

Switches for Automotive Ethernet

Use Cases for the RAD-Pluto and RAD-Jupiter

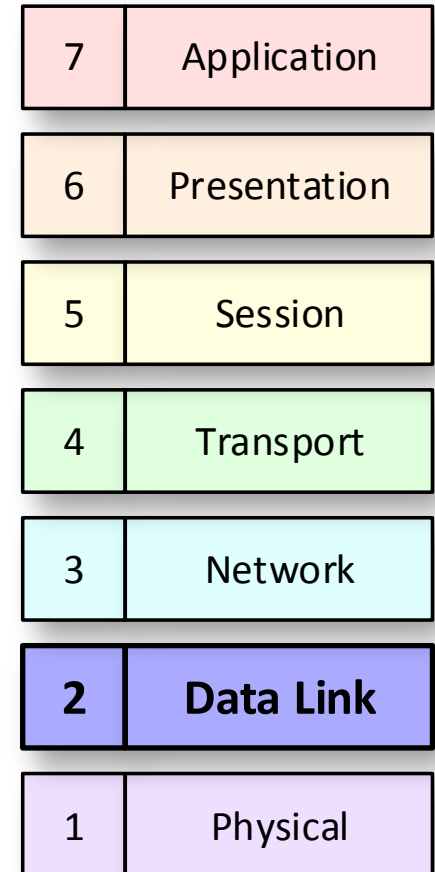


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Product & Applications Manager

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Switches are OSI Layer 2 Devices

- Media Access Control (MAC)
- Forwards frames based on physical address
- Lowest level
 - Device addressing (MAC)
 - Message formatting
 - Error detection
 - QoS (VLAN)
- Higher Level Protocols
 - Logical Addressing / Connections
 - Fragmentation / Reassembly
 - Acknowledgement and Flow Control



Managed vs. Smart vs. Unmanaged Switches

- Unmanaged Switch
 - Little or no configuration
 - MAC Based Routing
 - Unknown addresses “flooded” to all ports (or dropped until the address is no longer unknown)
 - Ingress traffic effectively builds a table of which MAC addresses reside on which ports
 - Possibly static L2 Address table configuration
- Smart Switch
 - Basic VLAN Support (Static Config, Enforcing Tag/Priority, tag/un-tag, etc.)
 - Port Mirroring

Managed vs. Smart vs. Unmanaged Switches

- Managed Switch enhances QoS and Security
 - Addition of host processors or embedded cores
 - Dynamic VLAN management (MVRP)
 - Manage Redundant Paths (Spanning Tree Protocol, etc.)
 - AVB/TSN Protocols
 - Deep Packet Inspection
 - Ingress Policing and Limiting

RAD-Pluto

5-Port Smart Switch

5-Ports

- 3x 100BASE-T1
- 1x 100BASE-T1 or 1x 1000BASE-T
- 1x USB3/GIGE Bridge

Integral CAN/LIN Interfaces

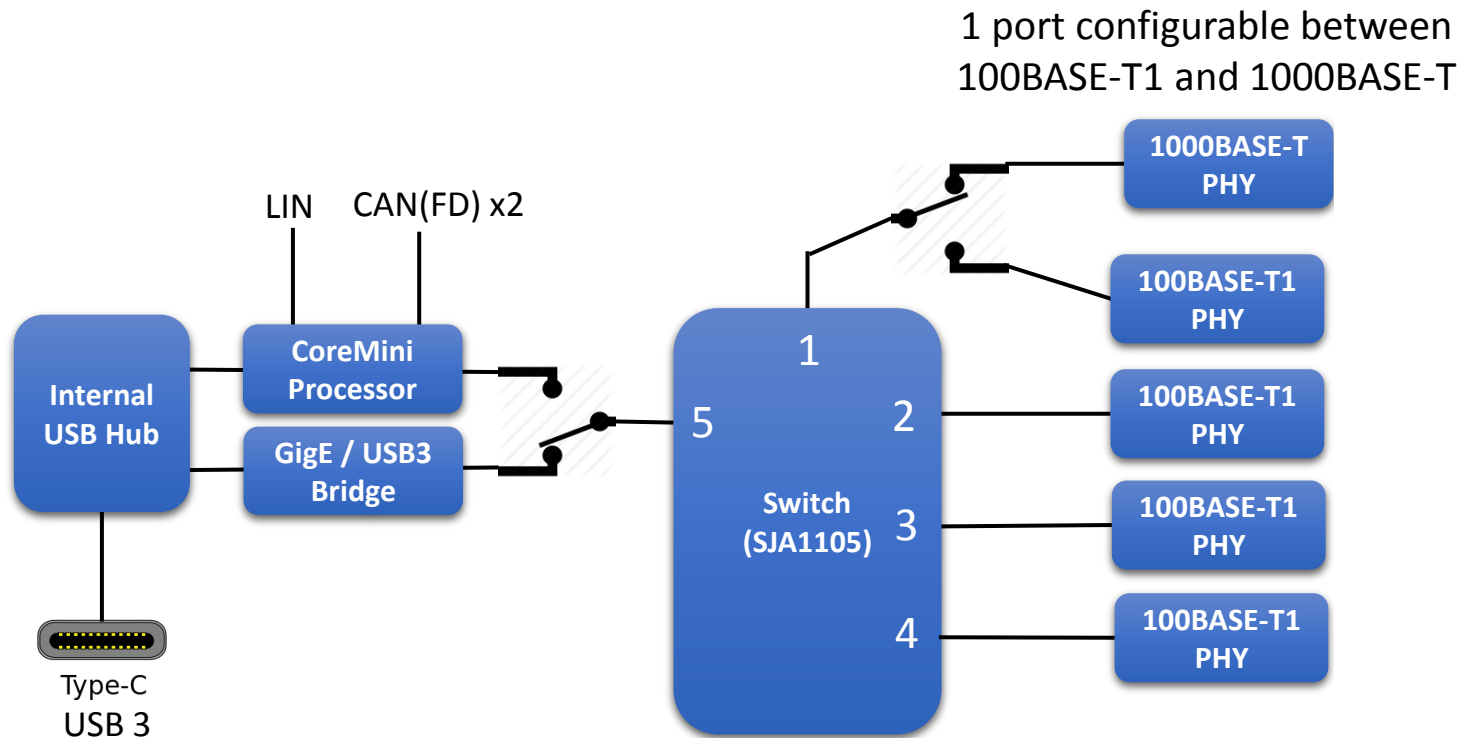
- 2x CAN-FD
- 1x LIN
- Embedded Function Block Execution

