	PLC MAC ADDR	…	10.0.0.10	10.0.0.11	. . .	User Data

Ethernet Frame

Routed EtherNet/IP I/O Communication

Communicating devices belong to different logical Ethernet networks



Ethernet frame sent:

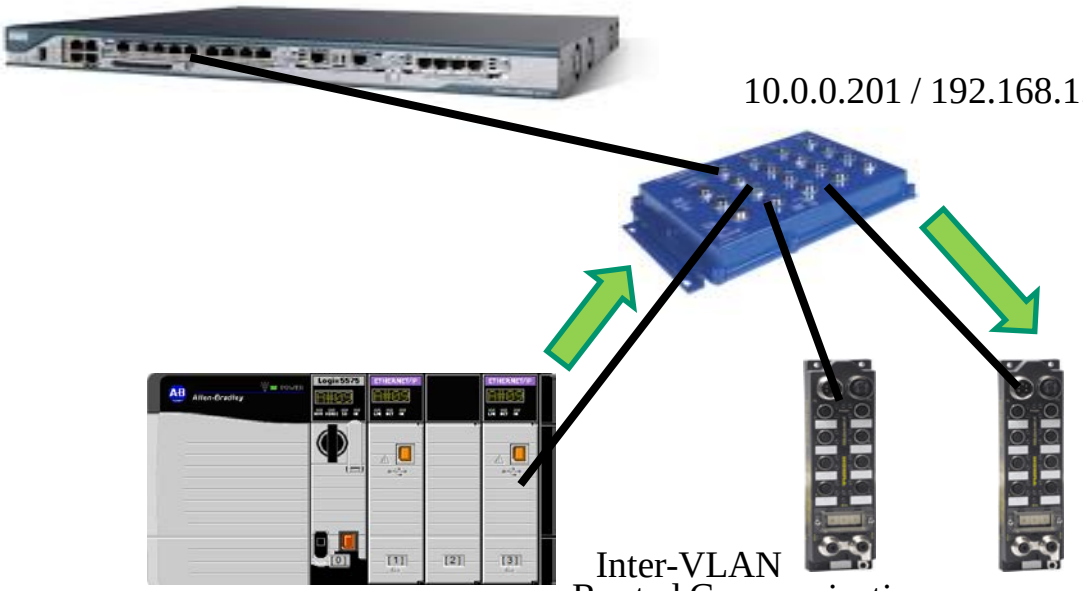
Router MAC ADDR	PLC MAC ADDR	…	10.0.0.10	192.168.1.11	…	User Data

Ethernet frame received:

I/O Block MAC ADDR	Router MAC ADDR	…	10.0.0.10	192.168.1.11	…	User Data

Routed EtherNet/IP I/O Communication

Switch with single hop inter-VLAN routing feature



Ethernet frame sent:

