Subcommittee on Communications, Technology, Innovation, and the Internet

Hearing on

"The Evolution of Next-Generation Technologies: Implementing MOBILE NOW"

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Chairman Thune, Ranking Member Schatz and members of the Subcommittee, thank you for the opportunity to testify on the implementation of the MOBILE NOW Act.

Cisco, based in San Jose, California, designs and sells a broad range of technologies that have been powering the Internet since 1984. Across networking, security, collaboration, applications and the cloud, Cisco integrates new technologies providing a highly secure, intelligent platform for digital business and business operations, enabling our customers to manage more users, devices and things connecting to their networks. Our customers include businesses of all sizes, public institutions, governments, and service providers. Cisco has over 15,000 U.S. patents and employs over 75,000 people globally, with more than half in the US. Our wireless portfolio provides indoor and outdoor wireless coverage designed for seamless roaming use of voice, video, and data applications. These products include wireless access points that are standalone, controller appliance-based, switch-converged, and Meraki cloud-managed offerings. This past year, we introduced Catalyst and Meraki Wi-Fi 6 access points designed for high-density public or private environments to improve speed, performance, and capacity for wireless networking in both homes and enterprises.

Mr. Chairman, in a 2018 letter to FCC Chairman Pai, you said "the MOBILE NOW Act is critical for paving the way for wireless innovation and securing American leadership in next-generation technology." Cisco agrees.

MOBILE NOW has changed the debate, and revolutionized spectrum policy. It gave permission to have bolder conversations about spectrum, how to use it efficiently, and how to speed up the deployment of new technologies.

For example, no longer does industry need to wait until existing channels get congested with traffic before discussing the need for new allocations, and for regulators to approve them. Spectrum allocations can now be made on the basis of fostering new technology that enable

consumers and businesses to take advantage of the best technologies industry has to offer, accelerating innovation in edge devices, applications, and more.

No longer are we focused on incremental additions to existing allocations that for decades stood as the way in which spectrum was allocated – instead, the Act specifies large swaths of spectrum be identified and made available.

No longer are we ignoring the utility of mid-band spectrum – the legislation emphatically points to the importance of mid-band spectrum for both licensed and unlicensed technologies, and tasks the FCC and NTIA to evaluate a variety of bands and make spectrum available.

It is in our country's best interest to have these bold conversations on how to strengthen our economic and technological well-being through the use of licensed and unlicensed technologies.

For example, Mr. Chairman, you yourself have noted that more than half of all US data traffic will run over unlicensed technologies, and that given the strong growth in data traffic, unlicensed technologies will need access to 500 megahertz to 1.6 gigahertz of spectrum in order to stay abreast of consumer demand.

FCC Commissioner O'Reilly agrees. "It is undisputed that the exponential growth of wireless data, especially over unlicensed networks, has led to severe congestion in our highly-prized unlicensed spectrum bands, primarily 2.4 and 5 GHz." Currently, Cisco estimates that 50.4 percent of total Internet traffic in 2017 was initiated or completed on Wi-Fi, and that share will grow to 56.6 percent by 2022, at the same time that the base of Internet traffic is growing three-fold.

Why is the demand for unlicensed spectrum both strong and growing? FCC Commissioner Carr explains: "Wi-Fi networks are the workhorses of our connected lives. We hear so much in telecom about the difficulty of connecting the 'last mile.' And when we are at home or at work the final few feet of that last mile are often spanned by Wi-Fi, Bluetooth, or another unlicensed technology. Few realize that without Wi-Fi and the unlicensed spectrum it uses, even the best commercial wireless networks would strain to keep up with consumer demand. In fact, … even among Americans with unlimited mobile data plans, two-thirds of their data still rides on Wi-Fi."

And it's not just our smartphone addiction that is creating demand. It's also the connected devices you now find all around you. A few years ago, there was no such thing as a wireless Smart TV to enable streaming services from the Internet. Today, that market segment for Smart TVs alone is barreling toward the $200 billion mark, with more innovation on the way.

Your TV isn't the only thing that's gotten "smart." In homes across the country, connected home security, smart lighting, heating and cooling systems, doorbells, appliances, wireless speakers and your Kindle all use Wi-Fi.

