

ITS Exchange Standards

**Center-to-Center & Center-to-Field Devices
NTCIP & Other Standards**

C2C

C2F

Bob Rausch, P.E.

robert.rausch@transcore.com

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Outline

- ▶ Overview of NTCIP
- ▶ Physical Architecture
- ▶ Center-to-field for ITS devices (C2F)
 - ▷ Protocol standards
 - ▷ Content standards
 - ▷ **Wireless adaptations**
- ▶ Center-to-center for traffic management (C2C)
 - ▷ Protocol standards
 - ▷ Content standards
- ▶ More information
 - ▷ Where/how to acquire the standards

INTRODUCTION TO NTCIP **CENTER-TO-FIELD**

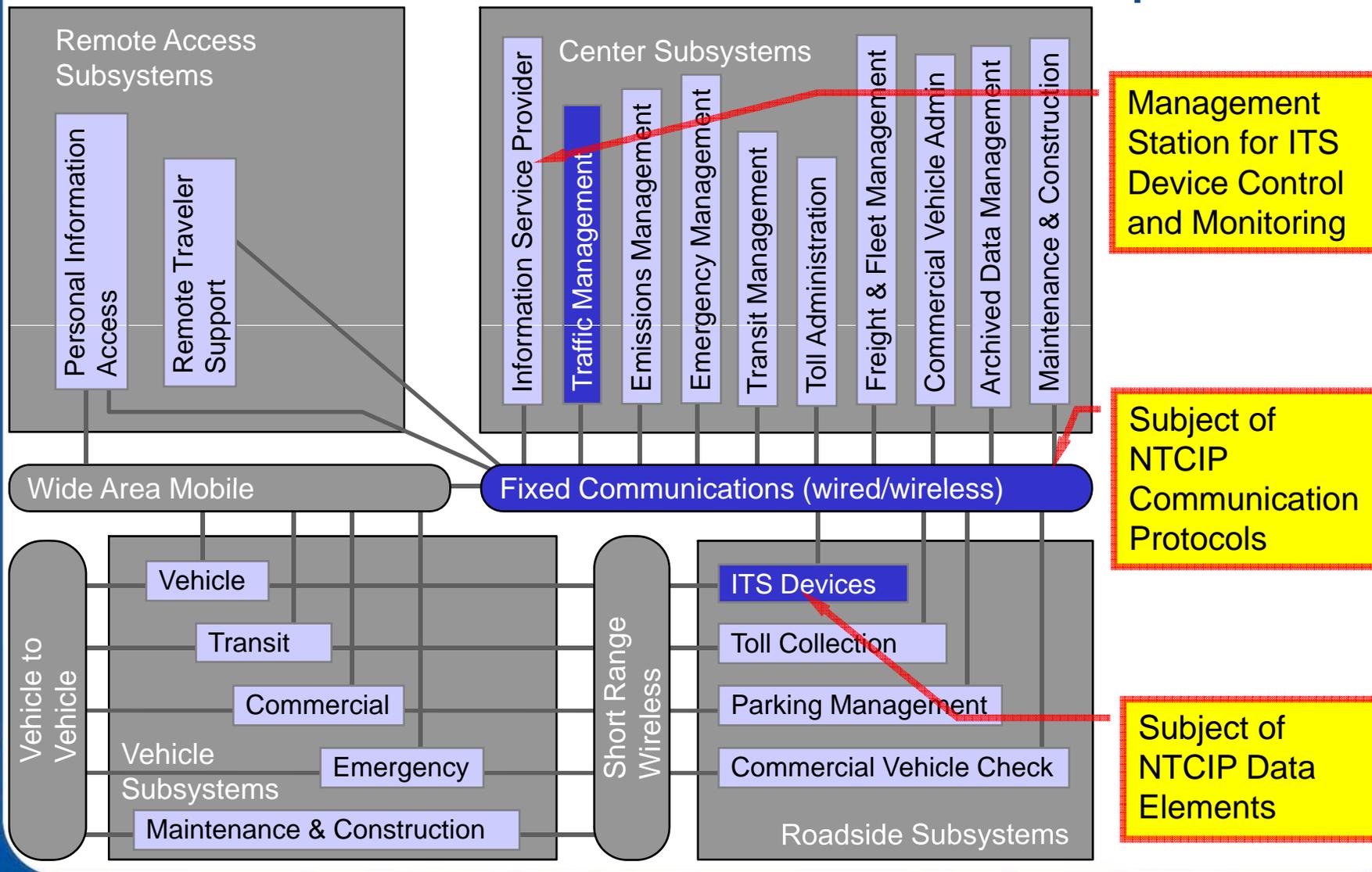
C2F

What is the NTCIP?

- ▶ **N**ational **T**ransportation **C**ommunications for **I**TS **P**rotocol (NTCIP)
 - ▷ *Where ITS = Intelligent Transportation Systems*
- ▶ The **NTCIP** is a family of **open** standards, defining common communications protocols and data definitions.
- ▶ NTCIP was/is a joint effort of the:
 - ▷ American Association of State and Highway Transportation Officials (AASHTO)
 - ▷ Institute of Transportation Engineers (ITE)
 - ▷ National Electrical Manufacturers Association (NEMA)
- ▶ Web Site: www.ntcip.org

