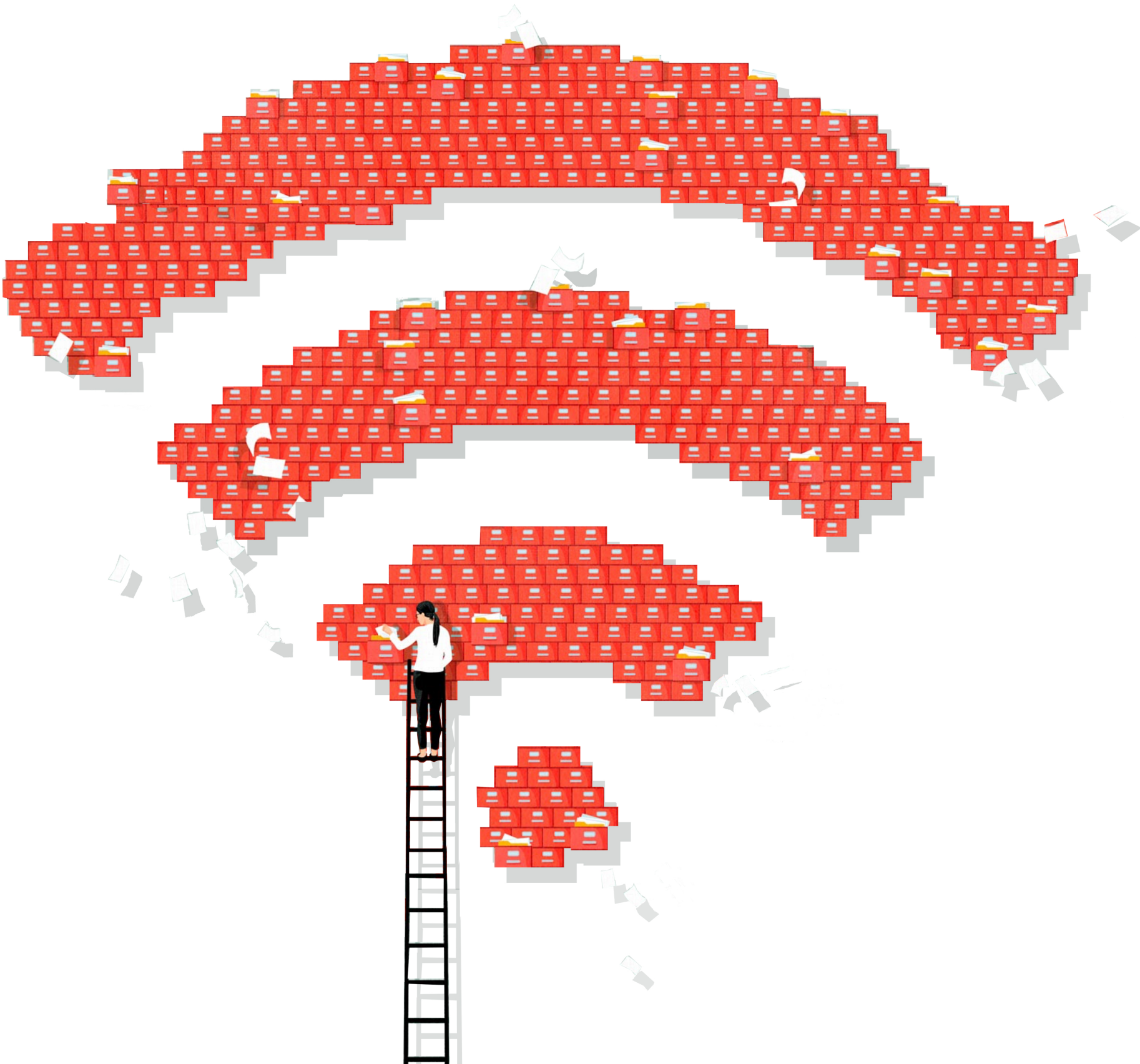
MERCKU PRESENTS

Wi-Fi: The Definitive Guide



Contents

5 What Internet Service Providers Need To Know About Wi-Fi

6 The Future Potential of Wi-Fi

Appendix

Chapter 1
What is Wi-Fi?

In 2020, the question “What is Wi-Fi?” probably seems elementary. Wireless internet connectivity has become so common in most of the developed world that for many it is taken for granted as a utility, like electricity or running water. For most homeowners and office workers, Wi-Fi connectivity doesn’t require much consideration aside from its initial set-up by their internet service provider and the occasions when it becomes temporarily unavailable.

So why did we decide that the world needs a comprehensive Guide to Wi-Fi in 2020? A few reasons:

To provide a **single, accessible reference** to explain the often confusing terms, specifications and acronyms that can make Wi-Fi seem confusingly technical.

To **dispel the common misconceptions** about Wi-Fi technology that prevent businesses and end-users from making smart decisions.

To **educate decision-makers** about advances in Wi-Fi, since the potential of this seemingly mature technology is still **far** from fully realized.

Why Should You Listen to Us?

Why should you trust Mercku as a Wi-Fi expert? Mercku was founded in 2017 to explore the full potential of Wi-Fi technology in an increasingly connected world of Smart homes and cities. While Mercku itself is a relatively young company, it was built on the decades of experience of our technical founder Yihong Qi. He was one of the first engineering leaders at Blackberry and is a fellow of the Canadian Academy of Engineering as well as the American National Academy of Inventors with over 400 patents, including that for the modern cellphone antenna.

The members of Mercku’s executive team are recognized as thought leaders in Wi-Fi and Smart Home technology and often share the latest insights as keynote speakers at major technology and telecom industry conferences, such as Wi-Fi NOW, Parks Associates CONNECTIONS, Web Summit, Slush, Telco Trends, FITCE, and many more.

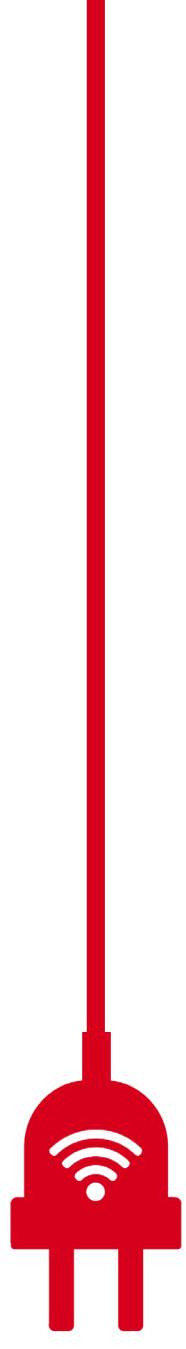
The Origin of the Word “Wi-Fi”

Let’s start by dispelling one of the most common misconceptions about Wi-Fi. The name “Wi-Fi” is not short for “Wireless Fidelity”. Wi-Fi is simply a trademarked term by the IEEE for the 802.11x protocol that we’ll be discussing in more detail below.

In fact, Wi-Fi isn’t short for anything and never has been!

Despite this fact, this misconception is so common that industry leaders and respectable tech publications often include the phrase “Wireless Fidelity” in their press materials. This may have also been perpetuated by the early days of the Wi-Fi Alliance when they adopted the tagline “The Standard for Wireless Fidelity”.

With that fun bit of Wi-Fi trivia out of the way, let’s move on to the more practical Wi-Fi knowledge that you came here for...



The History of Wi-Fi

1971 The Presentation

First public demonstration of ALOHAnet, a wireless packet data network operating on UHF (Ultra High Frequency) radio waves connecting 7 computers spread across four islands without phone lines.

1973 Network Standard

- Initiated by Bob Metcalfe of Xerox Palo Alto Research Center
- Memo about Ethernet network standard for connecting computers.
- This was the beginning of a central standard for connecting computers rather than separate proprietary solutions.
- Set the stage for a similar wireless standard.

1985 Open Network Use

- Federal Communications Commission, America's Telecom regulator, opens the ISM (Industrial, Science, and Medicine) Band of the Wireless spectrum for use in communications without a government license.
- The frequencies include 900MHz, 2.4GHz, and 5.8 GHz, which are still commonly used today.

1990 The Father of Wi-Fi

The IEEE 802.11 Working Group for Wireless LANs is founded. It is led by Vic Hayes who is sometimes known as the "Father of Wi-Fi".

1993 Public Hotspots

The concept of a public access Local Wireless Network is introduced by Henrik Sjödin. The term hotspot wouldn't be coined until 1998.

1997

802.11 - 2 Mbps

Historic Wi-Fi Developments

1999

802.11b – 11 Mbps

The Wi-Fi Alliance

The Wi-Fi Alliance is founded as non-profit trade association working for universal compatibility and quality user experience.