Use Cases

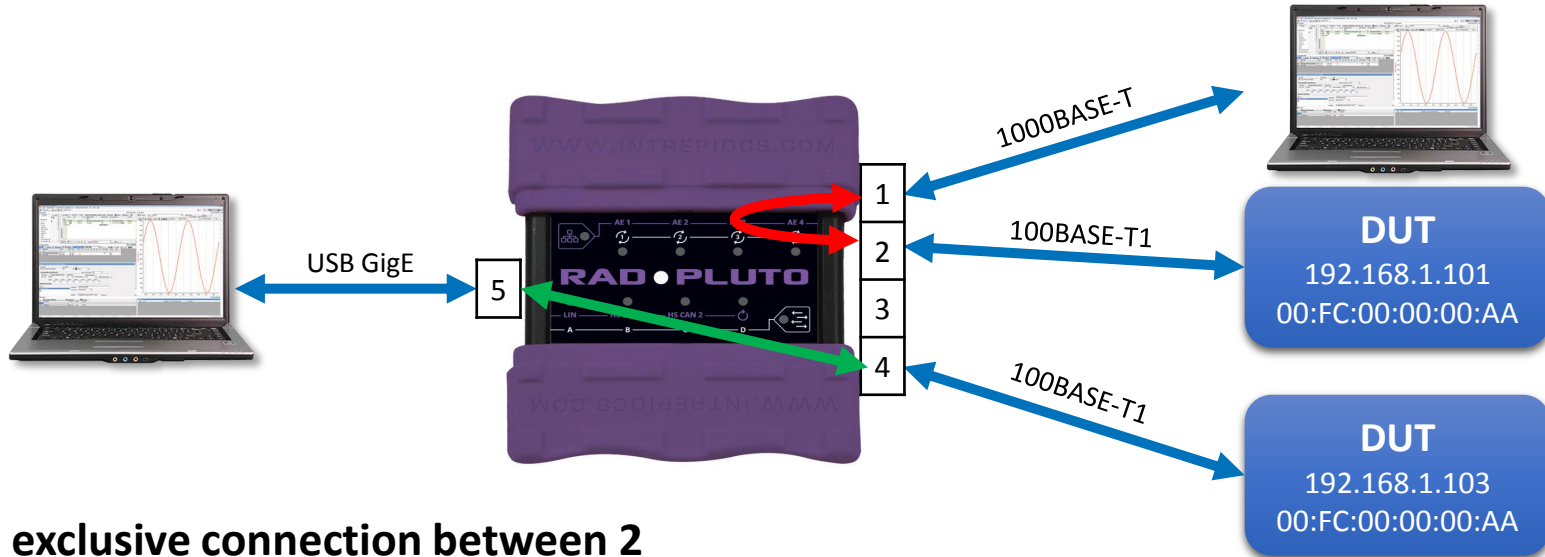
- Gateway applications
- Media Conversion
- Frame Mirroring and VLAN tagging for advanced debug and monitoring.



RAD-Pluto Block Diagram



Media Conversion



Make exclusive connection between 2 ports. Block traffic from all other ports.

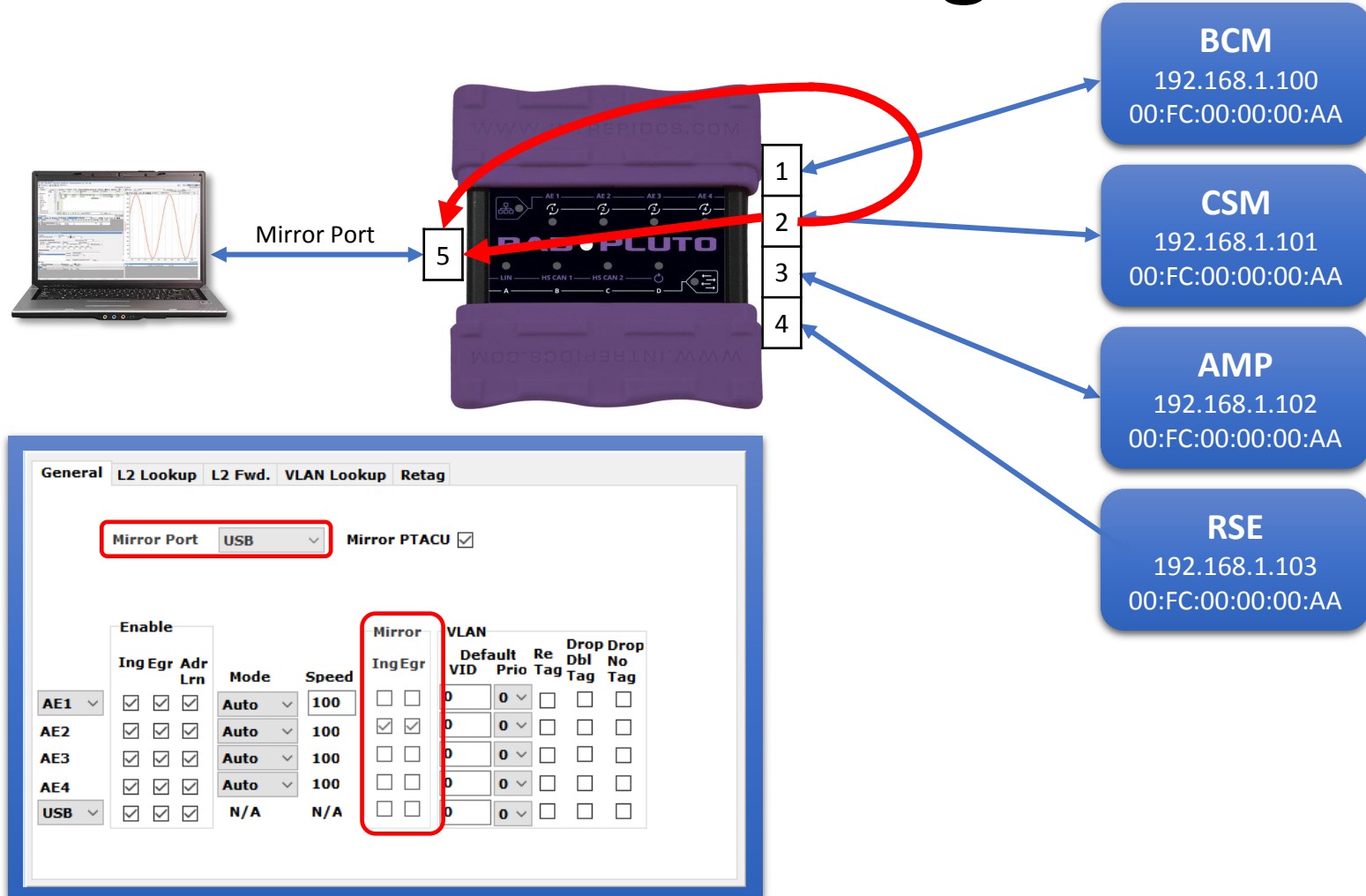
- Broadcast Domain: Block broadcast messages from select ports.
- Reach_Port: Selectively block traffic between ports.
- Flood Domain: Block flooding of unknown addresses to selected ports.

