Regional Seminar for Europe and CIS
Spectrum Management and Broadcasting
29-31 May 2017
Hotel Roma Aurelia Antica, Convention Centre
Rome, Italy

Spectrum Management Aspects Enabling IoT Implementation

Pavel Mamchenkov, ITU Expert
Rapidly Growing Industry

IoT is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ICT)*

IoT is Significantly Growing Market

<table>
<thead>
<tr>
<th>Number of M2M Connections</th>
<th>Annual Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0 (2014)</td>
<td>0.8 Trillion, USD</td>
</tr>
<tr>
<td>27.0 (2024)</td>
<td>4.0 Trillion, USD</td>
</tr>
</tbody>
</table>

* Definition from Recommendation ITU-T Y.2060

Source: GSMA. Spectrum for the Internet of Things

Source: IoT World Forum

IoT Layers as defined by IoT World Forum

1. Physical Devices & Controllers (The "Things" in IoT)
2. Connectivity (Communication & Processing Units)
3. Edge Computing (Data Element Analysis & Transformation)
4. Data Accumulation (Storage)
5. Data Abstraction (Aggregation & Access)
6. Application (Reporting, Analytics, Control)
7. Collaboration & Processes (Involving People & Business Processes)

Source: IoT World Forum

Spectrum related issues are attributed to Physical Devices and Connectivity layers.
Rapidly growing IoT industry is entirely in the scope of the traditional spectrum management environment.

* Source: Recommendation ITU-T Y.2060
IoT is heterogeneous in terms of radio technologies, applications and business cases, spectrum requirements and spectrum access methods. It creates an obvious demand for sustainable regulation for successful implementation.
# IoT and Spectrum Harmonization

**Current ECC view on IoT spectrum harmonization:** "There does not seem to be a strong case for the specific designation of specific frequency bands for M2M, … no single frequency band defines M2M (i.e. no single frequency band should be viewed in isolation) per se…"

<table>
<thead>
<tr>
<th>Public Mobile Networks Bands (LPWA Licensed Bands)</th>
<th>Satellite Bands</th>
</tr>
</thead>
<tbody>
<tr>
<td>allocated or identified for the implementation of 2G, 3G, 4G and 5G EC-GSM-IoT, NB IoT, LTE-eMTC</td>
<td>Variety of MSS and FSS Bands PPDR and Fixed Service Bands</td>
</tr>
<tr>
<td>Largely harmonized</td>
<td>Industrial IoT and Critical Infrastructure in PMR bands 80 MHz, 150 MHz, 400 MHz and FS bands 5725 – 5875 MHz ITS-G5, LTE-V2X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LPWA Non-cellular Bands</th>
<th>LPLA Bands</th>
</tr>
</thead>
<tbody>
<tr>
<td>169 MHz, 433 MHz, 863-870 MHz, 870-876 MHz and 915-921 MHz, 2400 to 2483.5 MHz, 5150-5350 MHz and 5470-5725 MHz Sigfox, Weightless, Ingenu, LoRaWAN</td>
<td>169 MHz, 433 MHz, 863-870 MHz, 915-921 MHz, 2400-2483.5 MHz, 5150-5350 MHz and 5470-5725 MHz Bluetooth smart, IEEE 802.11ah, IEEE 802.15.4, ZigBee, Z-Wave</td>
</tr>
</tbody>
</table>

## Starting from a Scratch?

### Largely harmonized

### Partly harmonized

## IoT Spectrum Harmonization Pros

- Global harmonization increase economy of scale.
- Globally harmonized spectrum simplifies regulation.

## IoT Spectrum Harmonization Cons

- There is presently a wide variety of spectrum solutions available for diverse use cases, making harmonization partly achievable.
- May result in implementation delay and restriction of technological neutrality.
# Spectrum Authorization and Spectrum Pricing with IoT

IoT is the notable example of Spectrum Rights and Spectrum Commons dilemma

<table>
<thead>
<tr>
<th>Spectrum exclusivity</th>
<th>Operational requirements</th>
<th>Technology</th>
<th>Regulatory regime</th>
<th>Spectrum pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shared Spectrum</strong></td>
<td>Used on a non-interference and un-protected basis Applications having no high requirements for low latency. Applications having no requirement for ultra-reliable connections. Operating over a short range (low power devices).</td>
<td>LPWA Sigfox, Weightless, Ingenu, LoRaWAN LPLA Bluetooth smart; IEEE 802.11ah; IEEE 802.15.4; ZigBee; Z-Wave</td>
<td>General Authorization Model</td>
<td>Spectrum pricing No spectrum related fees</td>
</tr>
</tbody>
</table>

The RSPG of European Commission – “Taking into account the multiple applications, use cases and operational requirements, there is no “one size fits all” in terms of spectrum management for IoT”.
**The benefits of SRD harmonization include increased interoperability, globalization of markets resulting in economies of scale and expanded equipment availability, improved spectrum management and enhanced circulation of equipment.**
The role of a regulator as relates to technology is to proceed with un-biased policy considering the relevant needs, risks, and benefits of various stakeholders entities – consumers and industry, public and private, enterprise and government etc.