2003

802.11g – 108 Mbps

Spectrum Increases

- The World Radio Conference allocates the 5GHz band of radio spectrum for wireless access devices.
- The Calypso Wireless C1250i phone is announced as the first phone to allow both cell phone and Wi-Fi VoIP calls.

2005

802.11e – 108 Mbps

100 Million Chipsets

Wi-Fi chipset shipments top 100 million annually.

2009

802.11n – 600 Mbps

The 1 Billionth Chipset

The 1 billionth Wi-Fi chipset is sold.

2010

1 Million Hotspots

1,000,000 Wi-Fi hotspots are estimated to be active worldwide.

2014

802.11ac – 1.7 Gbps

802.11AC Router

D-Link releases the first portable 802.11ac router.

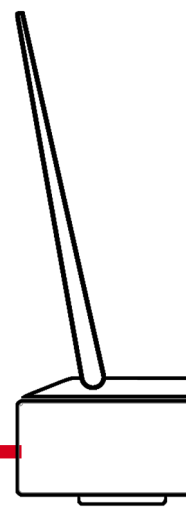
2015

70,000,000 Hotspots

70,000,000 Wi-Fi hotspots are estimated to be active worldwide.

2019

802.11ax – 3.5 Gbps

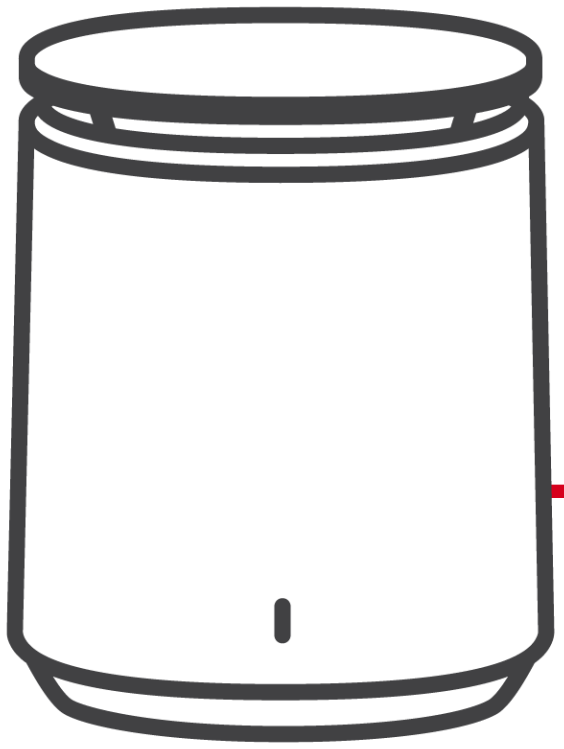


How Wi-Fi Works, an Overview

Wireless networks use radio waves, just like cell phones, TVs and radios. Basically:

1. A device's wireless adapter translates data into a radio signal and transmits it using an antenna.

2. A wireless router receives the signal using a transceiver and decodes it. The router is usually connected to the internet via a wired Ethernet connection.



The Global Impact of Wi-Fi

Over the last twenty years, high-speed wireless internet connectivity has gone from a luxury reserved for research labs to a utility that many couldn't imagine living without. In fact, in a 2016 poll by AT&T, 87% of people said they'd rather give up chocolate than internet connectivity and 40.5% said they'd rather give up sight in one of their eyes!

As of January 2020, there are as many as 4.54 billion active internet users worldwide, and that number is anticipated to increase to 6 billion by 2022. While internet penetration has been the most complete in developed nations, future growth is expected to be driven by rapid adoption in developing nations. For example, the relative year-over-year user growth in countries like Western Sahara last year was 364%.

According to a report by the Wi-Fi Alliance, the annual global economic value of Wi-Fi was $1.96 trillion in 2018, with expectations to grow to $3.47 trillion by 2023. And that value is not just from technology companies providing hardware and service; companies outside the technology sector make 75% of internet profits.

With free or inexpensive Wi-Fi now available in most stores, hotels, airplanes, and even underground subway trains, users can stay connected to work, socialize, and shop in places where their mobile signal can't reach. Hotspots, or public internet access points, increased with an estimated 47.7 million between 2014-2018, or 1 hotspot for every 20 users increasing from 1:150 in 2014.

In 2016, a report from the Human Rights Council of the United Nations General Assembly declared access to the internet to be a basic human right, integral for allowing individuals to "exercise their right to freedom of opinion and expression." Individual countries have taken that direction to enact new laws and policies. In Canada, the CRTC (the government's telecom agency) issued a rule declaring

Chapter 2
Wi-Fi Basics

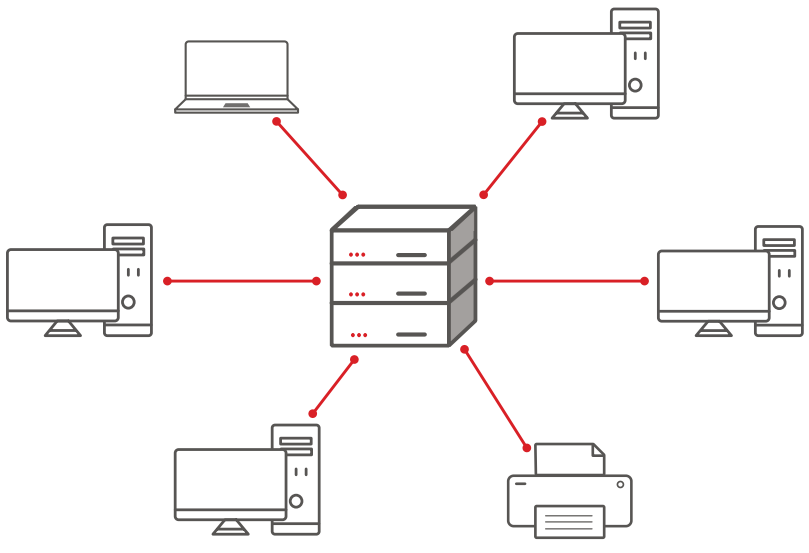
Wi-Fi Basics

Since Steve Jobs put the internet in our pockets, the need for connectivity has spread to our TVs, thermostats, home security systems, children's edu-tainment, baby monitors, and even our refrigerators. All of these new appliances and devices need to transmit data across the internet, placing a large burden on our wireless routers.

Trying to ease this burden has forced the best of us to resort to neo-caveman rituals, like twisting the antennas in odd configurations, booting and rebooting our routers to trip up the router demons, hanging wires on walls in distant rooms, or pasting tin foil trails on our ceilings—whatever makes us think we're improving our connectivity.

We would be better served to take a moment to revise our understanding of Wi-Fi technology, how it works, and how the next generation of devices need it to work, so that we can optimize our connections without experiencing interruptions. Let's start with the basics and try to wrap our minds around how our Wi-Fi systems work.

Basic Definitions



LAN

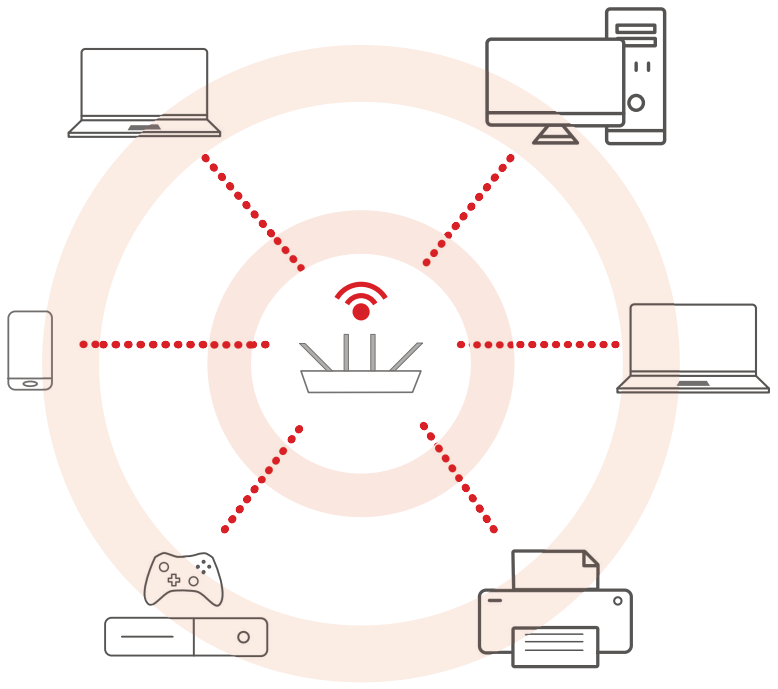
Local Area Network – A connected network of computers, printers, or other wired devices in a limited area.

