Reimagine the RAN™

Parallel Wireless Overview

September 2015

Reimagine the RAN

Team Expertise Came Together to Reimagine the RAN
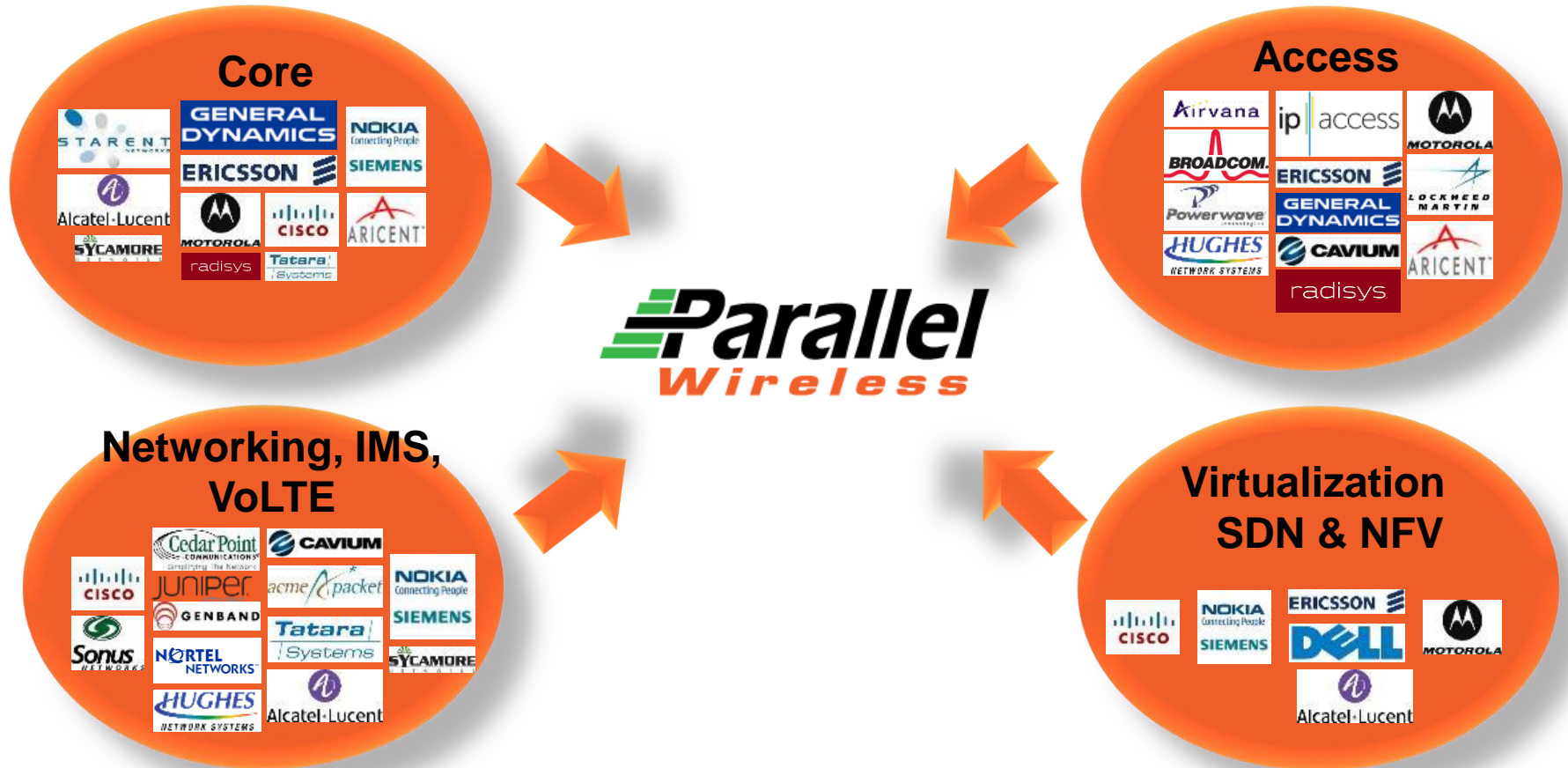
Leadership Team

Steve Papa, CEO and Chairman.
- Founder & CEO of Endeca, acquired by Oracle for $1.1B.
- Strong record of building and launching successful technology companies
- BSE from Princeton University

Rajesh Mishra, President and CTO.
- Two decades of experience in wireless, wireline, and cable space
- 25+ patents assigned and pending
- Sonus, Tatara, Bell Labs/ Lucent, Cedar Point, Hughes Networks, Tellabs/Steinbrecher & Cognition
- BS from IIT

Kaitki Agarwal, VP of Engineering & Operations.
- Worldwide wireless product development teams leadership for over 20 years
- 20+ patents pending and assigned,
- Starent/Cisco, Cedar Point, and Lucent/ Bell labs
- BS from IIT, MBA from Babson College.

