Wireless Network Evolution and Virtualization, where are we now and where are we headed?
Outline

- The 4G and 5G market, status and forecast
- The CBRS Opportunity
- 5G Introduction
- Importance of 4G
- XRAN introduction
- Network Virtualization
The 4G and 5G market status and forecast
- 5G, still early days... Do not forget 4G!!!
- 5G will be supported by existing 4G infrastructure

Mobile data traffic grew 82 percent between Q1 2018 and Q1 2019

• The growth needs support
• More bits per second, for less
• Ideal for our XRAN strategy

Mobile subscriptions
Unit: Million
5G | LTE | WCDMA/HSPA | GSM/EDGE | TD-SCDMA | CDMA | Other technologies
Smartphones | Feature phones | Mobile PCs/ToWNETS/ Routers
Year: 2014 - 2024

Source: Ericsson (June 2019)
Are you ready for 5G?

The most frequent question from customers: “Are your products and solutions ready for 5G?”

- A lot of customers and suppliers are on different levels of 5G understanding
- All suppliers will answer “yes”…
- Let’s try to dig a bit deeper

Yes!
Supplier-1
5G readiness
- Unknown

Yes!
Supplier-2
5G readiness
- Not really...
- Low-mid bands
- No 5G use cases

Yes!
Supplier-3
5G readiness
- No 5G at RAN
- Low-mid bands
- No future 5G evolution

Yes!
Supplier-4
5G readiness
- Partially at RAN
- No RF units
- No 5G DUs

Yes!
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5G readiness
- 100% vRAN, live in networks
- Low-mid-high bands RF NR distribution
- NFV, MEC
- Slicing
- Orchestration
- Beamforming
- Extreme Capacity
- 100% 5G “end-to-end”

True 5G experience is extreme capacity, # of connected devices, low production cost, reliability, low latency, intelligence at the edge, virtualization.
The CBRS Opportunity

Wi-Fi Wireless – Typically congested, Density challenged
• Well known use cases, well known limitations
• 802.11-based technology, requires separate security layers

CBRS / OnGo – Up to 2.4Gbps of capacity available
• Available to venue owners for private use
• LTE-based, 15 Channels up to 160Mbps per, inherent security

Mobile Operator Cellular – Owner/Controlled by Operators
• Provides transparent high speed mobile connectivity
• LTE or 5G based technology, speed dependent on MNO
U.S. Spectrum Map

Current Licensed Band Spectrum

- Licensed 600 thru 2500MHz
- AT&T: 150MHz, Verizon: 115Mhz, T-Mobile: 110MHz, Sprint: 200MHz, Other: ~120MHz

Add Mid-Band Spectrum

- 3550 to 3700 MHz (150MHz) CBRS
- 3700 to 4200 MHz (500MHz FCC)
- 5925 to 6425 MHz (500MHz FCC)
- 6425 to 7125 MHz (700MHz FCC)

Add mmWave Spectrum

- 27.5 – 28.35 GHz (2X425 Mhz)
- 37.6 – 38.6 GHz (5X200MHz)
- 38.6 – 40 GHz (7x200MHz)

MHz Bandwidth

- ~650MHz BW
- 1850MHz BW (2.8X)
- 3250MHz BW (5X)
Capacity

CBRS provides channelized spectrum that is dedicated for private use by location.

- CBRS 3.5GHz: 150
- T-Mobile: 110
- Verizon: 114
- AT&T: 180
- Sprint: 202
- 2.4 GHz WiFi: 83
- 5.6 GHz WiFi: 125

Shared
Licensed
Unlicensed

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Key Mobile Phones are Now Supporting OnGo
If we only look at the world thru mobile phone lenses we might miss something.
Many new devices are emerging with CBRS spectrum (Band 48) support.
Building IT systems span many areas and connecting them is expensive business.
But why?

Businesses need more agility, more flexibility.

The cost to move wired equipment is expensive.

