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The bridge to possible

Cisco Connected Rail Solution Enables Modern Railway Signaling System

Communications-Based Train Control (CBTC)

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@WeiZou_

BRKIOT-2105

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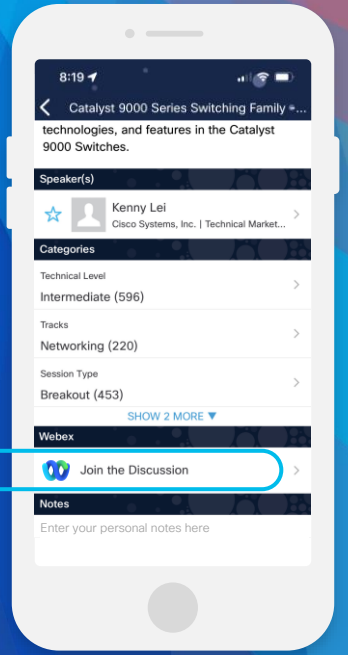

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Agenda

- Introduction
- Key drivers, benefits, and challenges
- Cisco CBTC reference architecture
- Solution components
- Design considerations
- Conclusion

Introduction

Investment on transportation

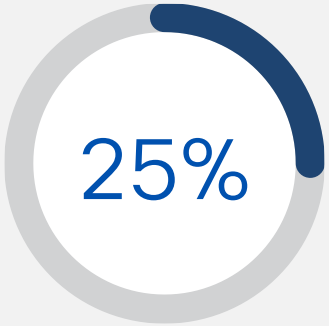
- The US Bipartisan Infrastructure Law will provide $284 billion in new spending for transportation
- $66 billion in passenger and freight rail, representing 11-fold increase in historical funding levels
- $5 billion for rail infrastructure and safety improvement grants
- $3 billion for railroad crossing elimination program
- The European Green Deal is estimated to include €87.5 billion in investment related to rail infrastructure

Key drivers, benefits and challenges

World metro figures 2021

In 2019, average 190 million passenger per day

were taking metro globally



of rail infrastructure growth globally, approximately 3,300 km track was put in place between 2018 to end of 2020

Global operational fleet vehicles increased 28,000 to

UITP World Metro Figures 2021

Definition of communication-based train control

IEEE 1474.1: CBTC system is a continuous, automatic train control system utilizing high-resolution train location determination, independent of track circuits;

continuous, high-capacity, bidirectional train-to-wayside data communications;

and train-borne and wayside processors capable of implementing automatic train protection (ATP) functions, as well as optional automatic train operation (ATO) and automatic train supervision (ATS) functions.

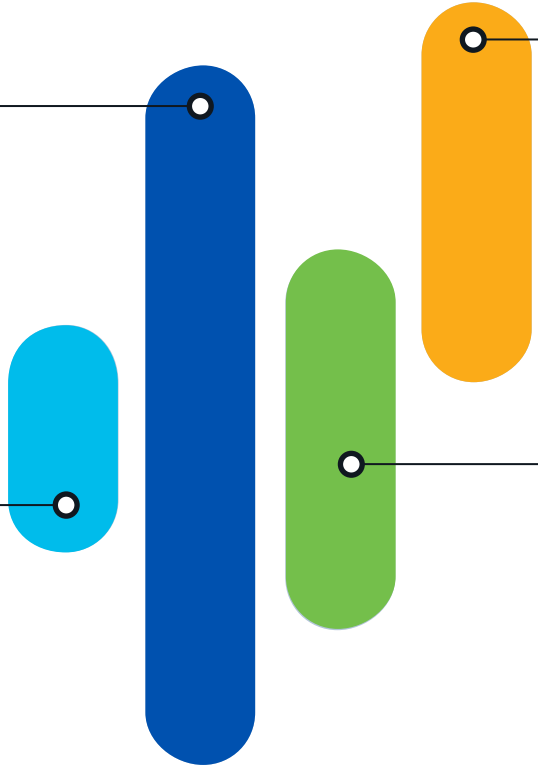
Key benefits CBTC brings

- Simpler architecture, less equipment to implement and maintain
- Flexible to rail operators to respond to schedule changes and emergencies
- Faster services and smoother rides to passengers
- More accurate real-time arrival information

- High degree of accuracy for train detection
- Better speed regulation and maintain safe braking distance
- Reduced accidents significantly

- Keep the headway between operating trains at minimum
- Grades of Automation enables energy efficient
- Reduced power consumption, less air pollution

Challenges and requirements in deploying CBTC



Resilient and highly available infrastructure

- Mission critical systems demand network redundancy and high availability
- Scalable for any deployment size
- Legacy and siloed network difficult to manage

Ultra-reliable train-to-wayside wireless

- Reliable train-to-wayside wireless communications
- Low latency, fast handoff, and extremely low packet loss

Challenging Environment

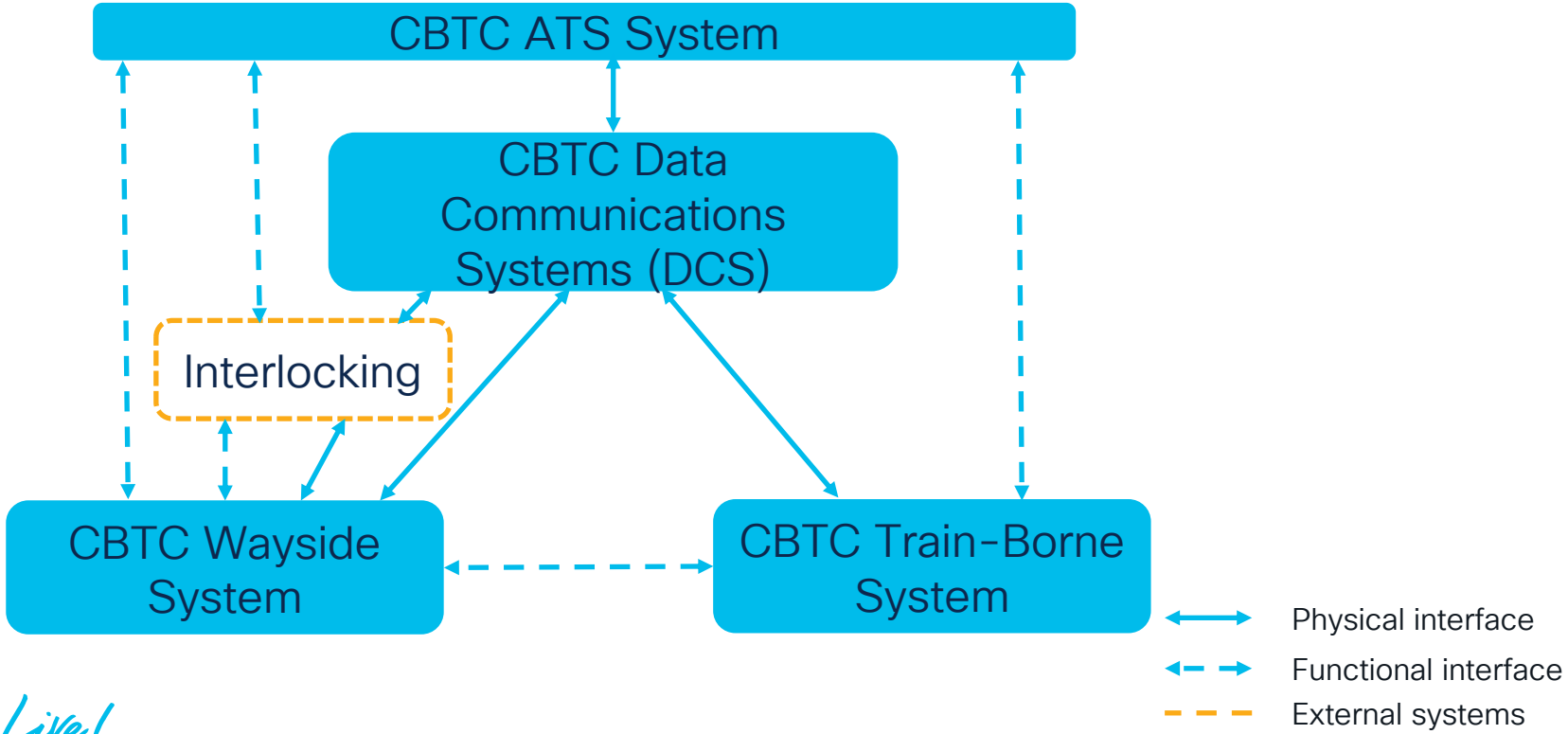
- Harsh and extreme condition
- Unpredictable and dynamic environment
- Signal interference and range restriction