Ingress	BC_Domain					Reach_Port					FL_Domain				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
AE1/RJ45	☒	☒	☐	☐	☐	☒	☒	☐	☐	☐	☒	☒	☐	☐	☐
AE2	☒	☐	☐	☐	☐	☒	☐	☐	☐	☐	☒	☐	☐	☐	☐
AE3	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
AE4	☐	☐	☐	☒	☒	☐	☐	☐	☒	☒	☐	☐	☒	☒	☐
USB/CM	☐	☐	☐	☒	☒	☐	☐	☐	☒	☒	☐	☐	☒	☒	☐

2 things to note

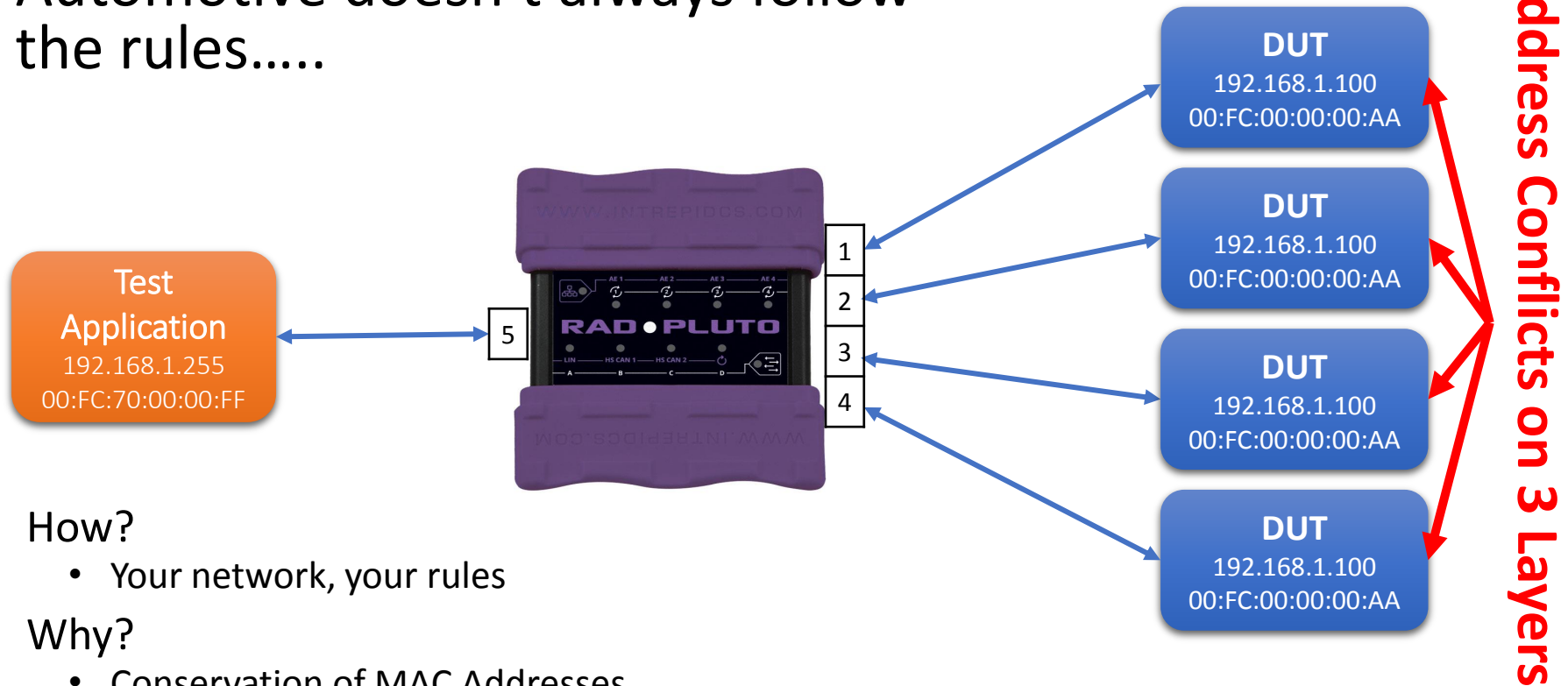
- A switch is a "Store and Forward" device which introduces more latency than a "true" media converter.
- Ideally statically configure L2 Address Table, or the switch to flood ports on unknown MAC addresses.

Port Mirroring



“Gang Testing” Identical DUT’s

Automotive doesn’t always follow the rules.....

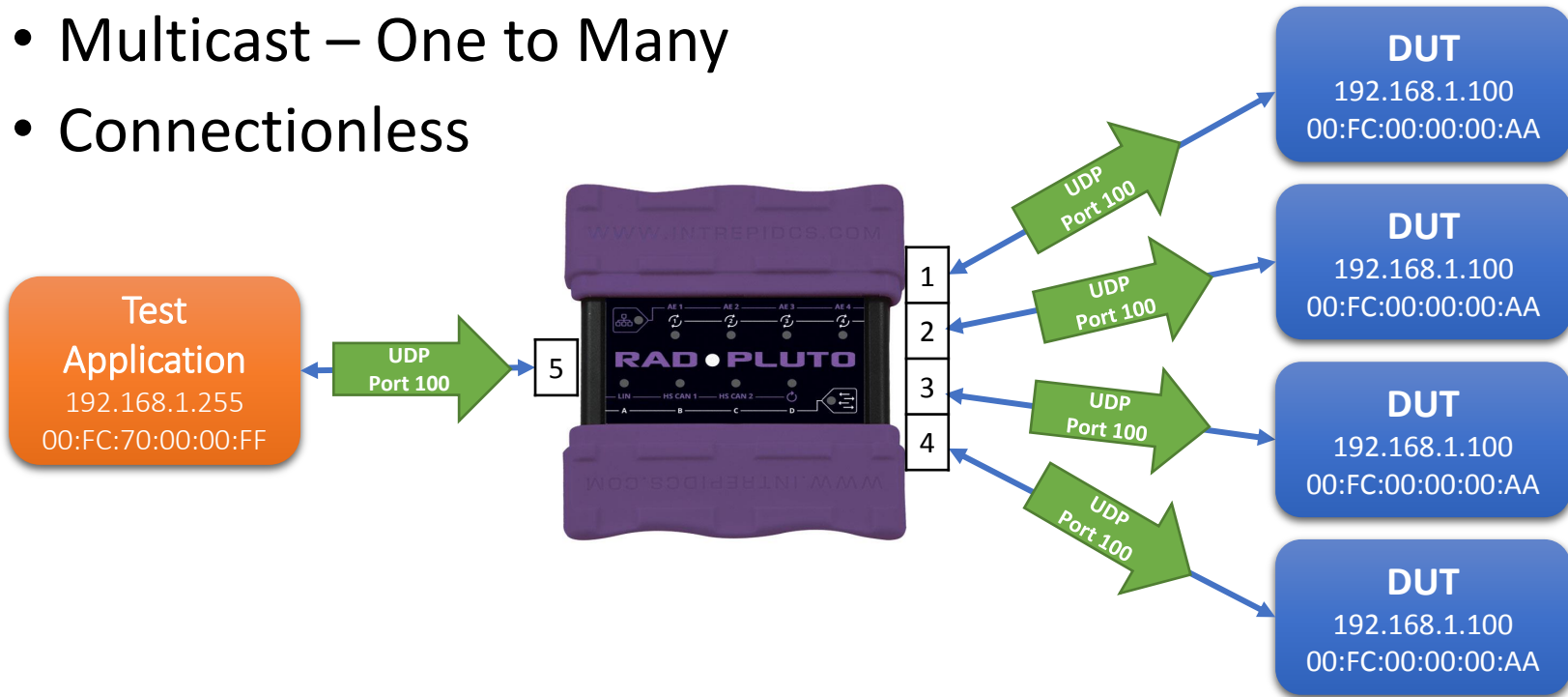


- How?
 - Your network, your rules
- Why?
 - Conservation of MAC Addresses
 - Simplifies system development, manufacturing, diagnostics, etc.