This is especially true in specific industries such as retail, industrial, and healthcare.
Healthcare

Staff Comms
- Persistent connectivity
- Controlled access
- Inherent security

Patient Monitors
- Untethering patients
- Common backhaul
- Inherent security

Equipment
- Connection required
- Adaptable bandwidth
- Inherent security

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Healthcare Mobile Transformation

Key Issues

• Data security concerns
• Persistent connectivity
• Deterministic capacity
• Extensible to Wide Area
• Data continuity
• Workflow automation
Retail

Digital Experience
• Persistent connectivity
• Move anywhere
• Zero Tech to Change

Clerk Tools
• Mobile scanning
• PTT communications
• Store security

Operations
• Secure transaction
• Dedicated bandwidth
• In-store only operation

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Enabling Enterprise IT Mobilization

Standard mobile handsets and specialty handsets will emerge with support for CBRS.

Small form factor devices for extending Ethernet and USB connectivity to IT equipment.

Multi-function gateways extending IoT, Wi-Fi, PoE connectivity over CBRS.

Private Wireless Handset Mobilization

Private Wireless IT Device Extension

Private Wireless IT Network Extension

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Sports/Entertainment/Convention

Rolling Vendor Kiosk
Point-of-Sale Sites

Portable Video
AI/Analytics

Portable Ingress:
Scanning / Facial Rec.

Unwired Sound
Control Networks

Mobile In-Event
Video Cameras

Dedicated
Fan Engagement

Volumetric Video
Collection & Delivery

Team Communications
& Play Reviews

Enhanced Analytics

Portable Signage

Security & Operations

Athlete Monitoring

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5G Introduction
5G, Introduction 5G experience

5G, the balance between coverage, frequency, capacity and RF bandwidth

Data capacity/latency/intelligence

Extreme capacity layer
Very High Density, extreme demanding industrial capacity

Basis capacity layer
High Capacity, Urban and indoor deployment

Coverage layer
Rural coverage, deep indoor penetration from outdoor

Coverage & Indoor penetration

5G experience

True 5G experience is extreme capacity, # of connected devices, low production cost, reliability, low latency, intelligence at the edge, virtualization.
5G, Introduction 5G experience

- 5G is a technology... not a specific band
  - Advanced antenna systems
  - Mobile Edge Computing
  - Slicing
  - Extreme capacity
  - Low latency, using shorter slot duration to open new real-time critical services
  - Low data production cost

- This enables true 5G use cases

- Fiber-like wireless speed, multi-Gbps data rates, utilizing large 5G bandwidths, 100's of MHz

- Existing low-bands will eventually also carry 5G
  - Re-farm 4G to 5G NR to increase capacity, via dense spectral reuse (5G slots fits existing 3G/4G raster)

- The Spectrum-width on the low bands will be relative limited, limiting the 5G capacity on low bands
- The low bands would potentially provide good deep indoor penetration for 5G
The devices are (almost) here....

### 5G device availability (3GPP)

<table>
<thead>
<tr>
<th>Band Description</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Second half</td>
<td>First half</td>
<td>Second half</td>
</tr>
<tr>
<td>High Band (mmWave)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28GHz</td>
<td></td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>High band</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39GHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-band (sub 6GHz)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5GHz</td>
<td></td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>2.6GHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-band (sub 1GHz)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDD bands (1800Mhz lead band)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **High Band**
  - Very High Density, extreme demanding industrial capacity
- **Mid Band**
  - High Capacity, Urban and indoor deployment
- **Low Band**
  - Rural coverage, deep indoor penetration from outdoor

### Coverage & Indoor penetration

- **Coverage layer**
  - Rural coverage, deep indoor penetration from outdoor
- **Basis capacity layer**
  - High Capacity, Urban and indoor deployment
- **Extreme capacity layer**
  - Very High Density, extreme demanding industrial capacity

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The 5G Landscape

5G Mobile Operator
- Unlimited data plan, elevated experiences
- 5G NSA (anchored in LTE) at launch
- Mobile Edge Computing, MEC
- CPE for wireless backhaul
- LTE 4G as a coverage/capacity foundation layer

Private 5G Enterprise network
- 5G compliments Wi-Fi, but with cellular grade security & mobility
- Standalone 5G
- Reused “public spectrum”, high isolation thanks to the high frequencies
- CBRS in USA
5G Network Slicing