The power of Wi-Fi is transforming not only how we live, but how we work and learn. In offices and schools, laptops, smartphones and tablets use Wi-Fi to connect to your email server, allow you to take video calls, connect to large smart screens for video conferencing, share and jointly

create documents and then lets you print them. From warehouses to factories to clothing retailers to restaurants to commercial aviation to hotels, Wi-Fi is ubiquitous. In fact, some of the most intensive uses of Wi-Fi are in work settings, along with other environments where large numbers of people are looking to connect; university campuses, airport concourses, sports stadiums, and convention centers are all transforming and providing better customer experiences thanks to Wi-Fi.

With all the activity supported by unlicensed technologies, it should be no surprise that there have been economic measurements of what that activity means to the US economy. FCC Commissioner Jessica Rosenworcel has noted: "Wi-Fi adds more than $500 billion to the United States economy every year— and $2 trillion globally. It has democratized internet access, helped carriers manage their networks, and fostered all sorts of wild innovation." The thing I like about the Commissioner's quote is that it gives you a sense that the economic success story of Wi-Fi continues to grow – as we innovate the technology, find new uses for it, and connect more things with it. It's no surprise that the Wi-Fi Alliance has estimated the value of Wi-Fi - in the US alone – could reach nearly $1 trillion by 2023.

Industry has had a close eye on demand growth and has been responding in two ways. First, we have been innovating, through five, and now six, generations of Wi-Fi technology, each more efficient and powerful than the last. Second, we have been looking for more spectrum. In the Middle Class Tax Relief and Job Creation Act of 2012, Congress directed the FCC and NTIA to study both 5350-5470 MHz and 5850-5925 MHz to determine if those bands could be opened to unlicensed use, which would have given Wi-Fi access to most of the 5 GHz band while sharing with incumbents. In the case of the first band named, the answer was "no" and in the case of the second, the FCC is adopting a Notice of Proposed Rulemaking later this month, seeking comment on whether 45 MHz of the band could be utilized by Wi-Fi, while still meeting intelligent transportation requirements that the band was intended to support. In sum, despite best efforts – by you, the FCC and the NTIA – The Middle Class Tax Relief and Job Creation Act has thus far provided no new spectrum for Wi-Fi – in fact, there has been no new spectrum for Wi-Fi since 2003.

Let's think back to 2003. In 2003, we didn't have thin notebook computers; they were still six to seven years in the future. We didn't have Smart TVs; they were still dumb. We didn't have Kindles. Nintendo Wii was 3 years away. And in 2003, we still had to wait 4 years for the iPhone. Today, we're running all these devices and countless more on the same spectrum allocation using generations of innovation in every home and workplace in America.

In 2003, although the Commission had, on paper, opened up an additional 255 megahertz of spectrum in the 5 GHz range for unlicensed devices, it came with a catch – that the technology deployed there needed to be able to avoid government radars. It turned out that doing so added cost – to the devices themselves, and also "costs" in terms of activities the radios had to perform unrelated to consumer or enterprise traffic. As a result, low cost consumer devices never operated in these new frequencies. Instead, they were relegated to the 5 GHz bands that were not encumbered with sharing requirements – only about 225 megahertz of spectrum. And so, as demand continued to rise, the only way to address it was through innovation in technology.

Today, as we look to 2020 and beyond, the unlicensed industry is at a pivotal moment.

First - there is no dispute - demand continues to rise. More powerful devices and more powerful broadband networks, including 5G, mean that we use our unlicensed connectivity more. Second, new technology – much more spectrally efficient than in the past – is requiring new spectrum. Our Wi-Fi technology shares a common building block with licensed cellular services. To permit the throughput speeds that consumers are demanding of their devices, both technologies need wider radio channels, much wider than in the past. This was an important contribution of MOBILE NOW, enabling regulators to look for large swaths of spectrum to support this engineering reality for both licensed and unlicensed services.

For the unlicensed community, these dual realities of rising demand and a need for wider channels, sparked an evaluation that led the industry to take a hard look at the 6 GHz band. The opportunity to deploy multiple 80 megahertz or 160 megahertz wide channels was as attractive to the cable industry as it was to enterprise manufacturers like Cisco and to smartphone makers as well. Cable providers must simultaneously support a great user experience throughout a household where multiple people are individually using a broadband connection. Cisco increasingly faces dense deployment requirements of customers who are relying on Wi-Fi more than they ever did in the past, while smartphone manufacturers, like Apple, must produce devices that stay ahead of evolutions in cellular technology.

