Spectrum Sharing – A Key Lever for Future Evolution of Mobile Broadband

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Outline

1. Vision & Motivation
2. Spectrum Role
3. ASA/LSA
4. Standardization & Regulation
5. Conclusion
The thirst for mobile data will continue to grow exponentially

3D, high- and ultra-high definition screens
Video integrated everywhere
Digital universe continues to grow exponentially
Everything from and on the cloud
Billions of connected objects
Traffic demand grows exponentially both for cellular and complementary local area offload

Source: Cisco VNI Mobile Forecast 2013

Wi-Fi and LTE-U new opportunities in unlicensed high frequency bands for local area traffic offload

Cellular traffic grows exponentially

HSPA, LTE-(A), 5G
Mobile data traffic continues to increase

Combined downlink data volume for over 100 Nokia HSPA and LTE customers

Graph showing data traffic over time from May-12 to May-13.
Nokia Technology Vision 2020
Delivering 1GB of personalized data per user per day profitably

Key requirements for networks towards 2020

- Support up to 1000 times more capacity
- Reduce latency to milliseconds
- Teach networks to be self-aware
- Flatten total energy consumption
- Reinvent Telcos for the cloud
- Personalize network experience
Outline

1. Vision & Motivation
2. Spectrum Role
3. ASA/LSA
4. Standardization & Regulation
5. Conclusion
Optimize spectrum below 6 GHz access and enable above 6 GHz access
Expanding the spectrum assets to deliver capacity and experience

<table>
<thead>
<tr>
<th>Availability LOS</th>
<th>Spectrum availability</th>
<th>Antenna technologies</th>
<th>Interference</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS</td>
<td>~1 GHz carrier bandwidth → High data rates</td>
<td>Low Rank MIMO/BF → efficient beam steering</td>
<td>More noise limited (70-90GHz)</td>
</tr>
<tr>
<td>NLOS</td>
<td>~100 MHz</td>
<td>High Rank MIMO → higher data rates</td>
<td>Interference coordination/rejection</td>
</tr>
</tbody>
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<table>
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<tr>
<th>Cell size</th>
<th>cm Wave</th>
<th>dm Wave</th>
<th>mm Wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS/NLOS</td>
<td>~100 MHz</td>
<td>&lt;~10 MHz</td>
<td>~1 GHz</td>
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- **cm Wave**:
  - ~100 MHz

- **dm Wave**:
  - <~10 MHz

- **mm Wave**:
  - ~1 GHz carrier bandwidth → High data rates
  - Low Rank MIMO/BF → efficient beam steering
  - More noise limited (70-90GHz)

Different spectrum licensing, sharing and usage schemes.
Spectrum: *The Real Estate for Mobile Broadband*
A proper network deployment goes hand in hand with a sound spectrum strategy

<table>
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<tr>
<th>Coverage</th>
<th>Capacity</th>
<th>Densification</th>
<th>Overall Efficiency</th>
</tr>
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<tbody>
<tr>
<td>800/850, 900, 700, UHF FDD, ~10MHz BW Macro</td>
<td>1800/1900, 2100, 2600 FDD, ~20MHz BW Macro + light HetNets</td>
<td>2600, 3500, 2300 TDD, ~20MHz BW dense HetNets</td>
<td>We cannot generate new spectrum, but we can optimize its use!</td>
</tr>
<tr>
<td>2300: LSA</td>
<td>2300: Co-primary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3500: Co-primary</td>
<td>ISM, 5000+: Unlicensed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We cannot generate new spectrum, but we can optimize its use!
Main levers to optimize spectrum use for Mobile Broadband in bands below 6 GHz
10x spectrum for 1000x capacity

Dynamic combination of fragmented spectrum
• Wideband RF technologies

Additional harmonized spectrum for LTE by re-farming & re-assignment

Unlock more spectrum by Licensed Shared Access with predictable QoS

Carrier aggregation

400-700 700-900 3600 5400

2.1 GHz 2.3 GHz 2.4 GHz 2.6 GHz 2.9 GHz 3 GHz LSA
Carrier Aggregation
Dynamic combination of fragmented spectrum

Increased peak data rates
- 20 MHz
- 20 MHz
- 10 MHz
- 10 MHz
- 300 Mbps
- 225 Mbps
- 150 Mbps