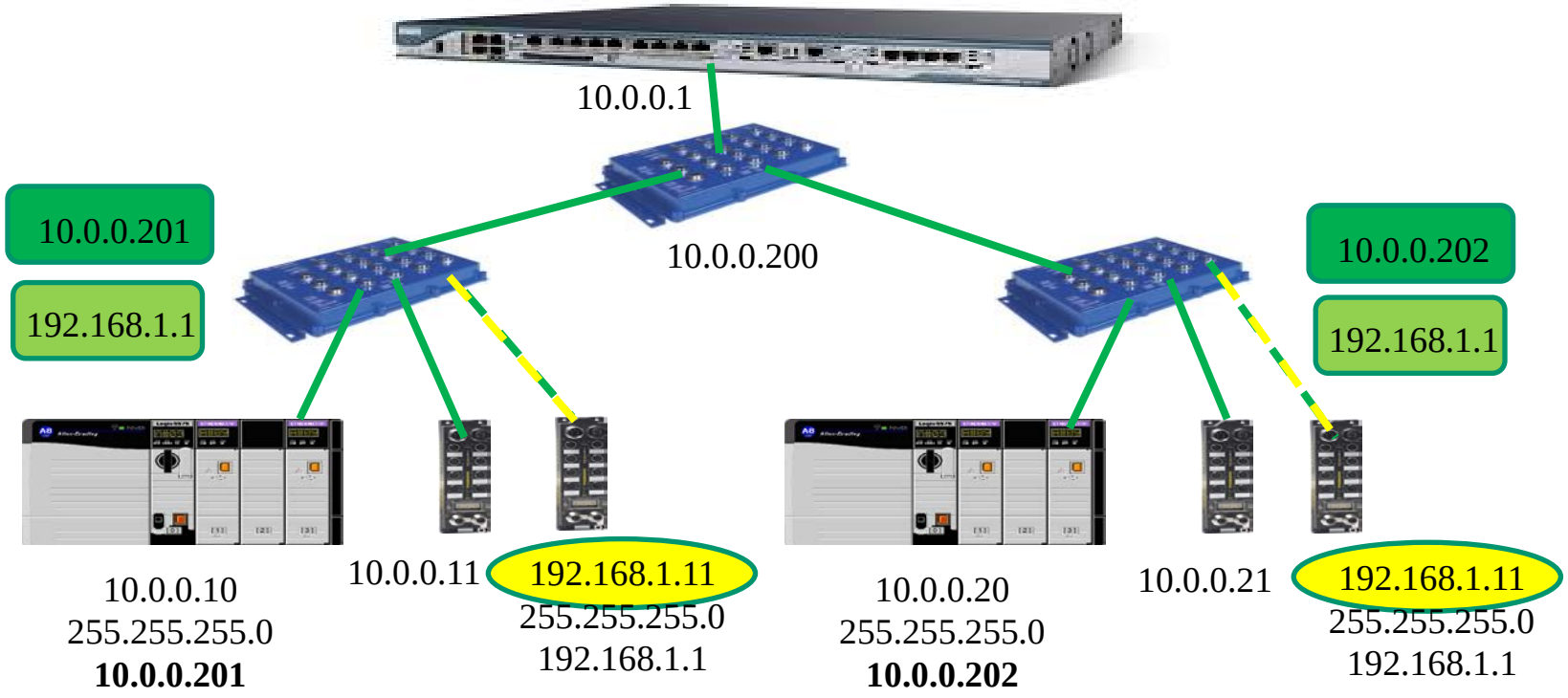
Switch MAC ADDR	PLC MAC ADDR	…	10.0.0.10	192.168.1.11	…	User Data

Ethernet frame received:

