cisco Live!

TURN IT UP

#CiscoLive

The bridge to possible

5G Converged SDN Transport

xHaul Architecture

Jakub Horn

BRKSPM-2001

Agenda

- Introduction
- 5G Network Requirements
- 5G Technologies
- Cisco xHaul Transport
- Conclusion

5G

Voice	Browsing	Video	Experiences
2G	3G	4G	5G

Innovation

Radio & Voice/Data Evolution → Service & Network Revolution

Revenue

Linear: Subs + Data = Revenue → Non-Linear

eMBB · URLLC · mMTC

10GBps
Peak data rate

5ms
Latency

1M devices/ km^2
Device density

10TBps
per km^2

5G - Key Use Case Categories

Enhanced Mobile Broadband (inc. Fixed Wireless Access) → Increased bandwidth and capacity

- Extra capacity delivered through new 5G frequency bands
- Not too concerned with connection density or latency

Massive Machine-type Communication → Scale, Reliability

- Focused on low power wide area NB-IoT with high connection density and energy efficiency

Ultra-reliable, Low Latency Communication → Push data plane to the edge, intelligence in network

- For mission critical use cases (self driving, Public safety, ...)
- 1-25 msec latency

Source: Recommendation ITU-R M.2083

Emerging - Low Latency → Push data plane to the edge, Intelligence in Network

- Low latency applications, entertainment

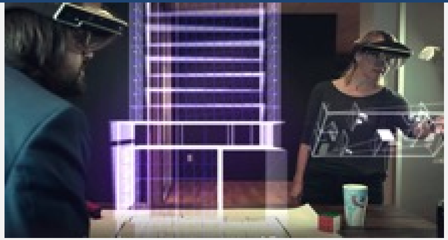
5G Business Proposition

SP Mobile Revenue mix:

2025	Consumer 45%	Enterprise 30%	Vertical 25%
Today	Consumer 70%	Enterprise 25%	5%

Consumers

Enterprises



Verticals

cisco Service Creation & GTM

SP, or Private 5G

- eMBB
- eFWA
- eMTC
  - Supervisory Control
  - Data Acquisition
- NaaS Models "Slices"

where (e) means beyond 4G capabilities

5G

- Bandwidth
- Lower Latency
- Scale
- Critical Resiliency
- Cloud Agility
- API Programmable
- Cost Reduction

CSP Service Examples

Fixed Wireless Access

1/10 Gbps to UE

Enterprise Low latency Service (UPF at Edge)

