



Reduce Ethernet Connected Cost with Daisy Chain

by: Michael Roche, Principle Network Applications Engineer, Schneider Electric

Many older automation fieldbus networks use a form of daisy chain topology. Daisy chain topology consists of a cable acting as a physical bus with taps or connectors installed close to the equipment location. The benefits are several: little to no infrastructure costs beyond the connectors, and installation flexibility as the cable can be easily routed from one device to the next. While Ethernet has enjoyed widespread adoption and vendor support in industry, there are attributes of Ethernet which make it more costly to deploy as compared to this legacy fieldbus design.

Ethernet networks require infrastructure equipment like hubs and switches. Switches introduce a per port cost that increases the overall cost of the installation. Adding to this cost are unused ports on Ethernet switches. While it may be prudent to order switches with extra ports, the effect is an increase in the initial cost of the network. Difficulty planning for future port requirements adds to the problem.

Ethernet also imposes distance constraints which require careful planning to efficiently locate switches. End devices typically use RJ45 Category 5 cable which must be located within 100 meters of the switch port.

An example of the difficulty of implementing Ethernet in bus applications is illustrated by a conveying application depicted in Figure 1. This conveying application uses a star topology.

There may be relatively few switch ports used within a 100 meter radius, and a separate media segment is required to each device, even if the devices are 1 meter apart. Inefficient utilization of

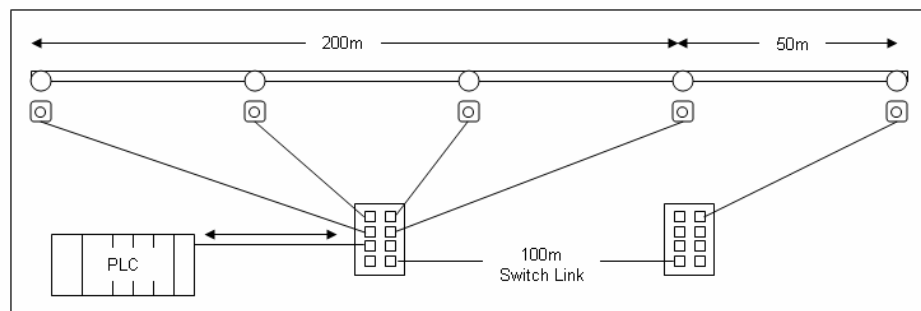


Figure 1

switches and switch ports adds to the overall installation cost. Further, inter switch link distances can exceed 100 meters requiring fiber optic media. Switches with fiber optic ports are correspondingly more expensive, as is the fiber media itself.

A daisy chain Ethernet topology addresses all of these issues, offering many of the benefits found in the earlier fieldbus'.

What is Daisy Chain Ethernet?

As shown in Figure 2, a daisy chain device has 2 embedded Ethernet ports which function as an Ethernet switch, as well as an interface to the local device. This allows information to flow to the device, or flow through the ports to other devices in the daisy chain.

Ethernet Daisy Chain allows devices to be cabled together in series using standard **Ethernet cable**, similar to legacy fieldbus' without the need for additional Ethernet switches. Cabling devices in series permits flexibility locating devices, eases installation, and lowers infrastructure costs. Point-to-point cable routing flexibility along with reduced installation costs offer a significant advantage over the costs and design constraints of a traditional star based Ethernet topology.

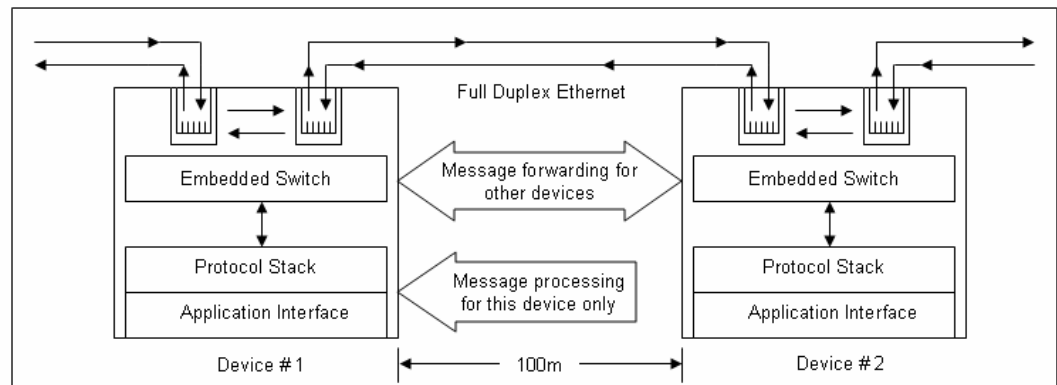


Figure 2

offer a significant advantage over the costs and design constraints of a traditional star based Ethernet topology.

While daisy chain can be deployed in a straight line bus topology, having a redundant ring daisy chain offers fast recovery in the event of a cable break. Simply adding a single switch with redundant capability connects the daisy chain to the overall network and affords robust redundancy.

