C101: Introduction to Communications Protocols and Their Uses in ITS Applications

ACTIVITY
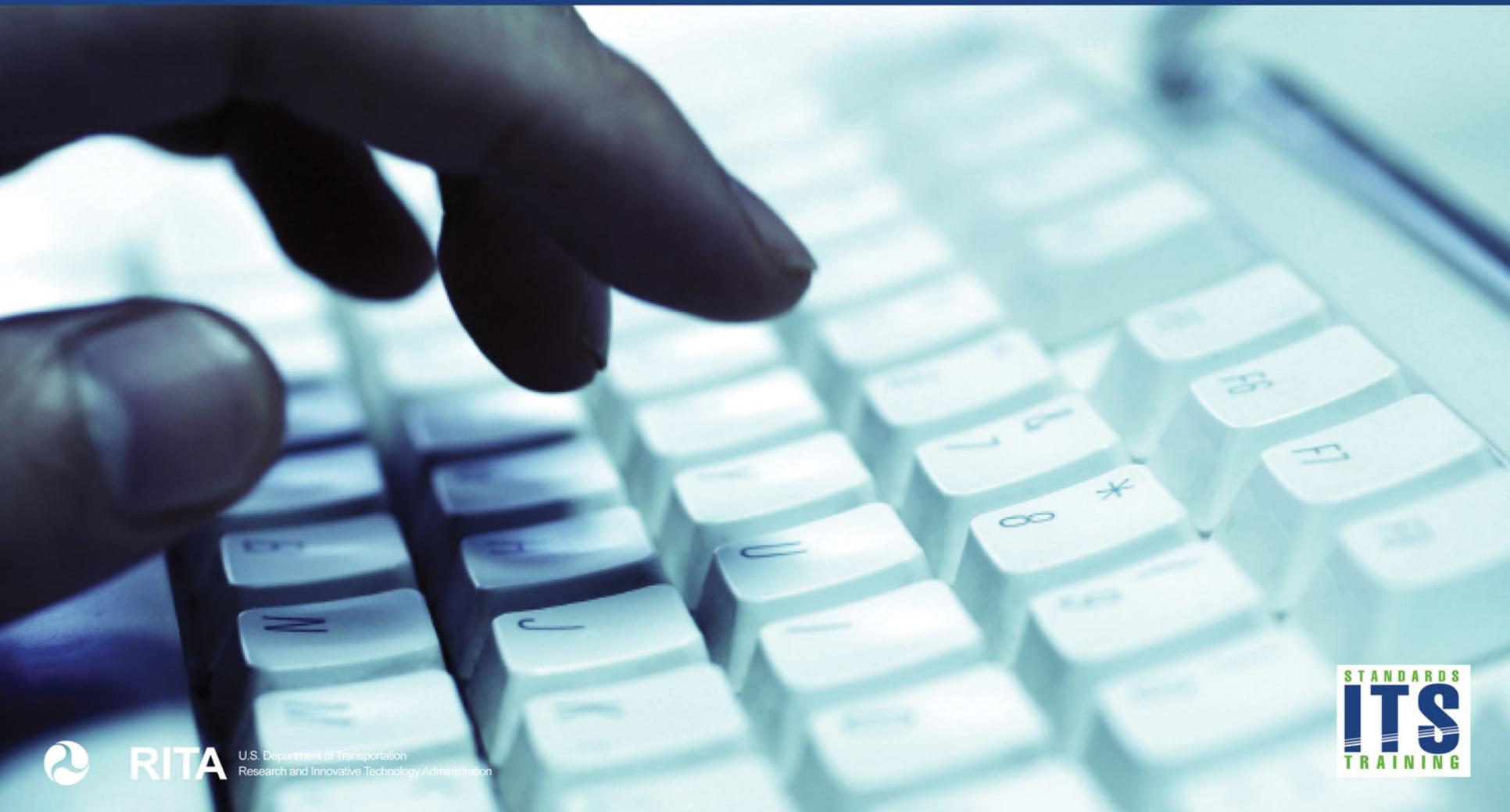
Instructor

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Target Audience

- Telecommunications, system administration, and network management staff

- Engineering staff

- System engineers, developers, and implementers
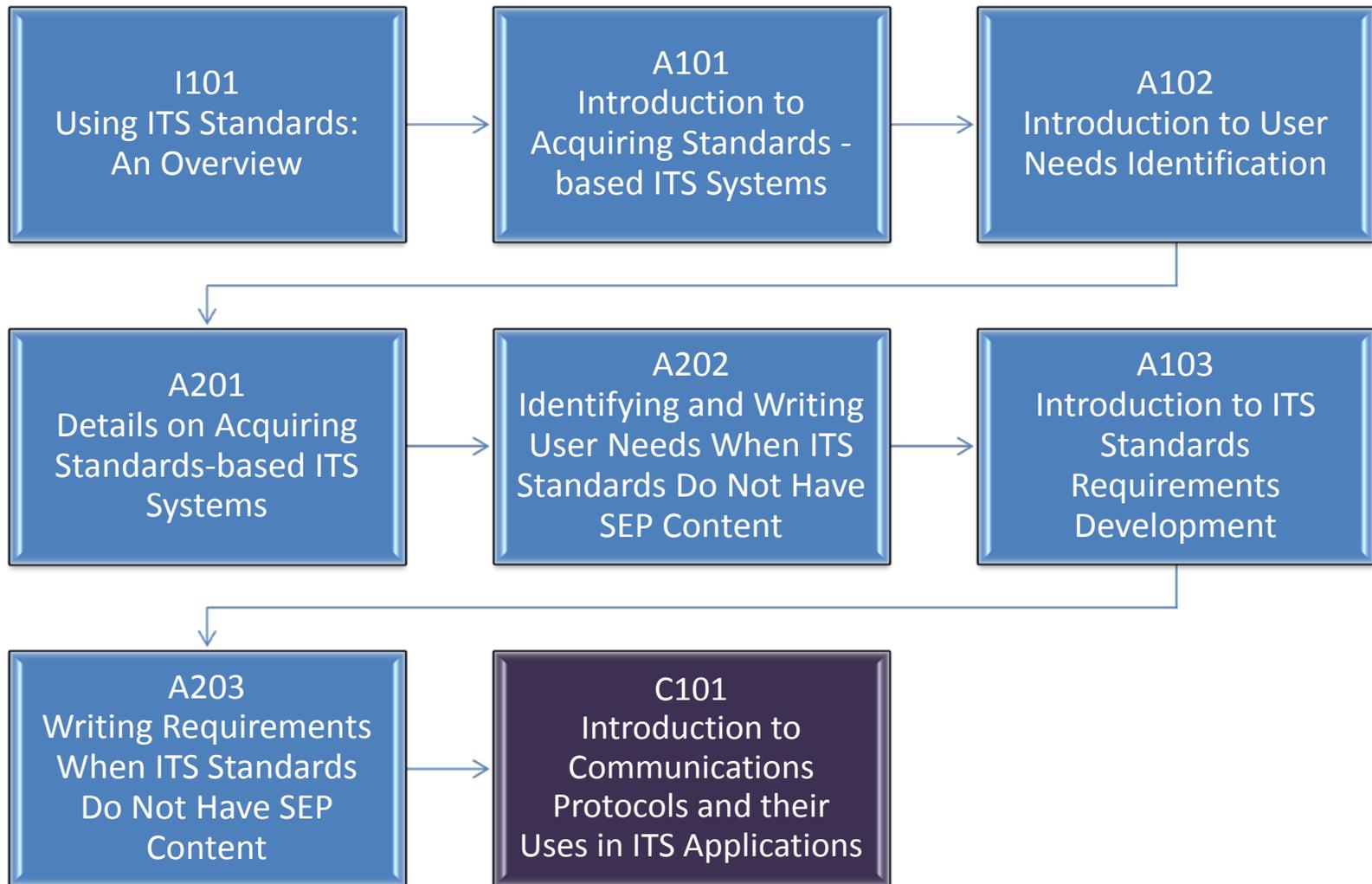
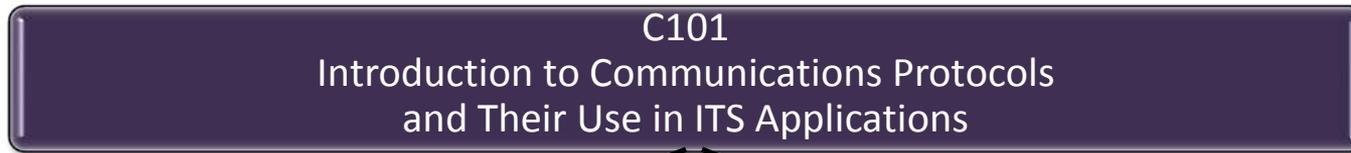- Traffic management and operations staff

Recommended Prerequisite(s)

- I101: Using ITS Standards: An Overview
- A101: Introduction to Acquiring Standards-based ITS Systems
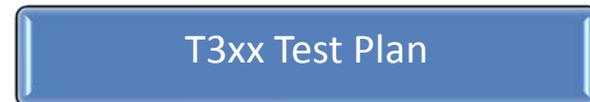
Curriculum Path (Non-SEP)

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┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│        I101         │ ──▶ │        A101         │ ──▶ │        A102          │
│  Using ITS Standards:│     │  Introduction to    │     │ Introduction to User │
│    An Overview      │     │ Acquiring Standards -│     │ Needs Identification │
│                     │     │  based ITS Systems  │     │                      │
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│        A201         │ ──▶ │        A202          │ ──▶ │        A103          │
│ Details on Acquiring│     │ Identifying and      │     │ Introduction to ITS  │
│ Standards-based ITS │     │ Writing User Needs   │     │ Standards            │
│      Systems        │     │ When ITS Standards   │     │ Requirements         │
│                     │     │ Do Not Have SEP      │     │ Development          │
│                     │     │ Content              │     │                      │
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│        A203         │ ──▶ │        C101          │
│ Writing Requirements│     │ Introduction to      │
│ When ITS Standards  │     │ Communications       │
│ Do Not Have SEP     │     │ Protocols and their  │
│     Content         │     │ Uses in ITS Applications│
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STANDARDS ITS TRAINING

Curriculum Path Continuation

C101
Introduction to Communications Protocols
and Their Use in ITS Applications

Center- to- Field Standards

A3xxa User Needs

A3xxb Requirements

T3xx Test Plan

Center- to- Center Standards

A3xxa User Needs

A3xxb Requirements

T3xx Test Plan

Learning Objectives

1. Be familiar with the basic terminology of the communications process used in the NTCIP.

2. Explain how the NTCIP Framework (Stack) fulfills functional requirements to meet operational needs.

3. Describe center-to-field (C2F) applications and their related NTCIP Standards.

4. Describe center-to-center (C2C) applications and their related NTCIP Standards.

Learning Objective #1 — Be familiar with the basic terminology of the communications process used in NTCIP

- What is a protocol? What is a standard?

- Communications Process
  - Open Systems Interconnect-Reference Model (**OSI-RM**) from the International Standards Organization (**ISO**)

  - National Transportation Communications for ITS Protocol (**NTCIP**) Framework

Let's Ask Ourselves a Question

"What is the first thing we do when we meet someone?"

