Managed Field Ethernet Switch CBT

Module 1: MFES Overview and Terminology

Welcome

Welcome to the Intelligent Transportation Systems, or ITS, Construction Engineering and Inspection, or CEI, Training for the Managed Field Ethernet Switch, or MFES. This is Module 1: MFES Overview and Terminology.

Purpose

You may have various reasons for why you are here. Some of you may already have a basic understanding of ITS devices and project inspection. After completion of this training, you will have a working knowledge of what a Managed Field Ethernet Switch, or MFES, is, and how to ensure that contractors have provided an approved and properly configured device.

MFES Related ITS Acronyms

As you may have noticed, there are a lot of acronyms used, including the industry itself.

For a full list of acronyms, please visit the Resources page.

Power over Ethernet, or PoE, describes the several standardized or ad hoc systems which pass electrical power along with data on Ethernet cabling. This allows a single cable to provide both data connection and electrical power to devices such as wireless access points and IP cameras.

PoE has a lower power rating of 15.4 watts. Power over Ethernet Plus has a higher maximum power rating of 30 watts. When using a Cat6 cable, the maximum distance between a PoE or a PoE+ switch port and an ITS device is 100 meters. The small form factor pluggable, or SFP, is a compact, hot pluggable transceiver used for both telecommunications and data communications application.

It interfaces a network device motherboard (for a switch, router, media converter, or similar device) to a fiber optic or copper networking cable.

VLAN – Virtual Local Area Network:
A virtual LAN is any broadcast domain that is partitioned and isolated in a computer network at the Data Link layer, also referred to as Layer 2. LAN is an abbreviation of local area network. To subdivide a network into virtual LANs, one configures a network switch or router.

A Wide Area Network, or WAN, is composed of at least a couple of VLANs, and the router or Layer 3 device is used as an intermediary device between the VLANs.

RSTP – Rapid Spanning Tree Protocol is a network protocol that ensures a loop free topology for any bridged Ethernet local area.

ICMP – Internet Control Message Protocol is used by network devices to send error messages and operational information indicating that a requested service is not available.

For a full list of acronyms, please visit the Resources page.

Fiber Termination Types

Fiber cable terminations are to be per the FDOT Standard Specifications for Road and Bridge Construction 633-2.1.3. Cable terminations to be used are types ST, or stab and twist, SC, or stick and click, LC, and FC connectors only, as specified by the plans or engineer.

The FC termination is not as widely used as it used to be, however, it may still be used on some signal projects.

Networking Terms

In addition to acronyms, here are a few important terms related to MFES.

Connectivity refers to a series of connections to form a copper or fiber path for digital information transfer.

Ethernet is a term referring to a family of computer networking technologies commonly used in local area networks or LANs. Systems communicating over Ethernet divide a stream of data into shorter pieces called frames. Each frame contains source and destination MAC addresses, and error-checking data so that damaged frames can be detected and discarded. Most often, however, it is higher-layer protocols that trigger retransmission of lost frames.

The **Source** is the device from which data packets are transmitted.

The **Destination** is the device which receives data packets from a source.

A **Default Gateway** is a layer 3 device which forwards all network traffic from a source, to a destination beyond the local layer 2 network segment.

IP Address is a configurable identifier for each device. In contrast, a **MAC address** is a burned in unique identifier for each device.

Subnet is a section or area of a network which allows routing of data while keeping excess data from other subnets from bogging down the resources. A VLAN is assigned a subnet.

A **Mask** is used to subdivide the network into subnets.

A **Trunk Port** is a switch port configured to allow receipt or transmission, or forwarding, of network traffic to two or more VLANs at Layer 2, that are accessible to the switch. A trunk port can carry traffic for multiple VLANs simultaneously.

The **Access Port** is the port to which the ITS device connects to obtain access to the network.

Telnet is a user command and an underlying TCP/IP protocol for accessing remote computers. Through Telnet, an administrator or another user with his/her computer/device can access someone else's computer or some other device, remotely. Telnet is an application layer protocol used on the Internet or local area networks to provide a bi-directional interactive text-oriented communication facility using a virtual terminal connection.

The term **Console** usually refers to a terminal attached to a device or a computer or mainframe and used to monitor the status of the system.

A **Ping** is a command that is sent to a network device requesting an echo response.