I/O Block MAC ADDR	Switch MAC ADDR	…	10.0.0.10	192.168.1.11	…	User Data

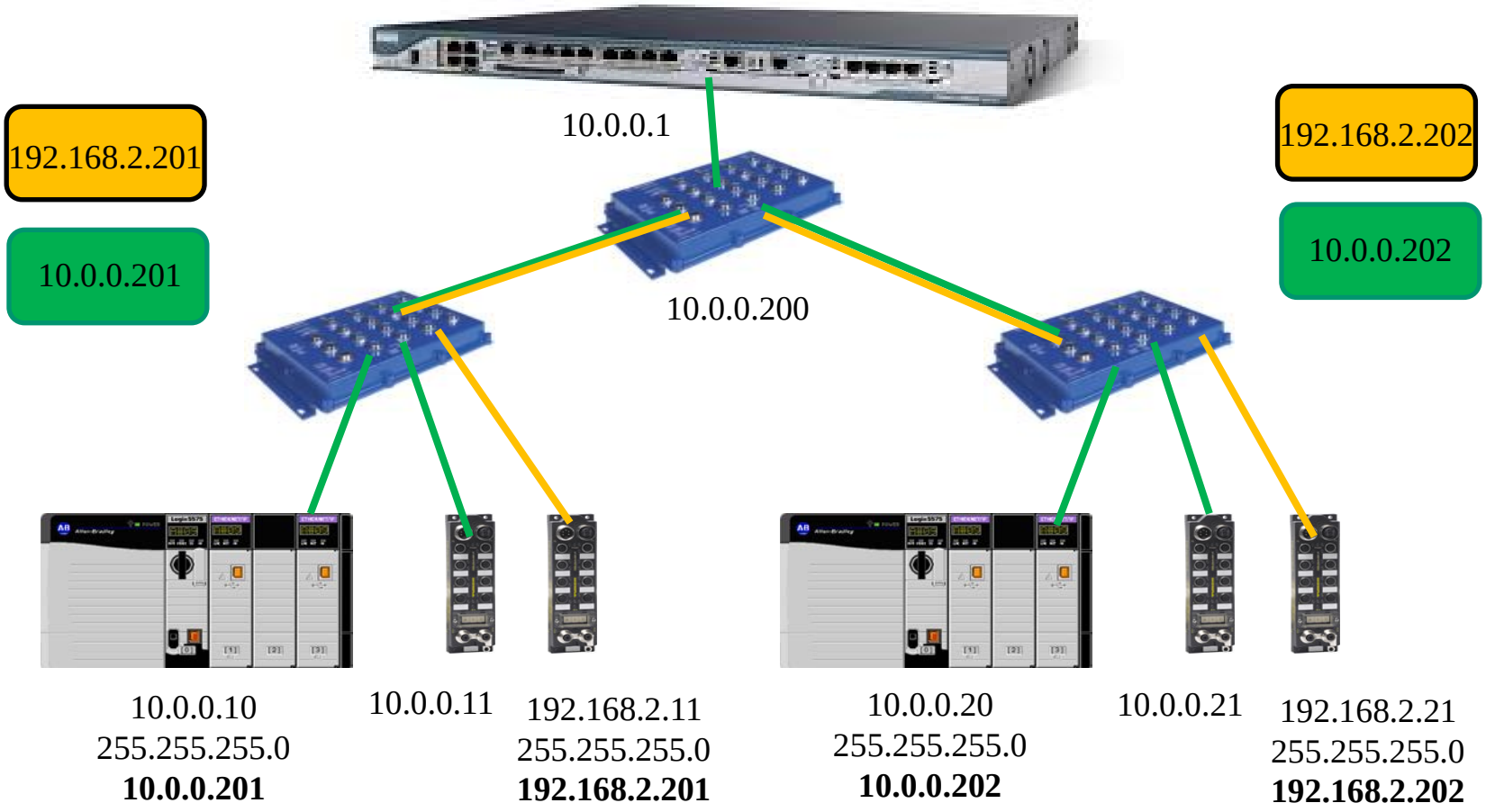
Single hop inter-VLAN routing capable switches

End devices take advantage of the single hop inter-VLAN routing feature by having their default gateway addresses point to a virtual router interface configured on the switch.



Combining single hop inter-VLAN Routing with trunking VLAN traffic between switches

Note the virtual router interface IP addresses and the end device default gateway addresses