We Observe Some "Protocol"

We greet each other with a hand shake….begin conversation… How are you?
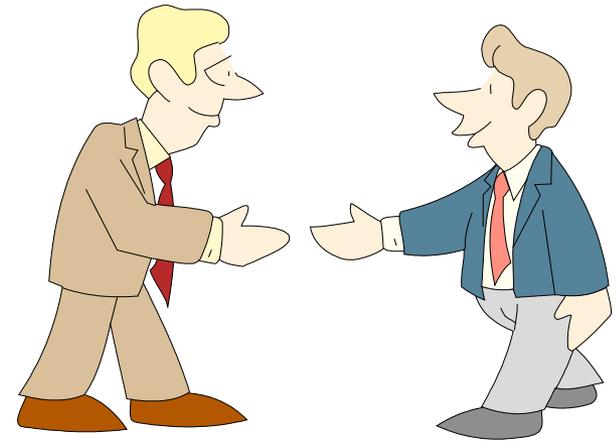
Computers Observe Protocol
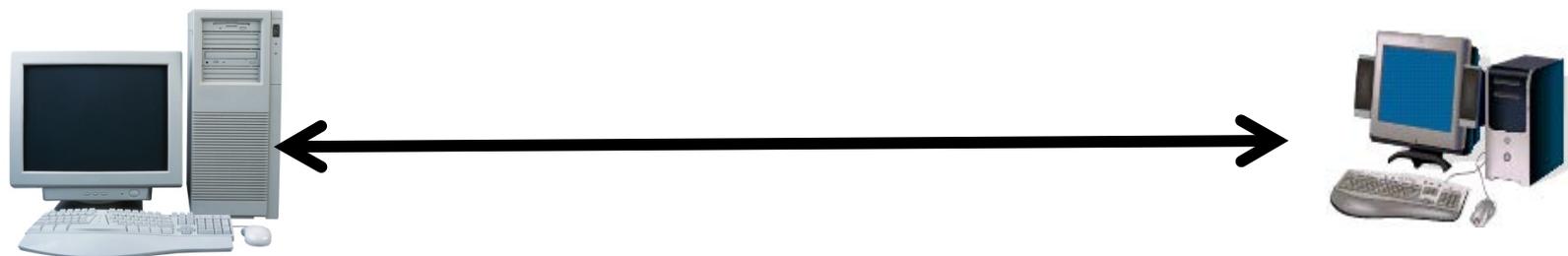
While two computers don't shake hands physically, they do observe some rules—conventions—to begin conversation or communication.

That is what a protocol is about.

What is a Communications Protocol?

- A protocol is *"a set of conventions that govern the interaction of processes, devices, and other components within a system."*

<div align="right">Ref. IEEE 610 Std.</div>

Example

- A protocol is *"a specific set of handshaking rules, procedures, and conventions defining the **format**, **sequence**, and **timing** of data transmission between devices that must be accepted and used to understand each other."*   *Source: NTCIP 1203 DMS standard*
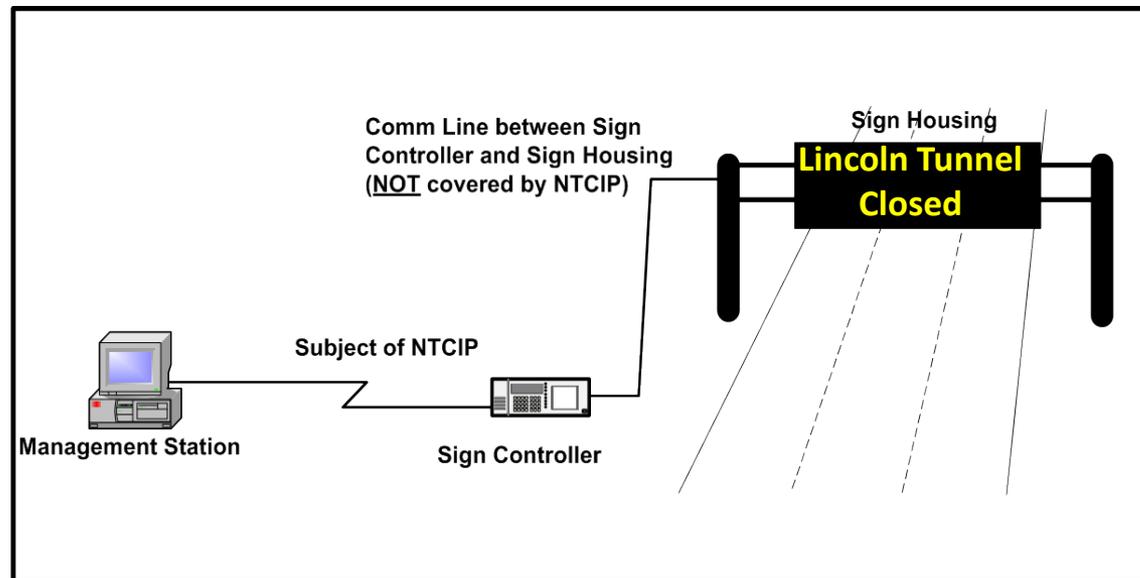
Parts of a Communications Protocol

- **Syntax** is the data and data format rules; these form the *Protocol Data Unit (PDU).*

- **Semantics** are the transfer rules for PDUs. They contain control information-error handling rules.

- **Timing** deals with performance requirements for the transfer.

What is a Standard?

A standard defines the rules for the exchanges of the data and establishes a format and mandatory definition for the data elements and sequences of exchanges. The standard will include both mandatory (normative) requirements and optional (informative) information to assist in using the standard.

Example of a Standard:

Manual on Uniform Traffic Control Devices (MUTCD)

"When a sign is used to indicate that traffic is always required to stop, a STOP (R1-1) shall be used."

"The STOP sign **shall be** an octagon with a white legend and border on a red background."
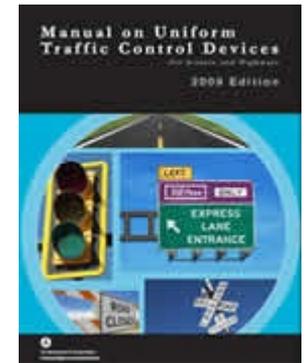
Source: FHWA

ITS Standards

Deal with Data (Information) Structures and Communications, and some ITS Hardware

Benefits

- Developed to assist in obtaining interoperable systems
- Lead to an open procurement process that reduces costs and allows a multi-vendor environment
- Define the interface design details
- Reduce work for the systems manager
- Contribute to the connected transportation environment, our national agenda

Communications Protocol and Compatibility

*"**Compatibility** is the ability of two or more systems or components to perform their required functions while sharing the same hardware or software environment."*
Ref. IEEE 610 Std.

When both ends use the **same** communications protocols they achieve compatibility.

Illustration

Compatibility

Source: Katz FDOT Dist.6

Integrated or stand-alone management station

Different Types of Devices Can Share a Communication Channel

ORIGINAL EQUIPMENT

SECOND SOURCE EQUIPMENT

How to Achieve Interoperability?

- ***Interoperability*** *is the ability of two or more systems or components to exchange information and to use the information that has been exchanged.*

  Ref. IEEE 610 Std.

- When both ends have compatibility (use the **same protocols**) and use the **same message** definitions for the information level, they achieve interoperability.

```
  A  <------------------------------------------->  B
```

Interchangeability

- Same functional and physical characteristics so as to be equivalent in performance and durability

- Ability to exchange devices of the same type without alteration to the device or adjoining items
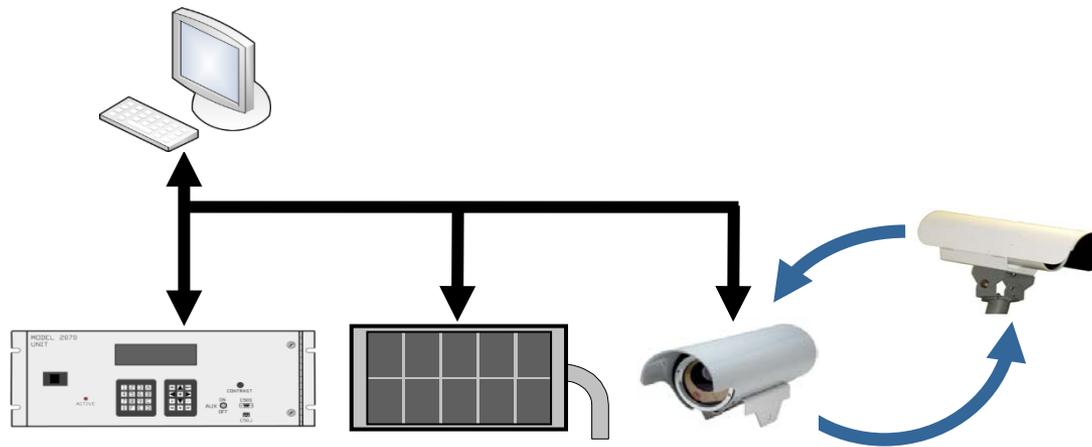
What is a dialog?

- Humans and computers both exchange information in orderly conversations called ***dialogs.***
- Dialogs are a sequence of exchanges (messages) that are carried out for a specific purpose.

Connection between the devices is the basis of a dialog.

| Point A | ←——————→ | Point B |
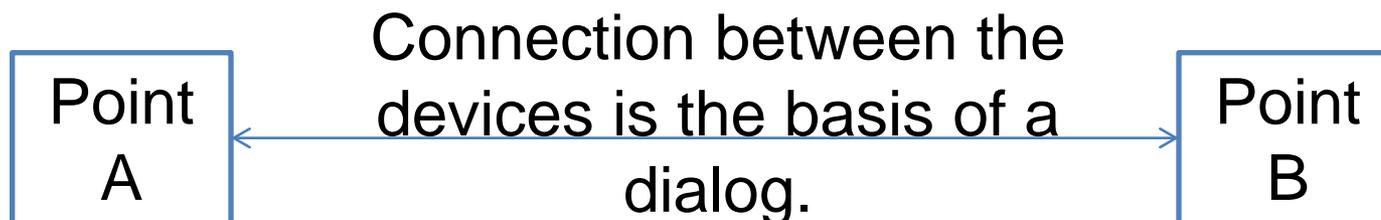
Benefits of a Common Protocol