UDP Outbound to Identical DUT's

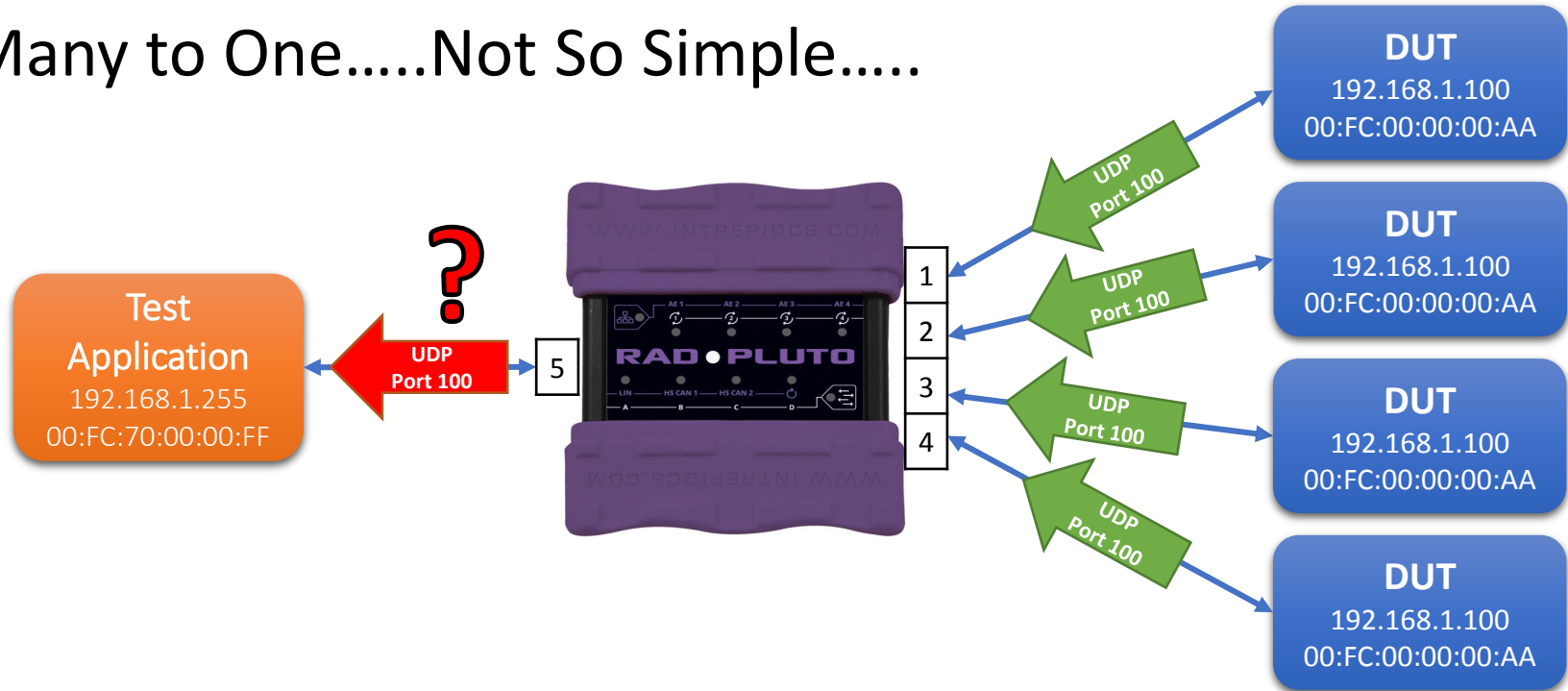
Simple

- Multicast – One to Many
- Connectionless



UDP Inbound to Tester (w/ address conflicts)

Many to One.....Not So Simple.....



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VLAN's

- Virtual LAN (VLAN)
 - Switched network: devices receive only traffic within their VLAN
 - Layer 2: VLAN Tag in Ethernet MAC Header (with priority)
 - Switch routes frames based on VLAN configuration
 - Static or Managed Configuration

Ethernet, Src: 00:FC:00:00:00:02, Dest: 91:E0:F0:00:FE:80
Destination: 91:E0:F0:00:FE:80
Source: 00:FC:00:00:00:02

VLAN tag
Tag protocol identifier (TPID): IEEE 802.1Q VLAN (0x8100)
Priority code point (PCP): 3 (3 bits)
Drop eligible indicator (DEI): 0 (1 bit)
VLAN identifier (VID): 2 (12 bits)

Type: IEEE1722
Frame Check Sequence: 0x4987E3F3 (Correct)

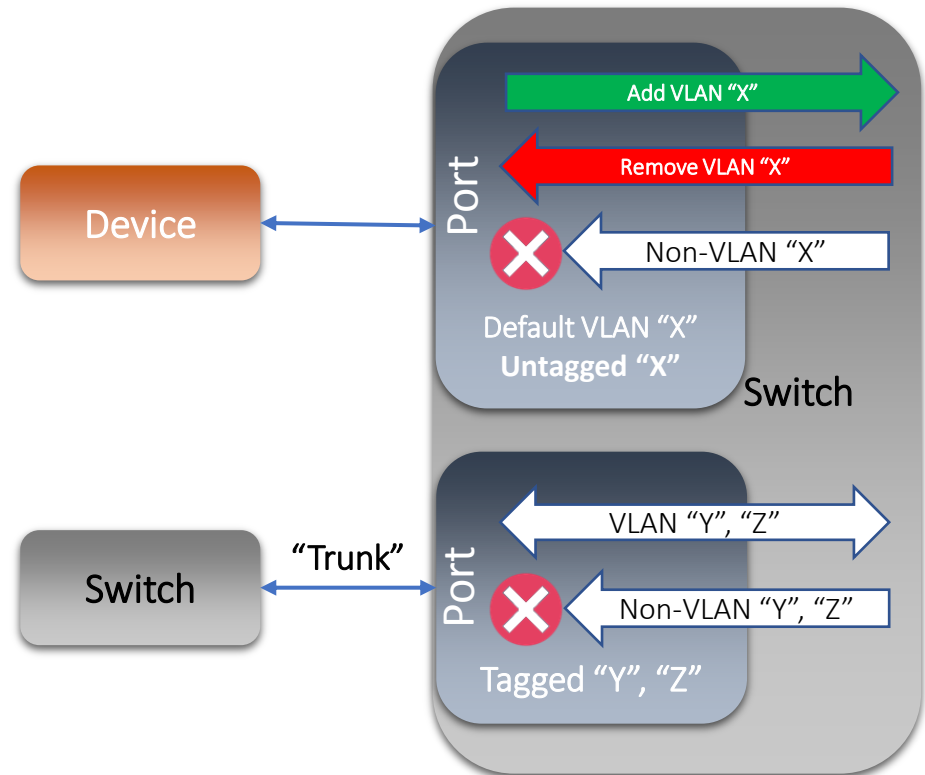
91	E0	F0	00	FE	80	00	FC
00	00	00	02	81	00	60	02
22	F0	00	88	77	00	00	FC