Sridhar Donepudi, VP, Systems & Architecture.
- Traffic & policy management, base station, Class 5 Switching, IMS Core and telephony application server extensive knowledge
- 15+ patents pending and assigned
- Cedar Point/Genband, Bell Labs/Lucent, Steinbrecher/Tellabs
- BS and MS in EE
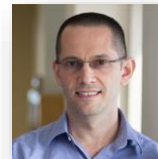
Increasingly Recognized by the Industry

2015

Finalist: **"Best Mobile Technology Breakthrough"**

2015

Finalist: **"Best Technical Platform based on Network Intelligence for SDN/NFV"**

2015

WINNER: "Most Innovative Wireless Service"

Finalist: **"Most Innovative SDN Product Strategy"**

Increasingly Recognized by the Industry

2015

Finalist: "**Most Innovative LTE Service**"
Finalist: "**Best LTE Core Network Product**"

2015

WINNER : "**Excellence in Commercial Deployment (Rural and Remote)**"

Finalist: "**Small Cell access point design and technology**
Finalist: "**Small Cell backhaul design and technology**

Increasingly Recognized by the Industry

2015

Finalist: "**Best Communication Solutions**"

2015

Finalist: "**Enabling Hyperconnectivity** with HetNet Gateway" for Wide Area Network category

FierceWireless names Parallel Wireless to "Fierce 15" Wireless Companies List of 2015

"Fierce 15" winners have been the emblems of **innovation**, our lists are an annual celebration of the **most creative and promising** privately held wireless companies.

All of our [Fierce 15] winners are engaged in interesting work that has **the potential to reshape the industry**. *They are the ones we should be watching in the years ahead.*

EE/Parallel Wireless Rural solution: Recognized for Innovation and Excellence

Parallel Wireless

Reimagine the RAN

- Complete **cloud-managed** networking solution
  - **Ease-of-deployment**: less specialized installation labor
  - **Automation** of configuration and ongoing optimization
  - Promotes advanced standards-based network element **interoperability** for multi-vendor, multi-technology HetNets
- **Innovation**: Built from ground up to leverage latest architectures
  - Emerging single chip silicon baseband solutions capable of handling full range from femto cell to macro sector
  - Unified approach to drive cost down
  - Orchestration of "bag of sectors" real-time
  - Controller runs on any off the shelf standard Intel server hardware (SDN/NFV)
- **Proven technology**: Rollouts are underway

Key Strategic Industry Inflection Points

More powerful/ less cost SoC/Moore's Law → more Capacity in a Smaller Form Factor at Lower Cost, *one $100 chip can handle one sector*

SDN/NFV → *network and operational simplification and cost reduction through elasticity/programmability and automation*

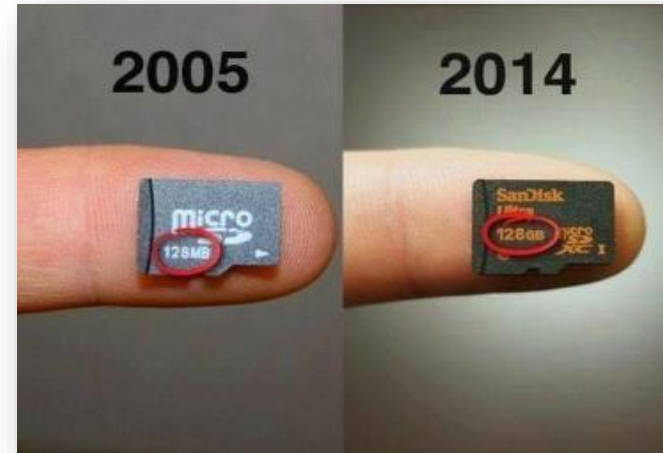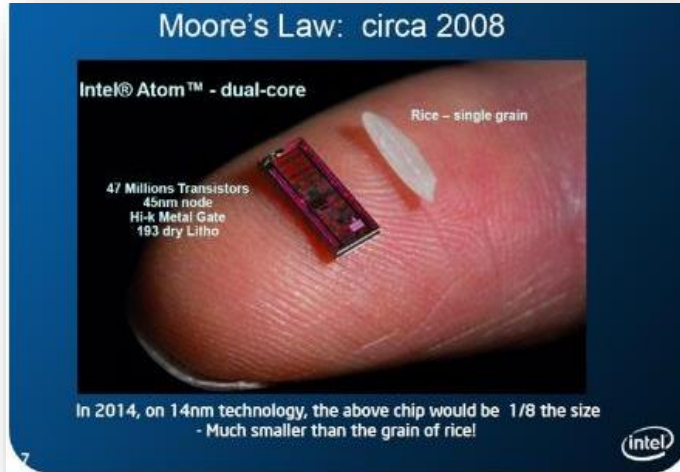## *Leveraging the two together makes a new RAN architecture possible ...*

