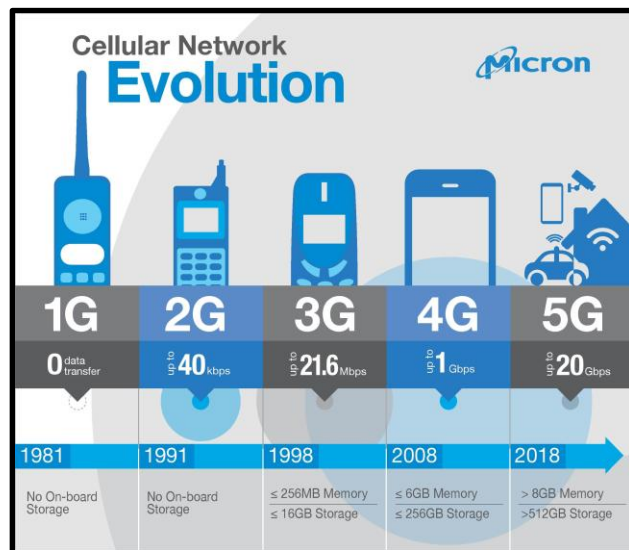


What is 5G?

Introduction

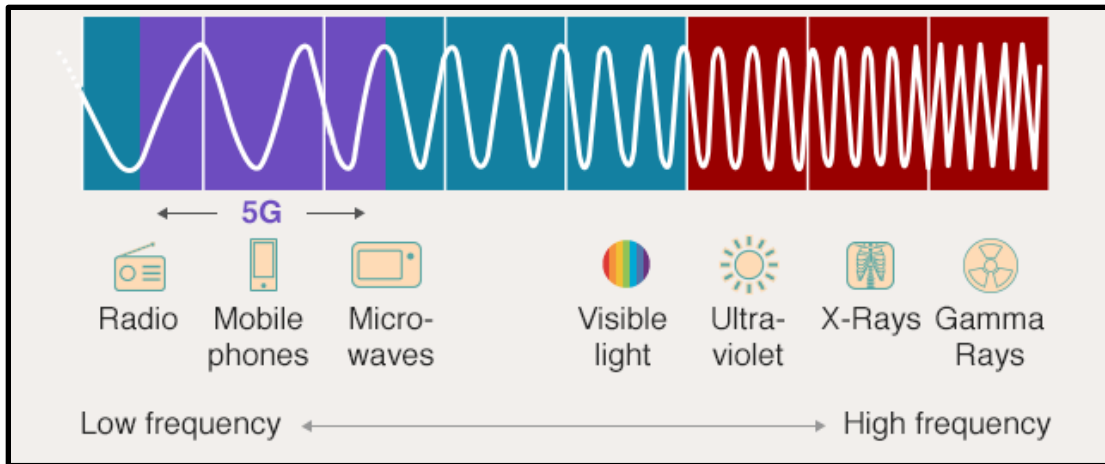
“The fifth generation of wireless technology promises more than just a faster network. It will help redefine the network, establishing a new global wireless standard for speed, throughput and bandwidth. A 5G network builds a bridge to the future.” - Verizon

The first generation of wireless technology arose with the first analog cell phones in the late 1970s. The first generation of mobile networks, also known as 1G, was introduced in 1979. 1G suffered major drawbacks such as poor coverage, a lack of compatibility between systems, and no roaming support between various operators. Despite these initial drawbacks, the first mobile network was a major success and in 1991, it allowed for the emergence of 2G with features such as Short Message Service (SMS), picture messaging, and Multimedia Messaging Service (MMS). By the end of the 2G era, the maximum speed of transfers was only 50kbps (kilobit per sec). In 2001, the third generation of mobile networks was launched. 3G enhanced data transfer capabilities and standardized the network protocol used by vendors. This era included the launch of the iPhone 3G in 2008, and the beginning of video conferencing, video streaming, and voiceover. The switch to 4G in 2009 was more complex as mobile devices needed to be specifically designed to support 4G rather than just switching SIM cards. 4G allowed for high-quality video streaming and a standard speed of about 15mbps (megabit per sec).



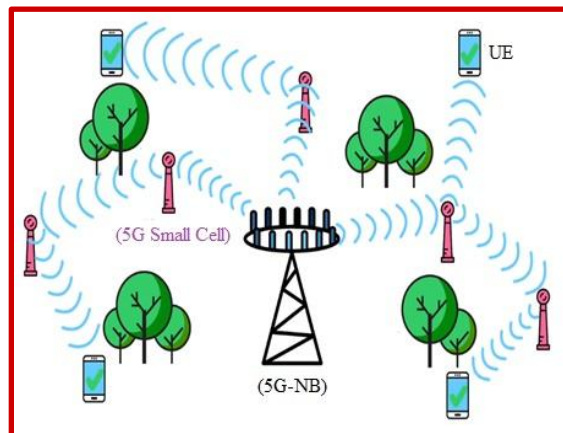
In the 1990s, the era “the Internet of Things (IoT)” was predicted to be the next big digital revolution. This is now upon us and with the expectation of billions of devices to need cellular network support, the fifth generation of mobile networks was released in 2019.

