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EtherNet/IP: Techniques for Fault Tolerant Networks

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Technical Track

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Introduction

This paper describes a protocol for EtherNet/IP networks that can tolerate multiple single point failures in network infrastructure and end devices.

This protocol is called Multiple Fault Tolerant Protocol or MFTP. A network based on the MFTP protocol is called MFTP network. The MFTP network is based on IEEE 802.3 and IEEE 802.1 standards and redundant infrastructure.

In MFTP network, the decision to switch between infrastructures is made individually in each end node.

MFTP Features

- ▶ MFTP targets integrated control systems i.e., systems combining motion, discrete and process control.
- ▶ MFTP is independent from the network infrastructure (switches, routers, etc.). No special features or implementation of the MFTP in infrastructure nodes are required.
- ▶ MFTP is a Layer 2 protocol. It does not require any changes to messages generated by upper level protocols.
- ▶ MFTP can be implemented in hardware or software depending on application requirements for fault tolerance.

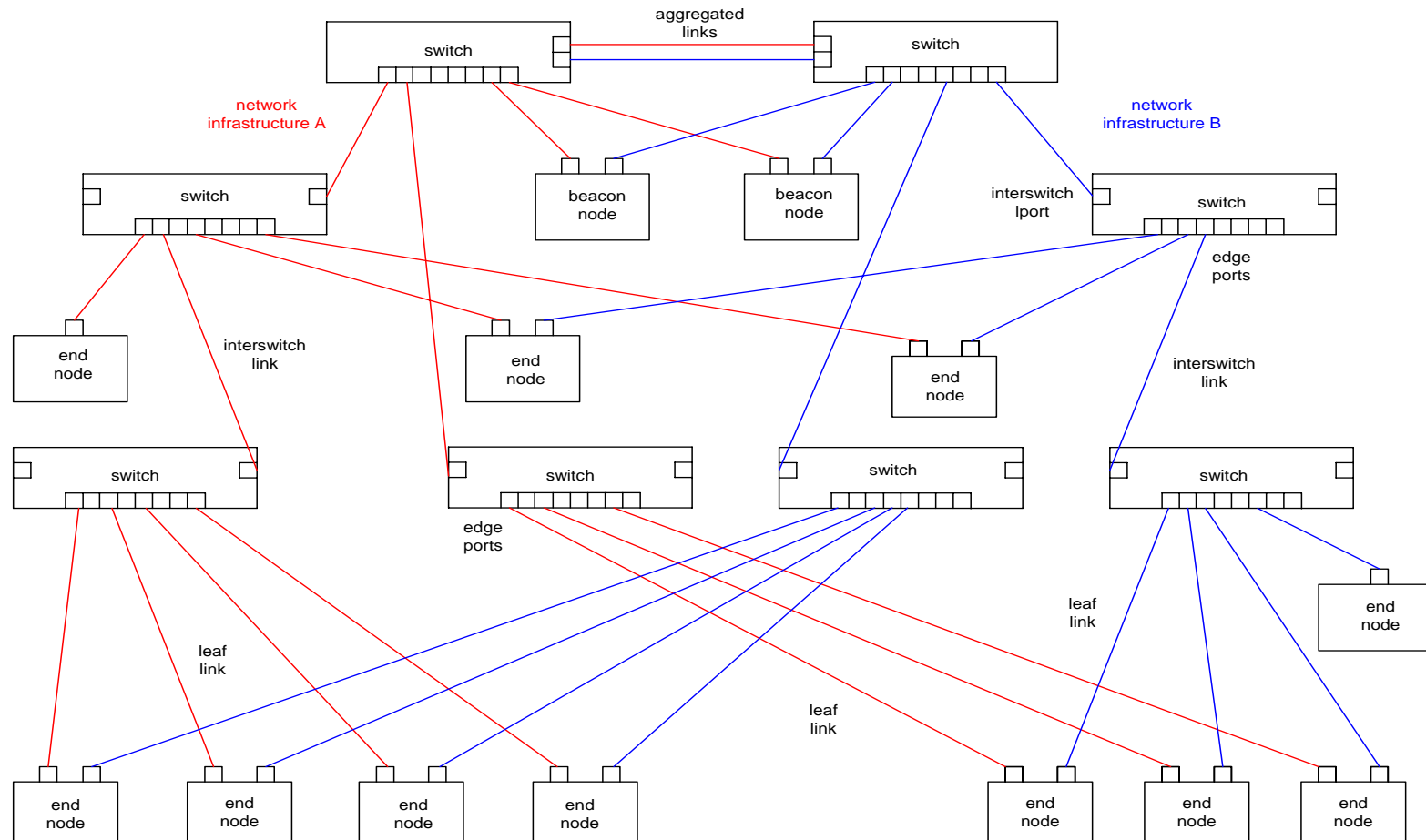
MFTP Features (cont.)