Moore's Law in Action

## More Capacity in a Smaller Form Factor at Lower Cost

Faster **Smaller** **Cheaper**

Moore's Law: circa 2008

Intel® Atom™ - dual-core

Rice – single grain

47 Millions Transistors
45nm node
Hi-k Metal Gate
193 dry Litho

In 2014, on 14nm technology, the above chip would be 1/8 the size
- Much smaller than the grain of rice!

(intel)

2005   2014

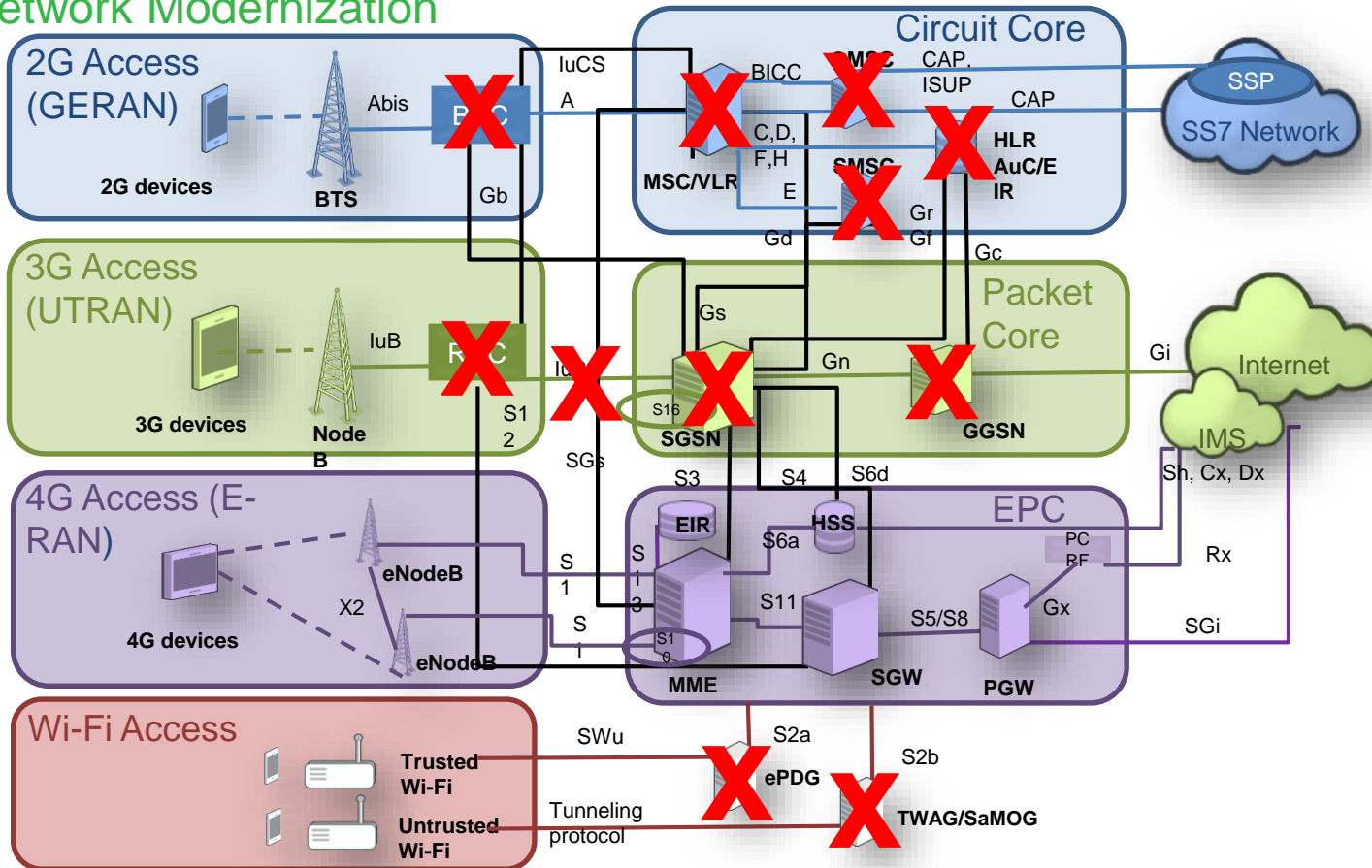|	**2007**	**2015**
	HP Superdome	**Commodity**
RAM 512GB	$6,000,000.00	$10,000.00
CPU 12 core	$2,000,000.00	$4,000.00