ITS National Architecture

Identified the Links – Context for standards development



NTCIP Center-to-Field Standards

Built on **SNMP**
Simple Network
Management Protocol



*Master Station
(In Station)*

Actuated Signal
Controllers



Environmental Sensor
Stations

CCTV Cameras &
Switches



Dynamic Message Signs

Data Collection &
Monitoring



Electrical Lighting
Management Systems

Traffic Sensor Systems



Signal Control Priority

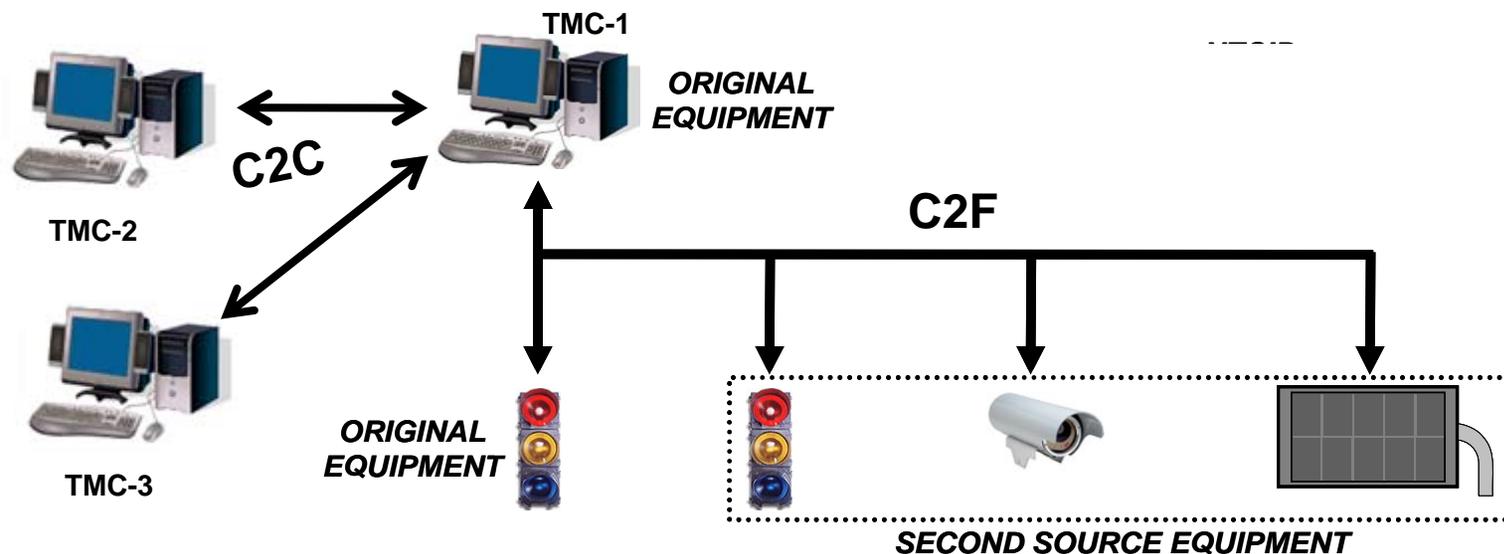
Field Masters



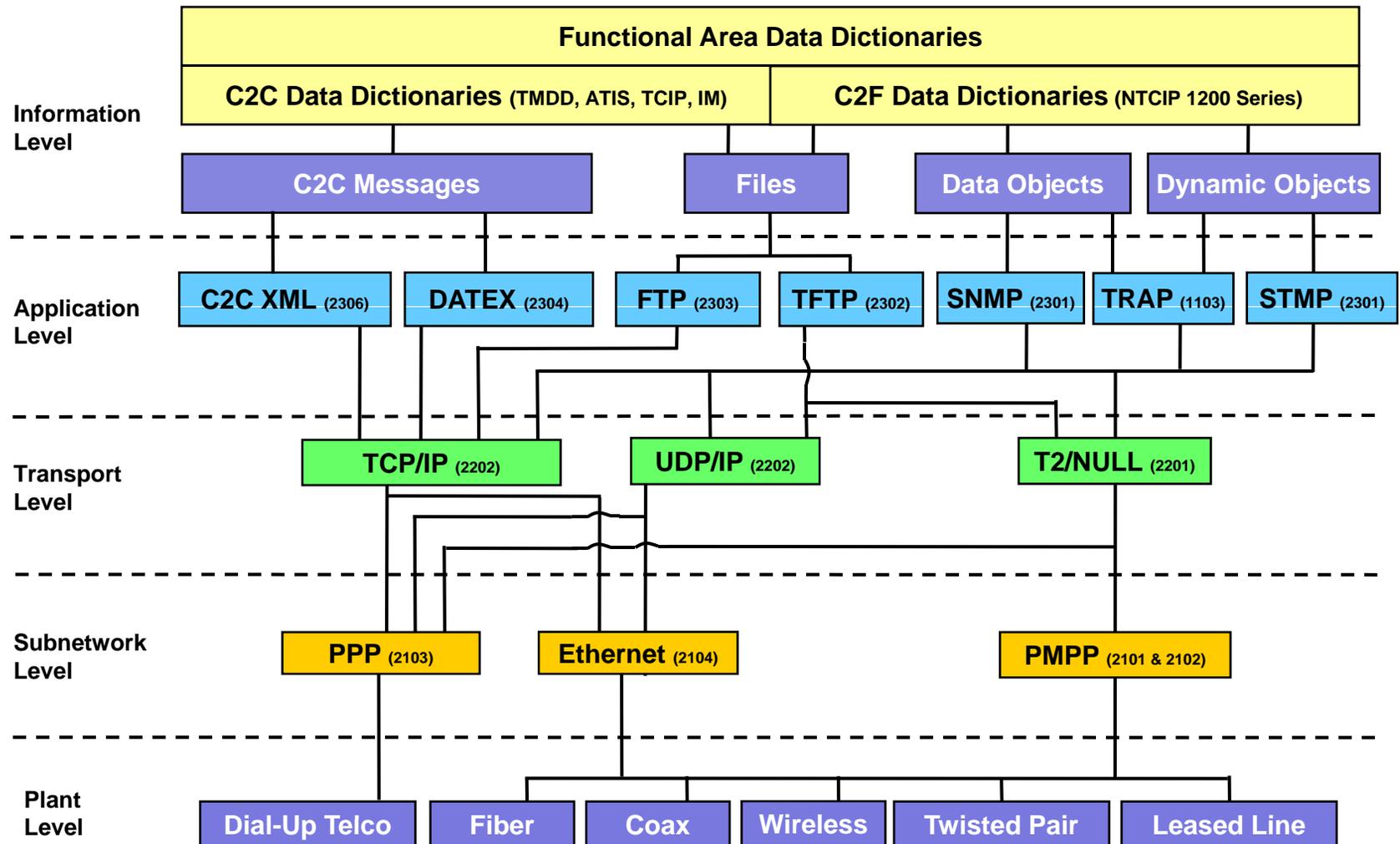
*Agent – Field Device
(Out Station)*

NTCIP Concepts and Benefits

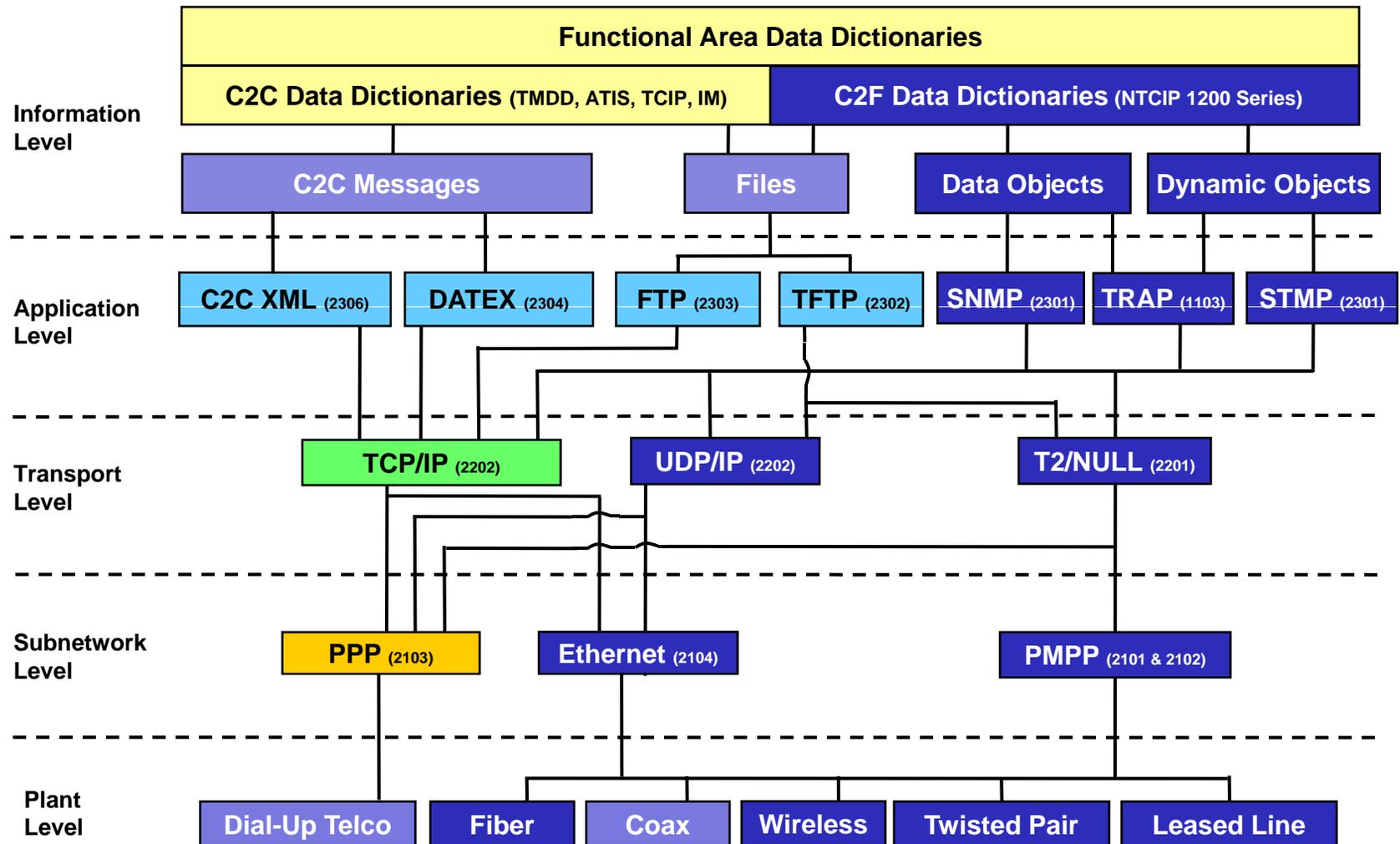
- ▶ Provides a choice of manufacturer
 - ▷ Supports interoperability of manufacturer's equipment when specifications are based on the NTCIP
- ▶ Phased/incremental procurement and deployment
- ▶ Different types of devices can communicate on a single communications network
- ▶ Enables interagency coordination and sharing of devices



NTCIP Framework



NTCIP Framework



PROTOCOL STANDARDS

2300 Series Application Profile Standards

Standard Number	Where Used	Standard
NTCIP 2301	C2F	Simple Network Management Protocol (SNMP)
NTCIP 2301	C2F	Simple Transportation Management Protocol (STMP)
NTCIP 2302	C2F	Trivial File Transfer Protocol (TFTP)
NTCIP 2303	C2F & C2C	File Transfer Protocol (FTP)
NTCIP 2304	C2C	Data Exchange (DATEX)
NTCIP 2306	C2C	XML-based Web Services (C2C XML)

C2F = Center-to-Field

C2C = Center-to-Center

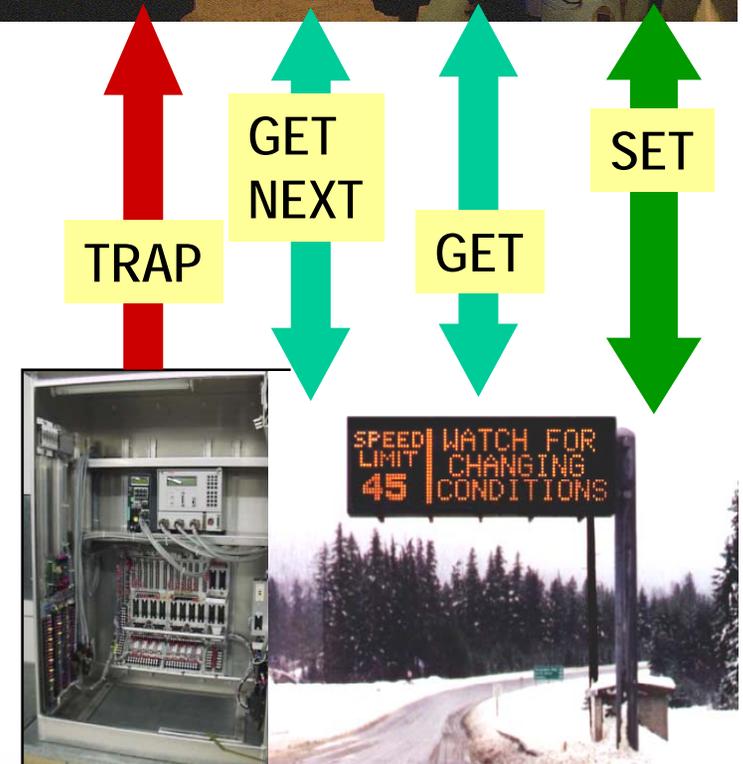
NTCIP 2301

- ▶ NTCIP-2301 AP-STMf (Application Level - Standard Transportation Management Framework):
 - ▷ Mechanism to exchange data independent of equipment or vendors
 - ▷ Refers to two base standards
 - ▷ SNMP – Simple Network Management Protocol
 - ▷ STMP – Simple Transportation Management Protocol
 - Developed for ITS applications

- ▶ **WARNING:**
 - ▷ Only SNMP is used for Most Devices

Simple Network Management Protocol (SNMP)

- ▶ **SET** command manipulates or stores values of an object
- ▶ **GET** reads the value of an object
- ▶ **GET NEXT**-reads more values – to step through all objects
- ▶ **TRAP**-reports unexpected event to central



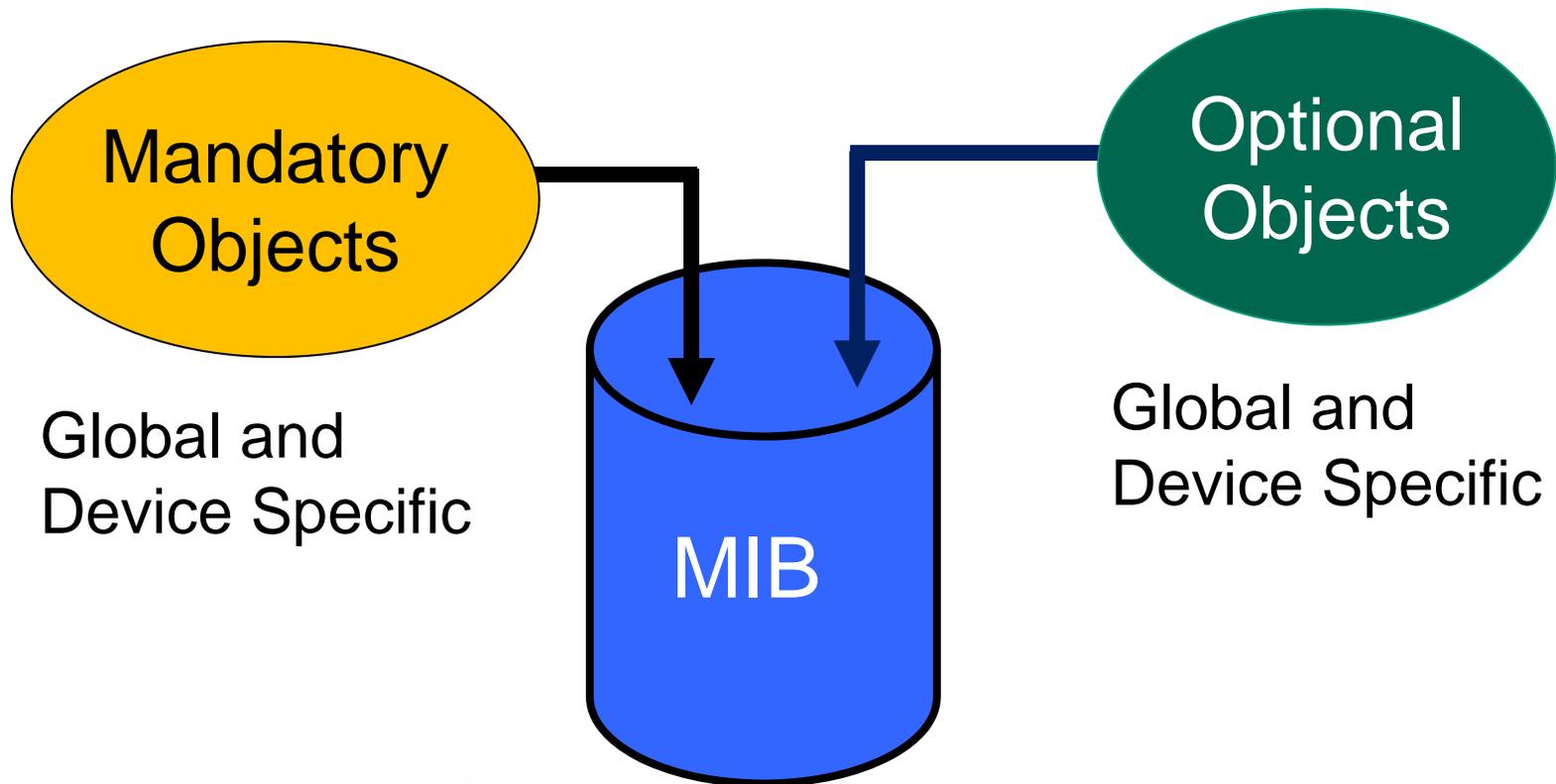
NTCIP 1103

- ▶ Identifies SNMP Operation
 - ▷ Simple Network Management Protocol
- ▶ Identifies STMP Operations
 - ▷ Simple Transportation Management Protocol
 - ▷ Dynamic Objects – efficiency in low bandwidth communications
 - ▶ Typically used for traffic controllers
- ▶ Specifies TRAPS – ***Exception Based Reporting***
 - ▷ Configure field device for real-time reporting
 - ▶ Triggers – “watch blocks” and measurements
 - ▶ Channels – where to report the data
 - ▶ Transmissions – “report blocks”
 - ▶ Supports aggregation – peer-to-peer and multiple TMC’s
- ▶ Event Logging Constructs
- ▶ *Note that Simple Fixed Message Protocol (SFMP) is not used.*

Management Information Base (MIB)

To comply with NTCIP, mandatory object Must be Required

User Must Specify Optional Needs and value ranges



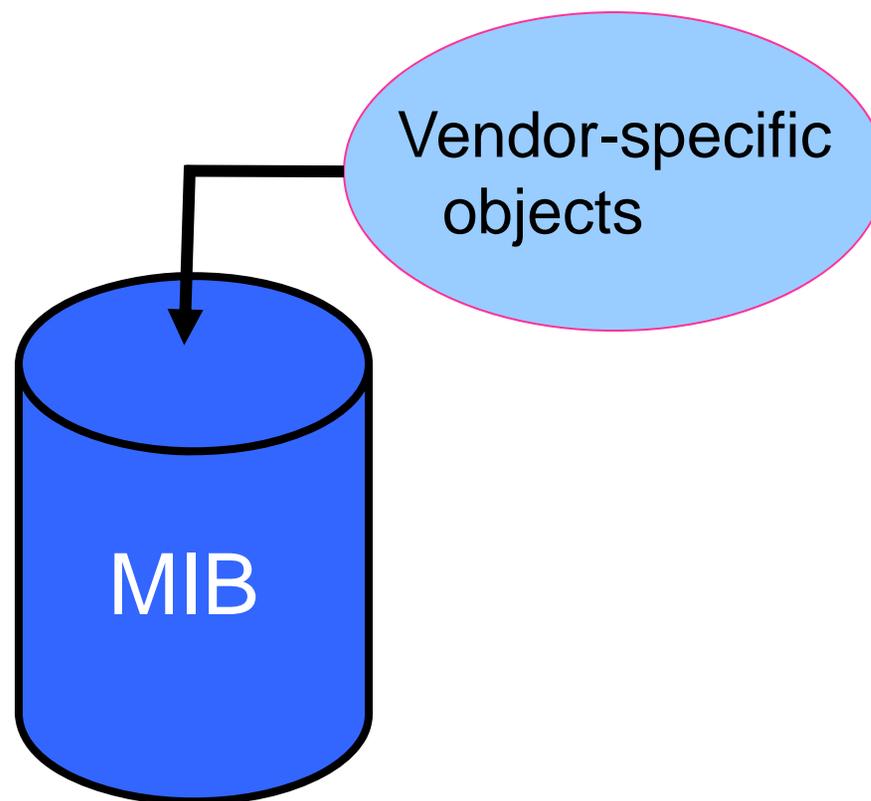
Implementation Specific Extensions

▶ Vendor/Agency-specific objects

CAUTION!

