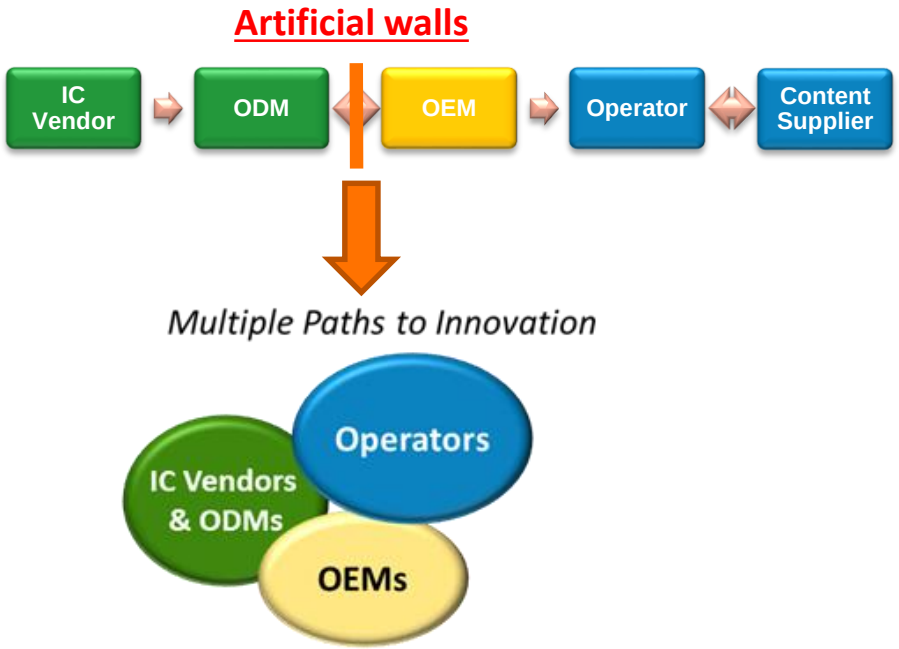
Intersection of 5G
&
Open Reference Platforms

Tom TOFIGH, PMTS , AT&T

Driving Force for 5G and Beyond:



Open & Democratized Interfaces

Disruptive Network Connectivity

Better, Faster, Flexible, Elastic Access,

Edge cloud and MEC Services

Emerging cloud centric Operating Models

- **Modular Capabilities / White Box**
- **Open Source Platforms & Blue Prints**
- **Economically Viable Eco Systems**
- **Digital Traceability / Dynamic Analytics**
- **AI/ ML , AR/VR, Robotics, Flying objects**
- **Predictive & Scenario Driven**
- **Micro Services & Third Party Applications**

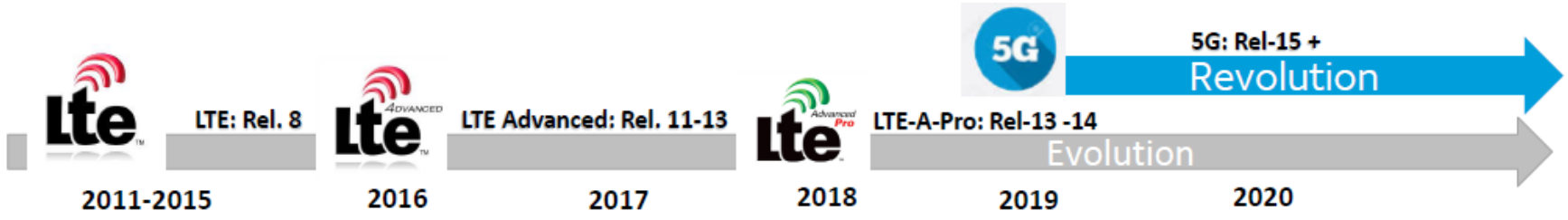
Empowered Customers

- **Seamless data sharing**
- **Remote Diagnostics**
- **Increase Trust and Transparency**
- **Enable Human and Machine Collaboration**
- **Lower Operating Cost**
- **Predictive and Zero Touch, Automation**

Rethink Possible®

Rise of Open RAN -> Unified SD-RAN for 5G and Beyond

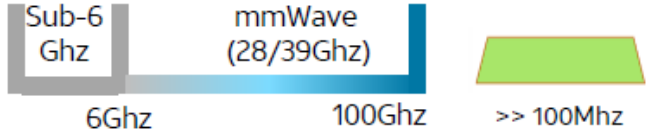
Technology / Standards



Spectrum

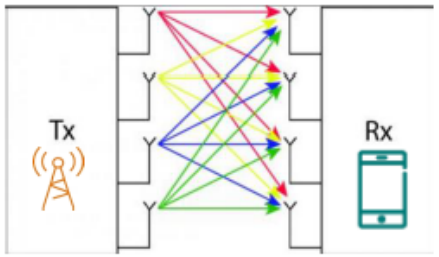
Name/Band	Frequency Band
700 B/C (B12/B17)	700Mhz
700 D/E (B29)	700Mhz
Cellular (B5)	850Mhz
PCS (B2)	1900Mhz
AWS1 (B4)	2.1Ghz
WCS (B30)	2.3Ghz
AWS3 (B66)	2.1Ghz

