Timing The Road To 5G

Front Haul, Back Haul and Multi-Access Edge Computing (MEC)

Ian Goetz, Juniper Networks

November, 2017


Market Trends:
Cloud, Agility, Virtualisation &
Content

Mobile & Enterprise Market Trends: The Customer Experience

MOBILE

Google amazon.com ebay NETFLIX

Trusted Reliability

Pervasive Coverage
Application Optimized

Seamlessly Converged

IoT

Microsoft Azure

Ubiquitous-Coverage

AUTOMOTIVE

amazon web services

5GAA Automotive Association

Low-Latency

Security

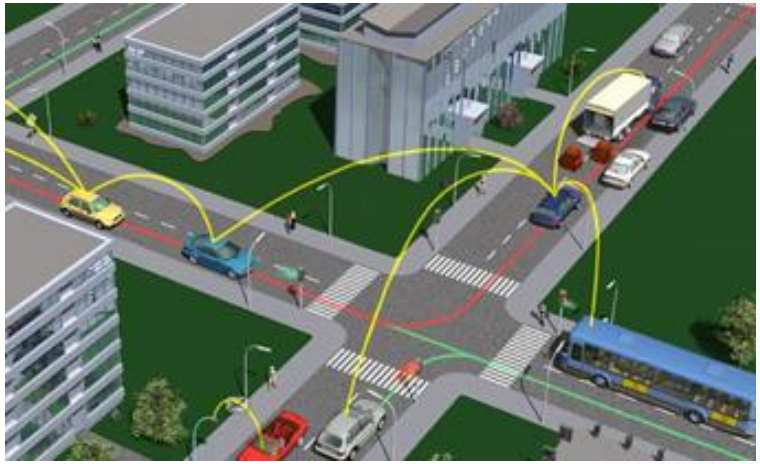
- **MOBILE**:
  - The Smartphone and Tablet, combined with 3G HSPA and 4G have driven the proliferation of applications for business, lifestyle and pleasure – BUT Most Value Added Services are now OTT
  - 4G Advanced and 5G drive towards low latency for IoT and Content is key for consumer segment
- **IoT & AUTOMOTIVE**:
  - Ubiquitous Coverage for Augmented Autonomous Vehicles & Smart Cities
  - Depth of Coverage for IoT – NB_IoT and Battery Efficiency
  - Battery, Security & Low Latency Drives Edge Computing

© 2016 Juniper Networks, Inc. All rights reserved.

Augmented Autonomous Vehicles: V2X

- **Augmented Autonmous Vehicles** – Network information allows better driver assist or autonomous systems
  - Lifetime of car is 20 years – can't rely on the on-board compute for life of vehicle
- **Coverage**: Automotive needs an access system that is selected by large geographies & regulators
  - Europe going with LTE / LTE-V
  - US leaning to DSRC (IEEE 802.11p)
  - Asia closer to LTE
- **Cost**: National Coverage costs a large amount – hence LTE & 5G Network usage
- **Business Case**: Efficiency – for fuel, smart cities, macro economics etc
- **5GAA**: Vodafone, Telefonica, BMW, VW Audi, Mercedes, Toyota, SKT, DT, Ford, Jaguar Land Rover, Samsung, DoCoMo, Verizon, etc
- **Security and Low Latency** are key to success

5GAA Automotive Association



Augmented Autonomous Vehicles

Platooning

© 2016 Juniper Networks, Inc. All rights reserved.

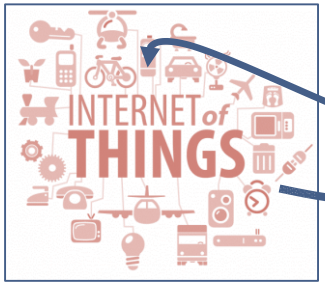
Market Units + Radio Module = IoT Device

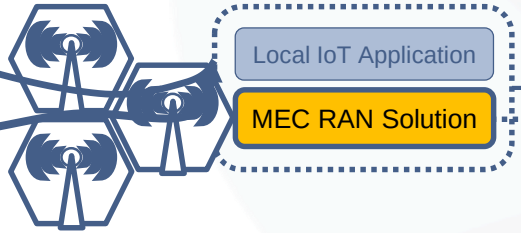
Security & Battery Life are key issues

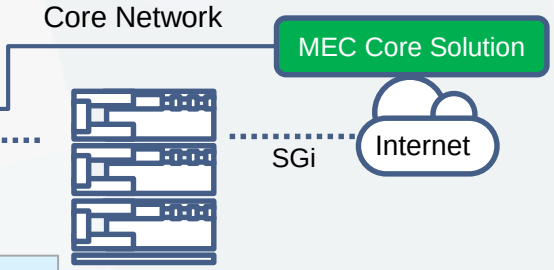
+

© 2016 Juniper Networks, Inc. All rights reserved.

Reducing Latency Directly Benefits IoT Device Battery & Business Case

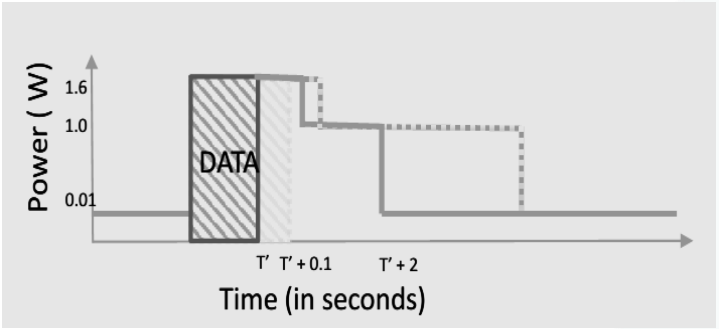


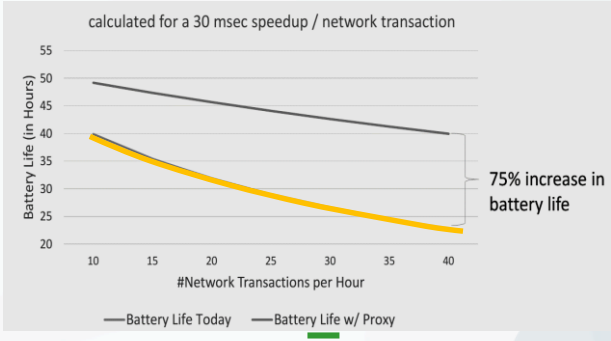




- Also Connected Car as due to connected use whilst engine off, hybrid or electric vehicles
- The more the battery is discharged, the more energy needed for recharge and hence emissions

Based on Microsoft cloudlet research by Dr. Victor Bahl





© 2016 Juniper Networks, Inc. All rights reserved.

