METEORCOMM LLC

ITCC Overview

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Agenda

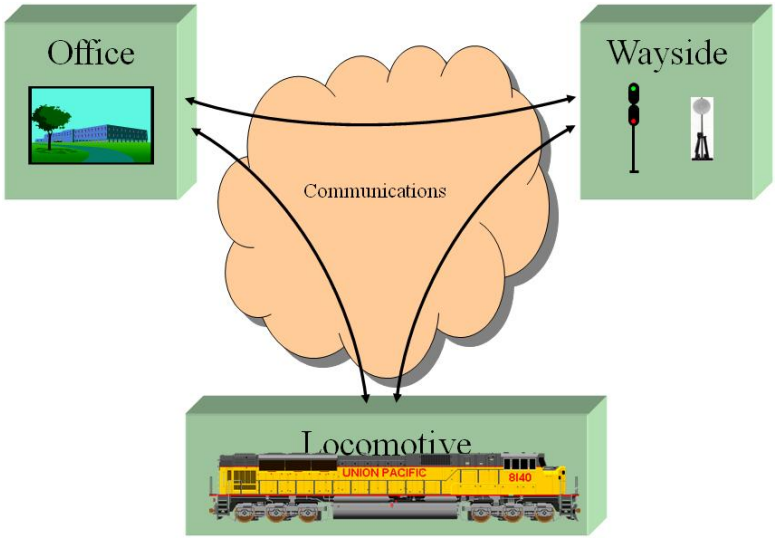
- Communication System (ITCC) Overview
- Messaging System (ITCM) Overview
- Systems Management System (ITCSM) Overview

Introduction

- MCC has created a robust and flexible PTC Communication System which supports reliable message delivery
- The Communication System is decoupled from PTC allowing for evolution of the communication system without impacting safety (and vice versa)
- Decoupling occurs through the creation of interface specifications and architectural layering
- Communication System interface specifications will be published through the AAR

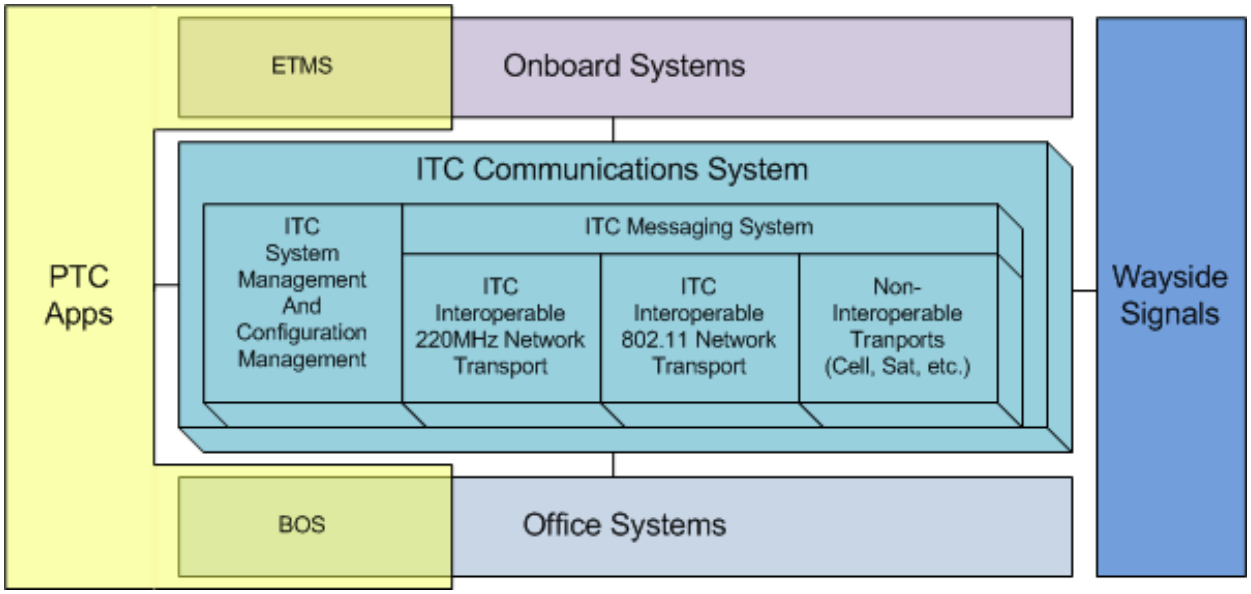
ITCC Overview

- ITCC – Interoperable Train Control Communications system
- The segment of the PTC system providing communications between each of the other segments over both wired and wireless networks



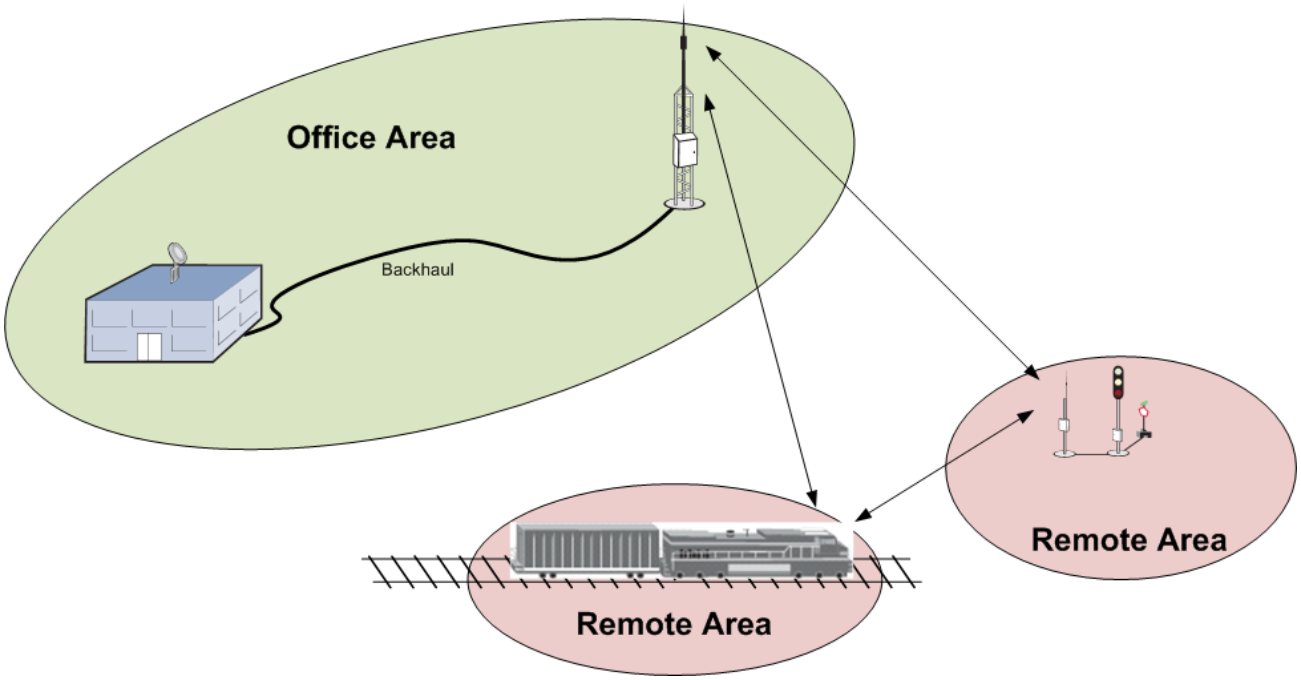
ITCC Products

- ITCM – Messaging System
- ITCR – 220 MHz Radio Network
- ITCSM – Systems Management System (SMS)