- Up to 3 bands, up to 40 MHz, in line with user equipment evolution
- 5, 10, 15 or 20 MHz per allocation
- High data rates also out of asymmetric and fragmented spectrum

Scalable

Increased average data rates
- Up to 20 MHz
- Up to 20 MHz
- Up to 20 MHz

- Extended spectrum pool
- Increased average data rates
- Increased cell edge data rates

Efficient

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- 470-698 MHz convergence will optimize shared use of the coverage spectrum between Broadcast and BroadBand.
- Shared use in C-band will enable wider bandwidths for dedicated small cell layers.
- Licensed Shared Access (LSA) will unlock additional spectrum for LTE.
- Additional Spectrum shall be allocated and put into use quickly.
- Exclusive Spectrum Access has top priority.

**Licensed Spectrum + Licensed Shared Access**
Spectrum usage models
Harmonization and global standards drive economies of scale

Mainstream Approach
Auctions of Cleared Spectrum

Exclusive Use
Ensures Quality of Service

Complementary License Model
Licensed Shared Access

Exclusive Shared Use
Exclusive use on a shared and binary basis in Time, Location, and/or Frequency with Incumbent (government, defense, etc.) Predictable Quality of Service

Shared Approach
Unlicensed (Wi-Fi, LTE-U, ...)

Shared Use
Unpredictable Quality of Service
A new way of licensing mobile broadband spectrum - Licensed Shared Access (LSA)

LSA can be implemented today using available terminals and network technology

Regulatory framework

- LSA spectrum to be licensed is identified by the government
- Subject to a private commercial agreement between incumbent and LSA licensee
Licensed Shared Access
Unlock more spectrum with predictable QoS

**Approach**
- Enables timely availability and licensed use of harmonized spectrum with predictable QoS
- Accelerates spectrum harmonization
- Leverages available LTE technologies to ensure early use and Economy of Scale
- Opportunity for lower cost and high quality licensed spectrum

**Operator benefits**
- Accelerates spectrum harmonization
- Leverages available LTE technologies to ensure early use and Economy of Scale
- Opportunity for lower cost and high quality licensed spectrum

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**Diagram:**
- 3.8 GHz LSA
- 3.5 GHz LSA
- 2.6 GHz LSA
- 2.4 GHz LSA
- 2.3 GHz LSA
- 2.1 GHz LSA

**License Zones:**
- Paris
- Reims
- Dijon
- Lyon
- Toulouse
- Le Mans
- Tours
- Marseille
- Nancy

**Exclusion Zones:**
- Paris
- Reims
- Toulouse

**Commercial sharing agreement under permission of the Regulator**
- LSA Licensee
- Incumbent

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LSA Demonstration

Hardware Setup
- LTE 2.6 GHz FDD
- LTE 2.3 GHz TDD
- LTE Terminals
- Nokia Flexi-BS (eNB)

ASA Network and Traffic Simulation
- ASA Controller
  - Spectrum Access of MNO <A>
- ASA Repository (Incumbent)
  - Available ASA Spectrum
  - Where? When?
- ASA Controller
  - Spectrum Access of MNO <B>
- LTE RAN emulation of MNO <A>
- LTE RAN emulation of MNO <B>

Hardware Setup
- Application Server
- NSN
- EPC
- Emulation
Nokia and Qualcomm bring ASA to life at MWC-2014

“What you show here... I can see that ASA technology is ready. Just regulation has to follow!”

Operator Comment

See our blog on MWC-14: http://blogs.nsn.com/mobile-networks/2014/03/05/nsn-and-qualcomm-bring-asa-to-life-opening-up-new-spectrum

Prominent Visitors

- Paul Jacobs, Former CEO of Qualcomm
- Mrs. Henseler-Unger, VP of BNetzA, German NRA
- Moiin Hossein, EVP Nokia
- Víctor Calvo-Sotelo Ibanez-Martin, Spanish state secretary of communication
- Pearse O’Donohue, EC Dep. Head of Cabinet of VP Neelie Kroes, formerly RSPG
- Anne Bouverot, GSMA Director General & Member of the Board
World 1st LSA over the air field trials proved the concept
LSA TD LTE 2300 with PMSE over the air field trial with e2e Finnish ecosystem

Trial included full e2e LSA ecosystem in Finland: regulator, incumbents, MNO and supplying industry in CORE+ project