Up to 20Mhz per carrier

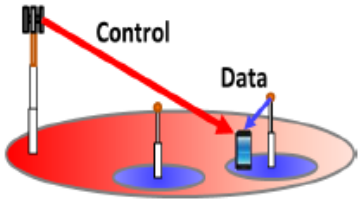


Radio Interface

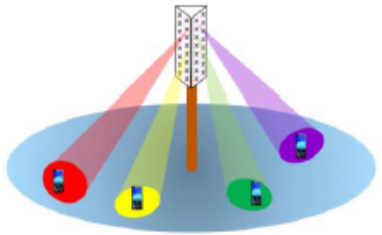
MIMO



Multi-RAT Dual Connectivity



Massive MIMO & Beam Forming



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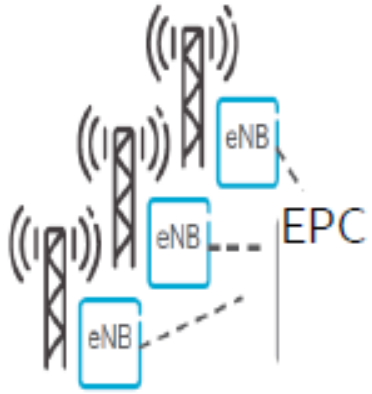
RAN Evolution & Transformation to SD-RAN
an Opportunity for “In band Radio Telemetry”



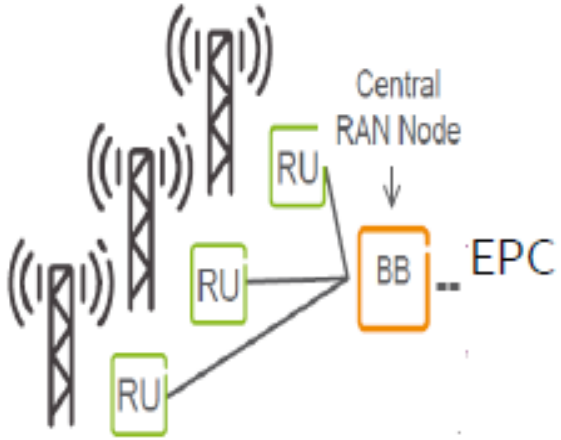
distributed RAN

dRAN

Distributed Radio Resources

Densify

Centralize

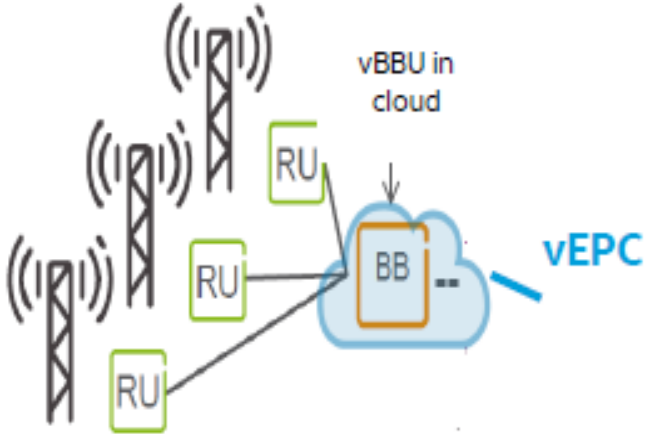


Centralized RAN

CRAN

Mix of High and Low Power Radio

Virtualize



Virtualized RAN & EPC → SD-RAN

vRAN

Split Architecture
Mobile Edge
Optimized
For Service Specifics
SDN/NFV

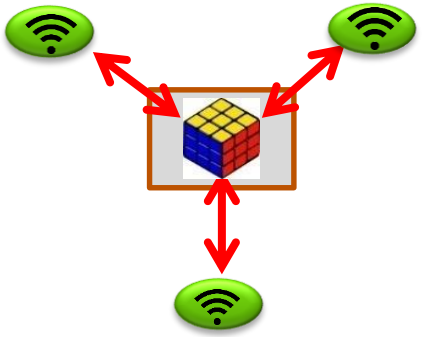
Open Platform with Democratized Interfaces

Need for programmable Radio pipelines + In band Network Telemetry

How about Control over Sharing and Coexistence

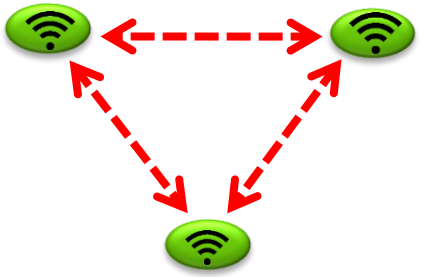
Coexistence allows two or more systems to operate with least impact to each other.

- **Often uncoordinated with focus on interference avoidance.**
- **Aggressive use of mostly unpaired spectrum in 5G may require some synchronization between coexisting systems.**



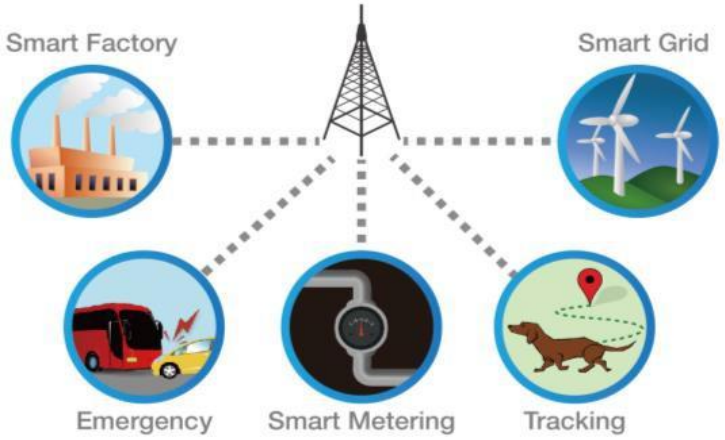
Sharing of common spectrum resources especially if proactive and coordinated can boost system capacity and performance