- ▶ MFTP networks will tolerate multiple single faults in network infrastructure and network interfaces on end device.
- ▶ The MFTP protocol allows realization of very large networks with 10,000 end devices or more and with worst case fault detection and switchover time of 1 ms or less for most types of faults. The low switchover time allows utilization of MFTP network in hard real time control systems.

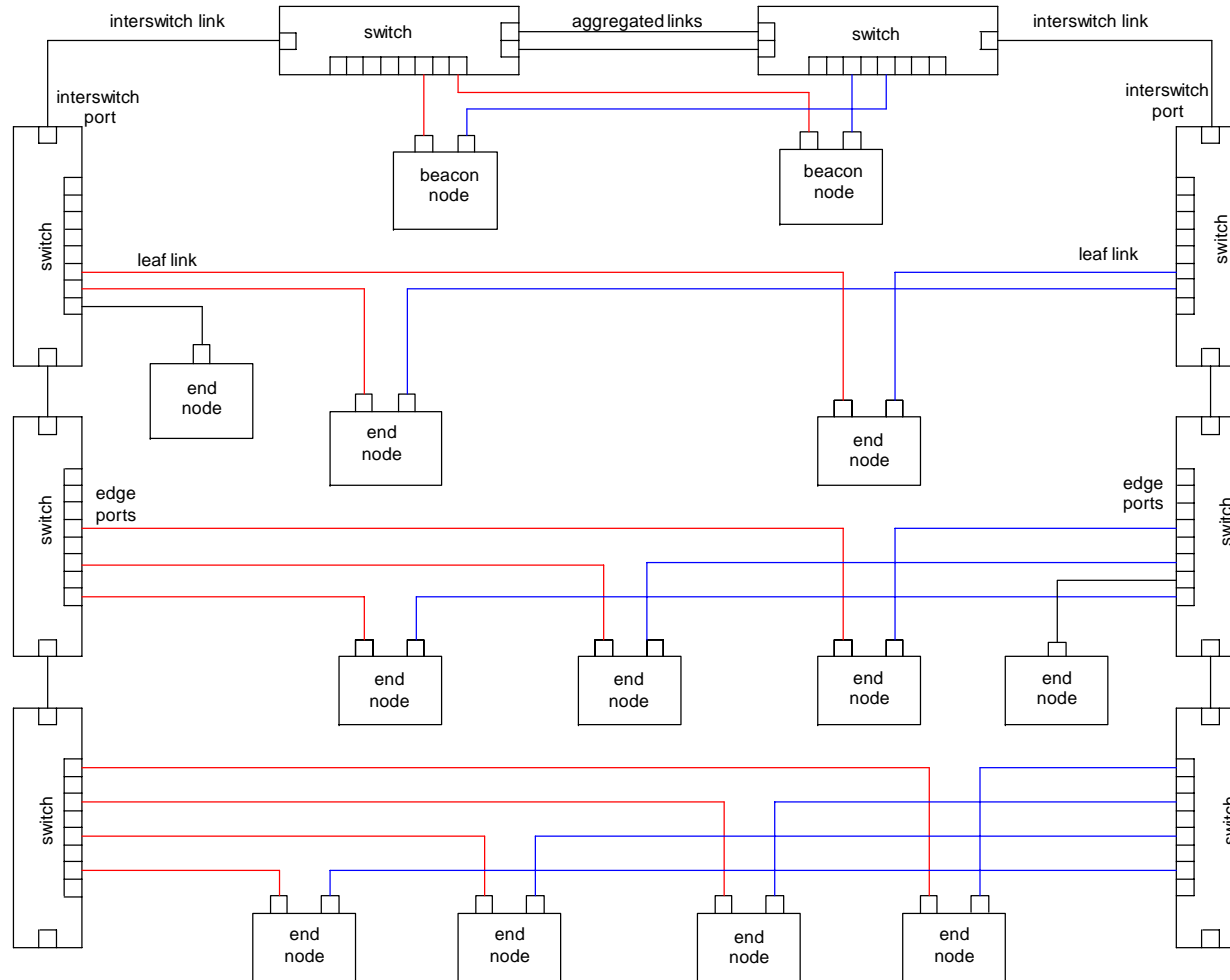
MFTP Features (cont.)