This approach may add hidden costs, risks, complexity in system integration, and higher maintenance for proprietary features

- 1. Insure that MIB is public/not proprietary**
- 2. All functionality must be fully specified**



Object Structure

dmsNumPermanentMsg	OBJECT-TYPE	Value
SYNTAX	INTEGER (0...65535)	e.g. 40
ACCESS	read-only	messages
STATUS	mandatory	

DESCRIPTION

"<Definition> Indicates the current number of Messages stored in nonvolatile, non-changeable memory (e.g., EPROM). For CMS and BOS, this is the number of different messages that can be assembled. See the Specifications in association with Requirement 3.5.6.1 to determine the messages that must be supported.

<Unit>message

<Object Identifier> 1.3.6.1.4.1.1206.4.2.3.5.1"

::={dmsMessage 1} ← Object Identifier

CONTENT STANDARDS

NTCIP 12XX Series Standards

NTCIP 1200 Series Information Level Standards (Data Dictionaries and Dialogs)

Standard Number	Device
NTCIP 1201	Global Objects (GO)
NTCIP 1202	Actuated Signal Controller (ASC)
NTCIP 1203	Dynamic Message Signs (DMS)
NTCIP 1204	Environmental Sensor Station (ESS)
NTCIP 1205	Closed Circuit Television Camera (CCTV)
NTCIP 1206	Data Collection (DCM)
NTCIP 1207	Ramp Meters (RM)
NTCIP 1208	Video Switch (VS)
NTCIP 1209	Transportation Sensor Systems (TSS)
NTCIP 1210	Field Management Station (FMS)
NTCIP 1211	Signal Control and Prioritization (SCP)
NTCIP 1214	<i>Dev: Cabinet Monitoring Systems</i>

NTCIP 1201 – Global Objects Definitions

- ▶ Common data elements for all field devices
 - ▷ Configuration
 - ▷ Time management
 - ▶ Includes Daylight Savings Parameters
 - ▷ Database management
 - ▷ Scheduled events
 - ▷ Reports
 - ▷ Auxiliary inputs / outputs

NTCIP 1202 – Actuated Traffic Signal Controllers (ASC)

- ▶ Data elements for controlling, managing and monitoring actuated traffic signal controller units
 - ▷ Phases
 - ▷ Detectors
 - ▷ Special functions
 - ▷ Coordination
 - ▷ Time based operations
 - ▷ Overlaps
 - ▷ Preempts
 - ▷ Etc.



*Based on operation described in
NEMA TS2-2003 Standard*

NTCIP 1203 – Dynamic Message Signs (DMS)

- ▶ Covers all Types of Signs - ***Widely Deployed***
- ▶ Every US vendor supports – *and many foreign*
- ▶ Sign Functions include:
 - ▷ Configuration
 - ▷ Message table
 - ▷ Sign control
 - ▷ Message control
 - ▷ Mark-Up Language for Transportation Information (MULTI) format
 - ▷ Illumination / brightness control
 - ▷ A variety of status monitoring of auxiliary equipment
 - ▷ Color and graphics



NTCIP 1204 – Environmental Sensor Systems (ESS)

- ▶ Data elements for describing ambient weather conditions and pavement conditions
 - ▷ Wind
 - ▷ Temperature
 - ▷ Humidity and precipitation
 - ▶ Rain
 - ▶ Snow
 - ▶ Ice
 - ▷ Solar radiation
 - ▷ Air quality
 - ▷ Etc.

*NTCIP Standard for
Roadway Weather
Information Stations (RWIS)*

NTCIP 1205

Closed Circuit Television Camera Control

- ▶ Data elements for controlling closed circuit television cameras
 - ▷ Pan, Tilt, Zoom (PTZ)
 - ▷ Iris
 - ▷ Focus
 - ▷ Labels
 - ▷ Control of auxiliary camera and enclosure devices

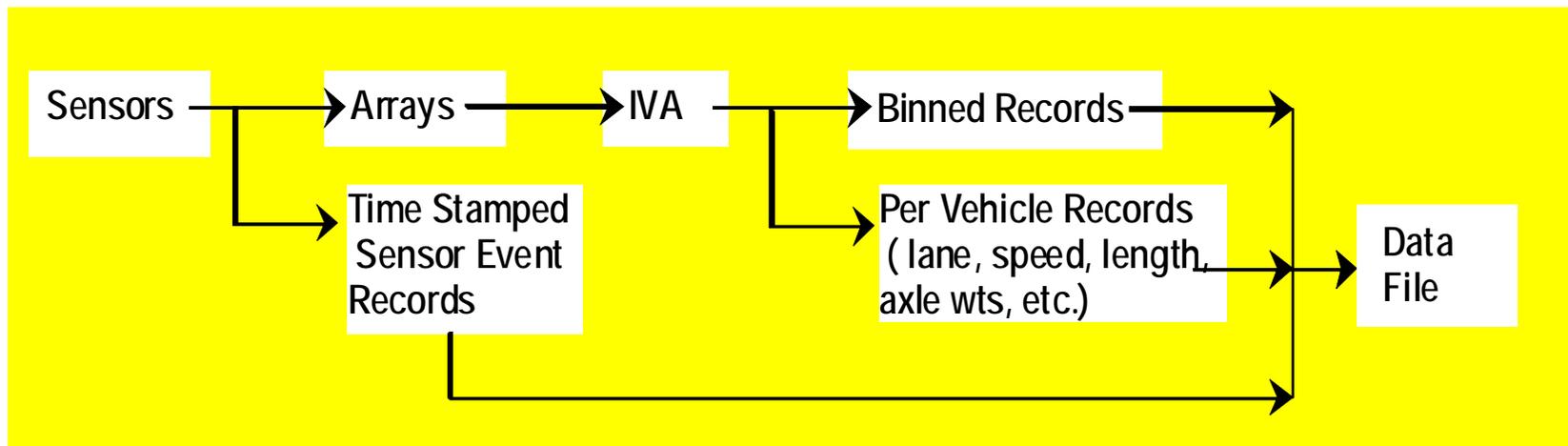


Supported by multiple vendors

NTCIP 1206

Data Collection & Monitoring (DCM)

- Configuration of remote monitoring stations
- Objects to support recording and uploading (or real time transfer) of collected data
- Includes individual vehicle information
- Includes aggregation into “bins” and files



NTCIP 1207 – Ramp Meter Control

- ▶ Data elements for controlling, managing, and monitoring signal devices used to manage access to freeways
 - Configuration
 - Traffic responsive
 - Metered lane
 - Scheduling
 - Physical inputs & outputs

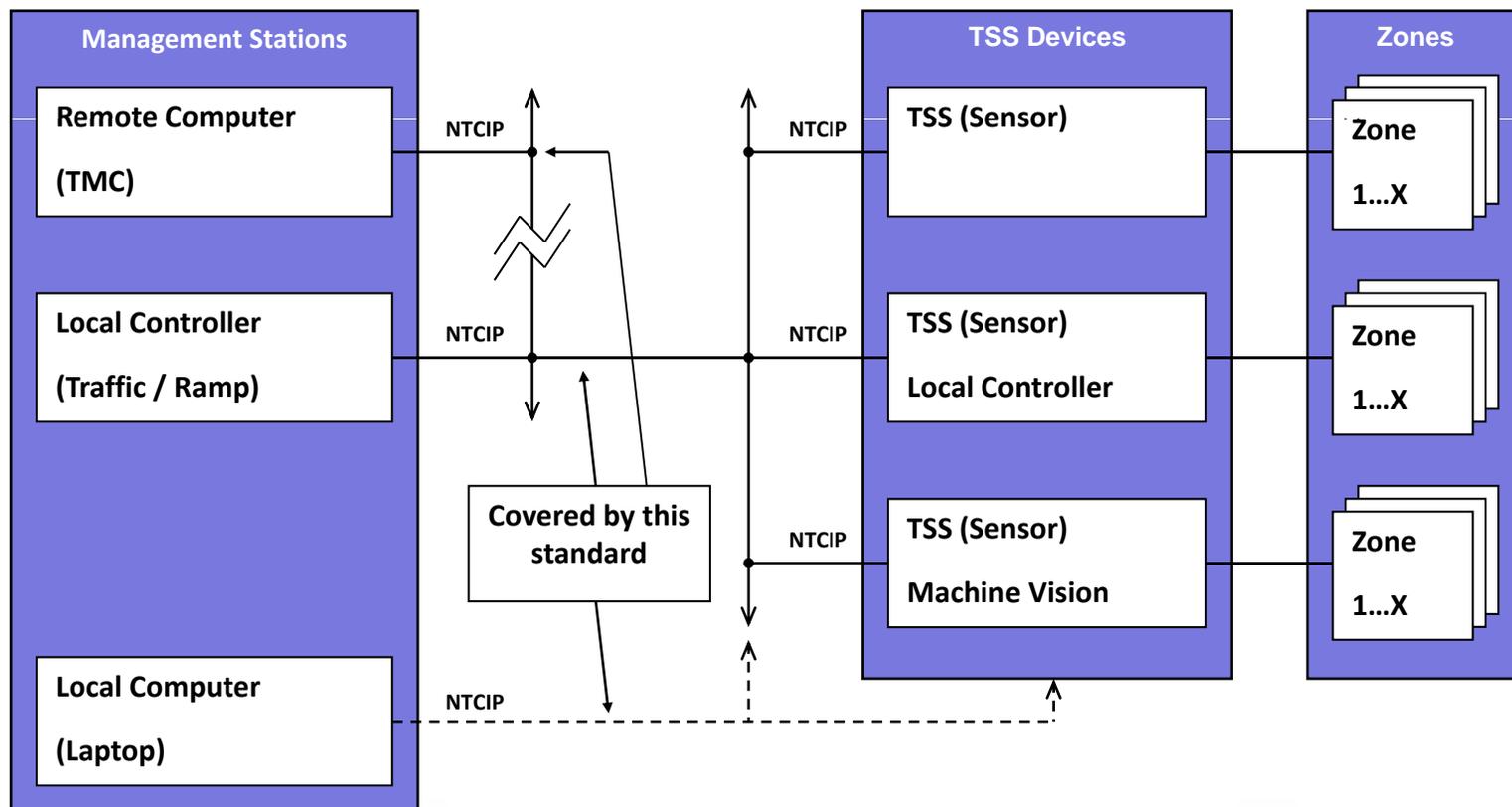


NTCIP-1208 Video Switching

- ▶ Data elements for video switch control and status monitoring
- ▶ Considered necessary where remote video switching was required to support limited bandwidth.

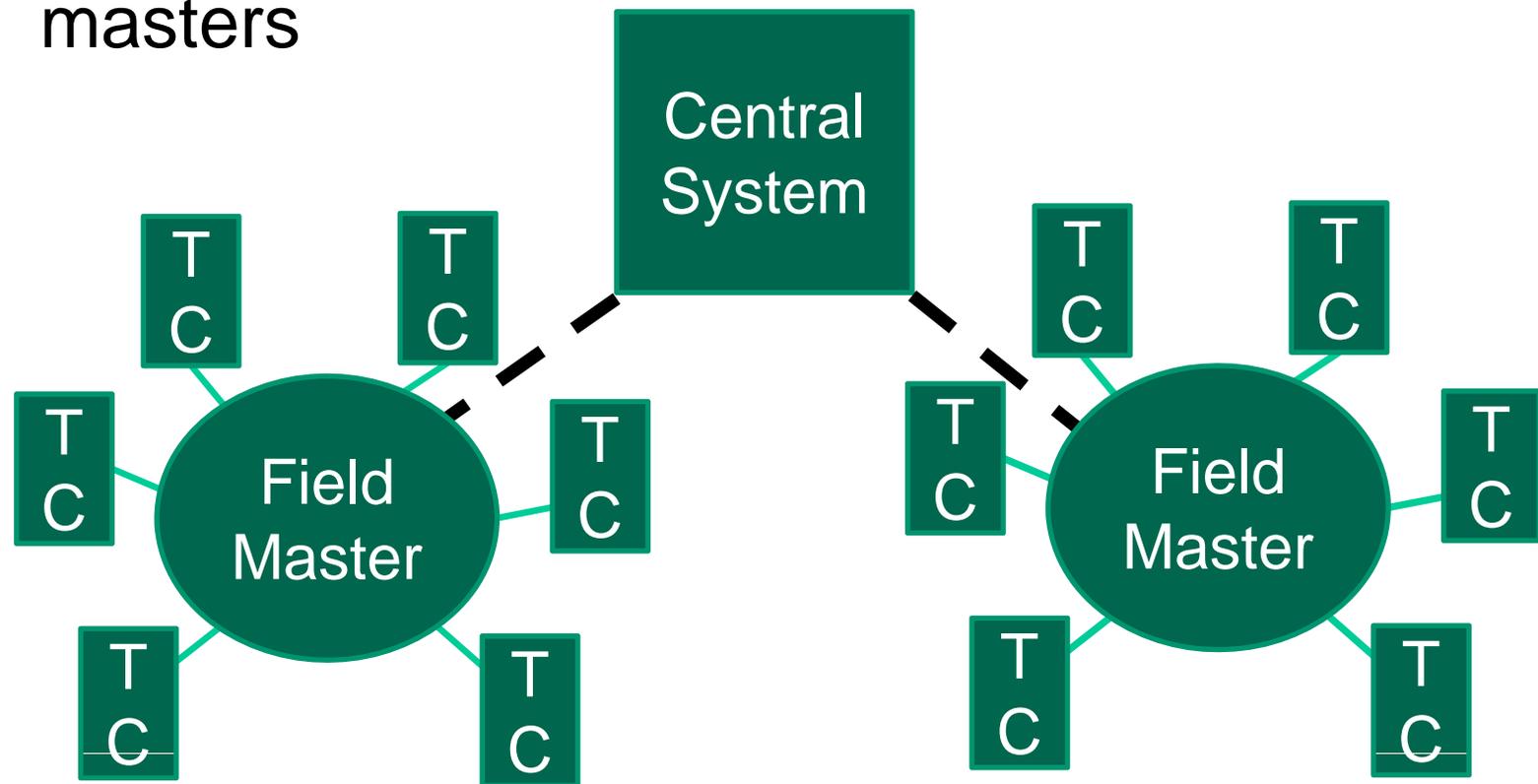
NTCIP 1209 – Transportation Sensor Systems (TSS)