CSP hosted Network Slicing for Public Sector Private Networks

Police, fire, hospitals with strict SLAs and Security

Private 5G Network Customized Enterprise Mobile Networks

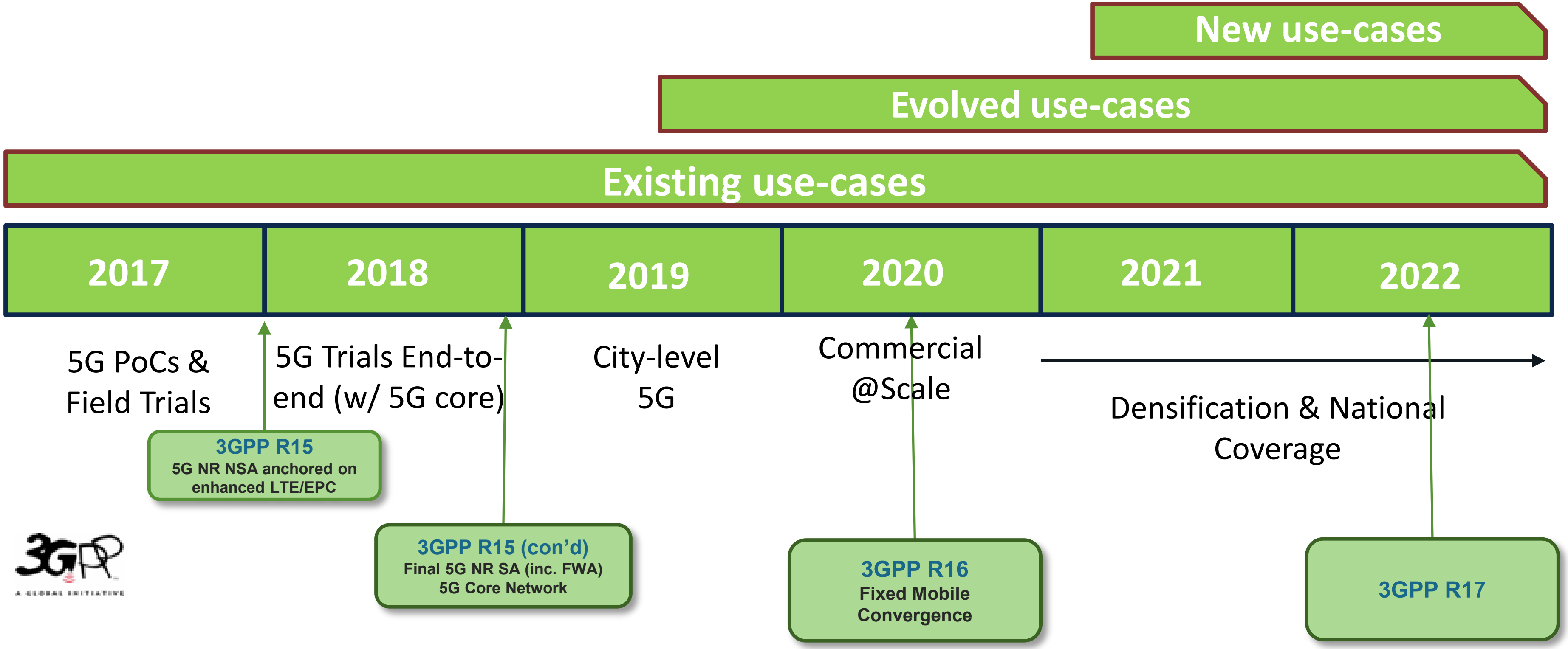
Mining, factory with private policies

Augmented / Virtual Reality Delivery

Augmented, virtual, and mixed reality for learning, gaming, 4K/8K

Video enablement required

Timeline to 5G @ Scale



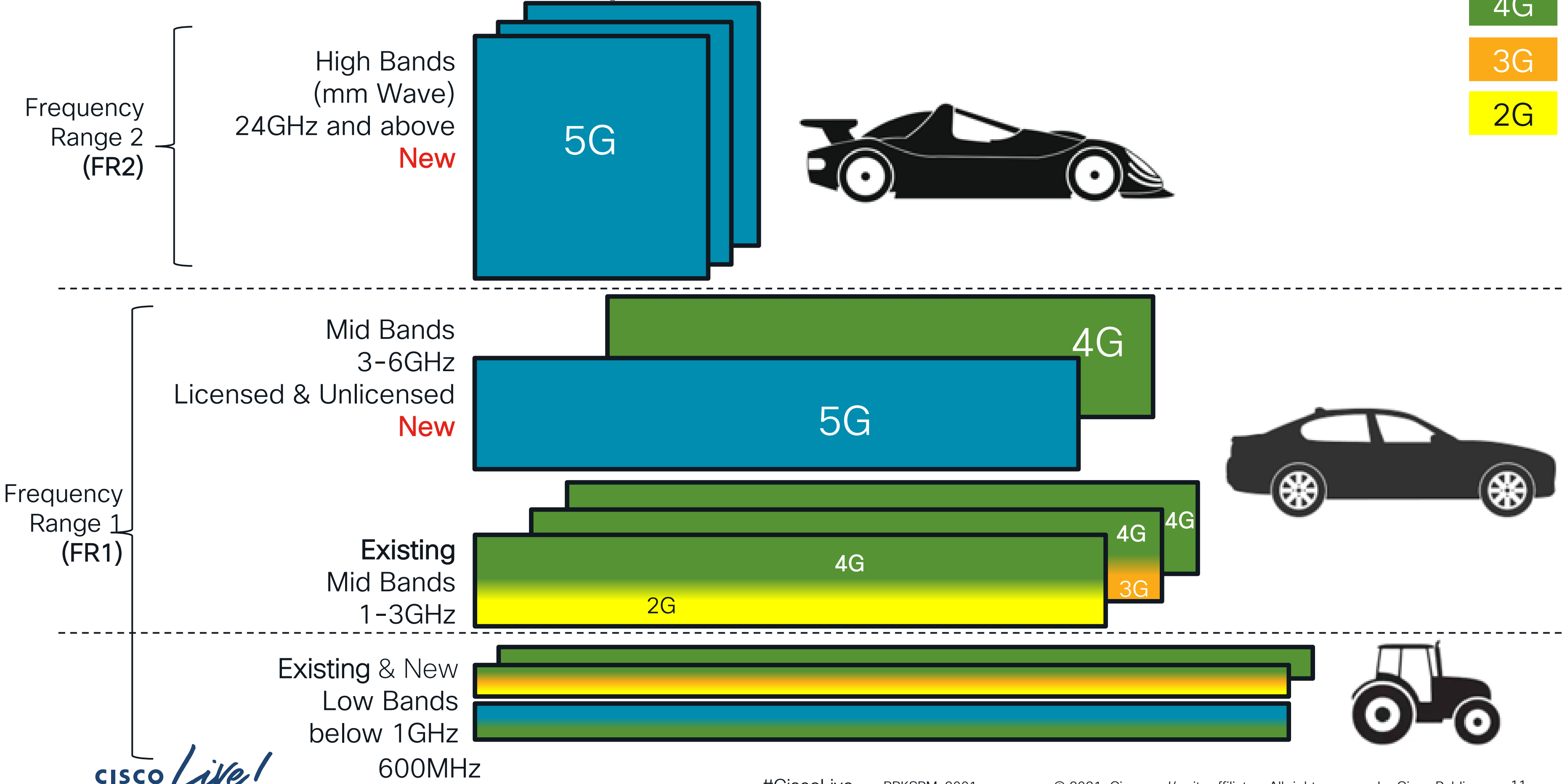
Five Architecture Pillars of 5G

New Radio	Decomposition	SW-Centric	Convergence	Automation
Higher Flexibility High BW, low latency Massive MIMO	Radio Access Mobile Core Converged Core Disaggregation	Virtualization Cloud Native Edge Computing Programmable	Any Access Common Sub Mgmt. Converged Transport Common Policy	Closed Loop Multi Domain Network Slicing Service Assurance

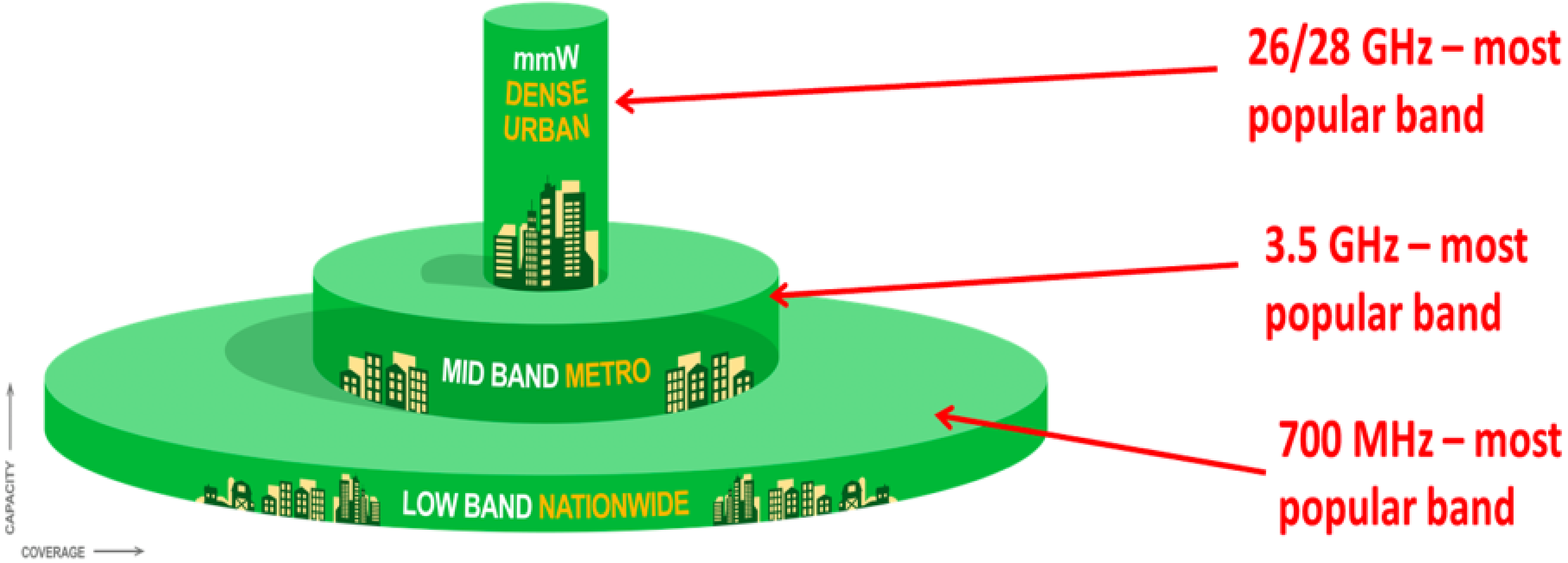
5G NR | 5G Systems Architecture

Applicable to today’s 4G LTE Networks as well

Mobile Network Spectrum



Perspective of Multi Band Spectrum Strategy



5G NR Radio Densification

5G NR Channel Capacity (& Throughput)

Labs, Showcases

Spectral efficiency	bps/Hz (Downlink)	LTE	example 20MHz FDD	LTE-A 3x20MHz FDD	5G NR	example Sub 6GHz 100MHz BW	mmWave 800MHz
Peak/Max Rate	*Theoretical max coded rate*	*15*	*300Mbps*	*900Mbps*	*23*	*2.3Gbps*	*18.4Gbps*
Cell Centre	Minimum rate achieved by top 5% of users	9	180Mbps	540Mbps	13	1.3Gbps	10.4Gbps
Typical	Typical median rate	2.0	40Mbps	120Mbps	2.9	290Mbps	2.32Gbps
Edge	Minimum rate achieved by 95% of users	0.1	2Mbps	6Mbps	0.12	120Mbps	96Mbps
Aggregate cell (multi-user) capacity	Average rate plus multi-user scheduling gain	2.2	44Mbps	132Mbps	3.3	330Mbps	2.64Gbps

* Design caveat: RF Channel capacity depends on many factors, like MIMO schedule deployed, UE capabilities, network loading, mobility, etc. Always consult customer for RAN design guidelines

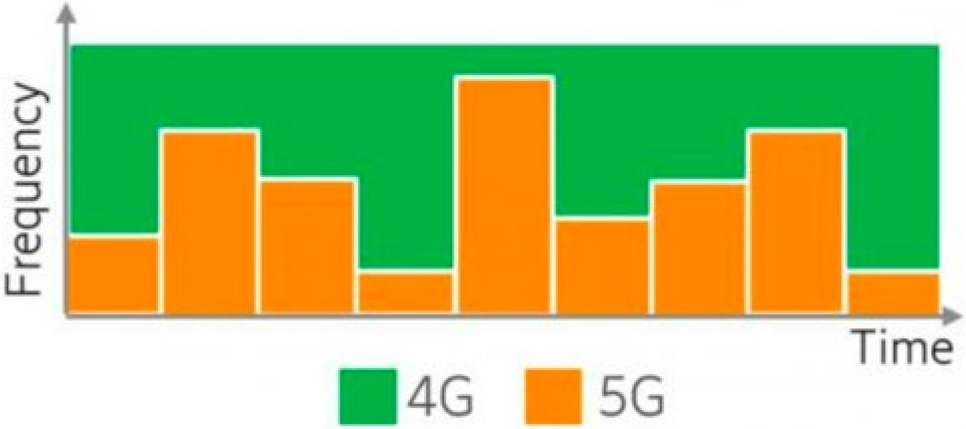
Network Planning

Access Transport Bandwidth: 1G→10G→25G
Edge/IP Core Transport Bandwidth: 10G→100G→400G

5G Dynamic Spectrum Sharing (DSS)

- The same spectrum bands dynamically shared between LTE and 5G NR
- The Radio Equipment Dynamically change radio resources between LTE & 5G NR

Low Band(s)
And / or
Mid Band(s)



RAN Decomposition and Virtualization

Functional Decomposition
Functions Separated to Allow Flexible Placement and Optimization