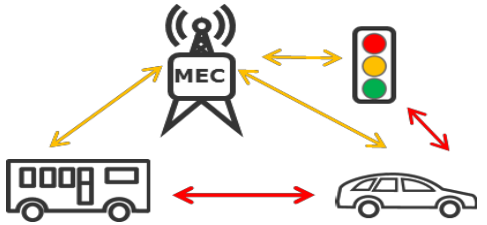
- **May be a combination of pre-arranged rules and opportunistic sharing**
- **May Involve Multi-Tier Priority Access Sharing**
- **Also benefits from synchronization when feasible**



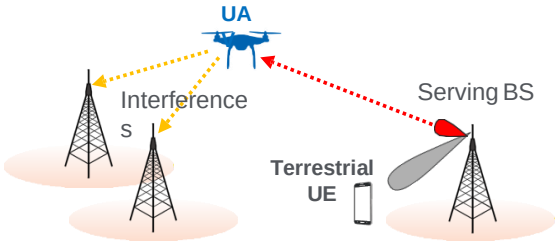
Does Unified Air Interface Helps with Coexistence?

Having a unified air interface and frame structure allowing concurrent operation of mixed numerologies helps with coexistence across use cases when (semi) synchronized.

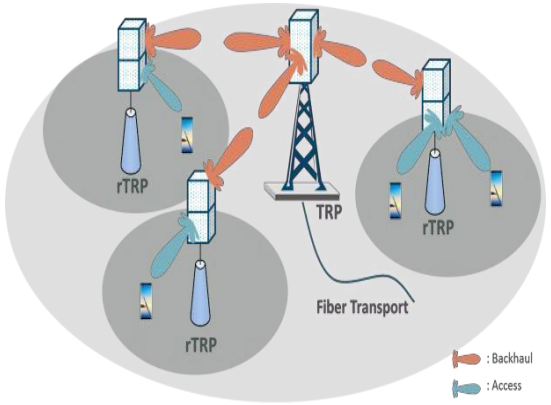




NR V2X (in R16+)



Non-Terrestrial Access Network (NTN in R16+)



IoT (in R16+)

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Source Samsung

Separation of Control and User plane → SD-RAN

User Plane

- PDCP
- High RLC
- Low RLC
- High MAC
- Low MAC
- High PHY
- Low PHY
- Radio/MIMO

Control Plane

- RRC Control
- ICIC Control
- Paging Control
- Bearer Control
- Admission Control
- System Broadcast
- Measurement Reporting
- AMF Control
- Power Control
- Antenna Configuration
- Frequency/Beam Control
- SD&C Control Interface
- SO Interface (A1)
- SON Control (E2)
- Slice MLB Control (E2)
- Handover Control (E2)
- Carrier Agg. Control (E1)
- SMF Control (Core)
- RAN Slicing Control (E2)
- Scheduling Control (E2)
- FCAP Control (NEM)

Radio Resource Manager -> (SD-RAN) -> Rise of ORAN

- Common Control & Configuration for Split Architecture
- Extended Control Configuration options to vendors specific features
- Unified vProbe and Analytic Registration process
- Well Known Functional Interface & APIs
- Measurement Configuration, Control and Reporting
  - RRC Measurement Config
  - RRC Measurement Report
  - L2 Measurement Config
  - L2 Measurement Report
  - Frequency Selections
  - Power Level
  - Antenna & Beam Forming Commands
  - Handoff Actions
  - Scheduling and Slicing RAN Control
  - UE Admission Control
  - Cell Configuration