Procurement through Multiple Vendors-Cost Savings

Management Station

Remote Management Capability

Easier System Expansion

Benefit of Industry Standard

Multiple Devices Common Low-Layers
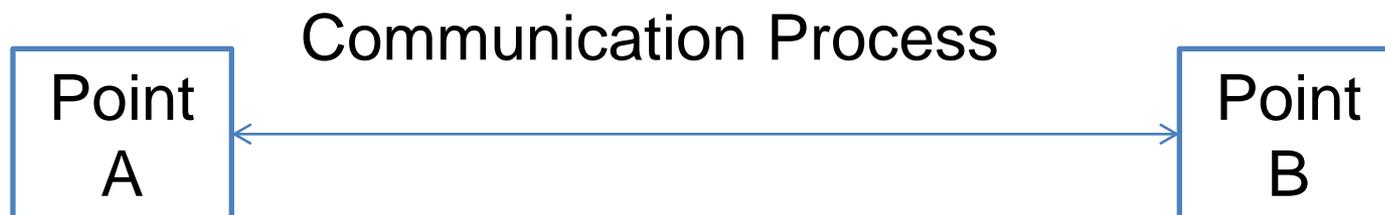
SB EXIT 20 CLOSED
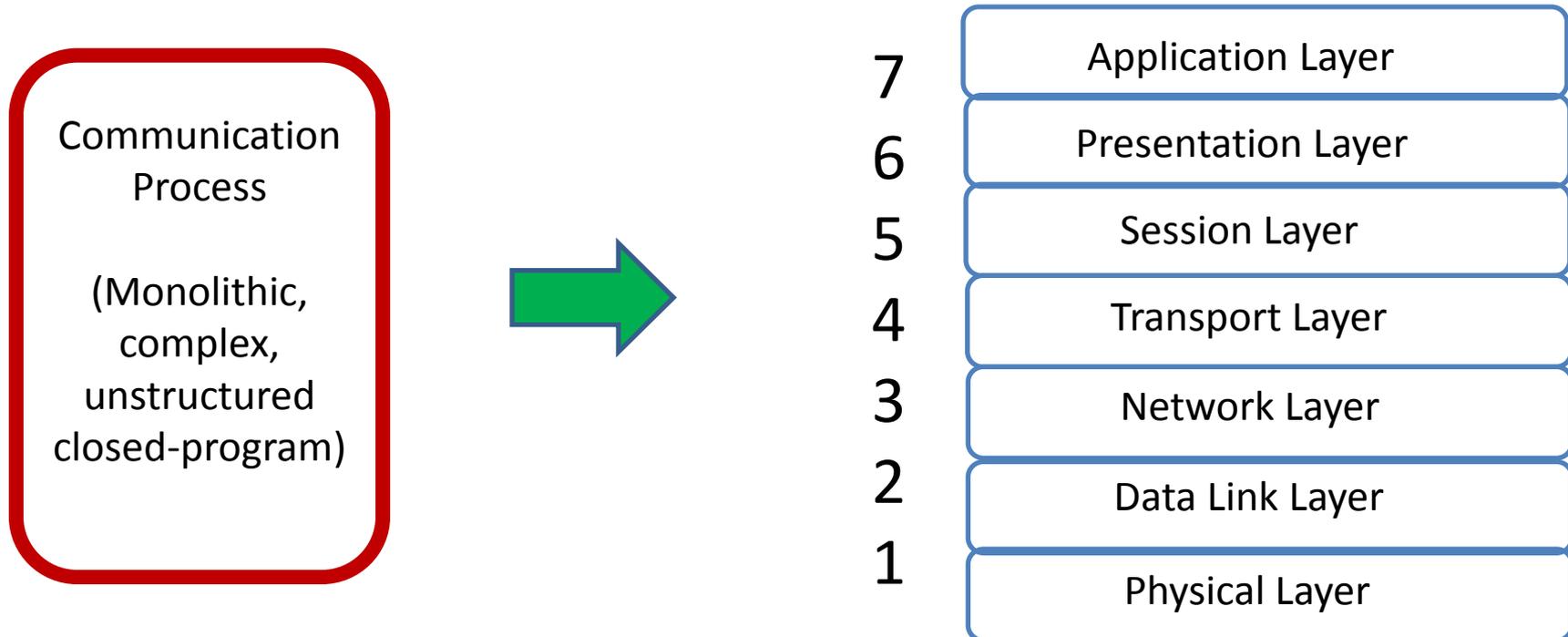
Multiple Vendors for Same Devices Competitive Market

What is a Communications Process?

- A communications process handles transmission of data or information between Point A and Point B, involves systems and/or devices, and requires protocols.

- A communications process requires two entities: a common communication medium and a common protocol and common language.