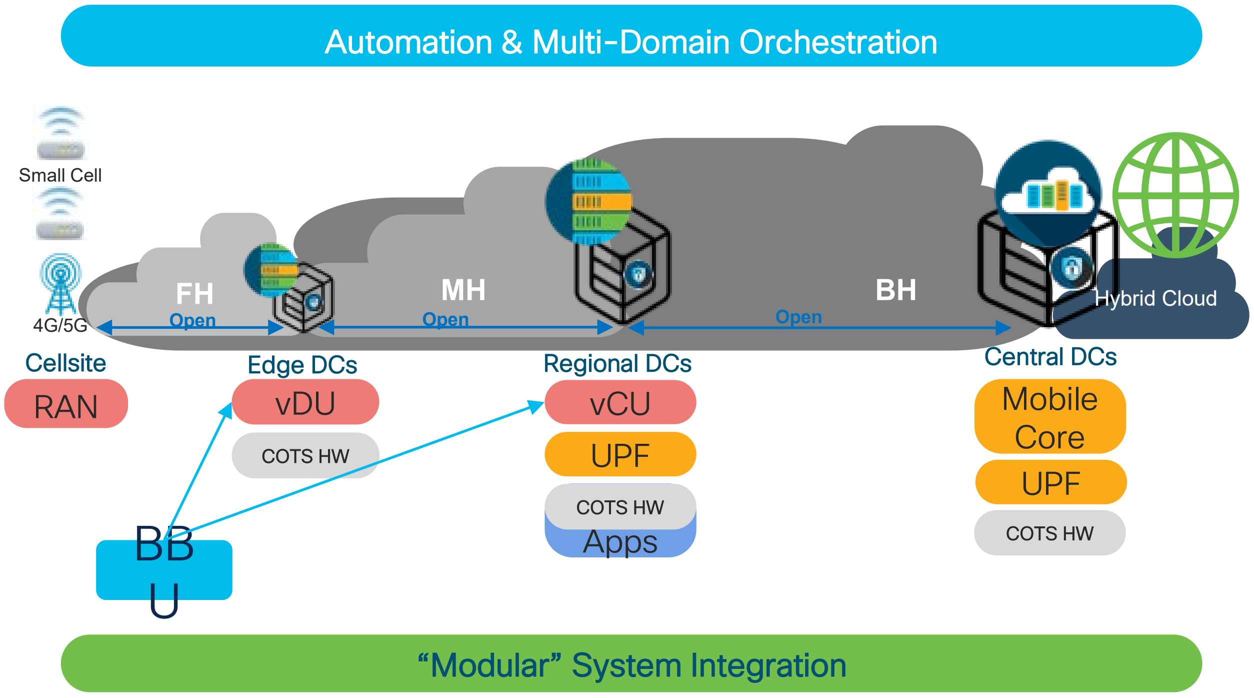
Disaggregation into SW + HW
Software-Centric Solutions Leveraging COTS Hardware

Open
Modular, Open, Multi-vendor,
More Options = Flexibility and Lower Cost

Multi-Use Case
5GNR, LTE, Small Cell, Indoor/Outdoor, mMIMO, Multi-band, mmWave, Private/Public, Enterprise/Consumer, etc.

Optimize for Lower Cost Operations
Agility, Lower TCO, Increased Automation

Enable New Services
Increased Service Flexibility, Velocity



Open RAN

- **Operator-Led Industry Alliance**
- Key Principles – Open and Intelligent
- Publishing Specifications, conducting testing, PoCs, etc

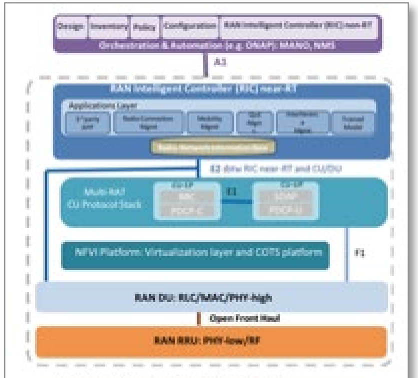


Figure 1: O-RAN Alliance Reference Architecture

Customers:
Rakuten, Japan
Dish Network, US
Vodafone, Europe
Orange, Europe

Cisco Open vRAN Ecosystem Overview

Accelerate the viability
and adoption of open virtualized RAN (vRAN)
solutions and ensure their extension into a
broader software-defined network architecture