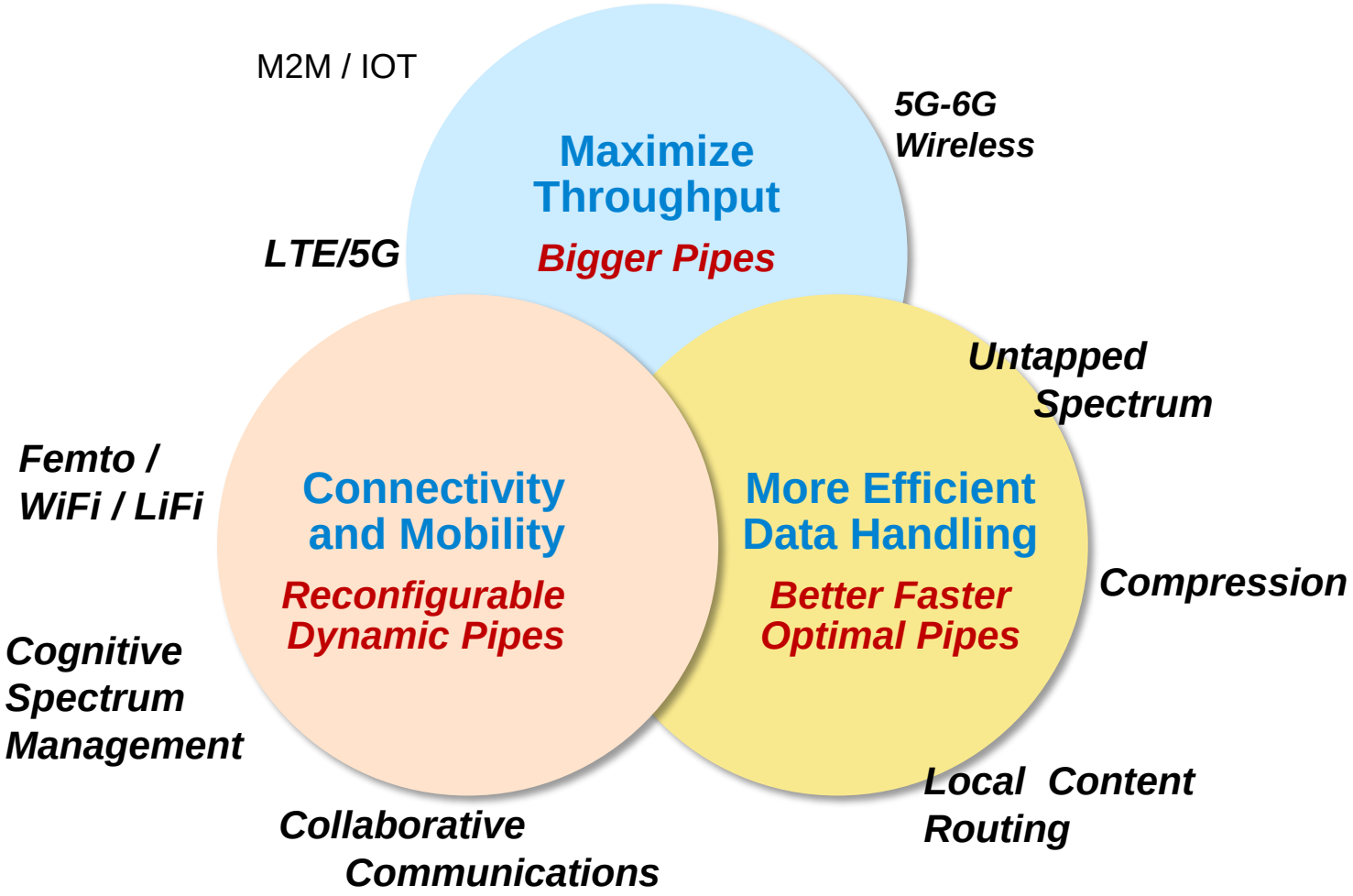
What Open Reference Platforms Offer

- Offers new user experiences
  - AR/VR , battery life , M2M, Edge clouds,
- **Provides for new types of connectivity services**
  - Seamless, carrier aggregation, QOS, Metering, etc.
- Provides for autonomous operational flexibility
  - Analytics, Performance, latency scale, security, Reliability, and programmability
- Performs frequent “control” across the RANs
  - hyper densified set of technologies and macro, small and micro cells.
  - Observability and Ml approach

RRC Measurement Config
RRC Measurement Report
L2 Measurement Config
L2 Measurement Report
Frequency Selections
Power Level
Antenna & Beam Forming
Handoff Actions
Scheduling ,
Slicing RAN Control
UE Admission Control
Cell Configuration

Leads to Adaptive Analytics for 5G with Open Reference Platforms

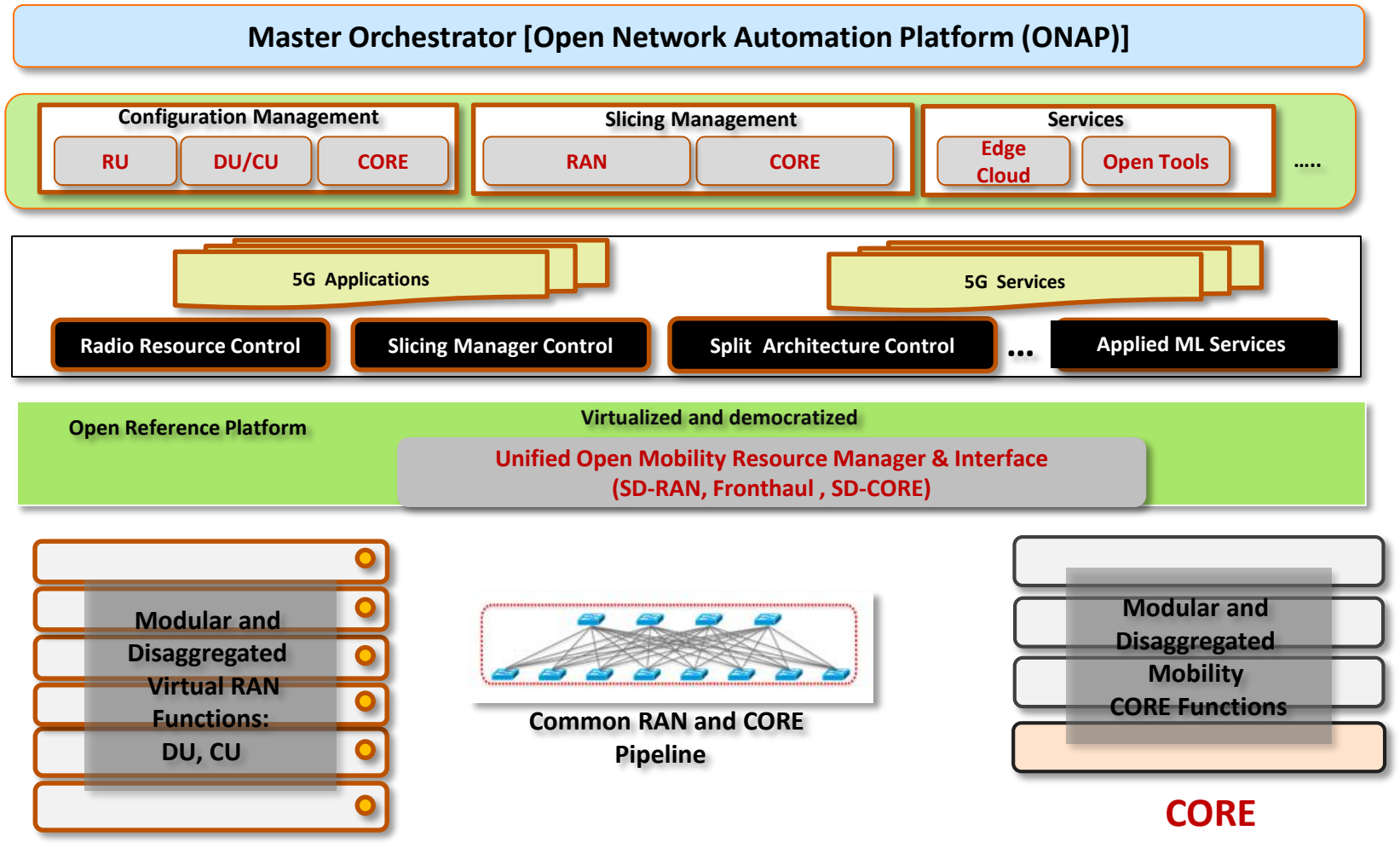
"The Services of The Future"