Security

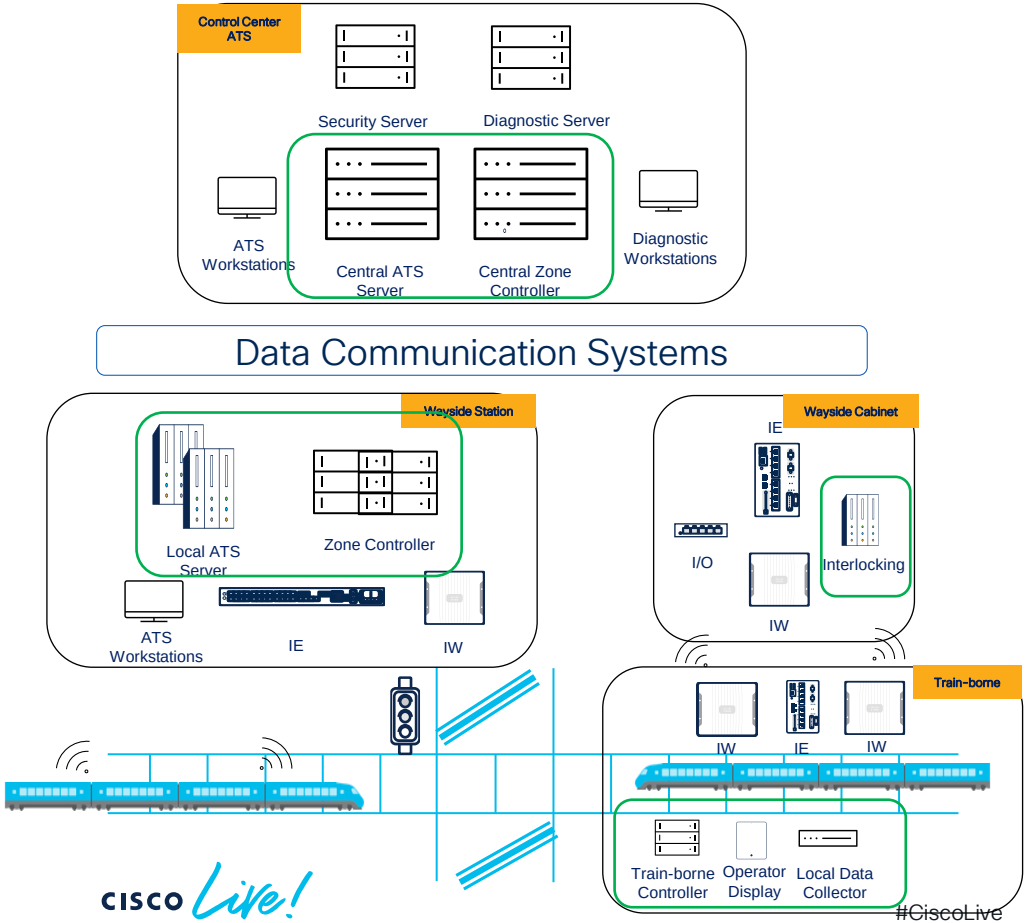
- Limited security implementation
- Expanded security vulnerability
- Catastrophic impact when vital system is compromised

CBTC reference architecture

CBTC major subsystems



CBTC high level communication flows

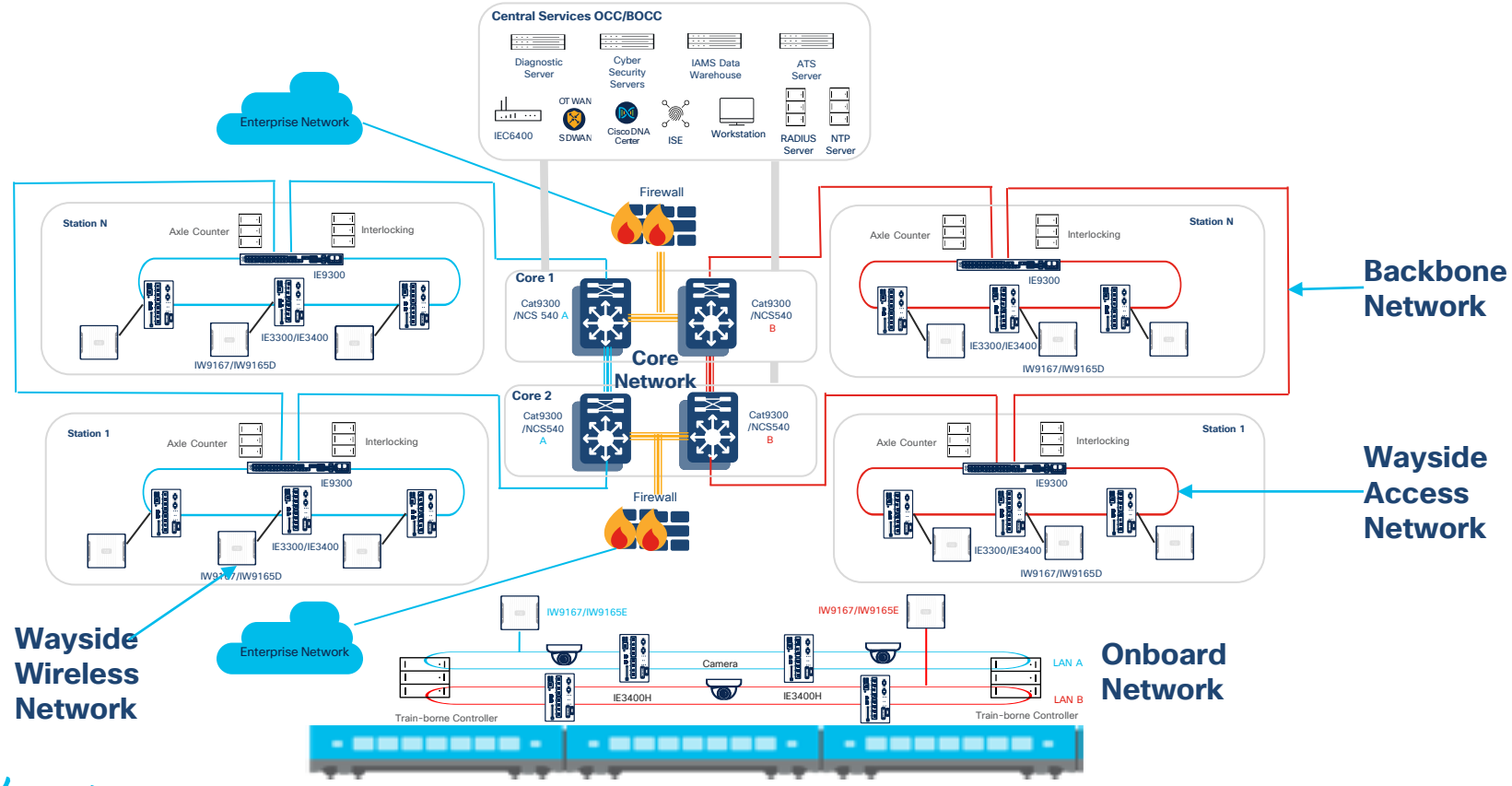


- From CBTC ATS at Control Center
  - To CBTC Wayside: temporary speed restriction, route/section blocking, work zone
  - To CBTC train-borne: emergency brake reset, dispatch request, dwell time, stop/hold at/skip station request, inhibit automatic door open/close, stop/restart train request, speed, passenger information systems
- From CBTC Wayside
  - To CBTC ATS: CBTC fault reports, train movement authority information
  - To CBTC train-borne: absolution position reference, train length validation, route status, location of train ahead, infrastructure speed limit, train speed limit, switch status, rail conditions etc.
- From CBTC train-borne
  - To CBTC ATS: train location, identification, fault reports
  - To CBTC Wayside: train location, train operation mode