At 6 GHz, the nature of incumbents means that unlicensed use is highly complementary to existing uses. Microwaves transmit and receive antennas are typically located at high elevations (e.g., a tower on a ridge or a tall building). Unlicensed devices are typically low, and if not low, then inside a building. Microwaves are high-power and outdoors. Unlicensed is mostly indoor and low power. These are complementary technologies from an interference analysis perspective.

The unlicensed industry commissioned a Monte Carlo style engineering study that took into account all of the known microwave links listed in the FCC's databases, and in a computer simulation, randomly placed 1 billion unlicensed devices according to the US population – so placing more devices in cities where there are more people. What we found was encouraging – that even by taking an unlicensed radio operating as it would in the 5 GHz band (i.e., no new mitigations), there was virtually no interference and what little interference there was would not cause any degradation to incumbents' microwave links. If the link needed to be highly reliable and operate at five "nines" of reliability, it would continue to operate at five "nines."

The FCC agreed that sharing this band seemed promising. But we all understood that our initial study was not completely dispositive on the question of harmful interference.

That is because within 6 GHz are incumbent use cases that support critical infrastructure and public safety, in addition to telecommunications and mobile activities of broadcasters. The FCC was very clear – for a sharing regime to work, the unlicensed industry would need to show that incumbent operational capabilities would not be impaired, now or in the future.

FCC Chairman Pai said it best. "This band is currently populated by microwave services that are used to support utilities, public safety, and wireless backhaul. But studies have shown that sharing this band with unlicensed operations is feasible—and can put massive amounts of new spectrum into the hands of consumers…. We're aiming to have the best of both worlds: protect today's incumbent users of the band while turbocharging the Wi-Fi networks and applications of the future."

The unlicensed industry therefore responsibly proposed a suite of mitigations to do just that – meet the requirement not to cause harm now or in the future while allowing Wi-Fi to share the band. We proposed three classes of devices, each subject to its own unique set of mitigations.

For higher power outdoor and indoor devices, we proposed using a database approach to avoid microwave links as those are licensed by the FCC. A mechanism we called Automated Frequency Control, or AFC, would inform higher power devices of available frequencies in a specific geographical location. For devices receiving instructions from a properly tested and defined AFC, interference is not an issue – those devices will be operating in frequencies other than those in use by nearby microwaves.

We also proposed a Low Power Indoor class which would likely become the largest group of devices, such as Wi-Fi access points in your home or business. The mitigation technique is essentially lower power. For indoor devices, radio emissions degrade when trying to exit buildings, and the vast majority of devices would operate low to the ground, away from microwaves.

Finally, we proposed Very Low Power devices with power spectral density levels 40 times lower than those for indoor low power devices. An example would be using Wi-Fi to connect your laptop or watch to your smartphone.

We then studied those classes of devices using a variety of techniques – from the traditional way that engineers use to place new microwaves into the band, to virtually flying down the main beam of a microwave link from a receiver to see, in an urban setting, if Wi-Fi devices might be in the main beam and contribute to a possible harmful interference event. We simulated the impact of devices on an actual link in an experimental lab set up. We examined specific "worse case" links. We studied how microwave links are engineered to understand how they would respond in the face of unlicensed energy. All of this, and more, is contained in the record of the FCC docket.

In doing this, we wanted to understand - will the microwave links continue to operate as designed? That is not a question of who the licensee is because the physics of microwave, and often the vendors, are the same no matter what the use case. It's a question about whether radio emissions from unlicensed transmitters create harmful interference to existing users and thereby block the links from performing its mission. We also wanted to inform the incumbents of our thinking, and ideally persuade the FCC staff to adopt our point of view.

How do you make a determination that unlicensed use of the band will not cause interference?

You must start with a clear understanding of the technology used by incumbents. How strong or powerful are the radio signals that are being transmitted from point A to point B? Much of this knowledge today comes from what are called "propagation models" that predict, mathematically, how signals behave in unobstructed "free space" or open air or, alternatively, in the presence of ground clutter such as buildings and trees. As it has always done, the FCC analysis must decide which models are reasonable ones to use in analyzing the band.

What practical constraints exist in designing a link? For example, it turns out radio emissions are sometimes devilishly inconsistent (especially so in the wee hours of the morning), so microwave designers use power and antenna technology to ensure that the links work all the time, without question.

For radios that can be adjusted to change throughput speed (known as "modulations") are there minimums needed to support specific applications? You may not need the fastest throughput to accomplish the mission, but there may be a minimum that has to be honored.