Edge Cloud Solutions That Support Increased Data Usage & A Richer Multimedia Experience

ossible®

Rise of Open Reference Platform Blue-Prints



- Time critical operations offloaded to FPGA
  - Disaggregated control from user planes and micro services
  - Common Control & Configuration of RUs, DUs, and CUs
  - Dynamic vProbe and applied ML
  - Open Interface & APIs
  - Context Driven Networking (Closed feed back loops)

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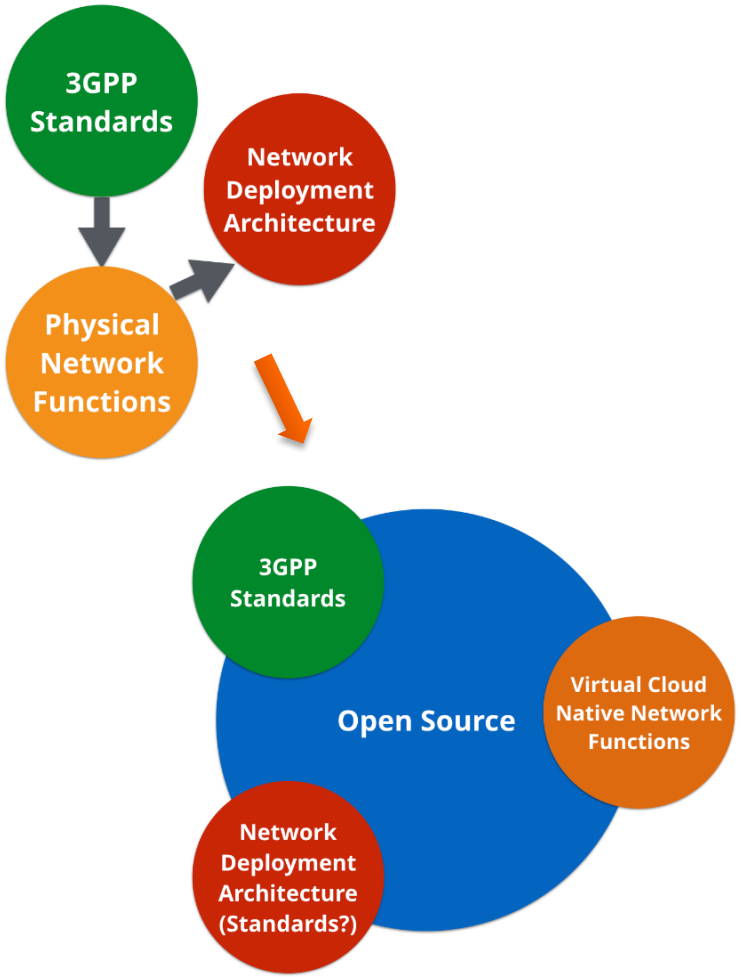
Source: The Linux Foundation/AT&T

Open Source Communities & Standards



On-Going Collaboration Efforts

X-RAN/ORAN
ONAP
ONF
TIP
Etc.