CBTC DCS traffic profile parameters

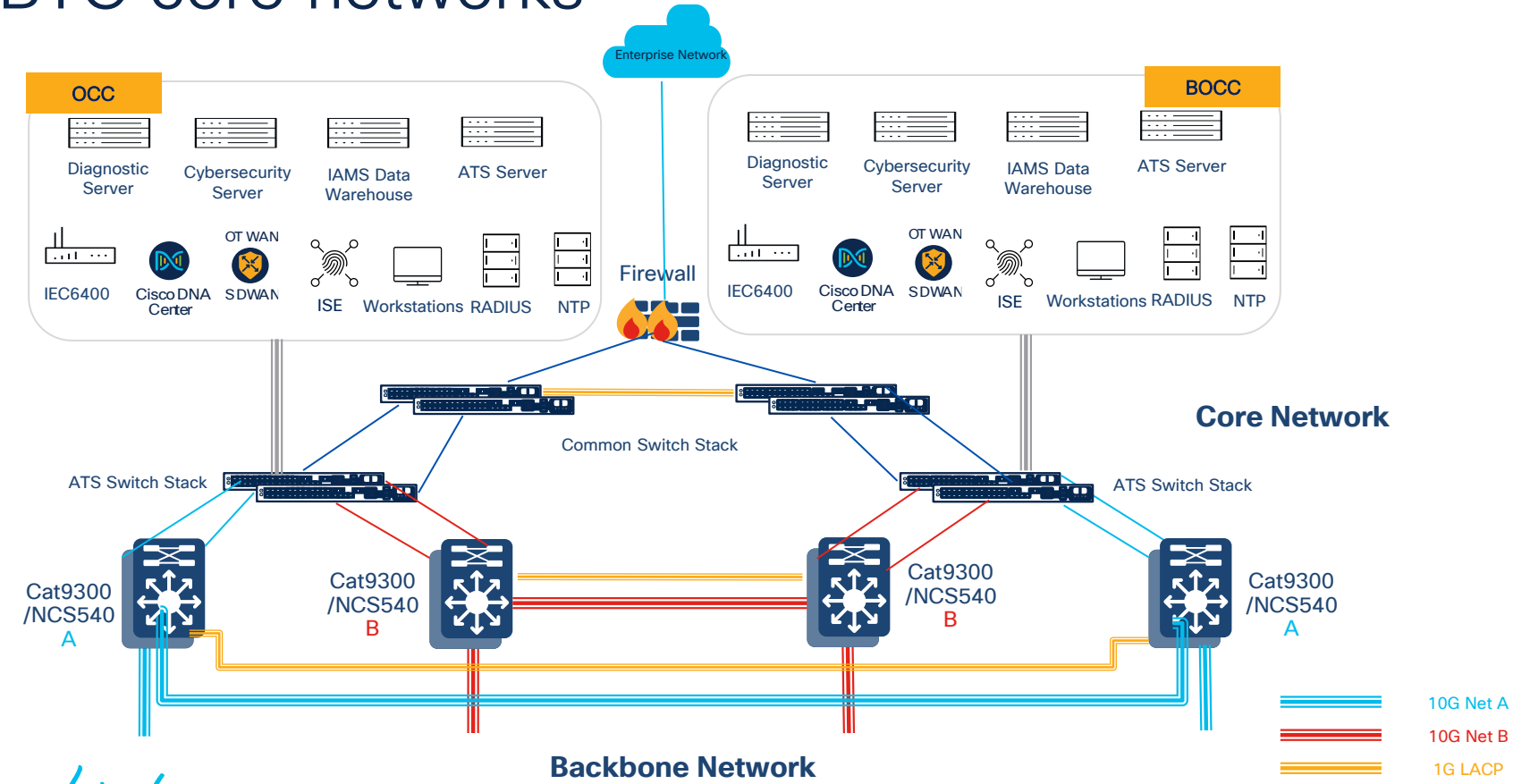
- Throughput: Kbps – Mbps (~1 Mbps per train and per network)
- Latency: wired <= 10 ms, train-to-wayside wireless <=100 ms
- Network convergency time after single point of failure <= 500 ms (50ms most stringent)
- Packet loss <= 1%
- Train speed up to 150 km/h