Traditional Network Architecture

Insanity is a Generous Word
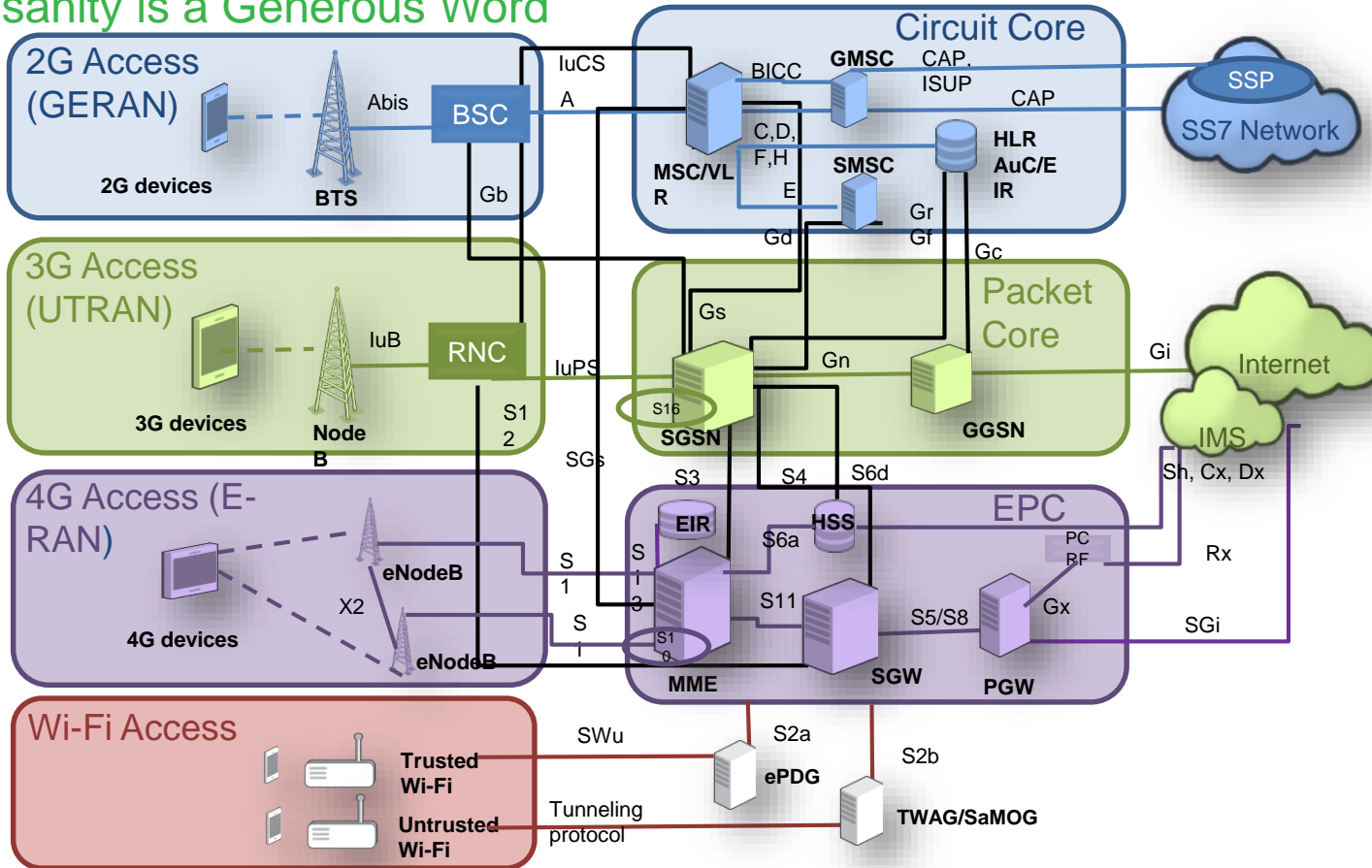
- **3** independent networks