Open Source
EPC, RAN

Open Reference Platforms

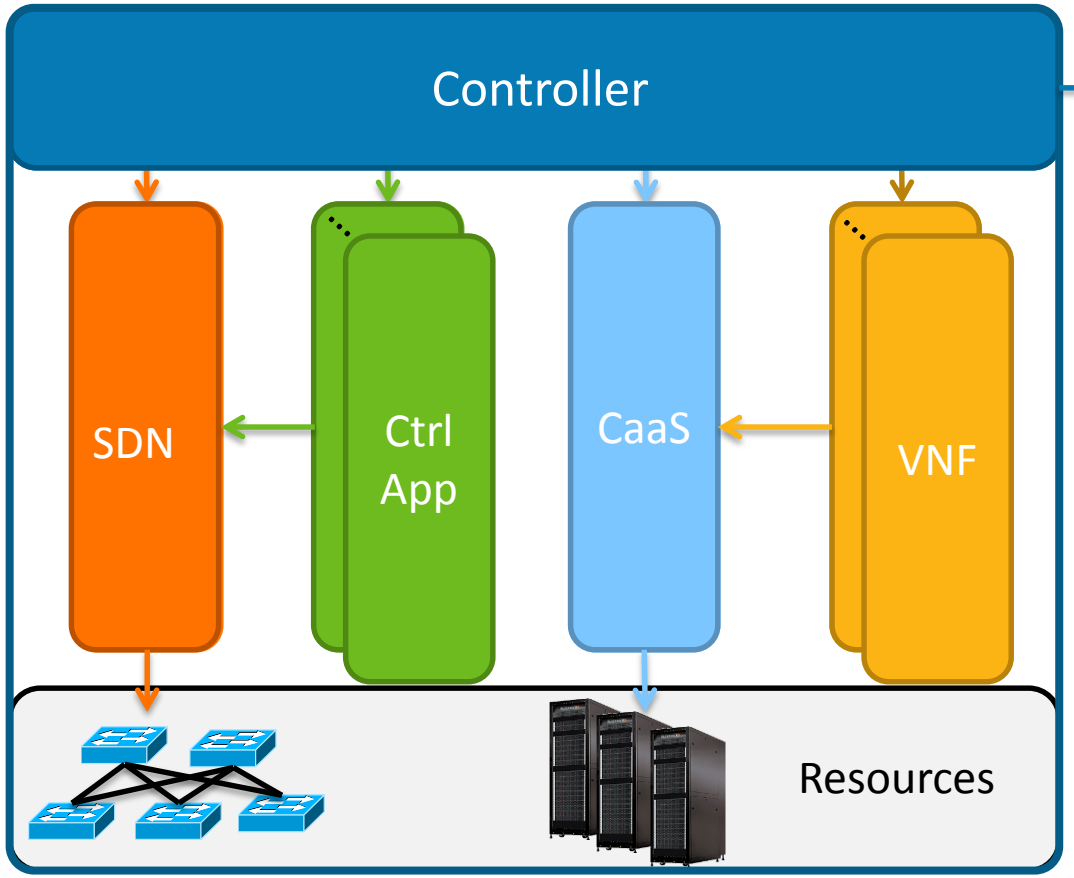
Non-Open Source
EPC, RAN

Micro-Services
Applications

3GPP
IETF
IEEE
MEC
ETSI

Open Platforms & Opportunities

Adopts Micro-Services with Control as a Service



- Defines Authoritative State
- Mediates Trust
- Enforces Policy/Invariants
- Activates Data Path

Source; ONF

Rethink Possible®

Challenges: Open and Democratized Abstractions

Graph abstraction Representing Radio Networks (Multi-RATs)

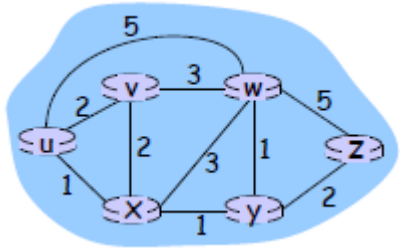
Graph: G = (N, E, L, B, etc.) or (nodes, Links, Slices, Beams)

N = set of routers / Radios = { u, v, w, x, y, z }

E = set of links ={ (u,v), (u,x), (u,w), (v,x), (v,w), (x,w), (x,y), (w,y), (w,z), (y,z) }

L = set of Slices = {sub ((u,v), sub (u,x), sub(u,w), sub(v,x), sub (v,w), sub (x,w), sub(x,y), sub (w,y), sub (w,z), (y,z) }

B = set of radio Resources at time T = Associated { u, v, w, x, y, z }



Goals:

- Understand principles behind Abstraction
- Understand principles behind service Layers & Multi Tenancy
- Understand principals behind dynamic Analytics & Trigger Functions