Cisco CBTC DCS reference architecture

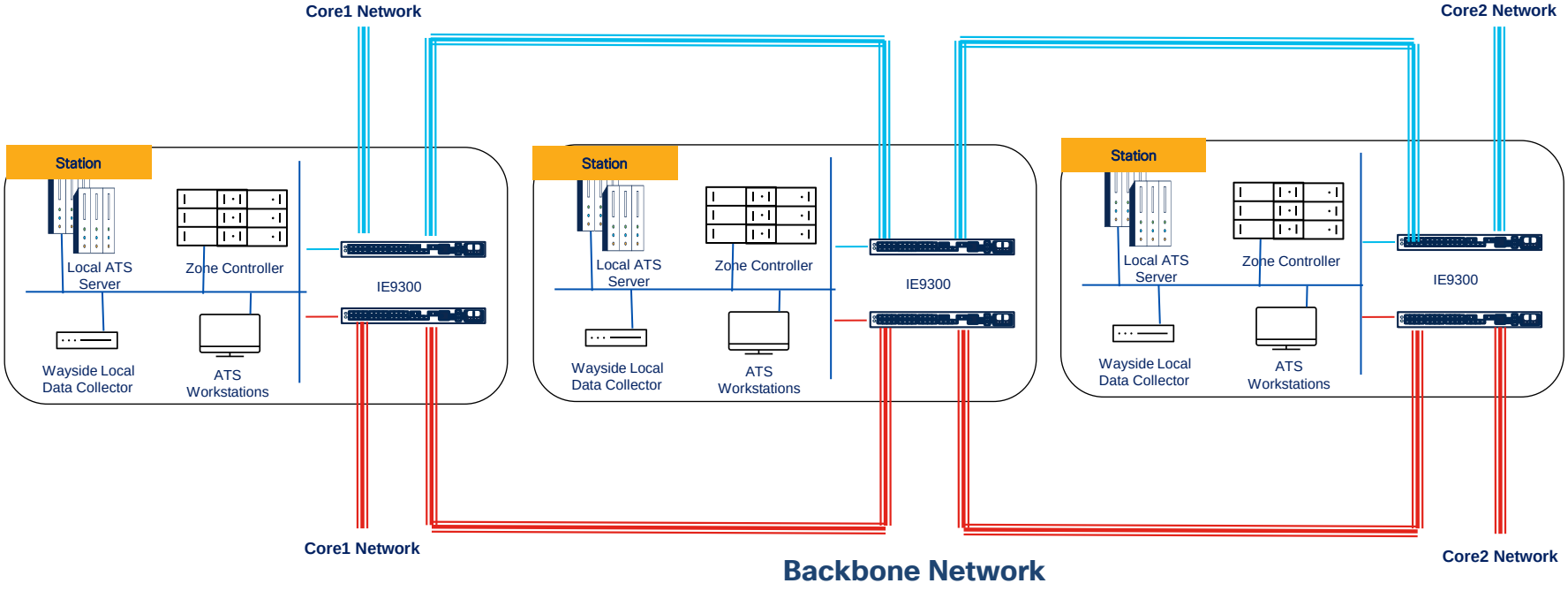


Solution components

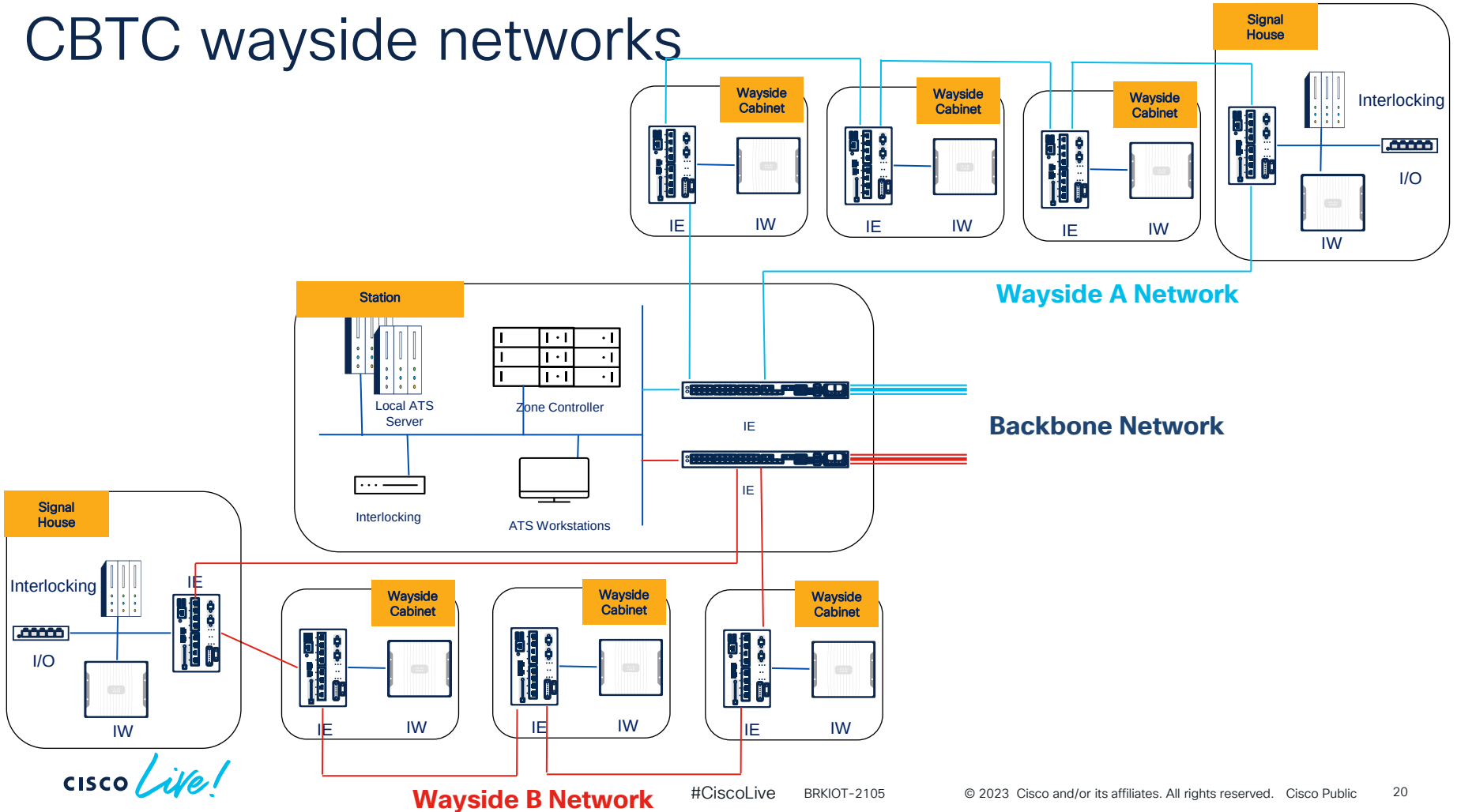
CBTC core networks



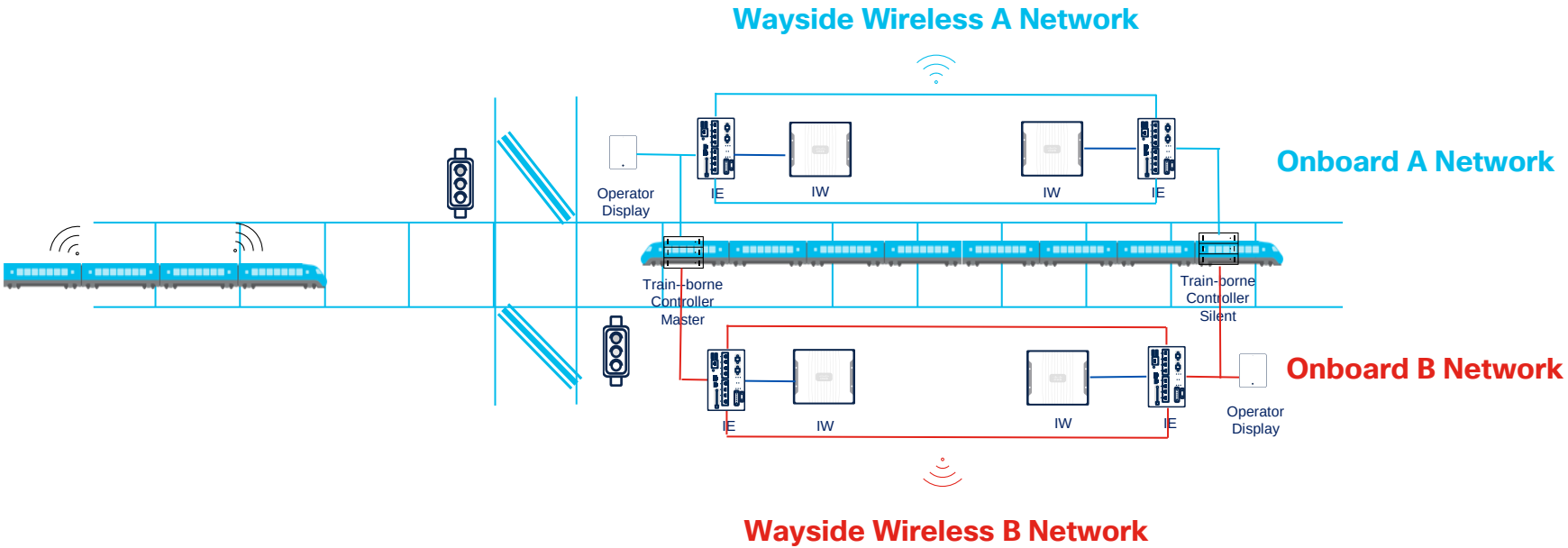
CBTC backbone networks



CBTC wayside networks



CBTC onboard networks

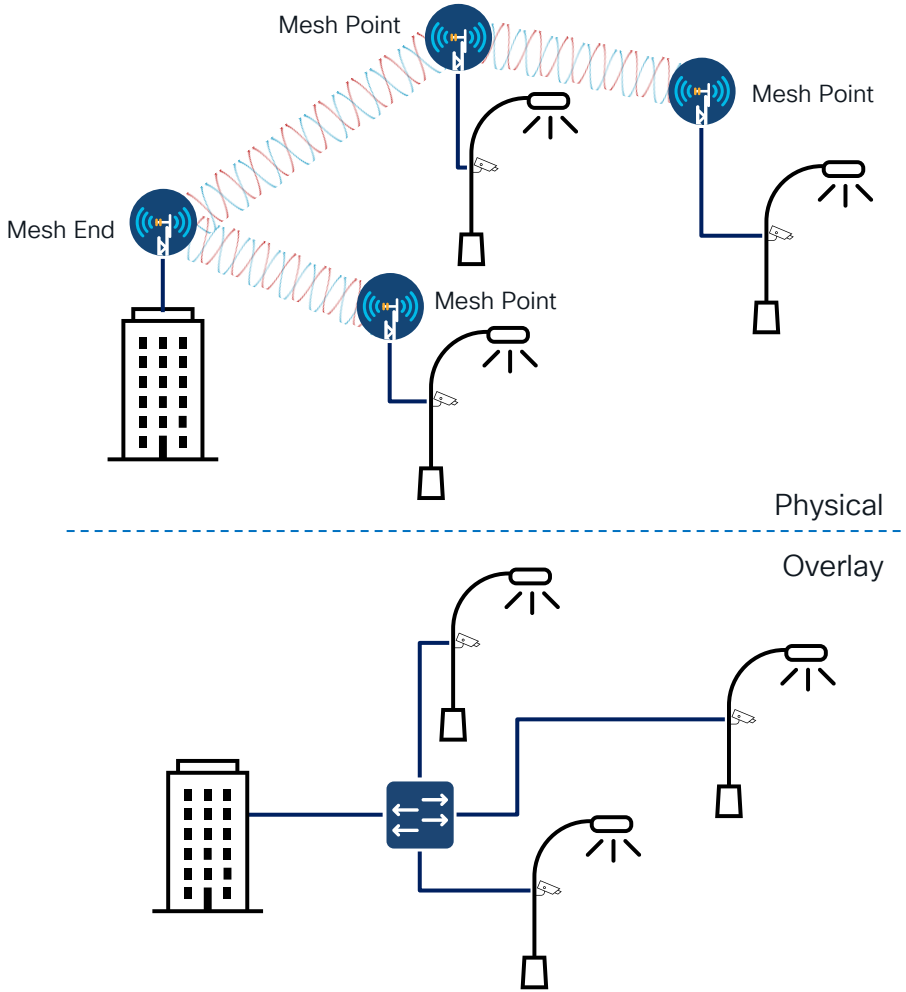


Design considerations

CURWB and hardware choice

What is Cisco URWB?