Communication Process

```
┌─────────┐                                    ┌─────────┐
│  Point  │ ◄────────────────────────────────► │  Point  │
│    A    │                                    │    B    │
└─────────┘                                    └─────────┘
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Open Systems Interconnection (OSI) Reference Model (RM)

Structured Approach: Each Layer Performs a Specific Function with an Assigned Protocol
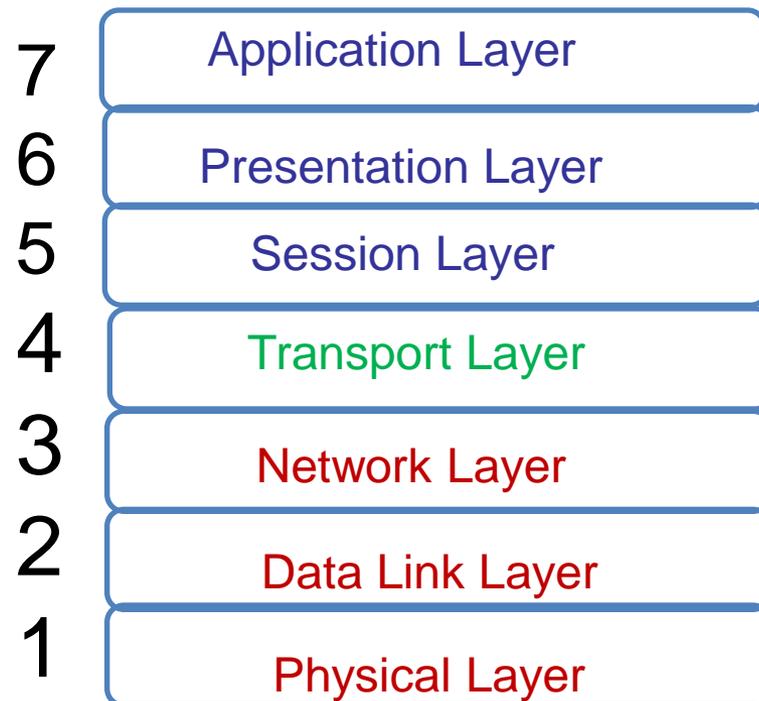
Communication Process

(Monolithic, complex, unstructured closed-program)

7	Application Layer
6	Presentation Layer
5	Session Layer
4	Transport Layer
3	Network Layer
2	Data Link Layer
1	Physical Layer

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STANDARDS ITS TRAINING

Understanding the Logical Structure of the OSI-RM

Upper three layers provide application services-user requirements.

Intermediate transport layer separates or masks upper and lower layers.

Lower three layers provide end-to-end-network services.

7	Application Layer
6	Presentation Layer
5	Session Layer
4	Transport Layer
3	Network Layer
2	Data Link Layer
1	Physical Layer

NTCIP Framework
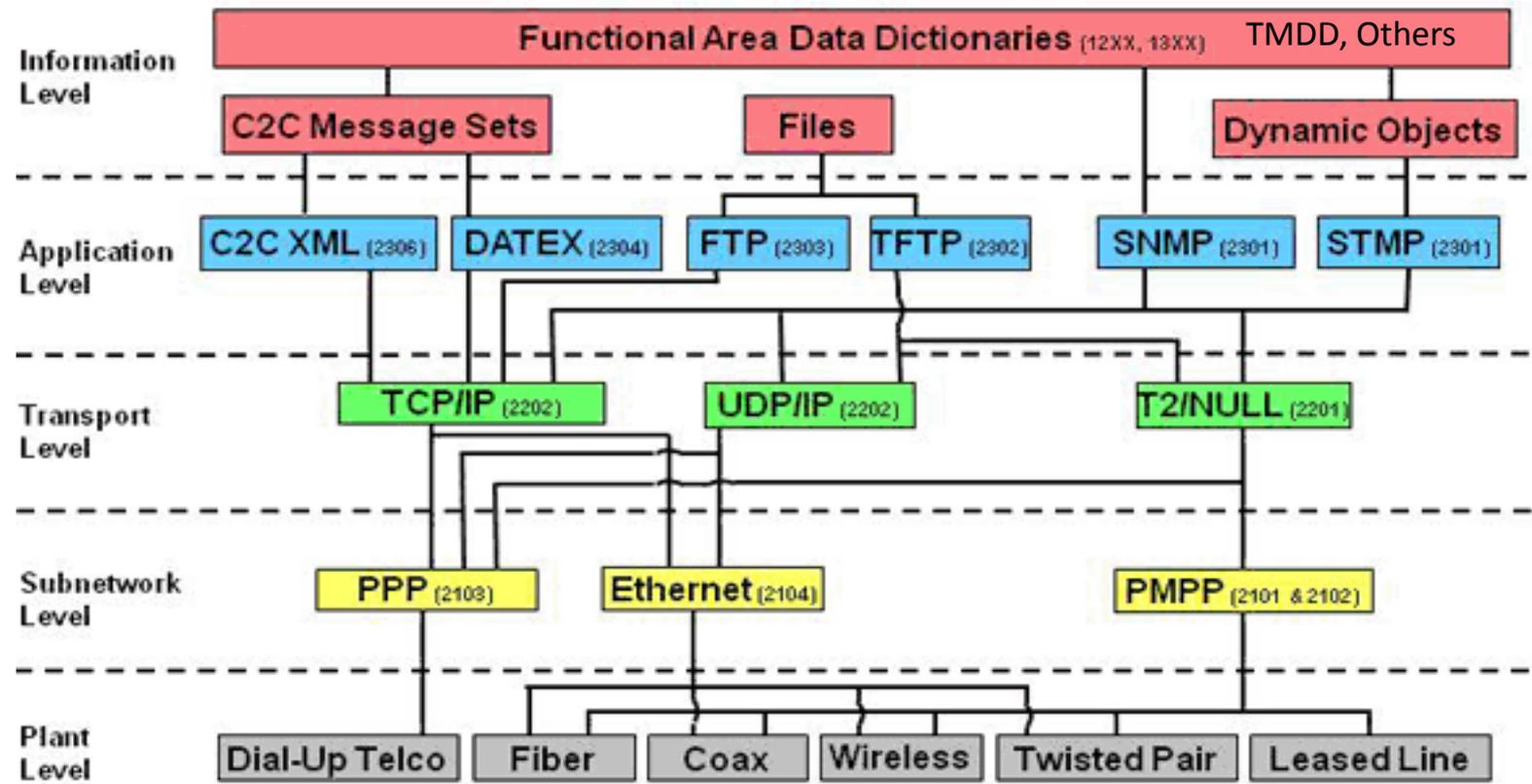
Note: At each level, there are profile standards to choose from. A profile standard is a collection of standards. (23xx, 22xx, and 21xx are profile standards.)

Information Level

Provides Data Dictionary Standards

NTCIP LEVELS

- NTCIP 12xx series standards contain object definitions (vocabulary) used to configure, control, and monitor field devices.

- Functional Area Data Dictionaries such as the Traffic Management Data Dictionary (TMDD)

INFORMATION

APPLICATION

TRANSPORT

SUBNETWORK

PLANT
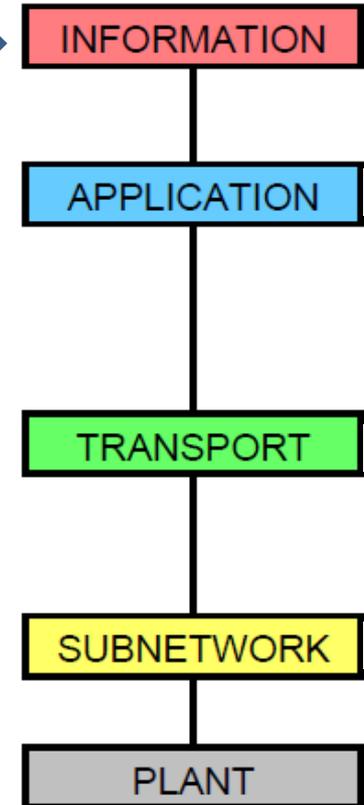
Application Level

Provides Standards to Exchange Data/Information

- For communications interface with Field devices (C2F)
- For information exchange with systems (C2C)

NTCIP LEVELS

INFORMATION

➡ APPLICATION

TRANSPORT

SUBNETWORK

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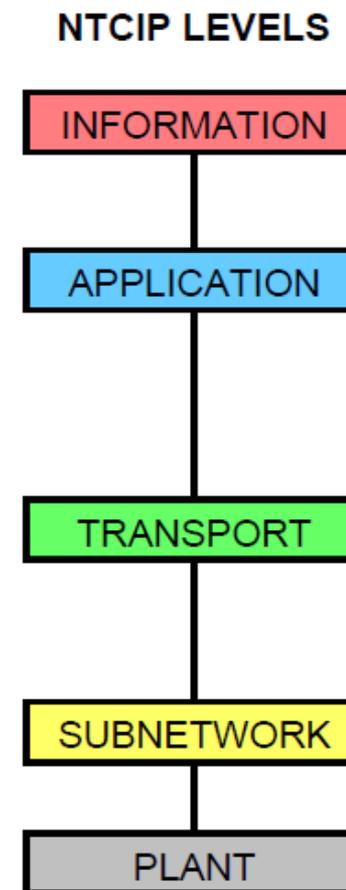
Transport Level

Provides Transport Protocols

- For connection-based transport service with TCP/IP
- For connection-less transport service with UDP/IP
- For non-routable (direct) transport service for low speed legacy situation with T2/NULL

NTCIP LEVELS

INFORMATION

APPLICATION

→ TRANSPORT

SUBNETWORK

PLANT
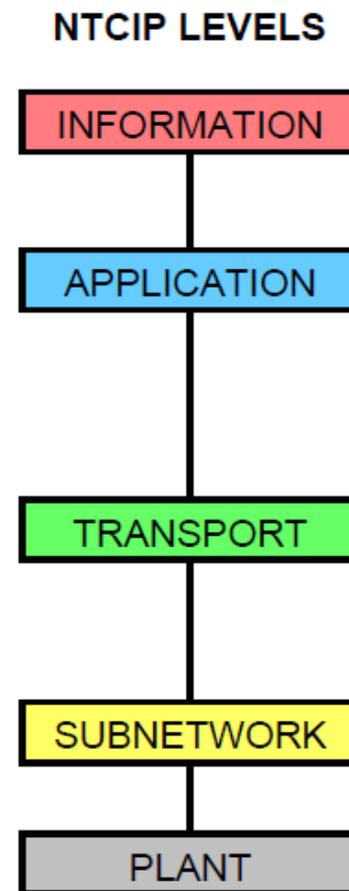
Subnetwork Level

Provides Subnetwork Protocols Standards for Network Services

- Ethernet
- Point-to-Point Protocol (PPP) is a connection to each device; used for dial-up circuits using V series modems.
- Point-to-Multipoint Protocol (PMPP) is a shared connection where each device is assigned an address and shares a twisted pair, for example.

NTCIP LEVELS

INFORMATION

APPLICATION

TRANSPORT

SUBNETWORK
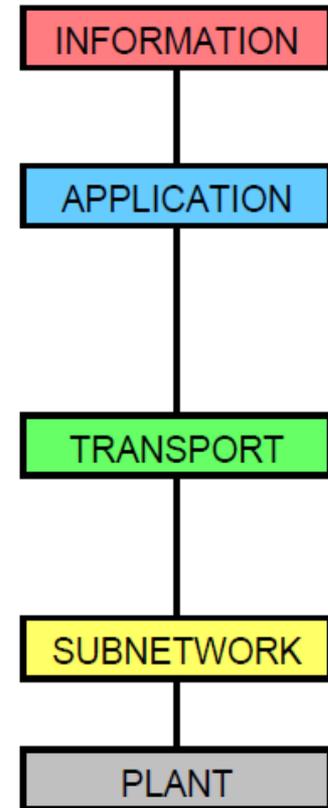
PLANT

Plant Level

Plant Level includes Physical Layer

- At Plant Level, data in the form of "bits" are transmitted across a physical infrastructure (connectors-wires).

- Examples: Fiber Optic cable or Wireless Network

- Communication engineers perform bandwidth analysis and plant network design to enable this task.
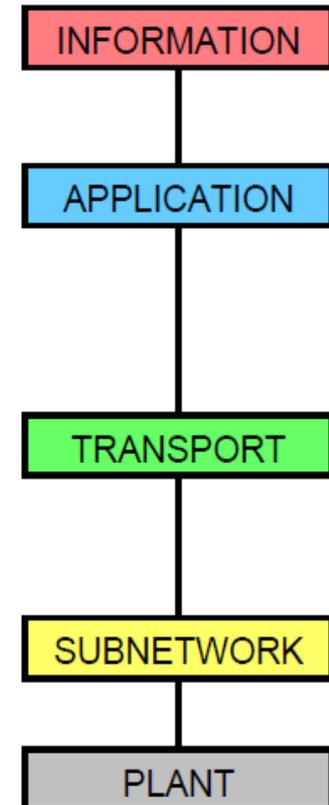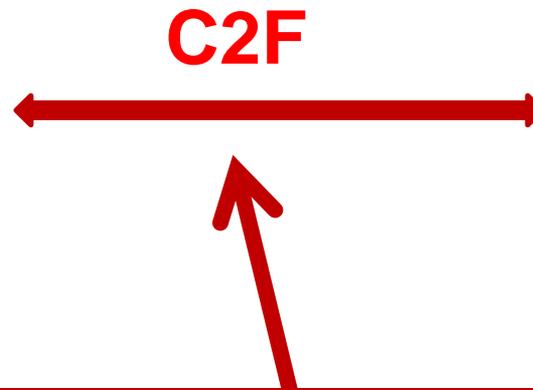
NTCIP LEVELS

INFORMATION

APPLICATION

TRANSPORT

SUBNETWORK

PLANT

Illustration-1

Communications Process for C2F Dialogs

C2F

Information Level NTCIP 1203 DMS

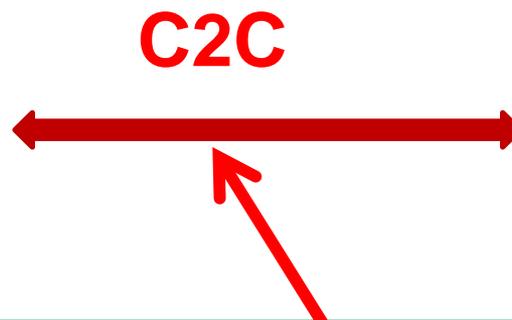**Application Level SNMP**

Transport Level Protocol

User Selects Standards

Illustration-2

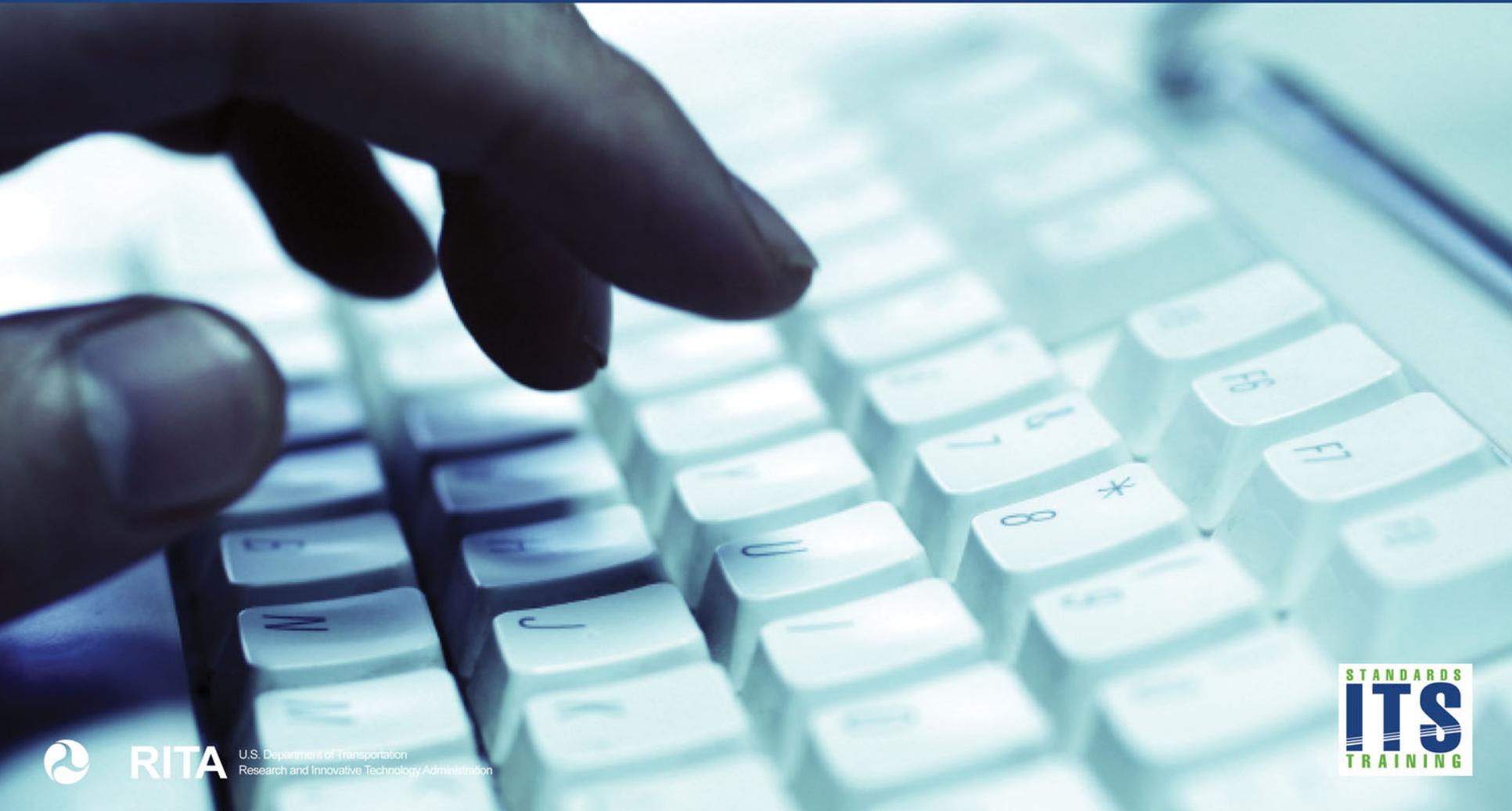## Communications Processes for C2C Dialogs

C2C

Photos: Raman Patel

Information Level TMDD Standard

Application Level NTCIP 2306 XML Profile

Transport Level TCP/IP Standard

Note: A Profile Standard is a Combination of Standards. NTCIP 2304 DATEX is also a C2C Profile.

ACTIVITY

C2F Device <u>Data</u> Standards are Located at:

Answer Choices

    a) Information Level
    b) Application Level
    c) Transport Level
    d) Subnetwork Level

Review of Answers

a) Information Level

   Correct, because Information Level does provide C2F device data standards.

b) Application Level