Areas

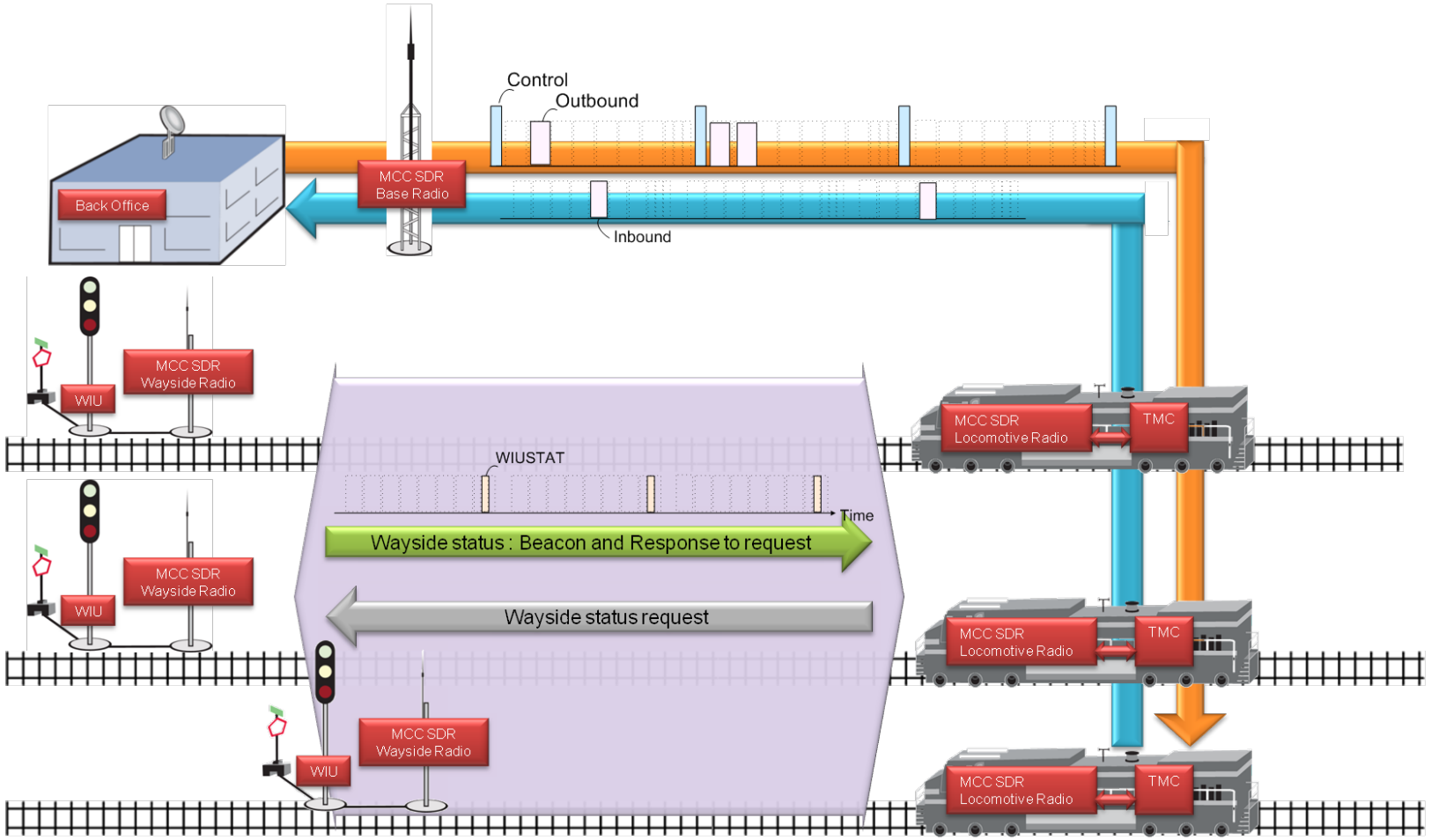
- The ITC Communication System is segregated into two types of Areas
  - Office Area – Data centers and Base stations
  - Remote Area – Locomotives and Waysides



Transports

- Within ITCC, the wireless transports are made up of
  - Narrow-band networks (low data through-put and high coverage such as 220 MHz)
  - Broad-band networks (high data through-put and low coverage such as 802.11)
- Broad-band networks are primarily targeted for initial bulk data downloads
- The narrow-band network is intended to be geographically ubiquitous and is primarily used in continuous communications (e.g. wayside status, position reports)
- The narrow-band network can serve as a secondary network for initial bulk data download
- The communications system provides data communications between Office segments over an MPLS network

Communication Patterns

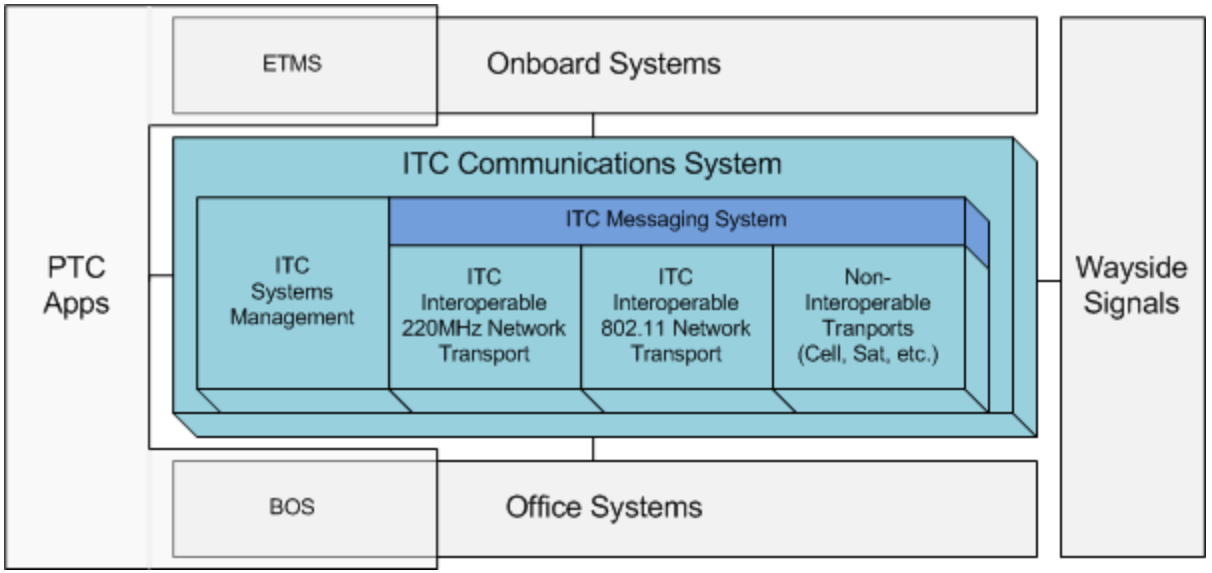


Reliability Mechanisms

- Overlapping coverage strategy in 220 MHz Radio Network
- Multi-layered High Availability Architecture in ITCM Back Office
  - Plans for Redundant Architecture in ITCM Remotes
- Multiple Redundant Transports Supported by ITCM
- Multiple Layered WIUStatus Delivery Mechanisms
  - Direct P2P constant beaconing
  - Direct P2P BeaconOn requests
  - Direct P2P GetWIUStatus emergency request
  - Redundant Base Relayed beaconing
  - Subscriptions through the office supporting multiple transports
- High Availability Architecture in ITCSM Back Office

