Preferred Path Routing (PPR): Cellular Transport Network evolution for 5G and beyond

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BUILDING A BETTER CONNECTED WORLD

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**March 25th 2019,
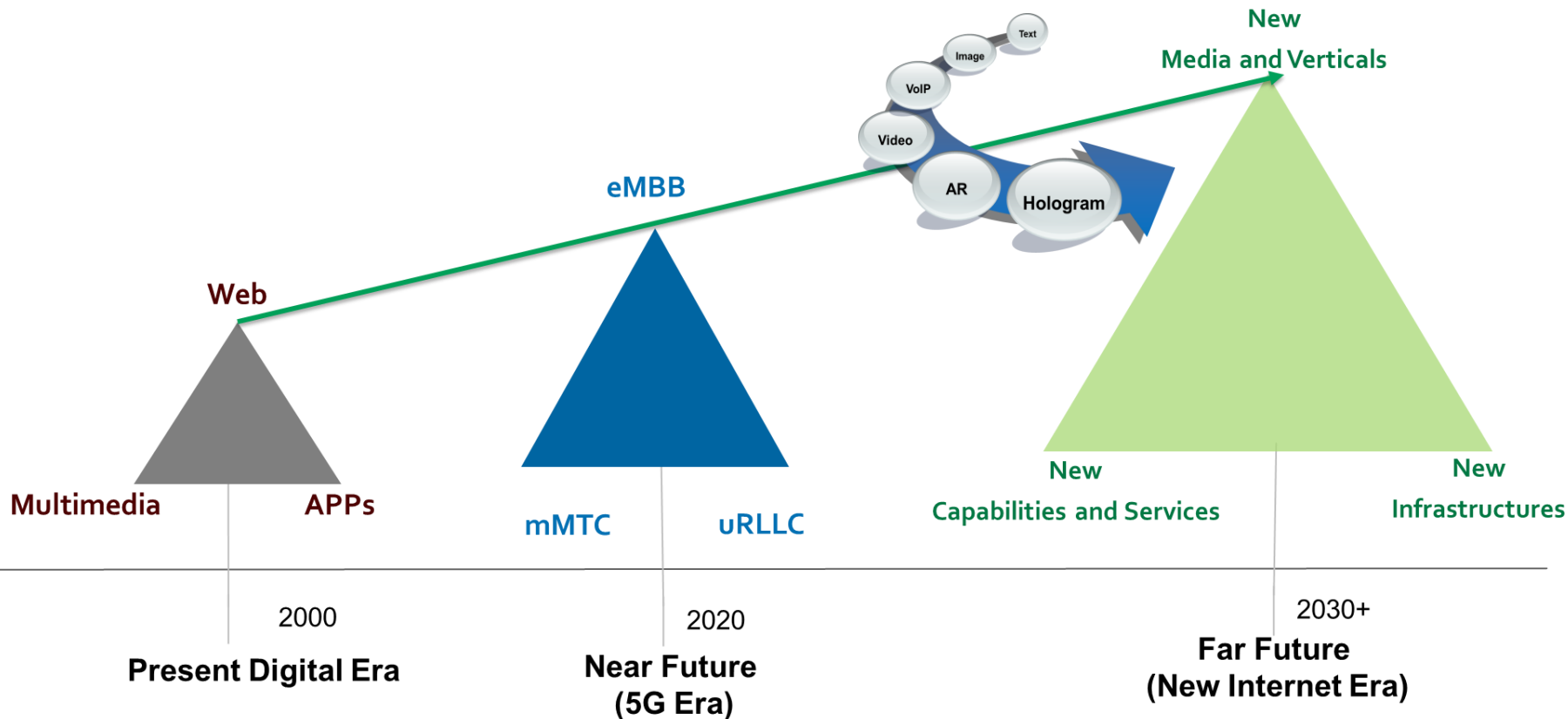6G Summit, Levi, Finland**

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Agenda

Part I : Network-2030 (ITU-T FG-2030)

- ❑ **What's pushing the boundary of current transport networks?**

- ❑ **IP Networks and Missing pieces**

- ❑ **ITU FG-2030 Initiative**

Part II : 5G Transport Evolution beyond eMBB

- ❑ A look at 5G Transport Network

- ❑ Challenges with 5G Transport

- ❑ A solution framework: Preferred Path Routing (PPR)

- ❑ Research & Standardization

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Where the Internet is going?