And finally, how are the incumbent links and receive antennas positioned geographically and by height?

Then and only then can you examine the new use case – unlicensed – to evaluate mathematically whether the incumbent links will experience harmful interference.

A word about harmful interference vs interference. Radio emissions are notably untidy. Interference is something all radio engineers must plan for as it is a common condition. Harmful interference, however, needs to be avoided because it stops the radio from completing its job.

With the AFC design likely to be subject to a further, follow-on proceeding, what interference questions are most pressing for the FCC to resolve in a 6 GHz Report and Order?

The important use case for unlicensed in the record that has attracted the most attention is Low Power Indoor (LPI), and by extension, Very Low Power devices. Engineers will look at the power levels, for LPI – the building entry or exit loss caused by building materials, reasonable propagation models, and calculate whether the unlicensed energy in a main beam or reaching the receiver will cause harmful interference. They will do so using a variety of assumptions and techniques, trying to be conservative in their analysis to overstate the possibility that the analysis will reveal an issue.

Based on the voluminous engineering record to date, Cisco – and the unlicensed community -- remain optimistic that a set of mitigations can be found that allow robust use of the band by unlicensed devices including Low Power Indoors and Very Low Power, while continuing to give incumbents full use of the band for their current and future needs.

Of course, incumbents and the FCC staff are examining this exact question in parallel with the unlicensed industry – all with a goal of getting to the most accurate answer possible. It's a lot of hours of engineering staff time, and we are deeply grateful for the Commission's willingness to

engage this task. At the conclusion of all of this work, the FCC's engineering staff will decide what analysis is reasonable, and will base their findings and recommended mitigations on what the staff believes will protect incumbents.

Incumbents have also raised questions about testing. It's important to understand the role of testing, because there is a lot to understand.

As an initial matter, it is important to note one fundamental point. Even when rules are adopted, existing devices cannot simply switch to using 6 GHz. They simply do not have the capability to do so. For one, existing devices do not have the silicon to allow them to operate in the 6 GHz range. For another, they do not have the all-important FCC identification number that would allow them to operate under whatever new rules are adopted. As a result, even if they could magically operate in 6 GHz, it would be illegal for them to do so without passing FCC certification specific to 6 GHz.

Second, the unlicensed industry is no stranger to testing – testing is our friend, not our enemy. All unlicensed devices must undergo testing for adherence to FCC rules, and new rules to allow unlicensed devices into new bands must themselves be tested. In fact, we have to test the rules before we can test the devices in order to make sure the rules work as intended.

The AFC mechanism for high power devices is a good example of this. No rules exist today that would allow Cisco or any other company to design and implement an AFC. The FCC first needs to specify those rules to enable prototype AFCs to be built. Depending upon how much the FCC specifies in its Report and Order, additional rules and requirements may need to be adopted in a follow-on proceeding. Once prototype AFCs are built, it becomes possible to test the AFC rules to see if they work as intended. That is a process that we've seen in all sharing scenarios – from Dynamic Frequency Selection in 5 GHz, to TV White Spaces databases, to CBRS databases. Once the rules have been tested, then and only then can manufacturers bring forth actual AFCs to be tested for commercial use. To do so, the AFCs will need to be tested by the developer, likely tested by a third party, and then, likely tested by the FCC lab as well.

This is a process that will take some time, and the unlicensed industry is hopeful that, unlike CBRS, it is a process that can be measured in months, not years. It is also a process that is conducted transparently, with stakeholders of all types participating.

As with all operations in unlicensed bands, the FCC remains in the driver's seat before, during and after market entry. The unlicensed entry has a strong stake in ensuring that market entry is successful, because without the FCC continuing to approve devices, significant investment will be lost.

We continue to believe that, from an engineering perspective, sharing the band with unlicensed is both possible and desirable.

We further agree with FCC Chairman Pai: "This decision will help [the FCC] meet the [Congressional] mandate … to make more spectrum available for unlicensed use. It is also part of our aggressive and balanced spectrum strategy: pushing more licensed and unlicensed

spectrum into the commercial marketplace and including a mix of low-band, mid-band, and high-band spectrum. And with the massive amount of wireless traffic that is off-loaded to Wi-Fi, opening up this wide swath of spectrum for unlicensed use could be a big boost to our nation's 5G future."

Thank you for the opportunity to testify on the implementation of the MOBILE NOW Act.