- **3** different architectures
- **3** centralized cores
- **+** Wi-Fi architecture
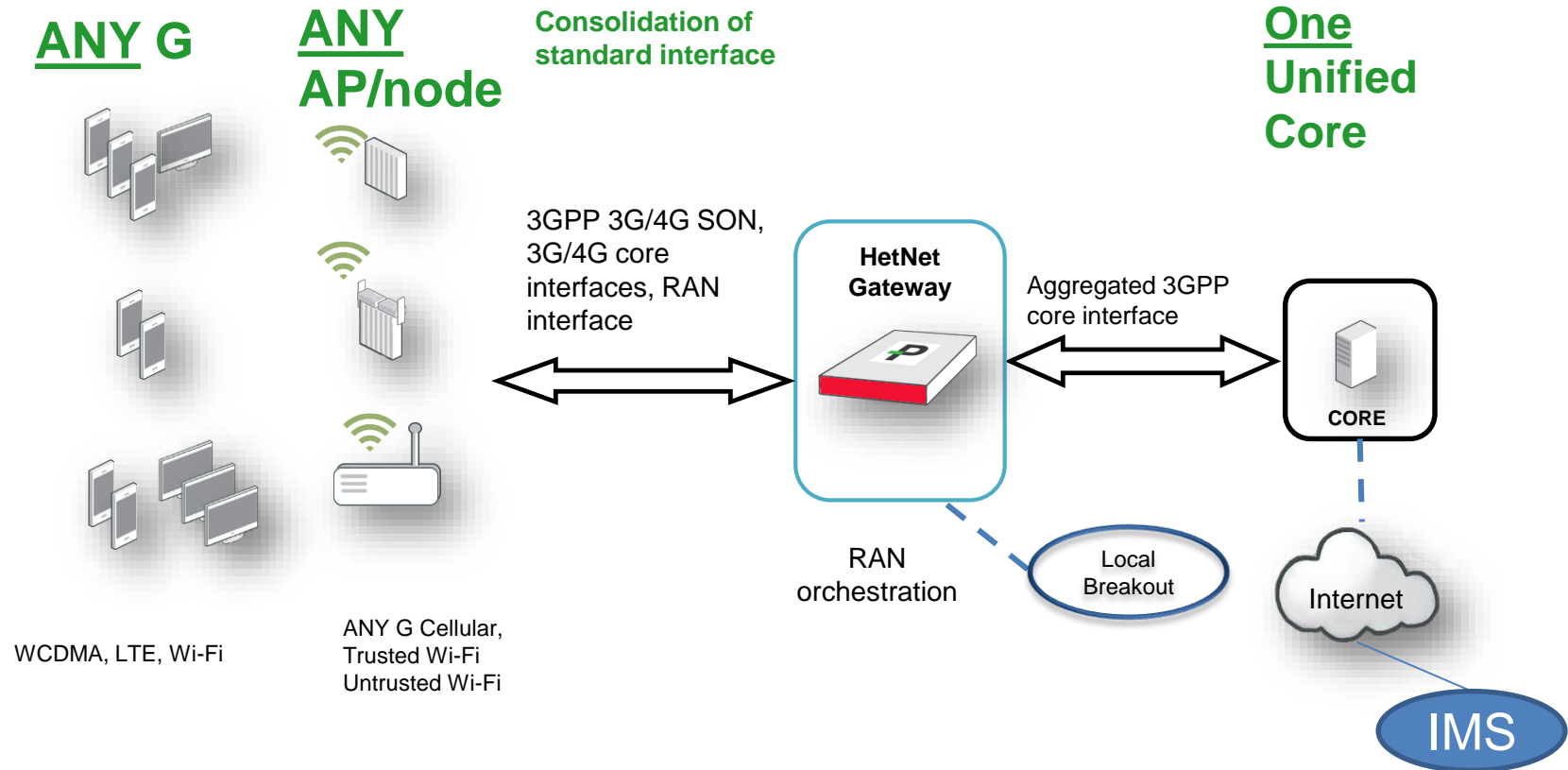
Traditional Network Architecture