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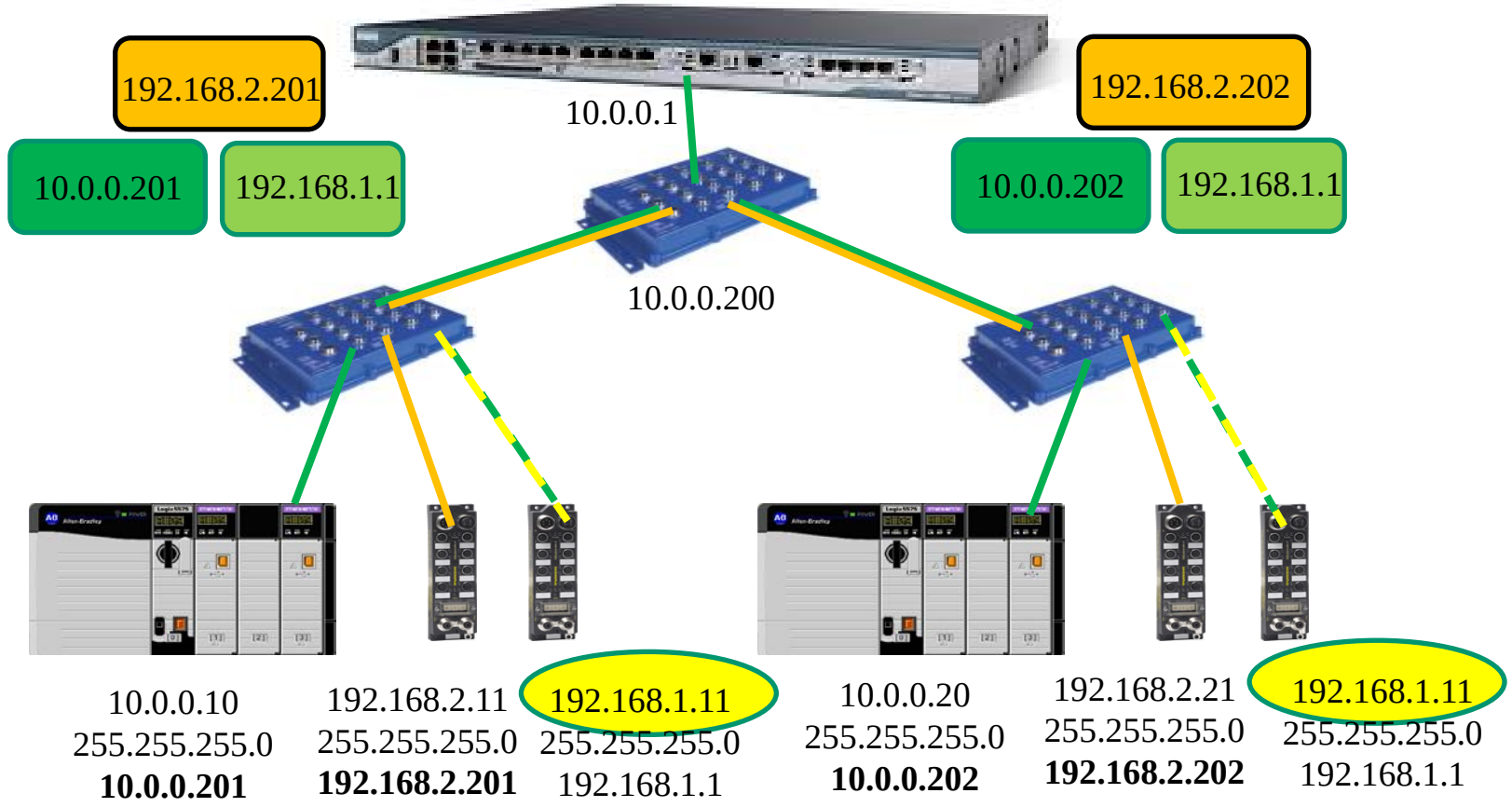


Advantages / Limitations of Single hop inter-VLAN routing

Advantages:

1) Limited, local routing capability;
2) Multiple restricted access, privately addressed networks can be built;
3) SNMP traffic statistics supporting private networks are available for remote monitoring and management.

Limitations:

1) Only unicast traffic can be routed;
2) Traffic is only routed for end devices that are aware that a switch supports this service.

Alternatives to Single hop inter-VLAN routing

1) Implement a true layer 3 switch (more expensive and more complex solution, significant IT concerns, every device requires a unique IP address)
2) Deploy truly isolated Ethernet I/O networks (Controllers must support multiple Ethernet interfaces, Isolated I/O networks are difficult to troubleshoot)
3) Expand the size of allowable networks (every device on an existing network needs to be reconfigured, ensure every device on a large network can tolerate worst case background broadcast traffic conditions)
4) Install Network Address Translation (NAT) Gateways (cascaded NAT gateways can become difficult to manage)
5) *Procure a controller Ethernet Interface card that simultaneously supports multiple IP addresses.*

I/O Device Communication Needs

What is the value in assigning a globally unique IP address to an I/O device?