New
Media and Verticals

Text

Image

VoIP

Video

eMBB

AR

Hologram

Web

Multimedia   APPs

mMTC   uRLLC

New
Capabilities and Services

New
Infrastructures

2000   2020   2030+

Present Digital Era   **Near Future
(5G Era)**   **Far Future
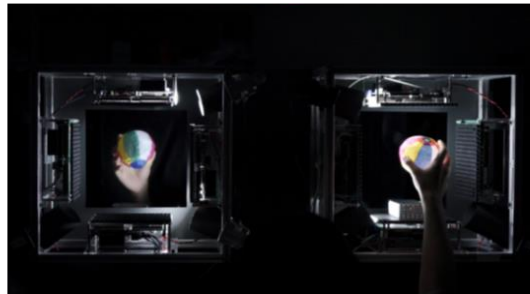(New Internet Era)**

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New technologies are emerging in 2030 and thereafter?

Digital Senses and Reality

Haptic Technologies and Terminals
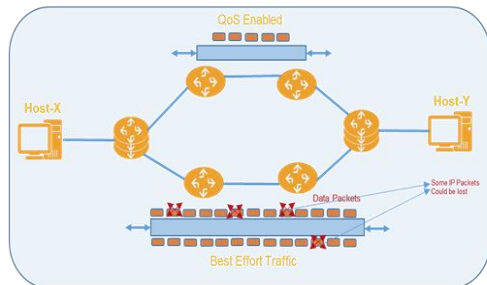

Holographic Verticals and Society

Image Sources: Internet, ACM, IEEE, ABC

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Internet in the far future (2030 and beyond)

New Media and Vertical (HTC)

Immersive Virtual Malls and Shopping
Tele-surgery

High Volume (Tbps)
Interactive Digital Exchange

Dense persistent states (3D RAM)

Self-holographic Telepresence

Super-ultra delay (μs)
Explosion-prevention Cars

Federated Internet
Enhanced Pervasive Survivability

Advanced μ-tactile M2M
Industrial Self-Avatar

Security by Trust

New Network Capabilities & Service

Trustable Infrastructure and Communications (TIC)

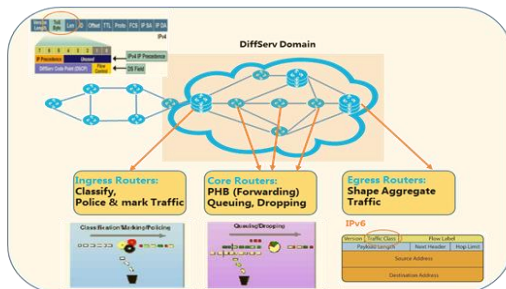Source: Key Note Speech @IEEE NetSoft2018: Huawei USA

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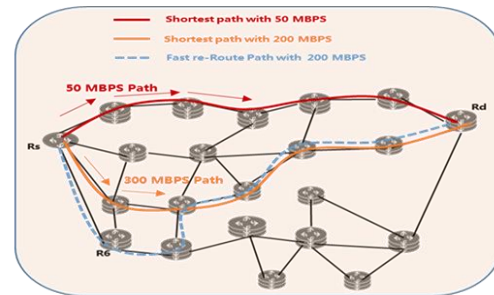# What Services does the Current Internet Provide at the Infrastructure Level?