- ▶ In MFTP networks it is possible to connect non-fault tolerant end devices on the same network with fault tolerant end devices and to add or remove end devices, fault tolerant or otherwise, to or from the network dynamically during run time.
- ▶ In MFTP networks it is possible to support IEEE 1588 time synchronization, if needed.
- ▶ It is possible to extend this approach to Gigabit Ethernet.

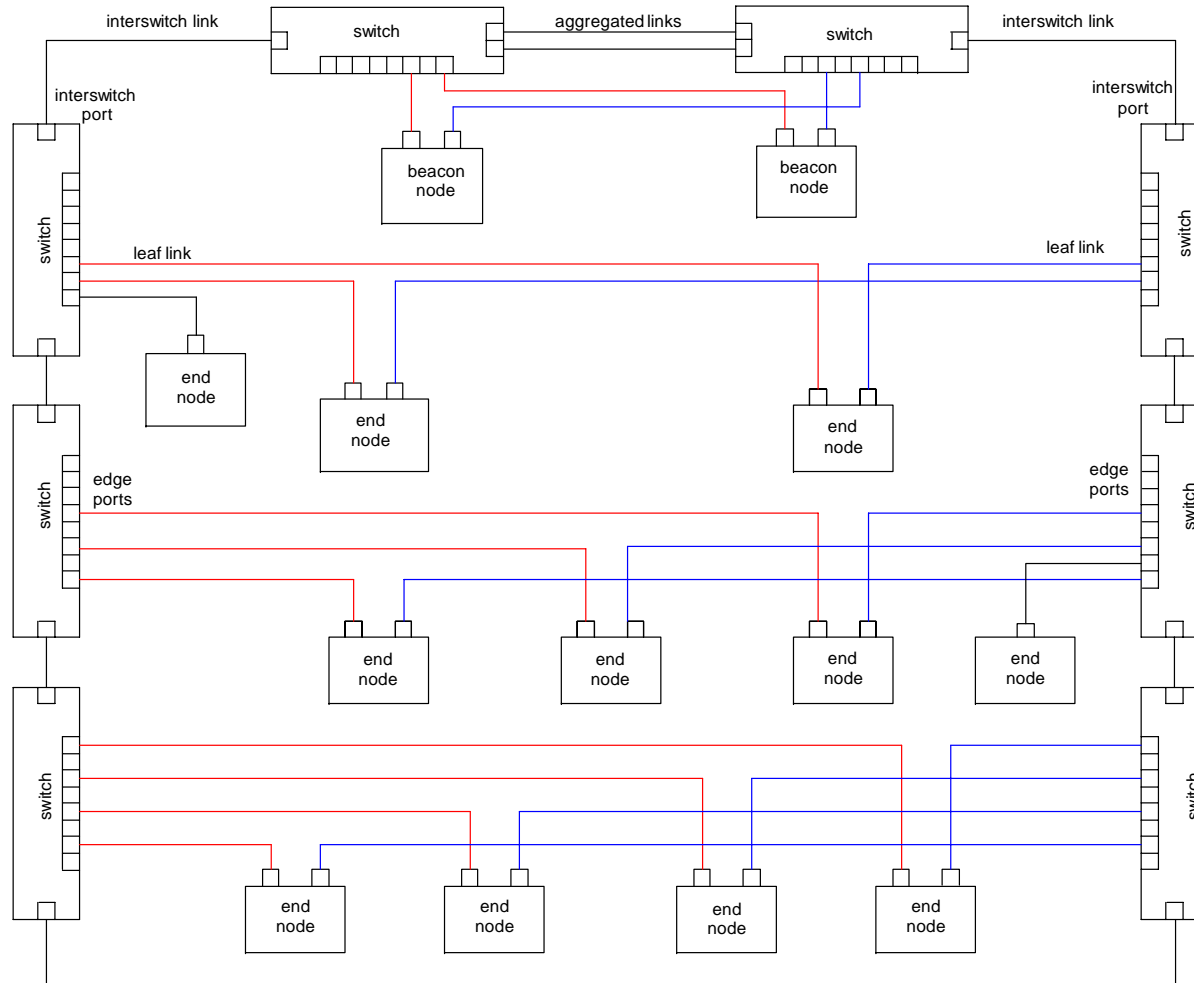
MFTP Network Example (star)