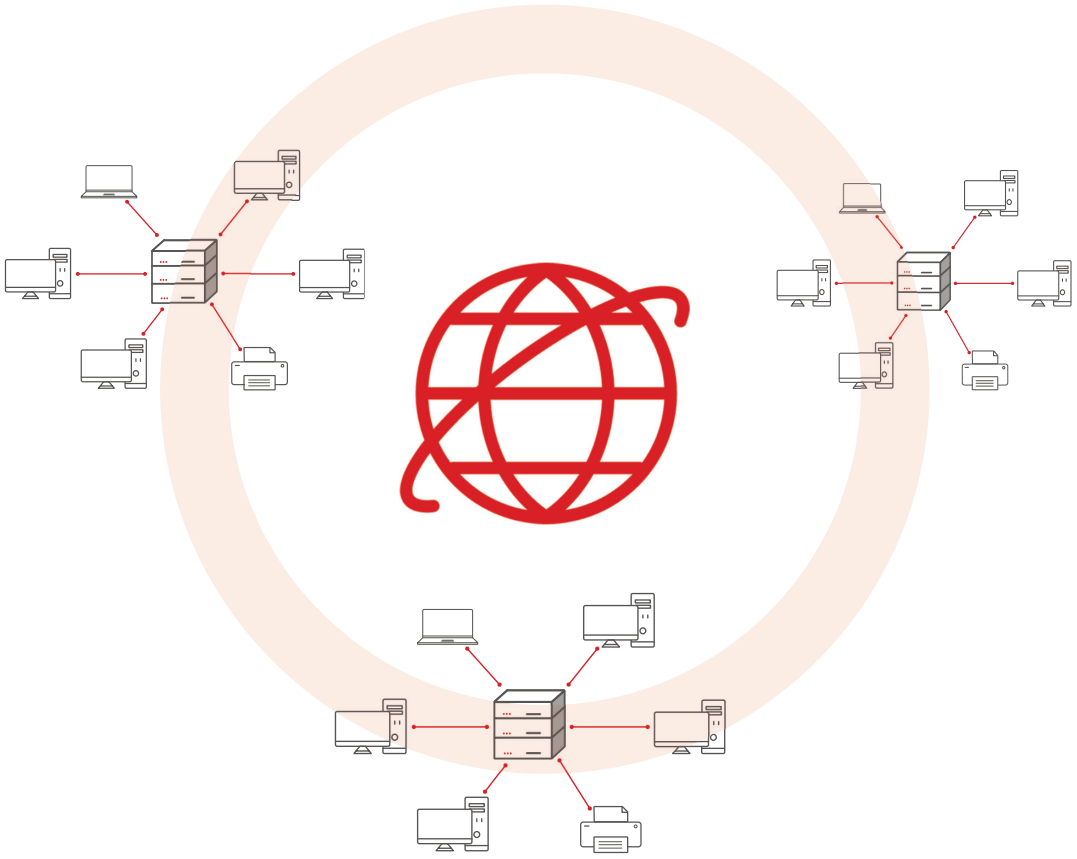
WLAN

Wireless Local Area Network – A wirelessly connected network of wireless devices.

Wi-Fi

The radio technology used to serve devices on a WLAN.





WAN

Wide Area Network – A network of connected LANs, or in other words, the internet.

The Need For Speed

If bandwidth is the pipe, then throughput is the water. The larger the pipe, the more water can flow through it. Throughput is how fast the water is actually flowing.

BANDWIDTH

Bandwidth is the rated capacity of your internet connection—usually the high number advertised by your Internet Service Provider (ISP).

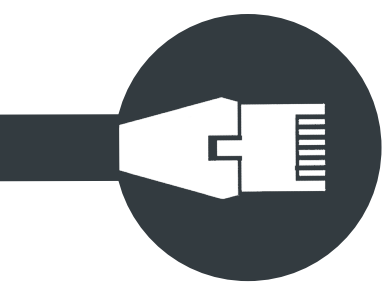
THROUGHPUT

Throughput is defined as the actual transfer rate of data. Your ISP may claim 100 Mbps, but in practice, you may experience much lower speeds (throughput) due to a number of factors beyond your ISP.

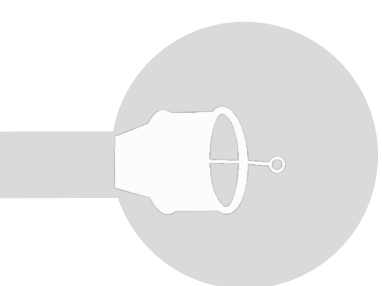
Connection to Your ISP

Your ISP is the company you pay monthly for internet usage. They don’t own the internet, but they do maintain the lines and equipment that provide you with internet access.

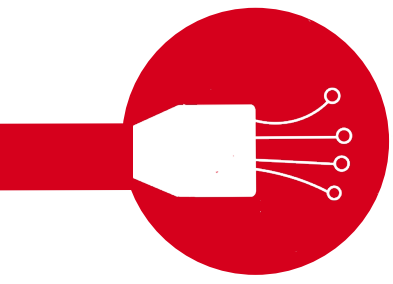
There are three ways ISPs deliver internet to your home or office. Your ISP provides a wired connection through either a DSL phone line, a cable tv line, or a fiber optic line.



Digital Subscriber Line	Bandwidth	Pros	Cons
Same lines used by home or office telephone connection. Many DSL broadband providers bundle internet and phone services together.	10-60 Mbps	Dedicated line (less affected by traffic); More stable speed.	Signal strength diminishes over longer distances.

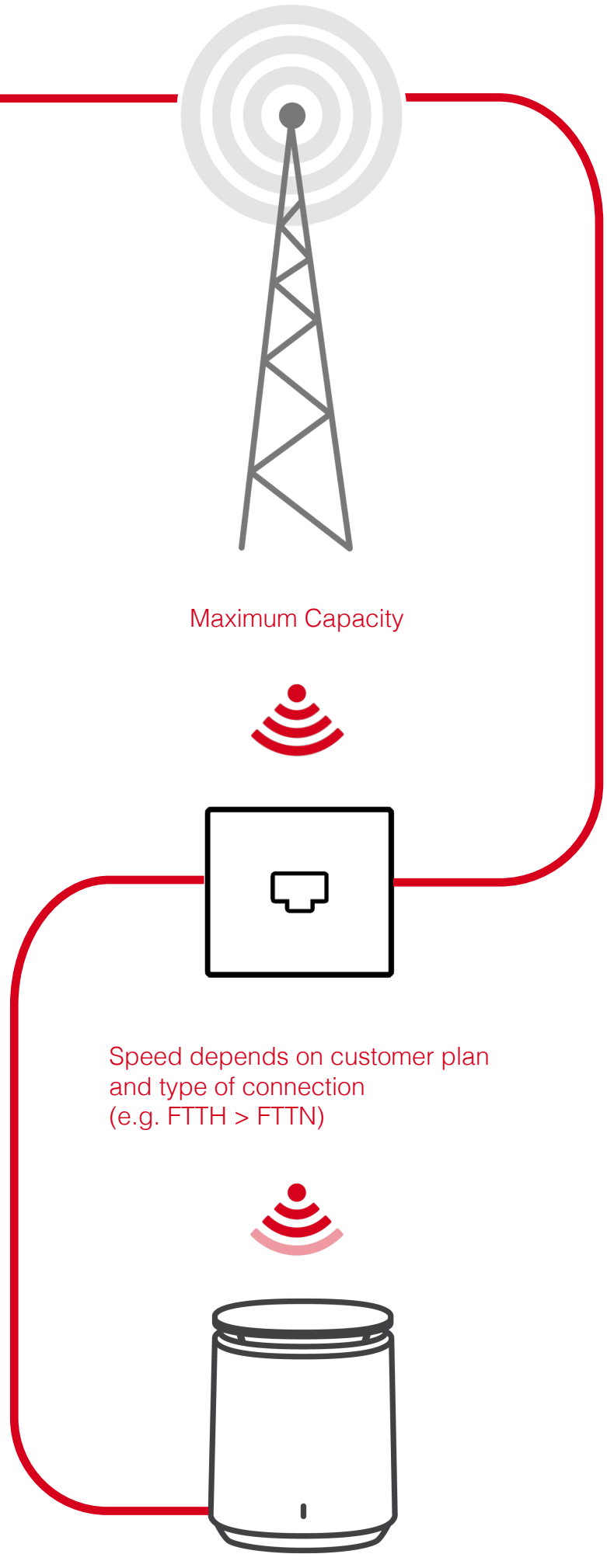


Cable	Bandwidth	Pros	Cons
These lines are the same coaxial cables used for decades by your cable TV provider. Many Cable TV providers also bundle internet services with their TV packages.	30-100 Mbps	Not affected by distance; Faster at low traffic times.	Slow during high-traffic times.



