Experience. Outcomes.

5G – More than Just a Wireless Upgrade

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The 5G Journey

Ciena's involvement in 5G standardization

Standards Bodies (Active Participation & Monitoring)

IEEE	IEEE 5G	IETF	ITU	ETSI World Class Standards	3GPP A GLOBAL INITIATIVE	CPRI Common Public Radio Interface
1914.1/.3 802.x	5G – EAD		Study Group 13 Study Group 15		Active Monitoring	Active Monitoring

Industry Forums (Active Participation)

xRAN | OIF Optical Internetworking Forum | MEF Metro Ethernet Forum | ngmn the engine of broadband wireless innovation | Small Cell Forum Solving the HetNet puzzle

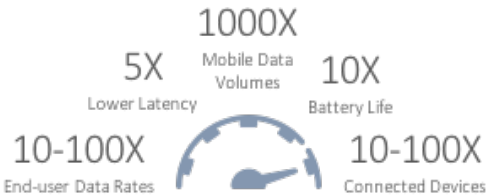
Open Sources (Active Participation)

ONAP Open Network Automation Platform | Open Compute Project | ONF | OpenDaylight | Telecom Infra Project

ONOS
CORD

The 5G Promise

Connectivity Anywhere and Anytime, to Anyone and Anything



Enhanced Mobile Broadband (eMBB)

Extremely high data rates, low latency, extreme coverage

Massive Machine Type Communications (mMTC)

Extremely large volumes, ultra dense coverage, small payloads

Ultra-reliable Low Latency Communications (urLLC)

Extremely high reliability and availability, ultra low latency

Order of magnitude increase in ***Complexity*** due to dynamic service variance,

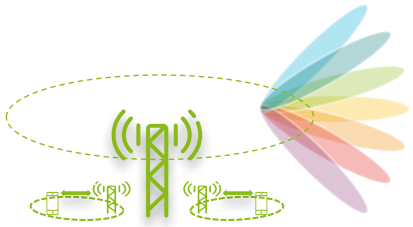
seeking a new design paradigm that preserves ***Simplicity*** while enabling extreme flexibility …

5G Journey

a multi-faceted path

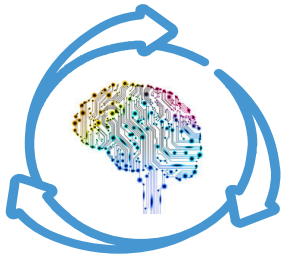
Wave-1: Telco Transformation [Now]

Convergence of IT and telecom for the Telco Cloud



Wave-2: 5G Access Evolution [2018+]