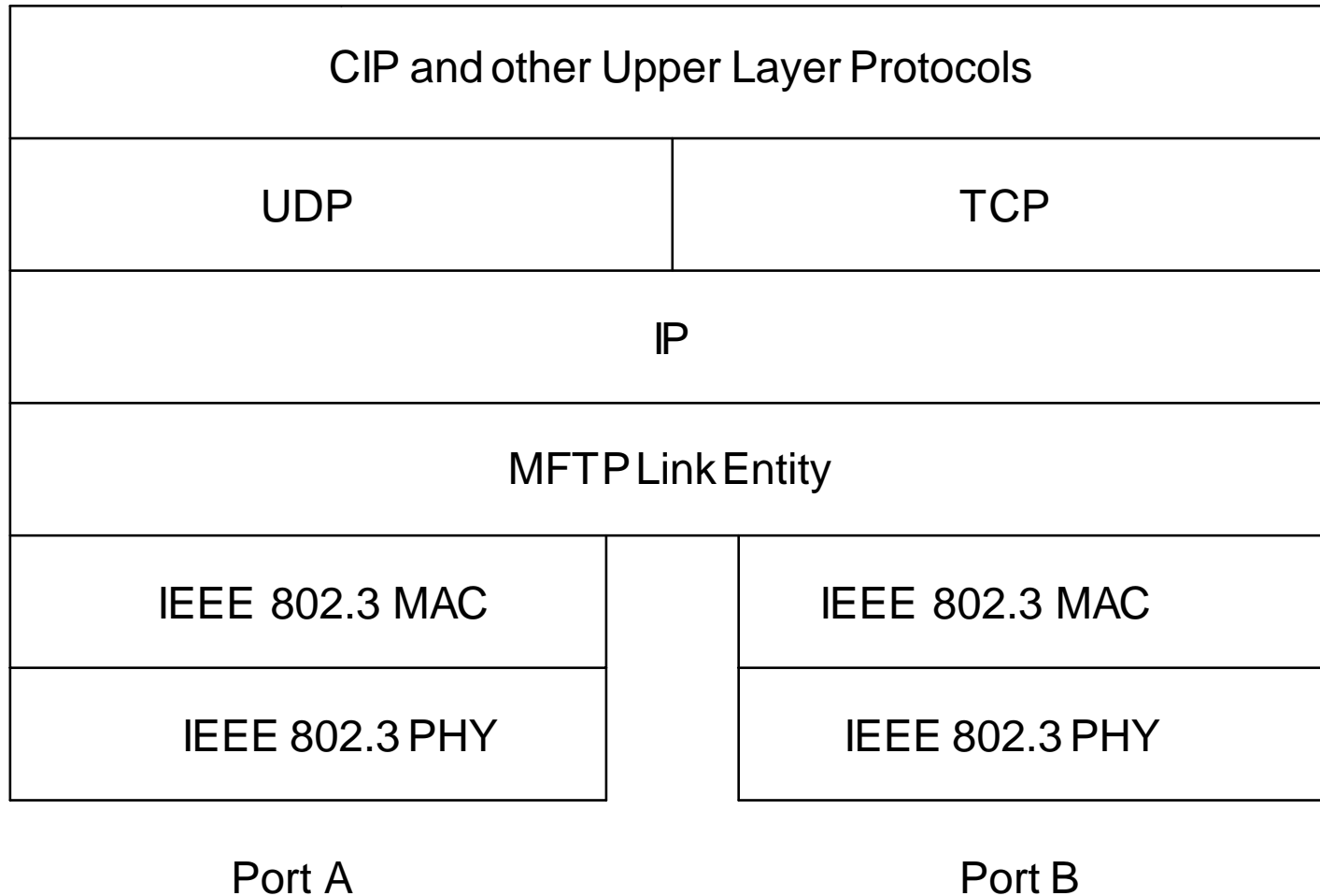
MFTP Network Example (linear)



MFTP Network Example (ring)