MOBILE: Back & Front Haul

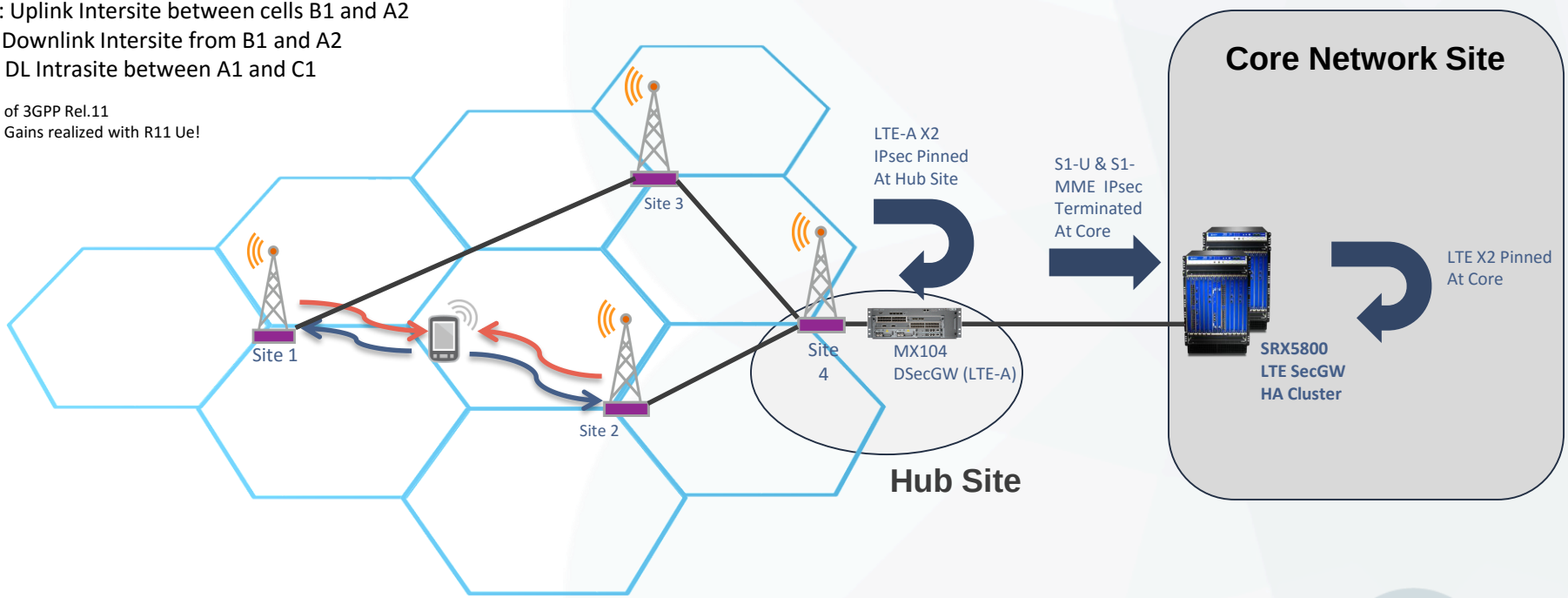
LTE-A to 5G Changes that drive a need for timing

LTE-Advanced: Coordinated Multipoint

Accurate Timing (Phase & Frequency) & Low Latency Are Key

- Black: Uplink Intersite between cells B1 and A2
- Red: Downlink Intersite from B1 and A2
- Grey: DL Intrasite between A1 and C1

Feature of 3GPP Rel.11
NB: Full Gains realized with R11 Ue!



- LTE Requires Frequency Timing: 50ppB
- LTE-A (Uplink CoMP & eICIC) Require Frequency & Phase:
  - Frequency16ppB, Phase +/- 0.5µSecs