Massive Bandwidth, Massive Performance and Massive Volumes

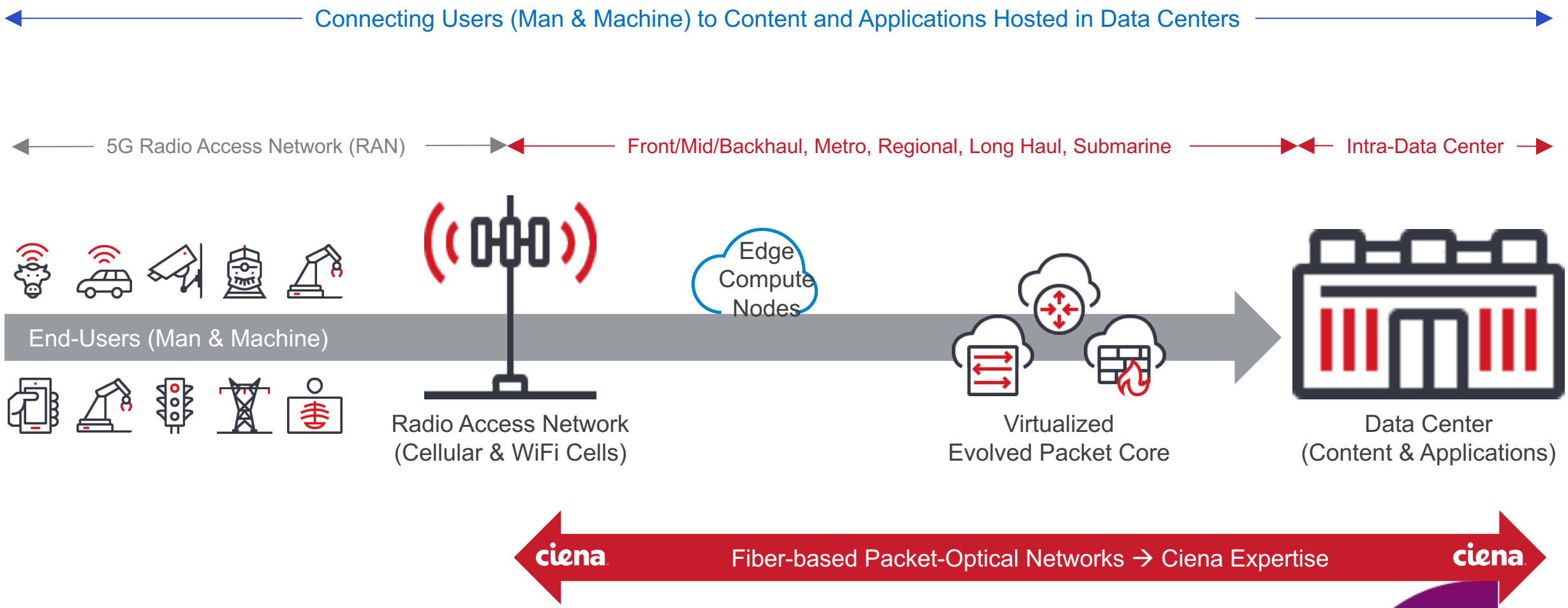


Wave-3: Distributed Intelligence [2020+]

Advancements in Artificial Intelligence and Machine Learning making the impossible, possible