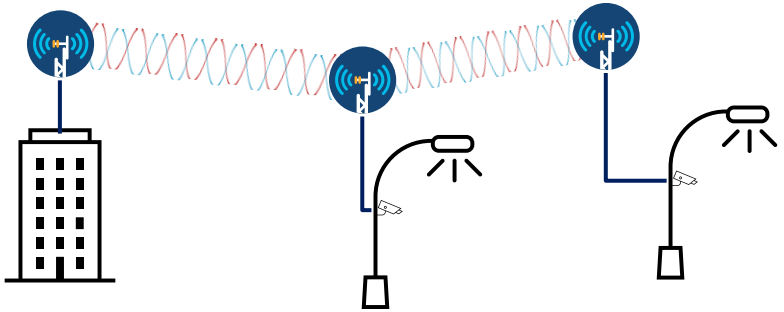
- Cisco UWRB is an overlay technology that emulates a virtual switch over wireless links
- Extends your network to fixed and mobile locations
- Supports VLANs and QoS
- Customized wireless-based MPLS transmission protocol PRODIGY™



Backhaul modes of operation

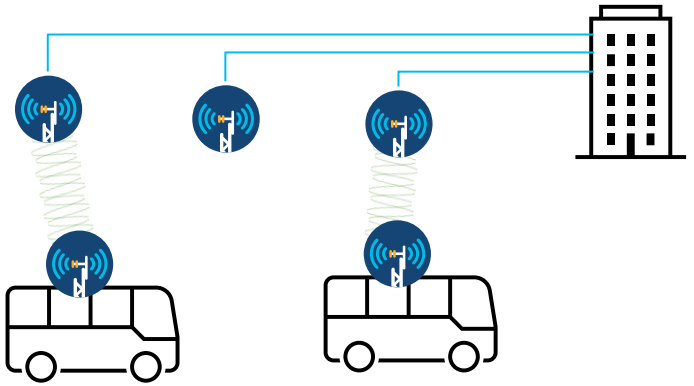
Fixed

Connect wired networks between static or nomadic locations

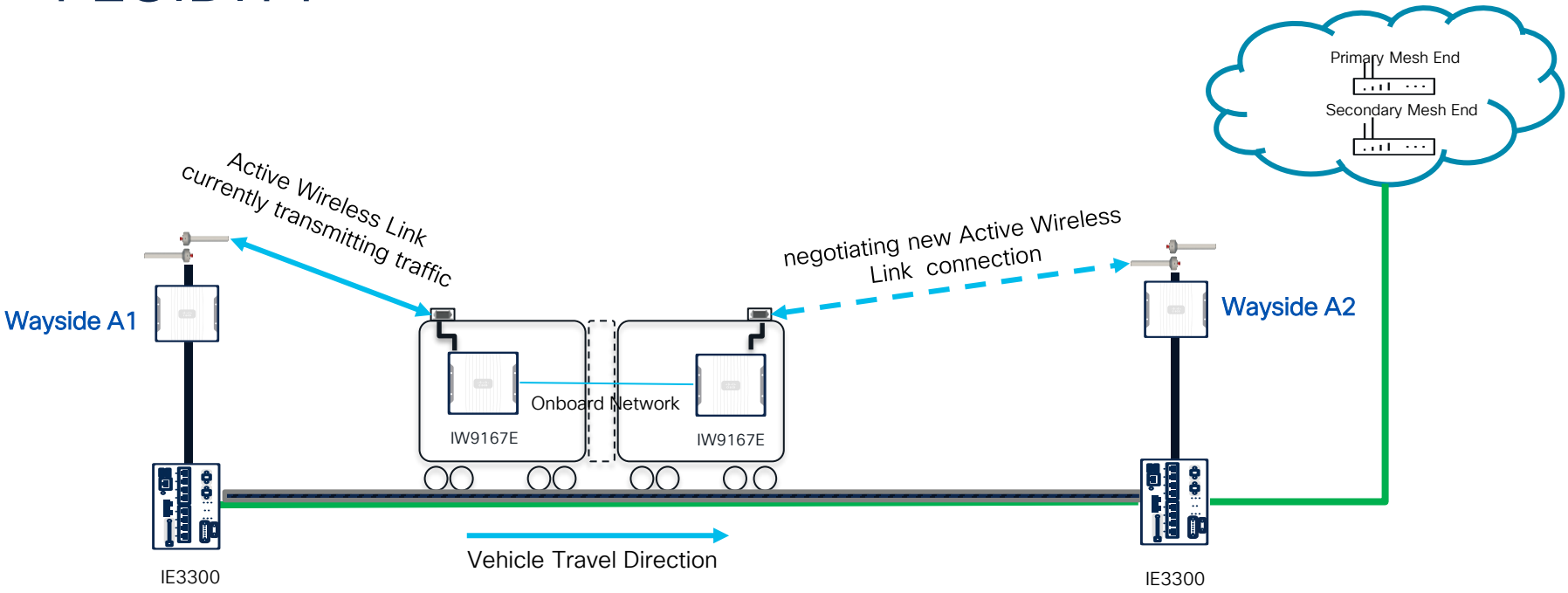


Mobility

Extension of fixed functionality to optimize connectivity for mobile assets with predictive handoffs



FLUIDITY



Cisco Catalyst IW9167E heavy duty access point

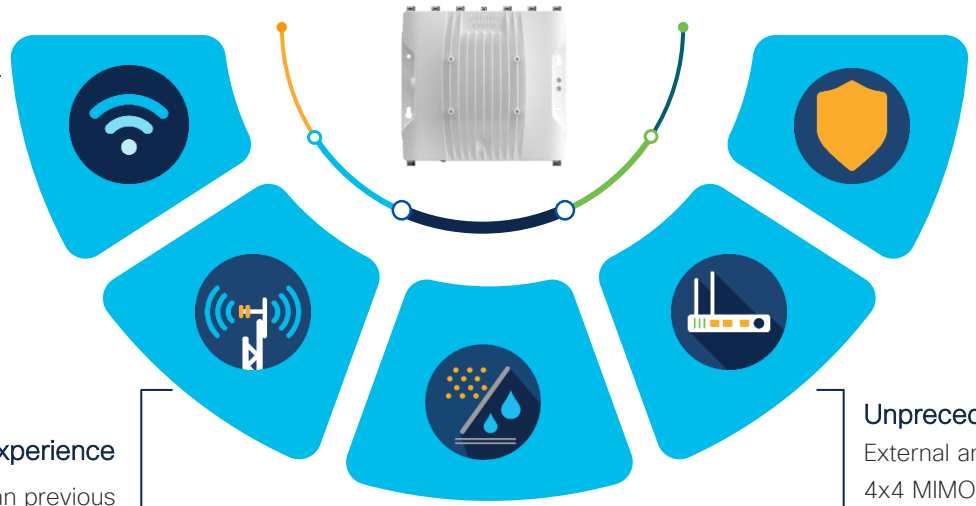
Unmatched Wi-Fi experience

High-throughput, low-latency

Tri-radio (2.4 GHz, 5GHz, 5/6GHz)

Cisco CleanAir Pro

Automated connections to 6GHz*



Improved Security

WPA3

Enhanced Open

AES Encryption for Wireless Backhaul

TLS 1.3

Improved backhaul experience

Higher throughput than previous generations

Multi-radio (5GHz, 5/6GHz)

Multipath Operations (MPO) reduces latency and maximizes reliability

Heavy duty design

Shock & vibration hardened
Extreme temperature range
Water & dust resistant (IP67)
Industrial certifications (e.g. rail EN50155)

Unprecedent hardware capabilities

External antenna – 8 x Type N

4x4 MIMO 4SS, Max data rate – 7.8 Gbps

Multigigabit RJ45, M12 or SFP+

Dual mounting options (Pole & Wall mount)

PoE (802.3at/bt/UPOE) and DC 24-48v inputs

GNSS, BLE, and Scanning Radio

*6 GHz use subject to regulatory agencies regulations and approvals

One platform, your choice: Wi-Fi 6/6E* or Cisco URWB

IW9167E heavy duty vs IW9165E rugged

Prototype devices pictured. Production device may vary.

