Port Forwarding:
Harris's MASTR V's Dual Star Network.

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Scope of Presentation

- Purpose
- Intro to MASTR V RF Base Station
- Dual Star Network
- Port Forwarding Protocol*
- Port Forwarding Walk-Through on Base Station

*This is the name Harris gives to protocol it uses to test Ethernet devices. What Harris calls “Port Forwarding” is in no way related to SSH port forwarding, port mapping, tunneling, or similar protocols.

Purpose:

- The MASTR V Base Station is a modularized software defined radio (SDR) base station designed for use in public safety (police, fire, etc.).
  - Modulated and demodulated data is digitized.
  - Separate modules with DSPs and microcontrollers (uC) are needed for demodulation, modulation, control, traffic routing, and PA handling.
  - Up to four channels can be implemented by a single system.
  - These processors need to communicate with each other in a highly reliable environment.
- Therefore, Harris chose to implement an Ethernet backbone with two switches to provide redundancy: a Dual Star topology.
- The Dual Star needs a way of determining which switch to use in a system, which is friendly to embedded OS. Harris created its own testing protocol called “Port Forwarding.”

Intro to MASTR V Base Station

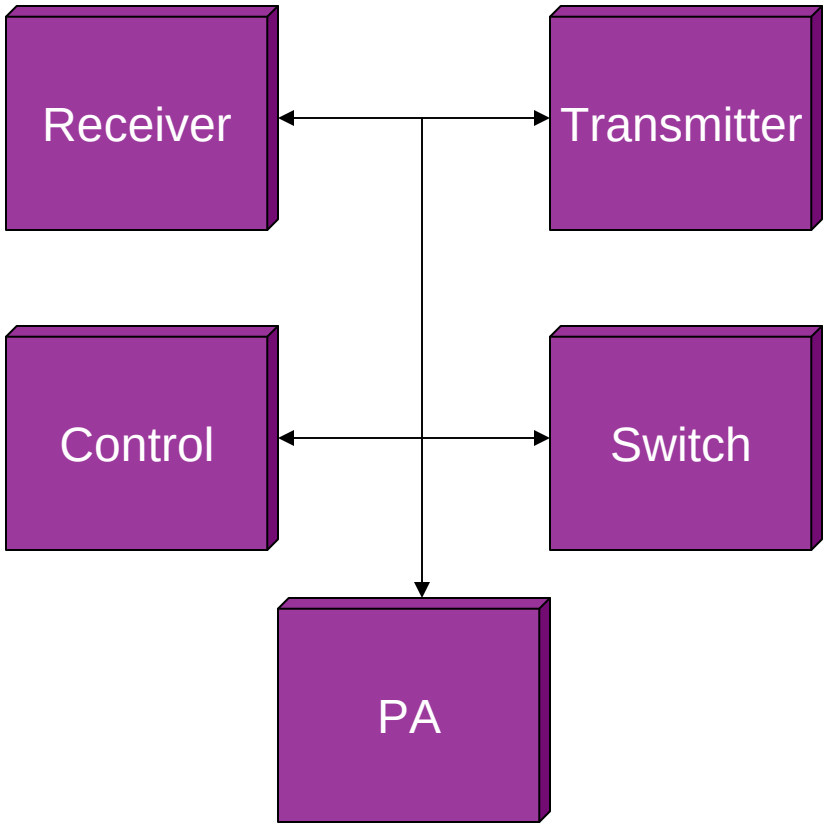
Backplane Modules

Dual Star Switches

Power Supply

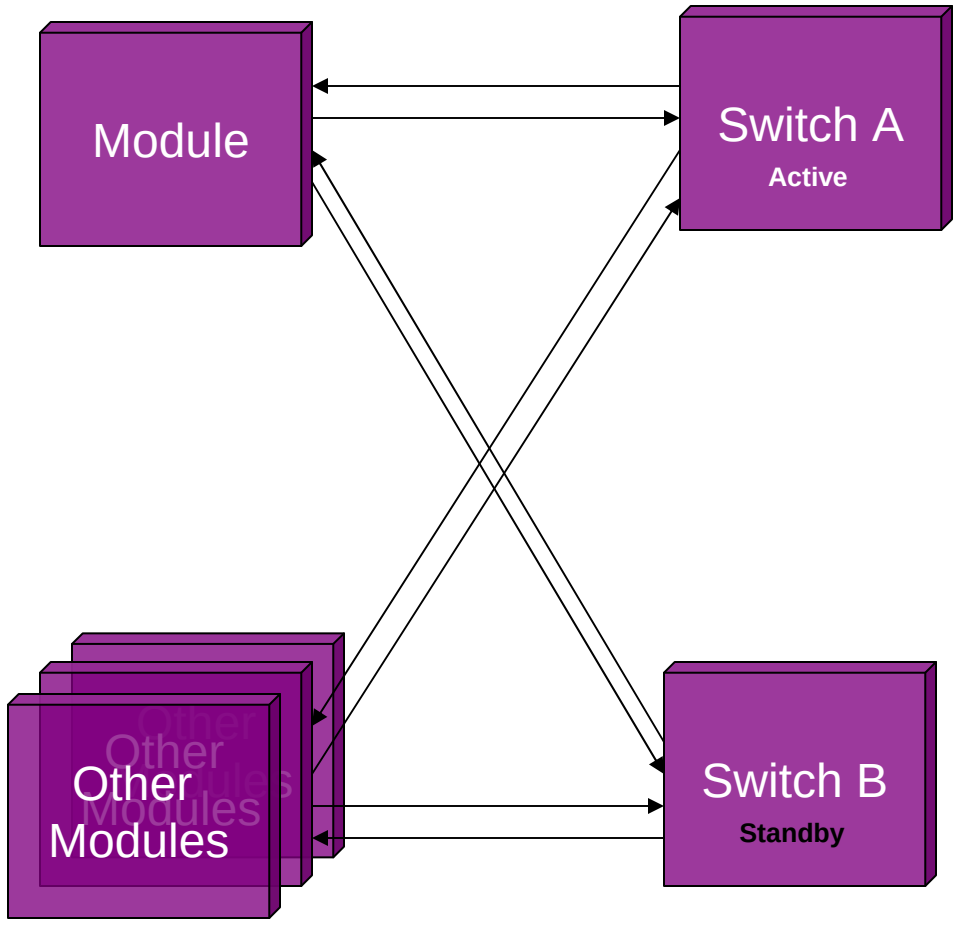
Linear Power Amplifier

- Receiver: DSP to demodulate data into IP and control RX.
- Transmitter: DSP to modulate IP packet data and control TX.
- Control: uC to route traffic & configure channel.
- PA: DSP to provide gain control and other control to Linear PA.
- Switch: uC to control network flow in switch.