Provide Architectural Optionality

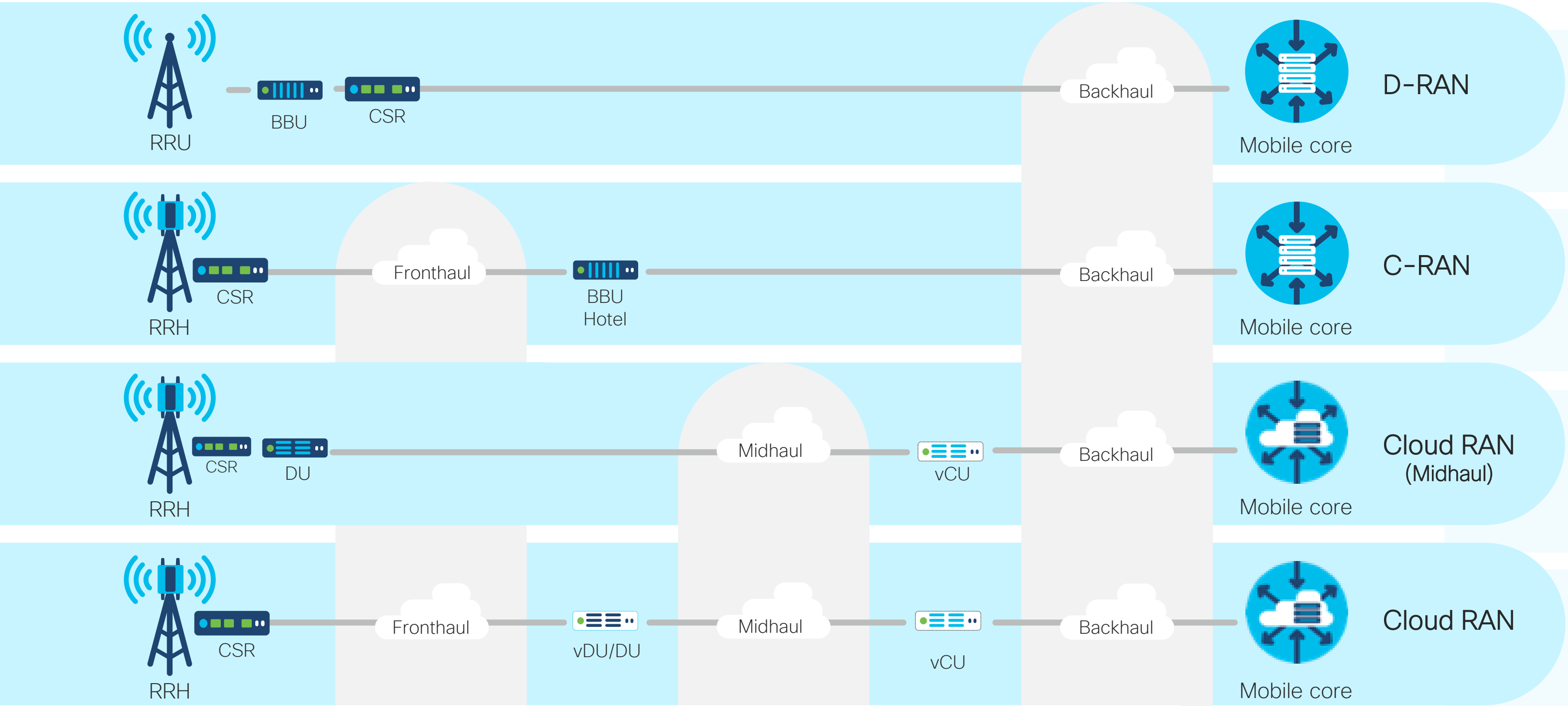
Technology

Economics

Operations

Consumption

RAN Transport Architecture Options



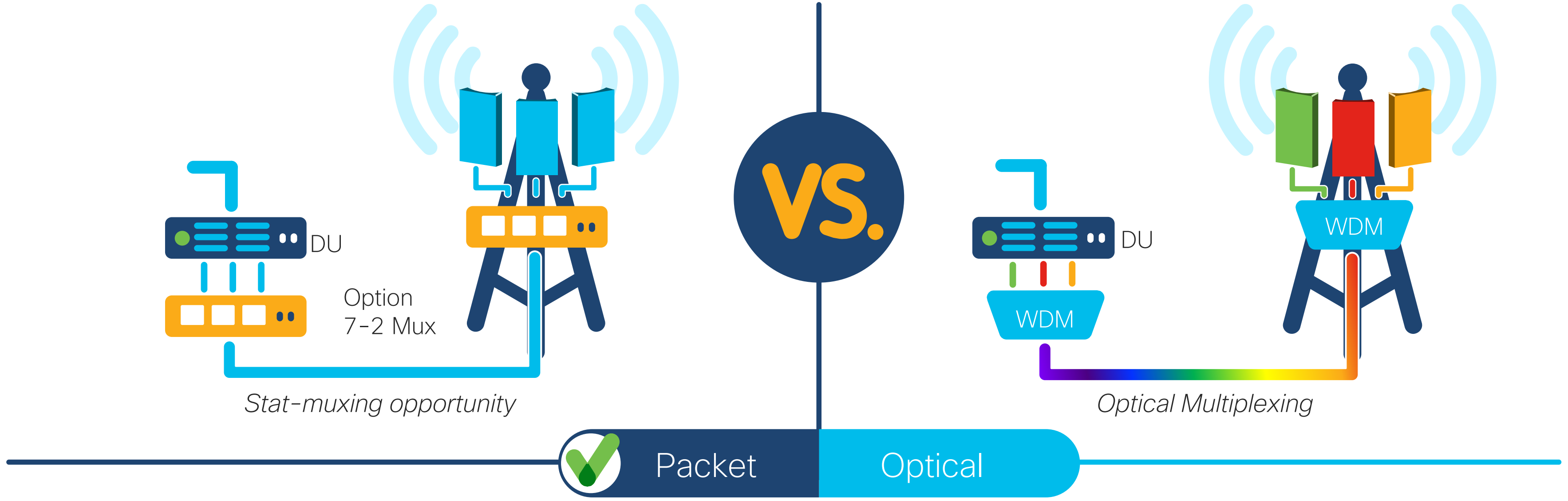
	Fronthaul		Midhaul		Backhaul
1-way latency:	75us/100 us (LTE) 160us (5G NR)	1-way latency:	1-25ms	1-way latency:	10ms
Typical distance:	<15KM	Typical distance:	>10KM	Typical distance:	>10KM
Interface(s):	10G/25G/100G/200G	Interface(s):	10G/25G/100G	Interfaces:	10G/25G/100G/200G

- Higher Speed Interfaces
- Lower Latency
- More Precise Timing & Synchronization
- Any-to-Any Connectivity

Radio Standards

Proprietary	**CPRI** Common Public Radio Interface ERICSSON HUAWEI NOKIA NEC	Internal interface of radio base stations between the **Radio Equipment Control (REC) and the Radio Equipment (RE)** http://www.cpri.info/spec.html	**CPRI Specification version 7.0** – October 9, 2015 (in addition to 1.4, 2.1, 3.0 , 4.0, 4.1, 4.2, 5.0, 6.0, 6.1)
	eCPRI Evolution of CPRI	To enable efficient and flexible radio data transmission via a **packet based fronthaul transport network like IP or Ethernet** http://www.cpri.info/spec.html	**eCPRI 2.0 [CPRI and eCPRI interworking] – May 10, 2019** eCPRI 1.2 – June 25, 2018 eCPRI 1.1 – January 31, 2018 eCPRI 1.0 – August 31, 2017
Standard	IEEE Advancing Technology for Humanity **1914.3-2018** **1914.1-2019** Standard for Radio over Ethernet Encapsulations and Mappings	Encapsulation and mapping of radio protocols for transport over Ethernet frames, using **radio over Ethernet (RoE)** https://standards.ieee.org/standard/1914_3-2018.html	Structure-agnostic – any digitized radio data Structure-aware – CPRI Native mode – digitized radio in-phase and quadrature (I/Q) payload
	3GPP **TSG Radio Access Network (TSG RAN)** https://www.3gpp.org/specifications-groups/ran-plenary	TSG RAN WG1 Radio Layer 1 specification TSG RAN WG2 Radio Layer 2 and Radio Layer 3 specification TSG RAN WG3 O&M requirements TSG RAN WG4 Radio performance and protocol aspects (system) TSG RAN WG5 Mobile terminal conformance testing TSG RAN WG6 Legacy RAN radio and protocol	
Open RAN	O-RAN **O-RAN Alliance** leading the industry towards open, interoperable interfaces and RAN virtualization https://www.o-ran.org/	**WG4: The Open Fronthaul Interfaces Workgroup** O-RAN Fronthaul Interoperability Test (IOT) Version 1.0 – October 2019 O-RAN Fronthaul Control, User and Synchronization Plane Version 2.0 – July 2019 O-RAN Fronthaul Management Plane Version 2.0 – July 2019 O-RAN Fronthaul Yang Models Version 2.0 – July 2019	WG1: Use Cases and Overall Architecture Workgroup WG2: The Non-real-time RAN Intelligent Controller and A1 Interface Workgroup WG5: The Open F1/W1/E1/X2/Xn Interface Workgroup WG6: The Cloudification and Orchestration Workgroup WG8: Stack Reference Design Workgroup, WG7 & WG9
Miscellaneous	**IEEE Std 802.1CM™-2018** Time-Sensitive Networking for Fronthaul https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8376066	OPEN **The OCP Telco Project** https://www.opencompute.org/projects/telco	**Telecom Infra Project (TIP)** Accelerate the pace of innovation in the telecom industry by designing, building, and deploying technologies that are more flexible and efficient

Benefits of Packet-Based Fronthaul vs xDWDM

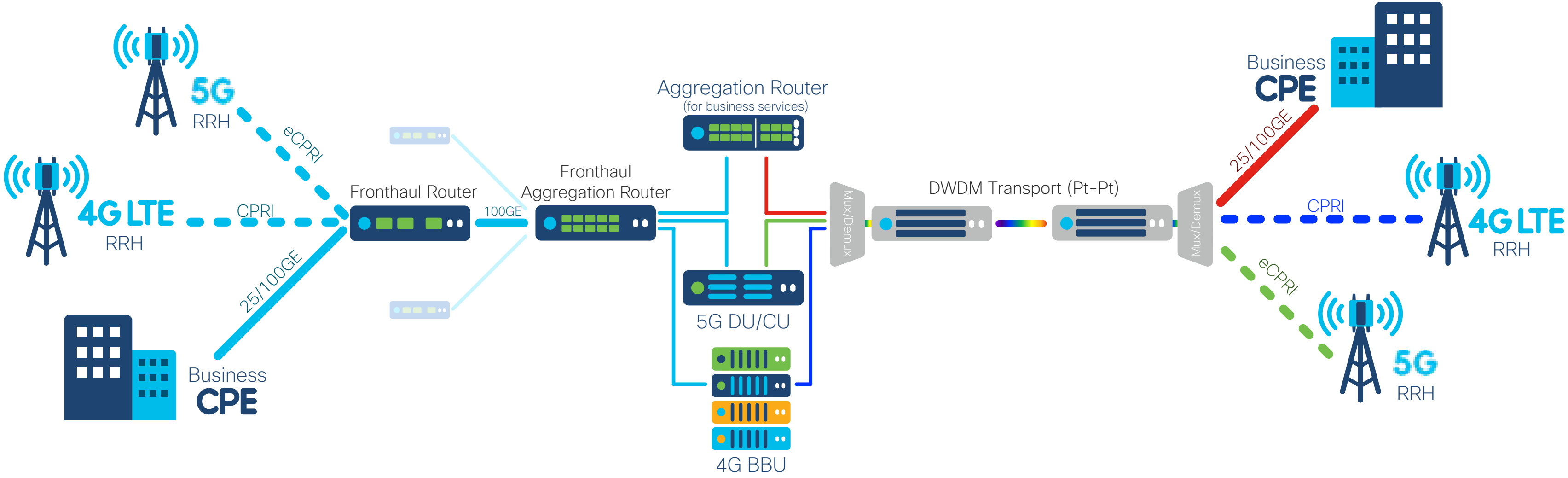


- ✔ Stat Mux Advantages
- ✔ Cost Effective
- ✔ Topology Independent
- ✔ Service Visibility & Transparency
- ✔ Scalable E2E Converged IP

- ✘ Optical multiplexing
- ✘ Non-scalable, architecturally rigid
- ✘ Point-to-point, topology dependent
- ✘ Limited service visibility
- ✘ Capex dependent scale