Best Effort

Differentiated Services

Traffic Engineering

- ✓ Differentiates Classes of Service
- ✓ Guarantees Bandwidth

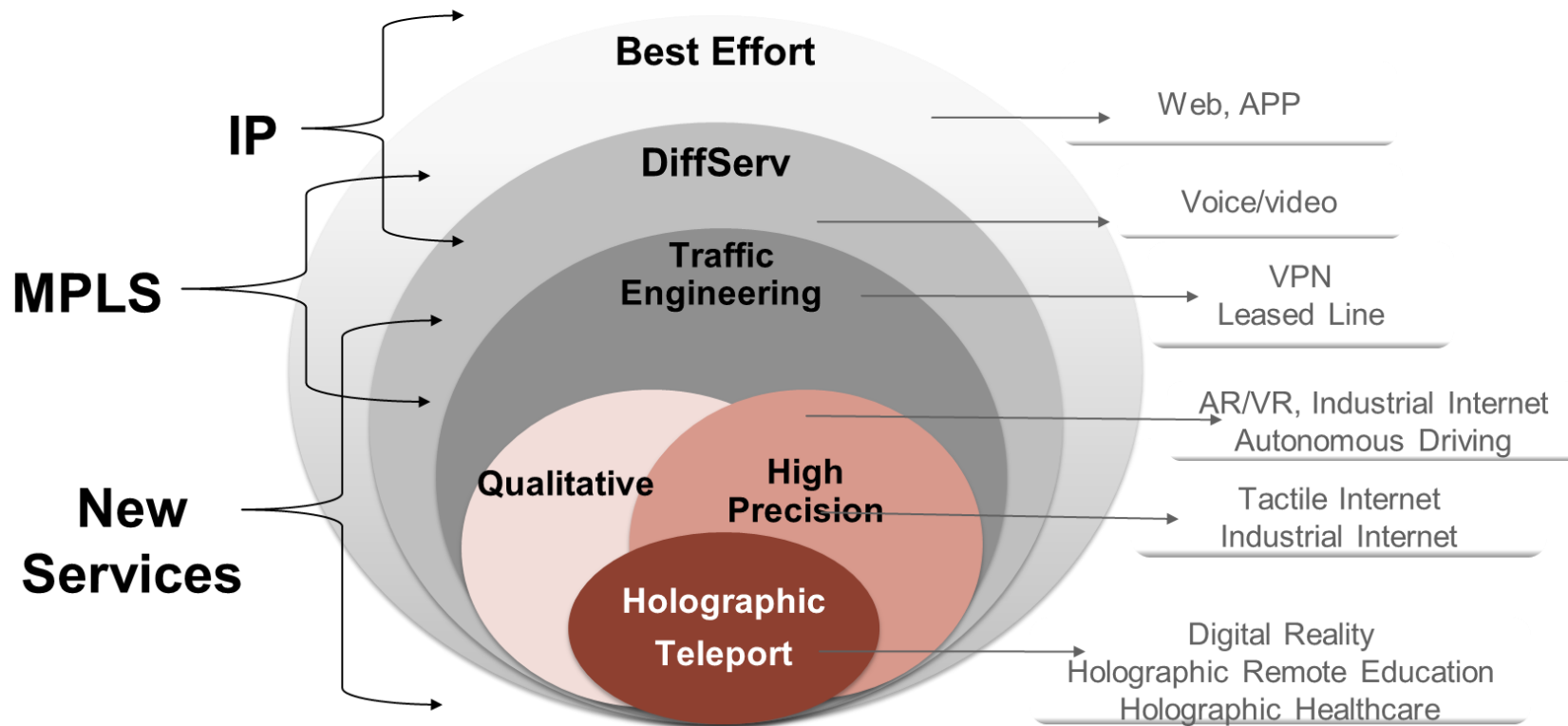- ✗ Fails to provide throughput guarantees
- ✗ Fails to provide guarantees of maximum latency (in-time)
- ✗ Fails to provide guarantees of precise latency (on-time)

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A Taxonomy of Services on the Infrastructural Level

ITU-T Focus Group Network 2030

https://www.itu.int/en/ITU-T/focusgroups/net2030/Pages/default.aspx

- **To identify gaps and challenges towards networks for the year 2030 and beyond**
- **To formulate all aspects of Network 2030, including its vision, requirements, novel and forward-looking use cases.**
- **To study the capabilities of networks for novel forward-looking scenarios, such as**
  - › holographic type communications
  - › extremely fast response in critical situations
  - › high-precision communication demands

Call for Participation in and Contribution to the 4th Workshop and FG Meeting
Saint Petersburg, Russian Federation
May 21st –23rd , 2019
Hosted by *Rostelecom* and supported by
Bonch - Bruevich Saint Petersburg State University of Telecommunications

The First ITU-T Workshop on Network 2030 and the Inaugural FG Meeting
New York City, New York, USA
October 2nd–4th, 2018
Host: New York University

https://www.itu.int/en/ITU-T/Workshops-and-Seminars/201810/Pages/Programme.aspx

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- ❑ **A look at 5G Transport Network**

