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Reply to RSPG Opinion for Public Consultation: *A Spectrum Roadmap for IoT*, RSPG 16-045

From Simon Forge, SCF Associates Ltd, Novembre 2016

SUMMARY

1. It would be useful if the Opinion document could focus on those economic foundations that will underpin the IoT – that is, a very low cost business case with enormous freedom to innovate in prototypes and bring first production versions to market quickly.

2. That would require free use of spectrum, without licence fees and minimal technical compliance rules. However, the consultation document's proposals and conclusions do not include the need for new and wider bands for LICENCE EXEMPT spectrum, well beyond the current minimal allowances. LICENCE EXEMPT bands would meet the need for lowest cost and rapid market entry.

3. Use of the spectrum for the IoT should reflect the actual uses of the IoT. The major applications are industrial, including the utilities (electricity, gas, water, sewage, oil). This implies that data rates may range between 10 bits per hour and 1Mbps with the majority being under 20kbps.

4. As many applications may require long distance propagation ranges, eg of the order of a large EU Member State, for utility management, lower frequencies than suggested in the diagram on page 3 are more likely to become optimal.

5. The four factors above point to the need for LICENCE EXEMPT bands across a far wider swathe of the spectrum than UHF and 3 - 5GHz. These will tend to be not so much the centimetric and millimetric bands but VHF, HF and lower bands, to provide longer distance propagation with lower attenuation, as afforded by such bands.

6. This implies a much lighter authorisation framework than that suggested in the consultation document (which is unlikely to enable the IoT but more likely to constrain it). A LICENCE EXEMPT regulatory regime would only require agreed technical conditions to be met on interference, and so makes economic sense as it can be:-
   - Rapid in compliance
   - Low cost
   - Universal across the EU, and later globally

7. The use of lower frequency bands will require increased R&D efforts into the technical solutions for compact antenna design, beyond current levels.

8. Industrial applications may form 90% of all applications. So industrial applications need to be shown as main element in the user sector table on Page 4, as they are currently absent. Other applications may be further away and less in economic significance.

9. The relationship between what is being proposed for so-called '5G' and the mainstream IoT applications is tenuous. The mobile and entertainments industries, their chip suppliers and some regulators, such as the FCC, expect 5G to offer, by 2020: high bandwidth, of the order of 1Gbps; use of the millimetric frequencies up to 100GHz; and low latency of less than 1microsecond. Such specifications are ideal for streaming video on demand (SVOD) including video games. However the relation between IoT requirements and 5G technical performance goals seems fragile. Also, just how rural coverage equal to urban may be achieved seems quite unclear.

(The topic of Spectrum for the IoT is currently the subject of a study by SCF Associates Ltd.)

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1 The focus of the RSPG Opinion Paper needs to change

In general the Opinion paper tends to look back at previous and existing applications, not the future possibilities. Moving away from the spectrum allocation norms of the last hundred years will be a key priority as the Internet of Things becomes a reality.

However this movement towards unlicensed spectrum, although spearheaded by the IoT, is likely to become more general as the demand for the business use of the radio spectrum expands. The economic advantages of unlicensed spectrum will become increasingly evident, as the added value of Wi-Fi in unlicensed bands has amply demonstrated.

Although the Internet of Things is still emerging (so it is also referred to as machine to machine, M2M, communications) some major trends are becoming distinct that can be used to indicate the spectrum needs.

For optimal spectrum allocation, it is necessary to examine the practical implications of building IoT networks in terms of their demands for spectrum, from the viewpoint of their systems and architectures, with the standards that are emerging. There is a the further factor of the wider attractiveness of such allocations for all types of services as well as the implications for regulatory authorities of such a fundamental change to spectrum allocation

In many applications, the IoT is evolving towards an industrial radio network for the outdoors and extreme environments, as much as for in-building domestic devices for the consumer[1]. [GE,2016]. Many IoT network systems may use some basic Internet communications protocols but may never communicate with the Internet or the World Wide Web. Such configurations contrast with the web platforms for multimedia documents, with hyperlinks connected over fixed line broadband.

So a perspective from control engineering using radio communications is perhaps a more useful model for the IoT than the consumer Internet. Few fully coherent approaches to implementing the IoT have been proposed, that would apply across all the many types of possible applications – and probably never will be – as leading industries pick their own winners[2] [ITU-GSR 2015]. Consequently, its spectrum demands are likely to be driven by quite different applications and usage contexts to 'indoors and sheltered' multimedia document delivery patterns for human interaction over broadband Internet access.

[1] GE-2016, *Welcome to the Industrial Internet*, General Electric Automation, from www.geautomation.com/industrial-internet

[2] ITU-GSR 2015, Global Symposium for Regulators, GSR Discussion paper: Ian Brown, OII, Regulation and the Internet of Things. International Telecommunication Union, Geneva.

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2 Communications patterns describe the focus of IoT spectrum demands

The IoT's communications patterns are also quite different to those of a mobile voice or data channel for human communications, commonly being bursts of data[3].