   Incorrect, because C2F data standards define data only, while the Application Level houses only the protocols.

c) Transport Level

   Incorrect, because Transport Level protocols are used for data transfer and they are not device data standards.

d) Subnetwork Level

   Incorrect, because Subnetwork Level protocols are used for sharing a communication channel and they are not device data standards.

Summary of Learning Objective #1

Be familiar with the basic terminology of the communications process used in the NTCIP.

- Discussed the communication process
  - What is protocol? What is standard?
  - *Compatibility* is achieved with the use of the same communications protocols.
  - *Interoperability* is achieved when systems are compatible and use the same dictionaries, dialogs, and protocols.

Summary of Learning Objective #1 (cont.)

Be familiar with the basic terminology of the communications process used in the NTCIP.

- Reviewed the seven layer OSI-RM
- Reviewed five levels of the NTCIP Framework and the tasks they perform

Learning Objective #2 — Explain how the NTCIP Framework (Stack) fulfills functional requirements to meet operational needs.

- What problem is NTCIP addressing?

- Organization of information level dictionaries

- Configuring, controlling, and monitoring of field devices (C2F-master/slave model)

- Information exchange among centers (C2C, peer-to-peer communication)

What Problem is NTCIP Addressing?

Inability to communicate between different vendors' devices or share a communication channel

- Proprietary vendor-specific devices' functionality
- Closed protocols for communications, which leads to sole source procurement and proprietary systems—more expensive future expansion and integration
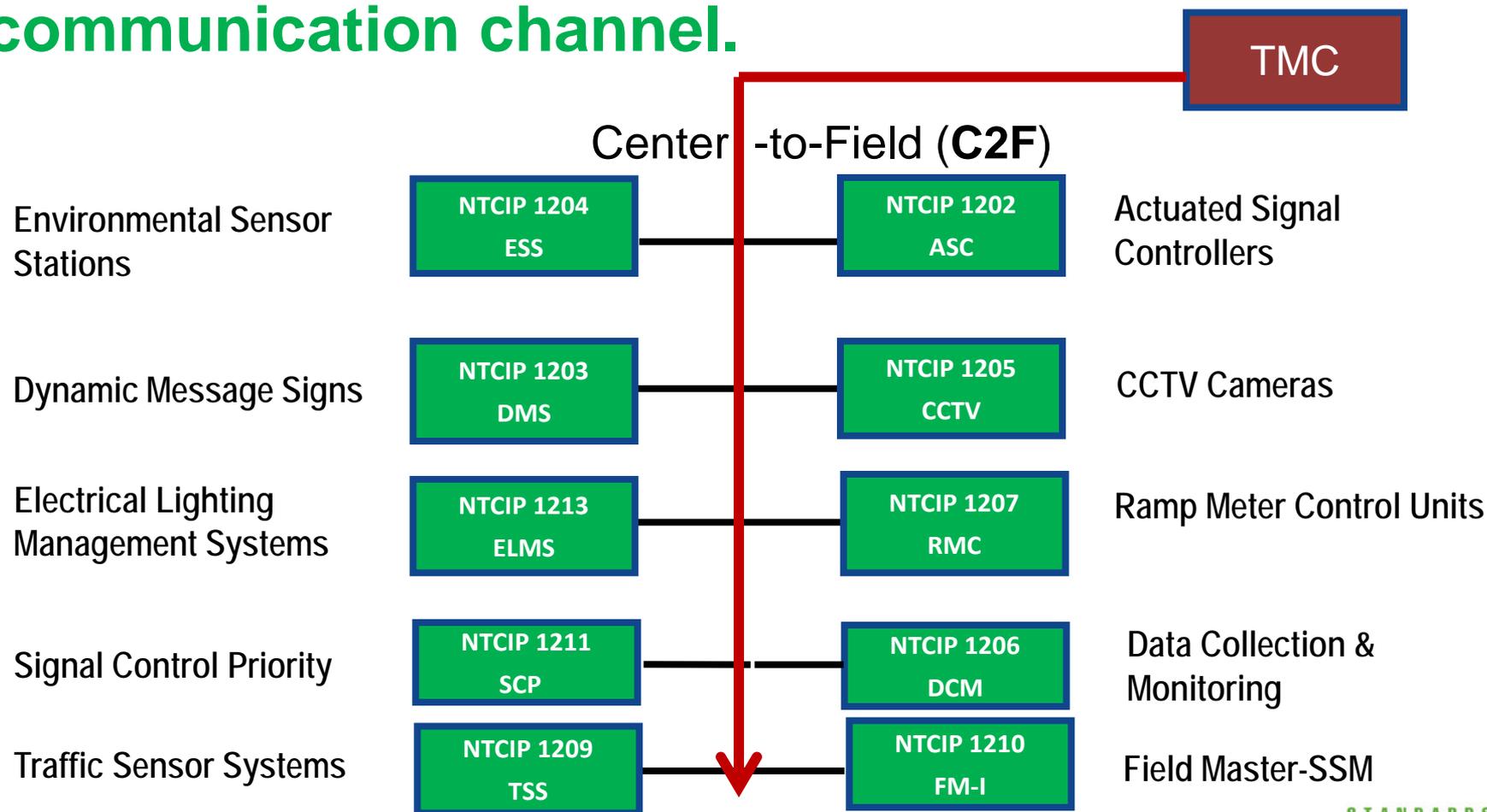
Solution Offered by the NTCIP Framework

- Interoperability and vendor independence with:

  - Common data format for definitions

  - Open communications standards

NTCIP-Based Device Data Standards

Devices from multiple-vendors can share a communication channel.

TMC

Center -to-Field (**C2F**)

Environmental Sensor Stations	**NTCIP 1204 ESS**
Dynamic Message Signs	**NTCIP 1203 DMS**
Electrical Lighting Management Systems	**NTCIP 1213 ELMS**
Signal Control Priority	**NTCIP 1211 SCP**
Traffic Sensor Systems	**NTCIP 1209 TSS**

NTCIP 1202 ASC	Actuated Signal Controllers
NTCIP 1205 CCTV	CCTV Cameras
NTCIP 1207 RMC	Ramp Meter Control Units
NTCIP 1206 DCM	Data Collection & Monitoring
NTCIP 1210 FM-I	Field Master-SSM

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# Data Dictionaries

Information Level: NTCIP 12xx

- Device dictionary contains **objects** that represent functions—features of a device.

- A3xx series training modules cover details on objects and their structure and communication interface.

What is an Object?

"A data structure used to monitor or control one feature, attribute, or controllable aspect of a manageable device" –NTCIP Standards

- Objects are structured with Abstract Syntax Notation One (ASN.1) Language.

Object 1
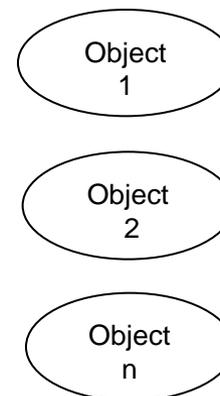
Object 2

Object n

Management Information Base (MIB)

- MIB is a human readable file format that contains objects designed for configuring, controlling, and monitoring a specific device.
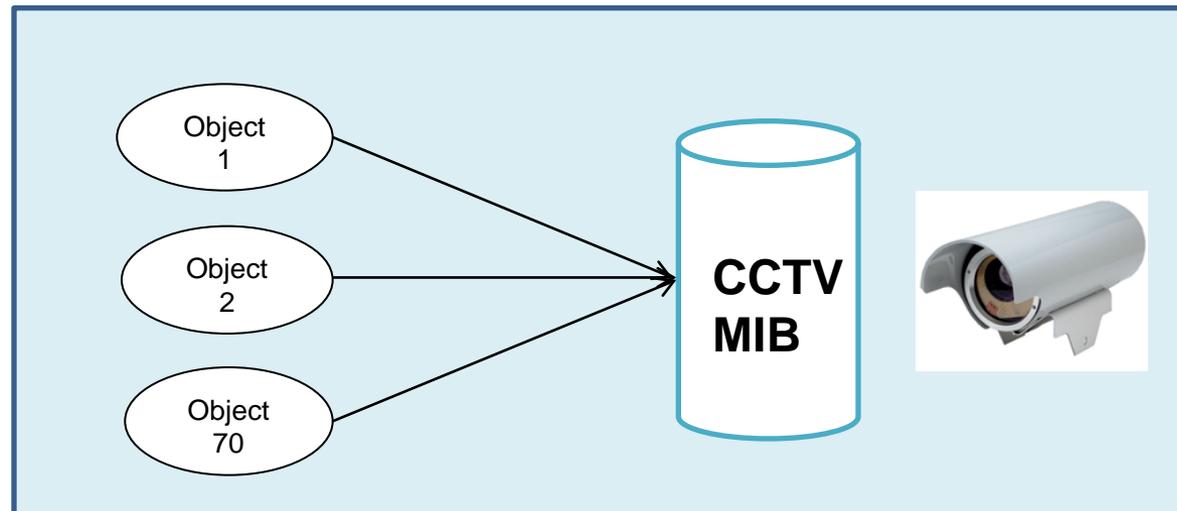

Illustration: CCTV MIB contains over 70 objects.

Protocol/MIB Relationship

MIB provides objects with values

SNMP operations manipulate **values** of objects

Behavior of the device function **altered**

Information Level C2C Data Dictionaries

- **SEP based:**
    - ❑ TMDD contains messages, data elements, and dialogs to support exchanges between traffic management systems.

- **Non-SEP based:**
    - ❑ IEEE 1512 Emergency Management standards contain only data elements and may not deliver interoperable systems consistently (without dialogs).
    - ❑ Other examples are ATIS and TCIP message standards. (See student supplement for references.)

Traffic Management Data Dictionary (TMDD)

Supports C2C System Interface Design

- Provides user needs and requirements related to traffic management applications

- Provides data elements, data frames, messages, and dialogs for system interface design

- Local project selects capabilities that are needed from the standard.

Other Functional Area C2C Dictionaries