- ❑ **Challenges with 5G Transport**

- ❑ **A solution framework: Preferred Path Routing (PPR)**

- ❑ **Research & Standardization**

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REL15 – 5G NR and 4G Core network (Simplified)
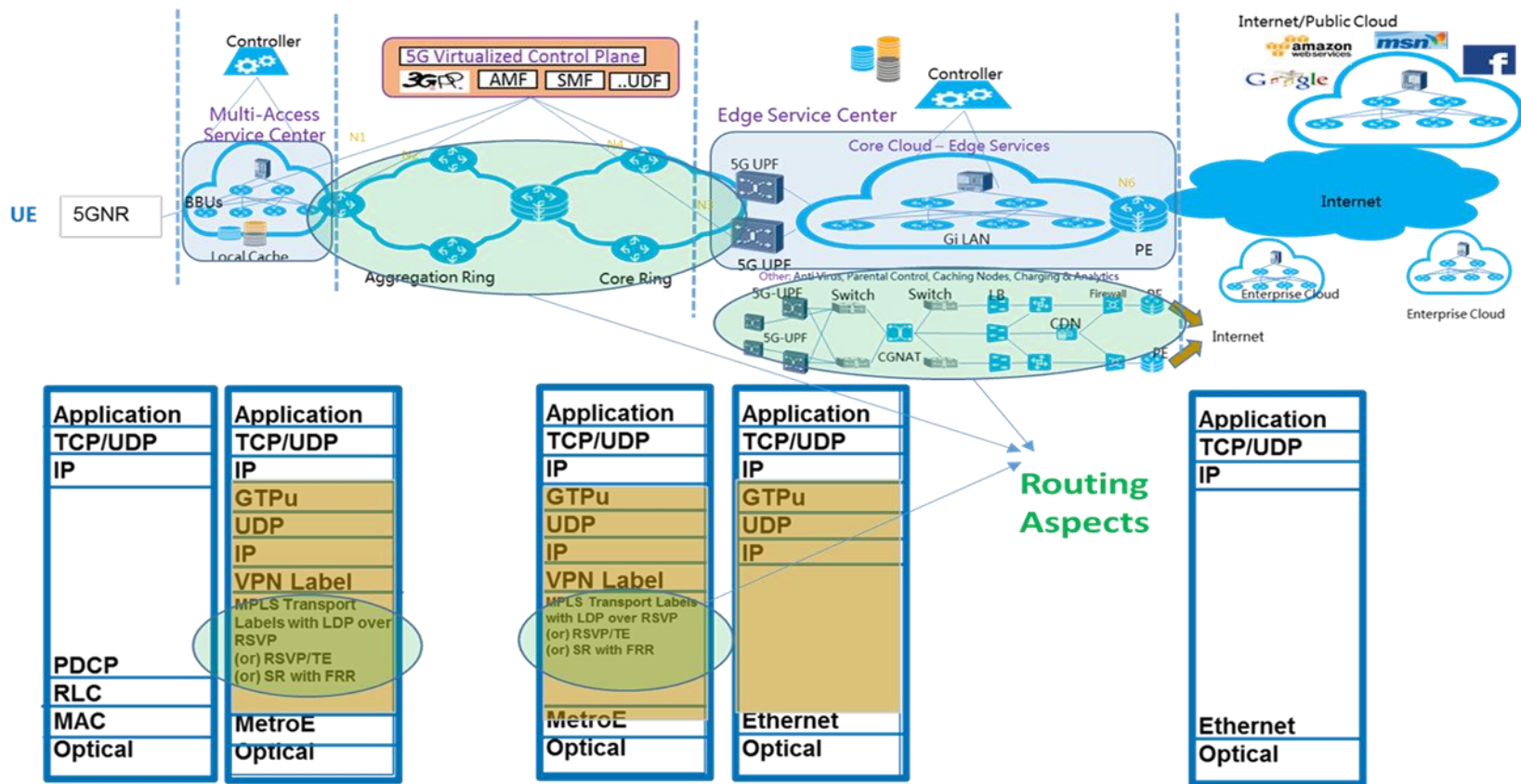
Challenges with 5G Transport Networks

- **Need transport network (Mid Haul, Back Haul) evolution to enable slicing**

- **Low data plane overhead is needed including advanced and dynamic TE**
    (Small packet sizes in various slices)

- **Must support different underlays to cater various deployments**
    (Need E2E solution with QoS)