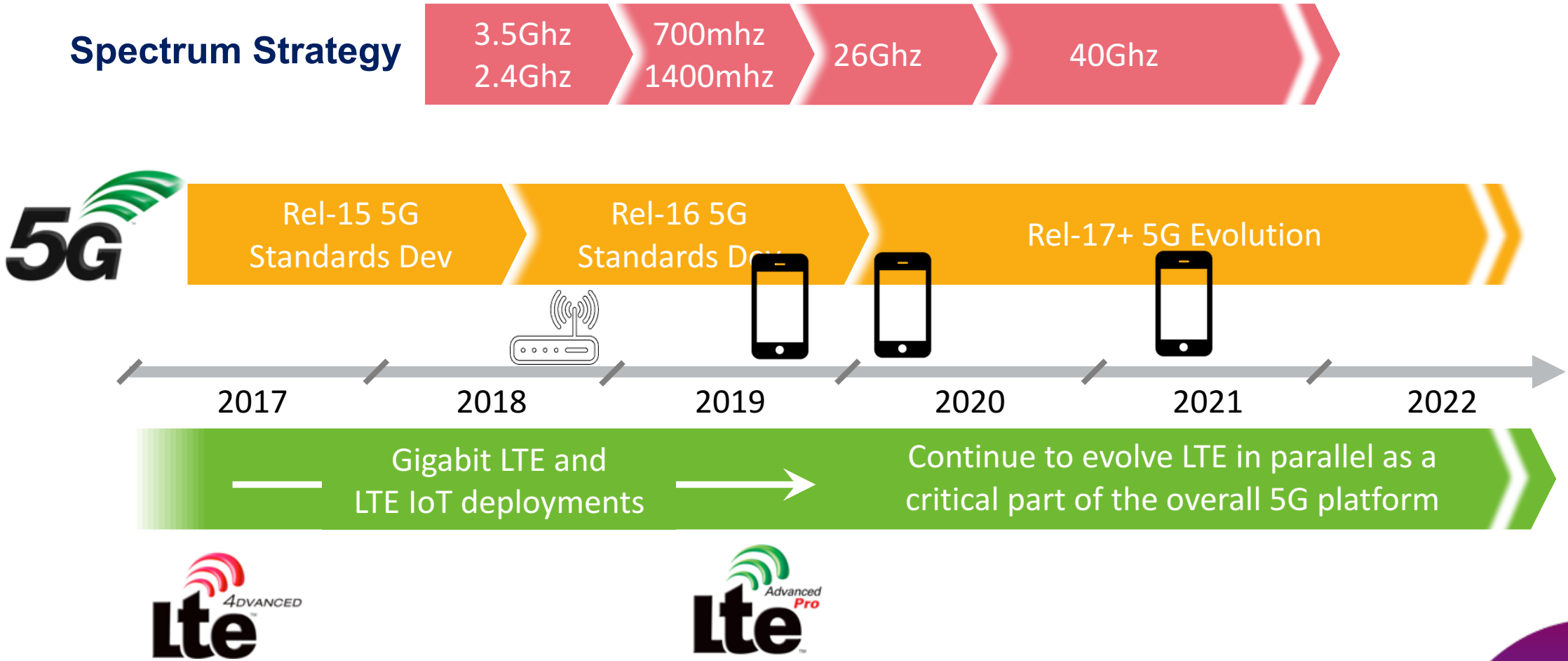
Where 5G Impacts Wireline Networks

Connecting users (man and machine) to data, content, and applications



The Evolution Path

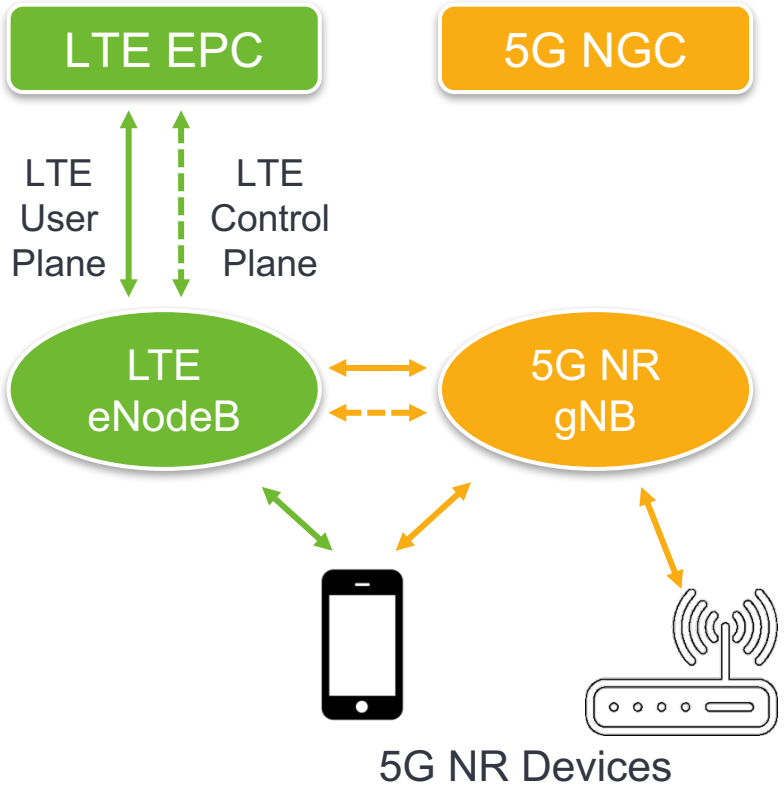
Standards, Spectrum, Business Cases alignment



5G NR (New Radio) Deployments Coexist with LTE in 2018/2019

Early deployment scenarios

MNOs 2018-2019 Deployment Architecture



Initial early deployments of 5G NR into existing Mobile Networks will be LTE Assisted & EPC connected. This is called 5G Non-Standalone (NSA) Mode.

With the addition of the extra radio capacity to the cell site, the existing backhaul requirements will increase.