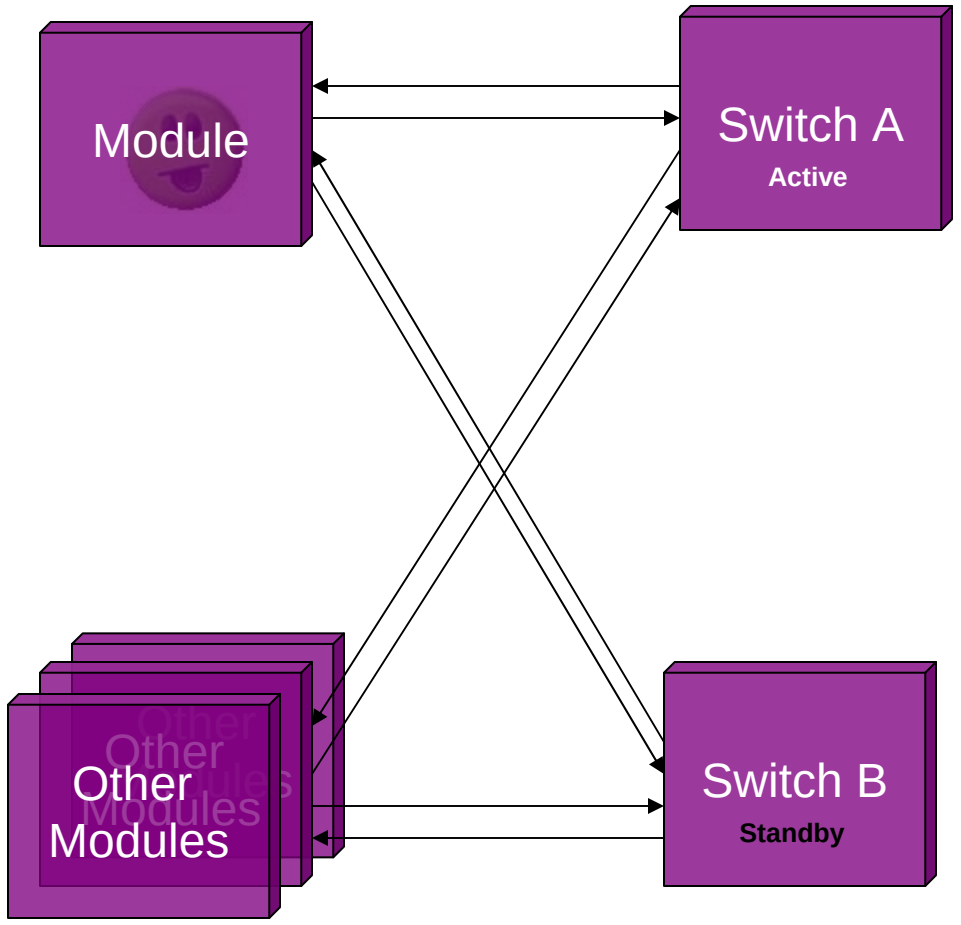
Dual Star Network

- Two switches: each module has a separate duplex connection to each switch.
- Each switch connects to all modules.
- One switch is active, allowing all traffic.
- The other switch is standby, in that it blocks all traffic except port testing packets.



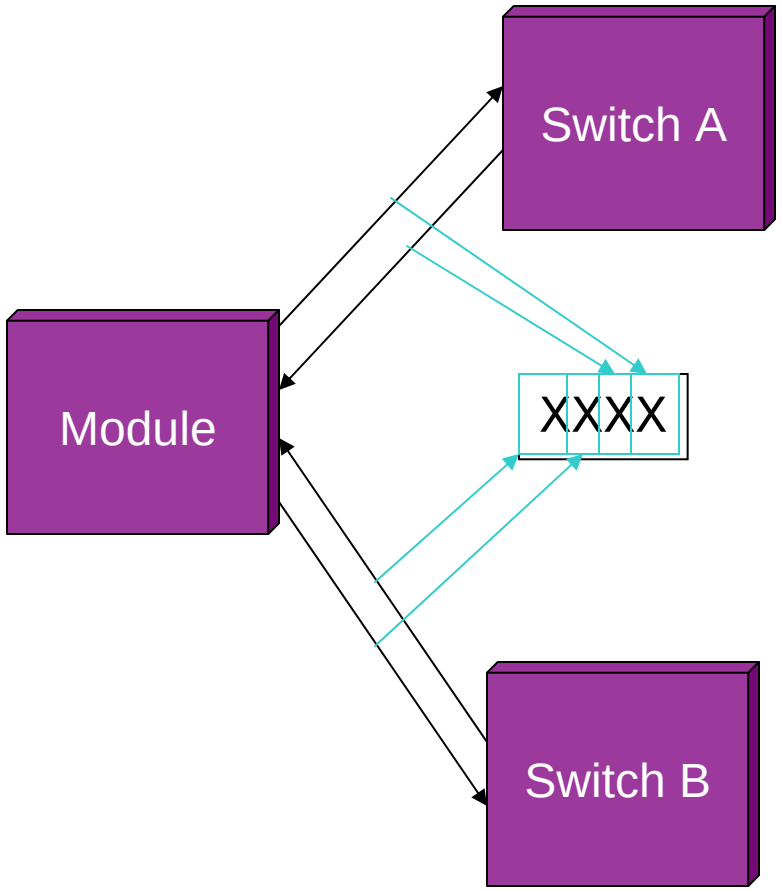
Dual Star Network: Port Testing

- Spanning Tree (RSTP):
  - Industry standard.
  - Module and switch send Layer 2 packets, which forward to all members.
  - Disadvantage: Custom Layer 2 not supported in most embedded environments.
- Port Forwarding protocol:
  - Invented by Harris.
  - Each switch transmits Layer 3 (UDP) packets to all modules to test and report conditions at a fixed period.
  - Each module transmits UDP packets to both switches to test and report conditions at same period.