Message Dissector

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VLAN Terminology

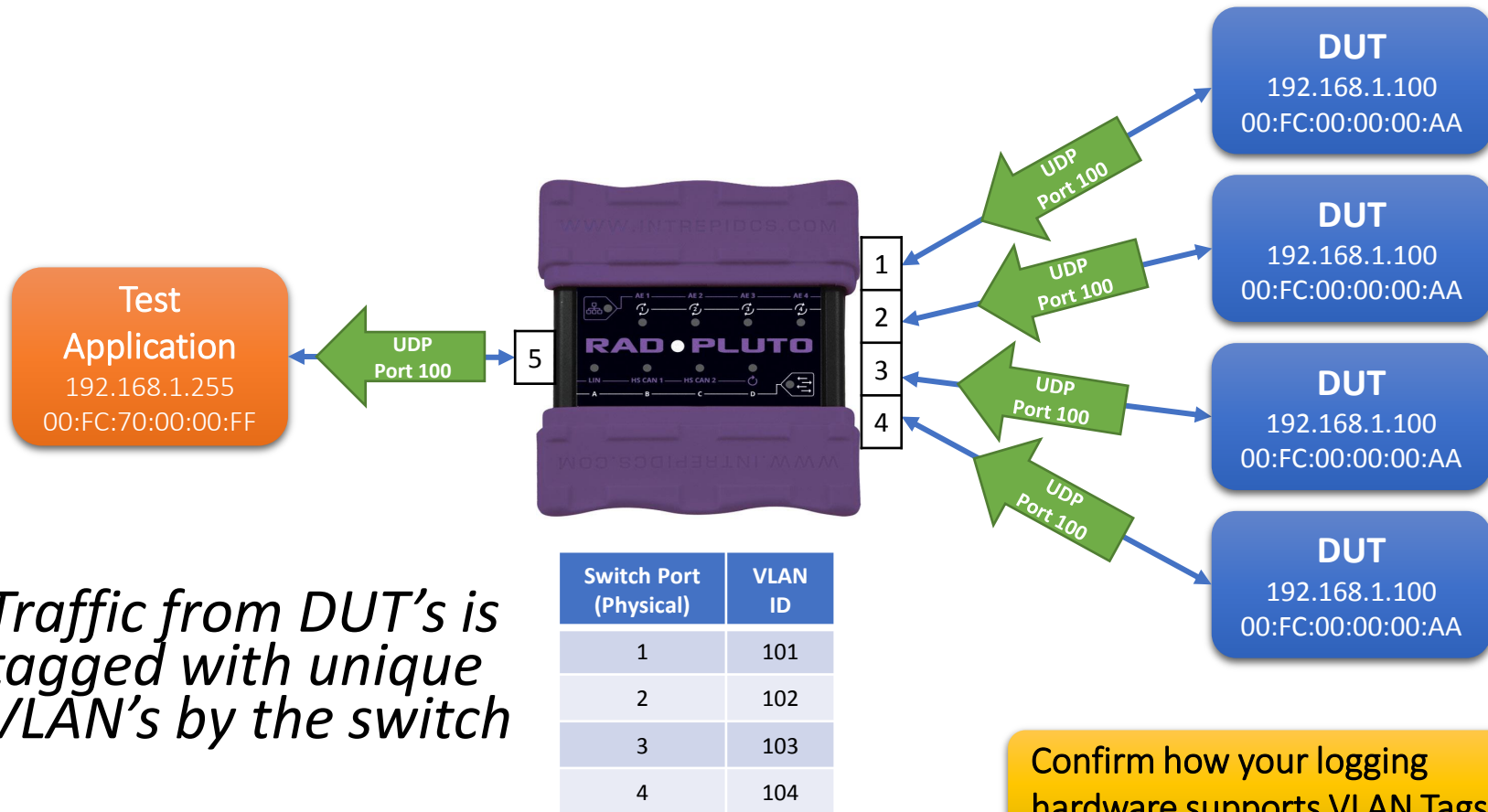
- Default VLAN: Tag added to any frame ingressing on that port
- VLAN Member: (Varying Definitions)
 - May define ingress rules, egress rules, or both
- Untagged Port:
 - Matching VLAN Frames Egress Untagged.
 - Port drops frames from all other VLAN's
 - Usually to connect a device to a specific VLAN.
- Tagged Port (or Trunk Port)
 - Member of 1 or more VLAN's
 - VLAN Tags unmodified
 - Drops non-member tags
 - Used as "trunk" lines between switches connecting VLANs



Definitions & Nomenclature can vary by manufacturer.
When in doubt, READ DOCS and EXPERIMENT

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UDP Inbound to Tester with VLAN's



Traffic from DUT's is tagged with unique VLAN's by the switch

Defining VLAN's

General L2 Lookup L2 Fwd. **VLAN Lookup** Retag

Mirror Port: None Mirror PTACU: ☒

Enable	Ing Egr	Adr Lrn	Mode	Speed	Mirror	VLAN	Drop Dbl Tag	Drop No Tag
AE1	☒	☒	Auto	100	☐	101	☐	☐
AE2	☒	☒	Auto	100	☐	102	☐	☐
AE3	☒	☒	Auto	100	☐	103	☐	☐
AE4	☒	☒	Auto	100	☐	104	☐	☐
USB	☒	☒	N/A	N/A	☐	0	☐	☐

1.) Assign default VLAN ID's for each switch port connected to a DUT.

