Wireless carriers grapple with shortage of wireless spectrum

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Almost every wireless gadget on the planet, from the lock button on your car keys to the iPhone in your pocket to the Wi-Fi in your favorite coffee shop, runs over the electromagnetic spectrum.

And those invisible signals are worth tens of billions of dollars to companies such as AT&T Inc. and Verizon Wireless.

Dallas-based AT&T has cited the need for additional spectrum as one of the main reasons for its proposed $39 billion purchase of rival T-Mobile USA Inc.

"There's just going to be a constant need for additional spectrum," AT&T Chairman and Chief Executive Randall Stephenson said during a presentation after the deal was announced.

But what the heck is wireless spectrum?

And what does it mean that we're facing a shortage of spectrum, or a "spectrum crunch," as it's been called by Federal Communications Commission Chairman Julius Genachowski?

Rewind to high school physics class.

"You throw a pebble in a pond, and it creates these waves that go out," said Dale Hatfield, former head of the office of engineering and technology at the FCC.

"It's the same thing. When you move electric current in a wire, it creates a wave."

And the more waves you pack into a given space, the higher the frequency.

Using those signals to communicate and send data is a process that dates back more than 100 years to the work done by Guglielmo Marconi and other inventors.

But we've come a long way from the simple dot-dash of wireless Morse code.

Now wireless spectrum requires massive amounts of bandwidth for millions of different applications and users.

While a multitude of devices use wireless spectrum - everything from old-school broadcast television stations to baby monitors to military missile guidance systems - the biggest growth is in the cellphone industry.

AT&T has noted that mobile data traffic on its network increased 8,000 percent in the past four years.

According to network equipment maker Cisco Systems Inc., data traffic just on mobile networks last year was three times the amount of all data transmitted on the Internet in 2000.

For phones and other mobile devices, the most valuable wireless spectrum is in the frequency range of 300 megahertz to 3,000 megahertz.

Lower than that - down in the ranges where AM and FM radio operate -

transmission towers get huge and interference becomes a problem.

Higher than 3,000 megahertz - where radar systems and other devices operate - cellphone signals have trouble passing through even the flimsiest physical barriers.

"As you go to higher frequencies, the radio waves get more and more like light waves and can't get through buildings," said Hatfield, who is now executive director of the Silicon Flatirons Center for Law, Technology and Entrepreneurship at the University of Colorado-Boulder.

"They can't even get through a leaf on a tree if you go too high."

On every cell tower a wireless carrier builds to send out a signal to nearby phone users, the amount of spectrum is limited to the frequencies the carrier is licensed to use in that region.

Once too many users saturate the spectrum on that tower, signals fade and drop.

One solution is to build more towers.

Using the same slice of spectrum, you can connect more users by constructing more towers and keeping the number of users per tower low, since spectrum is reusable.

The wireless industry has certainly done that.

According to CTIA-The Wireless Association, a trade industry group, there were 253,086 cell sites at the end of 2010.

At the end of 2000, there were 104,288 towers.

But that solution is expensive and slow. You have to scout tower locations, secure building permits, spend money to build the towers, and lay copper or fiber optic cables to each tower to connect them to the main network.

You can also use less obtrusive short-range Wi-Fi networks to offload some of the mobile data load from your cell towers, or even offer users in-home mini cell towers, a technology known as femtocells.

Telecom analyst Roger Entner said that installing additional towers is a major engineering headache in its own right.

"Once cell sites become like 300 feet apart, it's not really physically possible to split them further unless you get pico and femtocells," he said. "It's awfully complicated. Cell site splitting is a real constraint."

Carriers can also devise more efficient ways to pack data on their existing spectrum.

Eventually, though, you simply need more spectrum.

"Demand for spectrum is rapidly outstripping supply," Genachowski said in a recent speech.

"We need to tackle the looming spectrum crunch by dramatically increasing the new spectrum available for mobile broadband and the efficiency of its use."

AT&T predicts that by 2015, it will transmit as much data over its wireless network every six weeks as it did in all of 2010.

"Even with more efficient radio technologies, even with some of the capabilities that we traditionally have to stretch spectrum as far as we

can get it to go, we can't outrun the growth that's in front of us," said Bill Hogg, senior vice president of network planning and engineering for AT&T.

There were 78.2 million active smartphones in the U.S. at the end of 2010, up 57 percent from 49.8 million a year earlier, according to CTIA.

But if the wireless industry is going to get more spectrum, it's going to have to come out of someone else's spectrum piggybank.

Managing the allocation of spectrum for different commercial applications is the job of the FCC.

The National Telecommunications and Information Administration handles all the federal uses of spectrum, such as by the Defense Department and other agencies.

In some ways, spectrum is the ultimate renewable resource.

For example, you can use the same frequency to transmit different signals in different locations, since the short range of the broadcast prevents interference.

That's why TV stations in different cities can use the same frequency.

What's more, you can use the same frequencies for a variety of applications.

Indeed, reallocating spectrum from one use to another is one of the biggest debates in the wireless industry these days.

Over-the-air TV broadcasters, for example, are sitting on some of the best spectrum for cellphone providers, at the lower end of that 300 to

3,000 MHz range.

With the number of over-the-air television viewers shrinking, many wireless companies and industry experts think those TV stations should hand over their spectrum to the FCC so the agency can auction it off to the highest bidders who desperately need the capacity.

The FCC has proposed such an arrangement, offering to give the broadcasters a cut of the money raised at auction, which would likely amount to billions of dollars.

Jerry Brito, a senior research fellow at the Mercatus Center at George Mason University and director of its technology policy program, said there's no reason for TV stations to continue hoarding such valuable wireless real estate.

"You could auction off the spectrum completely so that it goes dark over the air, and take all these folks (who watch broadcast TV) and just write them a check so they can subscribe to cable for the next 20 years, and it would take less money than you would make to auction it off," he said.

Ideally, Brito said, Congress would pass a law allowing anyone who owns spectrum to sell it to anyone who wants to buy it, without a government middleman, although such a completely free market solution is politically unlikely.

The FCC did conduct a major spectrum auction in 2008, as the move from analog TV broadcasts to more efficient digital signals freed up spectrum in the 700 MHz frequency band.

AT&T will begin activating the airwaves it licensed at that auction for its 4G network this year.

President Barack Obama has endorsed a plan that would reallocate an additional 500 MHz of spectrum from broadcasters, government agencies and other groups to be auctioned off over the next decade to raise a total of nearly $30 billion.

The first auction could happen as early as next year.

In the meantime, AT&T and other carriers have been buying spectrum from other wireless companies, consolidating their holdings while waiting for new resources.

Some critics argue that there's no such thing as a spectrum crunch, as carriers such as AT&T have vacuumed up huge swaths of it over the last few years.

But Hogg at AT&T said the growth trends will eventually swamp all the spectrum that's currently usable for mobile broadband.

"What's available on the market is what we have to help solve the problem in the short run, while the FCC works on what additional spectrum they'll make available," Hogg said.

"When you start to get out past 2015, there's no telling what innovation may come to market and what new uses that we'll find for wireless technologies."