IGMP snooping is the process of listening to Internet Group Management Protocol, or IGMP, network traffic. This feature allows a network switch to listen in on the IGMP conversation between hosts and routers. By listening to these conversations, the switch maintains a map of "which links need which IP multicast streams."

Open Systems Interconnection, or OSI, is a reference model for how applications can communicate over a network. A reference model is a conceptual framework for understanding relationships. The purpose of the OSI reference model is to guide vendors and developers so the digital communication products and software programs they create will interoperate and facilitate clear comparisons among communications tools interoperability of diverse communications systems using standard protocols. The OSI model partitions these communications into seven abstraction layers.

The network layer in the Open Systems Interconnection communications model knows the address of the neighboring nodes in the network, packages output with the correct network address information, selects routes and quality of service, and recognizes and forwards to the Transport layer incoming messages for local host domains.

Data link Layer 2 of the OSI Reference Model is responsible for switching, that is, the framing, error control, and transmission, of data packets over a single communications link. The Data Link layer is concerned with moving data across the physical links in the network.

The Network Layer, or Layer 3, in the Open Systems Interconnection communications model knows the address of the neighboring nodes in the network, packages output with the correct network address information, selects routes and quality of service, and recognizes and forwards to the Transport layer incoming messages for local host domains.

Rapid Spanning Tree Protocol is a layer 2 network protocol that ensures a loop-free topology for any bridged Ethernet local area networks.

Managed Field Ethernet Switch (MFES)

Now that we have covered definitions, we will get into the details about the Managed Field Ethernet Switch. Here are the items that will be covered in this training.

First, we'll learn some general information about what an MFES is, what it does, how it is commonly used in transportation projects, and some additional terminology.

The photo shows various components of a switch when it is first shipped. From left to right, there is a RS-232 console cable, the switch itself, the power supply, and two small form-factor pluggable transceivers.

You will learn more about each of these in the next few slides.

What is MFES?

So, what is MFES? Quite simply, an MFES connects roadside data at an ITS Field Cabinet to communication hubs and Traffic Management Centers, or TMCs. They connect all types of electronics located on roadways with the operators at the TMC.

The TMC operators are thus able to view cameras and analyze the speed of the traffic all because these switches provide this vital connection.

The MFES consists of the chassis, ports, status lights, and pre-installed firmware. Firmware is installed by the manufacturer to instruct the switch what to do with the various inputs and outputs and how to utilize configuration data inputs.

The MFES is used to transmit data to and from cameras, dynamic message signs, detectors, and other roadside equipment through its ports to the Traffic Management Center in a coherent and organized fashion. It also has the ability to simultaneously send this data to other locations, allowing operators at various geographical locations access to the data at the same time.

MFES configuration data includes IP addresses and other data programmed into the MFES by the system integrator. You will learn more about MFES integration later.

Because of Florida's heat and humidity, the MFES unit is hardened for use in ITS Field Cabinets without the need for supplemental air conditioning or heating. Not all MFES are hardened, therefore, it is extremely important to ensure that the MFES unit has this characteristic.

FDOT has adopted national standards known as NEMA TS2 for technical requirements on environmental hardening. All MFES on the FDOT Approved Products List, or APL, satisfy these requirements.

Layer 2 refers to an abstraction layer of the OSI model at which these switches function. According to the seven layers of the OSI model, the MFES functions at the Data Link layer, which is layer 2.

OSI Layers

Network communications follow the Seven OSI Layers of Communication. The MFES falls into the Layer 2 or Data Link layer. Routers are classified as Layer 3 or Network Layer devices. All of the layers are dependent upon the previous layers. For example, you cannot have Layer 2 without Layer 1, Layer 3 without Layer 1 and 2, etc.

For the inspector, a primary concern when he/she is looking at the initial layouts is that VLANs cannot be routed at Layer 2. It requires a Layer 3 switch to route VLANs. You cannot access another VLAN if you are only using Layer 2 devices. You have to have a Layer 3 device to connect VLAN to VLAN.

Example: when performing supervised testing in the field, inspectors can sit at any cabinet and can see all the devices on that VLAN from that switch; but if they wanted to look at cameras on another VLAN they would only be able to do that if the Layer 3 device was connecting the VLANs together. Layer 2 switches will forward VLAN traffic on to its adjacent switches until a Layer 3 device is found to accomplish the routing.