Choose a switch, available from many vendors, offering redundancy with fast recovery using the Rapid Spanning Tree Protocol (RSTP). RSTP is the IEEE 802.1w redundancy standard interoperable with switches from many OEM's. RSTP not only restores communications in the event of media disconnect or failure, it protects against accidental cabling loops which can cause non-RSTP networks to fail. Daisy chain RSTP monitors the health of the physical ring while blocking traffic to prevent a traffic loop. Should RSTP detect a failure in the ring, RSTP will recover and rebuild the network automatically to divert traffic around the failure.

Consider the same conveying application discussed earlier fitted with daisy chain Ethernet instead of a switch based star topology as shown in Figure 3. Message traffic between the PLC and end devices can be any standard 802.3 Ethernet protocol, from any automation OEM.

Note that there is an overall efficiency gained by having fewer Ethernet switches, less Ethernet media, and increased redundancy in the event of a

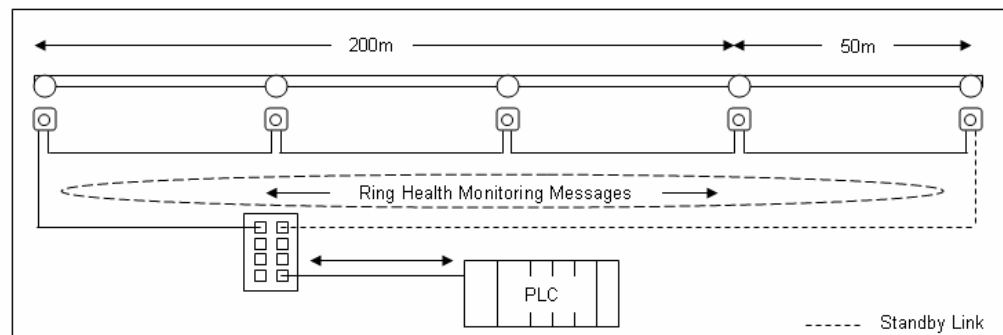


Figure 3

media or device failure. RSTP will send health messages around the ring to verify that the ring is intact. Should a message not be received, each device, including the switch, will exchange information to determine where the media failure occurred. The devices will then rebuild the network to route messages around the fault, as shown in Figure 4.

Once a media break or device failure in the network is detected, the Ethernet devices and the switch work together to reconstruct new message forwarding tables around the fault. The standby link will begin forwarding traffic around the problem segment and restore network communications.

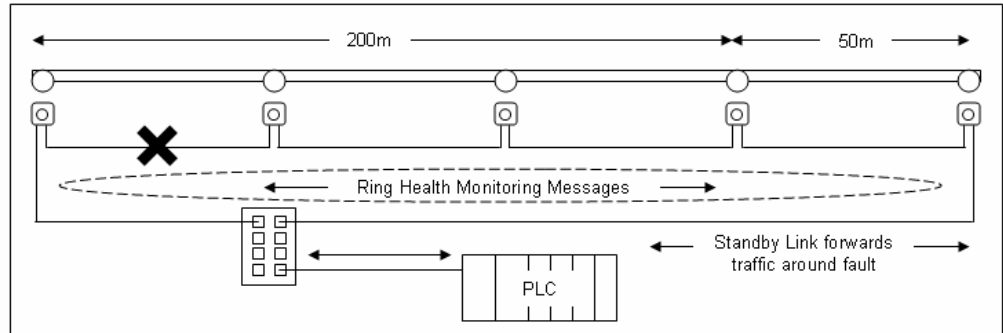


Figure 4

The total time from when the media fault occurs, until the time traffic begins flowing again ranges from under 100 milliseconds to less than 1 second depending on the switch RSTP capability. The entire fault detection and recovery effort is automatic. When the fault is repaired, the daisy chain RSTP will detect the change and restore the original configuration.

How many devices can be part of a daisy chain?

Up to 32 devices in a daisy chain can be sensibly deployed in an industrial setting. Theoretically there could be dozens of device deployed in a daisy chain because of store and forward technology. Daisy chain devices, like and Ethernet switch, use store and forward technology. This assures that each packet is checked for accuracy before being forwarded on the network. The cost of that accuracy is 20-40 microseconds latency for an average automation protocol message passing through each device.

This means that the total time it takes for a message to travel from the first device in the daisy chain to the last device, with 32 daisy chain devices and 'worst case' 40 microsecond latency for each device is less than 1.3 milliseconds.

Benefits of Ethernet daisy chain:

- Reduced cost per connection
- Lower infrastructure and media costs
- Device cable location flexibility
- Increased redundancy over Ethernet switched start topology
- Software configuration is optional but not required
- Simple, familiar installation
- Reduced cabinet footprint without additional switches
- Robust media redundancy
- Ease of maintenance

Daisy chain Ethernet offers the best of both worlds. Simple installation and setup with the robustness of the Ethernet protocol marries together 21st century technology with the simplicity of

earlier fieldbus'. Daisy chain Ethernet is also not restricted to any single vendor or organizational protocol. ModbusTCP, Profinet, and ODVA EtherNet/IP all work well, even together, in a daisy chain topology. This allows end users to mix devices, even using different protocols, in a single daisy chain for maximum convenience.

Automatic fault detection and recovery also allows individual devices to be taken offline and restored for service without significant interruption to other devices. Taken together, lower costs, easier installation, design flexibility and range, daisy chain Ethernet is an attractive evolution of the industrial fieldbus.

For further information please contact Michael B. Roche, Principal Network Application Engineer