ITCM Overview

- ITCM – Interoperable Train Control Messaging system
- Custom messaging solution that allows applications to exchange messages regardless of their physical location or type of connectivity (available transports)



System Boundaries

Railroads	MeteorComm	Other Railroad Vendors
• Messaging Hardware • Interoffice MPLS Network • Deployment Architecture • System Deployment • Wayside Status Relay Service	• Messaging Software (RHEL/MRG available - passed through from Redhat) • Messaging Reference Architecture • Hardware requirements	• Communication through ITCM via EMP over Class/D (or AMQP)

Key Architecture Principles

Reliability	• The system must avoid operational interruptions (high availability) • Multiple redundant transports (wired and wireless) must be supported
Efficiency	• The system must use the available 220 MHz spectrum as efficiently as possible
Independence	• The must not have a central point of dependence (distribution) • The system should minimize dependencies between architecture layers (e.g. abstraction between PTC app and 220 MHz network)
Flexibility	• The system shall support message types other than PTC (driving preemption) • The system must support intermittent connectivity of transports
Compliance	• The system must comply with all ITC guiding principles, ITC requirements, and applicable FRA regulations

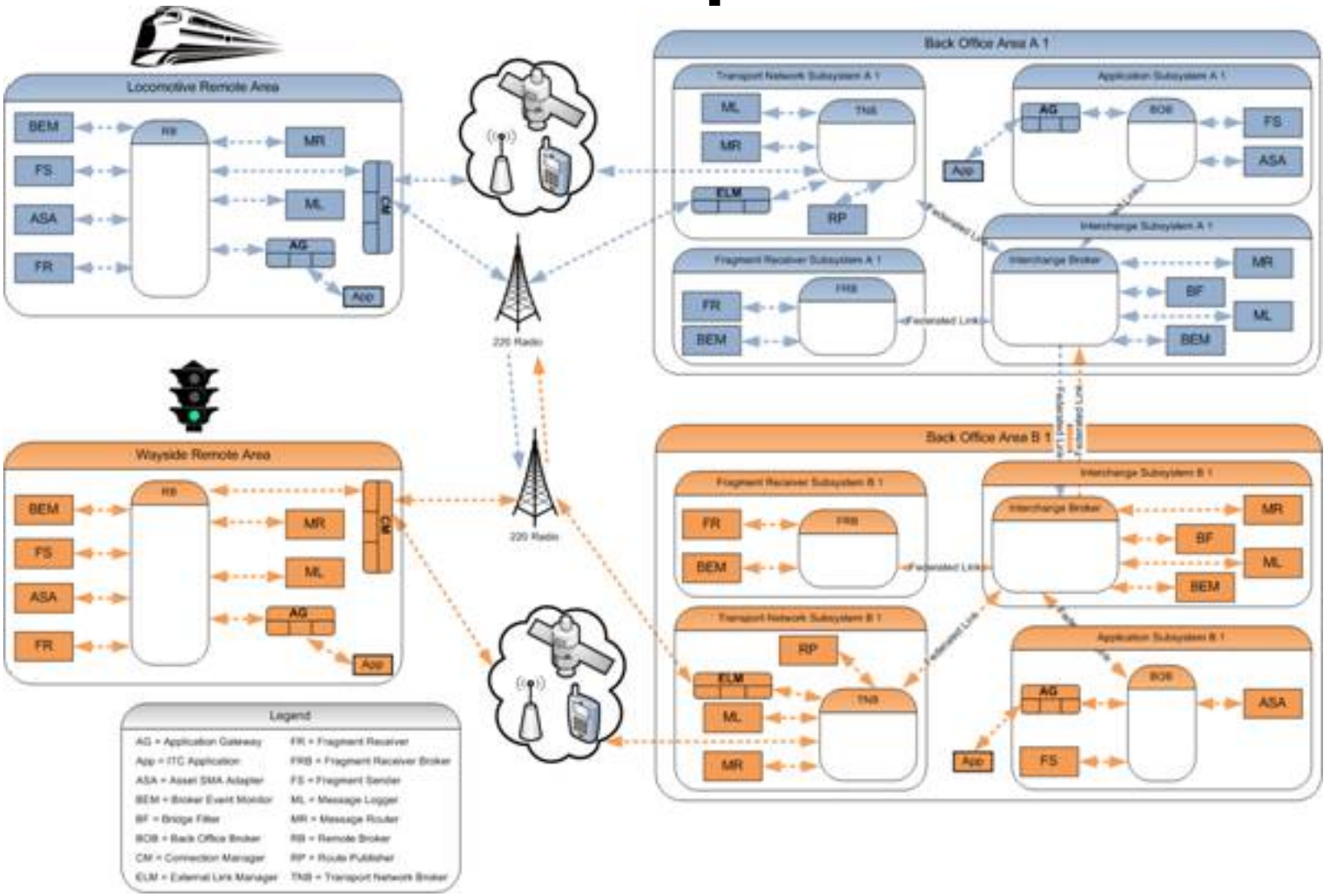
Major ITCM Functions

- Routing and delivery of messages between office and remote
- Routing and delivery of messages between offices
- Support for peer to peer broadcasts (e.g. WIUStatus)
- Transport selection
- Support for mobility
- Protocol Transformation
- Multi-Transport Support (220 MHz and wireless IP)
- Fragmentation
- Multi-Layer High Availability Design
- Support for Class/D & AMQP application transports