Fiber	Bandwidth	Pros	Cons
Fiber Optic Cable makes up the “backbone of the internet” with information flowing at the speed of light, unimpeded by traffic or distance. Direct “Fiber to the Home” connections are still rare in some parts of the world due to the cost of installation.	100-1,000 Mbps	Super fast, not affected by distance or traffic.	High cost of installation.

Factors that Affect Your Internet Speed



1. Internet Service Provider

The speed of broadband ethernet connection provided by your Internet Service Provider (ISP)

2. Installed Broadband Ethernet Connection

The device connection capacity and processing speed of your Wi-Fi router

3. Gateway Modem & Wireless Router

The signal strength between your device and Wi-Fi router

4. Receiving Device

Can be affected by interference from overlapping radio frequencies

Connection to Your ISP

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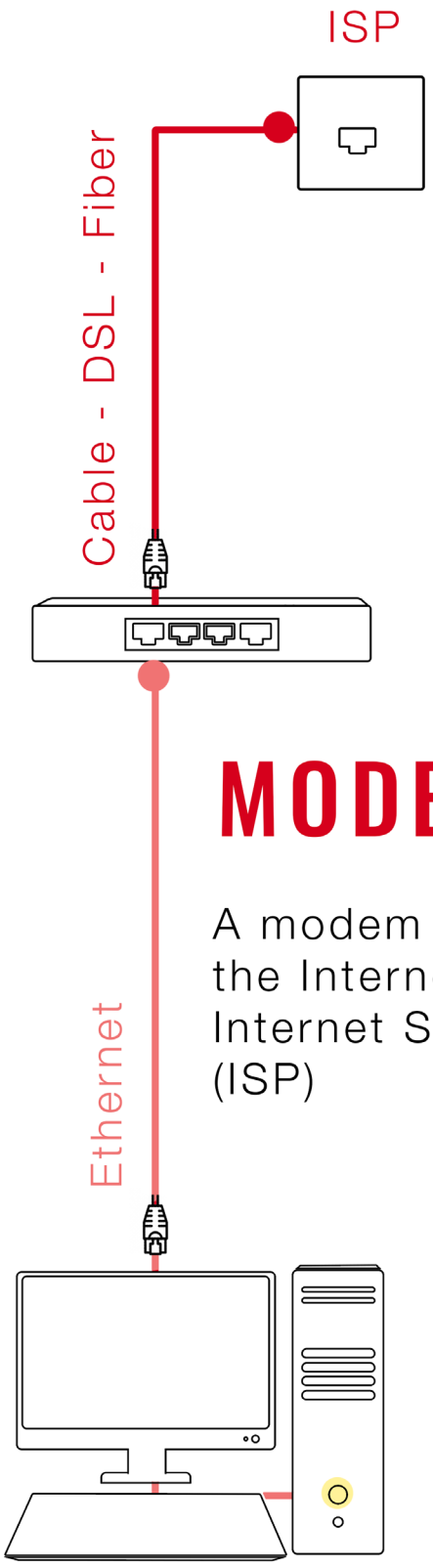
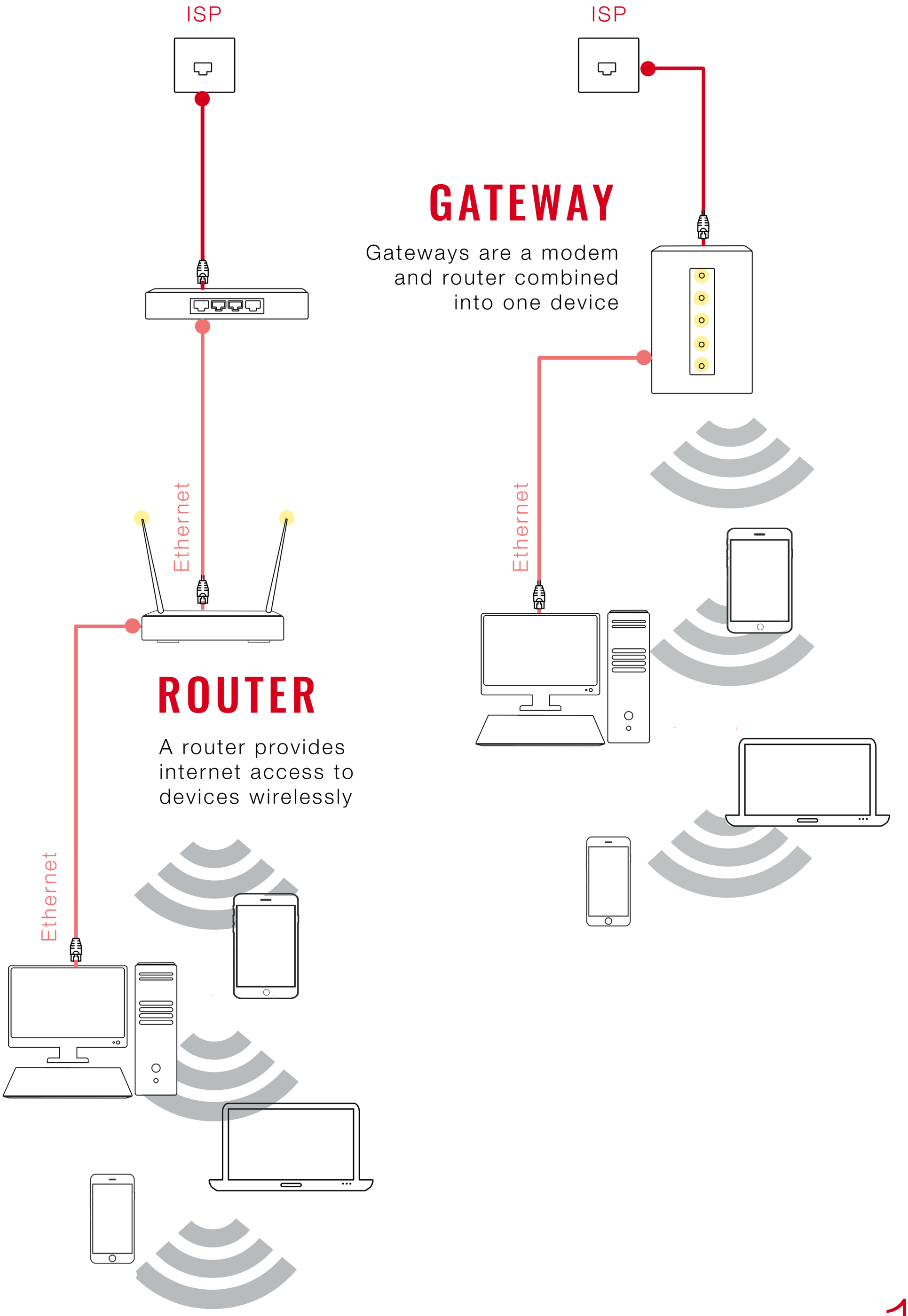


Modem vs. Router vs. Gateway



GATEWAY

Gateways are a modem and router combined into one device

ROUTER

A router provides internet access to devices wirelessly

Competition for Connection

The number of devices your router can support is an important consideration as we strive for increased connectivity in our homes, especially as we deploy a greater number of smart home appliances.

Older routers may only be able to transmit data to one device at a time. When you try to load a website, or do anything requiring an internet connection, you are sending a data request to your router. Your router then relays your request to the wider internet and sends the requested data back to you before it can process the next request, creating a wait time. In homes with few devices, this wait time may be imperceptible because your router accomplishes these tasks within milliseconds.

However, in most homes with multiple computers, tablets, smartphones, and a growing number of smart appliances, these milliseconds can pile up into seconds. If multiple devices are trying to stream content or games, these routers can get overloaded very quickly. To have a functional smart home, we need Wi-Fi that can handle all our demands.

Newer Wi-Fi routers, such as the Mercku M2 Queen, use MU-MIMO (Multiple User Multiple Input Multiple Output). Employing multiple antennas, the router can leverage MU-MIMO techniques to support simultaneous devices' data transmission. Now each device can access and deliver content with greater ease and speed.

For more information refer to Chapter 4.