Comparing TCO for fronthaul

Packet vs optical fronthaul solutions



Packet-based fronthaul

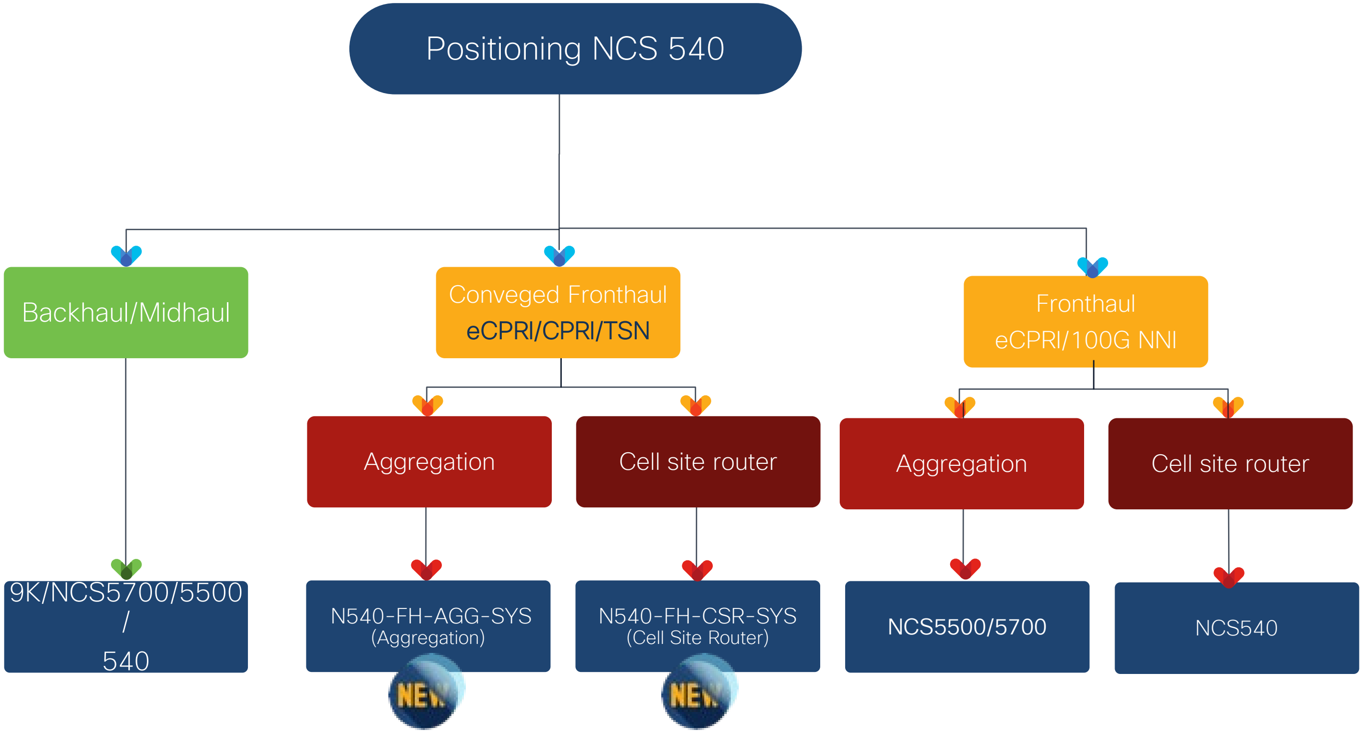
Up to **65%** TCO Savings

Optical-based fronthaul

Savings				
	+65% ROADM	+46% P2P Active DWDM	+40% P2P Passive DWDM	+13% P2P Passive CWDM