Network Modernization

- **More Reliable**
- **Much Lower Cost**
- **More agile**

Net Result: Unified Architectural Approach

Network Modernization -- Paving the Road to 5G

ANY G

ANY AP/node

Consolidation of standard interface

One Unified Core

3GPP 3G/4G SON, 3G/4G core interfaces, RAN interface

HetNet Gateway

Aggregated 3GPP core interface

CORE

RAN orchestration

Local Breakout

Internet

IMS

WCDMA, LTE, Wi-Fi

ANY G Cellular, Trusted Wi-Fi Untrusted Wi-Fi

Our Vision

Parallel Wireless is *reimagining the RAN* and building solutions that will enable and accelerate the long term transition from today's 3G/4G to tomorrow's 5G cellular networks.

Our Mission

Making carrier-grade cellular network deployments as easy and cost-effective as enterprise Wi-Fi.

Our Solution

HetNet Gateway(HNG) and Converged Wireless System (CWS).

Solution Features
RAN Unification and Simplification

- **Architectural simplification** and Architectural **Unification** across WCDMA, LTE and Wi-Fi
  - Simultaneous support of multiple air Interfaces
  - Single Authentication; Provisioning Simplification
  - Mobility and session continuity across WCDMA, Wi-Fi and LTE with local anchoring on HNG
  - Unification of QoS & Policy Control and Billing
  - Real-time SON across all technologies
  - Direct interworking with 4G EPC network, removing requirements for 3G network elements (SGSN, GGSN)
  - Security – SeGW support
- Allows hundreds of APs to **be abstracted** in a similar way to VMware allowing hundreds of servers to be managed as an abstraction
- **Carrier-grade**
- Runs on any **COTS**
- **Seamless** Wi-Fi ←→ cellular mobility with locally managed handoffs including VoWiFi and Trusted ←→ Untrusted Wi-Fi
- Local breakout
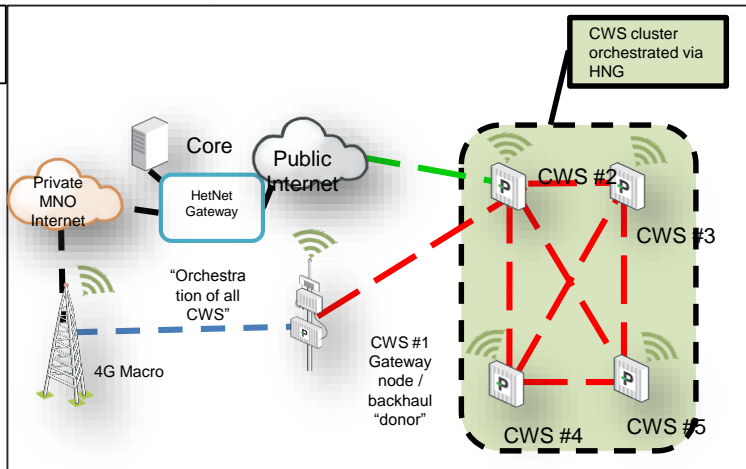- Local regulatory support (LI, etc.)

Solution Benefits
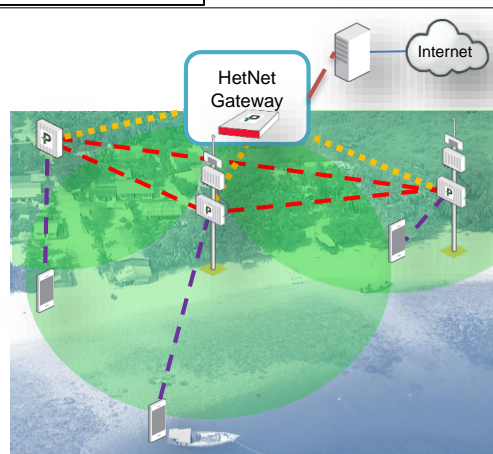## TCO Reduction + Superior User Experience

- **RAN unification**
  - Enabling Wi-Fi/cellular true convergence with architectural simplification based on software/removing silos
- **Subscriber QoS: seamless experience**
  - Full mobility support:
    - Handins and handouts of any type of UEs (regardless of the release)
    - Locally anchored and optimized mobility
    - LBS
    - User can travel seamlessly between different technologies
    - User w/bad experience can be moved onto another technology → transparent to the user
  - SON capabilities
    - Smart Camping (based on the type of traffic, load distribution and the speed)
    - ANR
    - ICIC
  - Support VoHSPD & VoWiFi with enabling smooth migration to VoLTE
- **TCO reduction**
  - Software based solution that runs on any COTS
  - Cost-effective Femto replacement
  - Can enable cost-effective APs
- **Easy integration** into an existing NFVI architecture
- **New revenue opportunities**: service enablement (voice, messaging, video, parental, anti-malware, etc.) over Wi-Fi to expand service delivery footprint
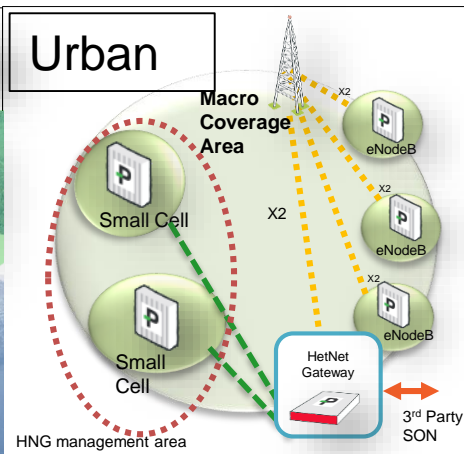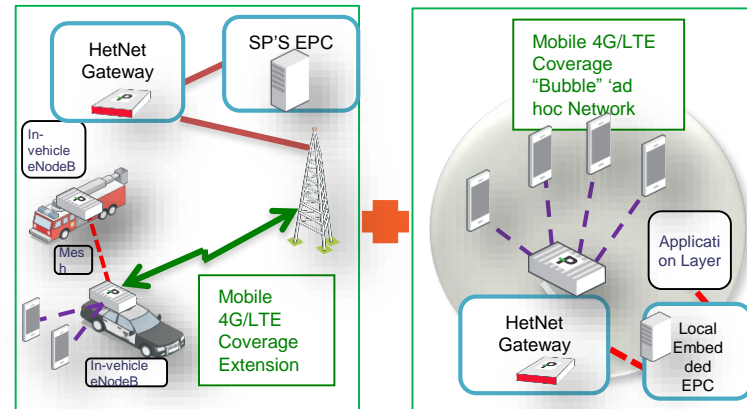
One Technology: Many Deployment Scenarios