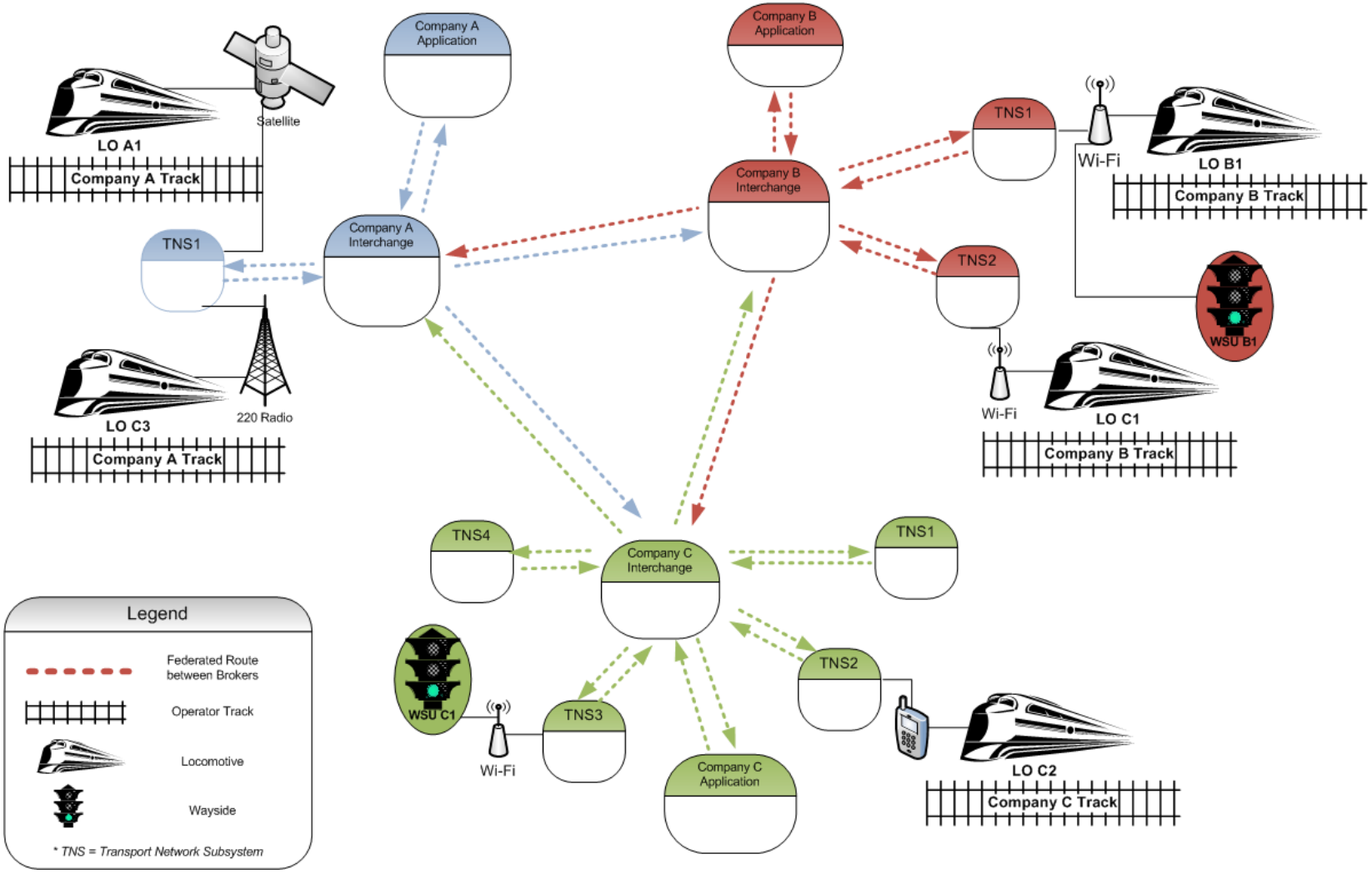
Basic AMQP Concepts

- Brokers – a related group of exchanges and queues
  - Exchanges – Route message to appropriate queues based on exchange type, applications write to them
  - Queues – Bound to exchanges, applications read from them
- Federation – Connections between brokers to pull data
- Clustering – Provides reliability in the event of a failed broker

ITCM Components

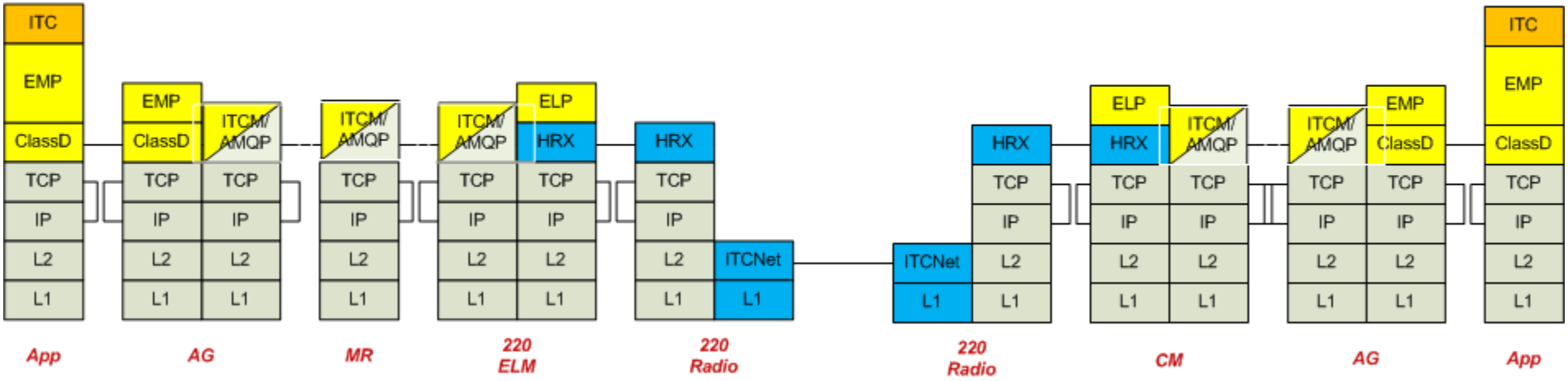


Operating Environment



Primary Protocols Detail

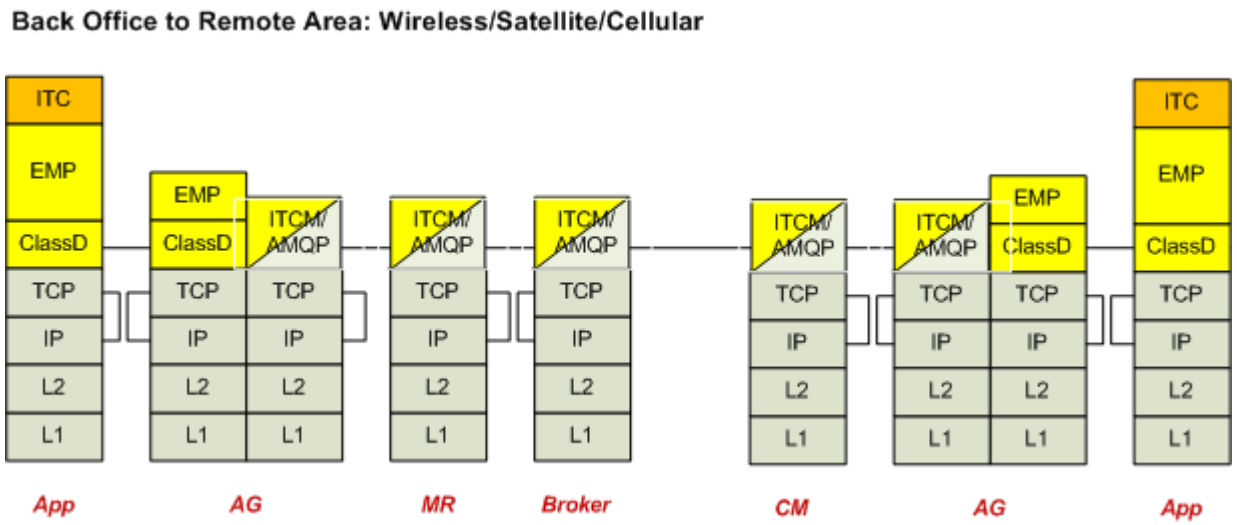
Back Office to Remote Area: 220 Radio



Notes

- Header stripping is not shown as the stripped header is part of the payload and not used in transmission between components.
- All communication between components passes through brokers, but for clarity the brokers are not shown unless they are at a boundary between the back office or remote.