Source: ACG – An Economic Comparison of Fronthaul Architectures for 5G Networks

xHaul Portfolio

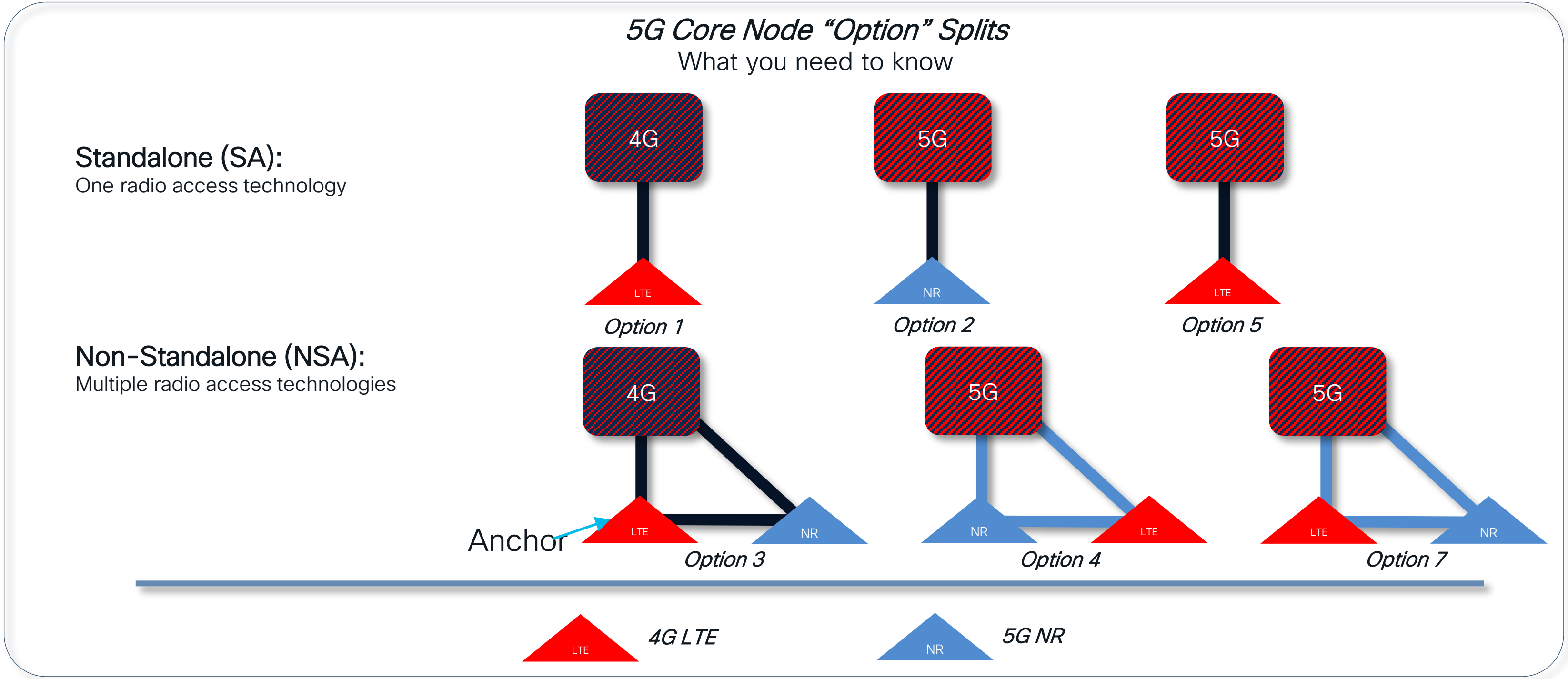


eCPRI is fully supported on shipping NCS540 portfolio

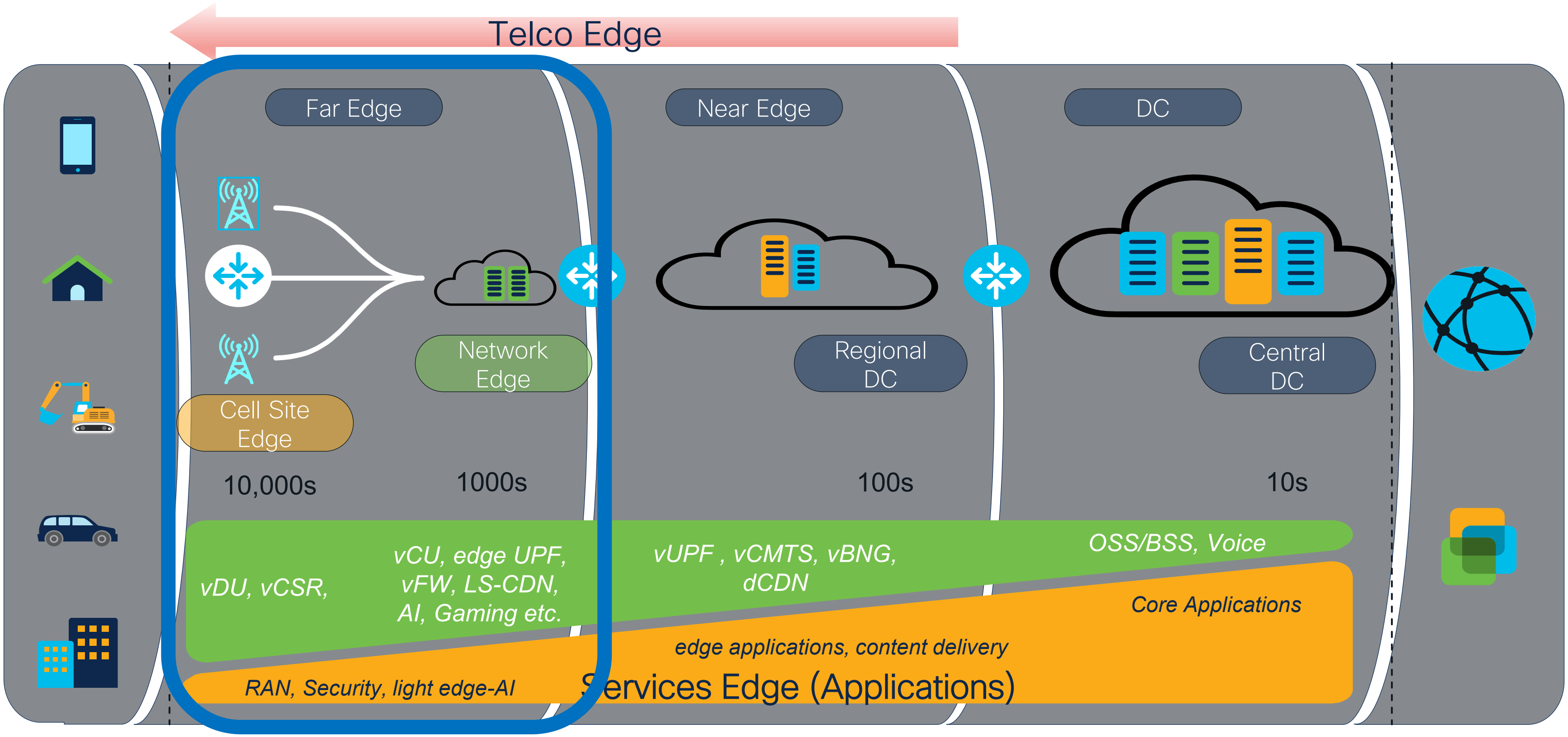
You will hear about 5G Option Splits...

Mobile Core Options

Mobile Core Decomposition = Control Plane (CP)+User Plane Function (UPF)



Transition to the Telco Edge



Operators Challenge @ the Network Edge

Scalable Disaggregation, Ultra Low Latency

$ CAPEX + OPEX
PER EDGE SITE

POWER
#RU per RACK

Demands Improved: Latency, Jitter, Synch, Core BW

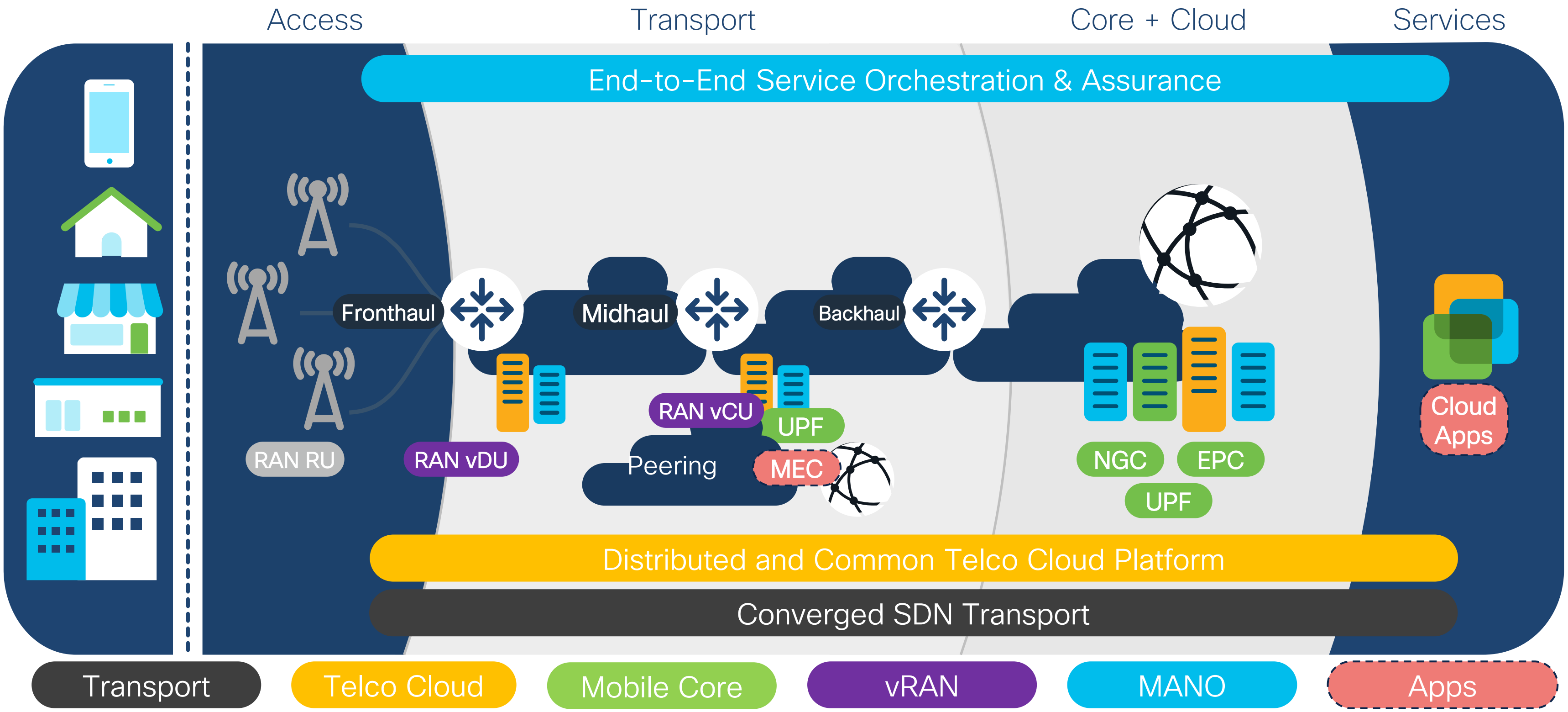
COST Optimized
REVENUE generated
Edge

Agile, Flexible and Replicable across 1000s of edge sites

EASY TO OPERATE

PROFITABLE

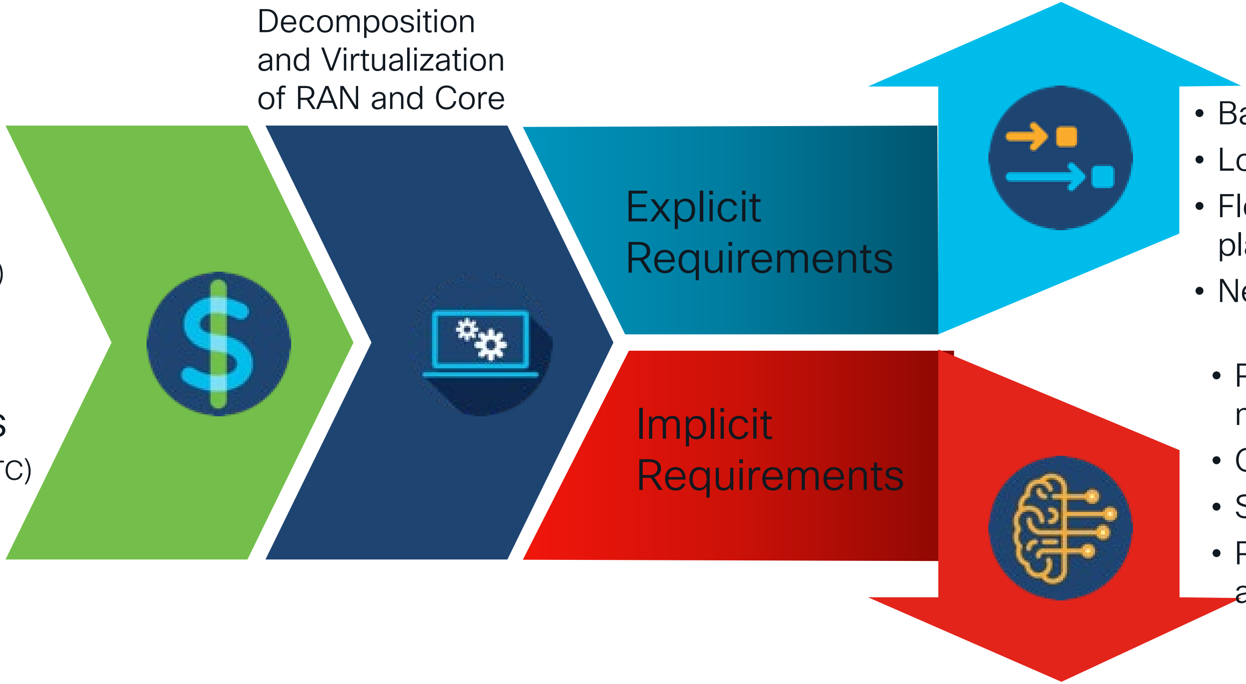
5G Network Transport Evolution



What’s Different in 5G Transport?