LSA Ecosystem
LSA in Europe
Research – Standardisation – Regulatory Bodies and Administration

- METIS
  http://www.metis2020.com
- CORE+ project
  http://core.willab.fi
- CoMoRa
  http://www.comora.de

Research

Standardisation
- ETSI
- 3GPP
- European Conference of Postal and Telecommunications Administrations
- - 48 European countries cooperating to regulate posts, radio spectrum and communications networks
- European Telecommunications Standards Institute
- Third Generation Partnership Project

Regulatory Bodies & Administration
- European Commission
- Radio Spectrum Policy Group (RSPG)
- ITU
- International Telecommunications Union
LSA in Europe
Basic Documents in Standardisation

- ETSI TR 103 113 (published 2013)- System Reference Document for LSA
  "Mobile broadband services in the 2 300 MHz - 2 400 MHz frequency band under Licensed Shared Access regime"

- ETSI TS 103 154 (V0.0.16, Draft 09/2014)- System Requirements for LSA (approved in Mainz, Sept. 2014)
  "System requirements for operation of Mobile Broadband Systems in the 2300 MHz - 2400 MHz band under Licensed Shared Access"

- ETSI TS 103 235 (V0.0.2, Draft 09/2014) – System Architecture for LSA
  "System Architecture and High Level Procedures for operation of Licensed Shared Access (LSA) in the 2300 MHz-2400 MHz band"

- RP-140158 SI proposal on spectrum sharing (Mar 2014)
  SI proposal on spectrum sharing for LTE with reference to LSA

  SI proposal for several topics related to RAN support for LSA

- S5-145142 Licensed Shared Access (LSA) standardization (Oct 2014)
  Discussion paper for SA5 on OAM aspects related to LSA

- S5-145228 Licensed Shared Access (Oct 2014)
  Discussion paper for SA5 on LSA architecture
LSA in Europe
Basic Documents in Regulatory Bodies and Administration

- ECC Report 205 (approved 02/2014): Licensed Shared Access (LSA)
- ECC Decision (14)02 (approved 06/2014): MFCN in 2300-2400 MHz
- ECC Recommendation (14)04 (approved 05/2014): Cross-border coordination in the frequency band 2300-2400 MHz
- CEPT Report 55 (draft Jun 2014): Technical conditions for wireless broadband usage of the 2300-2400 MHz frequency band
- CEPT Report 56 (draft Jun 2014): Harmonised technical and regulatory conditions for the use of the band 2300 - 2400 MHz for MFCN
- RSPG13-538: RSPG Opinion on Licensed Shared Access
- RSPG11-392: Report on CUS and other spectrum sharing approaches
- RSPG 10-348: RSPG opinion on Cognitive technologies
- ITU-R Report M.2242: Cognitive radio Systems Specific for IMT
- PNDR M. [LMS.CRS2]: current under finalization stage a report on Cognitive radio systems (CRSs) in the land mobile services, where LSA is being discussed as one approach of accessing shared spectrum to be enabled by CRS technologies and their capabilities
- In WP5D under 5G/Vision 2020 and IMT 2020 currently spectrum sharing is one key driver for accessing additional spectrum resources for future systems beyond 2020, under which LSA is considered as preferred access method,
LSA in Europe
Timeline (Status September 2014)

Standardization aspects:
- Support of multi-vendor 3GPP networks
- Standardized state-of-the-art interfaces, especially between LSA Repository and LSA Controller to limit integration efforts
- Re-use of existing 3GPP functionalities to meet time to market requirements for new spectrum (e.g. OAM Itf-type2)
- Phased approach from static and semi-static to dynamic LSA sharing scenarios
- Future–oriented approach with flexibility in sharing rule adaptations and extension to further spectrum bands
Cognitive Spectrum Sharing

Key Messages

• Cognitive Frequency Sharing
  ✓ provides higher capacity
  ✓ enables high peak rates
  ✓ provides better overall spectrum utilization

• LSA enables timely availability and licensed use of other incumbents’ harmonized spectrum with predictable QoS

• LTE-A design has all the seed for cognitive radio network evolution

• More dynamic sharing concepts including spectrum pooling are being researched

• Spectrum pooling allowing aggregation of multiple operators spectrum can be beneficial especially for dense small cell networks e.g. at 3.5GHz
Q&A