

Chapter 2 R&TD

Problems (sample answers)

1. Differentiate between Basic vs. Applied research and provide examples?

The Basic Research leads to new knowledge and provides scientific capital. The knowledge provides the means of addressing a good number of practical problems though at the same time it may not give a complete specific answer to any of them. A perfect example of this fact is the discovery of gravitational waves after a century of expectation in 2016. The Applied Research on the contrary is designed to answer specific questions aimed at solving specific practical problems. The knowledge acquired through applied research has specific commercial objectives in the form of products, processes or services. A good example could be the use of single base transceiver station (BTS) to support various radio access technologies in late 2000s as compared to having a one-to-one mapping between the BTS and the radio technology.

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2. What are the benefits of Operator/Vendor joint innovation centers?

The joint innovation centers help in bringing the research more closure to practicality. The results from such ventures speed up the stages of product development and deployment.

3. What is mobile receive diversity?

The mobile receive diversity is about having more than one antenna in the receiving direction in the mobile phones (user devices).

4. What are the key ingredients of a robust research ecosystem?

A robust research ecosystem comprises of strong government policy, energetic university and industrial research institutions, emerging startups, mature technology companies, funding for both basic and applied from government and private institutions (including venture capital firms) and a large pool of talented researchers. Only a few countries have all these ingredients to establish and maintain a dynamic ICT research ecosystem.

5. Why basic research is dwindling in ICT sector?

The basic research is dwindling since ICT companies are operating in a highly competitive and commoditized environment pushing them to quickly bring products to market with razor thin margins. There is immense competitive pressure to focus on short term rather than on longer term in the corporate world.

6. Discuss in a group how to improve the standing of basic research in telecommunications and overall R&D ecosystem?

Chapter 3 Radio Frequency Spectrum

Problems (sample answers)

1. What is electromagnetic spectrum?

The electromagnetic spectrum is the range of all types of electromagnetic radiation that runs from radio waves to gamma rays.

2. What is radio spectrum?

The term radio spectrum refers to the frequency range from 3 kHz to 300 GHz corresponding to wavelengths ranging from 100 kilometers to 1 millimeter.

3. What is the role of ITU-R and WRCs in spectrum management?

The ITU-R (International Telecommunications Union Radiocommunication Sector) is the body that identifies frequency bands for almost any type of wireless communications that happens all around the world. These types include but not limited aviation, broadcasting, maritime, mobile communications, public protection and disaster relief, satellite services, etc. The allocation and identification of frequencies takes place at the ITU World Radiocommunication Conferences (WRCs). These inter-governmental events take place every three-to-four years to address the frequency related needs of the world. WRC is the most significant conference related to frequency spectrum organized by ITU with the mandate to review, and, if necessary, to revise the radio regulations which govern the use of scarce resource i.e. frequency spectrum.

4. What are the anticipated spectrum requirements for 5G?

Spectrum is required not only in air interface, but also for backhaul and to some extent in the fronthaul. Fronthaul is the link between a pool of base band units and remote radio units (RRUs) which collectively formed the concept of C-RAN (cloud/centralized radio access network). Backhaul (first leg between RRUs and Core Network) is a major challenge for 5G but to some extent it can be fulfilled with wired medium such as optical fiber cable and technologies such as very-high-bit-rate digital subscriber line 2, etc. However, to the most part the air interface (link between wireless user/device and remote radio unit) is where the vast majority of the spectrum is required. The ITU-R has estimated that the total global spectrum requirements for IMT will be in the range of 1,340 (for lower user density settings) to 1,960 MHz (for higher user density settings) for the year 2020.

5. What is Spectrum Sharing?

Spectrum Sharing is defined as the collective use of a frequency band by two or more parties. Sharing can take place in both licensed and license-exempt bands.

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7. Why an effective air interface design is needed for 5G spectrum management?

First, there expected to be several bands for 5G distributed over a large range of frequencies so the air interface has to be flexible enough to accommodate all such bands. These bands could be contiguous/non-contiguous and can fall anywhere from sub 1 GHz up to 100 GHz. Secondly, the air interface has to deal with all the possible spectrum sharing scenarios. The sharing can take

place in both licensed and un-licensed bands, with or without the involvement of 5G networks. The main challenge that it needs to manage concerning sharing is interference while optimizing the efficiency of the spectrum. The interference can be managed in various dimensions including time intervals, orthogonal/non-orthogonal frequency resources, locations with sufficient separation, spatial, and orthogonal codes. Last but not least, are the significant variations in uplink and downlink traffic ratios (that even exist today), imply the need for a flexible air interface design to effectively manage traffic asymmetry.