Layer 2 devices are on the FDOT APL. Layer 3 devices are NOT on the FDOT APL at this time.

MFES Switches in APL (Examples)

The FDOT Approved Products List for MFES currently contains 14 products from 11 different brands. The Approved Products List is a dynamic list; thus, the number of brands and products are expanding. These switches come in various shapes, colors, and sizes.

Each FDOT district may utilize a particular brand for various reasons. All MFES units have the basic minimum functionality that meets the Standard Specification for Road and Bridge Construction. As a result, regardless of the brand, all MFES units should be able to communicate with each other. However, there may be special features specific to the brand that may not be available in other brands. These features or needs may be specific to an individual district.

MFES Front Face

This switch shown here has 12 copper, or Ethernet, ports, labeled as 1 through 12. Copper ports are used for distribution to local communications equipment. Of the 12 ports, ports 1 through 8 are labeled as Power over Ethernet. These ports provide both power and communications to the device. The communication port speeds of these ports range from 10 to 100 to 1000 Megabits per second, which supports all types of ITS devices, as well as laptop computers. These ports are called access ports because they provide access to the network.

Note: It is the responsibility of the designer to determine the optic type, number of ports, the port speed and required protocols. The Districts have different preferences related to the Power over Ethernet use.

Ports 9 through 12 provide Ethernet communications only. The communication port speeds are also at 10 to 100 to 1000 Megabits per second, and provide access to the network.

Ports 13 through 16 utilize small form-factor pluggable transceiver ports or Gigabit Interface Converters, that convert the electrical currents (digital highs and lows) to optical signals, and optical signals to digital electric currents. These ports are used to connect adjacent switches to each other.

As a result, they are called trunk ports which connects a switch to another switch or router and have communication speeds up to10 Gigabits per second.

Be aware that different manufacturers have their ports configured differently. The project plans identify the numbers and types of ports and Gigabit Interface Converters required for each Managed Field Ethernet Switch.

Fiber Optic Interfaces (Gbic)

Gigabit Interface Converters, or GBICs, are essentially fiber transceivers. They are used to connect one switch to another switch. These converters have lasers of various power levels. The range of the single mode laser can be up to 120 kilometers.

The CEI personnel should confirm that the strength of the GBIC laser corresponds to the distance between the neighboring switches. The different color latches on the GBIC correspond to the different distances they can reach. You want to make sure that the Gigabit Interface Converters are the same color on each end.

MFES Side Panel

The side of this switch contains the power input port and the RS232 serial port. The serial port is labeled as “CONSOLE” next to the port.

The RS232 cable that was shipped with the switch is used to connect the computer to the serial port for initial configuration. The Ethernet switch ports on the front of the switch and the various protocols that the switch will use during its operation can be configured from this serial port. Each District may implement specific protocols based on their individual network configuration. The CEI personnel should contact the District ITS Network Manager for configuration parameters.

This picture shows another type of serial port, recognizable by the 1010 symbol next to it. Do not confuse this port with normal Ethernet traffic as it does not have a link light or an activity light.

MFES Front Face

In this example of a Managed Field Ethernet Switch, the power supply is on the left and the switch on the right. Looking at the power supply, the AC power conductors, hot, neutral and ground terminate on the lower half of the power supply and the DC conductors on the upper half. As an Inspector, make sure that these conductors are properly secured and terminated.

On this switch, all terminations and ports, including the console and communication and DC power, are located on the front face. Unlike the previous example, the switch utilizes an RJ45 or 8 Position 8 Contact input for its console port. The light blue flat cable shown is serially connected to the computer during initial configuration. The Contractor configures the switch to utilize various protocols for operations and configures the ports for communication. The configuration usually takes place at the Contractor’s facility prior to the switch being deployed in the field.

Depending on the manufacturer, the chassis ground for each switch is located in a different spot on the switch casing. In addition, the chassis ground for each power supply is located in a different spot on the power supply casing. In this example, the chassis ground for the power supply is an unmarked screw located below the AC input. The chassis ground for the switch is an unmarked screw below the switch ports. Typically, there would be a ground symbol to indicate that this is the chassis ground.