5G Network slicing:
• Enables operators to build virtual end-to-end networks tailored to application requirements

- Network slicing allows operators to split a single physical 5G network into multiple end-to-end virtual “independent” networks
- This allows to dedicate different slices based on specific application driven QoS parameters
- This can assure key parameters tailored to the specific use case
- XRAN supports 5G Network Slicing
5G NSA and SA

5G NSA
- Anchored in 4G LTE
- 5G is supported by existing 4G infrastructure
- 4G is needed to support control plane
- Easy path to 5G hot-spot deployment

5G SA
- Independent 5G
- Simplification
- Improved efficiency, lower cost
- Ultra reliable, low latency
- Full 5G support
- Enhanced Mobile Broadband
- Still mobility support to 4G
5G is needed to deal with the mobile challenges

The transformation needs real 5G functionality

4G
- Latency: 10mS
- Capacity: High
- Peak Data Rate: 1Gbps
- Available Spectrum: 3GHz
- Density: 100 thousand connections per km²

5G
- Latency: <1mS
- Capacity: Extreme
- Peak Data Rate: 20Gbps
- Available Spectrum: 30GHz
- Density: 1 Million connections per km²
- Ultra Secure
- Network Slicing
- Ultra Reliable
- Edge Intelligence & Analytics
- Beamforming / Massive MIMO
- Low production cost per bit

True 5G use-cases is much more than only supporting the band
4G is still very important
But do not forget 4G!

4G is the foundation of 5G

- 4G is mandatory for 5G NSA
- 4G will serve as a coverage layer
- 4G is going to carry the bulk of the capacity initially
- 4G will still play a major role
- DAS and DRS are important solutions for 4G
- High performance 4G platform is key for the future
introduction
As mobile traffic increases, mobile networks and the equipment that runs them must become more virtualized, flexible and intelligent.

Here, we discuss the benefits of network virtualization, and its use in achieving scalability in cloud RAN, also incorporating SDN and NFV.
"virtualization" clarity – what is VRAN, really.

- CRAN is NOT Virtualization.
  - Hiding the hardware in a central location does not make it a vRAN!

- "Splitting" the Baseband (RAN) protocol stack is NOT Virtualization.

**virtual**

/ˈvɜːtjuə(ə)l/, ˈvɜː.tjuəl/

defined as: NOT PHYSICALLY EXISTING AS SUCH BUT MADE BY SOFTWARE TO APPEAR TO DO SO.
1 - INDUSTRY ONLY 100% Software RAN

- Full-stack LTE L1-L3
- No hardware accelerator

2 - TOP Performance

- Best in class RF Performance
- Scalable from Small to very large Venue and Metro Area

3 - 40%+ CAPEX & OPEX Saving

- Immediate saving in hundreds of venues
- Increase saving while deploying network densification
DAS Installation – Traditional eNB

- Current DAS is interfaced with RF to the signal source (eNodeB)
- From the DAS MU to RU a completely transparent system is in place
- This transparency will save investments throughout the RAN evolution
DAS Installation – XRAN

• JMA-TEKO DAS stays in place and evolve

**Fully Adaptive Baseband**
- Takes venue wireless to next generation
- Only vendor with **100% Software** (Layer 1-3)
- 3GPP LTE, CAT-M, NB-IoT, and 5G Path

**Leverage our RF Distribution expertise**
- Full control of our RF technology
- Top RF Engineering talent in the industry
- Natural Migration for Existing Venues

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TEKO Platform Today
Baseband 100% in software, completely separated from proprietary hardware.