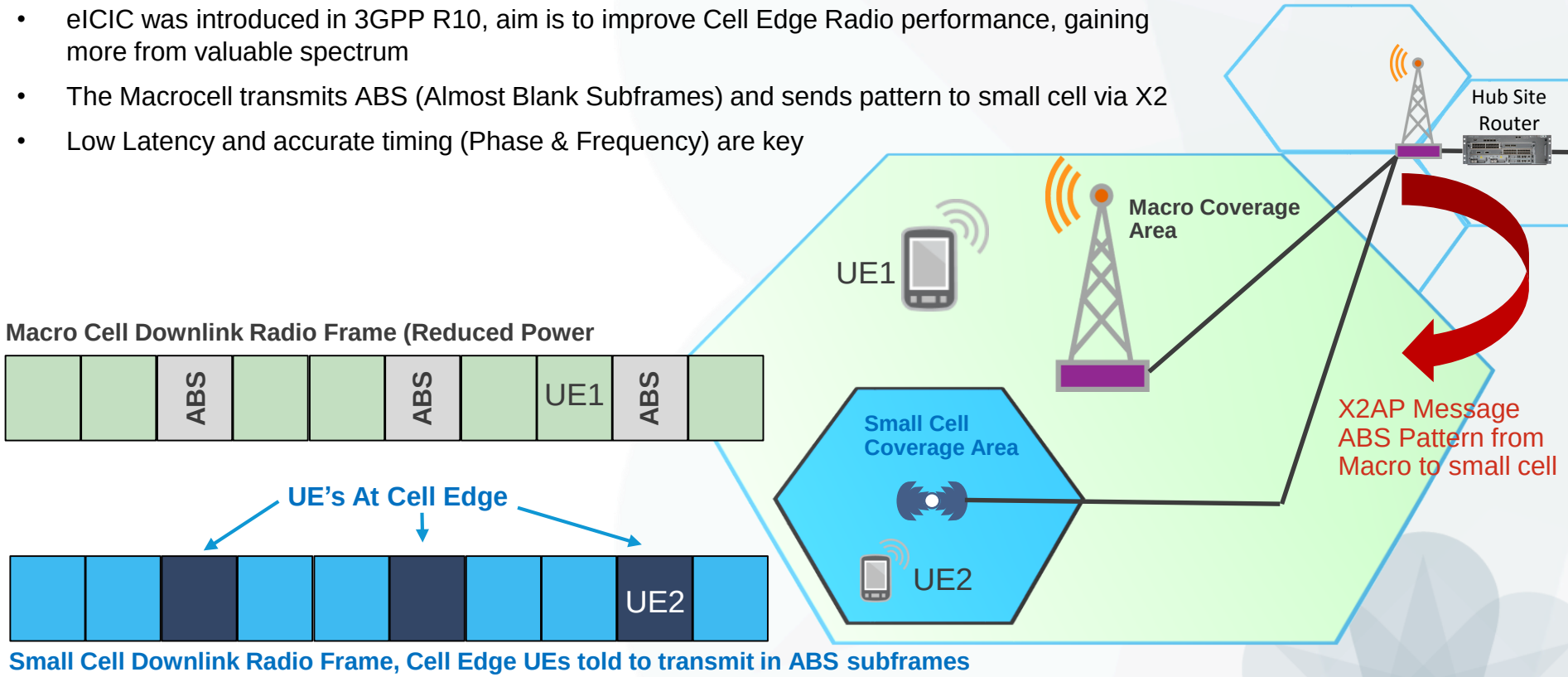
© 2016 Juniper Networks, Inc. All rights reserved.

eICIC: enhanced Inter-Cell Interference Coordination

Accurate Timing (Phase & Frequency) Are Key

eIC IC Feature of 3GPP Rel.10

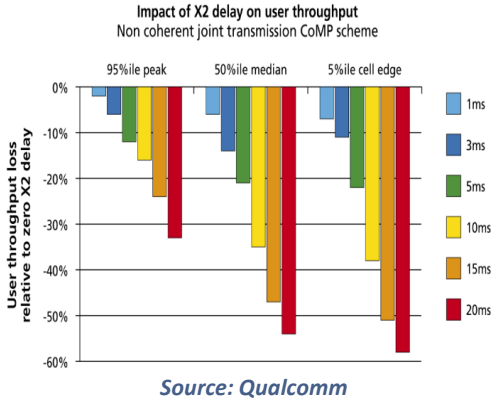
- eICIC was introduced in 3GPP R10, aim is to improve Cell Edge Radio performance, gaining more from valuable spectrum
- The Macrocell transmits ABS (Almost Blank Subframes) and sends pattern to small cell via X2
- Low Latency and accurate timing (Phase & Frequency) are key



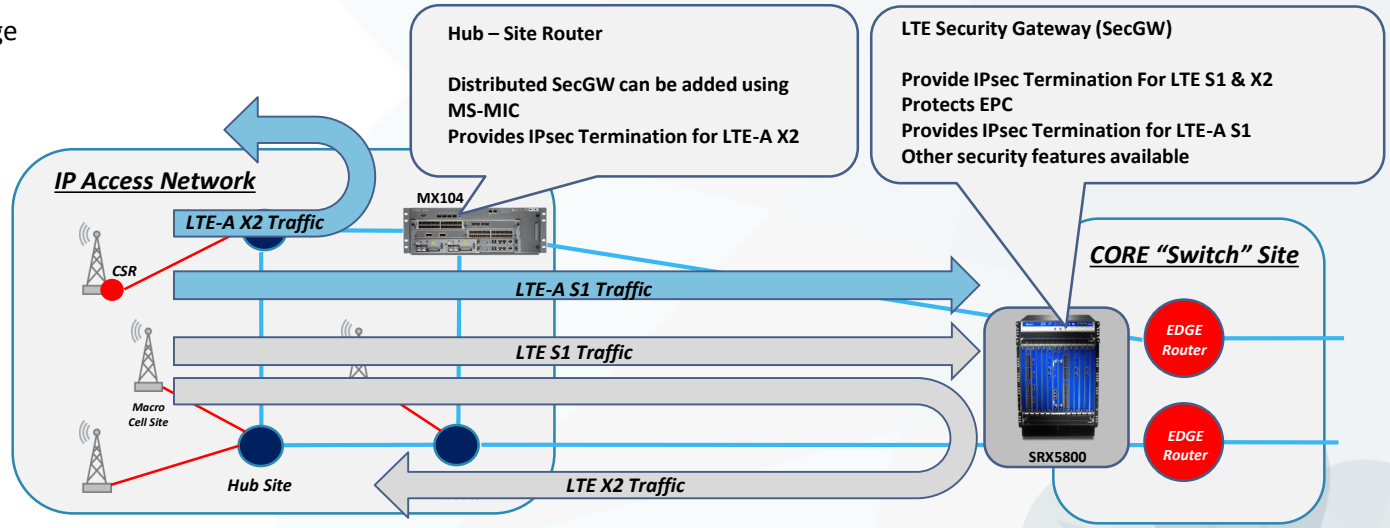
© 2016 Juniper Networks, Inc. All rights reserved.