Legend:
NGC: Next Generation Core
gNB: 5G NodeB
eLTE: Evolved LTE

Intercepting LTE-LTE-A and Initial 5G NR Non-Standalone (NSA) Deployment

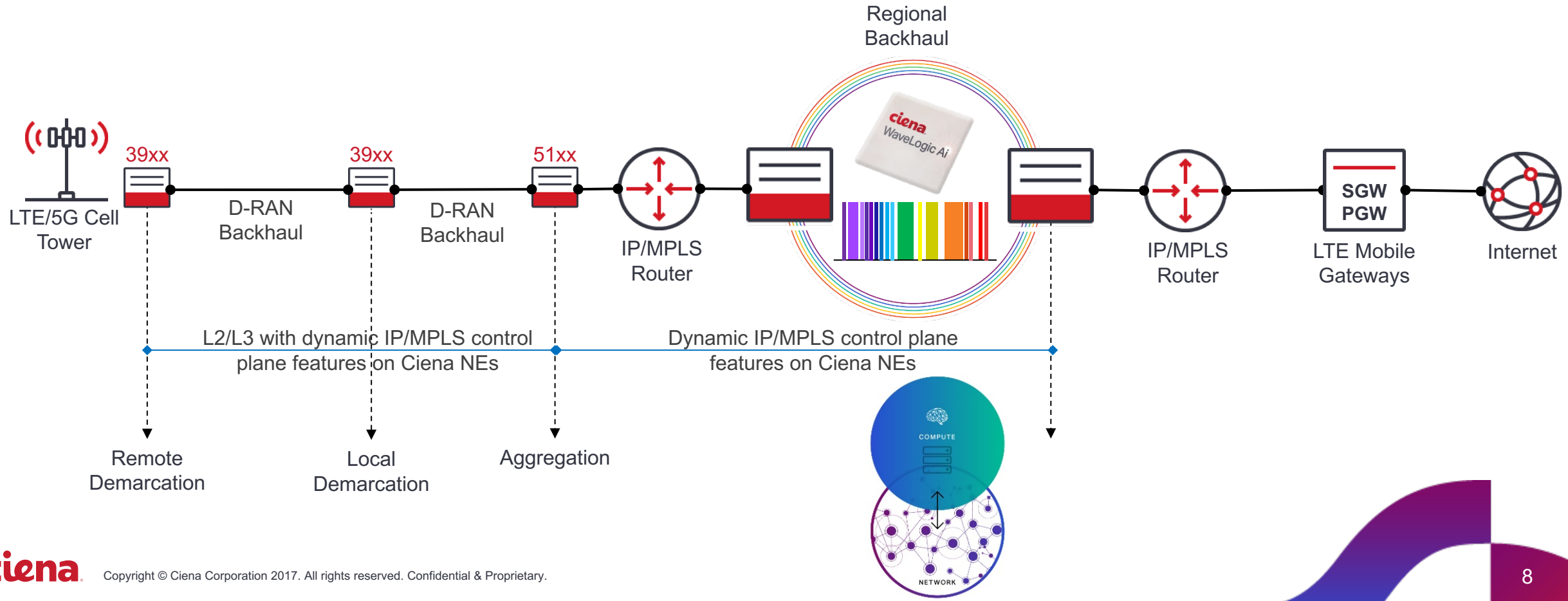
Addressing both scale and performance

100 Gbps

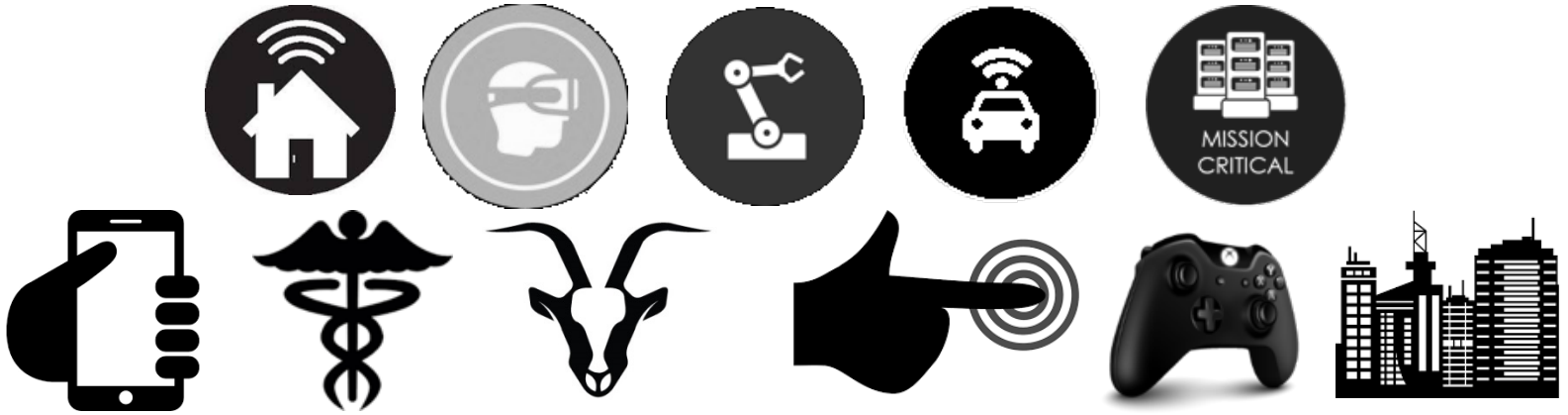
Massive Capacity

Blue Planet Intelligent Automation

- Blue Planet MCP (39xx / 51xx)
- Blue Planet MCP (6500)
- Blue Planet Data Center Controller