Port Forwarding

- The Port Forwarding packet consists of 4-bit “maps” for the condition of each module’s connection to both switches.
- In the port-forwarding packet, each module’s map represents the connection status of:
  - Switch-B-to-module
  - Module-to-Switch-B
  - Switch-A-to-module
  - Module-to-Switch-A



Port Forwarding

- Each module *and* switch keeps a set of internal maps of every module's connections.
- These maps are what the module or switch will transmit as a PF packet.
- The module or switch knows of a bad connection if it fails to receive a PF packet from a source. It updates the maps with what it knows first hand.
- The rest of the info comes from previously received PF packets.

Module 1

Module 2

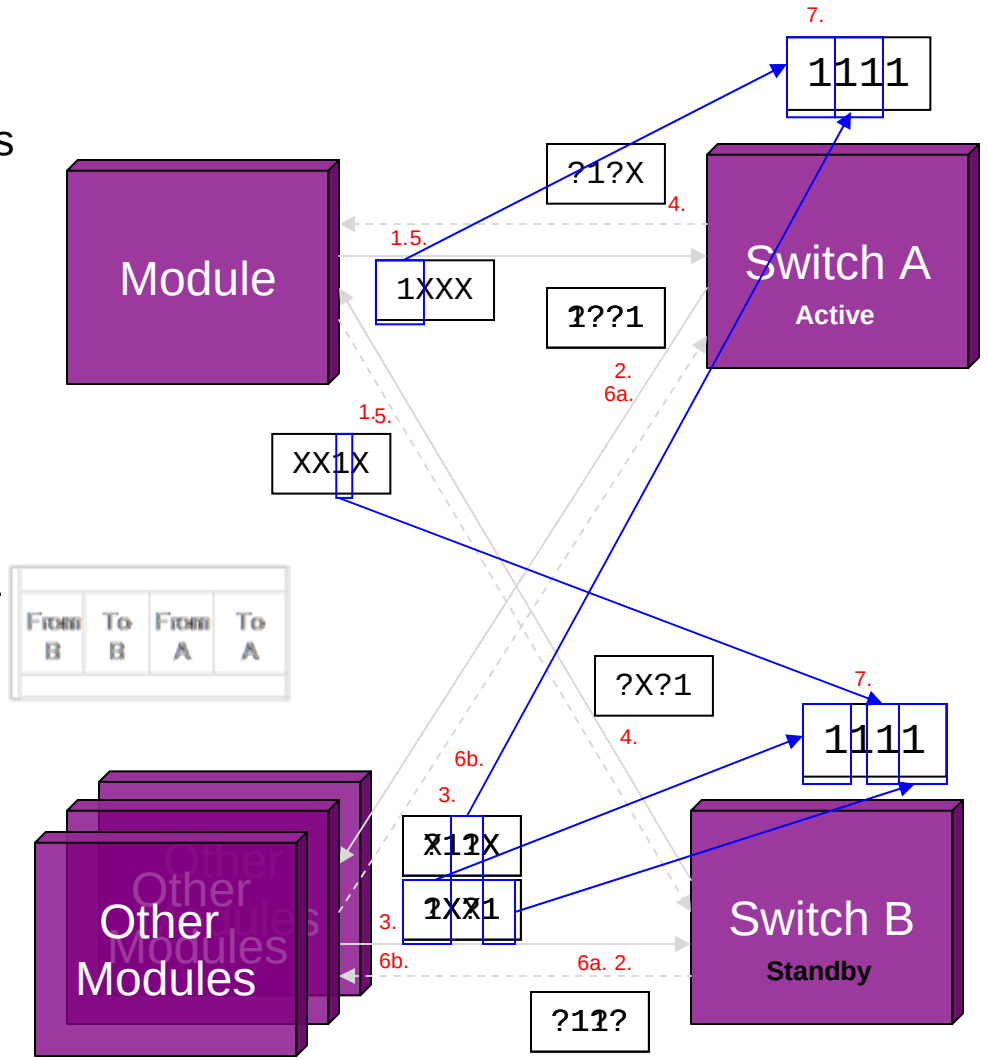
Last Module

Port Forwarding map

- For our examples, the nibble “map” diagrams are represented as follows:
  - ‘0’ means bad connection.
  - ‘1’ means good connection.
  - ‘X’ means “don’t care.”
  - ‘?’ means unknown, or unknown at this time.