- Emergency Management Messages (IEEE 1512)

- Advanced Traveler Information System (ATIS); Data Dictionary (J2353), Messages Sets (SAE J2354)

- Transit Communications Interface Profiles (TCIP) Applications (APTA Standards)

See Participant Student Supplement for where to find these standards.

How to Combine a Set of Standards for C2F?

Create a Stack by Selecting a Protocol at Each Level

▪ Data Dictionary for the Device	**NTCIP 12xx**
▪ Protocol to Exchange Data	**NTCIP 23xx**
▪ Transport Protocol	**NTCIP 22xx**
▪ Subnet Protocol	**NTCIP 21xx**
▪ Communication Plant	**Fiber or….**

Example of DMS Deployment Stack

DMS Dialogs can be carried out with this Stack.

C2F
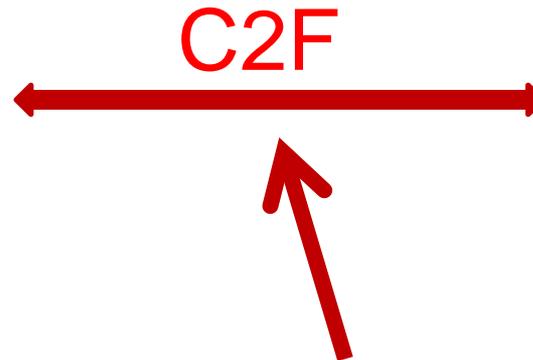
Source: NYCDOT

Plant level communications could be any medium.

NTCIP 1203 DMS

NTCIP 2301 SNMP

NTCIP 2202 UDP/IP

NTCIP 2103 PPP

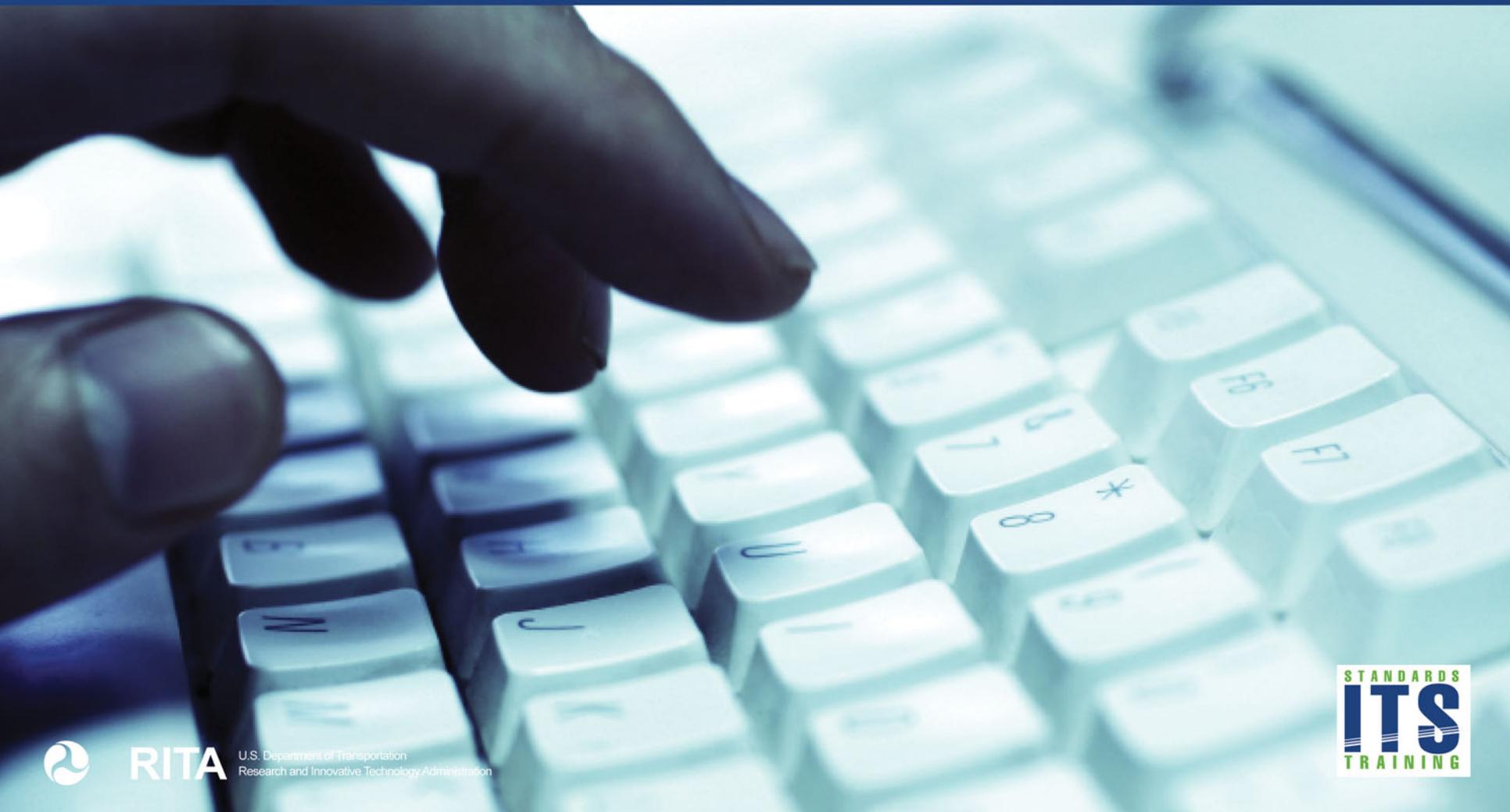# How to Combine a Set of Standards for C2C?

Create a Stack by Selecting a Protocol at Each Level

Example: Traffic Management

- Functional Area Data Dictionary—**TMDD**

- Application Profile—**NTCIP 2306 XML**

- Transport—**NTCIP 2201 TCP/IP**

- Subnetwork—**NTCIP 2104 Ethernet**

- Web—Connectivity

ACTIVITY

NTCIP 12xx Device Standards Provide:

Answer Choices

a) Management Information Base (MIB) for each field device

b) Application protocols such as Simple Network Management Protocol (SNMP) and Simple Transportation Management Protocol (STMP)

Review of answers

a) Management Information Base (MIB) for each field device

   Correct, because NTCIP 12xx series standards provide a device-specific MIB.

b) Application protocols such as SNMP and STMP

   Incorrect, because application level protocols are covered by NTCIP 23xx series standards.

Summary of Learning Objective #2

Explain how the NTCIP Framework (Stack) fulfills functional requirements to meet operational needs.

- Discussed problem being addressed by the NTCIP Framework

- Discussed how **Information Level** NTCIP 12xx series device data dictionaries provide objects to meet C2F operational needs

- Discussed how **domain-specific** dictionary provides data concepts to support C2C operational needs

Learning Objective #3 — Describe Center-to-Field (C2F) applications and their related NTCIP Standards

Operational Needs

- Define SNMP Network Management Model

- Structure of SNMP Messages (Get/Get Next, SET, and TRAP), PDU format

- STMP, FTP, TFTP

Operational Needs

C2F Standards Supports Management Station for:

1. Configuring a device (parameters)
2. Monitoring a device and gathering data
3. Controlling device functions or actions
4. Retrieving logged/events reports when something "unexpected" happens

(Exception reporting by agent)

C2F Protocols

Protocols Available for Managing Field Devices:

1. Simple Network Management Protocol (SNMP)

2. Simple Transportation Management Protocol (STMP)

3. File Transfer Protocol (FTP)

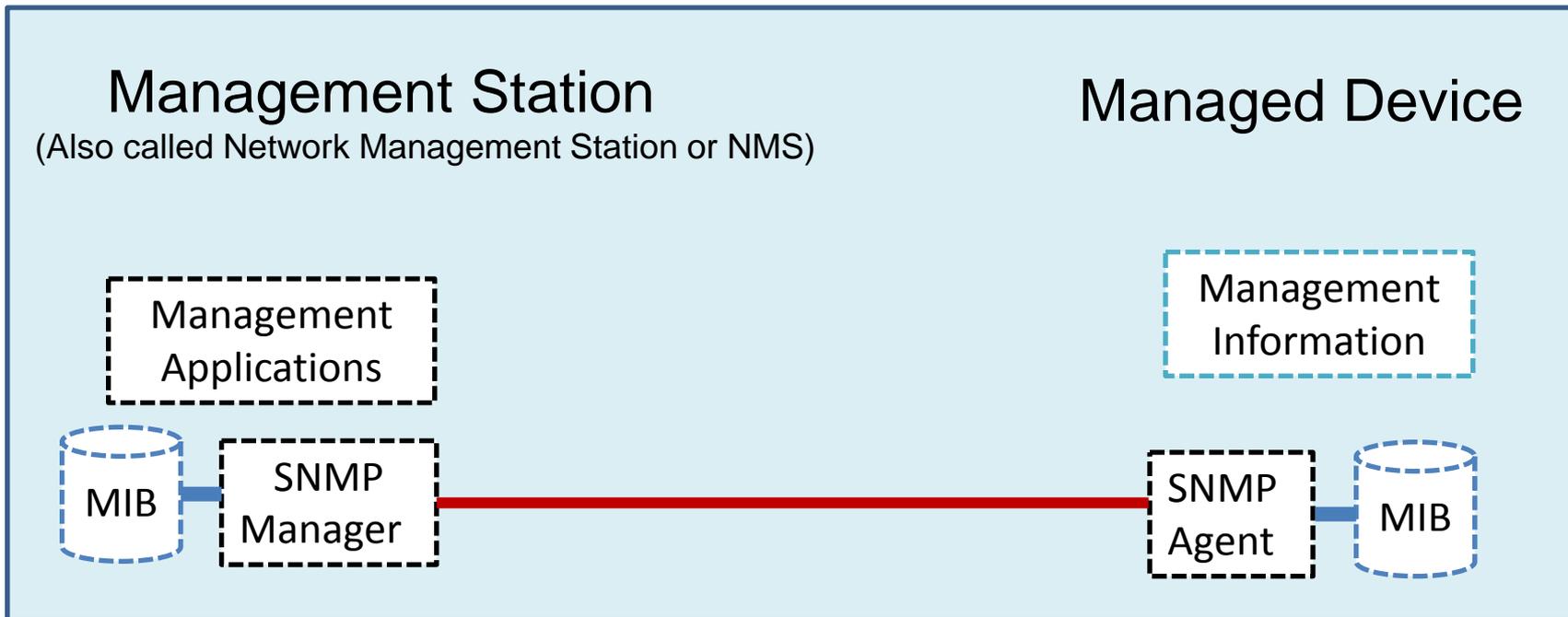4. Trivial File Transfer Protocol (TFTP)

Simple Network Management Protocol (SNMP)

- A C2F communications protocol that is simple and flexible

- Used in network management to monitor and control devices remotely:

  - Manages network devices such as routers, bridges, firewalls, switches, etc.
  - Manages ITS devices such as traffic controllers and Dynamic Message Signs (DMS)

SNMP Network Management Model

Provides Capability for Remote Management

Management Station
(Also called Network Management Station or NMS)

Managed Device

Management Applications

Management Information

MIB — SNMP Manager ———— SNMP Agent — MIB

Key Components of an SNMP Model

- **SNMP Manager**: an application program that contacts an SNMP agent to query or modify the database at the agent

- **SNMP Agent**: a software that runs on a device and maintains information about configuration and current state of database

- **MIB**: describes the information about the device being managed

SNMP Operations

- **Retrieving** the *value* of the management information accessible by an agent [Read-GET operation]

- **Modifying** the *value* of the management information accessible by an agent [Write-SET operation]

- **Reporting** an *event* or condition by the agent to the manager [Trap operation in the Internet space, but NTCIP does not support this capability at this time]