Mobile Backhaul: The Move To LTE-A And On To 5G

- LTE-A Features such as Coordinated Multi-Point (CoMP) and Enhanced Inter-cell Interference Coordination, (eICIC) become available as s/w upgrades to 4G base stations from 2016
- These features drive close coordination between cell sites and place requirements on the backhaul network:
  - **Timing**: Frequency & Phase: Frequency16ppB, Phase +/- 0.5µSecs
  - **Distributed Security**: X2 Handover Interface requires a latency of ≤3-5ms
- Accurate timing with many vendors current and installed backhaul solutions is a major change as accuracy relies on hardware
- The Core LTE Security Gateway remains at the Core site to terminate the S1 IPsec tunnels and to protect the EPC, Distributed LTE-A SecGW For X2, on the Hub-Site, deployed at Fibre Edge

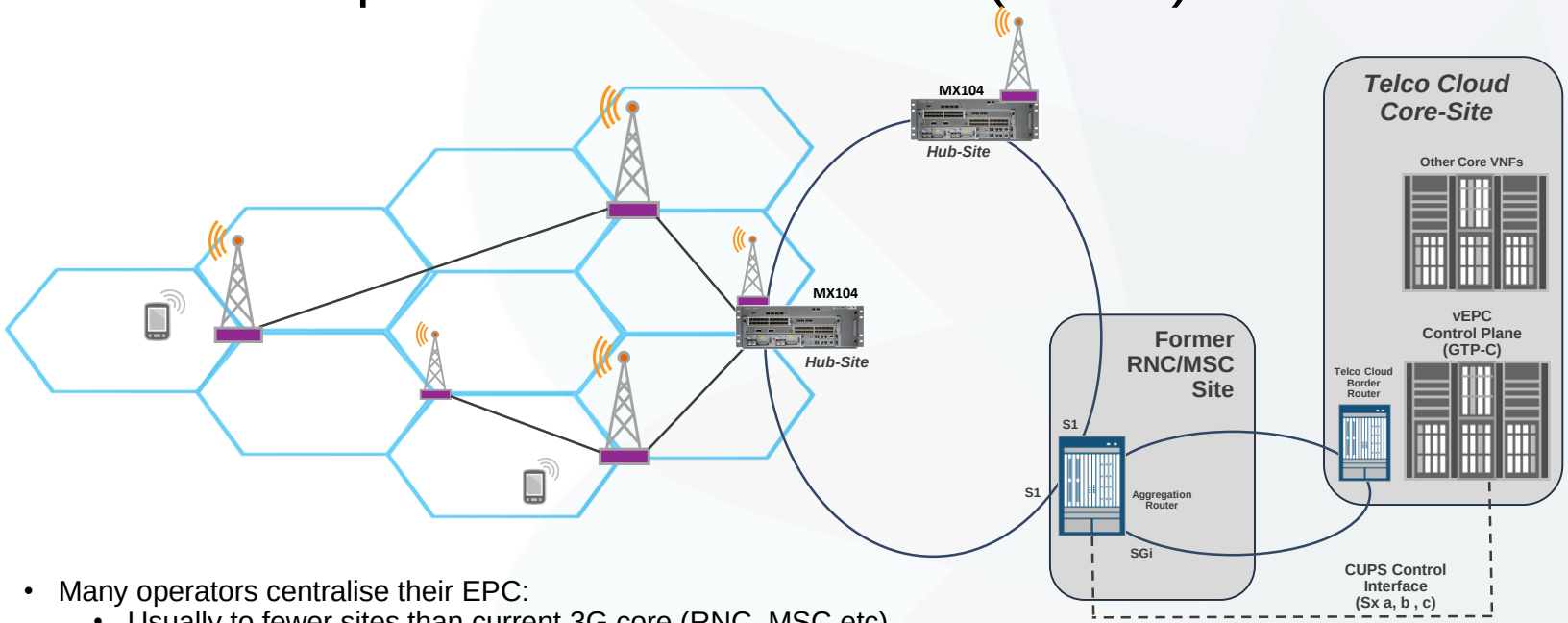


Source: Qualcomm



© 2016 Juniper Networks, Inc. All rights reserved.

4G To 5G Evolution Impacts : Distributed EPC (CUPS)