- ▶ Data elements for detection systems
- ▶ *Configuration of Traffic Monitoring Stations*



NTCIP 1210 – Signal System Masters

- ▶ History – distributed masters
- ▶ Data elements for “closed-loop” signal masters



NTCIP 1211 – Signal Control Priority

- ▶ Data elements for vehicle priority at signalized intersections
- ▶ Configuration, status, and control information
- ▶ Requests for priority or preferential treatment of different classes of vehicles:
 - ▷ Transit
 - ▷ Emergency service
 - ▷ Commercial fleet vehicles

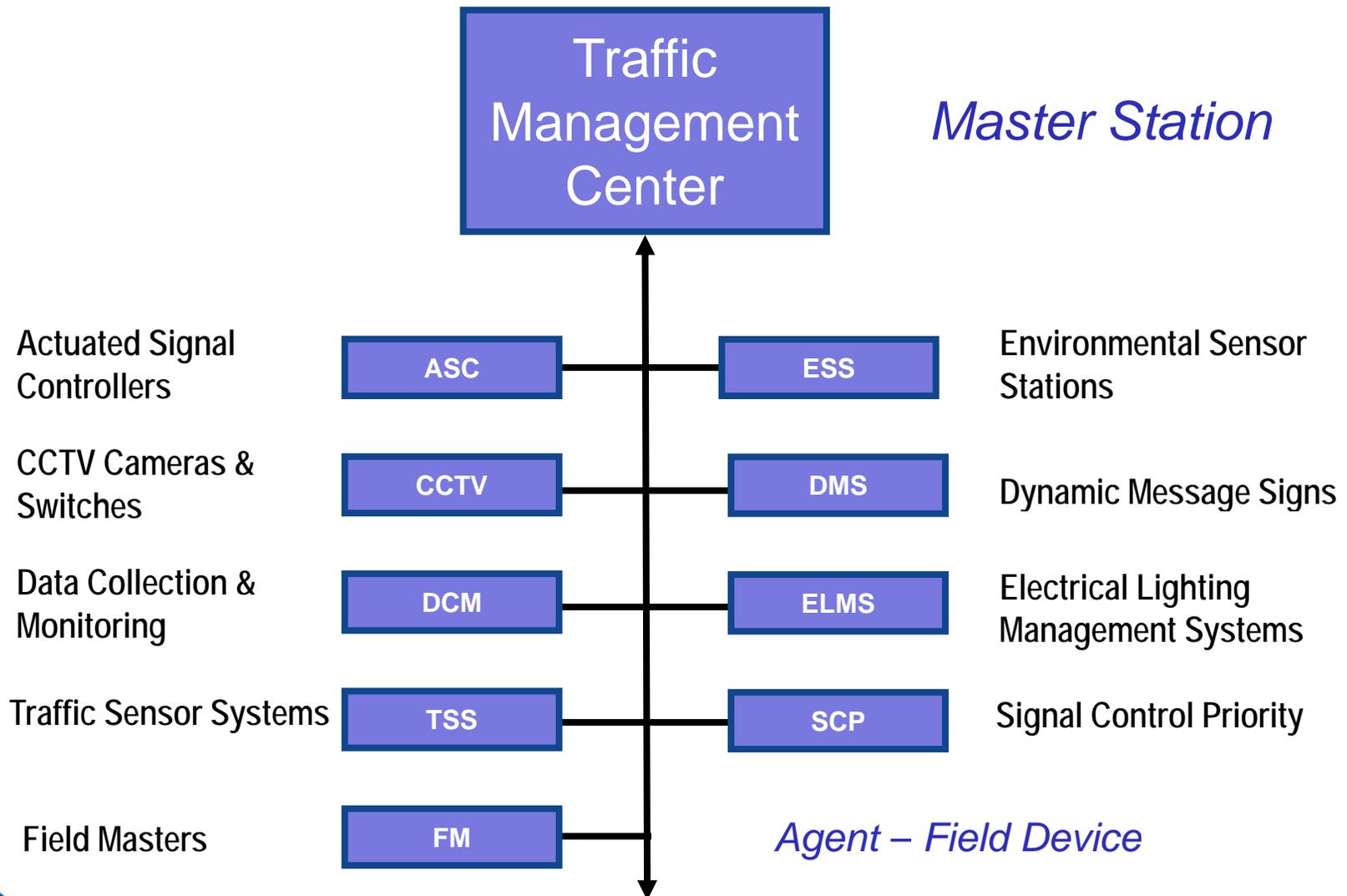
This is undergoing some changes to reflect distributed processing

NTCIP 1213

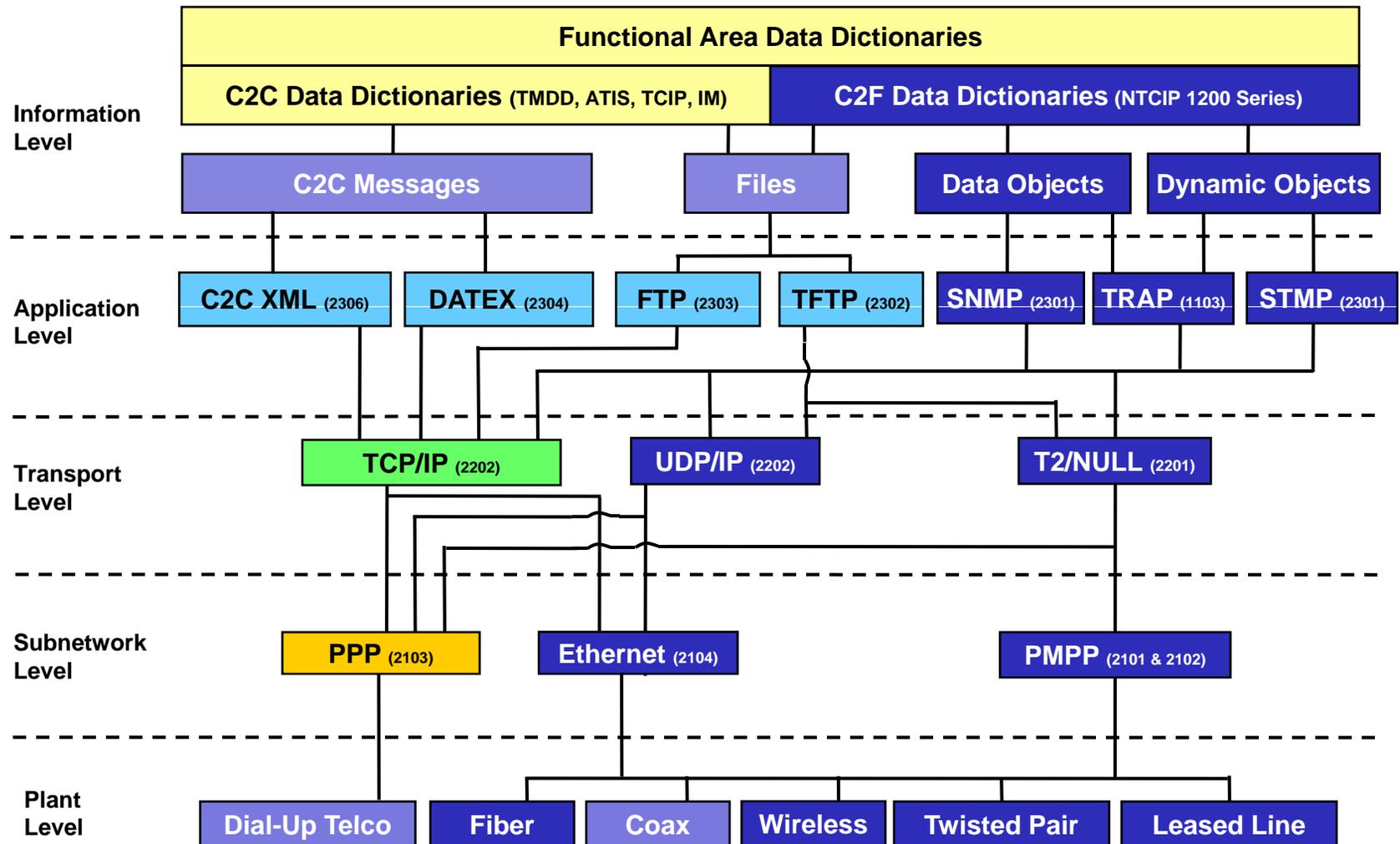
Roadside Electrical and Lighting Management System (ELMS)

- ▶ Parameters represent the configuration, status, and control information
- ▶ Some agencies modify lighting to manage incident clearance.

Recap- NTCIP Center-to-Field Standards



Recap - NTCIP Framework



Deployment

- ▶ Virtually every DMS being deployed – NTCIP
- ▶ All US & many foreign Sign Vendors support NTCIP
- ▶ All US Traffic Controller Vendors support NTCIP
- ▶ Ramp Controllers being deployed
- ▶ ESS being widely deployed
- ▶ CCTV cameras being deployed – multiple vendors
- ▶ Most other devices have some deployment - -

- ▶ NTCIP being deployed on a variety of media
 - ▷ Copper, Fiber, 3G, Point-to-point wireless, networked wireless, leased services (DSL, Voice, Cable)
- ▶ STMP widely deployed for traffic controllers (1200 bps media)
- ▶ 1103 Traps – relatively new – Summer 2008
 - ▷ NYC DOT Deployment ~12,000 in process

Adapting NTCIP For Wireless Operation

Reference:

NTCIP 1201 – Global Objects

NTCIP 1202 – Actuated Signal Control Objects

NTCIP 1103 – Traps, STMP, Events, etc

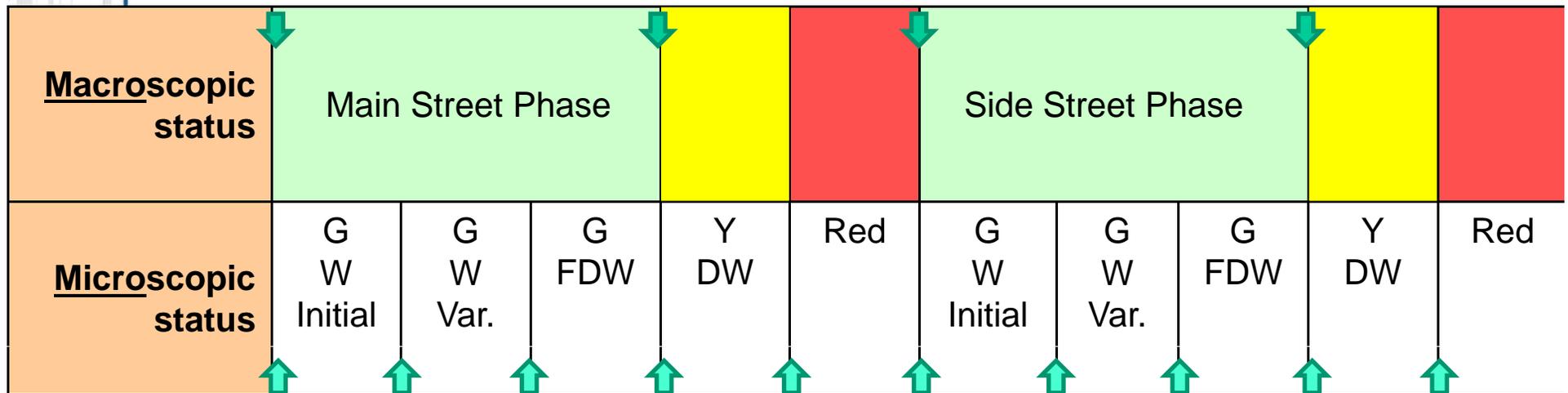
User Needs – For Wireless Operation

- ▶ Maintain **second-by-second** data fidelity
- ▶ **Reduce bandwidth** due to polling and no change responses (~90% wasted bandwidth)
- ▶ Support **configurable monitoring** requirements
- ▶ Compensate for **lost packets and latency**
- ▶ Cope with other channel anomalies

NTCIP Approach – Traps (1103)