SNMP Messages

Request Messages   (Retrieval/Modification operations)

- *GetRequest message   [give me information on..]*

- *GetNextRequest message [get more information from the MIB…..get next piece of information]*

- *SetRequest message   [do this action for me on..]*

Response Messages   (Retrieval operations)

- *GetResponse message   [here is the information]*

Exception Reporting

- Two ways to report conditions within NTCIP
  - Event logs
  - Traps (Future)

- Event logs allow user-defined events to be logged with a timestamp for later retrieval using **GetRequest.**

- Traps allow these events to be reported immediately to the management station, but this mechanism is not yet standardized by NTCIP.

ACTIVITY
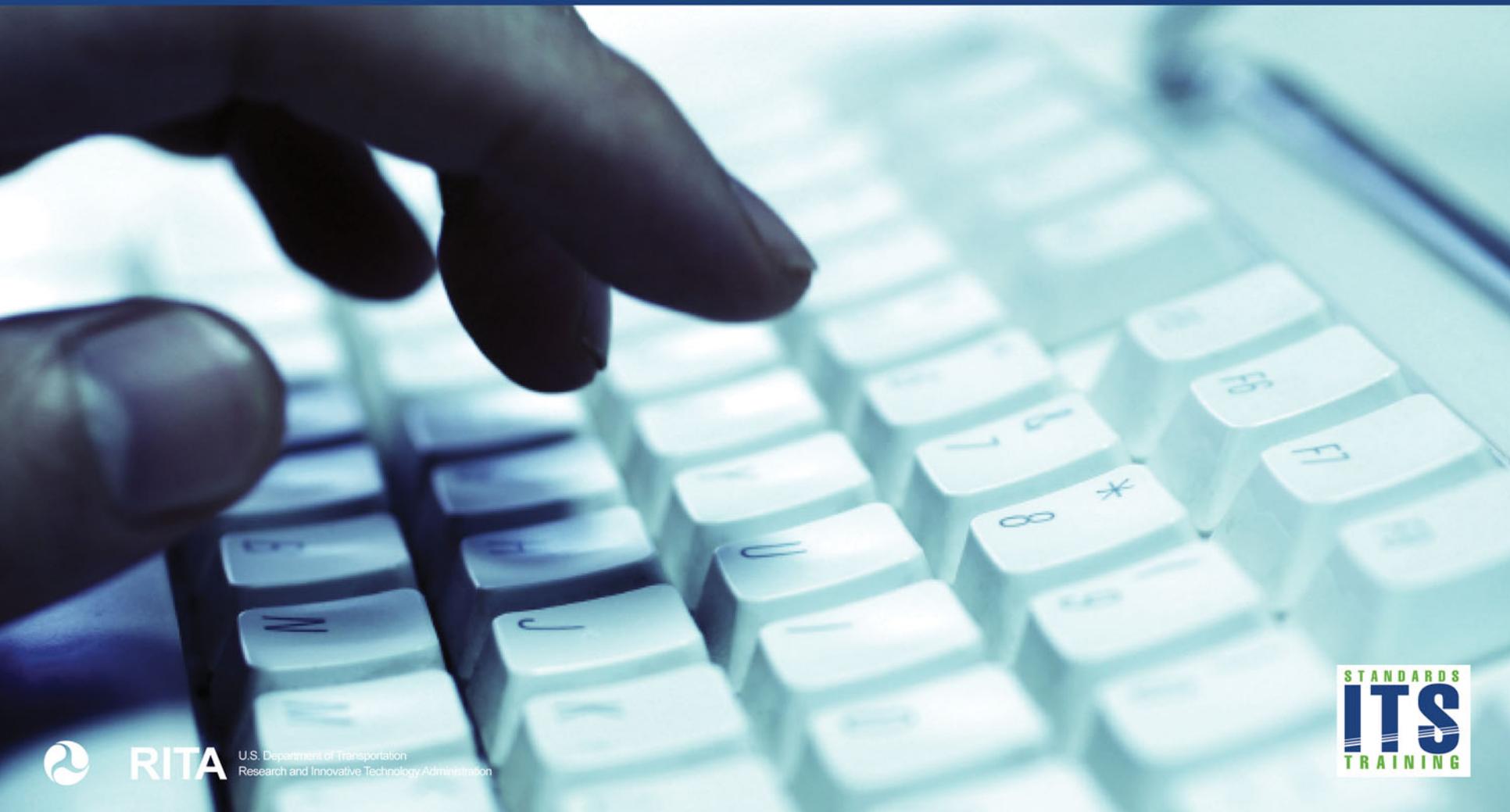
To gather data from a detector station, the central SNMP Manager initiates:

Answer Choices

a) GetRequest message
b) SetRequest message
c) Trap message
d) GetResponse message

Review of Answers

a) GetRequest message
Correct, because GetRequest retrieves values from the agent of the detector station.

b) SetRequest message

Incorrect, because SetRequest message is for modifying a value.

c) Trap message

Incorrect, because Trap message does not apply; it is not issued by the SNMP manager.

d) GetResponse message

Incorrect, because GetResponse message only returns a value requested by GetRequest message.

Simple Transportation Management Protocol (STMP)

- A variation of SNMP, designed to work with 13 specially designed "*dynamic objects.*"

- Any device could use STMP, but it was only adopted by ASC devices because it allowed the more efficient use of the bandwidth for the real-time retrieval of status information.

Simple Transportation Management Protocol (STMP) (cont.)

- It has been used in wireless networks and Ethernet to allow multiple objects to be packed into a single block and retrieved with a single GET operation.

- Refer to NTCIP Guide 9001 v04, NTCIP 2301, and NTCIP 1103 v02 for more information.

File Transfer Protocol (FTP)

- FTP (NTCIP 2303) is a TCP/IP-based Protocol.

- Examples:

  C2F: Environmental Sensor Stations (ESS) standard uses FTP to visually inspect weather conditions and/or verify the reported weather conditions by retrieving camera snapshots.
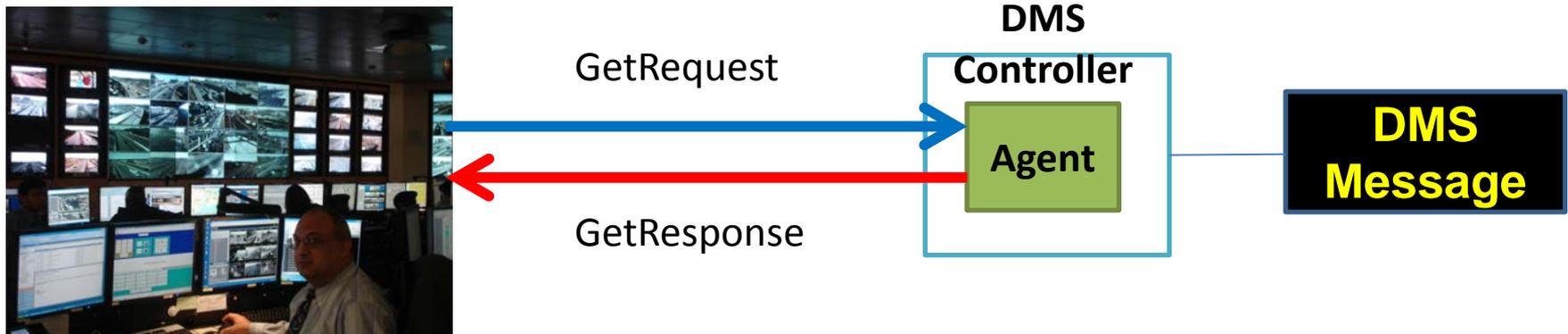
  C2C: FTP is used in the XML-DIRECT.

Trivial File Transfer Protocol (TFTP)

- TFTP (NTCIP 2302) works with UDP/IP (User Datagram Protocol-connectionless).

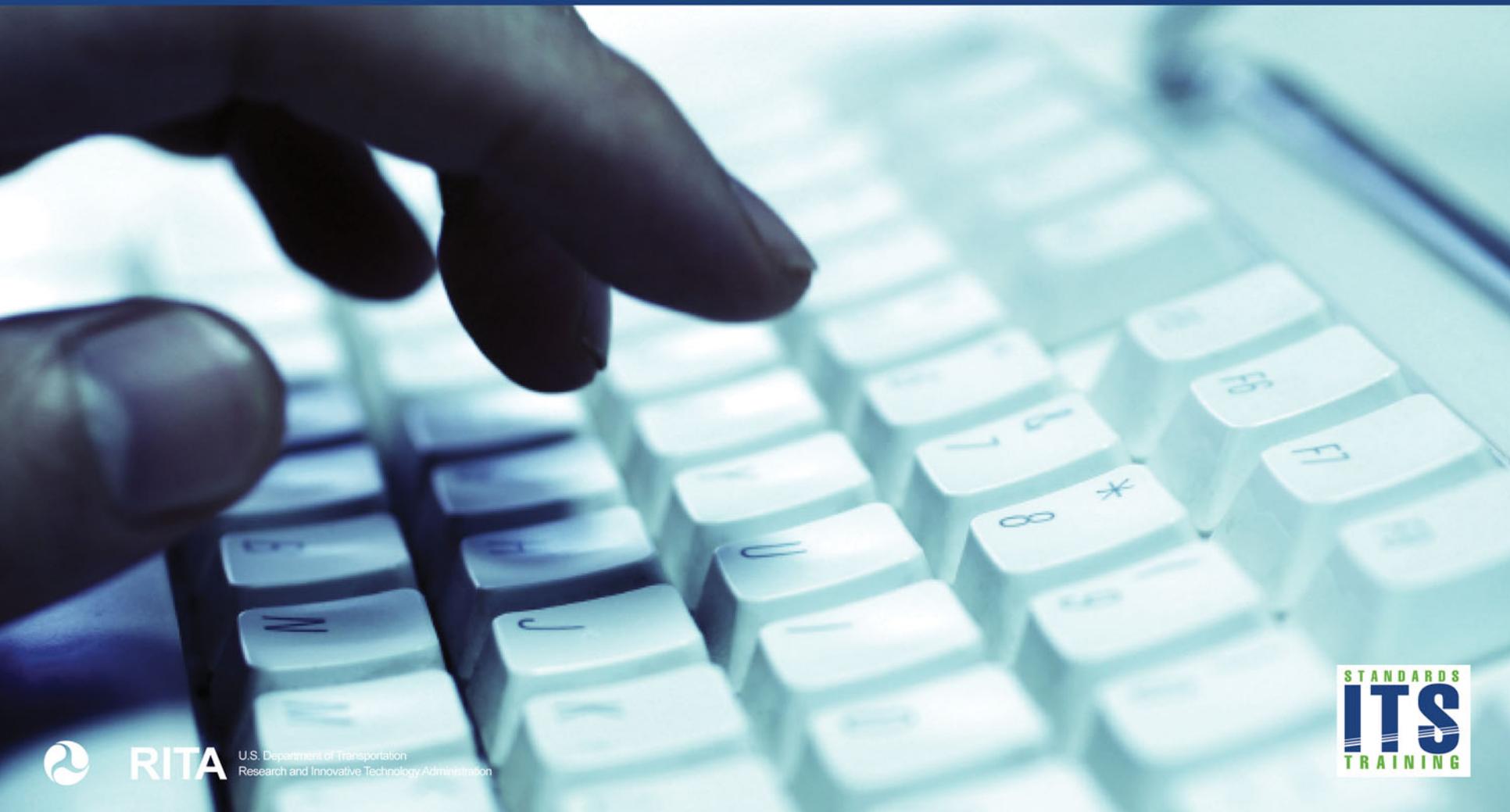- Efficient protocol for transfer of small files

Illustration

- TMC requests to retrieve the current status of a DMS.
- Agent responds with a value.

- Central system translates the response for the user who interprets the response and makes decision on the next step.

ACTIVITY

STANDARDS ITS TRAINING

Which of the following is a preferred protocol for monitoring a DMS?

Answer Choices

a) SNMP
b) FTP
c) STMP
d) NTCIP 2306 XML

Review of answers

a) SNMP

Correct, because SNMP is typically used by convention to interface with the DMS in the field.

b) FTP

Incorrect, because FTP is only used for file transfer.

c) STMP

Incorrect, because STMP can be used only in ASC applications and by convention it is not typically used for DMS or other devices.

d) NTCIP 2306 XML

Incorrect, because NTCIP 2306 XML is a profile standard used in C2C applications.

Summary of Learning Objective #3

Describe Center-to-Field (C2F) applications and their related NTCIP Standards

- Reviewed operational support provided by the C2F standards: configuration, monitoring, and control.

- Discussed protocols used in the C2F applications and focused on the SNMP model and services it provides.

Learning Objective #4 — Describe Center-to-Center (C2C) applications and their related NTCIP Standards

- Center-to-Center (C2C) Operational Needs
- Communications System Interface
- TMDD Data Concepts
- Components of NTCIP 2306 XML Profile
- Messaging models used in NTCIP 2306 XML

C2C Terminology

- W3C — World Wide Web Consortium
- XML — eXtensible Markup Language

  Encoding method for messages
- WSDL — Web Services Description Language

  Center's Public Interface Format
- SOAP — Simple Object Access Protocol