In the Project Plans, the cabinet layout sheet should show the bond between the switch chassis ground and the cabinet ground as well as another bond between the power supply chassis ground and the cabinet ground.

Serial Cables

Most switches only need a basic serial cable to configure them. This is a straight DB9 to DB9 cable and will fit directly onto a serial port.

Some switches utilize an 8 Position 8 Contact port for serial communications and require a rollover cable. Whereas other switches use cables that transition from an 8 Position 8 Contact to DB9 for serial communications. Note: if you look closely you will notice that the cable is flat, which is another way to recognize it as a rollover cable and is not to be confused with a regular Ethernet cable.

But most computers and laptops made today do not have a DB9 port, which is why you might have to add a DB9-to-USB adapter. Make sure that if you add the USB adapter to the cable that you install the correct drivers for it and use communication ports 1 through 4; otherwise your terminal software may not work.

Check the Device Manager in Windows and confirm that it is configured for communication ports 1 through 4; otherwise your terminal software may not work.

Terminal Emulation Software

You will need software like Hyper Terminal or Tera Term to utilize serial communications on your computer. Other software such as PuTTY and MobaXTerm can also be used. If this is the first time you have used the software, you will have to configure the software.

This software will include instructions on how to configure the software either on the device or in an accompanying or online manual. In the picture, you will notice text “57600-N-8-1”. This tells you how to configure the serial communications for the device.

If you are using a serial cable connected to a USB adapter, then check the hardware manager for the serial port and make sure it is set to “COM1” through “COM4”. Open the software, click Setup, and look for the correct Serial Port. This is where you will input your configurations for the device.

MFES function and why we use it

This figure shows how Managed Field Ethernet Switches provide connectivity between field devices and Traffic Management Centers. Three MFES units are outlined in the red boxes. The Aggregation

Switch and the Core Switch function at the Layer 3 level and can implement various routing protocols. The MFES functions at a Layer 2 level, providing management and access of device data and video to only those who need it.

Managed Field Ethernet Switches include networking features that aren't found in simple unmanaged switches. MFES specified by FDOT include management features such as network monitoring and network control that are configured at the project-level and District-level network architecture. The MFES device controls network traffic to send the right data, such as CCTV images, DMS messages, and MVDS data, to the correct data user, for example, a TMC Operator, at the right time.

These features control how data travels over the network and who has access to it. The ITS inspector must verify that the System Integrator has configured each MFES unit as required for each ITS Cabinet and as required by the overall network architecture. The network architecture includes local area networks, or LANs, and wide area networks, or WANs. Through the use of MFES, the LANs are most often virtual LANs, meaning they are configured networks rather than physical networks.

This is an example of one way the MFES can be set up. The cable itself is Layer 1, and the data that is traversing the cable is Layer 2. Be sure to check with the District because each District might have them set up a little differently. For example, MFES to MFES is Layer 2; MFES to the Aggregation Switch is Layer 2; the Aggregation Switch can be Layer 2 or 3.

MFES Connections Between Cabinets

Each MFES is connected to each other via fiber pairs through fiber jumpers or patch cord, to the patch panel. A pair of fiber cords is used for each connection: one fiber cord to send data and the second to receive data. In this example, the network topology is commonly known as a daisy chain configuration.

RING configuration (example)

The following diagram shows a dual ring configuration. A minimum of two fiber strands are needed to form the two concentric rings. Data traverses clockwise in one fiber ring and counterclockwise in the other fiber ring. The data is transmitted and received at each Managed Field Ethernet Switch through its trunk ports.

Some ports have not been configured, whereas others have been configured as access ports. Each of the access ports can be assigned one VLAN. This example also shows that VLAN 10 and VLAN 11 have been assigned to various ports on the MFES. In order to preserve consistency, check with each agency on how they would like the VLANs to be assigned.

The following diagram also shows a dual ring configuration. A copper network cable is shown as a complement to the fiber strands to form the ring. Data traverses bidirectionally on the copper cable, therefore, only one cable is needed between the switches. The major disadvantage of copper network cables is that their distance limitation is only 100 meters.

In the example shown, the copper ports have been reconfigured from access ports to trunk ports. It should be noted that the default settings on switch ports are enabled; thus, to prevent unauthorized access to the network, the unused ports should be disabled.