Signal Strength and Coverage

Though not assisted by tin foil, ritual chants or dances, the signal strength of your wireless router can be negatively affected by:

NUMBER OF CONNECTED DEVICES

FREQUENCY OF SIGNAL

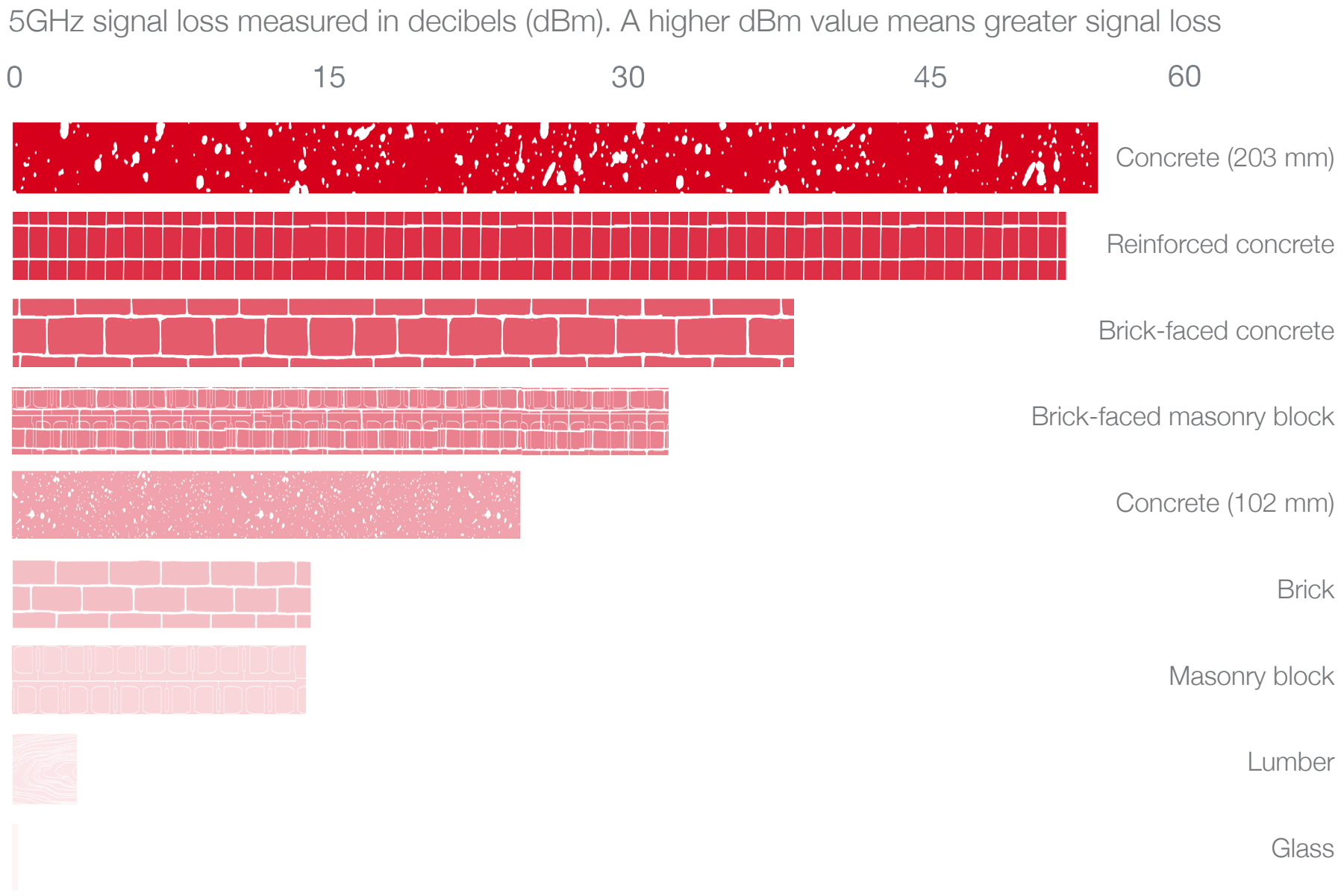
OVERLAPPING OR COMPETING CHANNEL FREQUENCIES