Rural

CWS cluster orchestrated via HNG

Core

Public Internet

Private MNO Internet

HetNet Gateway

CWS #2

CWS #3

"Orchestration of all CWS"

4G Macro

CWS #1 Gateway node / backhaul "donor"

CWS #4

CWS #5

Resilient Island Mesh

HetNet Gateway

Internet

Urban

Macro Coverage Area

HetNet Gateway

Small Cell

X2

eNodeB

X2

X2

eNodeB

Small Cell

X2

eNodeB

HetNet Gateway

3rd Party SON

HNG management area

Public Safety w/Bring Your Own Coverage (BYOC)

HetNet Gateway

SP'S EPC

Mobile 4G/LTE Coverage "Bubble" 'ad hoc Network

In-vehicle eNodeB

Mesh

Mobile 4G/LTE Coverage Extension

In-vehicle eNodeB

Application Layer

HetNet Gateway

Local Embedded EPC

- **Deployment Flexibility**:
    - Rural
    - Urban
    - Island Mesh
    - In-building
    - Femto Optimization
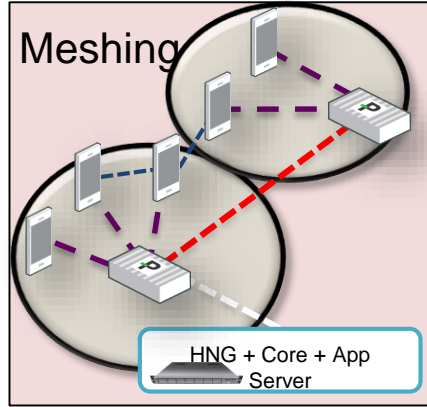   - IoT
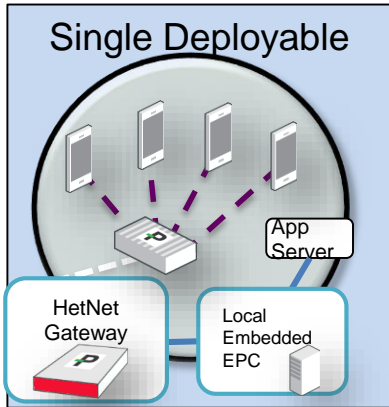   - Public and Emergency Services
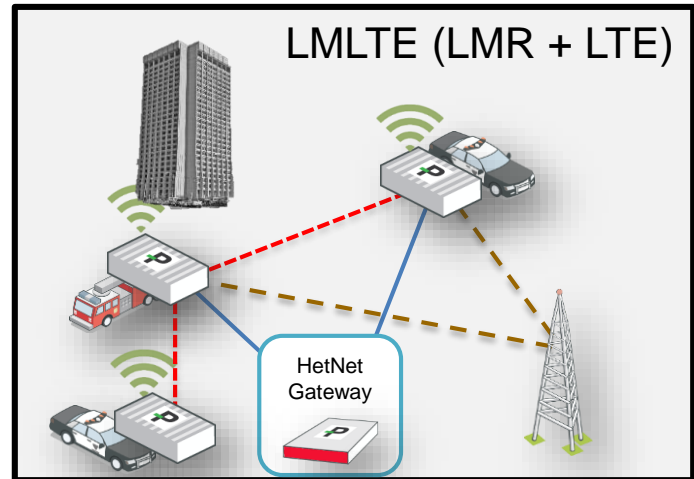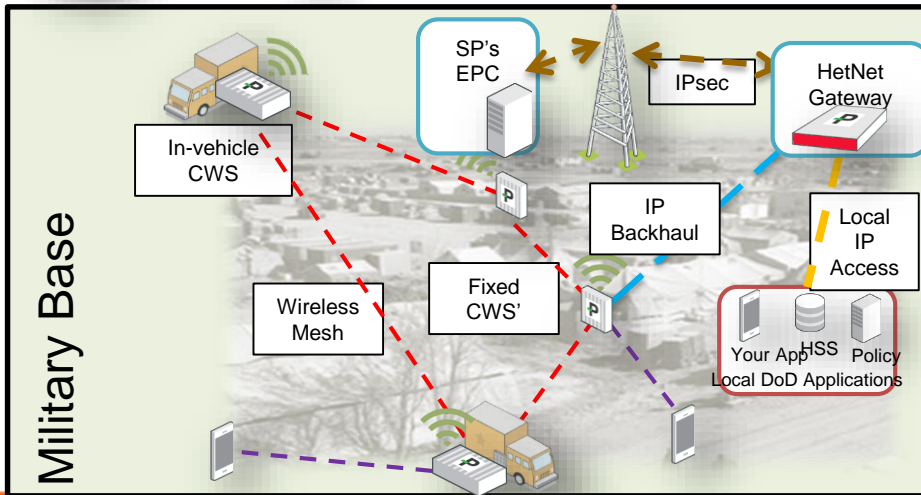   - ENT
- **Coverage**
- **Resilience**:
    - Self-optimization
    - Self-healing
- **Cost effective**: Intelligent software enabling cost-effective hardware and consumer devices