Cisco Catalyst 6E industrial wireless portfolio

	IW9165E	IW9167E
Application	Wireless client for mobile assets	Wireless backhaul for fixed and mobile assets
Radio	2 x 802.11ax radios (5GHz, 5/6GHz)	3 x 802.11ax radios (2.4GHz, 5GHz, 5/6GHz)
Antenna	4 x RP-SMA	8 x N-Type (f)
Modulation	2x2 MIMO	4x4 MIMO
Wireless Mode	WGB or URWB	WiFi, WGB, URWB
Ethernet	1 x 2.5Gbps + 1 x 1Gbps RJ45 Optional M12 adapter	1 x 5Gbps RJ45 + 1 x SFP+ Optional M12 adapters
Expendability	BLE, GNSS, GPIO	BLE, GNSS
Certifications	IP30, EN50155 -20C to +50C	IP67, EN50155 -50C to +75C

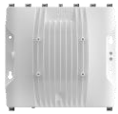
High-performance computing appliance for large-scale Cisco URWB networks

IEC6400 Edge Compute Appliance

- Based on the Cisco UCS C220 M6 Rack Server
- Support Multipath Operations
- High-performance up to 40 Gbps throughput
- Secure CSDL, Secure Boot

Compatible with

Catalyst® IW9167E Heavy Duty Access Point



Catalyst IW9165E Wireless Client

Catalyst IW9165D Heavy Duty Access Point

Cisco URWB Product Family*

*coming EoCY23

A comprehensive portfolio for every industry

Rackmount

Cisco Catalyst IE9300 Rugged Series

IP67

Cisco Catalyst IE3400 Heavy-Duty Series

DIN-Rail

Cisco Catalyst IE3400 Rugged Series

Cisco Catalyst IE3300 Rugged Series

Cisco Catalyst IE3200 Rugged Series

NEW

Cisco Catalyst IE3100 Rugged Series

IOS-XE Operating Software

Cisco DNA Center Management

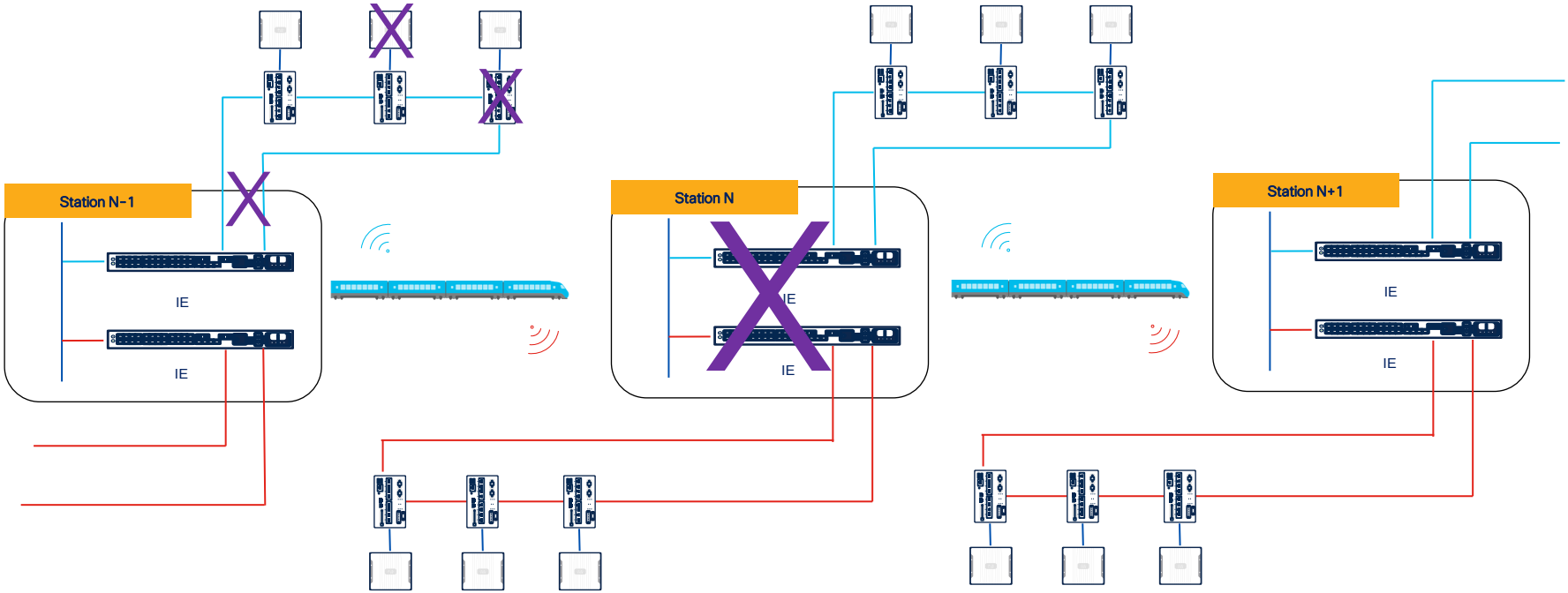
Advanced Visibility and Security

Redundancy design

CBTC DCS redundancy design

- Core network has redundant devices with redundant power supplies, connected through redundant links
- Backbone and wayside network are ring topologies
  - Backbone: The backbone ring utilize dedicated fiber optical cores
  - Wayside: two independent radio networks at different frequencies are provided, connected to opposite station
- Onboard network has two independent networks

Wayside and backbone redundancy in details



Security

APTA recommended practice for rail transit

2.3.1 Control systems (train control or SCADA)

Train control

Train control systems (TCS) provide automatic train supervision (ATS) and may include control capabilities to the control center. Train control systems may also provide automatic train protection (ATP) and automatic train operation (ATO) for train safety, control of train movements and directing train operations on the main line and in the yards.

Generally the field control equipment contains the vital logic controls, whereas the central office equipment monitors the rail system, providing the train controllers with the ability to manage train movement and schedules. The transmission media includes data paths among the system components.

Computer-based train control systems typically utilize one or more main servers operating on a real-time-based operating system. The network would be deemed extremely critical due to the functionality available to the applications.

A typical TCS may be designed as a completely segregated/autonomous network; however, interaction with other applications may require external connectivity. This connection to other networks should be secured in accordance with Section 5 in Part 2 of this *Recommended Practice*. This would include the use of intrusion detection systems (IDS) and firewalls at the boundaries and other network perimeter devices to secure the TCS network. Special precautions need to be taken if connectivity to Internet, Intranet or Extranet is allowed.

Securing Control and Communications Systems in Transit Environments
Part 1: Elements, Organization and Risk Assessment /Management

Source: American Public Transportation Association

Securing Control and Communications Systems in Rail Transit Environments
Part II: Defining a Security Zone Architecture for Rail Transit and Protecting Critical Zones