2.) Define VLAN ID's and make the switch port of the Tester a member of the VLAN's

General L2 Lookup L2 Fwd. VLAN Lookup Retag																										
VID	VMEMB port					BC_Port					ING_Mirr.					EGR_Mirr.					Tag_Port					
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
101	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	
102	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	
103	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	
104	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	

- VMEMB: Ingress Policing
- BC_Port: Egress Policing
- Tag_Port: Keep/Strip Tag

RAD-Jupiter

7-Port Managed Switch with AVB/TSN

7-Port Managed Switch

- 5x 100BASE-T1
- 1x 1000BASE-T1 or 1000BASE-T
- USB3/GIGE Bridge or 1x 1000BASE-T
- AVB/TSN Protocol Support
- Packet Inspection (TCAM)
- Per-port address whitelisting/blacklisting

Integral CAN/LIN Interfaces

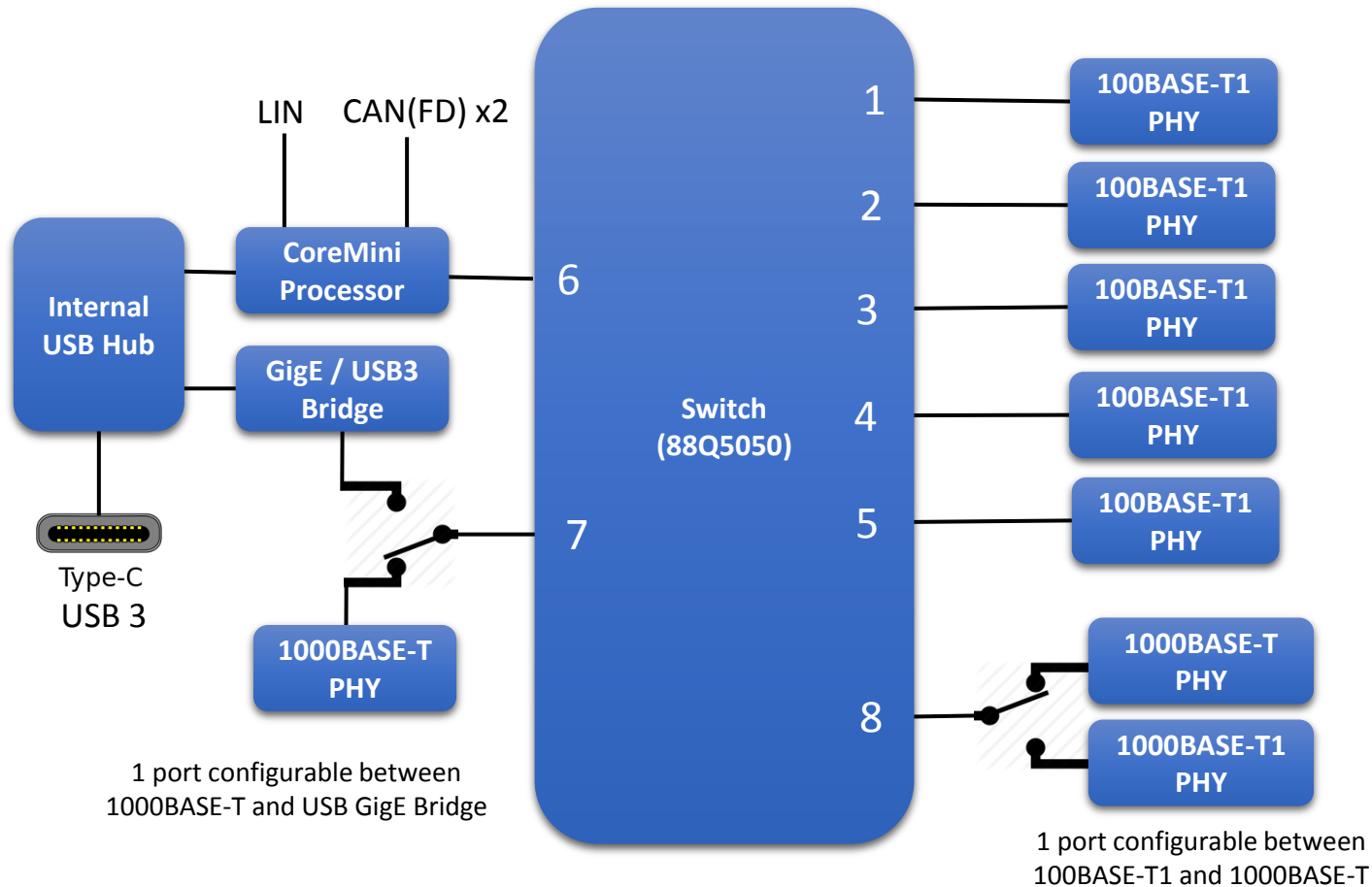
- 2x CAN-FD
- 1x LIN
- Embedded Function Block Execution



Use Cases

- AVB/TSN Development & Testing
- Gateway applications
- Media Conversion
- Frame Mirroring and VLAN tagging for advanced debug and monitoring.

RAD-Jupiter Block Diagram



Media Conversion (Jupiter)

- Similar to Pluto
- Different Config Interface
- 2 More Ports
- 1000BASE-T1 Available
- **Advanced** configurations allow “Cut-Through” operation



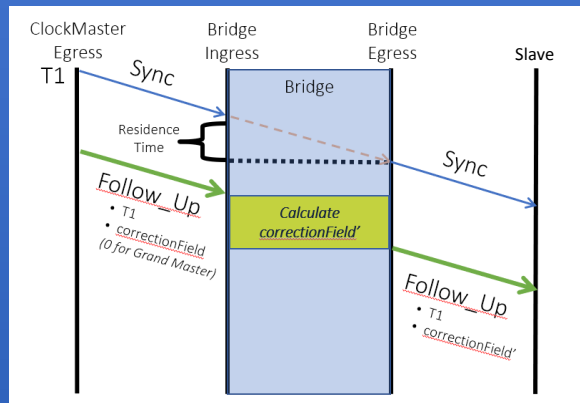
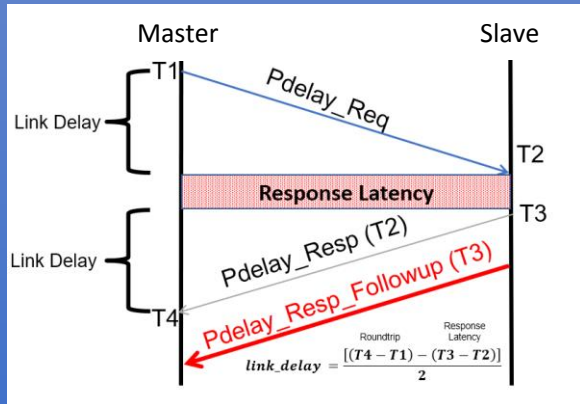
Automotive Switch Configuration Tool

Exit EEPROM Statistics Info

Board Configuration PTP VLAN Stream Reservation TCAM Port Mirroring Port Based VLAN Table Register Access

	Egress Port 0 (CPU)	Egress Port 1	Egress Port 2	Egress Port 3	Egress Port 4	Egress Port 5	Egress Port 6	Egress Port 7	Egress Port 8	MapDA
Ingress Port 0 (CPU)	☐	☒	☒	☒	☒	☒	☒	☒	☒	☒
Ingress Port 1	☒	☐	☒	☒	☒	☒	☒	☒	☒	☒
Ingress Port 2	☒	☒	☐	☒	☒	☒	☒	☒	☒	☒
Ingress Port 3	☒	☒	☒	☐	☒	☒	☒	☒	☒	☒
Ingress Port 4	☒	☒	☒	☒	☐	☒	☒	☒	☒	☒
Ingress Port 5	☒	☒	☒	☒	☒	☐	☒	☒	☒	☒
Ingress Port 6	☒	☒	☒	☒	☒	☒	☐	☒	☒	☒
Ingress Port 7	☒	☒	☒	☒	☒	☒	☒	☐	☒	☒
Ingress Port 8	☒	☒	☒	☒	☒	☒	☒	☒	☐	☒