5G RAN
(Sub-6Ghz, mmW)
+
5G Services
(eMBB, URLLC, mMTC)

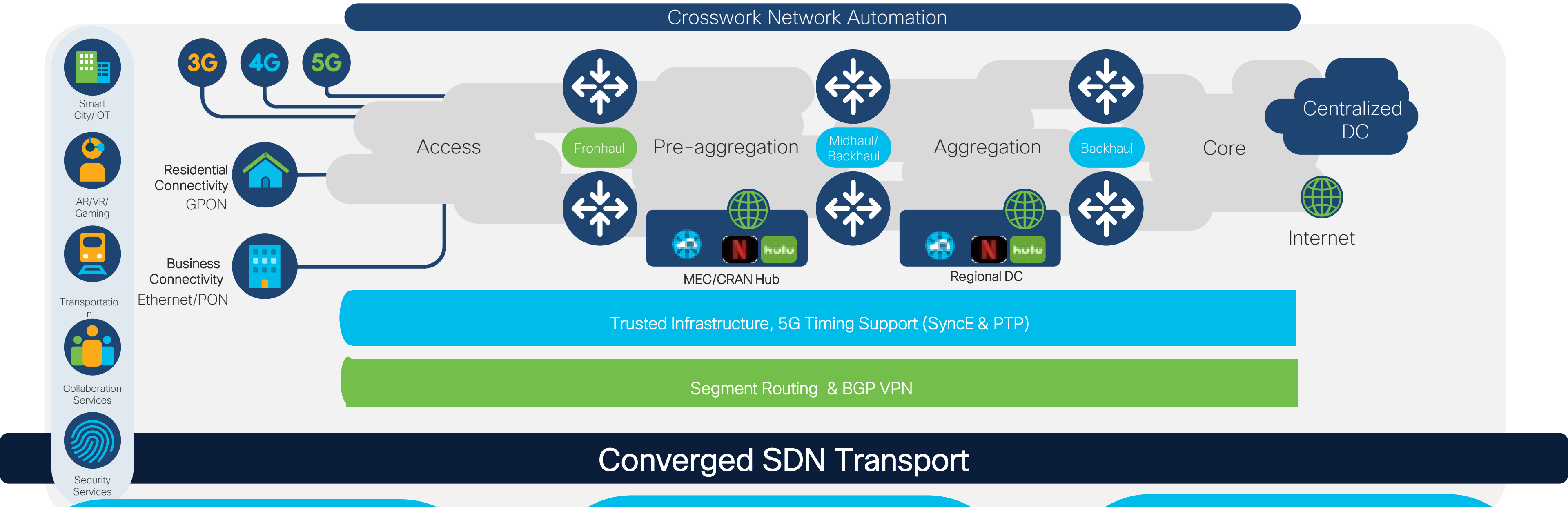
Decomposition and Virtualization of RAN and Core



- Bandwidth and scale
- Low latency
- Flexible service placement
- Network slicing

- Re-architect the network (MEC)
- Operational efficiency
- Simplification
- Reliability and awareness

Cisco Transport Strategy



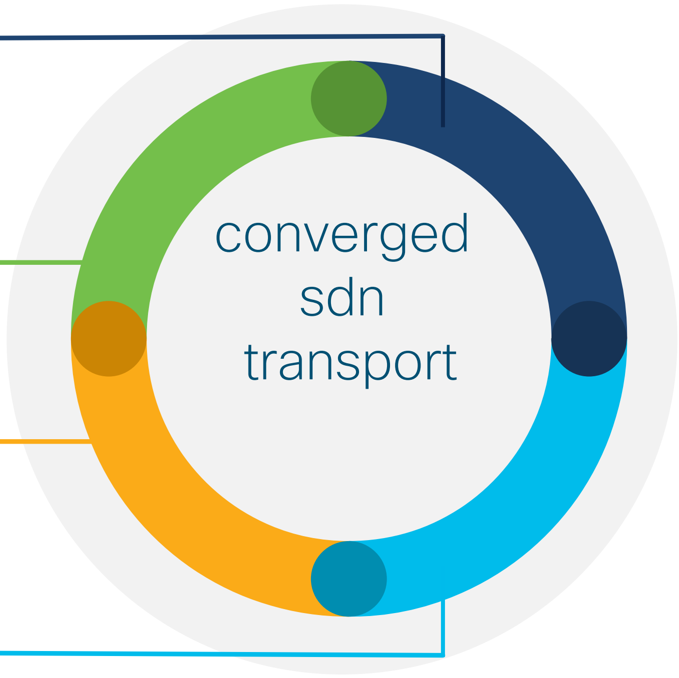
Converged Infrastructure for Wireline and wireless services

Single Technology End-to-end: SR and BGP VPN

Open, Programmable, SDN Based: NSO, SR-PCE, Cisco Crosswork

IP Transport Foundations “Done Right”

- high-performance, 5G-ready portfolio
- trusted infrastructure
- cross domain automation
- software-driven simplification



Lowering TCO by 62%

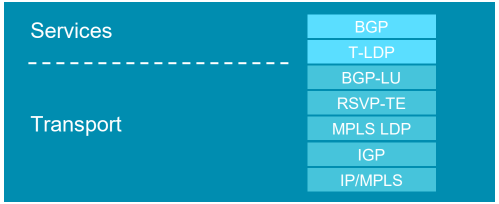
- 60% improved capital efficiency
- 66% better OPEX utilization
- 81% faster time-to-service

Forwarding Plane Evolution

Complete

Unified MPLS

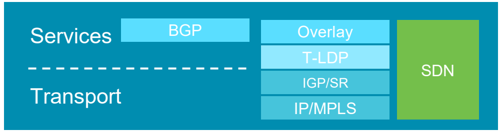
No Service stitching required: Reduce Touch Points, Build once-Use Many
End-to-End BGP Label Unicast
Fast Convergence: Remote LFA & BGP PIC



Complete

MPLS SR with Controller

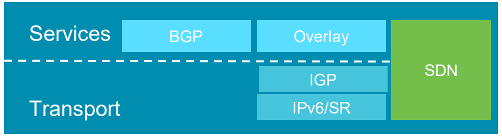
MPLS SR: optimised and simplified routing
Centralised management and orchestration
Distributed control plane



In Progress

SRv6

Further simplification and scaling
NFV
Centralised management and orchestration



Flexible & Smooth Transition for Brownfield

1 — From Any Legacy Technology

2 — To SR-MPLS

3 — To SRv6

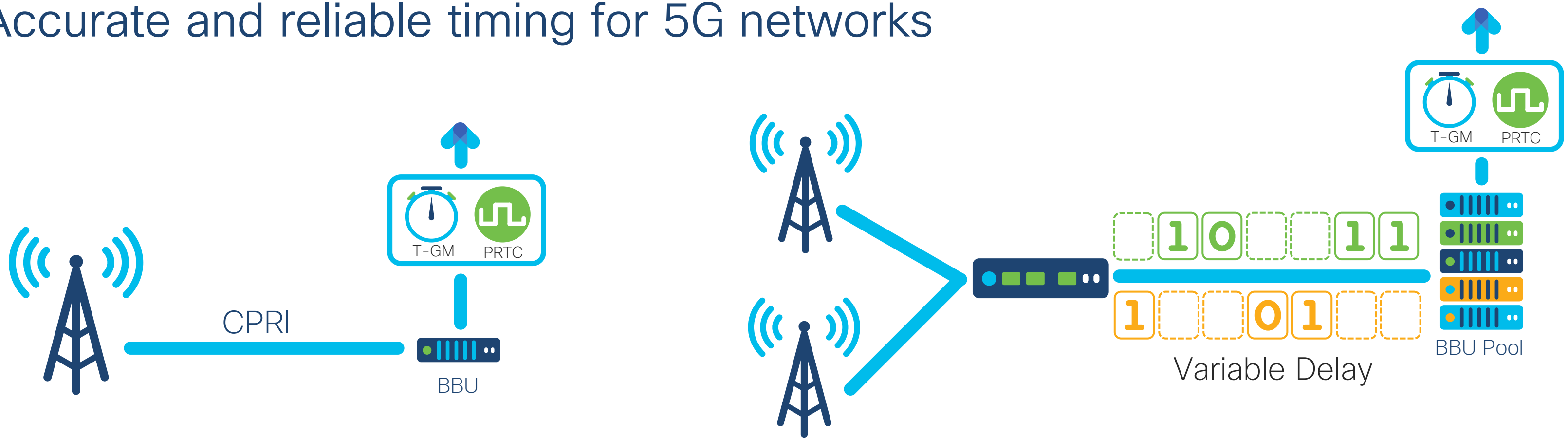
Possible Option

Smooth Migration

- SR interoperates, co-exists with LDP
- SR Multi-vendor
- NSO can facilitate the migration from legacy technologies