8. What is the spectral efficiency when the aggregate sector throughput in downlink is 1.6 Mbps in a 5 MHz channel?

0.32 bits/sec/sector.

9. What is the opportunity cost related to spectrum?

The opportunity cost is calculated by the savings that can be achieved by acquiring appropriate amount of new spectrum rather than investing in new radio base station cell sites (that will use the existing assigned spectrum).

10. What is the price/MHz/POP of 2x10 MHz of 850 MHz spectrum that was auctioned at a price of USD 395 million in Pakistan in 2016? The population was of the country at that time was 193 million.

\$ 0.10.

11. What is Spectrum Trading?

Spectrum trading is a process that allows the licensees of scarce resource to transfer or lease the license rights to another entity.

12. Research on the pro and cons of potential 5G frequency bands listed in table 3.3?

Chapter 4 Standards

Problems (sample answers)

1. Define Standardization from the perspective of vendors and operators?

The mobile telecommunications is highly governed by Standards to achieve economies of scale. Standards are documents that provide specifications about technologies. These are then used to develop products (equipment) enabling such technologies. The standards are published and maintained by Standard Development Organizations (SDOs). One of the main economic goals of telecom manufacturers and non-manufacturing vendors is put their research (contribution) in front of Standard Development Organization that include their IPR (Intellectual Property Right). If the contribution including patents becomes part of a standard they can expect to get considerable amount of royalty for years to come. The operators on the other hand relatively have a small patent portfolio and thus their target is not along this line. Their target, however, is to have their current technical challenges and future business requirements get incorporated into the standards.

2. Briefly describe the release development process of 3GPP?

3GPP standards are structured as Releases and the standardization work is contribution-driven. Each Release comprises of three stages referring to the achievement of certain milestone. The term stage is derived from the ITU-T method for categorizing specifications. The stages are:

- Stage 1 refers to the service description from a service-user's point of view.

- Stage 2 is a logical analysis, devising an abstract architecture of functional elements and the information flows amongst them across reference points between functional entities.
- Stage 3 is the concrete implementation of the protocols appearing at physical interfaces between physical elements onto which the functional elements have been mapped.

3. What are the steps of IEEE-SA standard development lifecycle?

The six steps are - Initiating the Project, Mobilizing the Working Group, Drafting the Standard, Balloting the Standard, Gaining Final Approval, and Maintaining the Standard.

4. What is the role of ITU-T Study Groups?

The standardization work is carried out by the technical Study Groups (SGs) in which representatives of the ITU-T member organizations develop Recommendations (standards) for the various fields of ICT.

5. What is the primary objective of ITU-R?

The ITU-R is responsible for global management of the radio-frequency spectrum and satellite orbits - limited natural resources.

6. 6. Define 3GPP activities for 5G?

3GPP is expected to accomplish its radio interface specification development task for submission to ITU-R in three Releases (Rel-14, Rel-15 and Rel-16). Rel-14 primarily deals with initial requirements and is expected to freeze in mid-2017. More precisely, the radio interface specification (standard) will be completed in two phases as stated by 3GPP RAN group.

Release-15 which is Phase 1, the fundamental features of new radio access technology will be formalized and it is expected to freeze in H2 2018. Phase 2 (Rel-16) will address all the remaining identified use cases and requirements and expected to be completed by December 2019 in line with submission to ITU-R.

7. What is NSS?

ITU-T in 2014 published the first ever guidelines for establishing National Standardization Secretariats (NSS) in developing nations to coordinate standardization activities and participation and contribution in ITU-T study groups. NSS is one of the action items of 'Bridging the Standardization Gap (BSG)' initiative, which is an effort to reduce the same between developing and developed countries.

8. What are three levels of NSS?

The guidelines take into account the different capability levels for standardization across the developing countries. It shows how it is possible to establish an NSS at three different levels or how to grow from NSS-General Level to NSS-Study Group Level and finally to NSS-Full Sector level.

- General Level: it is for such developing countries that have a general interest in ITU-T activities but their involvement with any of the ITU-T study groups is minimal.
- Study Group Level: it is for such developing countries that participate in some ITU-T activities and also in one or more of the ITU-T study groups.

- Full Sector Level: it is for such developing countries that are deeply engaged with ITU-T activities and also actively participate in many or most of the ITU-T study groups.

9. Define the role of COMSTECH?

A Science & Technology platform at the international level that represents OIC member states is COMSTECH (OIC Standing Committee on Scientific & Technological Corporation). The purpose of COMSTECH is the cooperation and promotion of Science and Technology within the world of OIC.

10. Discuss in group the pros and cons of having Standardization Secretariats at National vs. Regional levels?

11. Develop in group - a case study on the formation of NSS for a non-telecom but ICT industry?