IEEE 802.1AS – Time Synchronization for Time-Sensitive Applications in Bridged LAN gPTP

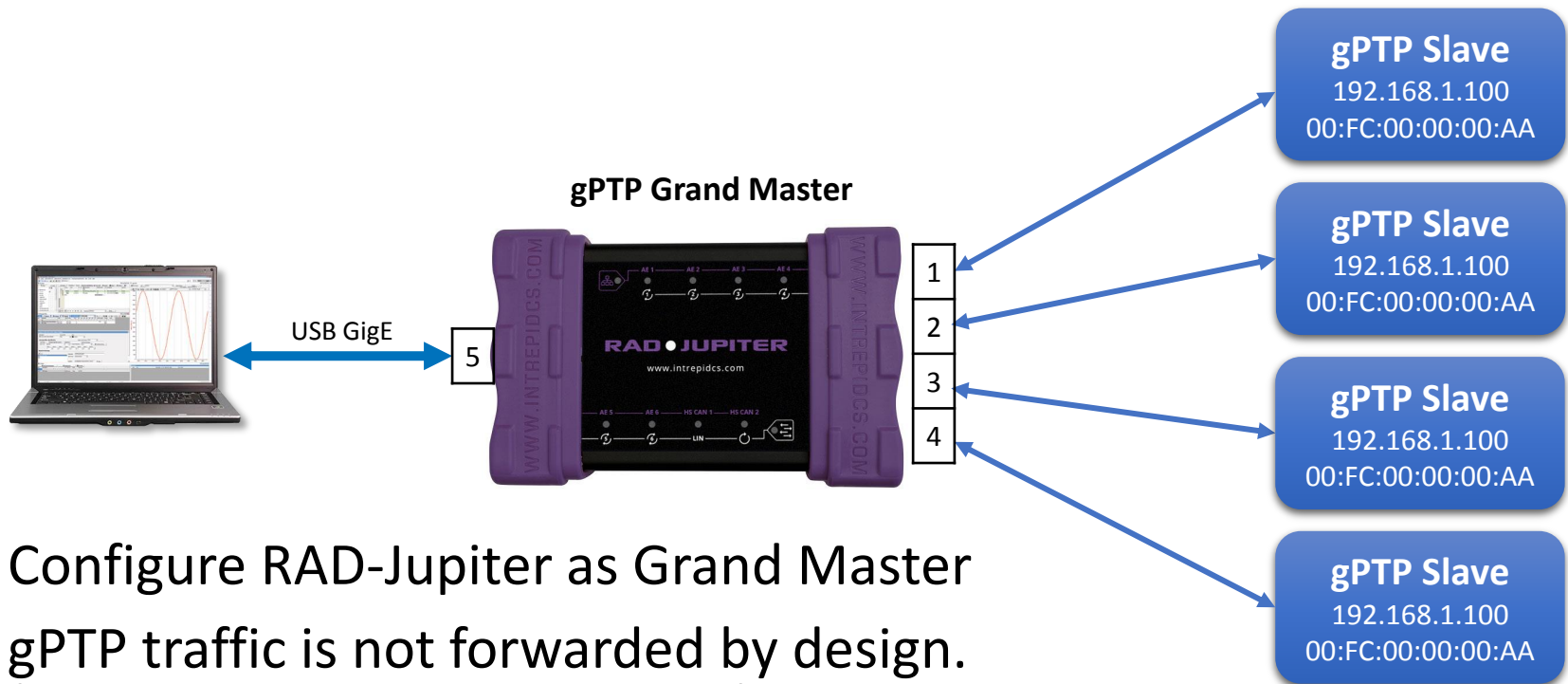


- Collect and Transmit Time Stamp Info
 - Link Delay Measurement
 - Clock Frequency Offset Compensation

- Residence Time Measurement
- Propagation of accumulated latency

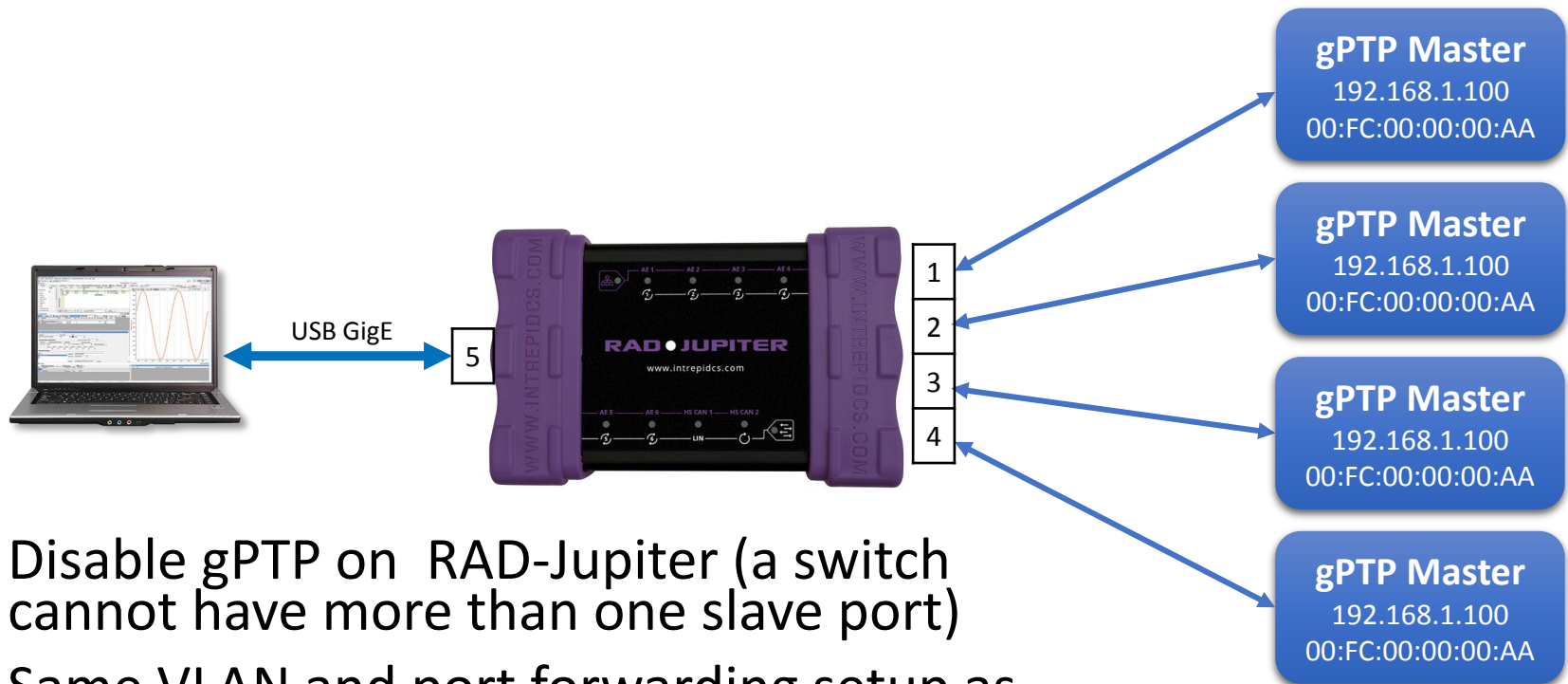
Requires managed switch supporting gPTP protocol