**Capital Cost Optimization**

*Brings cloud economics to the RAN*

- Baseband resources become globally pooled
- Leverages commodity COTS platforms
- Dynamically moves assets where they are needed
- Easy to change network capabilities via software

**Operational Optimization**

*Shifts operations to a DevOps Culture*

- Reduces power, cooling, and footprint
- Automates distribution of assets
- Enables agile innovation of network capabilities
- Streamlines delivery of continuous optimization
What is X-RAN

Organized in 3 Layers:

- Interface to the EPC (S1)
- Supervisory Interface

- Puts data into packets
- Splits data into UL & DL to L1

- Modulation of data to the air interface
- The MOST complex mathematical layer
So... In a COMPUTING world....
Designed to Work Seamlessly with active DAS

**Complete In-venue RF Flexibility**
- Digital CPRI Interface combined with...
- Analog POI+DAS Trays and...
- Over-Air Signal Source

Diagram:
- EPC to Traditional RAN Hardware (S1)
- Traditional RAN Hardware to X-RAN (S1)
- X-RAN to TEKO (CPRI)
- TEKO to Public Safety Head-ends (Analog)
- Public Safety Head-ends to Over the Air Signal (Analog)
Architected for Multiple Market Applications

- Centralized Data Center (CRAN)
- On Premises
- Regional Data Center

- Metro and Outdoor Areas
- Sports Venue
- Enterprise and Multi-Tenant
- Transportation
Architected for Multiple Market Applications
Eliminating stranded capacity
Adaptive Capacity, Network-wide Sharing

- Capacity sharing can span large geographic areas.
- Crossing time zones and venue utilization times increases sharing efficiency.
- Utilized dynamically across in-building enterprises, large venues, or outdoor small cells.
Why RAN as Software Makes Sense

- **COTS Hardware**: Leverages off-the-shelf computing and virtualization technologies – reducing the hardware component of solution assets and eliminating proprietary hardware.

- **Services Elasticity**: A more dynamic delivery framework enables a more elastic and scalable network architecture.

- **Faster Time to Market**: Empowers more innovation and customer-centric services with easier network-wide service creation and near real-time service delivery.

- **Operationally Efficient**: Delivers on new operational agility via capabilities like dynamic asset allocation, free of human action.
Complete software transformation

- The ONLY 100% virtualized software baseband platform.
- Completely eliminates need for complicated, proprietary hardware.
Radically reduced head-end footprint

- XRAN baseband reduces venue head-end footprint by 95%.
- Eliminates massive coaxial infrastructure to connect to DAS.

**Traditional eNB Equipment**

- 120 Rack
- 1,680 SF

**XRAN**

- 6 Racks
- 78 SF

Note: Illustration based on single operator, 250 sector, 4 bands and commonly used eNodeB equipment.
Significant Human Resource Efficiency

Install & Commissioning

- Streamlined commissioning
- Graphical operations interface

<table>
<thead>
<tr>
<th>Connection</th>
<th>Time Reduction</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTS to DAS</td>
<td>60% Less</td>
<td>16 Man Hours</td>
</tr>
<tr>
<td>XTRAN to DAS</td>
<td>95% Less</td>
<td>2 Man Hours</td>
</tr>
</tbody>
</table>

Physical Cabling Time

- Digital fiber BTS-to-DAS connectivity
- Eliminate 100% of coaxial head-end

<table>
<thead>
<tr>
<th>Connection</th>
<th>Time Reduction</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTS to DAS</td>
<td>60% Less</td>
<td>48 Man Hours</td>
</tr>
<tr>
<td>XTRAN to DAS</td>
<td>95% Less</td>
<td>2 Man Hours</td>
</tr>
</tbody>
</table>
Head-end Power and Cooling

Significant power and cooling savings per cell

Resulting 10 year savings across 1000 cells

1000 cells is representative of large venue (250 sector stadium) single operator
Head-end Space and Cabling Savings

**Traditional eNodeB Footprint**
Single MNO, 10 Sectors, 5 bands

**X-RAN Footprint**
Single MNO, 10 Sectors, 5 Bands

*Illustrative purposes only*

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Entirely reimagined dynamic capacity

Capacity assets centrally managed in cloud

Intelligence allocates capacity as needed

Venue capacity demand shifts over time

Servers sized to venue capacity needs
Open Standards, Open Interfaces, Open Ecosystem

- XRAN empowers operators with the highest degree of flexibility.
- Uses industry standards, open interoperability, and IT ecosystem platforms.