Primary Protocols Detail



Notes

- All communication between components passes through brokers, but for clarity the brokers are not shown unless they are at a boundary between the back office or remote.

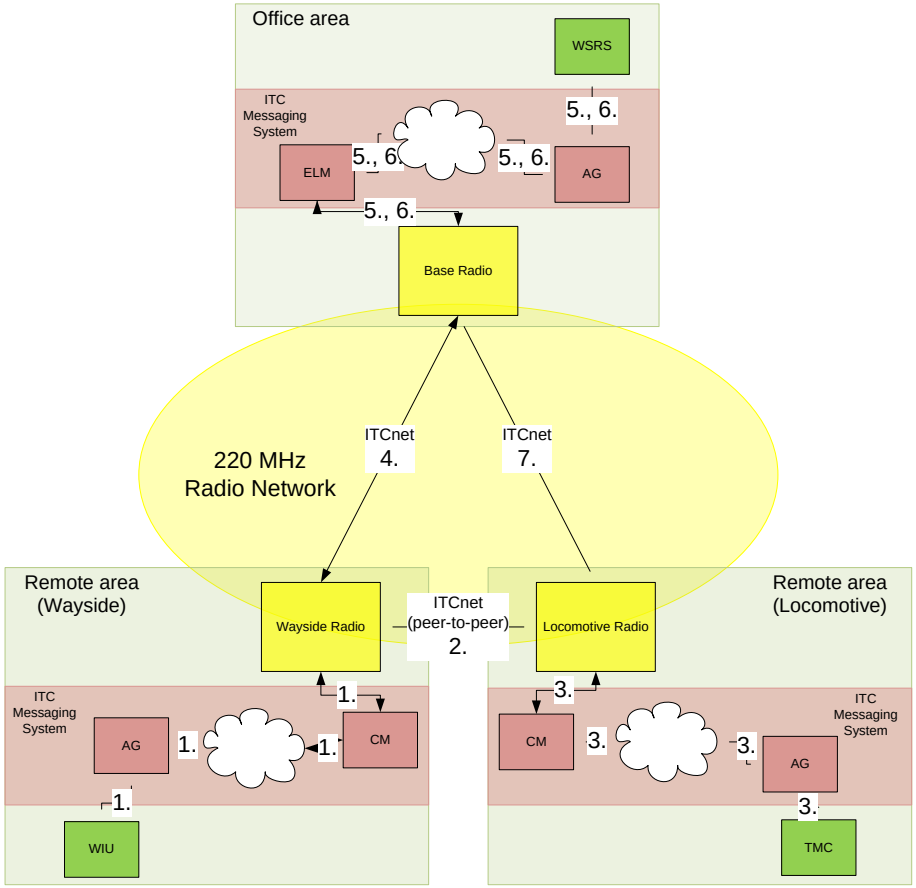
High Availability / Disaster Recovery

- Clustering for all brokers
- Multiple copies of each component
- Multiple copies of each broker cluster
- Hardware redundancy (network, disk)
- Application failover (Class D)
- Multiple Data Centers

- Active – Active configuration recommended

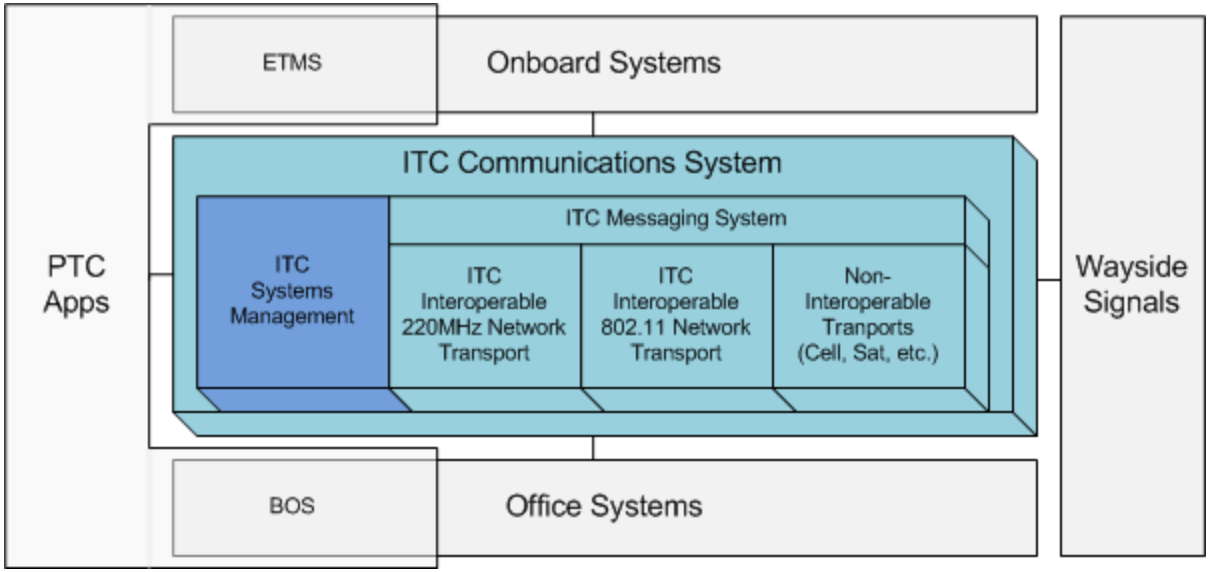
Wayside Status Relay

- Wayside messages heard by Bases (or transmitted on alternate transports) forwarded to Wayside Status Relay Service (WSRS)
- WSRS can relay (broadcast) messages through a Base to fill coverage gaps
- WSRS can also support subscription requests from Locomotives to deal with 220 MHz Network Failures
- WSRS component not currently offered by MCC



ITCSM Overview

- ITCSM – ITC Systems Management System
- Framework (Gateway, Protocol, and reference Agent) providing an interoperable method for remote monitoring and management of assets



System Boundaries

Railroads	MeteorComm	Asset Vendors
• Network Management Systems • Ticket Management • Key Exchange • System of Record • Configuration Management • Analysis, Filtering, Synthetic Events • Access Control – Role Authentication • File Repository • SMS Hardware • System Deployment	• ITCSM Gateway Components • ITCSM Agent Components • ICD & Protocols for SMS • APIs for SMA to Asset Communication • Secure File Distribution • Access Control – Role Authorization	• Executing upon and responding to ITCSM Agent requests • Local Secure Key storage • Other (depending on Asset capabilities)