- ▶ Use **event table** to establish triggers
 - ▷ Identify objects to watch and transmit
 - ▷ **Watch Blocks** for event monitoring
 - ▷ **Report Blocks** for what to report
- ▶ Establish the concept of “**channels**” to manage the transmission of trap data
 - ▶ Identifies a single management station
 - ▶ Channel Parameters: retries, queue, timeouts, etc.
- ▶ *Standard SNMP to download trap channel configuration parameters*

Status Monitoring – Exception Based Reporting



- ▶ Note the number of Messages/cycle (Typical 32 bytes per message)
- ▶ @ 90 second cycle
 - ▷ 90 STMP GET commands – *once per second status monitor*
 - ▷ 90 Controller Responses = 180 total messages
 - ▷ Change Triggered (i.e. Exception Based Reporting) **95%**
 - ↓▶ Macroscopic – 4 messages/cycle (reduction of 172) – incl. ACK
 - ↑▶ Microscopic – 10 messages/cycle (reduction of 160) – incl. ACK **89%**

Trap Modes

▶ **Acknowledged:**

- ▶ Trap message requires an acknowledgement from the receiving Manager otherwise it is resent (up to **retry limit**)
- ▶ New traps created while waiting can be **queued** for later transmission if configured as such

▶ **Non-acknowledged:**

- ▶ Trap message does not require an acknowledgement
- ▶ Can be queued if desired and link is waiting for an acknowledgement; dropped if link is in error or not to be queued

▶ **Forced:**

- ▶ Trap is transmitted regardless of link state

Data Aggregation

- ▶ Concept: accumulate events (queue)
Until:
 - ▷ Time expires
 - ▷ Size hits limit
 - ▷ **END** event occurs

Features

- ▶ Multiple trap channels can point to the same management station (*i.e. different retry counters and channel parameters can be used for the same management station*)
- ▶ “Events” can be sent *through* multiple channels (*i.e. the same trap data can be sent to multiple management stations*)
- ▶ Queue for each channel
- ▶ Supports multiple/backup TMCs
- ▶ Eliminates the need to poll

It Works! (7 September 2010)

- ▶ 2,314 intersections “on-line”
- ▶ >95% achieve 98% or > throughput/uptime
- ▶ Was used during the World Congress 2008

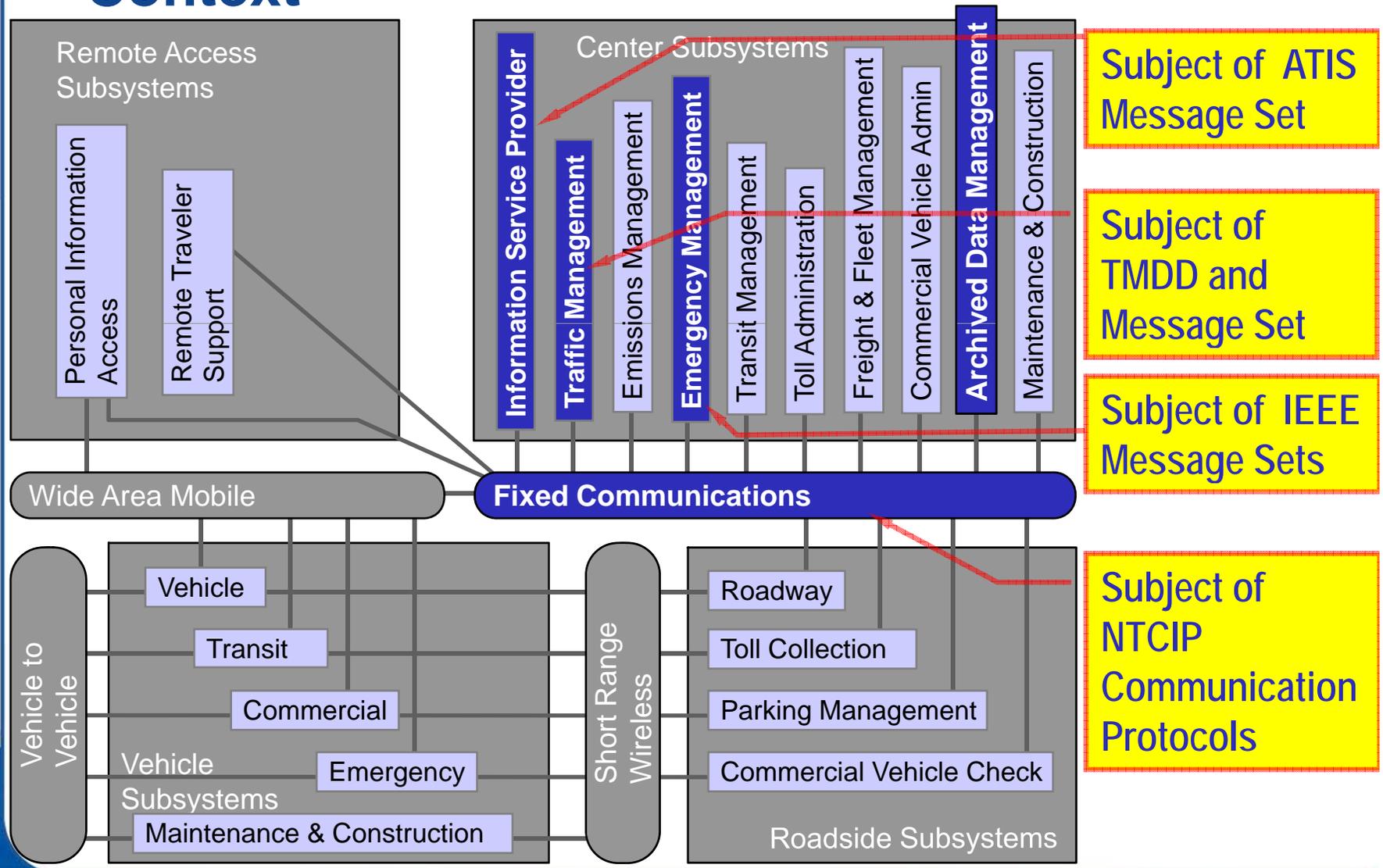
- ▶ Custom wireless network - >400 cell sites
- ▶ Uses VPN tunnels used for security
- ▶ Channels use 2 retries
- ▶ Of the remaining, ~1% do not communicate
 - ▷ Maintenance in process

C2C standards

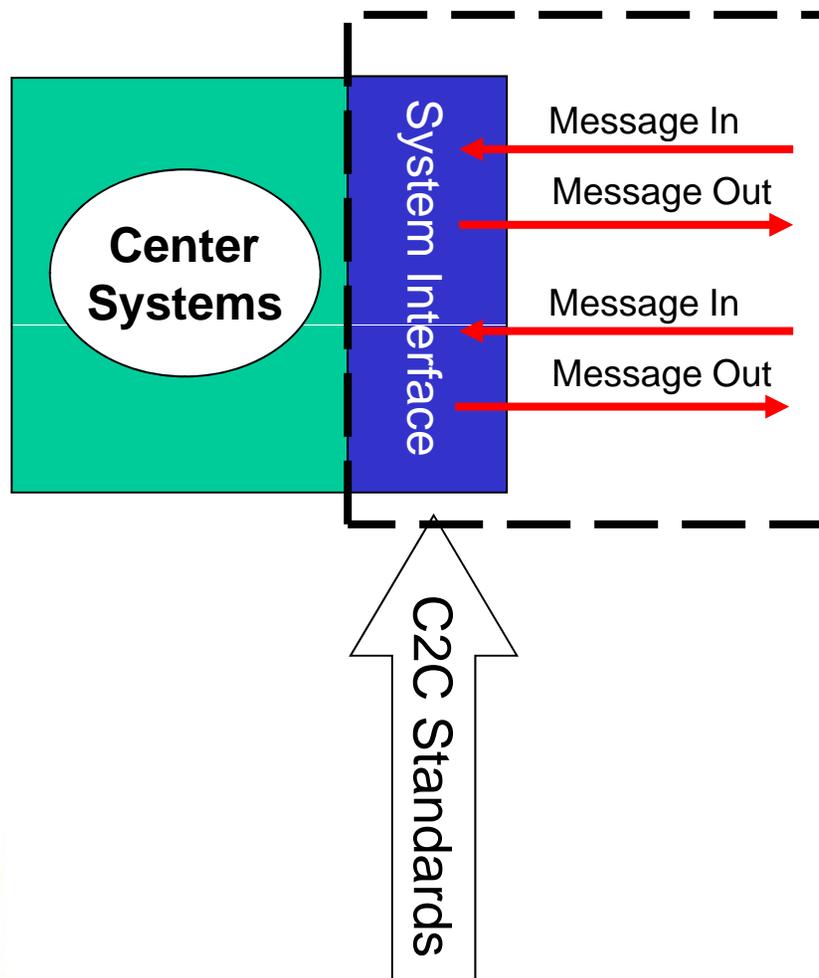
*Including Data Dictionary
and Message Sets*