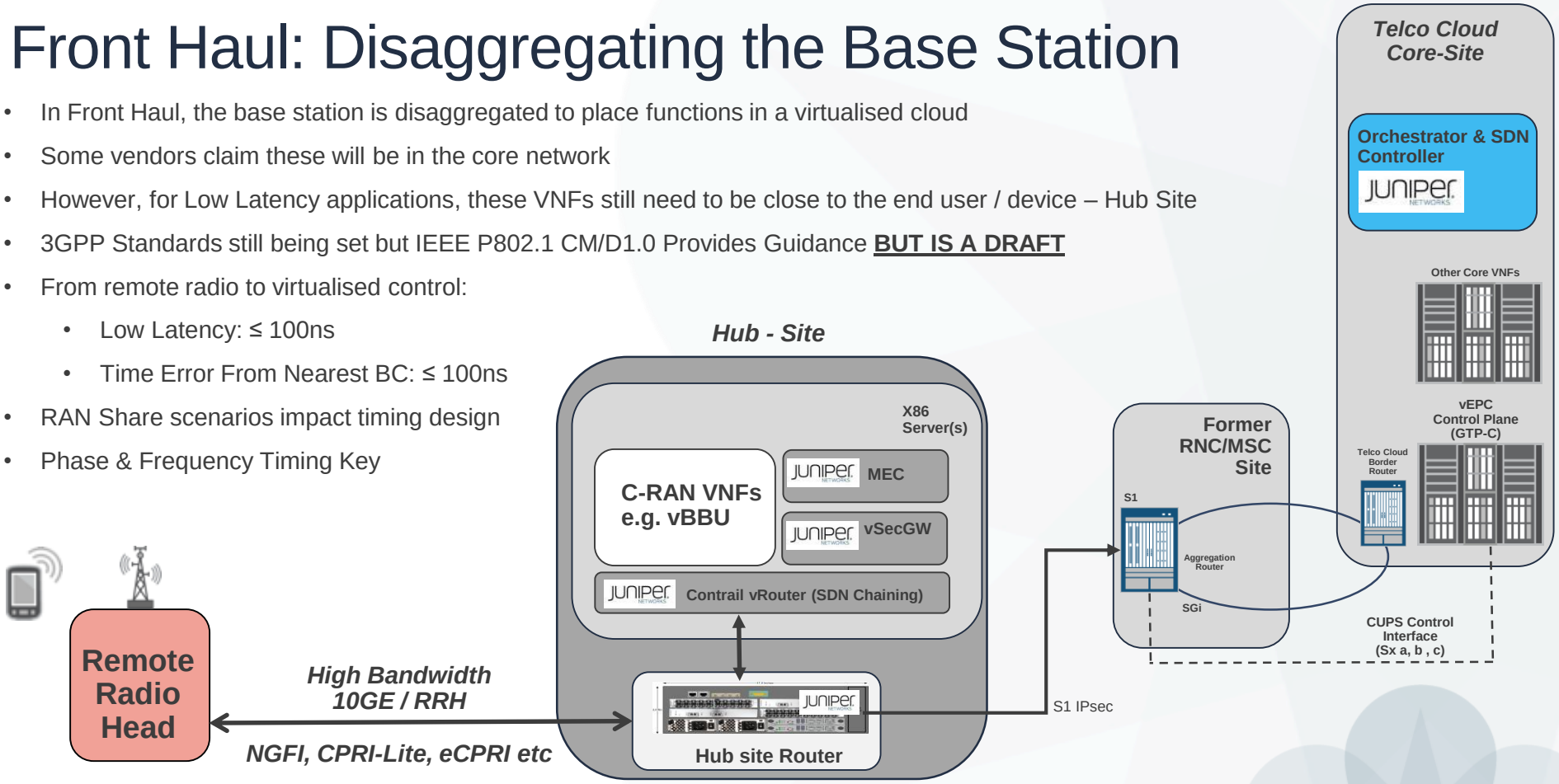


- Many operators centralise their EPC:
  - Usually to fewer sites than current 3G core (RNC, MSC etc)
- 3GPP CUPS (Control User Plane Separation) Allows EPC User Plane to move closer to the user
  - Potentially as far as the base station.
- This could reduce the Core Network Latency, placing the SGi close to the user BUT…..
- Mobility issues and signalling volume are likely to drive a complimentary approach with MEC:
  - CUPS allows centralised, NFV based vEPC Control Plane functions and distributed User plane – Former RNC/MSC Sites
  - MEC allows applications to run cost effectively at hub sites.

© 2016 Juniper Networks, Inc. All rights reserved.

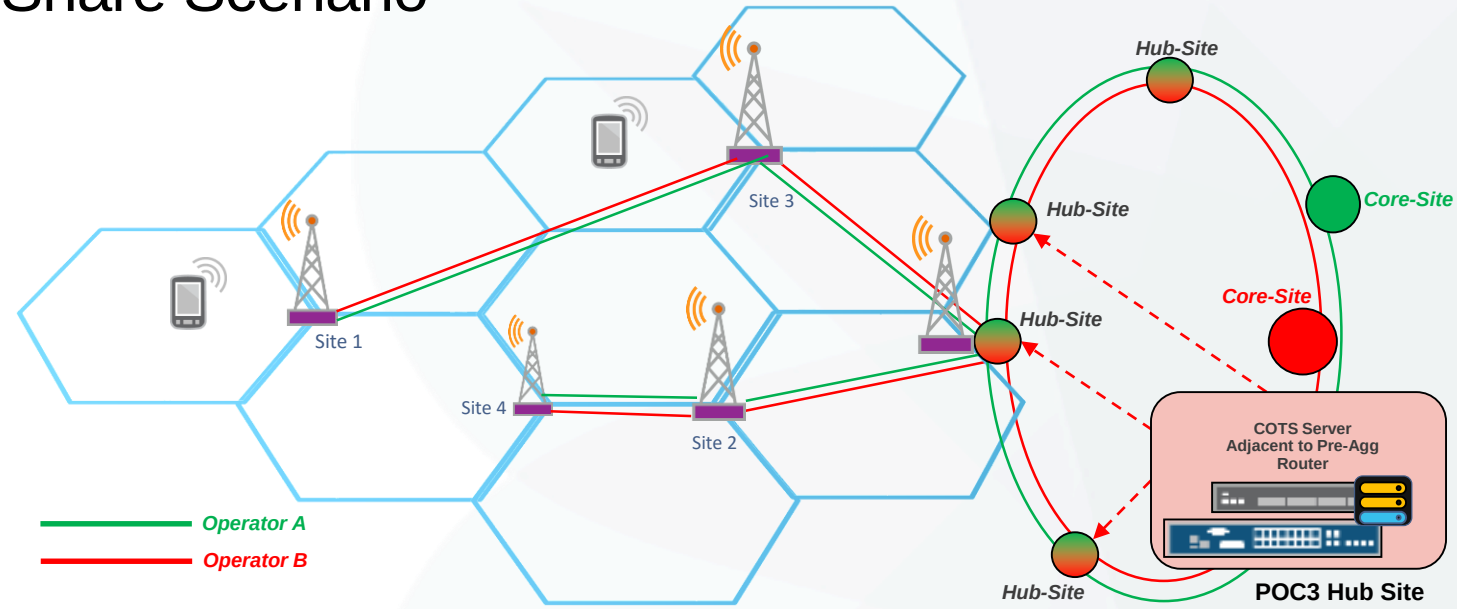
Front Haul: Disaggregating the Base Station

- In Front Haul, the base station is disaggregated to place functions in a virtualised cloud
- Some vendors claim these will be in the core network
- However, for Low Latency applications, these VNFs still need to be close to the end user / device – Hub Site
- 3GPP Standards still being set but IEEE P802.1 CM/D1.0 Provides Guidance **BUT IS A DRAFT**
- From remote radio to virtualised control:
  - Low Latency: ≤ 100ns
  - Time Error From Nearest BC: ≤ 100ns
- RAN Share scenarios impact timing design
- Phase & Frequency Timing Key



© 2016 Juniper Networks, Inc. All rights reserved.