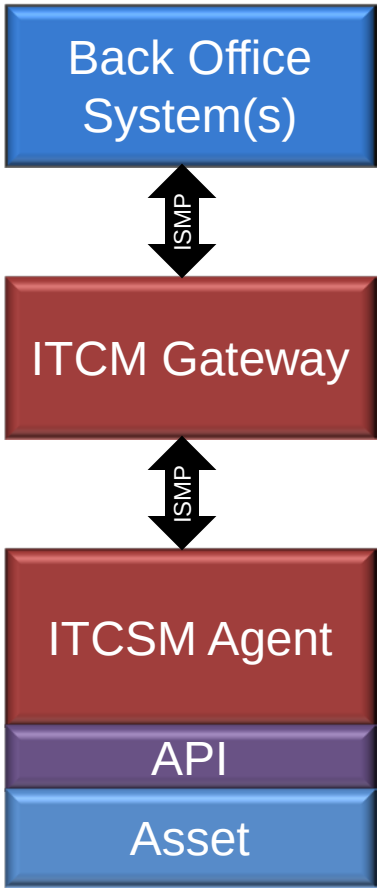
Key Architecture Principles

Exception	• The system is designed and coded to a standard set of interfaces, frameworks and platforms common to all Railroads • Exceptions must be handled by the individual Railroad
Enablement	• The system enables Railroad operations by collecting and distributing data and information (in most cases ITCM will be a pass-through responsible for orchestration and security)
Efficiency	• The system must be able to efficiently use all available transport s • Includes bandwidth constrained wireless networks (i.e. 220) and reliable IP transports (e.g. Cell, WiFi)
Compliance	• The system must comply with all ITC guiding principles and applicable FRA regulations
Accommodation	• The system must ensure all Asset types can be supported

Major ITCSM Functions

- Security Infrastructure for distributing sensitive data
- File transfer
- Asset-kit distribution and load over-the-air (Security, Configuration, Firmware/Software)
- Unsolicited notifications and status
- Full configuration management (Asset + ITCSM)
- File distribution
- Session management & access control
- Notification enrichment & propagation
- Command execution & diagnostics

Conceptual Architecture



The Back Office systems utilize ITCSM to enable management, control and configuration of managed assets.

The Gateway acts primarily as an orchestrator of ITCSM functions and a central point of trust for security. It enables communication between the Railroads and managed assets, as well as interoperability across Railroads.

The Agent serves as a standards-based proxy for purposes of passing commands, receiving responses, transferring files, and handling notifications.

Agents will either be linked-in to the asset executable or communicate through a wire line protocol understood by the Asset.

Systems Management Protocols

ISMP protocol is designed to support maximum efficiency over wireless transports (e.g. 220 Radio).