MFTP Stack

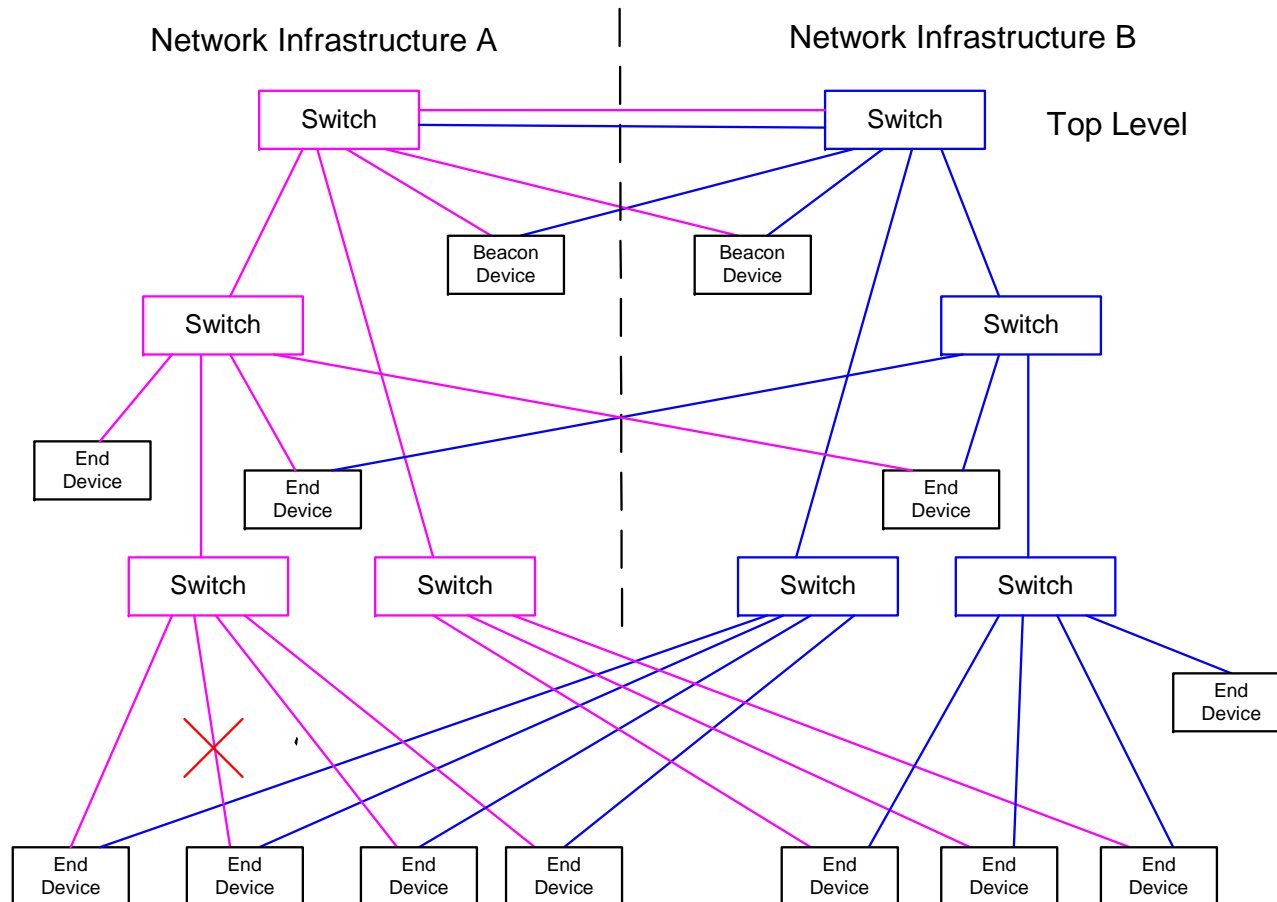


Fault Detection

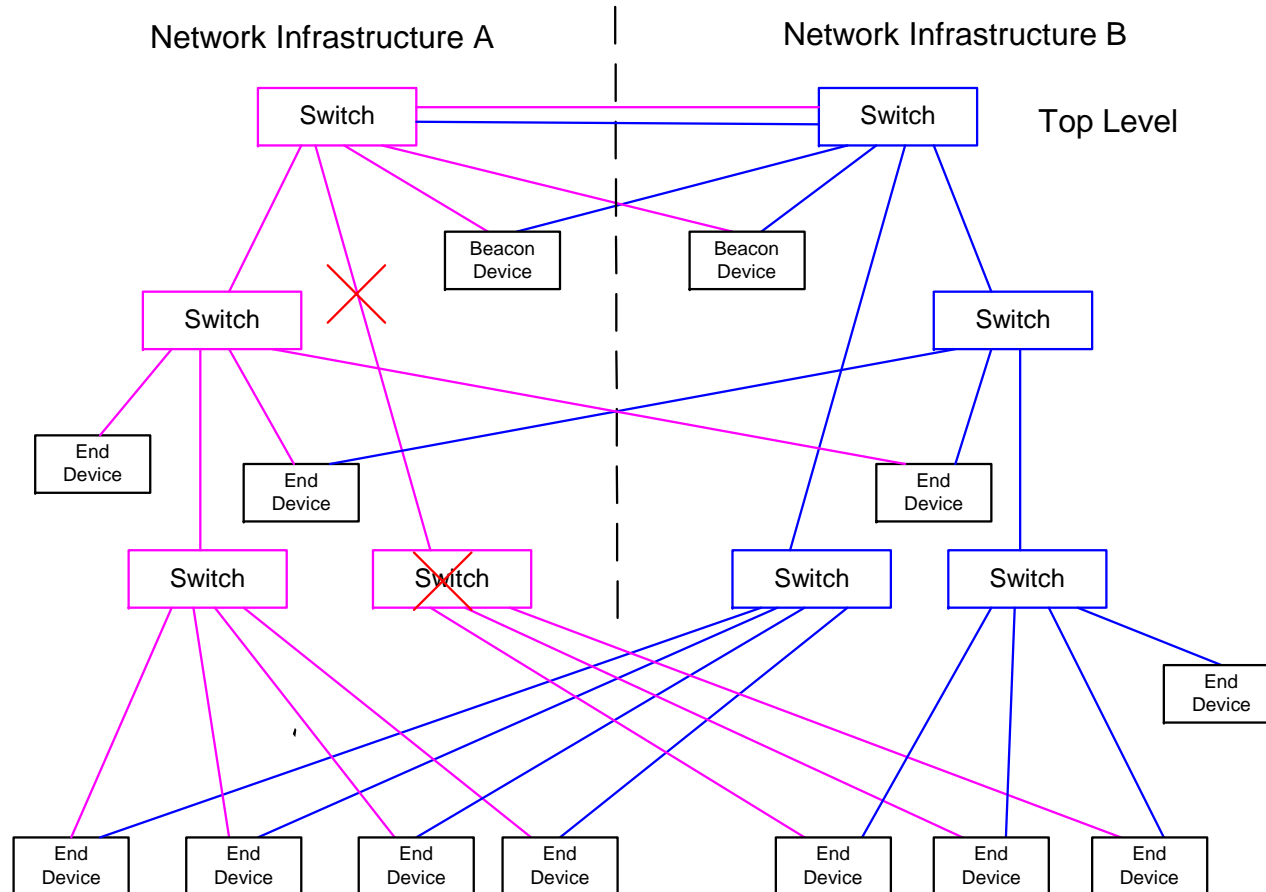
The following fault detection mechanisms are employed in the MFTP protocol:

- ▶ Link fault detection.**
- ▶ Receive path fault detection.**
- ▶ Transmit path fault detection.**