3.4 Cybersecurity risk zones

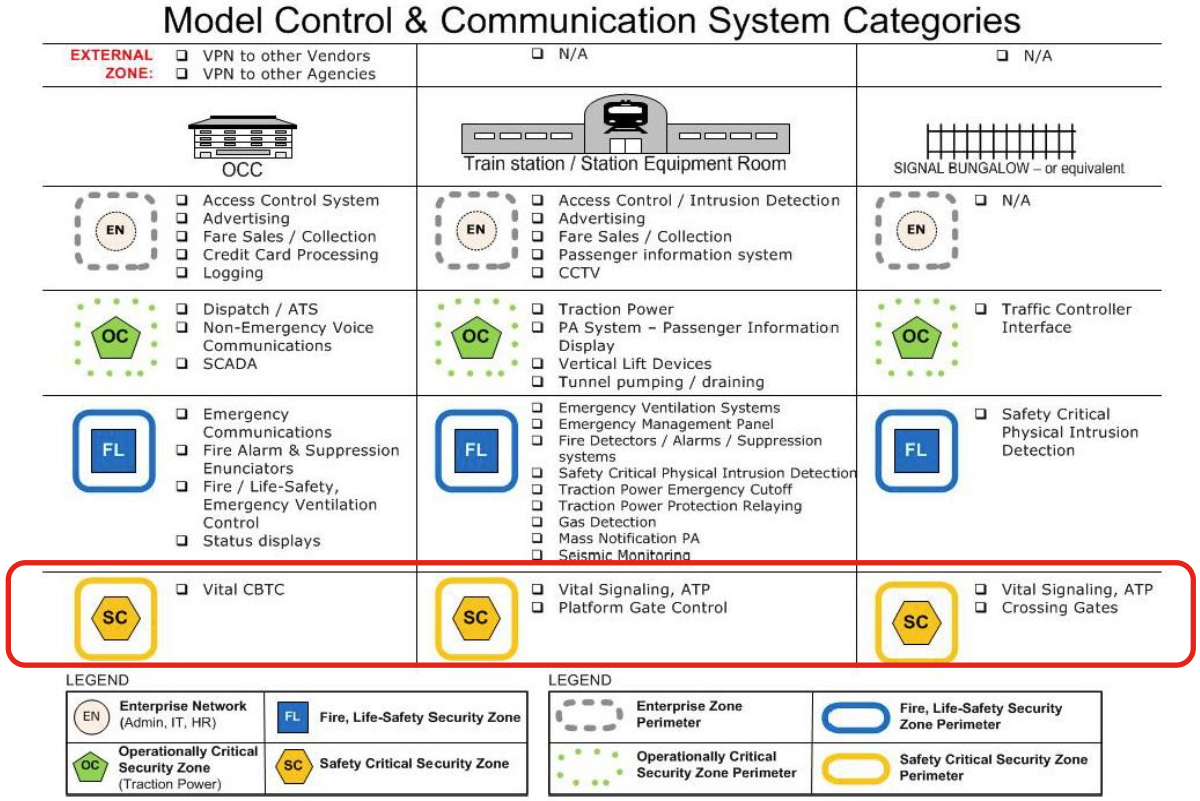
Figure 4 shows an overview of the key elements of a Defense-in-Depth strategic framework for a manufacturing facility.

A successful Defense-in-Depth approach requires agencies to partition control system components and functions into distinct zones based on specific security requirements. It is further recommended that the types of zones be limited in order to simplify the application of consistent controls. Each zone will require a unique security focus and strategy.

Architectural security zones segment hardware, software and networks into physically distinct areas with well-defined connections between them. Commonly, each architectural zone is managed by a separate business unit and is protected by a dedicated device, perhaps a firewall or other controlled device.

Cybersecurity risk zones (also known as impact zones) segment system functions into distinct impact areas with well-defined data exchanges among them. Cybersecurity risk zones present special planning challenges in that they exist within each architectural zone and potentially across them. Different business units may need to establish joint responsibilities in the security management and monitoring of a particular cybersecurity risk zone.

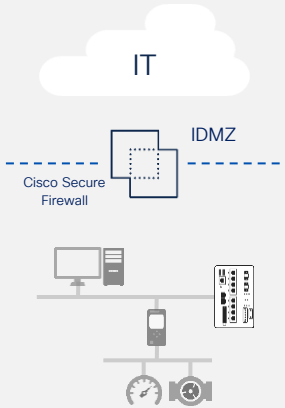
APTA rail transit zone categories



Cisco industrial security guidelines

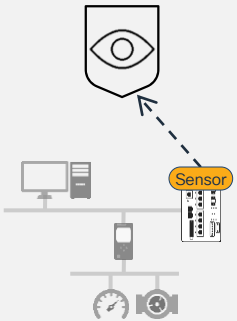
Build a Security Foundation

Define the IT/OT Boundary with Cisco Secure Firewall



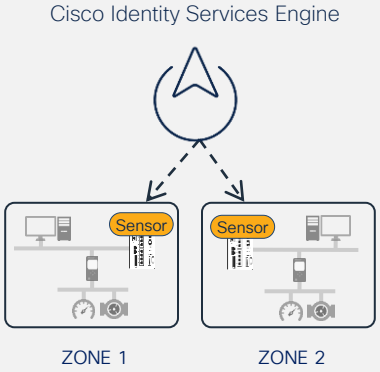
Gain Visibility & Device Posture

Network as a Sensor with Cisco Cyber Vision



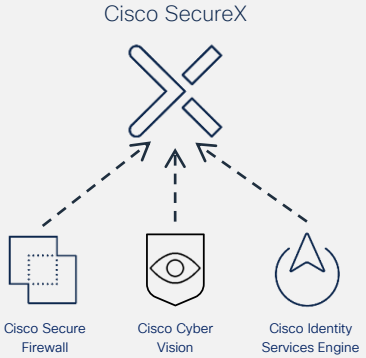
Segment network into smaller trust zones

Network as an Enforcer with Cisco ISE

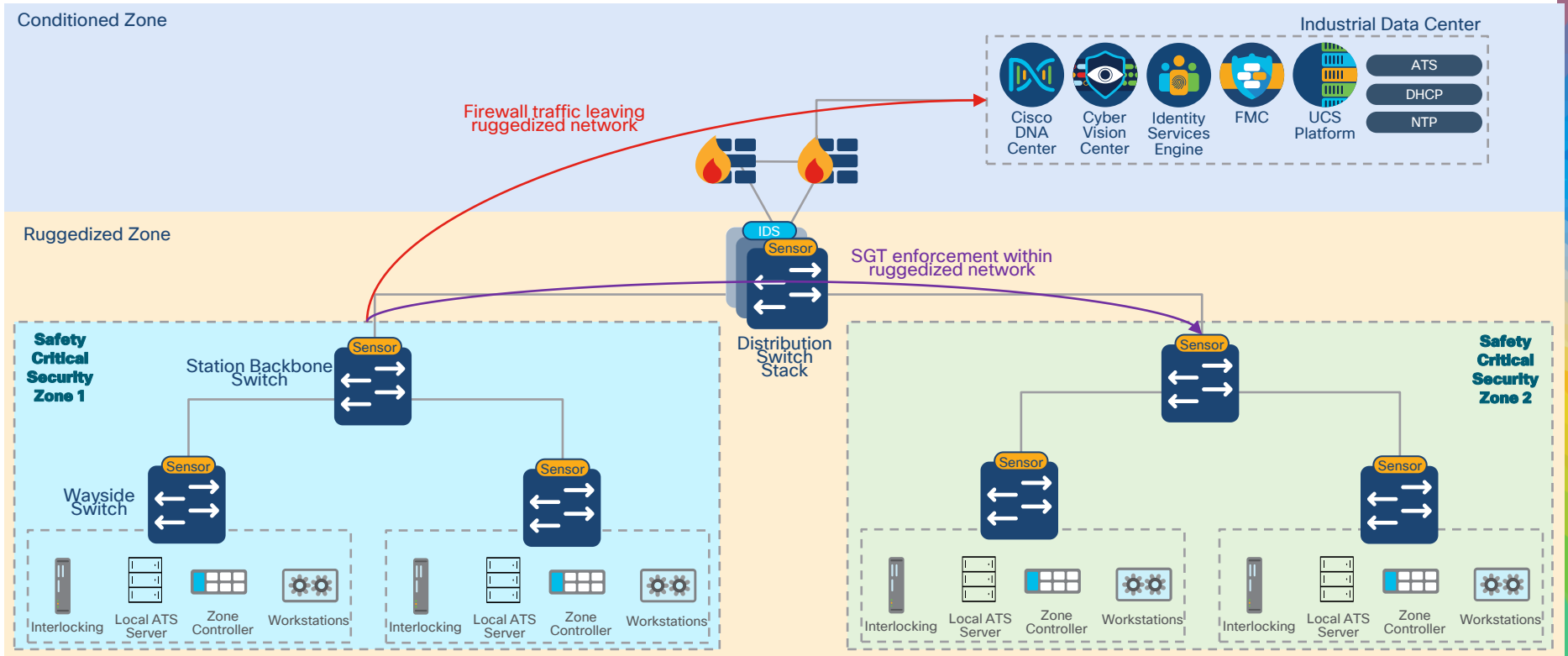


Develop an Incident Investigation & Response plan

Investigate threats & orchestrate response with Cisco SecureX



Network based zoning model



* Cyber Vision support for CBTC still to be validated, this picture represents concept only