5G Is More Than Just a New Radio Technology



Access Evolution

Massive Capacity

Densification

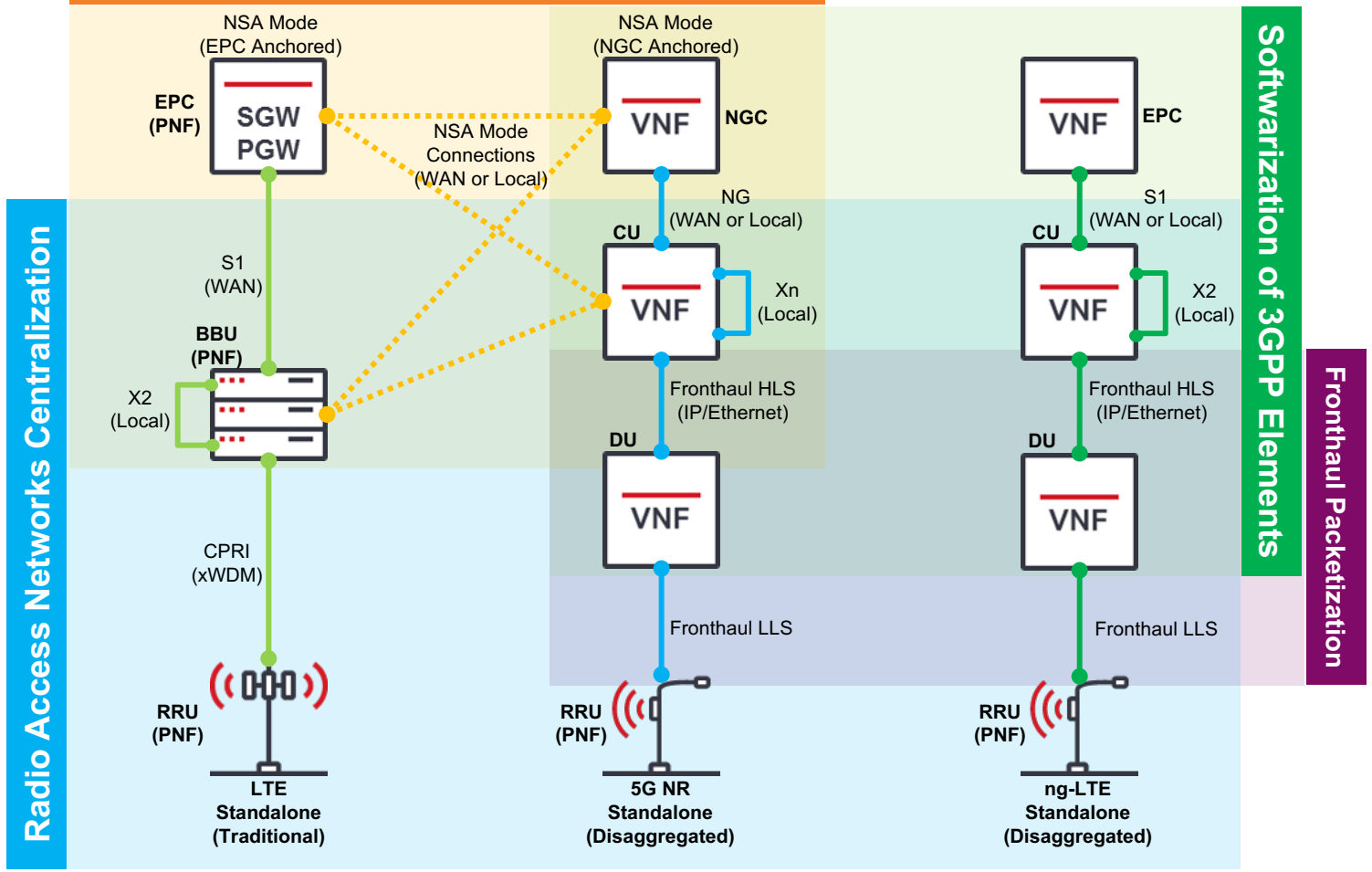
NFV Adoption

Edge Compute

Major Architectural Shifts Expected in 5G that Impact Wireline Networks

RAN Centralization ● Virtualization ● Fronthaul Packetization ● 4G/5G Co-located Deployments

NSA Mode Deployment Architecture



Terminologies & Key References

PNF: Physical Network Function	RRU: Remote Radio Unit	NSA: 5G Non-standalone Mode	NR: 5G New Radio
VNF: Virtual Network Function	DU: 3GPP Distributed Unit	NG: 5G Signaling	TRP: Transmit / Reception Point
BBU: Baseband Unit	CU: 3GPP Centralized Unit	LLS: PHY Low Layer Split	
EPC: Evolved Packet Core	NGC: 5G Next Gen Core	HLS: PHY High Layer Split	

Important Packetized Fronthaul Technologies

Fronthaul Low Layer Split Options **(Ethernet Yields Better Performance):**

- eCPRI 1.2 (Evolved CPRI)
- xRAN Fronthaul 2.0
- IEEE 1914.3 RoE
- Time Sensitive Networking (IEEE 802.1 TSN)

Fronthaul High Layer Split Variants **(IP or Ethernet):**

- 5G: 3GPP F1 (Specified in 3GPP Rel-15)
- ng-LTE: 3GPP V1 (Work Item for 3GPP Rel-16)