Precise Timing and Synchronization

Accurate and reliable timing for 5G networks



CPRI protocol delivers Sync | **How do we deliver Sync for 5G networks?**

ANSWER Advanced throughput optimization techniques such as Inter-Cell Interference Cancelation, MIMO coordinated multi-point data delivery require precise time synchronization.

- CPRI protocol delivers synchronization natively, eCPRI/RoE does not.
- eCPRI use cases require RAN transport to provide accurate phase and frequency synchronization

Cisco Routers support stringent phase and frequency synchronization **(PTP/1588 and SyncE in Transport Network)** requirements with up to Class C timing capabilities

Timing and Synch – Solutions

GNSS (GPS, Galileo) Receivers → Include GNSS receivers inside routers where appropriate

- Effective solution where site conditions allow (Sky view, $$)
- Susceptible to jamming (and increasingly spoofing)
- Time source for cell sites, PTP GM's and monitoring equipment

PTP/1588 and SyncE in Transport Network → Routers as high performance T-BC boundary clocks with Class C G.8273.2 performance

- Great solution: G.8275.1 with "on path support" for PTP
- Needs good network design in combination with SyncE
- End-to-end timing "budget" with accurate boundary clocks

All of the Above → Flexibility in the design of the equipment allows them to be used in any situation

- PTP/SyncE as a backup to GNSS receiver outages
- GNSS where it's cost effective, PTP everywhere else

Galileo photo © GSA

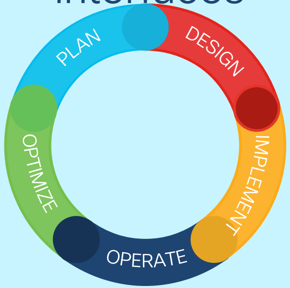
Open & Automated Management

Outcome-driven automation

Flexible NSO function packs

To automate provisioning of multi-vendor domains

Open APIs and management interfaces



To enable full operational lifecycle of the products

Cisco Crosswork portfolio

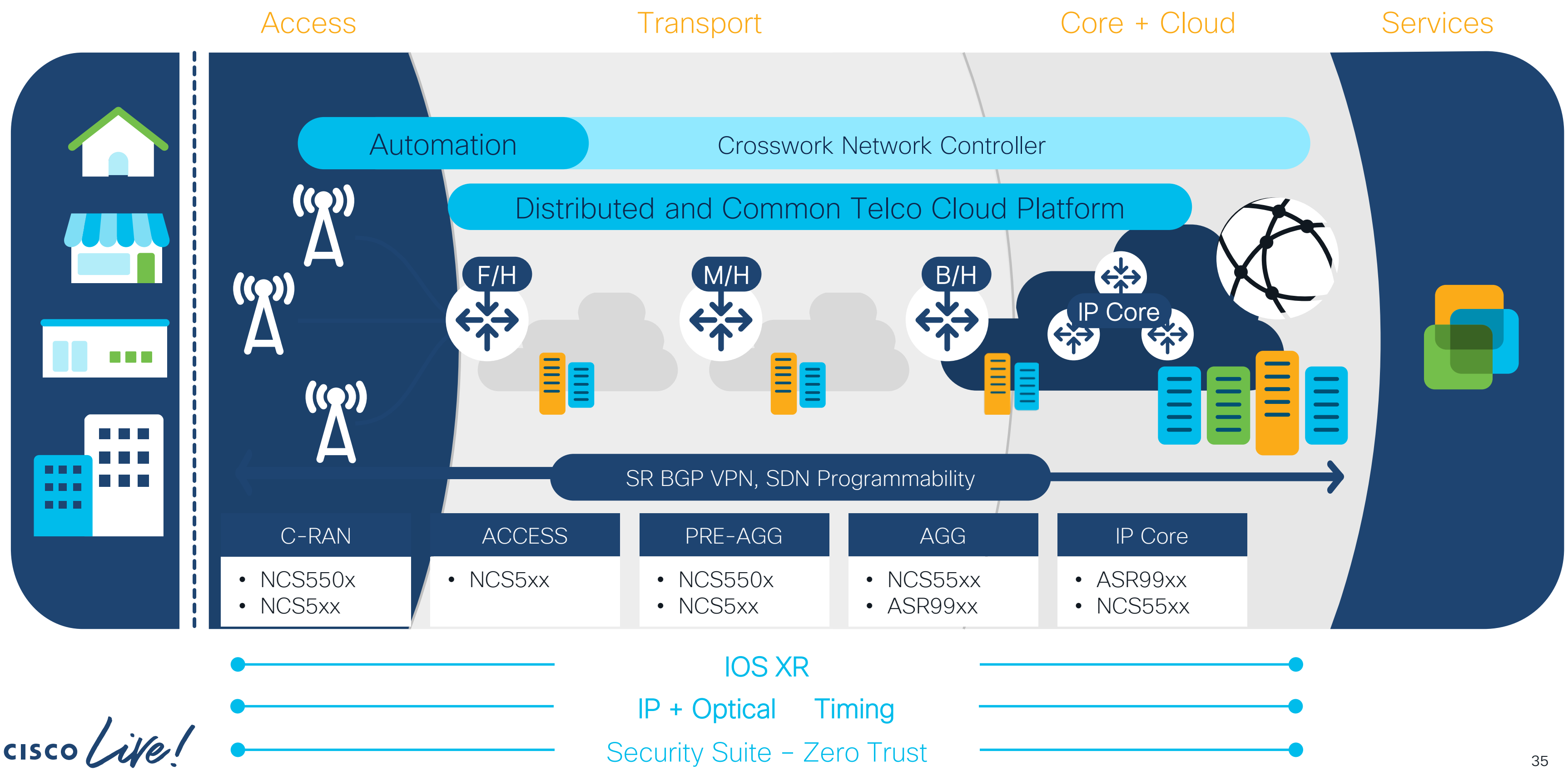
Cisco Crosswork

Crosswork Cloud

To provide full suite of FCAPs applications

Closed-loop and outcome-driven automation, on premises and in the cloud.
Simple integration into legacy RAN management domains & other NMS/OSS systems

Converged SDN Transport Solution



Network Slicing

Network Slicing is fundamentally an end-to-end **partitioning of the network resources** and network functions so that selected applications/services/connections may **run in isolation** from each other **for a specific business purpose**

Its about:

1) Network orientated Service Level Agreements (SLAs)
2) A multi-service network infrastructure offering a variety of services
3) Cost effective and Efficient

Toolset for transport level slicing

- QoS and H-QoS: Core and edge
- Forwarding Planes: Shortest Path / SR policies (SR-TE / Flex-algo)
- SR underlay performance management tools

Creating and managing the slice forwarding plane

- Virtual Private networks : L2 / L3 VPNs
- ODN and Automated traffic Steering (AS)
- VPN performance management tools
- Slice X-domain and domain orchestration

Customer slice instances and mapping to slice forwarding planes.

Cisco Validated Design Document

Converged SDN Transport High Level Design

- https://xrdocs.io/design/blogs/latest-converged-sdn-transport-hld
- https://xrdocs.io/design/blogs/latest-converged-sdn-transport-ig

5G Features covered:

- Clocking & Synchronization
- 5G Transport SR MPLS/BGP VPN
- Fronthaul will be covered in future release

Continue your education

- Demos in the Cisco campus
- Meet the engineer 1:1 meetings
- Walk-in labs
- Related sessions

cisco The bridge to possible

Thank you

cisco Live!

TURN IT UP

#CiscoLive