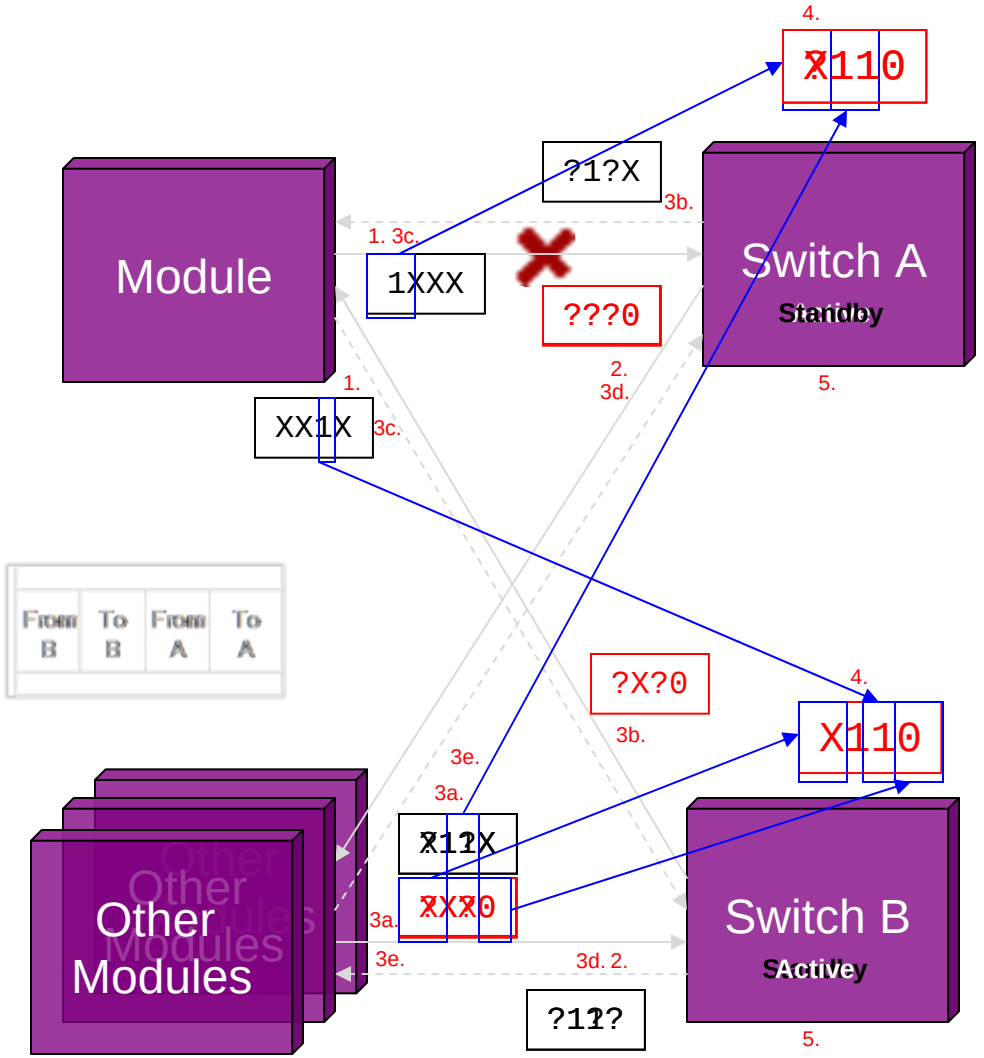
Base Station Example: All Good

1. Switches A and B see PF packets from one module.
2. They indicate to the other modules that this connection is good.
3. Other modules forward Switch A's info to Switch B, and switch B's info to Switch A.
4. The info comes back to the one module from A and B.
5. Module then reports its Switch-A-to-module connection status to Switch B and vice versa, forwarding source packets' info.
6. The switch-to-module info then trickles back to the other switch. Info takes about two cycles.
7. The info indicates that the switches do not need to change states.