- **Not optimized for multicast**

- **N9 interface, disaggregation of packet core and UPF mobility scenarios**

- **Beyond TI-LFA ➔ QoS aware backups is highly desirable for SLAs**

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Preferred Path Routing (PPR)
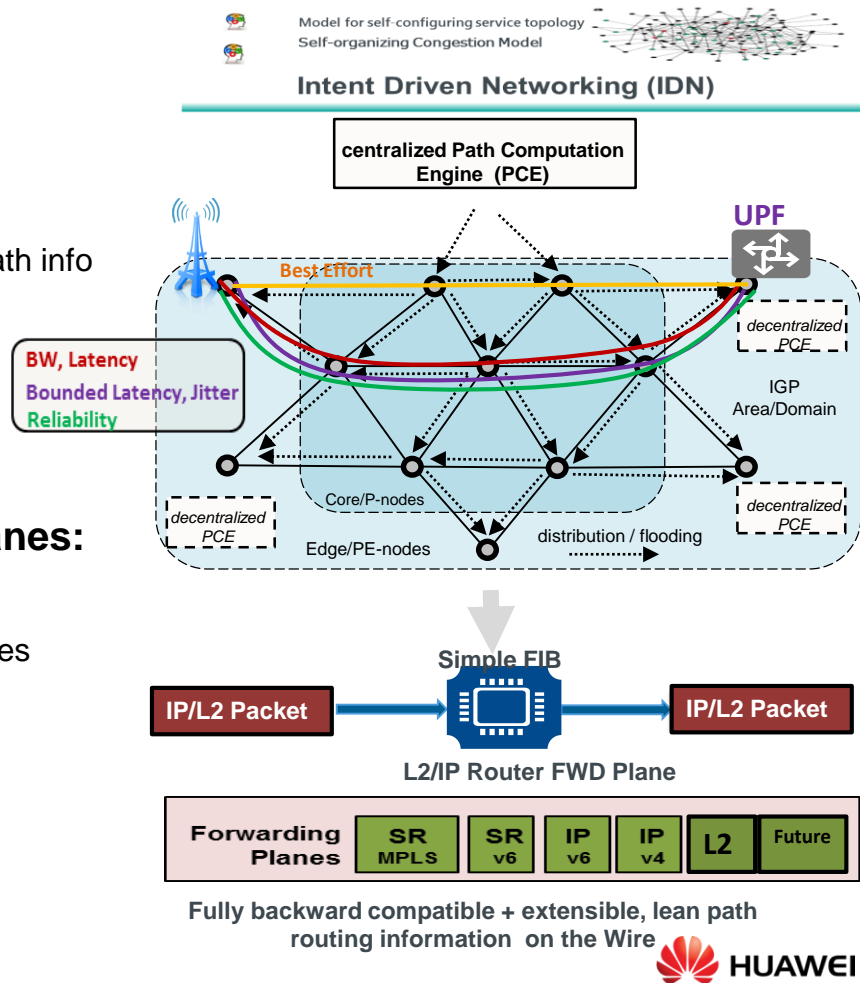## Key enabler Technology for XHAUL Transport Slicing

What is PPR?