WALLS

DISTANCE TO YOUR DEVICE

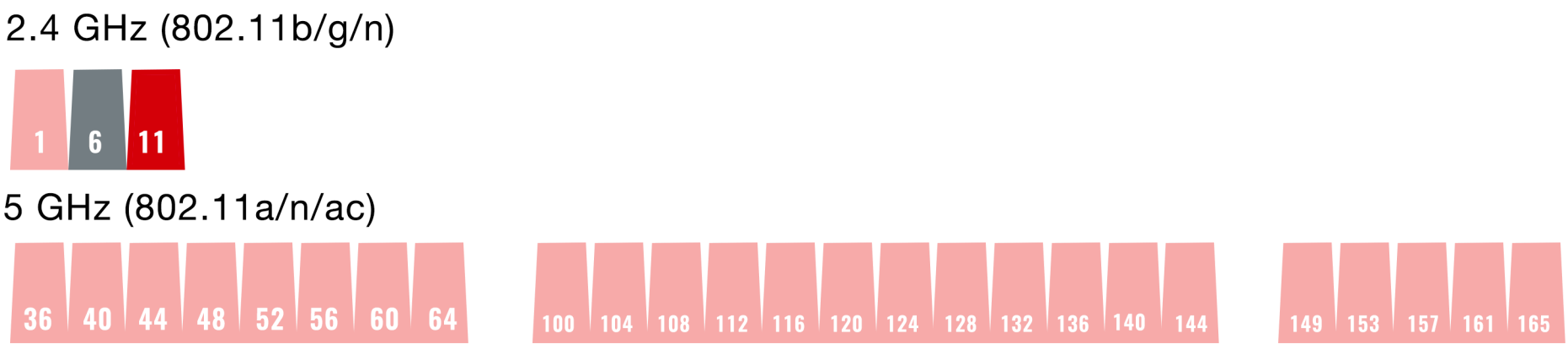
NUMBER OF CHANNELS

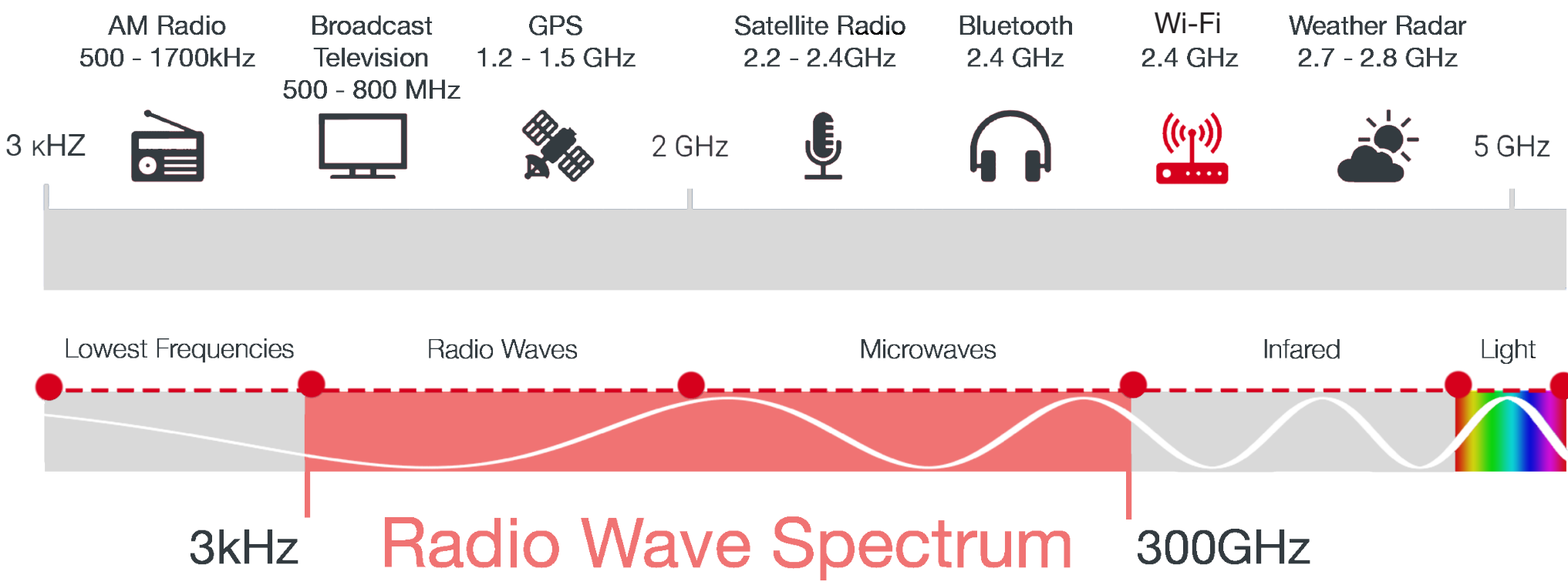
Wi-Fi Signal Loss by Building Material



Wi-Fi Frequencies and Channels

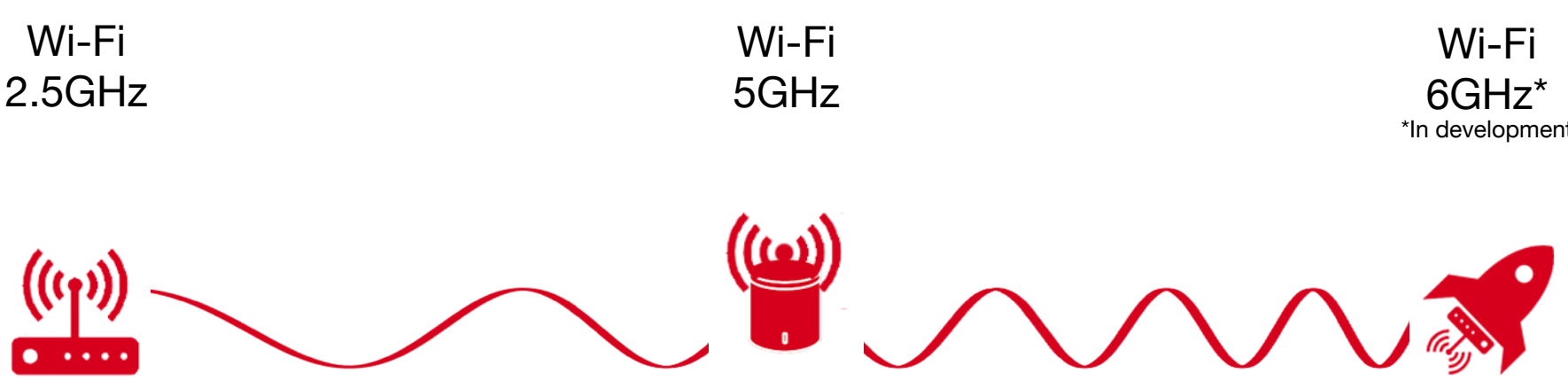
2.4GHz and 5GHz are not 100% exactly on their respective frequencies, but they operate on frequency bands. That's why a frequency band can be split into multiple channels. Below is an overview of the non-overlapping channels within the 2.4GHz and the 5GHz bands.





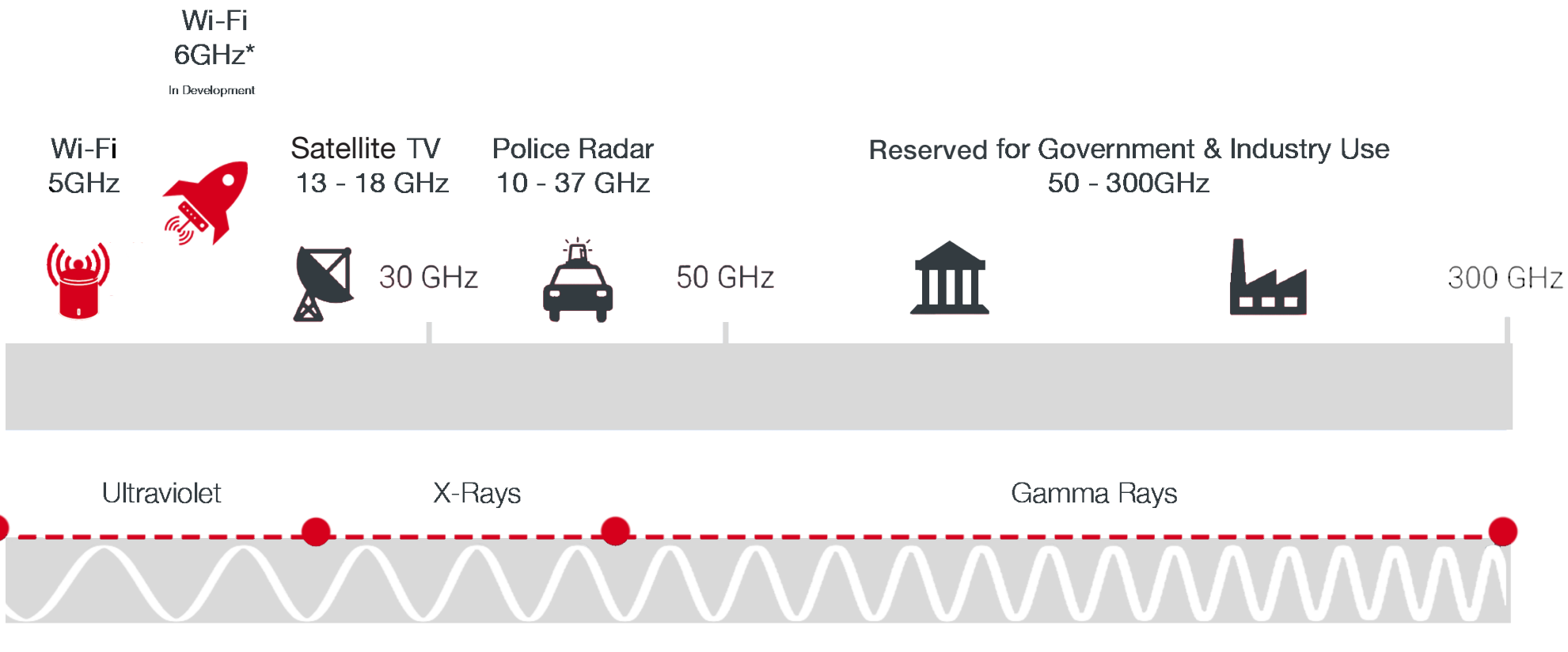
It wouldn't be just a metaphor to liken Wi-Fi to your FM/AM radio, because we're still talking about radio waves! Wi-Fi routers simply have higher frequencies. The frequency of a signal, measured in gigahertz, describes the number of waves, in billions, that pass through a fixed point in one second. Current Wi-Fi routers emit signals with frequencies of 2.4GHz or 5GHz. At the higher 5GHz frequency, data-transfer speeds are faster, but the range of the signal is shorter than that of 2.4GHz signals.

Like your car radio receiver, Wi-Fi routers also have channels. A 2.4GHz signal has only 11 channels to choose from. It's like the AM of radio—lower frequency and less hip—though powerful enough to reach the boonies! 5GHz Wi-Fi is the jazzier and more upbeat successor to 2.4GHz (just like FM is to AM).



"6GHz will help address the growing need for Wi-Fi spectrum capacity to ensure Wi-Fi users continue to receive the same great user experience with their devices."

- Edgar Figueroa, CEO, Wi-Fi Alliance



Interference

If you've ever used an FM radio transmitter in your car for a portable CD or DVD player, you'll know that if you drive into a new town that has an FM radio station broadcasting on the same channel you've chosen for your transmissions, you will experience interference. So, while your kids are screaming for you to fix it, and while avoiding head-on collisions, you frantically scan for FM channels that aren't being used for broadcast. You then reset your transmitter to use a non-overlapping channel. Your kids release you from their threats and go back to watching their movie, while you take three deep breaths and go to a happy place.

It's the same with our Wi-Fi routers, but the channel-switching happens automatically and every few milliseconds to ensure you are using the best connection channel. Your router may not be gripping a steering wheel, but we do sometimes yell at it as if it's a parent withholding our treats, "Not fair!"

Only three channels of a 2.4GHz signal's 11 channels are non-overlapping. This means that if you have four neighbors in close proximity, like in an apartment building, and everyone is using 2.4GHz Wi-Fi signals, the likelihood of at least two of your signals overlapping and interfering with each other is quite high.

A 5GHz signal supports 45 unique channels, 23 of which are non-overlapping. The chances of interfering with a neighbor's Wi-Fi radio frequency goes down dramatically for two reasons: one, because your router will automatically choose the channel with the least interference, and two, because the signal power at long distances trails off significantly.

Internet Addresses

Unlike your car radio, which only acts as a receiver, your internet-connected device acts as both a receiver and a transmitter. For effective communication, every connected device must have a unique address. This ensures data is not incorrectly sent to the wrong person's phone or computer. This "address" is determined by two numbers: your IP (Internet Protocol) Address, and your MAC (Media Access Control) Address.

An IPv4 IP address is a 32-bit number assigned by a DHCP server (Dynamic Host Configuration Protocol) or set manually, that identifies your LAN. In other words, an IP address tells the internet where you are (at home, in an airport, at a coffee shop, on the go).

Your MAC (Media Access Control) Address is the hardware number that is unique to your device. It's your device's fingerprint. Your MAC address is the way you tell your nearest DHCP server, and the Local Area Network, who you are.

What's a DHCP Server?

Your Wi-Fi router acts as a DHCP server and dynamically assigns unique IP addresses to the devices in your LAN. If your computer acts as a server (hosting websites, cloud services, etc.), then you may need to request a static IP address. You can change this in your router's settings.