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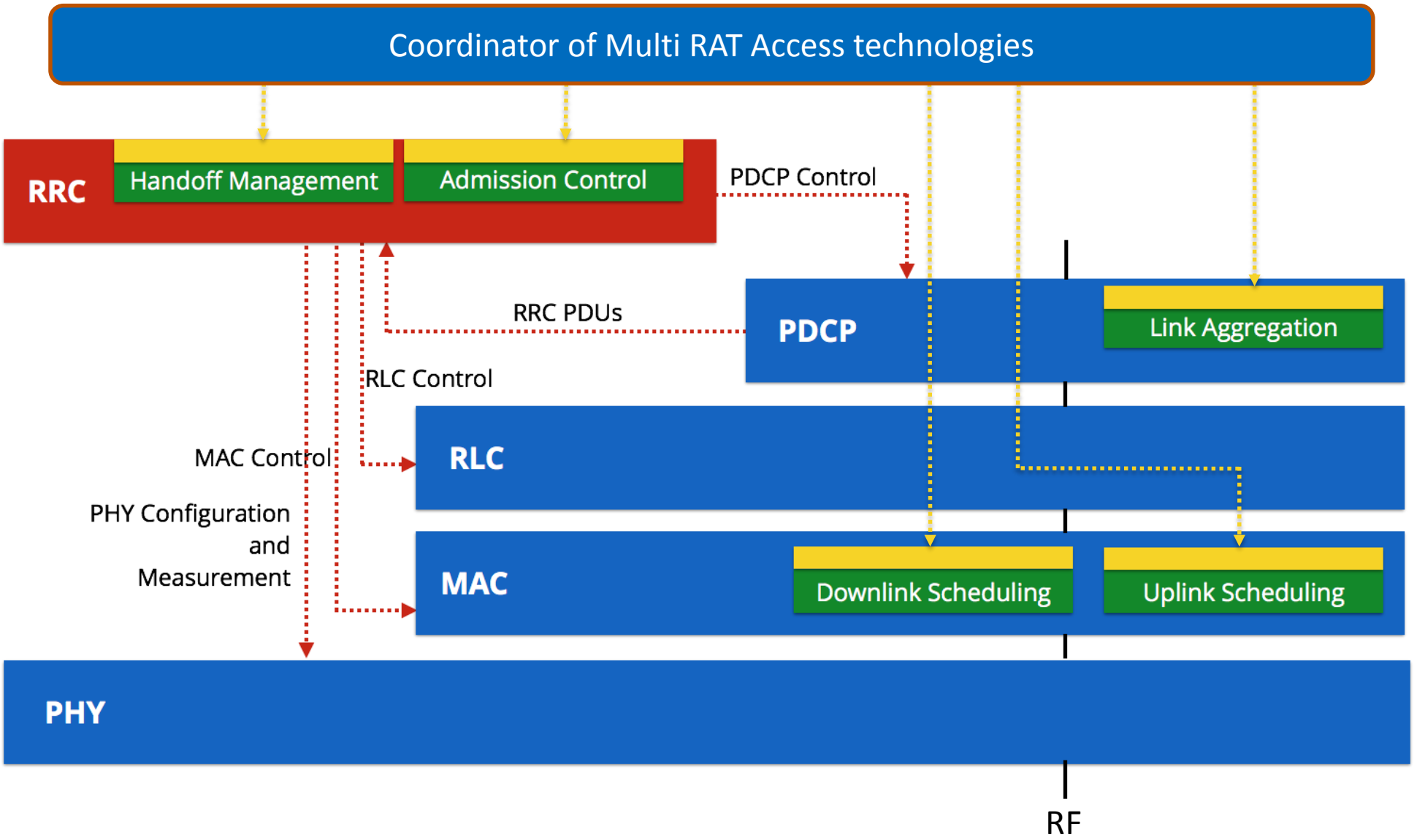
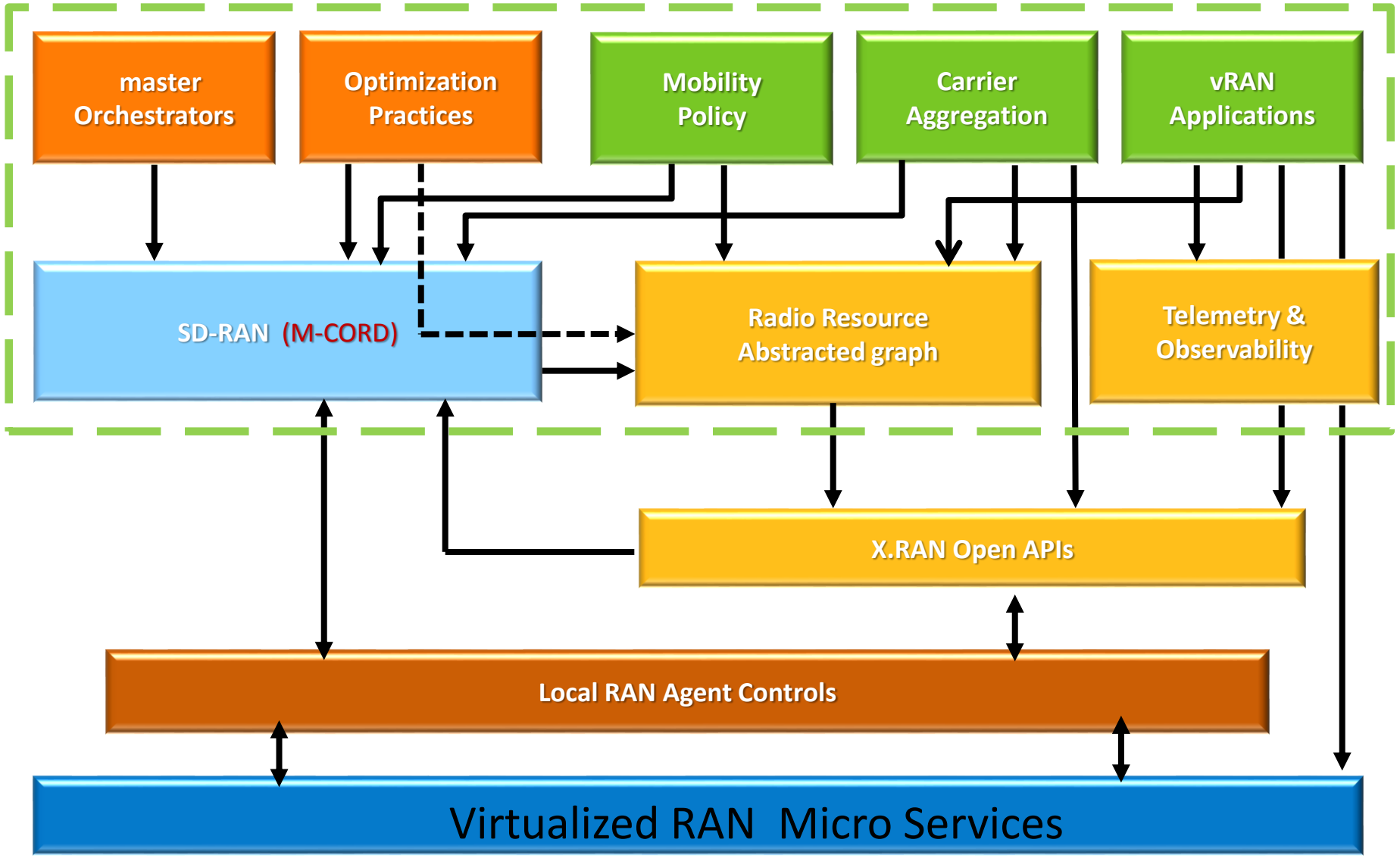
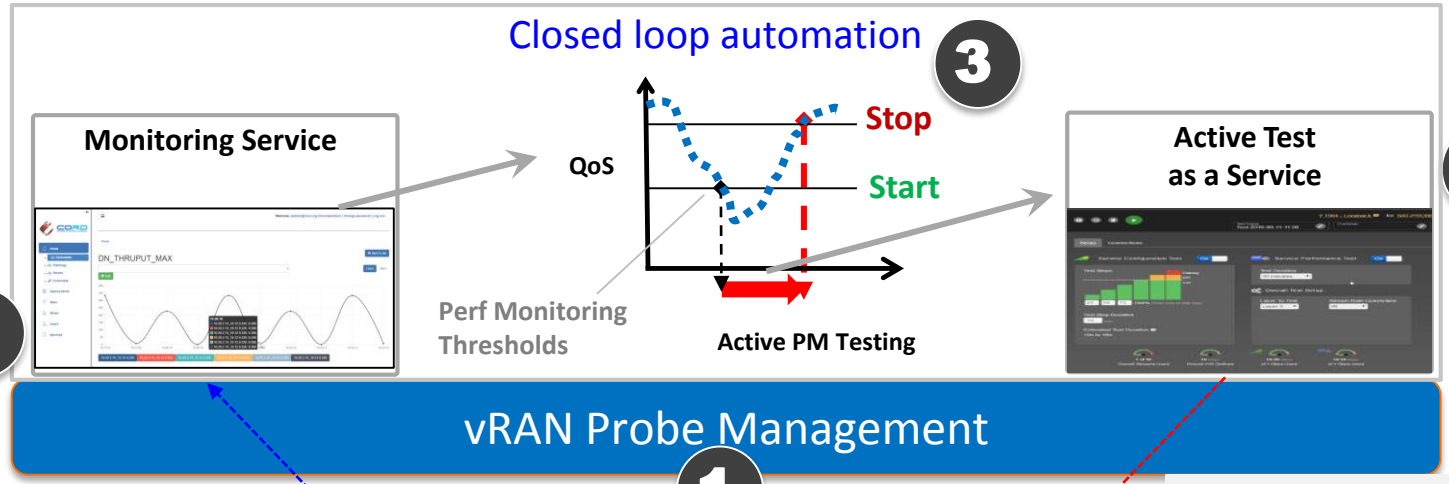
SD-RAN: Programmable RAN Operation Examples