South Korea was the first country to officially launch 5G in 2019, the newest generation for wireless connection, promising faster speeds, greater capacities, continuous connection, and faster response times. 5G allows you to download a high-definition film in seconds (something that would take more



than 10 minutes using 4G). 5G uses millimeter waves, waves that are of a higher frequency than the radio waves used for 4G, enabling it to travel much faster. However, these higher frequency waves have smaller lengths, meaning that they are much more easily absorbed by obstacles such as buildings or even rain. Look at the diagram above to see how 5G is shifting from radio waves to higher frequency waves with smaller lengths.

Since 5G waves can be more easily absorbed, we will need to increase the number of cellular towers to avoid having disconnections occur because you walked behind a tree. These cellular towers are known as small cells, as they are smaller than traditional cellular towers (and more efficient) and can be built in more frequent locations.



5G will enable better communication between devices, allowing the communication between autonomous vehicles (self-driving cars), enhancing virtual reality, improving our classroom technology, allowing us to do things faster online (downloading, video conferencing, etc), and bringing us closer to having smart cities and smart homes.

Northeastern Connections

Faculty Connection

Edmund Yeh is an Electrical and Computer Engineering Professor at Northeastern University whose research focuses on “networking and systems for data-intensive engineering, science, health applications, etc.” In collaboration with fellow researchers from Stanford University and the University of California at Irvine, Professor Yeh has acquired research grants from Cisco Systems and Intel Corp to learn more about “optimizing and securing 5G wireless edge networks.”



Northeastern’s William Lincoln Smith chair professor of electrical and computer engineering, Tommaso Melodia, believes that it’s time to start thinking about what a future with 6G technology should be like. The need for wireless systems is rapidly increasing and Professor Melodia believes this should be the focus for 6G innovation. In accordance with this, Northeastern University launched the Institute for the Wireless Internet of Things in late 2019, directed by Tommaso Melodia. According to Melodia, its goal is to “drive advances to change the way people are connected worldwide”.

Student Connection

Northeastern University’s Wireless Club, originally known as an amateur radio club, offers a maker space and workshops for students to explore their interests in electrical engineering topics. Their workshops have focused on a range of topics including soldering, ham radio, and 3D printing. They also have weekly meetings and opportunities to gain amateur radio certification.



5G technology utilizes radio waves to receive and transmit data to base stations in a similar way radio stations send out music from their stations. Sound waves are encoded in radio waves, send out by the radio stations, and decoded by radio receivers to bring the hottest tracks to listeners around the world. NU Wireless Club does the same when it comes to their amateur ham radio broadcasts.



NU Wireless Club also works on projects throughout the year - the LED Flag Project mockup, in particular, can be seen on the left. For this project, they designed and constructed an LED Board connected to a phone where what is written on the phone is shown on the LED lights. Some other projects they've done are a crude camera sensor, reflow oven, and air lights.

Do Now

Watch this quick video "[How 5G Works and What it Delivers](#)" to learn more about the applications of 5G, more about how it works, and the potential harms of it. After finishing the video, take a look at the following questions and discuss them with someone or think about them on your own (write down the answers!).

Discussion Questions:

- What devices can use 5G?
What are the applications of 5G?
- What do you think are the advantages of 5G compared to previous generations?
- What do you think is a drawback or disadvantage of 5G?
- Are there any harmful side effects to 5G?

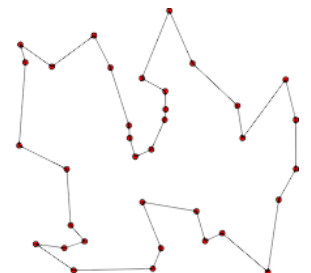
Activity

For this activity, we will be learning more about the internet and connectivity. This will be an experiment to help us understand more about our current internet speed compared to the speeds of 5G. 5G cell towers will need to be more frequent than 4G towers due to the lower frequency (easily absorbed but provides faster speeds). You should have access to a device and have an internet connection for this activity.

Materials Needed:

You can use any materials you want but here are some suggestions:

- A smartphone, laptop, or tablet
- Tape Measure



Steps:

- Using your device (phone, laptop, or tablet), open this [website](#) to find out the speed of your internet.
- Stand fairly close to your router (around 1ft or less away from it). Visit [SpeedTest](#) to find out the speed of your connection. Click “Test Again” on the page and record the new value (do this three times). This allows us to later find an average to make sure our values are accurate.
- Increase your distance from the router by 5ft (use a tape measure to help you out). Record the speed (do this three times again).
- Repeat the previous step for different distances increasing the distance from the router at a regular interval (so consistently increase your speed by 5ft or more).
- Watch this [video](#) to gain a better understanding of the difference in speed between 5G speed and your current speed.

Results Table:

Record the distance from your router and record the speeds three times per distance then find the average!

| Distance | Speed 1 | Speed 2 | Speed 3 | Average Speed |
|----------|---------|---------|---------|---------------|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Discussion Questions:

- What is the pattern that you observed? Does speed change with distance?
- How do the speeds compare to those of 5G? Watch this [video](#) to see 5G speeds.
- What does Mbps mean?

Share Your Results

We'd love to know how the activity and/or the “do now” turned out! What worked and what didn't work? Please share with us something you learned and/or send us pictures! Email us at

stem@northeastern.edu.

Related links/Extensions

- [Everything You Need to Know about 5G -- IEE Spectrum](#)
- [NU Wireless Club](#)
- [What is 5G - Verizon](#)
- [What does 5G Connection Hold in Store?](#)
- [IoT+5G @ Northeastern - Center for Research Innovation](#)
- [ECE Professor Edmund Yeh Receives Grants for 5G Wireless Research](#)