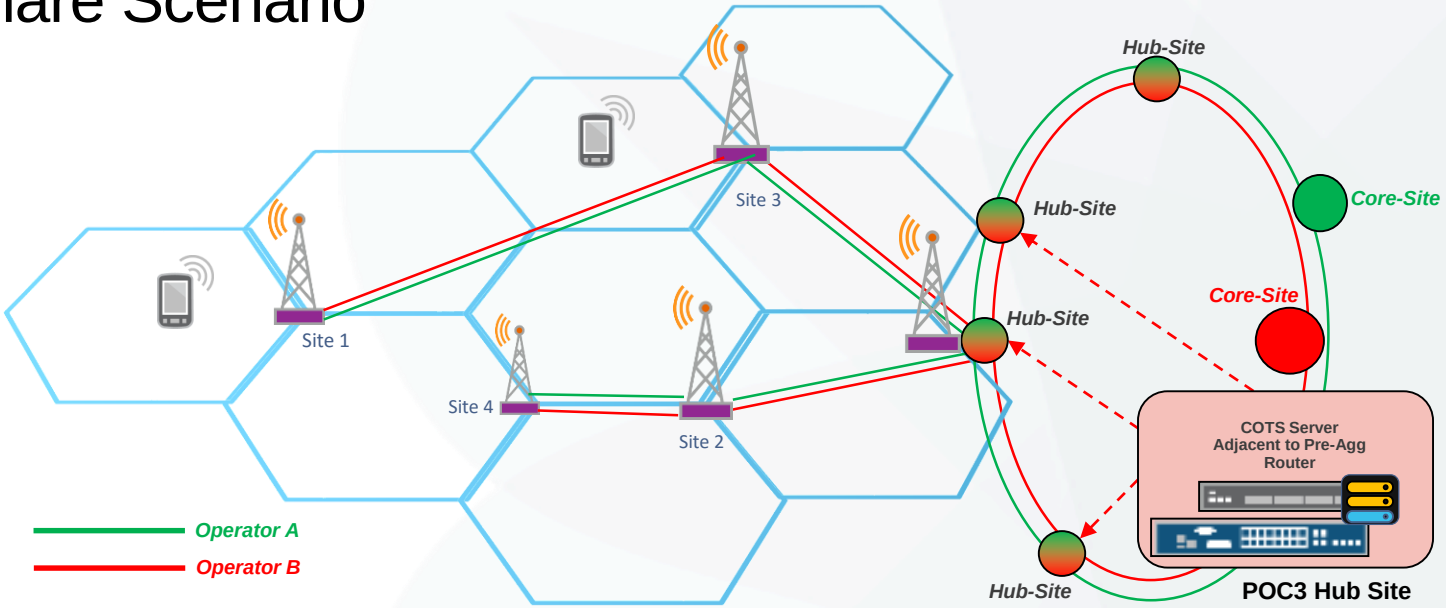
Passive RAN Share Scenario



- Passive RAN Share involves mainly "*Steel & Concrete*" sharing – e.g. Vodafone UK & O2 UK Cornerstone.
- Each operator sharing the site has their own eNode B cabinet and either shares the physical transmission from the cell to hub site or provides their own
- Hub site transmission infrastructure could be shared at the IP level
- IPsec tunnels from eNode B to core are not shared
- **Timing Would need to be shared in the PASSIVE RAN Share scenario when back haul is shared**

© 2016 Juniper Networks, Inc. All rights reserved.

Active RAN Share Scenario



- Active RAN Share involves Common eNode B infrastructure at the cell site, transmission is often shared to the hub site at least
- 3GPP standards enable the eNode B to have up to 6 IPsec S1 relationships with up to 6 core networks (EPC)
- Hub site transmission infrastructure could be shared at the IP level
- IPsec tunnels from eNode B to core are not shared
- **Timing Would need to be shared in the ACTIVE RAN Share scenario**

© 2016 Juniper Networks, Inc. All rights reserved.

Distributed Mobile Cloud:

MEC & Timing Still Required In Edge Compute Environment

Multi-Access Edge Computing (MEC)

Multi-Access Edge Computing (MEC) offers application developers and content providers cloud-computing capabilities and an IT service environment at the edge of the mobile network

MEC Characteristics

- Proximity
- Ultra-low latency
- High bandwidth
- Real-time access to radio network information
- Location awareness

MEC Standardised by ETSI ISG MEC

- Mobile Video Delivery Optimization using throughput guidance for TCP
- Local content caching at MEC
- Mobile Backhaul Optimization
- Traffic De-duplication

Network performance and QoE Improvements

- Security, safety, data analytics
- Active device location tracking
- MEC edge video orchestration
- Enterprise Mobility Services inc. Local Breakout
- V2I