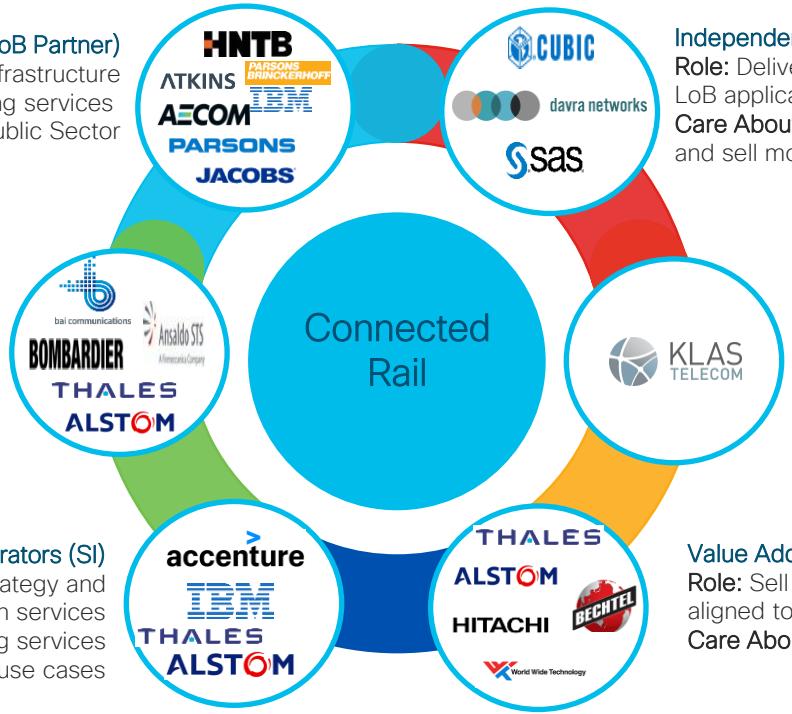
Conclusion

Connected rail ecosystem partners

A&E Consultants (OT/LoB Partner)
Role: Design/Engineer physical infrastructure
Care About: Expand consulting services for delivering end-to-end solutions for Public Sector

Services Operators & Installation
Role: Provide critical transportation operations and managed services
Care About: Grow vertical solutions in connected transportation

Systems Integrators (SI)
Role: Deliver large-scale strategy and business transformation services
Care About: Consulting services engagement in IoT use cases



Independent Software Vendors (ISV)
Role: Deliver analytics, IoT Platform and LoB applications validated on Cisco network
Care About: Access to Cisco partner/sellers and sell more SW licenses

Independent Hardware Vendors (ATMS & IHV's)
Role: Embed sensors, devices, SW into solution
Care About: Sell their products/services in our reference architecture

Value Added Resellers (VARs)
Role: Sell Cisco infrastructure & professional services aligned to government contracts
Care About: Build an IoT practice in the rail market

CX Industrial IoT networking enablement services

Suite of industrial networking services targeted at Cisco's IoT Partners to reduce solution implementation risk

- Industrial Networking advisory services to empower Partners on projects in the Mining, Rail, Oil & Gas, Transportation, Smart City and other industrial/outdoor verticals
- Reduce project risk through alignment to best practices and Cisco Validated Designs
- Pre-scoped, bundled services with price transparency
- Partner retains core deployment activities to enable a true model of partnership with Cisco
- Align to the broad IOT CVD portfolio

Overview of CX Services for Rail

Advisory services around key project milestones

Design Reviews

Cisco will help validate your designs

Testing & Validation

FAT, SAT, SIT and UAT Advisory

Outdoor Wireless Planning & Design

Predictive Modeling + Wireless Design Document Development

Outdoor Wireless Tuning & Optimization

Optimize RF deployment

Enable Cisco Partners in Model of True Partnership

Numerous options available within each service, with and without document development

15+ year rail industry experience

Full Cisco E2E 2005

Full E2E Network for Network Rail - 2009 - 2012

Rail Validated Design Released 2012 - PTC

Milan CBTC 2013 Fluidmesh Technology

Rail Validated Design 2014- Trackside

E2E Cisco and Fluidmesh Solution for Glasgow and Brussels

Rail Wireless Testing - Colorado TTCI - 2015

Rail Validated Design 2016 Trackside/ Train/Station

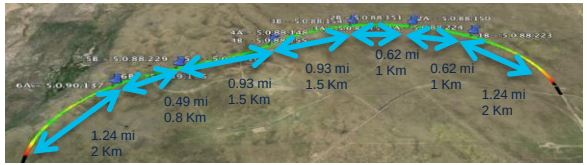
Project SWIFT Testing 2017

Baltimore First Converged Network for Operations and

Trackside Testing - Rail Alliance 2019

Acquisition of Fluidmesh 2020

CBTC Validation Testing Pending



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These points help you get on the leaderboard and increase your chances of winning daily and grand prizes

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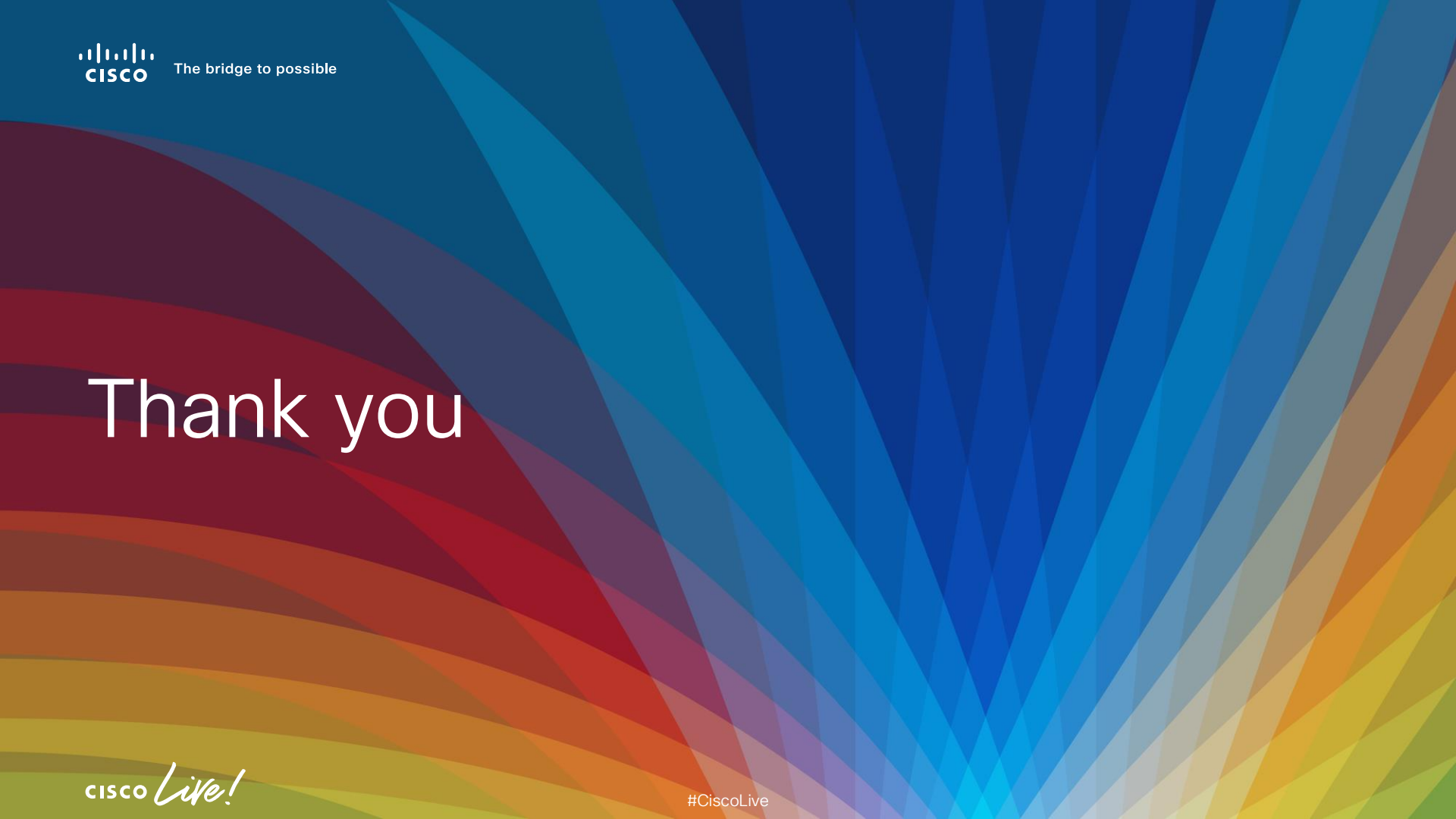
- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand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The bridge to possible
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