Insight

Everything You Need To Know About Spectrum: A Primer

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Introduction

Wireless communication plays an integral part in our daily life. However, wireless relies on an important resource: spectrum. This primer will present the basics, explaining what it is, which agencies regulate it, some of the basic terminology, and how it gets bought and valued.

What is spectrum?

Spectrum is the collective term for all wavelengths and frequencies of electromagnetic radiation, including visible light. Electromagnetic radiation travels as a wave of varying frequency, measured in hertz (Hz). All of the colors we see occur high in the spectrum at a frequency of 430–790 terahertz (THz). Shorter wavelengths are used in a wide range of applications for science, medicine, and communication. The range from roughly 3 kilohertz (kHz) to 300 gigahertz (GHz) is relevant for use in data applications and thus spectrum policy.

Data is transmitted wirelessly through devices that radiate waves within a certain range of frequencies, also known as bands. When two or more parties send out their transmissions in the same geographic area and spectrum band, the result is typically interference and both parties see a reduction in the quality of the information carried. How this rivalry is mitigated is the core question of spectrum policy.

Which agency regulates spectrum?

Spectrum policy is split between two agencies. While the Federal Communications Commission (FCC) has regulatory power over frequencies of spectrum used by the private sector, the National Telecommunications and Information Administration (NTIA) regulates

government spectrum. The FCC issues licenses typically for a 10-year period that grant permission to broadcast at a given frequency band in a geographic area. Licenses also limit the power level of radiators and the specific uses within that band. Licensed spectrum applies to most large scale communication such as AM/FM radio, wireless Internet service, and mobile telephony. Some bands are reserved for government uses only, while others can be used without a license, known as unlicensed spectrum. Everyone in the unlicensed spaces must accept interference but can radiate freely. For example, the 2.4 GHz band is unlicensed, and it is here where microwave ovens, Bluetooth, and Wi-Fi operate. Devices must be certified with the FCC and are limited to certain low levels, thus curtailing their range.

What do 3G, 4G, LTE, and 5G mean?

Wireless network technology is demarcated along generations and standards. The first generation (1G) mobile technology was deployed in the 1980s and has been followed every decade or so with a new generation. Currently, the third generation (3G) of technologies is ending its life cycle, the fourth generation (4G) is deployed and being improved, while the fifth generation (5G) is being planned. Each generation marks a change in speed, is typically incompatible with the previous generation, includes new spectrum frequencies, and has larger bands to support higher data transfer. While people often confuse it with 4G, LTE is a wireless data standard, much like Wi-Fi is a standard for unlicensed data transfer.

5G is expected to come about in the 2020s and could revolutionize mobile broadband. By utilizing much higher spectrum frequencies than 4G, this next generation will allow larger contiguous bands to be used, nearly five times the size of current 4G, allowing for much faster data transfer rates. New 5G technologies will allow spectrum to be used more efficiently, thus building out network capacity.

Where is spectrum used?

As mobile technology proliferates, demands for spectrum to power applications are rising. Everything from travel to reserving a table at a restaurant can be done in the spur of the moment, powered by spectrum. In 2015 over two thirds of Americans had a smartphone, almost doubling the amount in 2011. Total mobile traffic in the U.S. in 2015 grew 56 percent. Mobile data usage is projected to reach 3.6 exabytes per month in 2019, seven times more traffic than in 2014, 75 percent of which will be video.

Not only does mobile data account for a huge amount of consumption, it is tied to increased productivity and jobs. The sum of all economic activity generated by U.S. consumers and companies retained by American businesses totaled $194.8 billion in the most recent study.

As apps have become more and more integral to business' success, their value has exploded as well, growing from $10 billion in 2011 to $36 billion in 2014. New sectors have emerged as a result of wireless technology. The on-demand economy, fueled by companies like Uber, Lyft, and Airbnb, have dramatically changed the ways in which consumers purchase goods and services. The on-demand economy is not the only source of value that can be derived from the wireless industry. However, spectrum alone has no inherent value. Its value is instead derived from its function as an input in the production of wireless services which generate economic and social value.

How is spectrum valued?

Like any other asset, spectrum is valued to the extent that it can be used to earn returns. There isn't any abstract value that can be attached to it. Valuing an asset like spectrum involves estimating the asset's expected future cash flows and discounting them such that they are in terms of present value. Auction results, combined with information about the relative value of different bands, can allow for the entire spectrum to be valued. By this method, the 645.5 MHz of licensed spectrum available for mobile wireless service has been estimated to be worth $455 billion. In addition, the total value of licensed spectrum extends beyond its pure economic value. The total worth of social benefits of mobile wireless services is estimated at $5 trillion to $10 trillion.

How is spectrum allocated?

Originally, the Secretary of Commerce issued broadcasting licenses to anyone who applied, but after a series of lawsuits, the Federal Radio Commission was created in 1927. These functions transferred to the Federal Communications Commission (FCC) when it was formed in 1934. However, the FCC did not have a consistent system for allocating licenses besides accepting or denying license applications based on whether the license would serve the "public interest, convenience, or necessity." Licenses were allocated by various means from a competitive application process to random selection.

Since 1994, the FCC has allocated spectrum by auctioning broadcast licenses. In these auctions, bidders make offers of increasing value for licenses to utilize certain bands. The FCC is currently in the middle of the incentive auction, the first two-stage auction. In the first step, called the reverse auction, television broadcasters sell off their spectrum. Then the FCC will auction the spectrum they purchased in the reverse auction to wireless providers in a forward auction. Money earned from the reverse auction will first be used to cover the costs of running the auctions and any costs broadcasters will incur due to switching spectrum bands. Any profit after the conclusion of both auctions will be retained by the federal government.