Operator and 3rd party services

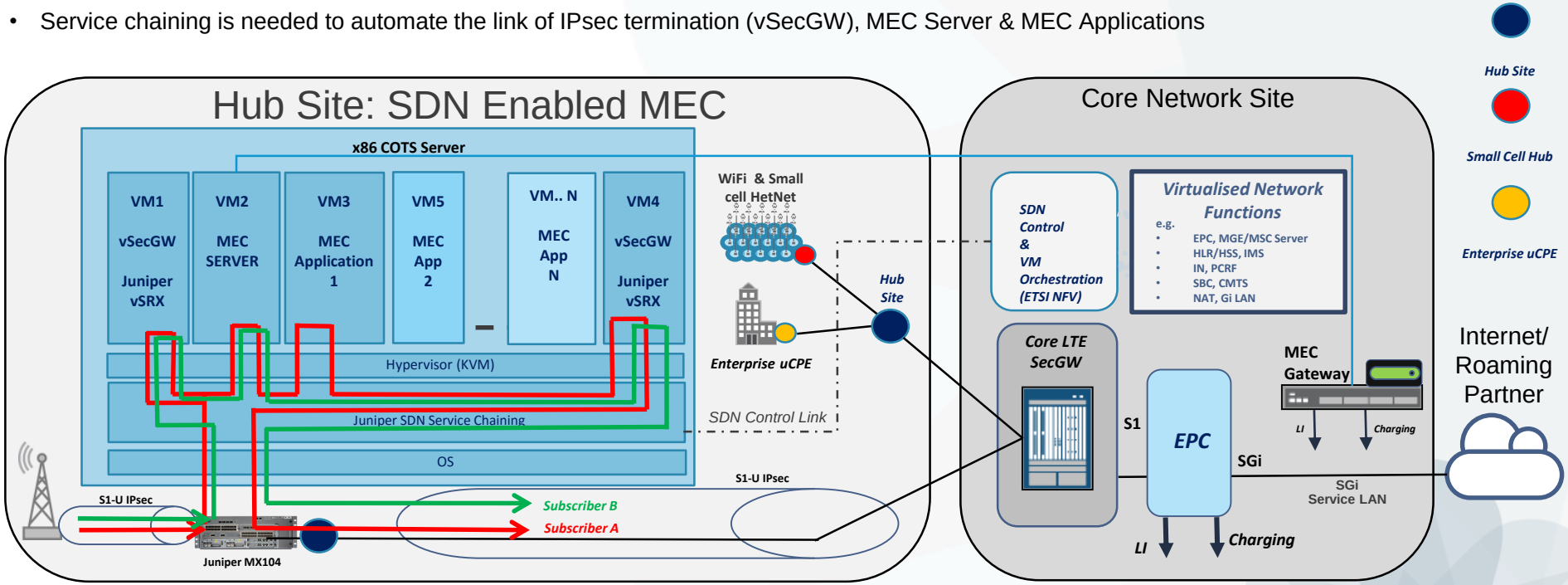
- Augmented reality, assisted reality, cognitive assistance
- Gaming and low latency cloud applications
- Edge video orchestration

Consumer-oriented services

© 2016 Juniper Networks, Inc. All rights reserved.

Edge Compute Services: MEC & SDN Automation

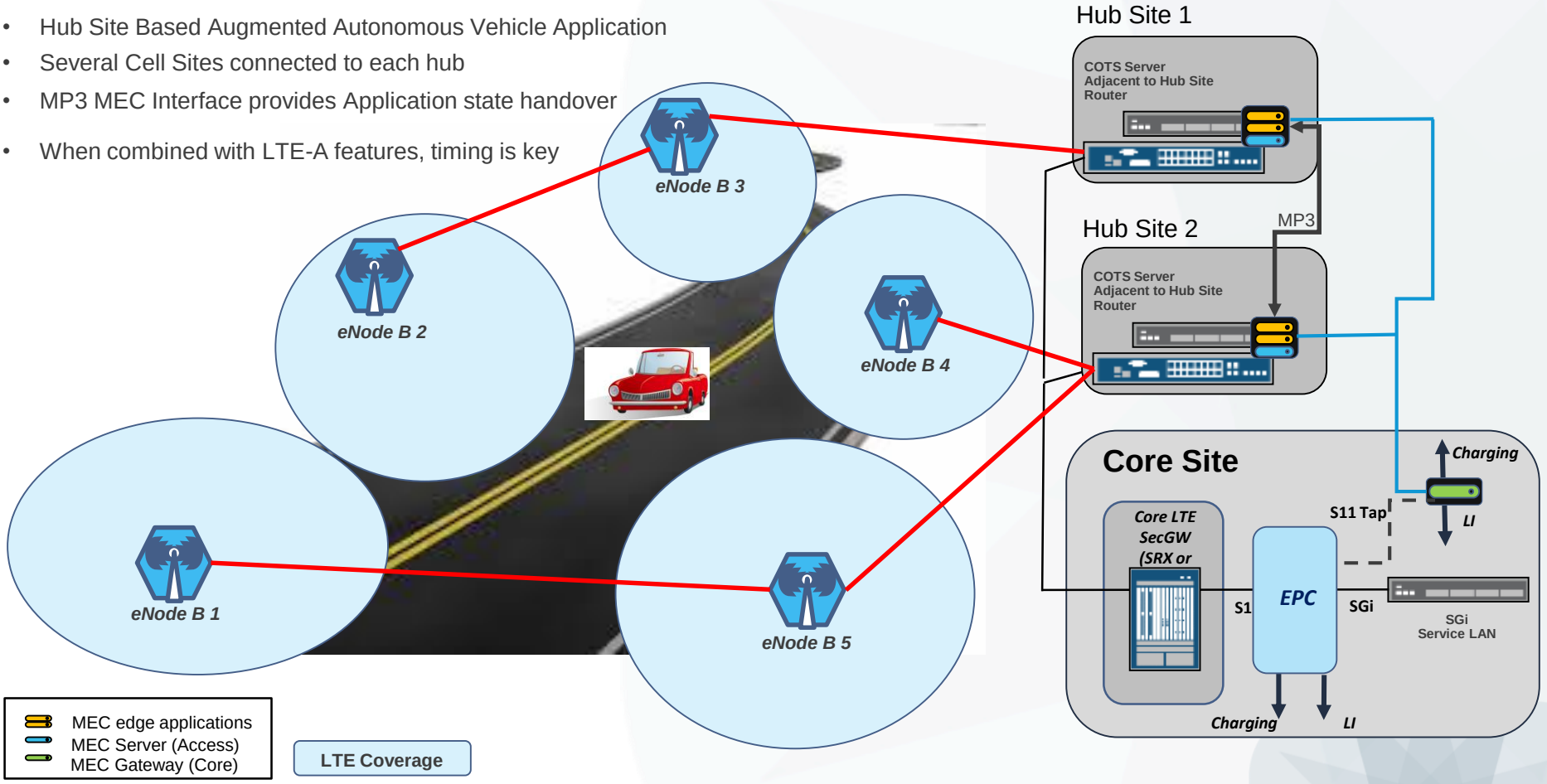
- MEC Enables applications to be deployed at the mobile network edge
- SDN Enables the chaining of MEC Applications and the Life-cycle Management of MEC Application VNFs using automation
- SDN Automation & Creation of services chains in the Telco Cloud DC and MEC Eco-system
- VNF Orchestration, such as Juniper Contrail Service Orchestrator, can be used to instantiate VNFs and manage their Life-Cycle
- Service chaining is needed to automate the link of IPsec termination (vSecGW), MEC Server & MEC Applications