ITS National Architecture Identified the Links

- Context

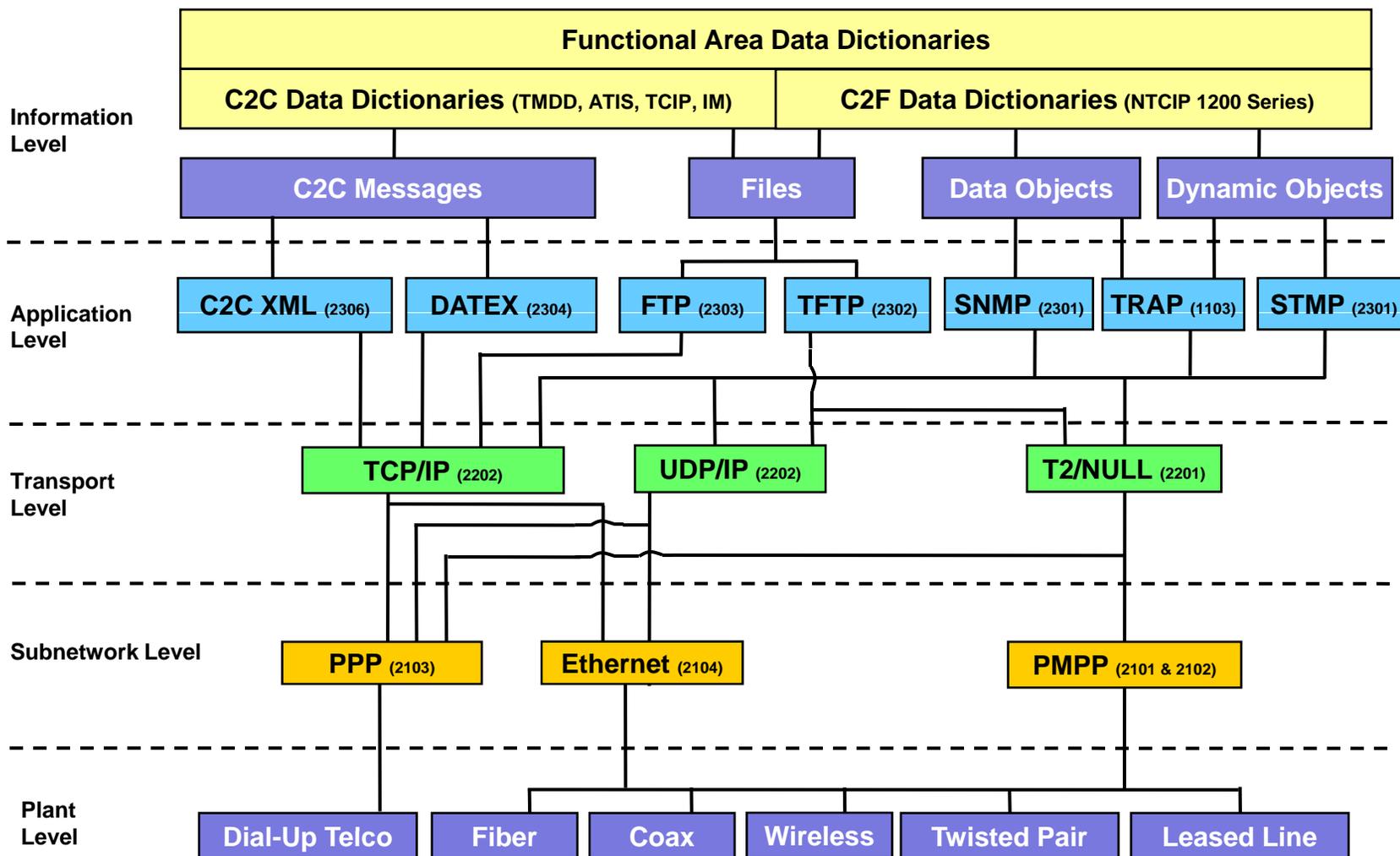


Domain of ITS C2C Standards

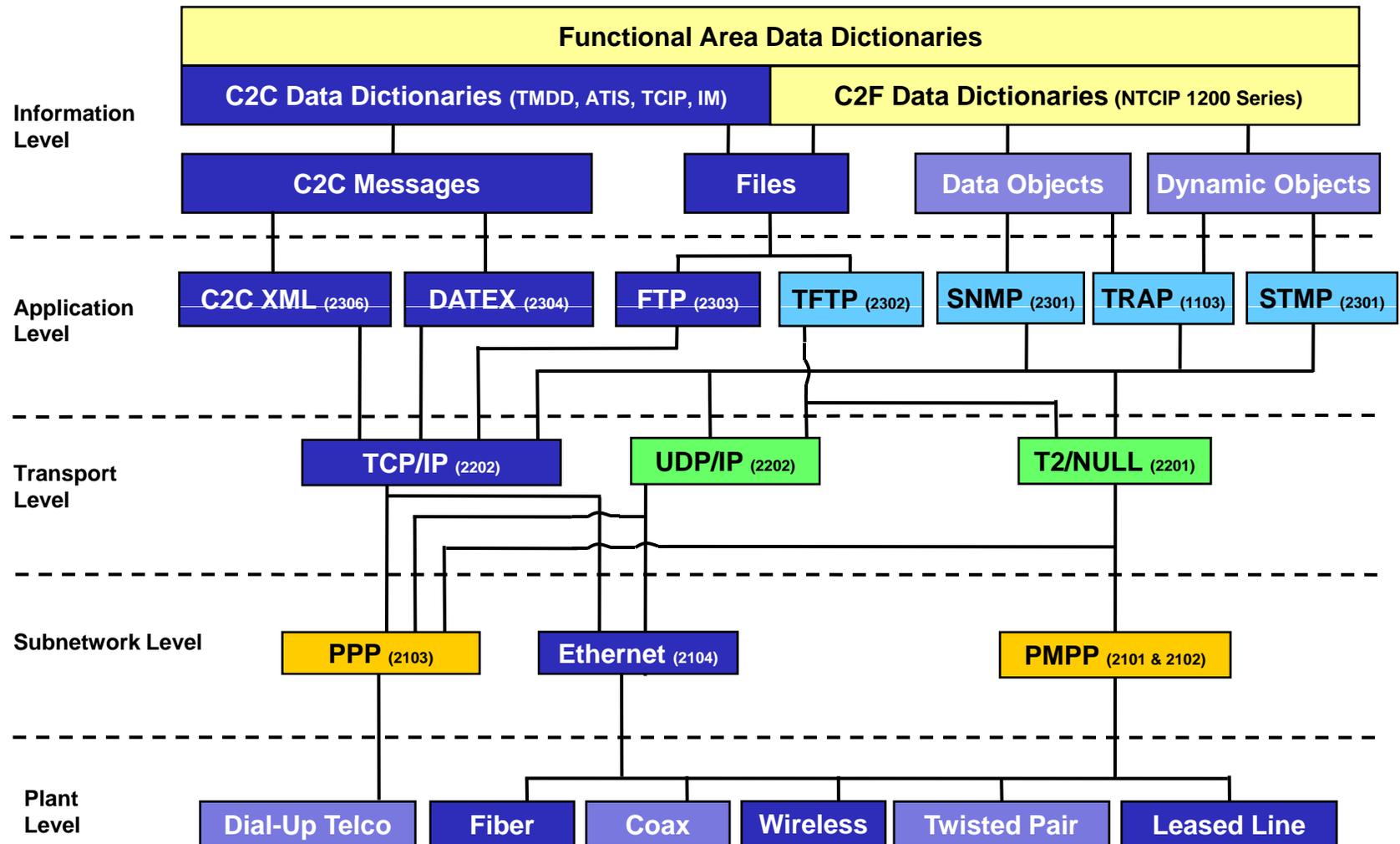


- The standards:
 - Standardize the **dialogs, messages, and data elements**
 - Standardize the interface to the system, **not the system functions**
- Standards were developed at the **national level** and may include information that local systems will not use
- Standards may need to be **supplemented** with additional information (to meet local needs)

NTCIP Framework



NTCIP Framework



The Development Process

Concept of Operations

Why we want our systems to communicate – User Needs



Functional Requirements

The system interaction requirements to meet needs



Data Elements Required

***Information content Standards
TMDD, IM, ATIS, Etc.***

Message Sets Required

Dialogs for the Exchanges



Protocol

Rules or “how” to exchange the information

Why Center-to-Center (Examples)

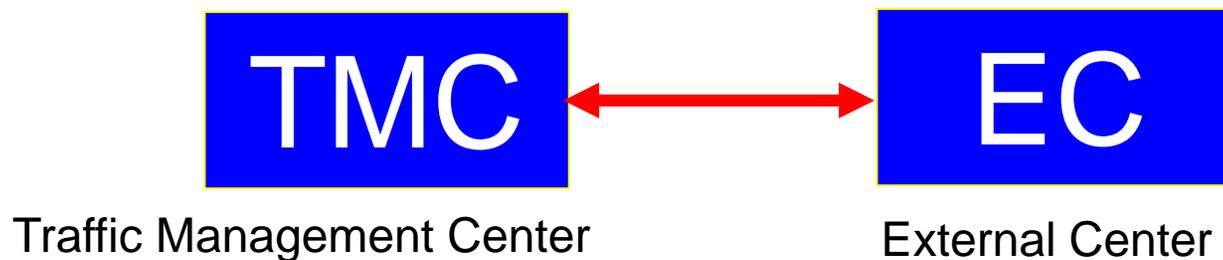
- ▶ Shared access of ITS devices
 - ▷ DMS, ramp meters, gates, CCTV, traffic controllers
- ▶ Cooperative incident and construction management
- ▶ Coordination between freeways and surface streets
- ▶ Cooperative traffic control across jurisdictional boundaries
- ▶ Support regional traffic information services
- ▶ Integrated corridor management
 - ▷ Toll way vs. Freeway, tunnels, bridges, arterials vs. Freeway, public transport
- ▶ Off – hours support for traffic management and infrastructure maintenance

What are the ITS Center-to-Center Standards?

- ▶ **TMDD** – Standard for Traffic Management Center-to-Center Communications
 - ▷ American State and Highway Transportation Officials (AASHTO) & Institute of Transportation Engineers (ITE)
- ▶ **IEEE 1512** – Family of data dictionaries for information exchanges between public safety centers and traffic management centers
 - ▷ Institute of Electrical and Electronics Engineers (IEEE)
- ▶ **SAE-J2354** - Advanced Traveler Information System Message Set (ATIS)
 - ▷ Society of Automotive Engineers (SAE)
- ▶ **NTCIP C2C** – AP-DATEX & AP-C2CXML
 - ▷ National Transportation Communications for ITS Protocol (NTCIP)
- ▶ **TCIP** – Transit Communications Interface Profiles
 - ▷ American Public Transportation Association (APTA)

Overview of Traffic Management Data Dictionary (TMDD Version 3.0)

Standards for Traffic Management Center-to-Center Communications



TMDD C2C Supported Operations

- ▶ TMDD identifies the **operational needs (from the concept of operations)**
 - ▷ **Manage assets** and other entities
 - ▷ **Manage information**
 - ▷ **Monitor status**
 - ▷ **Control devices**

High Level Requirements

- ▶ The **concept of operations** is translated into detailed **functional requirements**

Example to support remote sharing of DMS:

- ▷ DMS inventory information
- ▷ DMS status information
- ▷ DMS control requests:
 - ▶ Display message request
 - ▶ Cancel message request
 - ▶ Provide message library contents
- ▷ Responses to a DMS request

Dialogs, Message Sets, and Data Elements Deal With:

- ▶ Administration
- ▶ Security
- ▶ Events
- ▶ Network data
 - ▷ Traffic conditions
 - ▷ Weather conditions
 - ▷ Etc.
- ▶ Device status, properties & control messages for:
 - ▷ CCTV
 - ▷ DMS
 - ▷ ESS
 - ▷ GATE CONTROL
 - ▷ Highway advisory radio (HAR)
 - ▷ Lane control signals (LCS)
 - ▷ Ramp meters
 - ▷ Traffic signal control
 - ▷ Traffic detectors
 - ▷ Video switches

Incident Management

IEEE 1512

Emergency Management Center
Data Elements and Message Sets

Functional Area

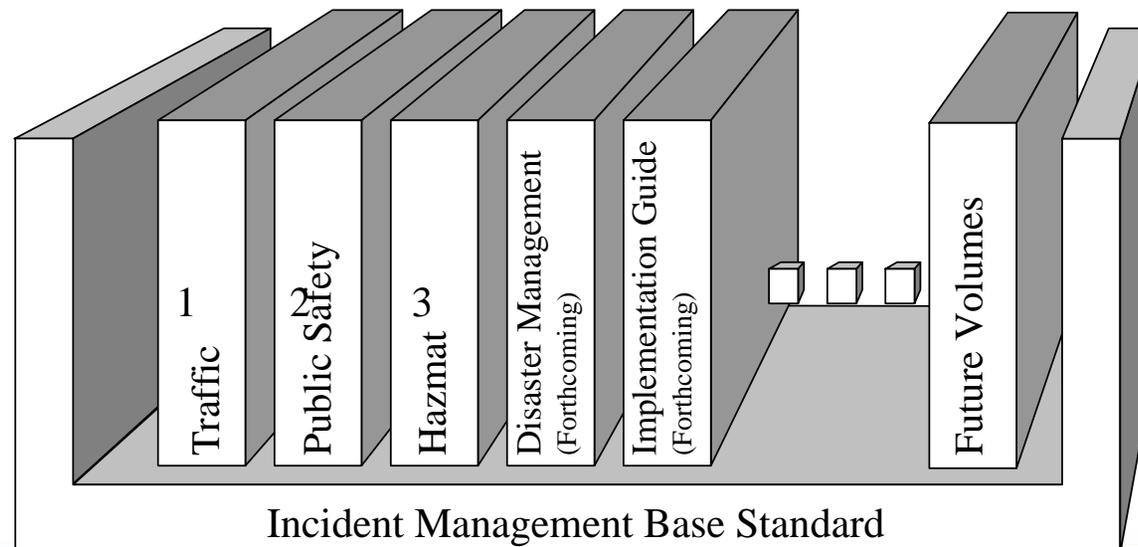
- ▶ Addresses the exchange of data about **transportation-related incidents** among emergency management centers through common incident management message sets
- ▶ Includes **message sets, data frames, and data elements**

1512 - Is a Family of Standards

- ▶ 1512-2006 – Base Standard

Message Sets for:

- ▶ 1512.1 – Traffic Incident Management
- ▶ 1512.2 – Public Safety Incident Management
- ▶ 1512.3 – Hazardous Material Incident Management
- ▶ 1512.4 – Entities External to Centers (e.g. Mobile Units)



Advanced Traveler Information Functional Area – J2354

ATIS Data Elements and Messages
Advanced Traveler Information Systems

Goal: Provide Interoperable Exchange of Traveler Information

- ▶ Inter-organizational exchange of traveler information:
 - ▷ Between agencies within a state
 - ▷ Between states
 - ▷ Between public agencies and private sector
 - ▷ Between Independent Service Providers and client devices
- ▶ Easy re-use, automated processing (for different applications, devices, and transmission media)
- ▶ Information types include:
 - Road construction
 - Congestion
 - Hazards
 - Weather
 - Routing

Types of Information in ATIS

- ▶ Events (planned/construction)
- ▶ Incidents (unplanned events)
- ▶ Road/Link Information (travel times, speeds)
- ▶ Weather Conditions (observations, forecasts, surface weather)
- ▶ Itineraries (driving and/or transit)
- ▶ Flight Information (departure, arrival)
- ▶ Parking (lot availability, reservations)
- ▶ Preference settings (account management)
- ▶ Directory services (Yellow Pages, eCommerce)
- ▶ Mayday (emergency help requests)

Center-to-Center ITS Standards Protocols

How the information is exchanged

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C2C Standards Deployment

There are currently 2 approaches

- ▶ **DATEX** Fixed Messaging Approach (ISO TC204)
[Developed by TC204 WG9 – used in EU]
Deployed in two major areas
 - Transom (Ny, NJ, I-95)
 - San Francisco Bay area

- ▶ **XML** Web Services Messaging Approach

Overview of NTCIP DATEX

*NTCIP 2304
www.ntcip.org*

DATEX Based on ISO Standards

- ▶ Based on ISO Standard 14827 – Parts I and II
- ▶ NTCIP 2304 – Application Profile
 - ▷ Specifies ISO 14827 options to be used in the US
 - ▷ Provides a Profile Requirements List (PRL)
 - ▶ Used in specification development
- ▶ *ISO and CEN are now working on the next generation DATEX*



***Applying Web Services
to ITS Standard Message
Exchanges***

NTCIP 2306
www.ntcip.org

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Definitions

- ▶ WSDL (**W**eb **S**ervices **D**escription **L**anguage) models Web Services
- ▶ SOAP (**S**imple **O**bject **A**ccess **P**rotocol) transports XML content
- ▶ XML Schema is a template for the XML-based messages (the content)

For more information on web services visit the World Wide Web Consortium web site (<http://www.w3.org/2002/ws>) for information about the Web Services Architecture.