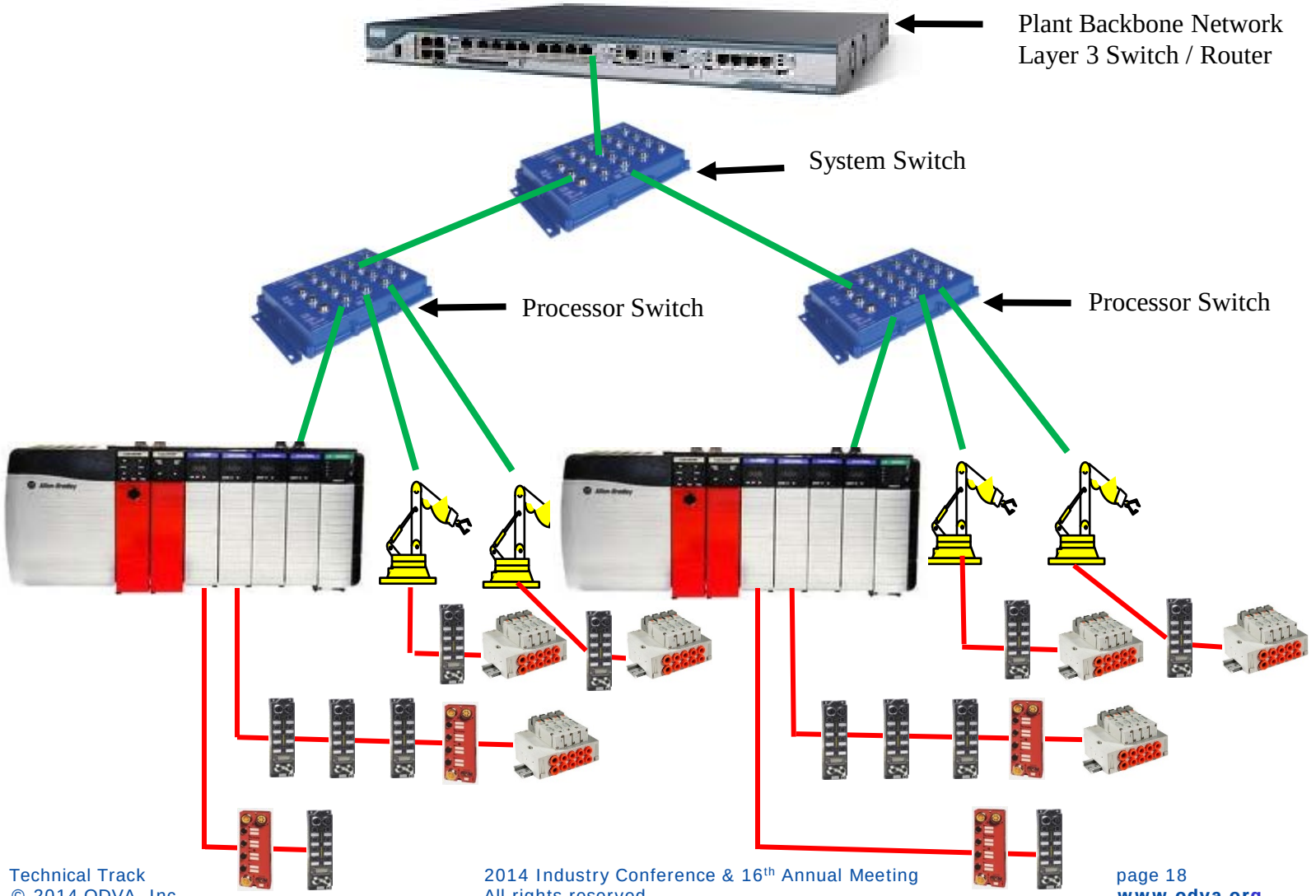
- There are extremely few devices that need to or would benefit from communicating with a random Ethernet capable I/O device.
- There are numerous reasons for isolating and/or securing an I/O device so that it is only able to communicate with a few other devices.

What devices need to communicate with a typical I/O device? Conversely, which devices does a typical I/O device have a legitimate and productive reason to communicate with?