© 2016 Juniper Networks, Inc. All rights reserved.

V2X Automotive: Low Latency Augmented Autonomous Vehicle Applications

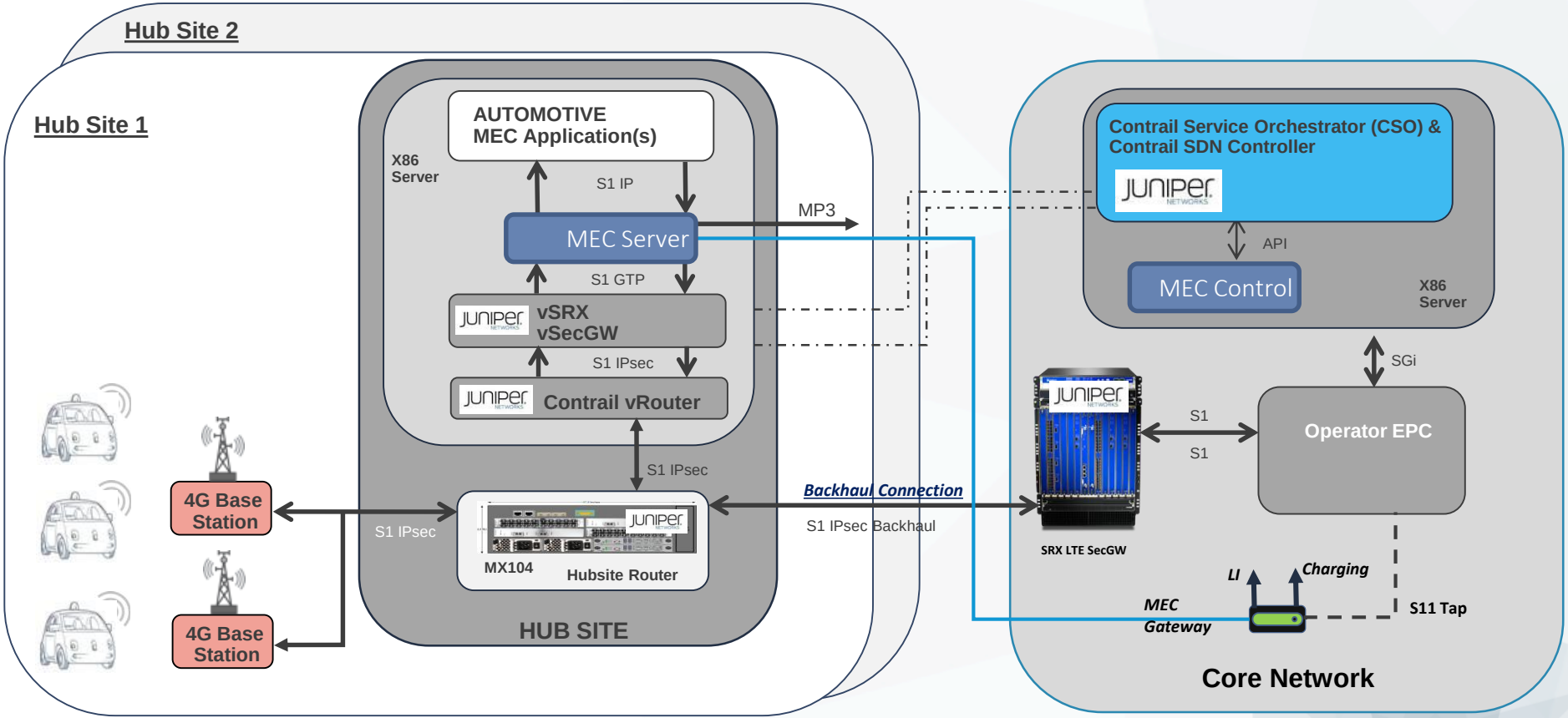
- Hub Site Based Augmented Autonomous Vehicle Application
- Several Cell Sites connected to each hub
- MP3 MEC Interface provides Application state handover
- When combined with LTE-A features, timing is key



© 2016 Juniper Networks, Inc. All rights reserved.

Automotive MEC Application:

- Size of x86 is dependent on the applications to be deployed: Need a discussion with application providers
- Two hub sites to allow MEC Server to MEC Server application handover.



© 2016 Juniper Networks, Inc. All rights reserved.

Thank you