Another way to acquire an IP address is through PPPoE (Point-to-Point Protocol over Ethernet). PPPoE is used by ISPs and this connectivity method usually requires username and password level authentication.

Your Wi-Fi router is the Wireless Access Point (WAP) between your device and the internet. Every AP (wireless or other) has its own MAC address and SSID (Service Set Identifier). The SSID of your router is also known as the network name, which is the name you see in the list of wireless options when you turn Wi-Fi on for your device. For example, "Jones Home" if you've changed the name in your router's settings, or "Mercku-1234" if you've just kept the preset SSID name straight out of the box.

Chapter 3
Wi-Fi System Solutions

So now you have an overview of what Wi-Fi is and how it works. But how do all these concepts affect you? A good starting point would be for us to understand what Wi-Fi can do for us, and which system is the best for the job.

Picture this. You're a restaurant manager, and you've just upgraded your Wi-Fi hotspot with a shiny new mesh Wi-Fi system such as the Mercku M2 Swarm. Your customers obviously benefit from free high-speed internet to post their food pictures on Instagram. But how can you get the most benefit for your business? Do you set up a password or let people freely access the network? Do customers need to enter their email address or Facebook account and grant you permission to contact them with marketing offers? Wi-Fi solutions can be configured to meet each business's specific goals.

Choosing the right Wi-Fi system for your needs can feel overwhelming with the number of products available in today's market. To help you make an informed decision, we have outlined the major types of systems that are available.

Dual-Band Systems

Dual-band systems are currently the market standard and have, (you guessed it) two bands. One band operates at the 2.4GHz frequency, and the other at the 5GHz frequency. The 5GHz band is what makes dual-band routers an outstanding improvement that has allowed them to largely replace single-band routers, which usually had only the 2.4GHz (and in some cases a single 5GHz) band.

It may be helpful to think of these two channels as highways. The 2.4GHz highway is older, frequently used, and has fewer lanes. Comparatively, the 5GHz highway is freshly paved, has extra lanes, and less traffic. For this reason, the 5GHz highway will be moving faster. The same applies to network traffic; The 5GHz band is faster and more stable.

Although not exclusive to dual-band, many routers from this generation enable MU-MIMO (“Multi-User, Multiple Input, Multiple Output”). This means that these routers can handle more clients efficiently by reducing network interference between competing requests. These systems also provide twice the bandwidth of single-band routers.

Tri-Band Systems

To further reduce signal interference, some routers use tri-band technology, which adds a second 5GHz band. Each 5GHz band supports gigabit speeds, and these routers offer three times the bandwidth of single-band routers.

The 5GHz frequency bands can also be used for internal system communication between the different nodes in Mesh Wi-Fi systems, also known as “backhaul”. Leveraging this approach, tri-band mesh Wi-Fi systems are able to reserve full capacity on the 2.4GHz and 5GHz bands for device communication, achieving the highest possible speeds.

At this point in the market, tri-band systems are significantly more expensive. Individual users will have to assess whether the upgrade is worth the extra price – for example if you are planning to connect a large number of 5GHz compatible devices.

For large homes or office spaces, where the strength of one Wi-Fi router is insufficient to provide a strong signal throughout, there are generally three solutions: **Wi-Fi extenders , Powerlines, and Mesh Wi-Fi**.

Wi-Fi Extenders

Wi-Fi extenders are one of the most common solutions to expand a Wi-Fi signal across a large area. Traditional Wi-Fi extenders are small and relatively inexpensive units that can be easily installed by simply plugging them into a wall socket within the range of your router to boost the reach of your router's signal. However, the extender will only boost range, not signal strength meaning you won't get the same speeds you would from the main router.

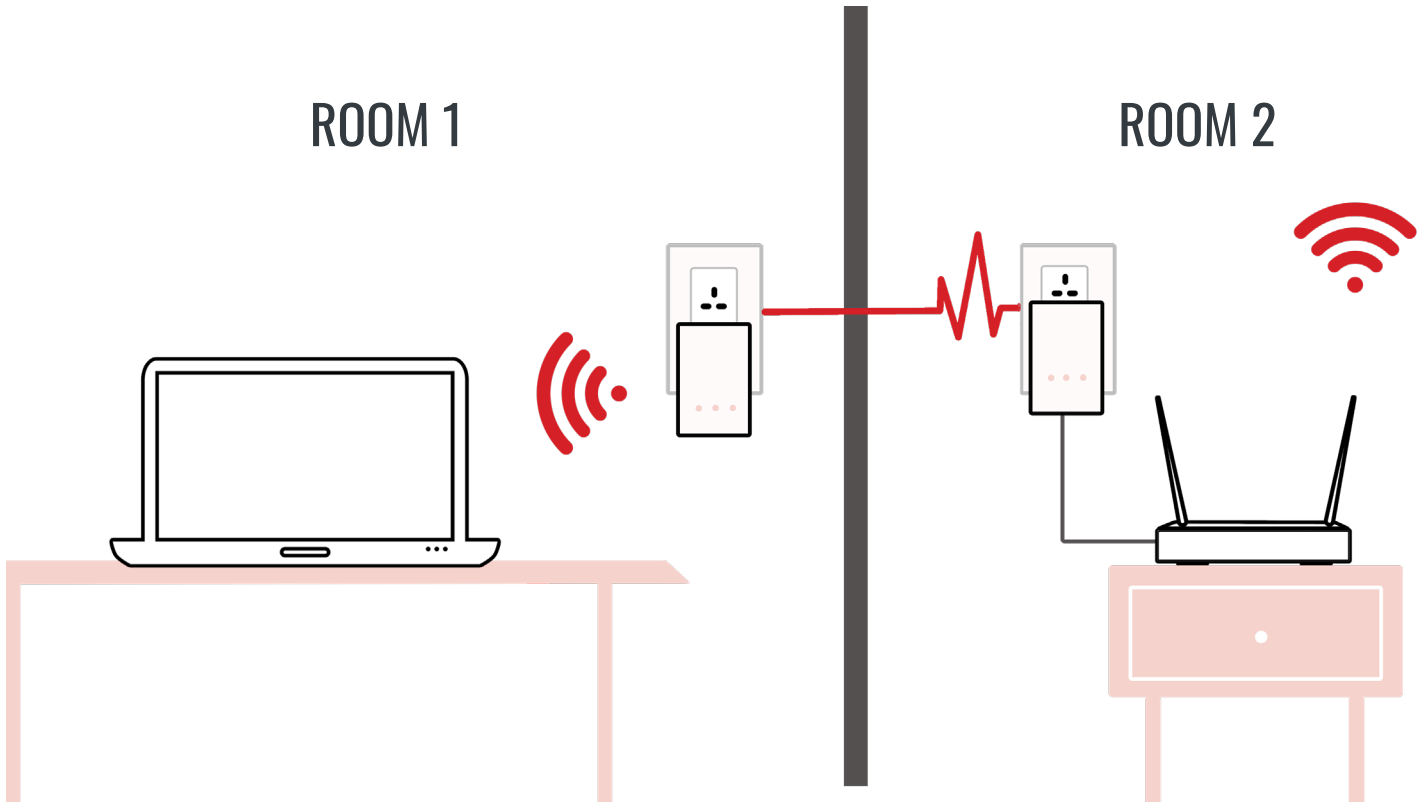
Even while operating off the router's AP connection, each extender has a different SSID and operates as a separate WAP effectively setting up separate networks for your devices to switch between. When you move outside the range of one extender and into that of another, you may experience short periods of disconnection as your device searches for and reconnects to the closest unit.

The signal will have degradation because it is beamed to another location, which can add latency and lower overall speeds. Your home setup (walls, furniture, or ceilings) can also result in additional signal degradation.

Powerlines

Powerline adaptors connect to your router wirelessly or via hard-wire, and leverages your electric grid to send your Wi-Fi signal to different rooms. This allows the signal to travel further and ignores the impact of walls on signal degradation. In terms of performance, powerline adaptors are superior to Wi-Fi extenders, however, they are still not as fast when compared to a hard-wired LAN solution since the physical connection between router and device is missing.