One Technology: Many Use Cases

Single Deployable

App Server

HetNet Gateway

Local Embedded EPC

Meshing

HNG + Core + App Server

- **Deployment Flexibility**:
  - Ad hoc networks: Single Deployable, Meshing, Disaster Recovery
  - Military base coverage
  - Special Force Operations
  - Public and Emergency Services
- **Control**
- **Resilience**:
  - Self-optimization
  - Self-healing
- **Cost effective**: Intelligent software enabling commodity hardware and devices

Military Base

In-vehicle CWS

SP's EPC

IPsec

HetNet Gateway

IP Backhaul

Local IP Access

Wireless Mesh

Fixed CWS'

Your App HSS Policy
Local DoD Applications

LMLTE (LMR + LTE)

HetNet Gateway

Example: Small Cell Deployment – What do we bring ?

- Simple quick Installation –
  - 1 hour to install and commission one CWS
  - Planning "Lite"
- Eliminates the backhaul challenge
  - Use what is available when it becomes available & aggregate all sources
  - In Band 4G Backhaul
  - Built in Multi-radio Mesh Backhaul
  - Fiber / public Internet
- Low cost of Operation
  - 80W power consumption
  - Standard domestic Supply

Result: Rural HetNets Economically Viable

UK's largest mobile operator, a subsidiary or Deutsche Telekom and Orange Telecom; operates **Europe's largest 4G network** with 31M connections

We … **can change the economics of providing mobile voice and data coverage**. The innovative capabilities remove significant obstacles to rural coverage and uniquely enable us to connect areas for the first time with both reliable voice services and our 4G wireless broadband.

Mansoor Hanif, Director Radio Access Networks and programs at EE.

One of the many visions for the 5G future is Heterogeneous Networks, or HetNets, where all the high speed data traffic is carried by vast numbers of small cells while the network control is carried by big over-arching cells. **EE is now rolling out HetNets.**

If EE was being its normal hype-filled self, it **would call its latest mobile trial in Cumbria 5G**. Its restraint is admirable – and the technology even more so.

Making carrier-grade cellular network deployments as easy and cost-effective as enterprise Wi-Fi

with

Self-configuration
Self-optimization
Self-healing
Multi-vendor Interoperability
Real-time ICIC and traffic mitigation
X2 brokering and S1 aggregation
Automatic resource allocation
Paging, handoff and signaling optimization/reduction

Summary - Reimagined and Unified RAN

- **One technology -- many deployment scenarios**: applicable to wide range of scenarios including new markets like Public Safety LTE

- **Improves user experience** with seamless multi-RAT handoff and more abundant coverage/capacity

- **Address the economics challenge of lowering cost per bit**
  - Improves CapEx with integrated functions over NFV, auto-provisioning, standardized commodity high-volume BBUs, and embracing interoperability
  - Improves OpEx with lower energy consumption, auto-optimization, monitoring and troubleshooting including routing decisions and QoS rules across the network, additional resiliency, and more flexibility
  - Lower time and cost to deployed Solution – Planning lite, Eliminates Backhaul Challenge, Simple, quick, low skill Install and commissioning

Thank You

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