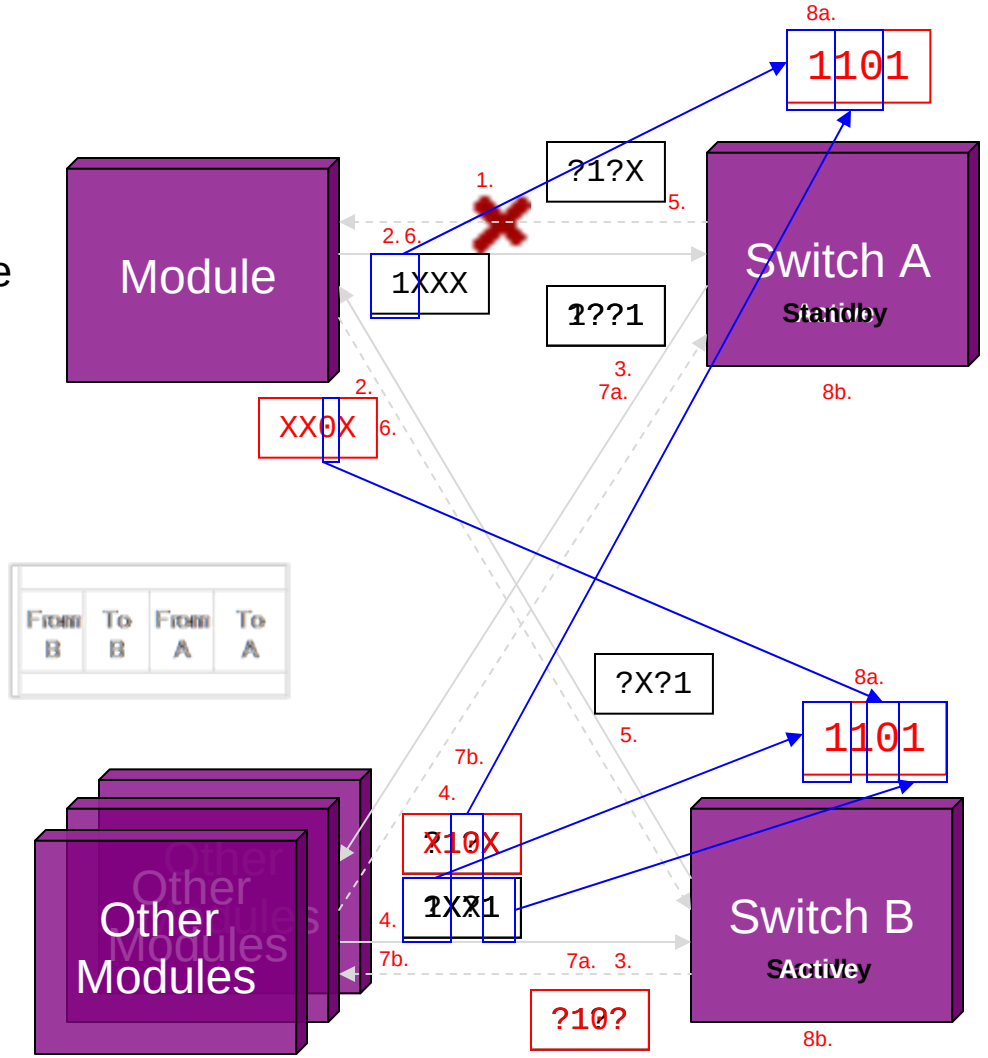
Base Station Example: Module-to-Switch Fault

1. Broken connection: module to Switch A. Switch A is unable to receive packet.
2. Switch A marks the path as bad. Switch B marks its path as good. Switches send this info to the other modules.
3. Other modules forward each switch's info to the opposite switch. The path continues.
4. Even though the bad uplink hides some info, there is enough info for both to conclude there is a bad module-to-A, and a good module-to-B.
5. Switch B becomes active and Switch A becomes standby.



Base Station Example: Switch-to-Module Fault

1. A broken connection occurs from Switch A to module.
2. Switch A receives packet from module. Same with Switch B. The fault does not propogate at this stage.
3. They send this info to the other modules.
4. The other modules forward this info back to the opposite Switches.
5. The switches send to the one module. Switch A's packet fails.
6. The module can finally report its link is bad.
7. The bad link report goes to the other modules, then Switch A.
8. Both switches can make logical judgments. Active and standby roles reverse.