  Communication method for XML Messages
- HTTP — Hypertext Transfer Protocol

  Web browser Transport Protocol
- PRL — Profile Requirements List (in NTCIP 2306)

NTCIP 2304 DATEX Application Profile Standard
NTCIP 2306 XML Application Profile Standard

Operational Needs (C2C)

System Interface Supports Information Exchange

1. Need to Share Event Information
2. Need to Provide Control of Devices, Share Status, and Data
3. Need to Provide Roadway Network Data
4. Need to Share Data for Archiving

Traffic Management Center	Center-to-Center (C2C) Communications ↔	Traffic Management Center
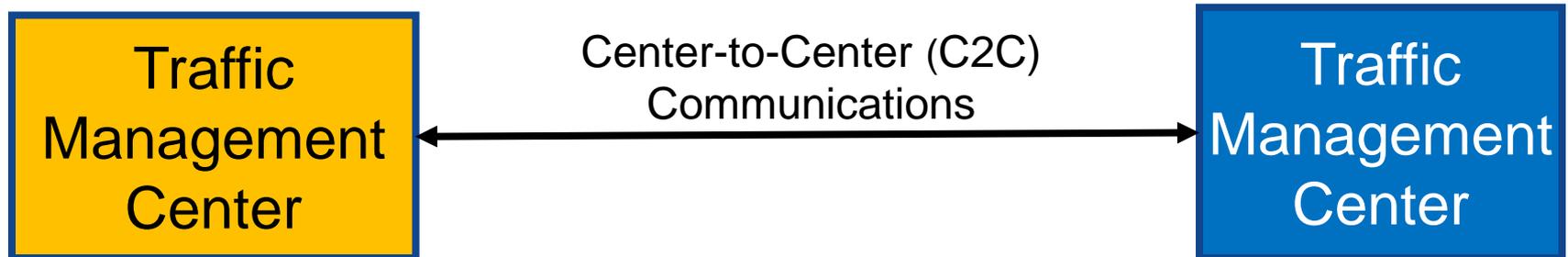
Types of Generic Dialogs (TMDD)

Dialogs are a logical sequences of messages put together to conduct a "conversation" between centers.

1. Request/Response   Information Sharing
2. Subscription   Information Updates
3. Publication   Published Information

NTCIP 2306 XML Application Profile

- TMDD Supplies:
  - Data Concepts in XML Format
   - Dialogs, messages' data-frames, and data-elements

- NTCIP 1104 Naming Conventions

- NTCIP 2306 Supplies:
  - XML Schema-WSDL-SOAP
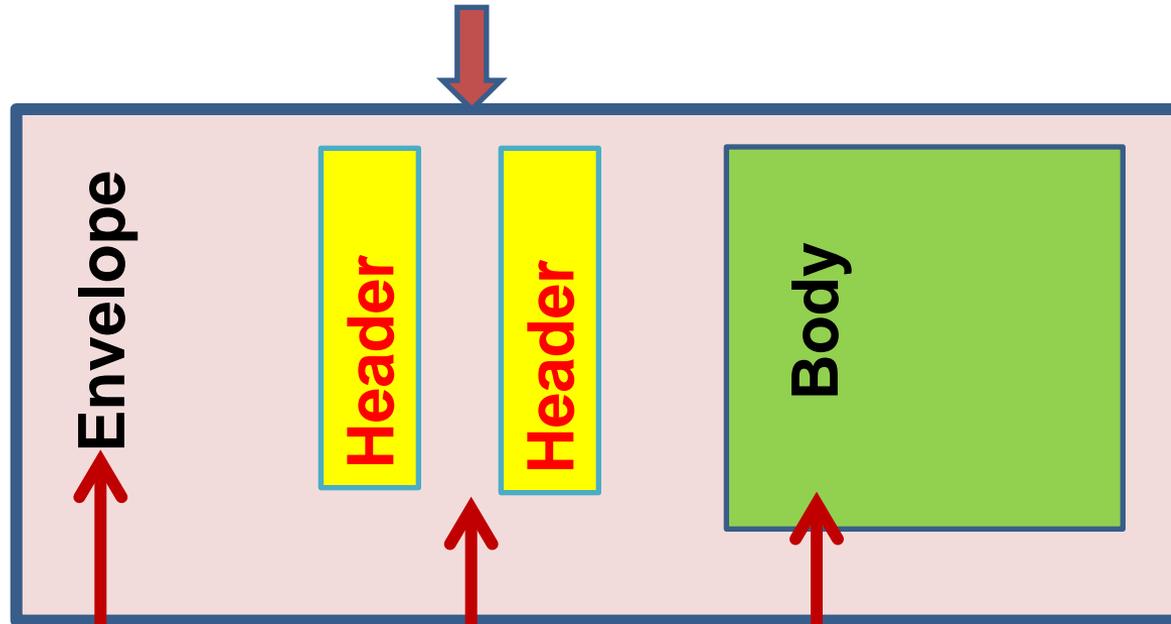 - Transport: HTTP or XML
  - TCP/IP

Introduction to Web Service

- A web service is any service (operation equivalent to functions) that is available over the Internet/Intranet.
- Uses a standardized XML messaging system
- Independent of operating systems or programming languages
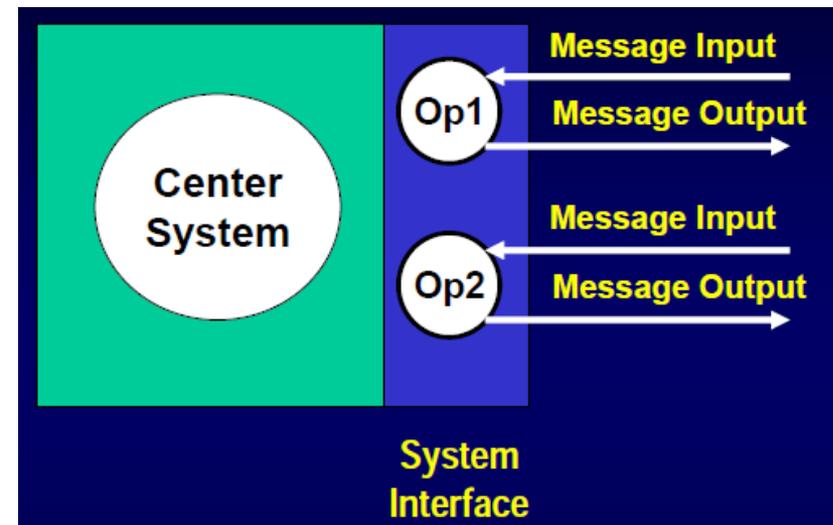
SOAP (Simple Object Access Protocol)

SOAP Encodes XML Message

|		
Carries Messages **Required**	Carry Instruction **Optional**	Carry Message Content **Required**

NTCIP 2306 Implementation

- Project specification needs are listed in a conformance statement.
- Profile Requirements List (PRL) allows user to state selected sub-profile options (ref. NTCIP 2306 standard).

Table 3 Profile Requirements to Solution Trace (Profile Requirements List)

Profile Requirements List (PRL)		NTCIP 2306 v01 Section	Mandatory / Optional	Profile Require-ment	Project Require-ment
1.0	SOAP over HTTP				
	a) WSDL Request-Response		O		
	- WSDL General	6.1	M		
	- Definitions	6.2	M	PR 3.1	
	- Types/Schema	6.3	M	PR 3.1, 3.2	
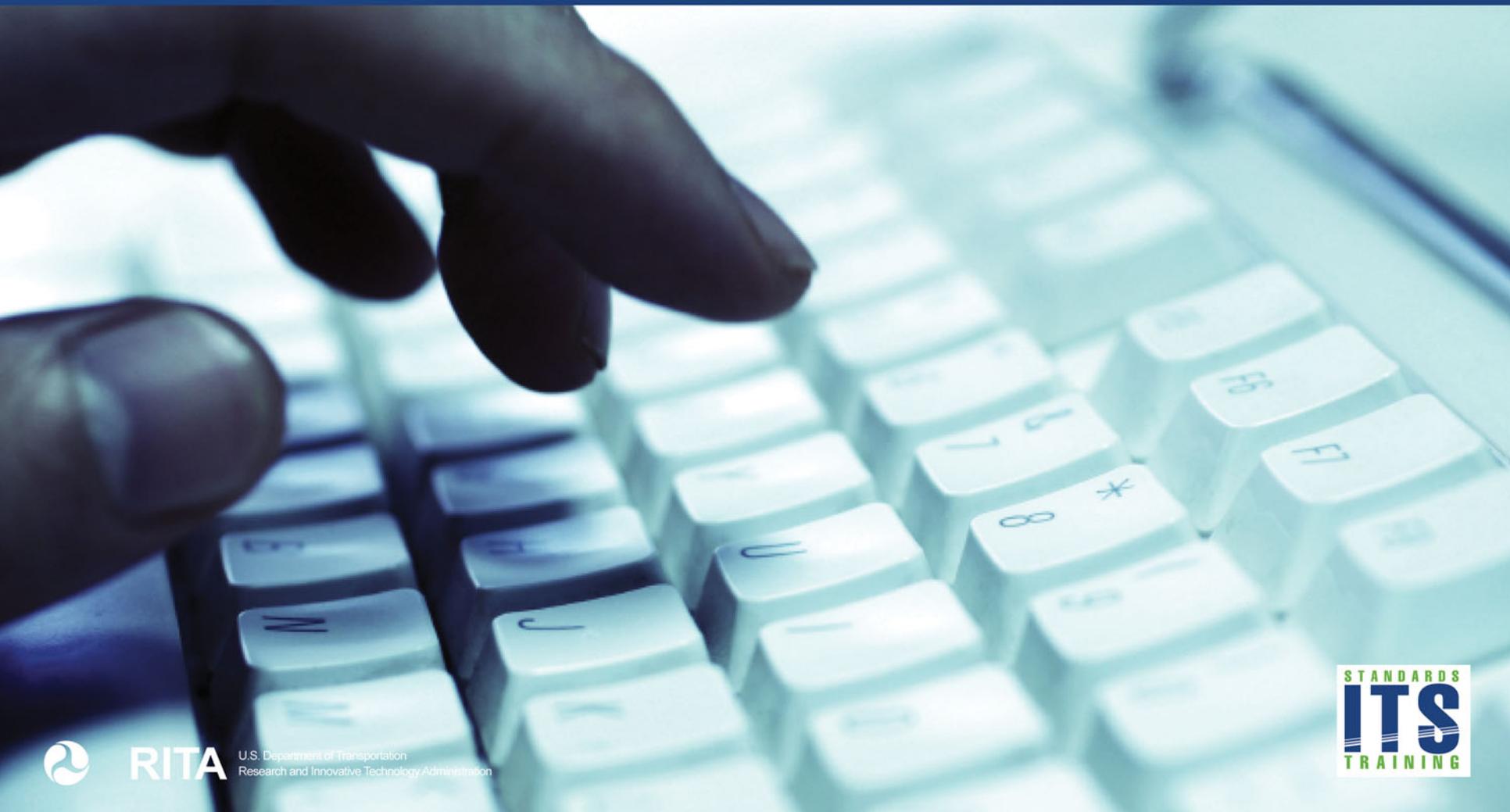
STANDARDS ITS TRAINING

ACTIVITY

Which of the following is NOT applicable to C2C?

Answer Choices

a) NTCIP 2306 XML
b) SNMP
c) SOAP
d) WSDL

Review of Answers

a) NTCIP 2306 XML

Incorrect, because NTCIP 2306 XML is applicable to C2C as a profile standard.

b) SNMP

Correct, because SNMP applies to C2F only.

c) SOAP

Incorrect, because SOAP is the transport protocol used in NTCIP 2306 XML.

d) WSDL

Incorrect, because WSDL is used in C2C as a language standard.

Summary of Learning Objective #4

Describe Center-to-Center (C2C) applications and their related NTCIP Standards

- Reviewed C2C Operational Needs

- Discussed C2C System Interface (SI)

- Discussed Generic Dialogs in TMDD

- Introduced NTCIP 2306 XML Profile

- Introduced Web service, SOAP, and WSDL

What We Have Learned

1. We have learned that the NTCIP Family of standards are based on the ISO's **OSI-RM**.

2. Two categories of the NTCIP communications standards are **C2F** and **C2C**.

3. NTCIP objects are based on the **ASN.1** language representation, which is an ISO standard.

4. NTCIP 12xx series device data standards are located at the **Information Level**.

What We Have Learned (cont.)

5. **SNMP** is used for remote management of ITS devices located in the field.

6. Specifically, SNMP performs **Retrieval** and **Modification** operations to manage a field device.

7. C2C standards used in the traffic management applications include the **TMDD** and **NTCIP 2306 XML**.

Resources

- Participant student supplement provides a list of references.

- NTCIP 9001 v04 Guide, NTCIP C2F and C2C Standards documents are available in the NTCIP library at www.ntcip.org

- TMDD Standard v03 and TMDD v02 Guide are available at www.ite.org.

QUESTIONS?

Additional Communications Modules

C201: Introduction to Simple Network Management Protocol (SNMP) and its Applications in the Field Devices Based on the NTCIP Standards

C202: Introduction to the Application Level Protocols for Center-to-Center Communication System Interface Implementation (NTCIP 2306 XML)