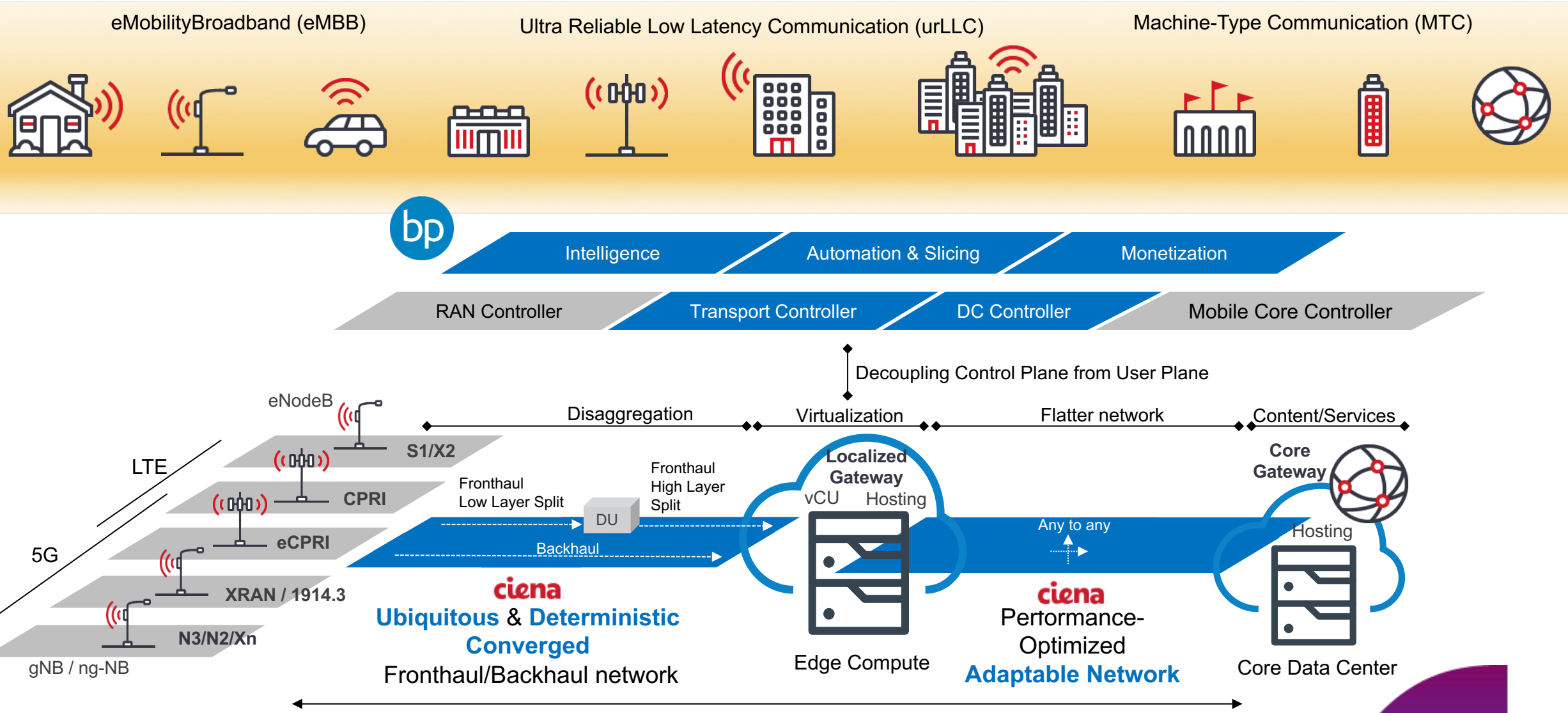
Transport Requirements for Converged Haul

FH/BH Interfaces	Bandwidth	Latency (One-way)
CPRI (LTE)	1 ~ 10Gbps / sector	65 ~ 75us
S1 or NG (NSA LTE)	1 ~ 2Gbps / site	S1: 30ms NG: 5ms
eCPRI (5G NR)	10 ~ 25Gbps / TRP	65 ~ 75us
3GPP F1 (5G NR)	1 ~ 10Gbps / DU	650us
S1 or NG (NSA 5G)	N x 100Gbps / CU *	S1: 30ms NG: 5ms

* Dependent on # DU sites groomed

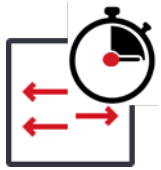
Development Areas for Wireless Infrastructure

Key Areas of Focus.



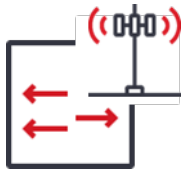
Ciena Solutions for Wireless Infrastructure

Deterministic Networking Technologies for Access, Aggregation and Core



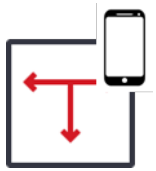
Time-Sensitive Ethernet Networking (TSN) in Wireless Infrastructure

IEEE 802.1 TSN



Radio Encapsulations over Ethernet (RoE) for Fronthaul

IEEE 1914.3 RoE



Sliced Packet Networking and Mobile Optimized OTN

ITU-T SG-15 SPN & MOTN Enhancements

Evolution Towards a 5G Network Solution

5G is more than a wireless upgrade, it's a wireline upgrade from radios to data centers, and everything in between

Initial 5G NR deployments will drive the need for greater capacity requirements in backhaul. Ciena's access portfolio is ready now.

5G NR & evolved LTE will enable new Packetised Fronthaul interfaces for which Ciena has invested in new additions to the portfolio in 2019.

5G NR & the introduction of the Next Generation Core brings new QoS service flows to the backhaul.

Virtualization of the RAN & Core, reduction in air interface latency & introduction of new service offerings drives Edge Compute needs.