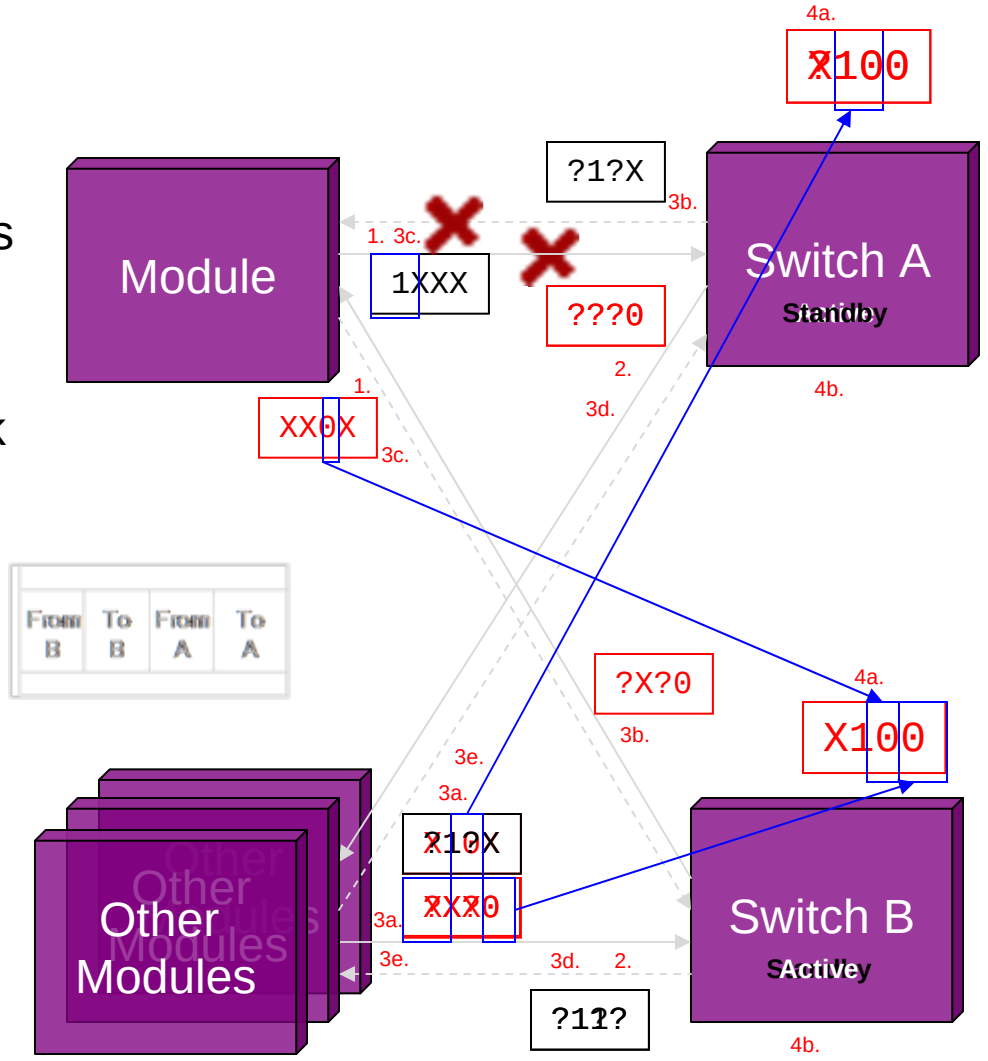


Conclusion:

- The Harris MASTR V Base Station is a software-defined radio consisting of multiple processors, which need reliable communication between them.
- The use of Ethernet in a redundant switch formation called Dual-Star provides an ideal design, which requires all ports be tested.
- A protocol invented by Harris called Port Forwarding, is chosen because of its flexibility in Embedded OSes vs. Layer-2 dependant industry standards like Spanning Tree (RSTP).
- Using case-scenarios, Port Forwarding can be demonstrated to work with a module whether or not it has a port fault with one switch.

Extra Base Station Example: Fault in Both Directions

1. A broken connection occurs in both directions between module and Switch A. This is a single failure point (PHY issues, bad handshakes, etc.).
2. Switch A reports the bad link in one direction to the other modules. Switch B reports good link in one direction to the other modules.
3. Both direction failures trickle to both switches.
4. Both switches can make logical judgments, despite hidden information.



Extra Base Station Example: Bad/Removed Module

1. Module is down or non-existent/removed.
2. Switches receive no packet from module, and tell the other modules.
3. The info goes to opposite switches.
4. The switches will try to send the info back to the module, but to no avail.
5. However, the switches already have enough information to work with.
6. The pattern indicates the module connections to both switches are down. No changes are made.