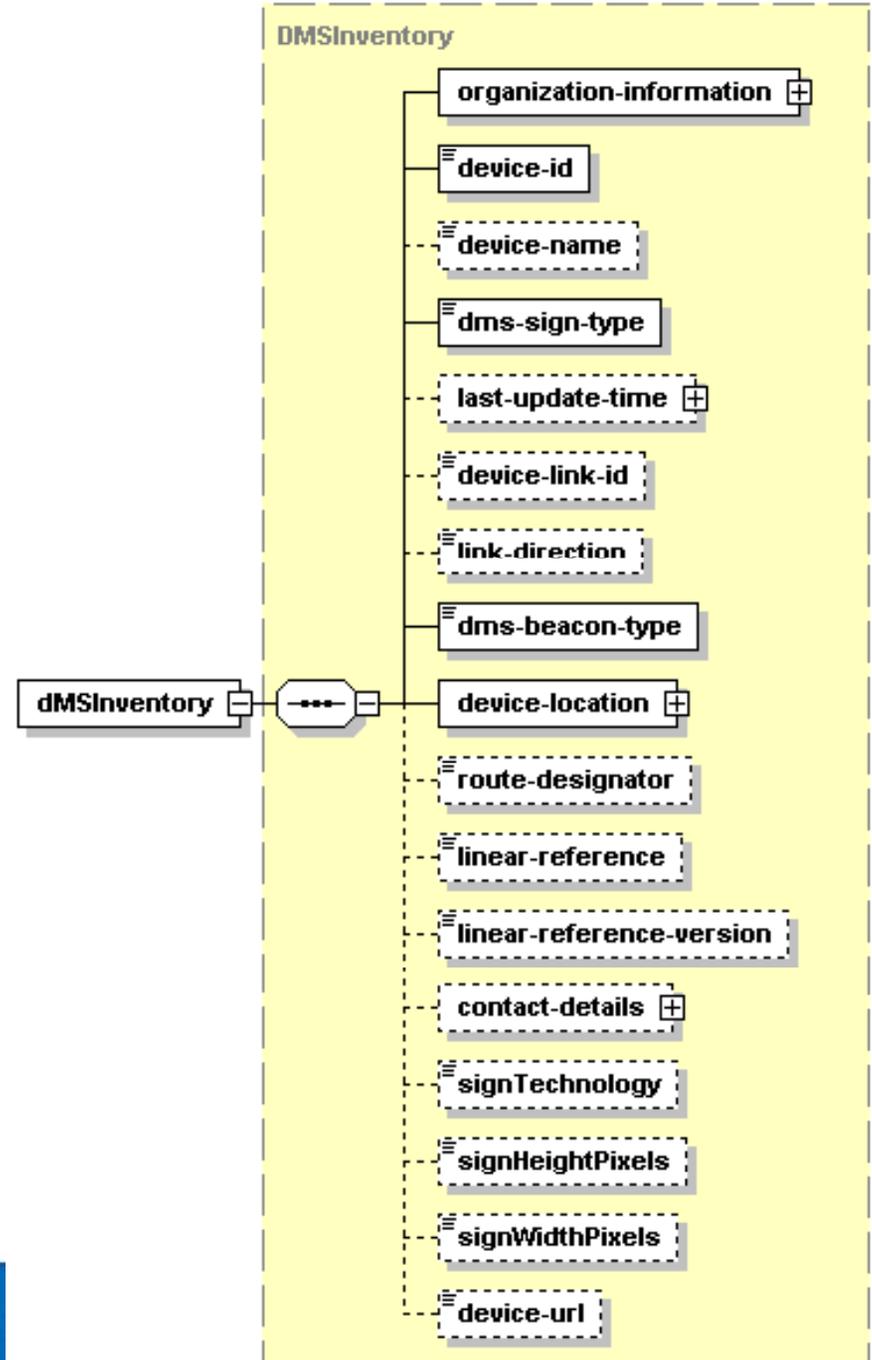
Example C2C XML Message Template

Typical of messages defined in the 1512, ATIS, and TMDD

Legend

mandatory

optional



NTCIP 2306 – Web Services Description, XML Encoding, and Transport

- ▶ Encoding
 - ▷ XML
 - ▷ SOAP
- ▶ Transport
 - ▷ FTP 'GET'
 - ▷ HTTP 'POST' and 'GET'
- ▶ Dialogs
 - ▷ One Way = Supports Bulk Data Transfer (file retrieval by name) **Simple**
 - ▷ Request - Response **Complex**
 - ▷ Subscription - Publication

XML Direct Approach

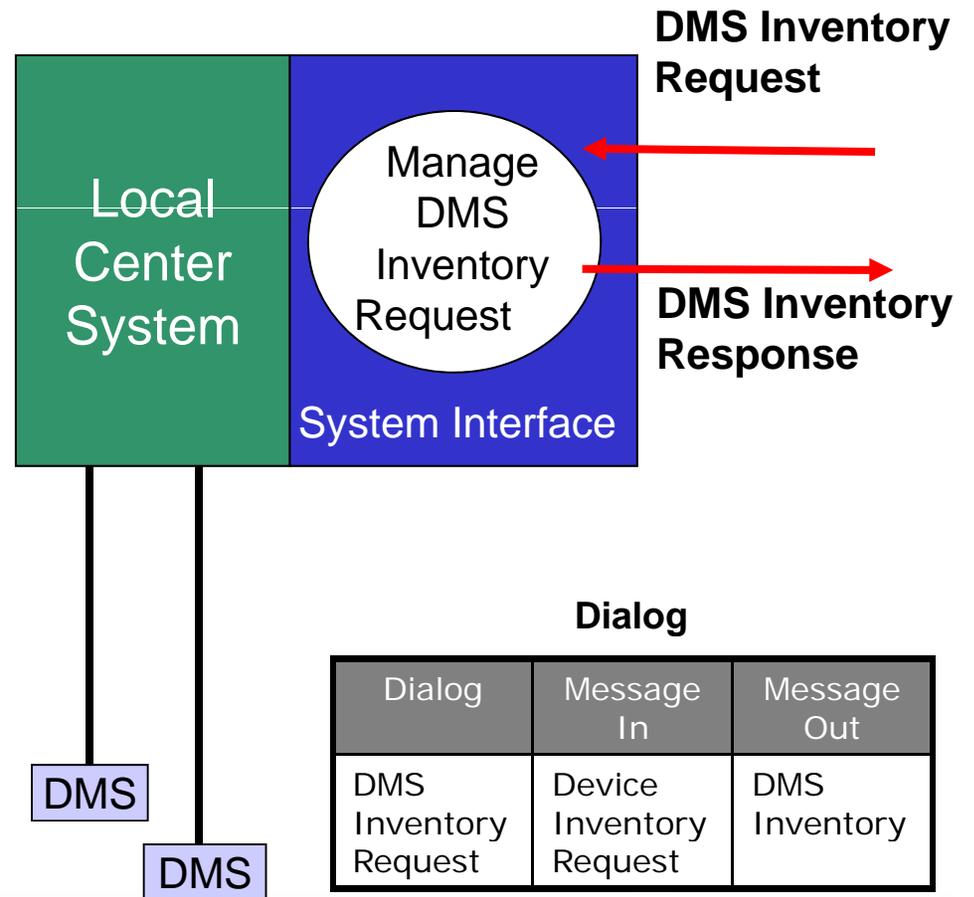
- ▶ XML *Direct* is an NTCIP C2CXML concept.
- ▶ Extends WSDL to support a **file sharing-based approach** for information exchange.
- ▶ Useful for bulk data transfer and simple posting of files on a web server.
- ▶ Files contain XML content
- ▶ Is implemented using FTP and HTTP and is useful for very **loosely** coupled systems

Regional C2C Integration Concept

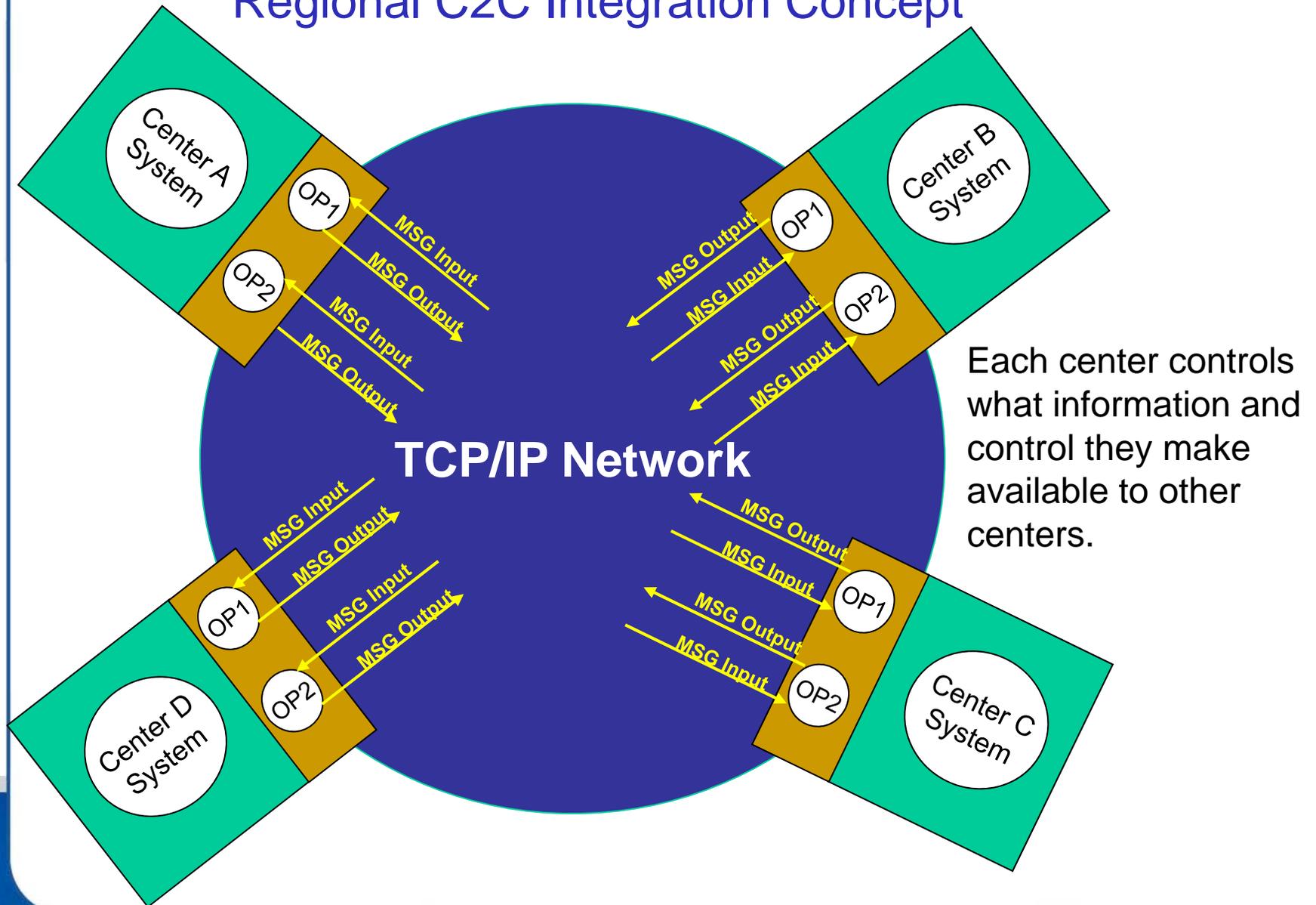
▶ Web Service

- ▶ Function:
 - ▶ Share DMS Inventory
- ▶ Message Input
 - ▶ DMS Inventory Request
- ▶ Message Output
 - ▶ DMS Inventory
- ▶ Message Encoding
 - ▶ SOAP
- ▶ Message Transport
 - ▶ HTTP