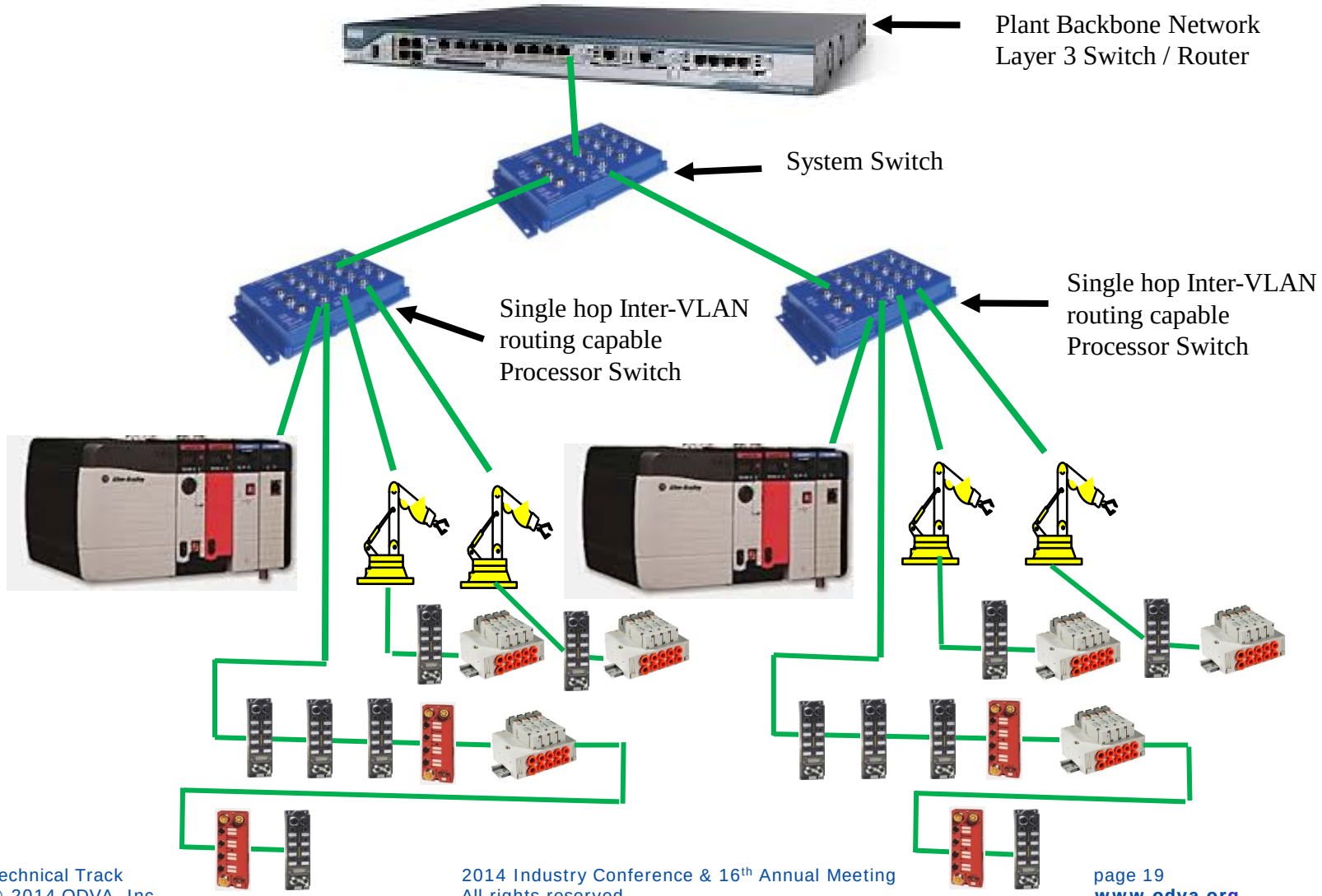
- A controller.
- A configuration device, a network monitoring device, a troubleshooting tool.
- A time server, a name server, an address server.

If there is a need to communicate with a distantly remote device, it will likely take place through a security server.

GM's Current EtherNet/IP Network Architecture with multiple DeviceNet I/O networks



GM's Proposed EtherNet/IP Network Architecture with multiple (linear DLR) EtherNet/IP I/O networks



Summary

- Ethernet I/O increases the manufacturing need for IP addresses by an order of magnitude or more.
- EtherNet/IP (unicast) real-time traffic can be easily and reliably routed.
- Single hop inter-VLAN routing is a capability that EtherNet/IP I/O can take advantage of. It is a feature that suppliers of advanced, managed, industrial Ethernet switches should consider implementing.

Acknowledgements

I would like to gratefully acknowledge the help and assistance of numerous individuals from Cisco, Hirschmann, and Rockwell Automation in conducting the experiments and participating in the discussions that resulted in this presentation and the accompanying paper.

I would also like to thank ODVA for allowing me to share my findings, observations, and opinions with you.

Questions?