MFES Connections Between Cabinets

Each MFES in a cabinet is connected to an MFES in a neighboring cabinet through a fiber backbone cable. Yellow colored single mode jumpers connect the switch ports to the patch panel. From the patch panel, each cabinet is connected to an adjacent cabinet through the single mode backbone cable.

A multimode fiber may be used and those are typically orange in color. A multimode fiber has a distance limitation of 550 meters. The multimode fiber is like a water hose nozzle set to a fine mist and has multiple light paths within it, but it does not travel as far as a single mode, which would be like a water hose nozzle set to a jet stream.

CEI personnel should ensure fiber jumpers do not interfere with closing the cabinet door. CEI personnel should also check the connectors used for all terminations and jumpers to ensure they meet the type that is required by the plans and specifications.

Governing Order of Documents

This slide shows the governing order of contractual documentation from 1 through 7. All FDOT Approved Product List Managed Field Ethernet Switches comply with Number 7, the Standard Specifications. These switches have been tested by the FDOT Traffic Engineering Research Laboratory, or TERL, against these specifications. In addition, the Engineer of Record, or EOR, may produce a Technical Special Provision, or TSP, shown as Number 2 on the list, which will describe how the MFES will be tested on the project. The TSP may include procedures for the Field Acceptance, Subsystem, and the Systems tests.

MFES References

There are several references relevant to the use and requirements for MFES. Primarily, the FDOT Standard Specifications for Road and Bridge Construction Section 684-1, and any associated technical special provisions, will be the only criteria you'll need to know. The Construction Engineering and Inspection personnel must be aware of which version of the Standard Specifications are in use for each project.

Specifications change from year to year. Two projects underway at the same time may use different versions. Specifications on a project can only be changed through use of a Supplemental Agreement.

Section 684-1.2 and the Compliance Matrix are the references that are used by FDOT's TERL to test a manufacturer's MFES. Apart from the FDOT Standard Specifications, a project may have additional MFES requirements. In that case, it will be the responsibility of the Contractor to demonstrate how the MFES unit meets the project requirements.

CEI personnel are responsible for ensuring that the Contractor provides the MFES unit approved by the Engineer of Record and the Department. This includes verification of the manufacturer, model, ports, and firmware version. CEI personnel should carry out inspections according to the complete set of contract documents that ensure the functionality of the system. For additional reading, please reference the relevant EIA/TIA, IEEE, and NEMA specifications.

MFES Specifications

The Engineer of Record will confirm the device is on the Approved Products List. CEI will verify the manufacturer, model, ports, and firmware version of the installed device against the approved project documents. CEI personnel should inspect the system according to the contract documents and to ensure that the system functions as required.

Knowledge Check

1. What is the main purpose of an Ethernet switch?
MFES connects roadside equipment at an ITS Field Cabinet to communication hubs and/or Traffic Management Centers (TMC).

2. Name the two modes that a switch port can be configured to.
Trunk and Access

3. What does hardened mean as it is applied to MFES?
Environmentally sound; able to withstand heat, cold, humidity; does not require air conditioning

4. What are the connectors between the switch ports and patch panels called?
Fiber jumpers (patch cord)

5. Which section of FDOT Standard Specifications for Road and Bridge Construction is the Specification Section for switches?
Section 684 and/or Network Devices

6. True or False. All cables connected to MFES need to be protected by surge protective devices.
False, depending on the device and the agency standards, only copper cables connected to MFES need to be protected by a surge protective device.

7. True or False. Because MFES device contains manufacturer preinstalled firmware, the MFES device is ready to use as soon as all the field cables are properly connected to the MFES device.
True, but the MFES device may require configurations such as the VLAN and IGMP.

8. True or False. Serial ports are used for the initial configuration of the MFES.
True, however, any port could be used to configure the MFES.

9. True or False. All MFES devices can be configured using any ports provided in MFES device.
True, the device can be accessed through the console or Ethernet ports but may need to be configured before accessing remotely.

Conclusion

This concludes ITS CEI Training for the Managed Field Ethernet Switch Module 1: Overview and Terminology computer based training. Please continue to Module 2: MFES Installation to complete this training.

Please contact the State ITS Program Development Engineer in the Traffic Engineering and Operations Office with any questions.

Thank you for your time and attention.