1. **eNB Interoperability:**
   - 3GPP Standards
   - X2 Interface
   - 2G, 3G, LTE Networks

2. **EPC Interoperability:**
   - 3GPP Standards
   - S1 Interface
   - Ericsson, Nokia, Huawei
   - Soon to add Cisco.

3. **An Open Ecosystem**
   - Linux software baseband
   - Off-the-shelf Servers
   - Virtualization

4. **Cloud / Software Operation**
   - Deployment
   - Updates
   - Capacity
   - 4G-to-5G

5. **OPEN CPRI:**
   - CPRI Standard Implementation
   - Open for Cross-vendor Interworking

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Open IT and cloud ecosystem platforms

- Intel
- Cisco
- Dell
- HP
- Linux
- Docker
- OpenStack

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XRAN Provides a Software Path to 5G

- LTE performance in software today.
- 5G performance in software tomorrow.

A software evolution towards...

- NR radio performance
- Split gNB DU/CU Layers
- 5G NG-Core and LTE EPC Interfaces
- New 5G wideband spectrum support
- Non-standalone for LTE & 5G
XRAN, The open system

• XRAN, standard Open Ecosystem
• Standard open interfaces, 100% 3GPP/ open standards compatible
• Standard off the shelf IT Servers
• New bands, functions and 5G upgrades are SW only
  • (HW for new frequencies at the MU/RU might be needed)
• Investment efficient, compact, energy efficient
• Capacity is # of users, shared across the network
An “Intelligent” Network must become Autonomic
An “Intelligent” Network must become Autonomic
## XRAN Major Benefits Summary

<table>
<thead>
<tr>
<th>Platform</th>
<th>OEM NodeB</th>
<th>XRAN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware-based</strong></td>
<td>Complex &quot;locked&quot; systems</td>
<td>100% Software System</td>
</tr>
<tr>
<td></td>
<td>Proprietary devices/chip-based</td>
<td>Open compute ecosystem</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td></td>
<td>Leverages economics of cloud compute</td>
</tr>
<tr>
<td><strong>OEM-specific</strong></td>
<td>Very large footprint</td>
<td>Standard Cloud / IT Servers</td>
</tr>
<tr>
<td></td>
<td>High power consumption</td>
<td>Small footprint</td>
</tr>
<tr>
<td></td>
<td>High thermal load</td>
<td>Very low power consumption</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>Hardware-based capacity</td>
<td>Elastic / On-demand</td>
</tr>
<tr>
<td><strong>Fixed / Stranded</strong></td>
<td>Hardware-based capacity</td>
<td>Capacity resides in cloud</td>
</tr>
<tr>
<td></td>
<td>No reutilization from site to site</td>
<td>Predictive intelligence moves capacity</td>
</tr>
<tr>
<td></td>
<td>Low RAN asset utilization</td>
<td>High RAN asset utilization</td>
</tr>
<tr>
<td><strong>Upgrades</strong></td>
<td>Hardware Replacement</td>
<td>Software Update</td>
</tr>
<tr>
<td><strong>Hardware Replacement</strong></td>
<td>Rip &amp; replace to achieve new capabilities</td>
<td>New capabilities are a software change</td>
</tr>
<tr>
<td></td>
<td>Costly truck rolls &amp; human resources</td>
<td>Download to sites from Cloud / NOCs</td>
</tr>
<tr>
<td><strong>Strategy</strong></td>
<td>Static &amp; Limited</td>
<td>Flexible &amp; Open</td>
</tr>
<tr>
<td><strong>Static &amp; Limited</strong></td>
<td>Locked to OEM hardware, no scalability</td>
<td>Open software that scales to venue needs</td>
</tr>
<tr>
<td></td>
<td>No option for edge services capabilities</td>
<td>Platform for Edge Intelligence &amp; new 5G services</td>
</tr>
</tbody>
</table>

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In Summary

100% Virtualized
Software RAN

Transformation of RAN to all software

Unparalleled operational efficiencies

Radically evolved in-venue solutions

Foundation of the 5G revolution
The right solution, across applications