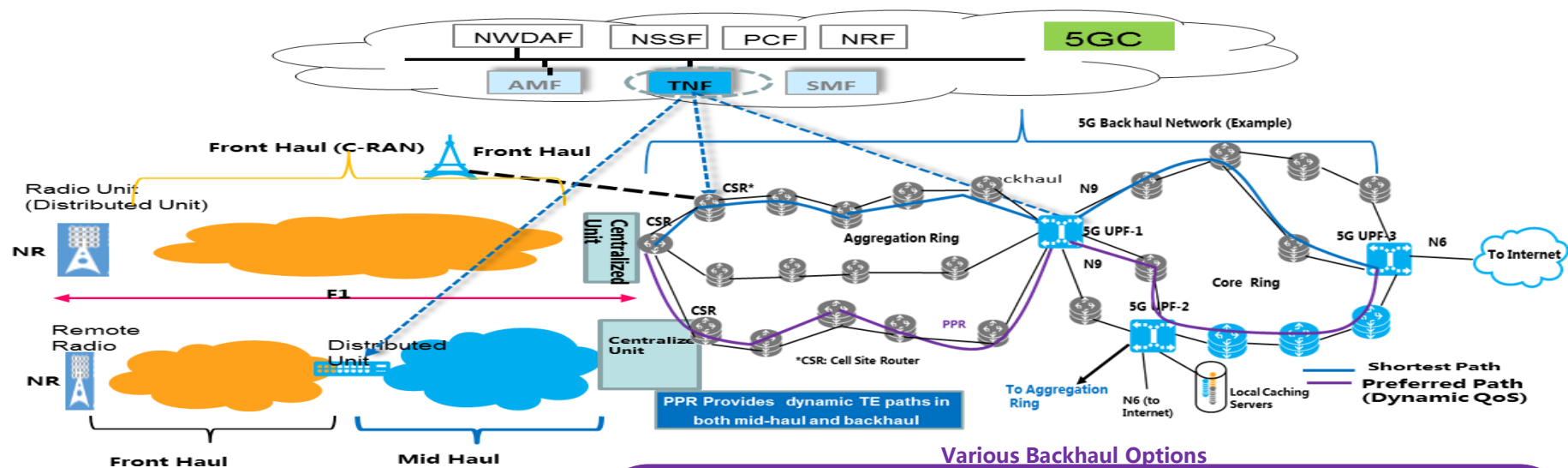## A Novel Signaling Architecture

- Reliable distribution (LSP IGP) to program PCE calculated path info (PPR-ID) to FIBs
- Agnostic to Forwarding Plane
- Strategic goal: control for future Forwarding Planes

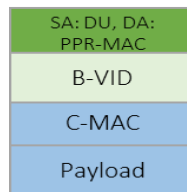## Benefits / Applicability to various forwarding planes:

- Support / Enhance networks where SR is not desired (IoT ?!)
- Extends Dynamic QoS to L2, IPv4, IPv6 and future data planes
- Software only upgrade or Driver for Next-Gen NPU upgrade
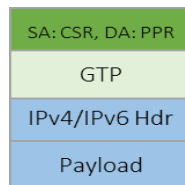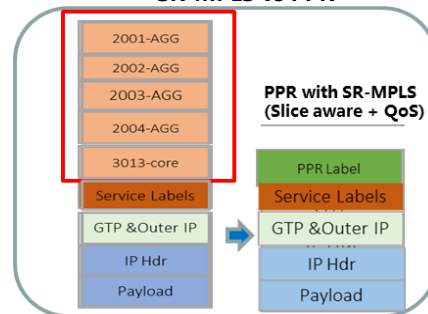- Support / Enhance SR-MPLS, SR-v6 (backward compatible)

Model for self-configuring service topology
Self-organizing Congestion Model

Intent Driven Networking (IDN)

centralized Path Computation Engine (PCE)

UPF

Best Effort

BW, Latency
Bounded Latency, Jitter
Reliability

decentralized PCE

IGP Area/Domain

Core/P-nodes

decentralized PCE

decentralized PCE

Edge/PE-nodes   distribution / flooding

Simple FIB

IP/L2 Packet → IP/L2 Packet

L2/IP Router FWD Plane

Forwarding Planes | SR MPLS | SR v6 | IP v6 | IP v4 | L2 | Future

Fully backward compatible + extensible, lean path routing information on the Wire