Transport Protocols

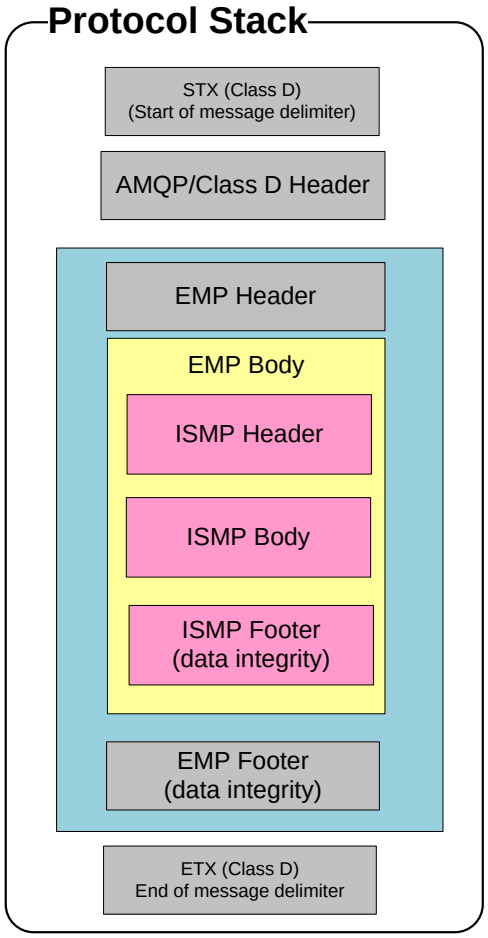
- Class D
- AMQP

Application Protocols

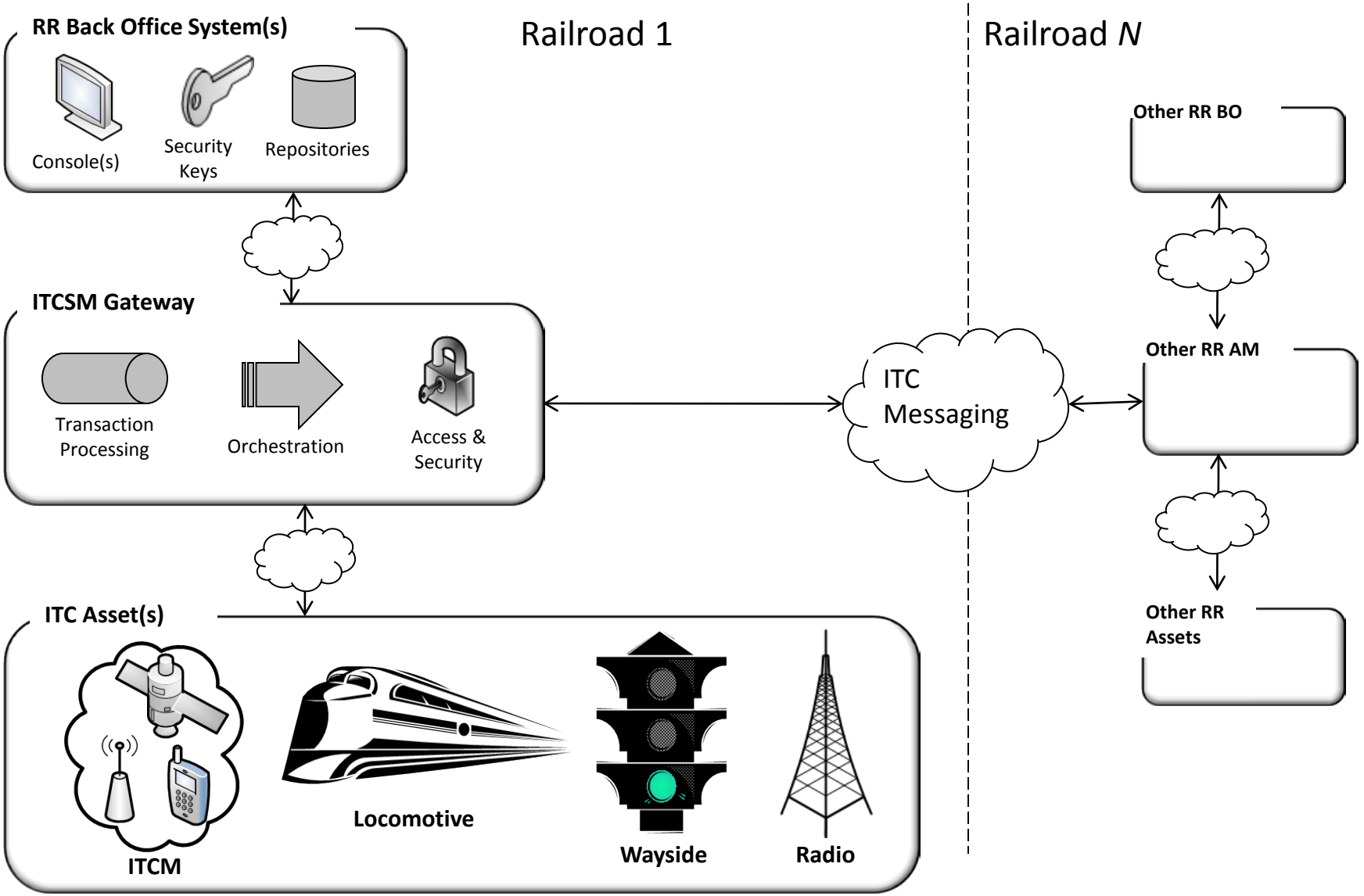
- EMP
- ISMP

Remote Protocols

- SNMP
- OpenSSH Suite

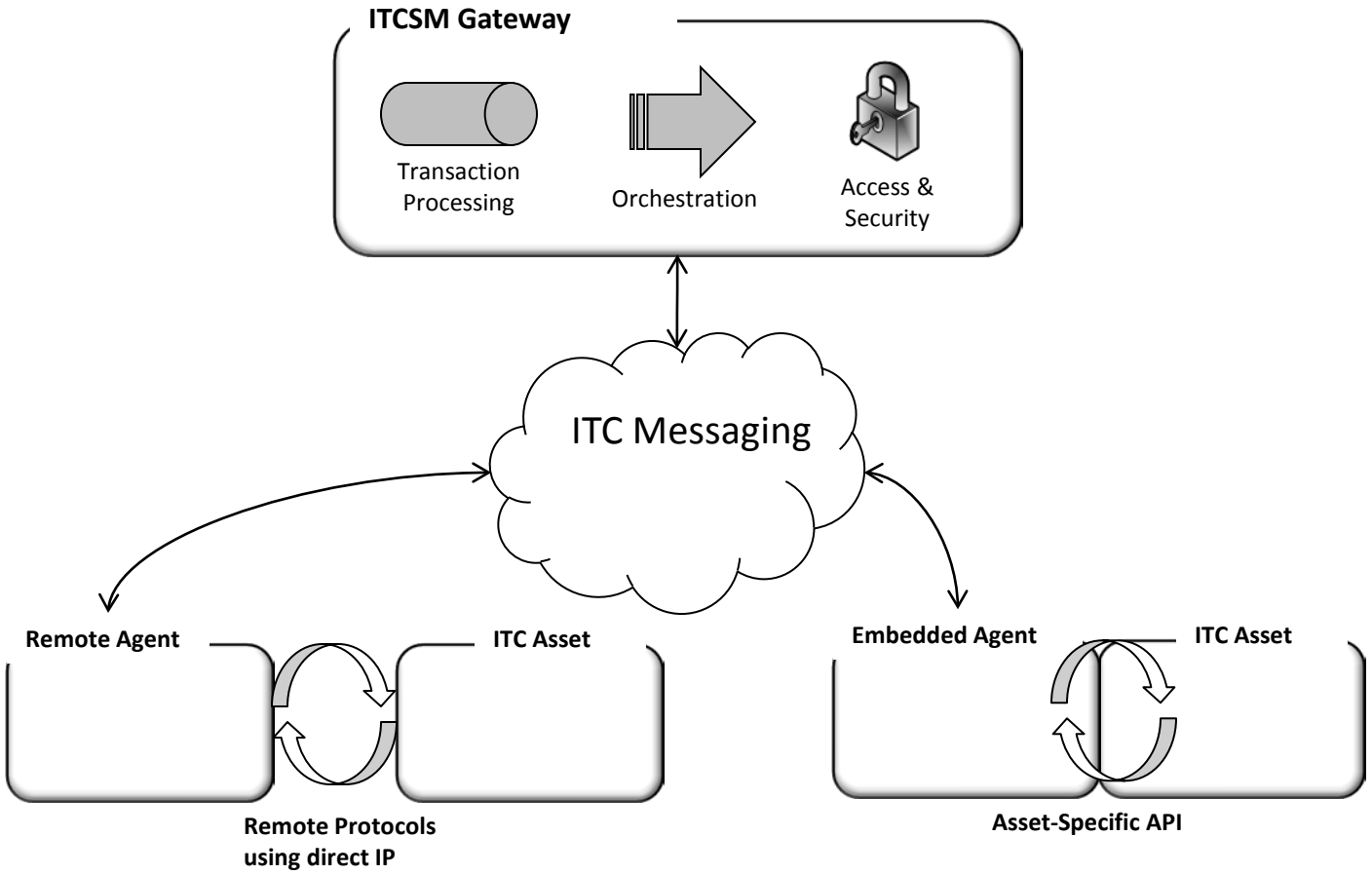


ITCSM Gateway



ITCSM Agent

Agents are either linked-in to the asset's executable (Embedded Agent) or use a set of remote protocols (Remote Agent).



ITCSM Agent Integration Options

OEM Vendors have three available options to support ITCSM:

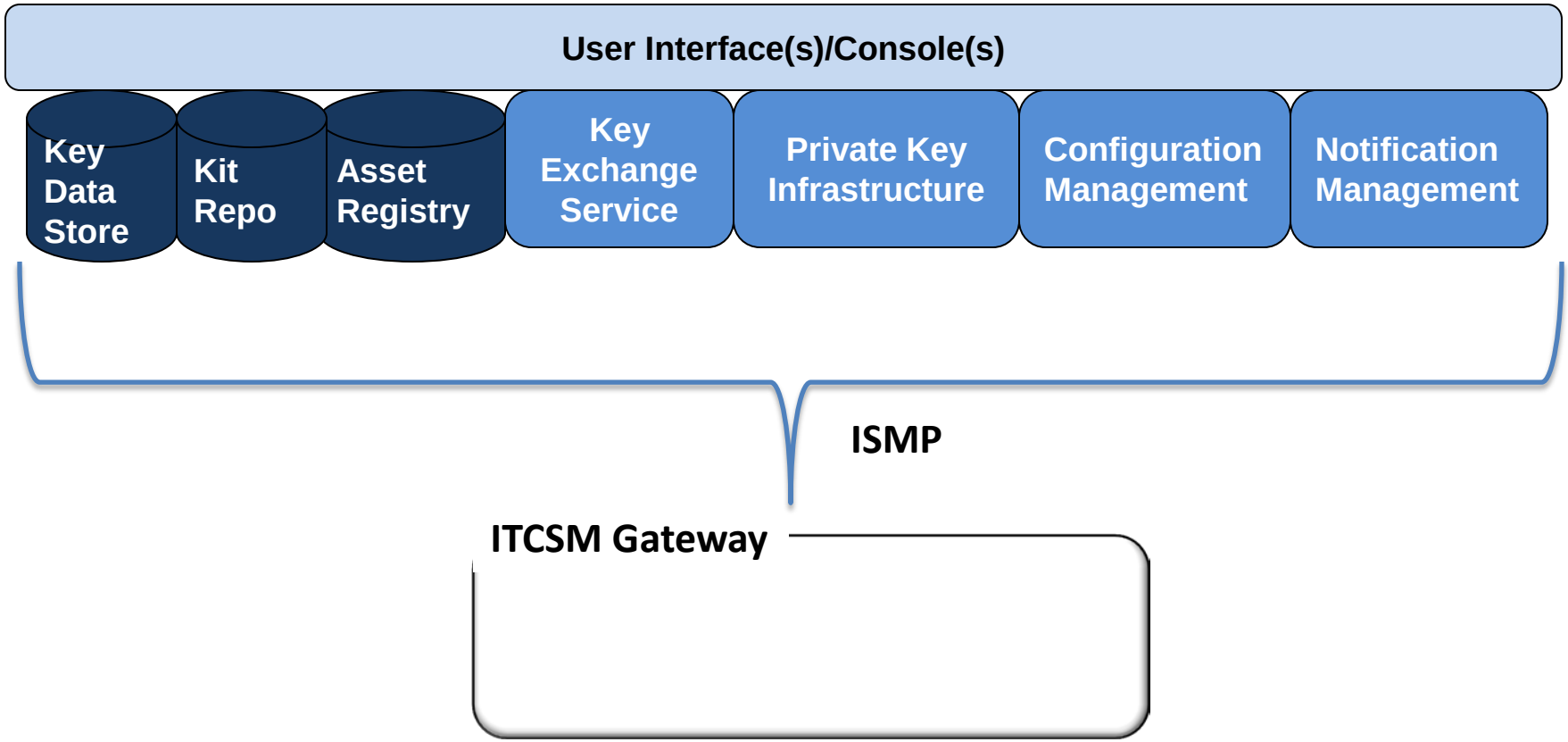
- Custom implementation
  - Meet ITC requirements with a custom agent implementation following the ISMProtocol
- Use ITCSM Agent source code
  - Use the MCC provided source code to as input for a custom agent implementation
- Integrate ITCSM Agent library
  - Develop to documented APIs in the MCC provided software library to reduce custom development