1. The wide range of IoT applications will need to be powered by a host of different technology capabilities targeted on specific functionalities.
2. To promote the full scope of IoT offerings, it is imperative that regulators employ an approach that adheres to principles of technological neutrality.
3. With regard to spectrum, flexible policy should be consistent with baseline technical rules that are technically neutral and allowing for both licensed and unlicensed uses.

1. Currently, a number of the standards apply across verticals, dealing with specific vertical domains.
2. There are numerous connectivity and interoperability standards and specifications that are not IoT-specific.
3. In order to achieve success in global IoT ecosystem there is the task to make the choice for one solution (notably architecture) across verticals that allows for cross domain interoperability.
Spectrum Re-farming with IoT

<table>
<thead>
<tr>
<th>Spectrum Re-farming with NB IoT</th>
<th>Practical Implementation Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In-band Operation</strong></td>
<td><strong>Re-farming for NB IoT:</strong> in-band operation does not assume regulatory intervention as being within the allocated band of an operator.</td>
</tr>
<tr>
<td><img src="Image" alt="LTE Channel" /></td>
<td><strong>Implementing NB IoT in GSM spectrum:</strong> the technology is highly spectrum efficient as allows frequency reuse factor $N=1$. At the same time, utilization of selected limited number of 180 kHz channels for NB IoT presumes modification of the remaining GSM frequency channel plans (re-farming).</td>
</tr>
<tr>
<td><strong>Guard band Operation</strong></td>
<td></td>
</tr>
<tr>
<td><img src="Image" alt="LTE Channel" /></td>
<td></td>
</tr>
<tr>
<td><strong>Stand-alone Operation</strong></td>
<td></td>
</tr>
<tr>
<td><img src="Image" alt="GSM Channels" /></td>
<td></td>
</tr>
</tbody>
</table>

IoT in licensed spectrum may require regulatory intervention for technically binding licences, as well as re-farming associated costs for GSM networks should be noted to ensure successful business cases.
Where spectrum sharing is technically and economically (!) feasible, regulators should apply advanced engineering practices to create environment for heavy “packing” of uses in the same band while protecting superior users.

New Opportunities for Spectrum Sharing

In 2016 the FCC opened up 150 MHz of spectrum in the U.S. around 3.5 GHz that it named Citizens Broadband Radio Service (CBRS).

In addition to sharing with incumbents — CBRS adds a ‘third-tier’ of general usage.

CBRS adds a ‘third-tier’ of general usage where anyone can use the spectrum when it is not used by the higher tiers (the incumbents or users that paid for a license). GAA will encompass IoT uses.

SAS – Spectrum Access System
ESC – environmental sensors or Environmental Sensing Capabilities.
CBSD – Citizens Broadband Radio Service Devices

Heavy industry companies can set up an Enterprise Private LTE networks and run industrial IoT applications.

Source: CBRS Alliance
Proposed IoT Regulatory Landscape and Use Cases

IoT regulatory landscape and use cases should be comprised of licensed and unlicensed networks/spectrum

1. Networks under general authorization regime (commons, class licences etc.) subject to certain regulatory conditions (EIRP limits, duty cycles etc.).
2. Spectrum is used on a non-interference and un-protected basis, as a result, mainly identified for low power devices.
3. Applications have no strict requirements for low latency and ultra-reliable connections.
4. Applications are delay tolerant.
5. Applications with no guarantees for sustainable QoS.

1. Number of Public Mobile IoT networks is defined by bandwidth of licensed spectrum available for MNOs.
2. Dedicated Mission-Critical IoT networks are likely to utilize newly harmonized spectrum bands, e.g. 870 – 876/915 – 921 MHz, FS bands, such as 5725 – 5875 MHz etc.
3. Applications requiring ultra-reliable connections in real-time communications.
4. Applications with high requirements for low latency.
5. High availability, guaranteed in-time delivery and QoS.
Thank You