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5G X-haul/Backhaul for PPR

PPR Provides dynamic TE paths in both mid-haul and backhaul

Various Backhaul Options
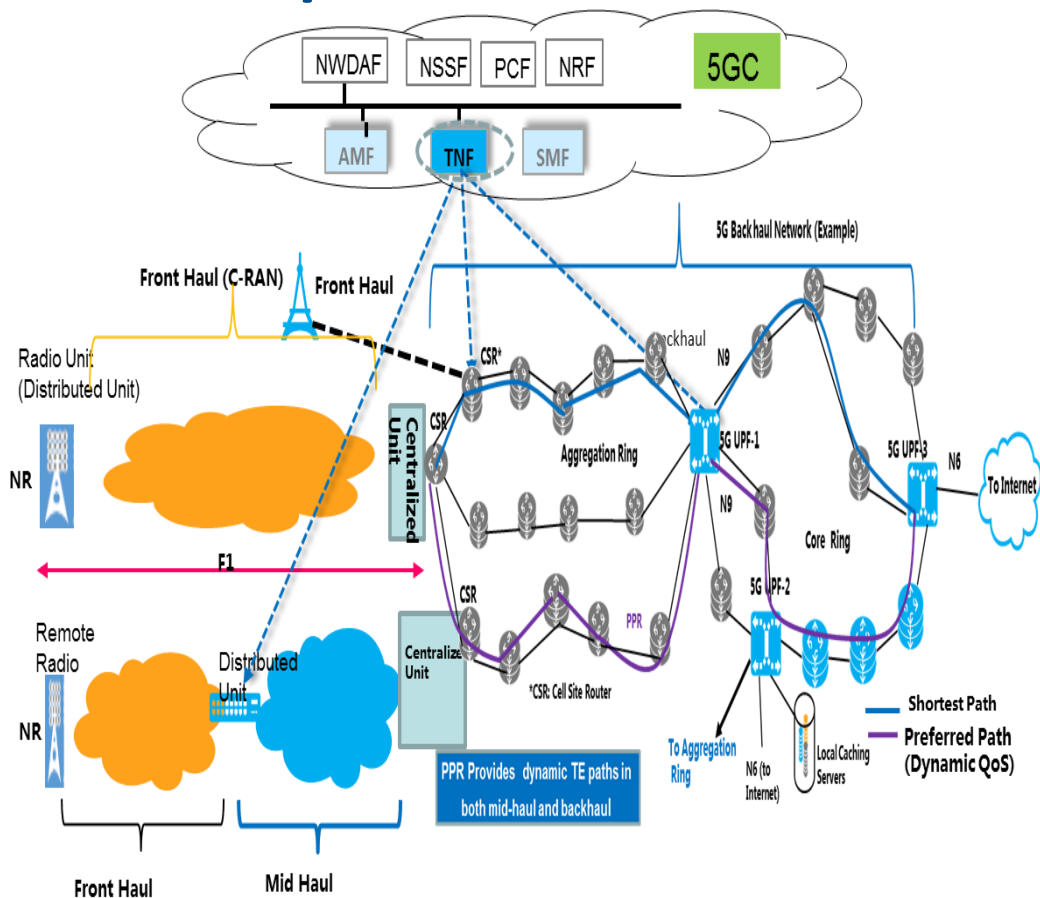
5G X-haul/Backhaul for PPR

PPR solution for 5G XHAUL

- **E2E Transport Undelay Slicing – L2/MPLS/IPv4/IPv6**

- **Provides SLA Guarantees in the X-Haul (key 5G requirement)**

- **On-demand & dynamic resource instantiation and management**

- **No data plane overhead and backward compatible**

- **Supports new 5G mobility scenarios and N9 Interface**

- **Enables introduction of future data planes**

**March 25th 2019,
6G Summit, Levi, Finland**

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Research in this area..

❑ **"Preferred Path Routing - A Next-Generation Routing Framework beyond Segment Routing"**

Uma Chunduri ; Alexander Clemm ; Richard Li

2018 IEEE Global Communications Conference (GLOBECOM)

Year: 2018, Page s: 1 - 7

❑ **"Preferred Path Routing (PPR) Graphs - Beyond Signaling Of Paths To Networks"**

Toerless Eckert ; Yingzhen Qu ; Uma Chunduri

2018 14th International Conference on Network and Service Management (CNSM)

Year: 2018, Page s: 384 - 390, IEEE Conferences

❑ **"Improving Performance and Scalability of Next Generation Cellular Networks"**

Ali Mohammadkhan ; K. K. Ramakrishnan ; Uma Chunduri ; Kiran Makhijani

IEEE Internet Computing

Year: 2019 , Volume: 23 , Issue: 1

Page s: 54 - 63, IEEE Journals & Magazines

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Research in this area.. (contd.)

❑ **Reliability and Latency management for Preferred Paths**

❑ **Computation of QoS aware Fast-ReRoutes with Preferred Paths and Graphs**

❑ **Path state optimization and efficient central and distributed computation of PPR Paths/Graphs**

❑ **Light weight capacity optimization in transport network topologies agnostic to source routing methodoligies**

❑ **...**

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Summary

1. Bigger challenges in transport networks and internet ➔ Join ITU-T FG-2030

2. While working on far future, make sure transport networks evolve to current 5G challenges w.r.t latency and reliability !

- • 5G and beyond needs more intelligence in both Mid-Haul and Backhaul.

- • PPR is a promising new X-Haul transport TE technology.
  - • It's scalable, intelligent (dynamic QoS, energy efficient, reliable) with path signaling for routing Next-Gen networks.

- • We should consider these challenges early on and continue to evolve!

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It's more than a wrap, Thank you!

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Questions or wish to collaborate..
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