Note:

- ITCSM provides a framework to support implementation of ITC and Railroad for interoperability and asset management. Each asset type and vendor will have a unique roadmap for implementation of features supported by ITCSM.

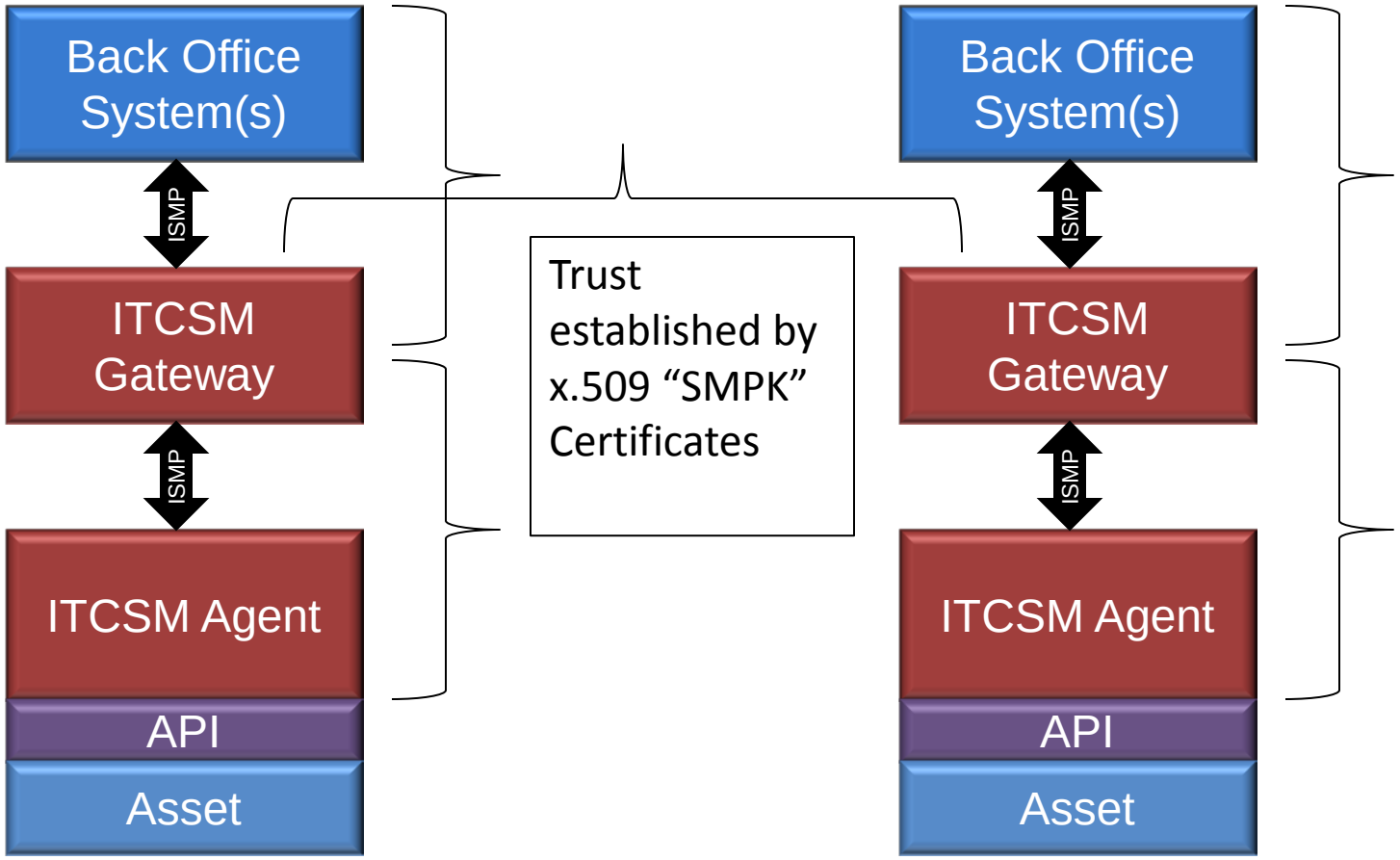
Back Office Systems Integration

Railroads must integrate their Back Office Systems to the ITCSM Gateway using ISMP.



ITCSM Security

Sensitive ITCSM communication is secured with x.509 certificates containing System Management Public/Private Keys (SMPKs).



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Appendix

Back Office Systems Concepts

- Network Management Systems
  - Identify and act upon asset notifications (Alerts) and other system anomalies (e.g. no status heartbeat from an asset)
- Configuration Management
  - Build stage and load kits, track progress of staging/loading, system of record for asset configuration
- Asset Registry
  - Maintain portfolio of assets and associated metadata
- Private Key Infrastructure
  - Generate, store and exchange private keys and digital certificates
- Middleware/State Machine
  - Correlate asynchronous communication and manages long-running workflows

ITCSM Security Algorithms

Keys are of configurable length to allow operational flexibility and future growth as the threat of defeat increases.

- Asymmetric (Digital Signatures & Envelopes)
  - Rivest, Shamir, Adleman (RSA)
  - Elliptical Curve Cryptography (ECC)
- Symmetric (Encryption)
  - Advanced Encryption Standard (AES)
- Hybrid
  - RSA/ECC envelope for AES key

Questions

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