gPTP Testing: Slave DUT



- Configure RAD-Jupiter as Grand Master
- gPTP traffic is not forwarded by design.
(DA is LLDP Multicast Address)
- Similar to previous examples using VLAN's,
but requires actively forwarding messages

gPTP Testing: Master DUT

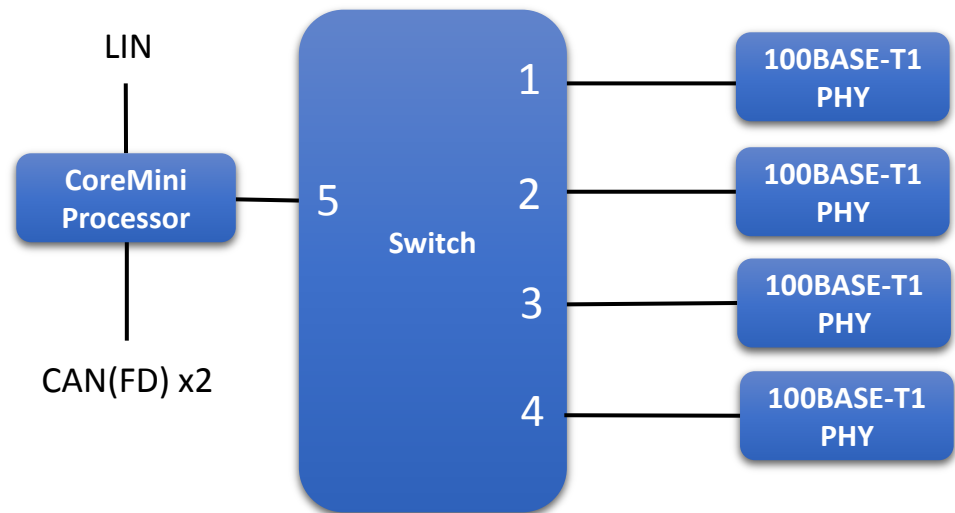


- Disable gPTP on RAD-Jupiter (a switch cannot have more than one slave port)
- Same VLAN and port forwarding setup as previous Slave DUT example
- Script periodic Pdelay Request to go out each port

Standard Profile (vs. Automotive)
may require additional scripting

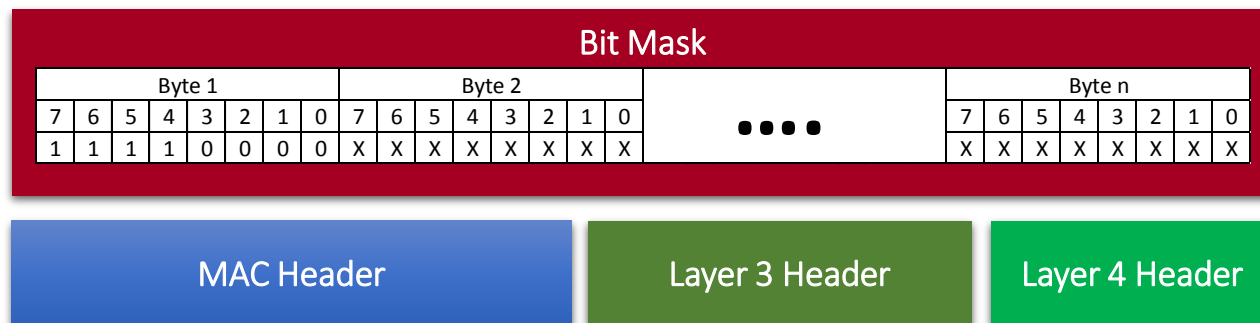
Gateway Functions

- Ethernet support in development for Intrepid's Gateway Builder
- Gateway implementations
 - Function Blocks
 - C Code Interface
 - Pack signals defined in DBC or LDF into UDP payload



Ternary Content Addressable Memory (TCAM)

- Method of Packet Inspection
- Bit mask is applied to a range of bytes
- “Ternary” = 1,0,X
- “Hit” occurs when the bit pattern matches the mask



TCAM Actions

A “hit” can trigger the following actions

- Drop the message
- Forward the message to a specific port(s)
- Override Destination Ports
- Add/strip/manipulate VLAN tags
- Reprioritization
- Forward the message to a host microcontroller for specific handling in software
 - Deeper Inspection
 - Cybersecurity
 - Logging, network statistics, diagnostics, etc.
 - Complex ingress policing (e.g. temporal, adaptive, etc.)
 - Gateway to another network

Example TCAM Rule

TCAM Base Entries (Entry Count: 5)	Value (First 48 Bytes)
✓ ☒ Port 2 SRP (IHU)	Pending Action: Add , Row: 0
Follow-up Group	None
☒ Source: Untagged Frame	NOTE: TCAM entry matching untagged source --> data/mask shortened by 4 bytes!
Data	01:80:c2:00:00:0e:00:00 00:00:00:00:22:ea:00:00 00:00:00:00:00:00:00:00 00:00:00:00:00:00:00:00 00:00:00:00:00:00:00:00 00:00:00:00
Mask	ff:ff:ff:ff:ff:ff:00:00 00:00:00:00:ff:ff:00:00 00:00:00:00:00:00:00:00 00:00:00:00:00:00:00:00 00:00:00:00:00:00:00:00 00:00:00:00
> Source Port(s)	
> Actions	
✓ ☒ Port 1 SRP (AUD)	Pending Action: Add , Row: 1
Follow-up Group	None
☒ Source: Untagged Frame	NOTE: TCAM entry matching untagged source --> data/mask shortened by 4 bytes!
Data	01:80:c2:00:00:0e:00:00 00:00:00:00:22:ea:00:00 00:00:00:00:00:00:00:00 00:00:00:00:00:00:00:00 00:00:00:00:00:00:00:00 00:00:00:00
Mask	ff:ff:ff:ff:ff:ff:00:00 00:00:00:00:ff:ff:00:00 00:00:00:00:00:00:00:00 00:00:00:00:00:00:00:00 00:00:00:00:00:00:00:00 00:00:00:00
TCAM Base Entries (Entry Count: 5)	Value (First 48 Bytes)
☐ Port 1	
☒ Port 2	
☐ Port 3	
☐ Port 4	
☐ Port 5	
☐ Port 6	
☐ Port 7	
☐ Port 8	
> Actions	
✓ DPV Override Action	
DPV: 0x0000003a	Port(s): 1, 3, 4, 5

TCAM Applications

- Hardware filtering
- Frame Dropping (AVB/TCP/UDP)
 - Intermittent errors
 - Filtering out stream from relevant traffic
- Change VLAN priorities or strip altogether
- Inject traffic
 - DoS
 - Spoofing

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Thank You!

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