Dropped packets and dropped calls are frequent in today's mobile cellular voice, image and video networks, while low resilience and reliability of its services (perhaps below 99% up time) are acceptable to consumers. These differences are compared in the brief summary table below in a wider range of comparators for environments, performance and purpose for the three major types of networks:-

Table 1 Comparison of today's Web and Internet with tomorrow's IoT

Attribute or factor	***Internet and Web technology***	***Mobile cellular technologies***	***IoT technology***
Basic technology	Information Technology	Mobile cellular technology	Control system and process technology
Power supply	Single or 3-phase AC, UPS, devices with rechargeable batteries	Single or 3-phase AC, UPS, devices with rechargeable batteries	May be DC only; battery for life or rarely changed or recharged
Radio environment	Usually benign	Relatively benign	Possibly very high interference
Bandwidth required	High throughput demanded – perhaps Gbps continuous streaming	High speed data (up to 10Mbps commonly, Gbps Future)	Low data rate normal and acceptable – perhaps kbps, for short messaging
Operational environment	Sheltered, and controlled, indoor	Indoors and street	Exposed outdoor / hostile indoor
System/component lifetime	3-5years	3-5years	5-20 years
Standards and maturity	Industry standards, methodologies and architectures; largely stable	Industry standards, methodologies and architectures; largely stable	Systems by vertical sector, still emerging
Maximum impact of failure	Loss of data/ privacy	Loss of conversation/ download/ short message	Loss of life/ major capital assets
Recovery process	Simple reboot	Await reconnection	Fault tolerance essential
QoS: performance dependability required	Long latency delays and packet loss accepted (best effort, no guarantees)	Long latency delays, dropped calls and packets accepted (best effort, no guarantees)	Delays are serious concern if outside set limits and lost packets should be recoverable
Configuration management	Many upgrades and patches; may be automated	Random for consumer devices; many upgrades and patches for network	Upgrade/ patching can be a major process - perhaps only by vendor

Thus the IoT's *functionality* is in many ways very different both to the existing Internet and to current commercial mobile cellular networks, although both might be used to some extent – for instance 2G GSM might offers a cheaper simpler network than 3G or LTE while Internet protocols over Wi-Fi are used in some industrial applications. Note that the mobile industry sees its cellular version of 5G as the basis of the IoT[4].

[3] Radio Spectrum for the Internet of Things (2016), Info, Vol. 18, No. 1, pp67-84, S. Forge

[4] Tim Skinner,Telecoms.com Intelligence, (2016), *The Road to 5G - Outlook 2016* - strong support for the IoT is the most important feature of 5G according to a third of respondents to a survey of 800 telecommunications industry professionals polled globally, 2016 in the telecommunications equipment supply and operating sector.

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3 A deeper analysis is necessary as fragmentation of IoT architectures dictates a variety of optimal spectrum ranges

As emphasised above, the requirements and scope of the IoT are far wider than the Internet in the breadth of physical implementations and performance demands. While the Internet has a single universal identification scheme with its DNS design for example, the architecture for an IoT RFID-tag based identification system (using a tree naming mechanism) may take a variety of quite different forms. Its network architecture must be scoped to map on to the physical infrastructure that its user industry employs, be it a sewage treatment works or an airliner. Thus IoT network architectures will differ widely among themselves, as they each must model a different real-world problem.

However there are some operational similarities. Most IoT systems must respond to real-world events, typically the change of state of a monitored parameter, so the most likely architecture will be *event-driven*. That implies the IoT architecture has to be fairly different to the standard Internet architecture. It should offer predictable and reliable latency and guaranteed delivery (not just 'best–effort') in order to efficiently and safely control energy grids, transport systems, manufacturing and processing plant, urban environments, smart buildings, homes and hospitals as well as to monitor environmental parameters on land and sea. Control systems for a process plant with a sensor-based network and programmable logic controller may require a specific master-slave design.

The basic Internet could be used but is not ideal. Thus for an IoT architecture, some strong differences become apparent to the web layered architecture with its applications employing extensions of mark-up languages for documents - difficult to implement for IoT systems although not impossible. The requirements for high reliability and consistent and known time delays also tell against mobile cellular, as may cost.

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4 General Implications for regulators – more co-ordination and monitoring with extra guidelines for users

The fundamental change is in the way NRAs have traditionally managed spectrum. The old (and often current) regime of spectrum regulation in general is to:-

- Forbid everything
- Only permit explicit exceptions with a licence or grant that implies ownership to one entity and excludes all other users.

The new regime for spectrum management may instead be to:-

- Allow anything
- Only forbid operations in explicit cases of interference to other users.

This implies novel regulator roles and factors to be taken into account for spectrum allocation and assignment decisions, with:-

Table 2 – the future spectrum manager – an NRA for licence exempt operations

Attribute	*Traditional NRA*	*Future NRA*
Role of Regulator	**Controller and commander**	**Coordinator and facilitator**
Decision Criteria	**How many users**	**How much interference**
Basis for decision	**Marketable property – restricted economic benefit from sale**	**Publicly owned commodity - widespread economic benefit from sharing**

Implications for NRAs in this type of regime may be summarised as:-

1 Reshape existing licences (for all forms of spectrum management) with subletting clauses added for sharing spectrum - possibly dynamically

2 Public services' spectrum with command and control grants or licences in perpetuity may perhaps evolve with:-

- Incentives to sublet/share, eg with AIP (administered incentive pricing [Ofcom 2009])
- Incentives to relinquish spectrum altogether, possibly with a commons emphasised (also with use of AIP)
- Technical audits of efficient usage through regular reviews for those with mandates to their spectrum.

3. More "active" regulatory role in deployment of licence exempt radio technologies:-
   - Greater international co-operation for harmonised LE allocations
   - National interference monitoring programmes
   - Type testing laboratories and rigs for interference level conformance, for pre-set power, duty cycle and pass-band frequency specifications, for both receivers and transmitters, under NRA aegis, perhaps via sub-contracted local laboratories.

4. Gradually a move to less regulatory activity on auctions, lotteries, etc, for commercial licences and trading

This is already happening to some extent inside a few EU NRAs.

Spectrum for the IoT is currently the subject of a major investigation by SCF Associates Ltd, pursued over the last two years and due to report next year.

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