Operation: Manage DMS Inventory Request

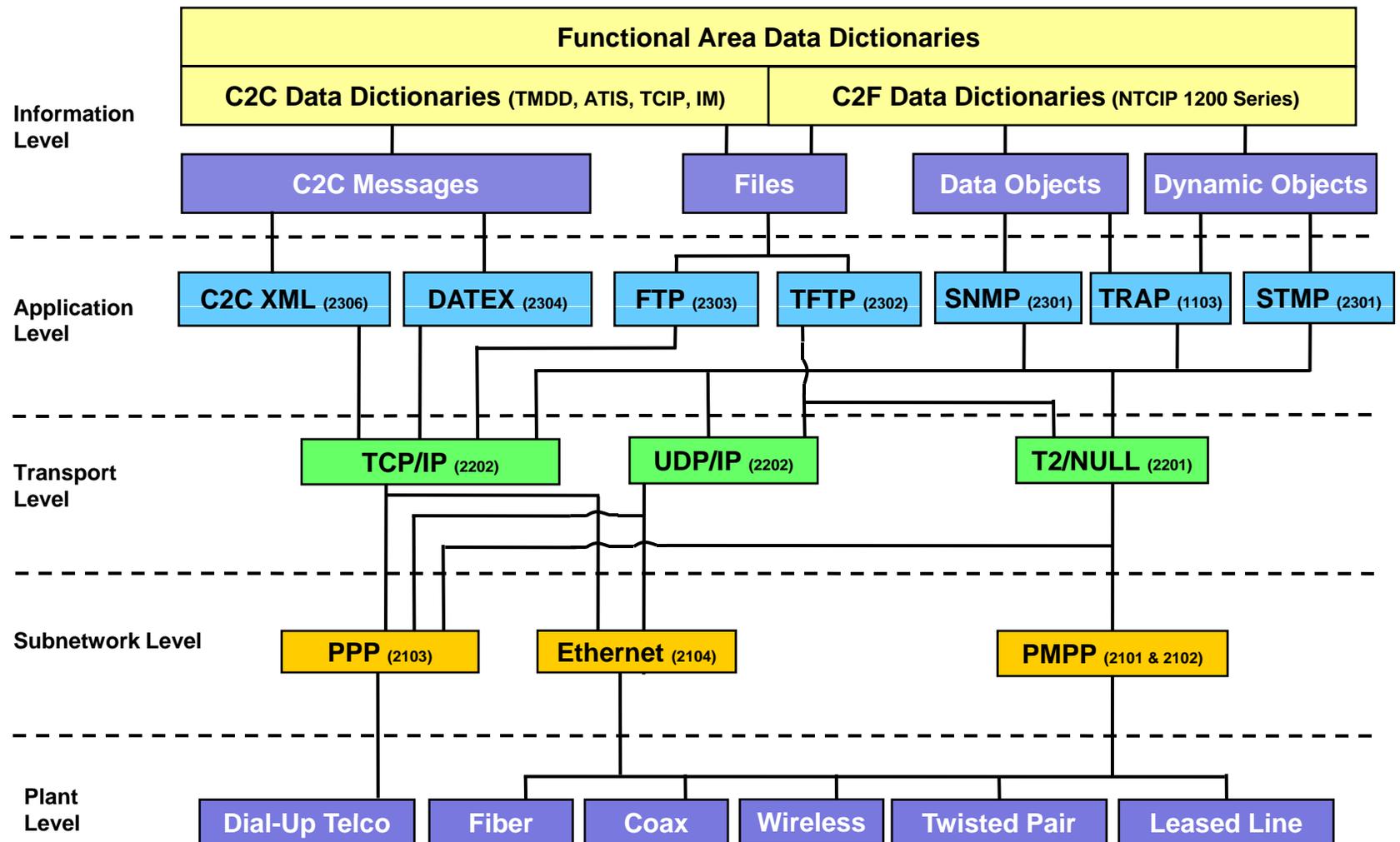


Regional C2C Integration Concept

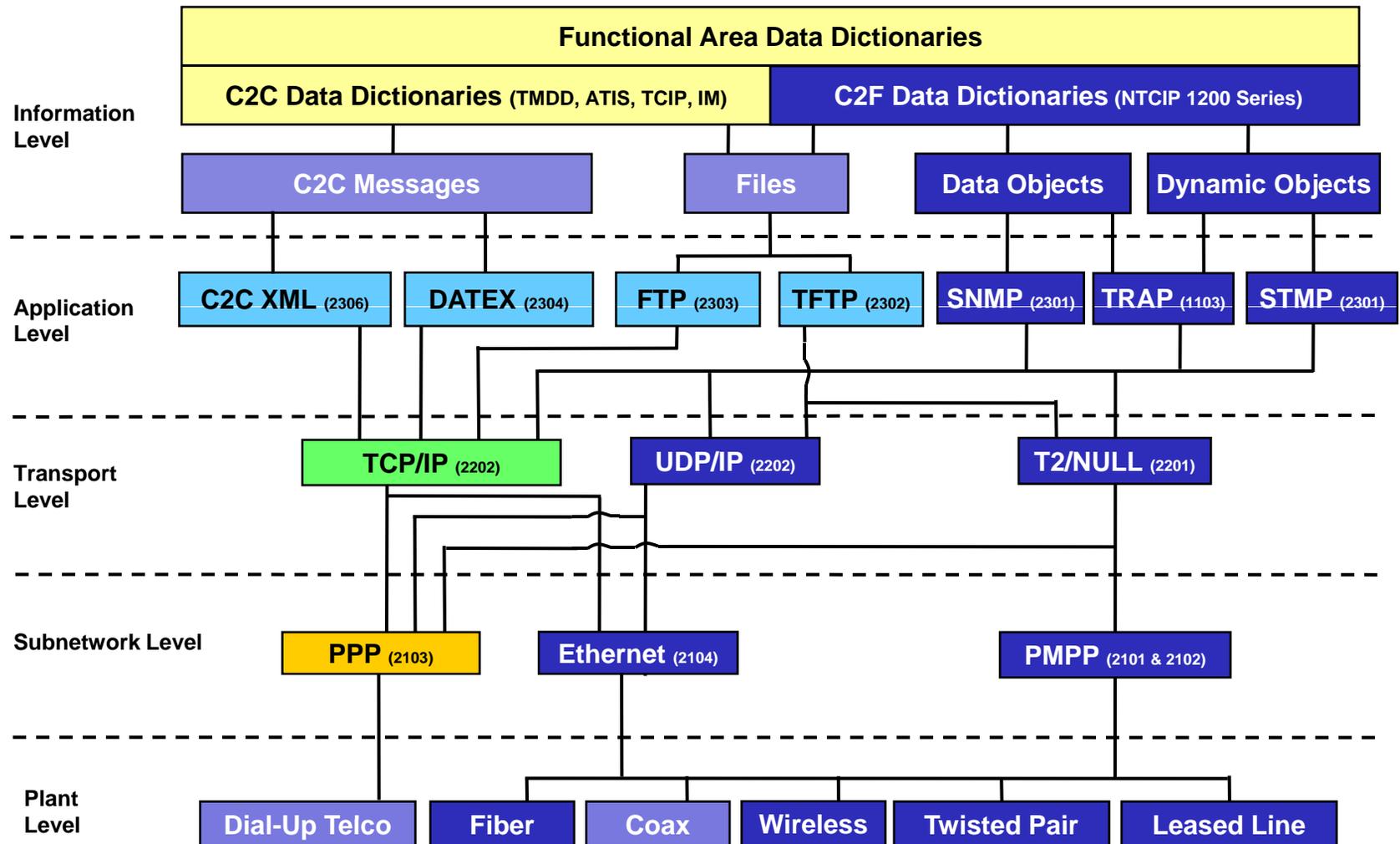


Summary

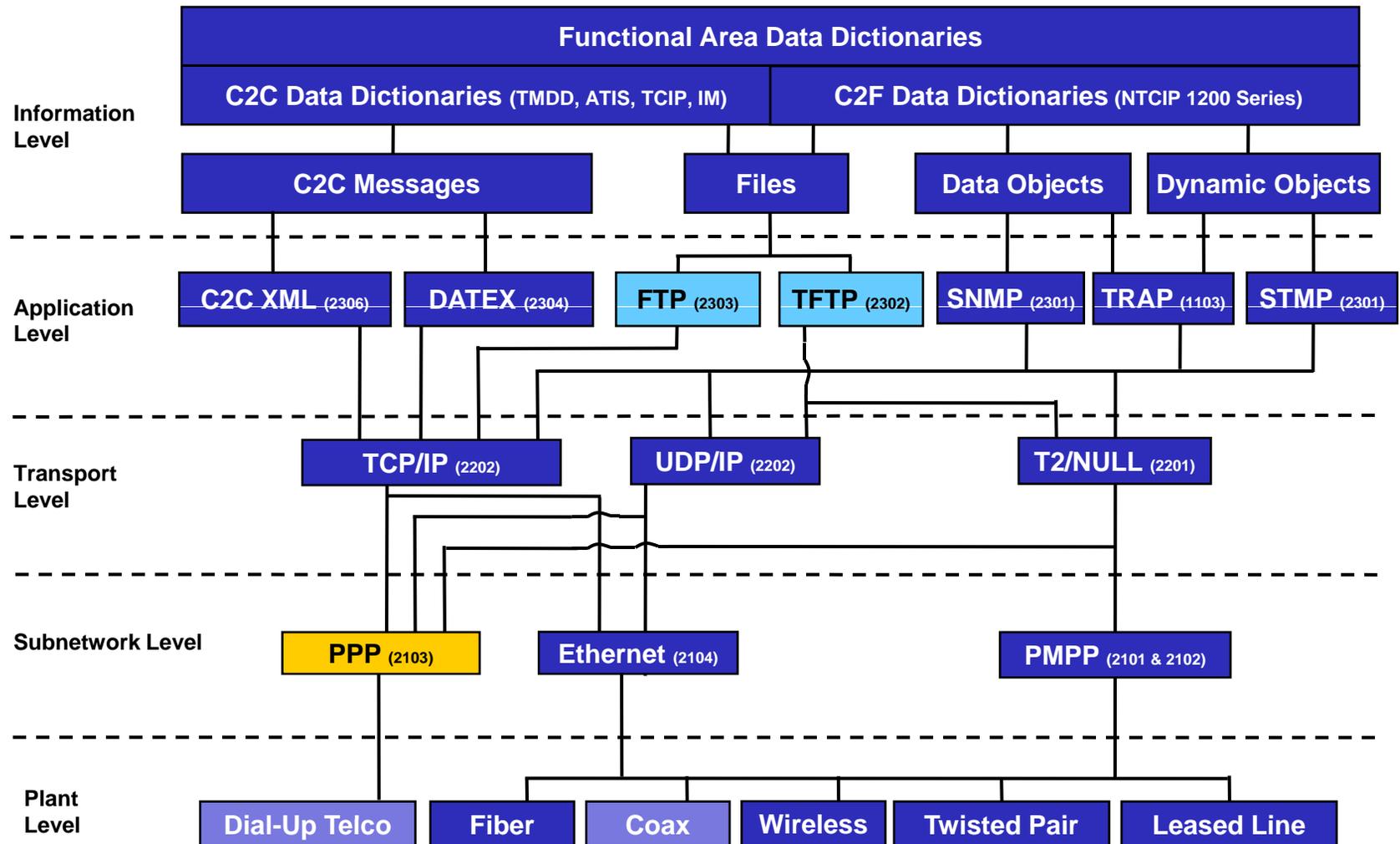
NTCIP Framework



NTCIP Framework



NTCIP Framework



Application of the Standards

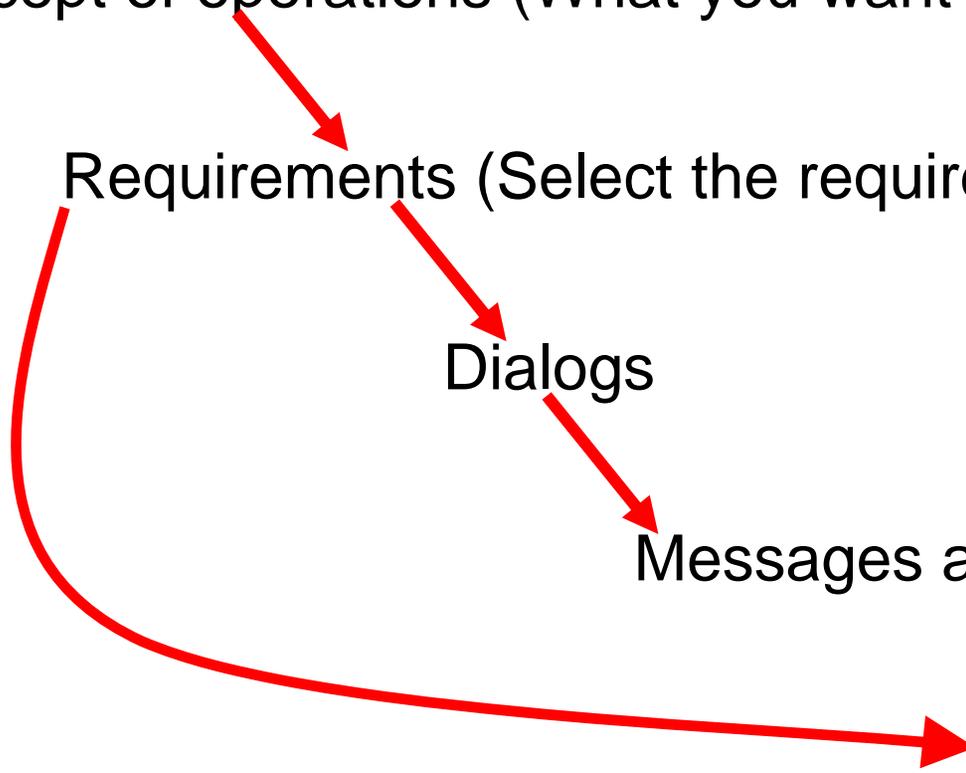
Concept of operations (What you want to do)

Requirements (Select the requirements)

Dialogs

Messages and data elements

Test Procedures



Be Careful - - -

- ▶ Stating “shall conform to NTCIP” as a blanket statement **DOES NOT WORK.**
- ▶ Agency need to use the *Requirements Matrix*, identify optional objects to be used, value ranges, custom information, etc.
- ▶ **Test** – if you are planning future additions, it is essential that you test both your central system and the field devices

Testing

- ▶ NTCIP 8007 Documentation for test procedures
- ▶ NTCIP 9012 provides a discussion of NTCIP testing
- ▶ There are a number of testing tools available to verify NTCIP conformance/compliance
 - ▷ Device Tester
(<http://www.intelligentdevicesinc.com>)
 - ▷ NTester (<http://www.trevilon.com>)
 - ▷ Others - - -

- ▶ NTCIP 9001 – NTCIP Guide

More Information

- ▶ www.ntcip.org
 - ▷ NTCIP Document Links
- ▶ <http://www.ite.org/standards/index.asp>
 - ▷ TMDD Document Links
- ▶ www.sae.org
 - ▷ Purchase standards ATIS
- ▶ www.nema.org
 - ▷ Purchase TS2
- ▶ www.ieee.org
 - ▷ Purchase Incident Management – 1512 standards

Thank you



Bob Rausch, P.E.

robert.rausch@transcore.com

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