Example: SD-RAN & Micro Services

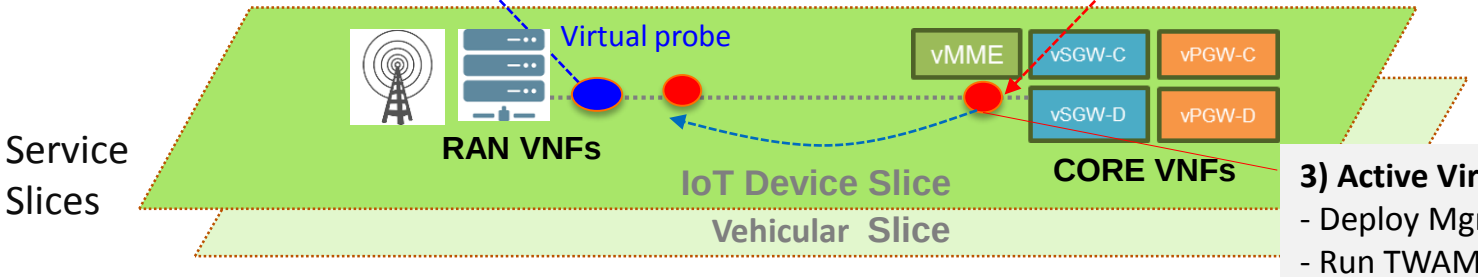


Adaptive Analytics Service



1) Assurance as a Service (Passive)
- Feed UP Session Metrics to vRAN RIC

2) vRAN RIC triggers test request for connectivity/PM session in an slice



3) Active Virtual Measurement Agents
- Deploy Mgmt. Agent VM instances
- Run TWAMP Perf Monitoring sessions

1. vRAN Software Platform
2. Model driven Passive Monitoring
3. Anomaly detection & Closed loop automation
4. Active Test as a service

Summary Remarks

- Aggressive spectrum allocations for 5G and beyond will require unified, open and democratized Interfaces.
- Opening up the interfaces, disaggregating RAN, white box deployment models with coexistence, should be a key focus for open source community and standardization bodies.
- ORAN could provide coordination and when feasible synchronization of multi vendor and white boxed radio access.
- Open Source + ML + In-band Radio analytics will play a key role in success of emerging Mobility Solutions.

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