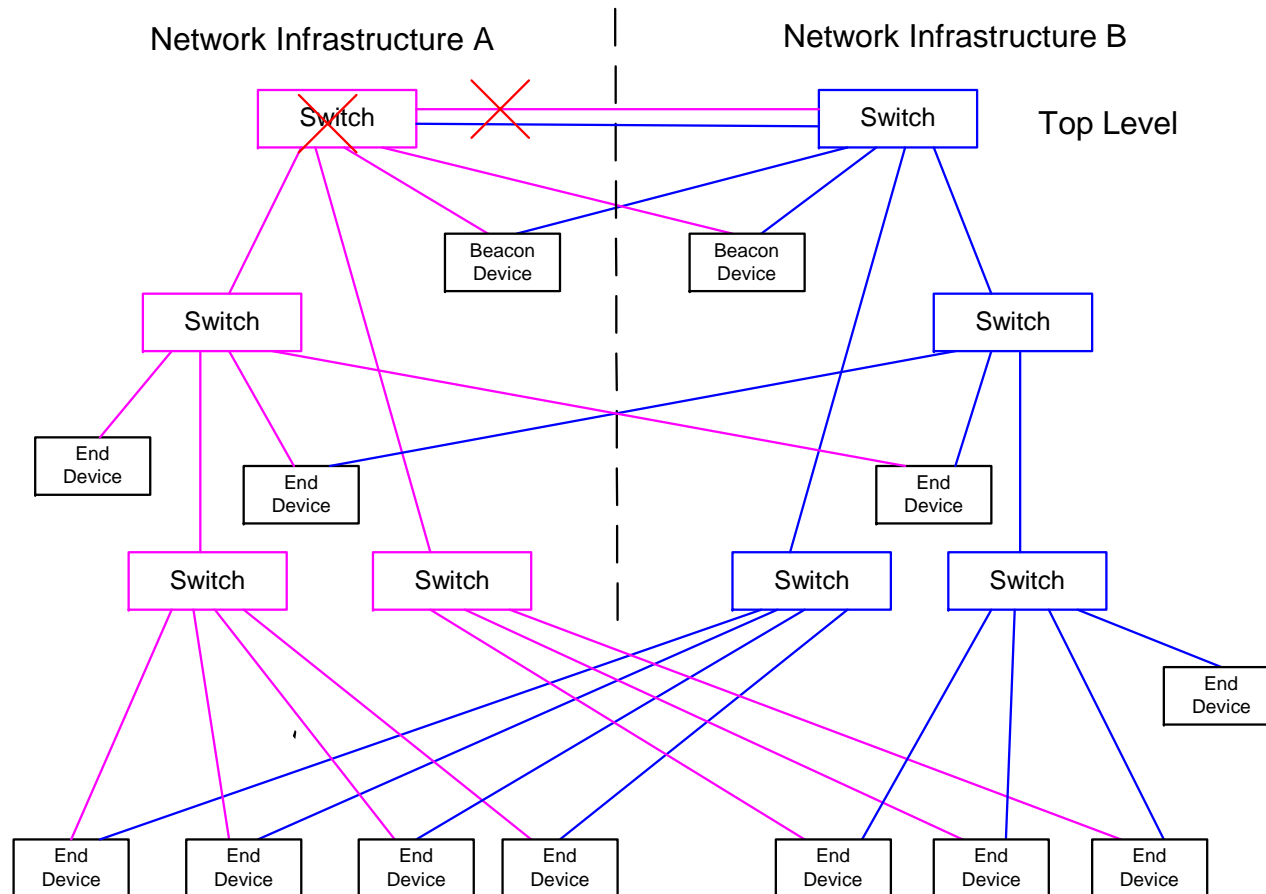
Single Fault Example 1



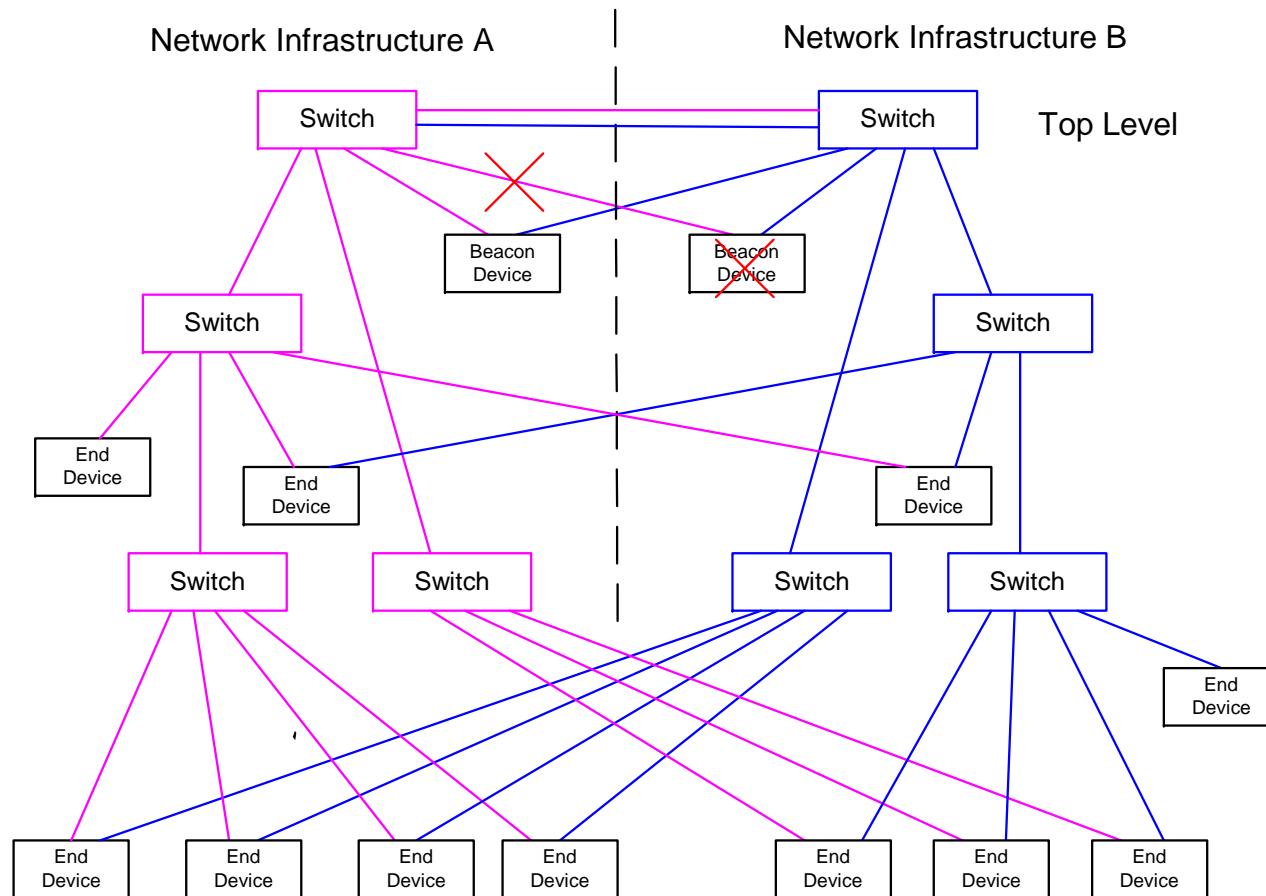
Single Fault Example 2



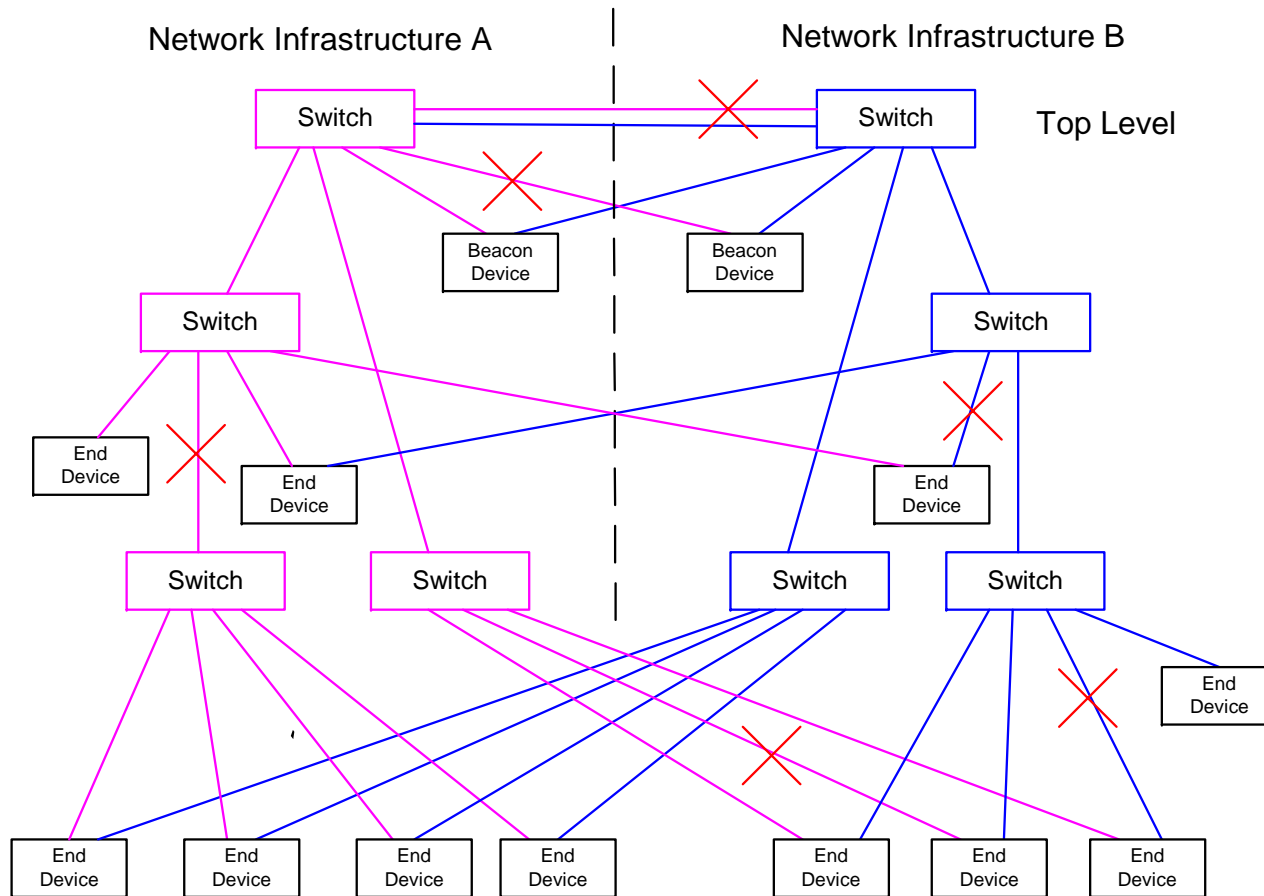
Single Fault Example 3



Single Fault Example 4



Multiple Single Faults Example



Performance

Consider: 3 switch level star network, 8-port switches, 500 nodes

- ▶ Beacon interval is 450 microseconds.
- ▶ End device declares a fault after a two-beacon timeout period or 1 millisecond (fault recovery time).
- ▶ Fault occurred in the opposite direction to beacon messages but not detectable in the Physical layer is considered the worst case. In this example and assuming 2ms RPI the fault recovery time will be 4.8 milliseconds.