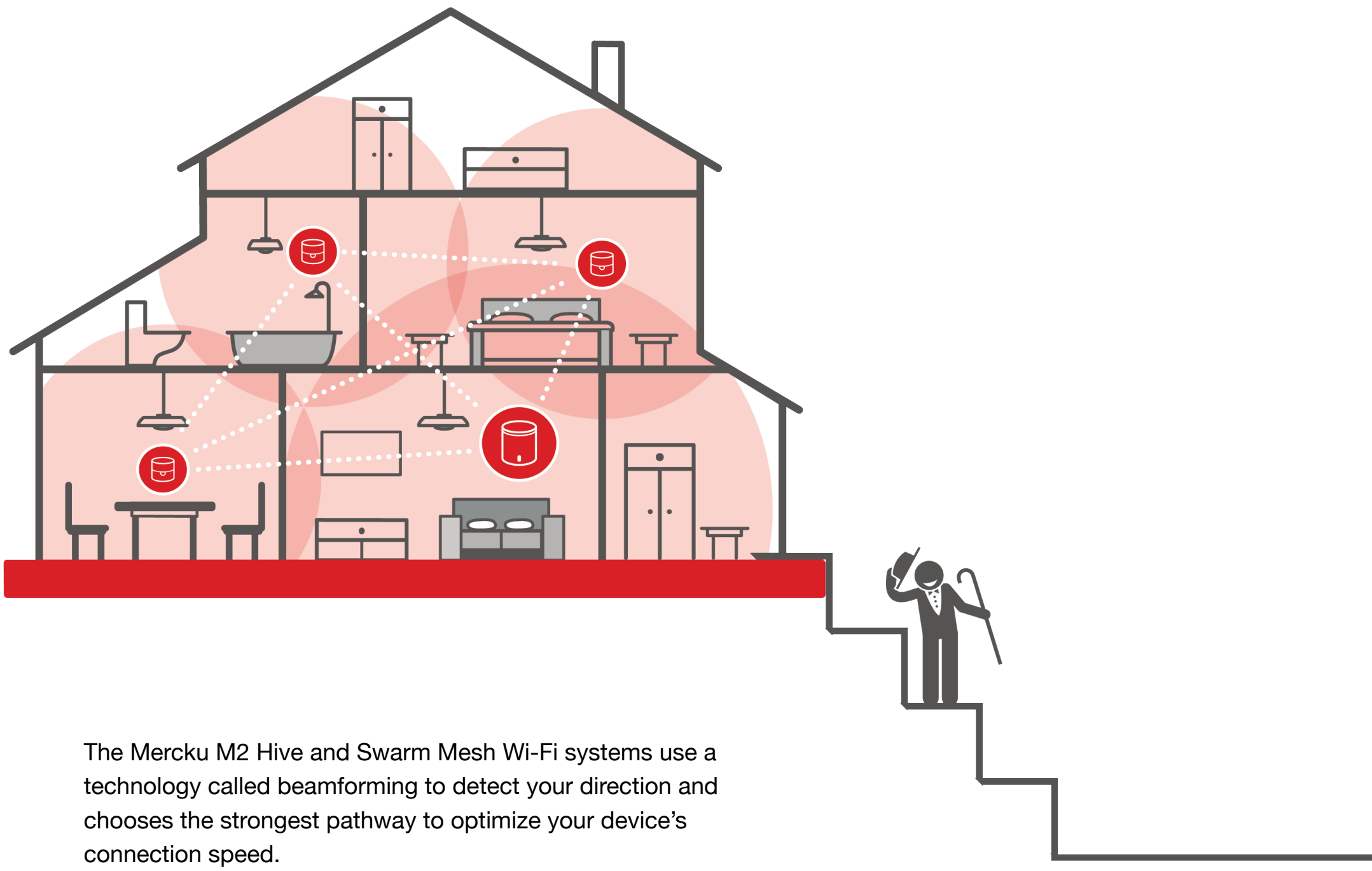
It should be noted that the performance of a Powerline solution is strongly dependent on your home's electric wiring, which means it's not suitable for every home. To set up this system no skills are required. It's a simple plug-and-play setup to extend the signal, with no impact on your home's electrical system.



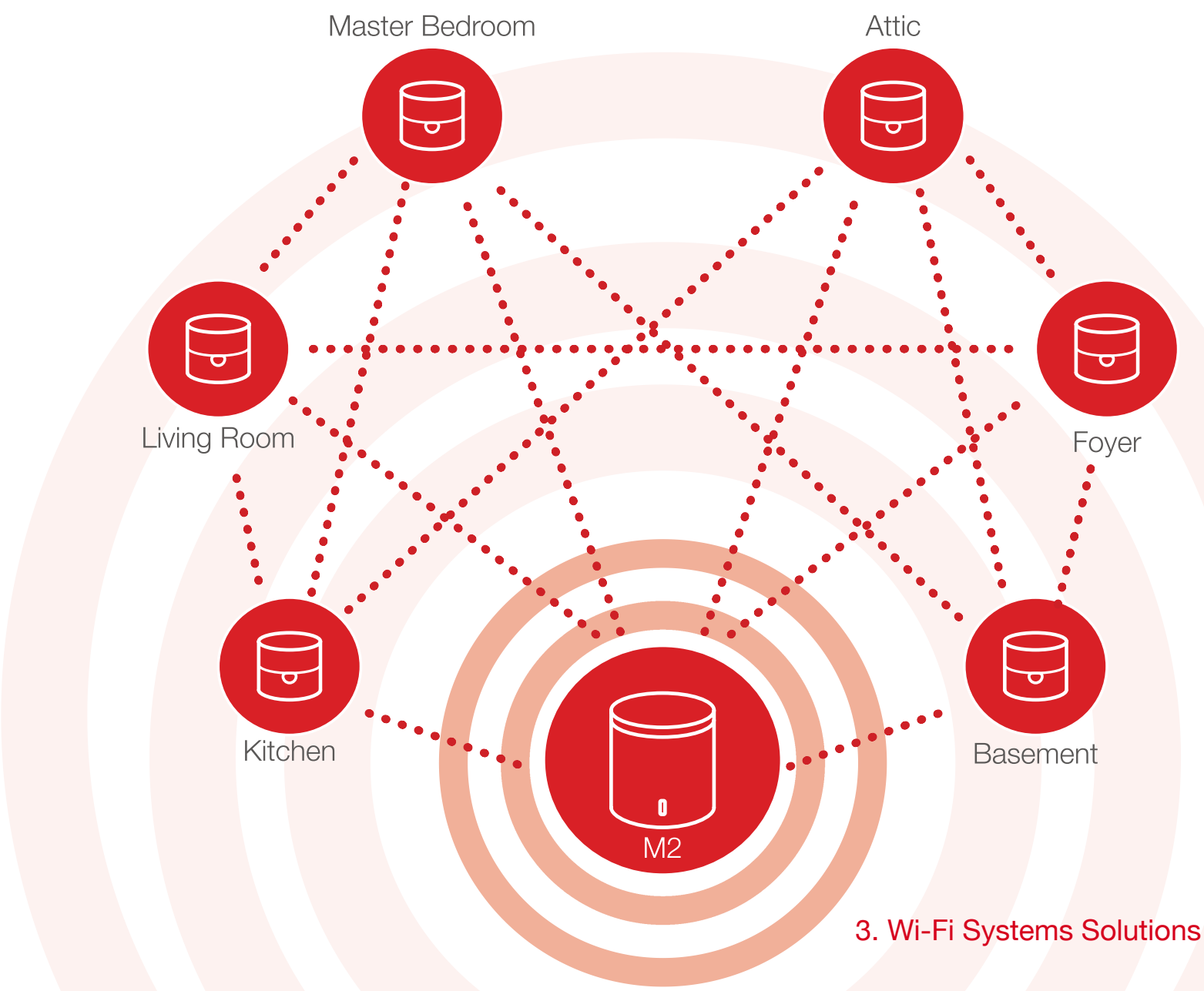
Mesh Wi-Fi

Mesh Wi-Fi employs a central router (or mesh point portal, MPP) and multiple "node" units (or mesh points) that can be installed throughout a large space. However, unlike the signal extenders we discussed above, the units form one seamless and unified "mesh" signal that extends the reach as well as the strength of connectivity to the mother router. When you walk from one room to another, your device maintains a connection to the same SSID and doesn't experience any hiccup in connection.

Additionally, each unit (or node) also acts as a unique Base Service Set (BSS). This means that you can set parental controls and other parameters (like blacklisting certain websites or set time limits, etc.) for each individual unit. The units can also be rearranged to strengthen the signal in areas with heavier usage, and the mesh network will again be automatically reframed. With a shared SSID, the same security protocol for your device's connection to the internet remains consistent throughout the entire mesh network.



The Mercku M2 Hive and Swarm Mesh Wi-Fi systems use a technology called beamforming to detect your direction and chooses the strongest pathway to optimize your device's connection speed.



Wi-Fi 6 Systems

Recently, there has been a lot of buzz around Wi-Fi 6, however, most consumers are not aware that there has been a Wi-Fi 1 through 5. Wi-Fi 4 (or “802.11n”) came out in 2009, and Wi-Fi 5 (“802.11ac”) has been the standard since 2014. So why do we need the 6th installment of Wi-Fi? Because user demands are continuously increasing.

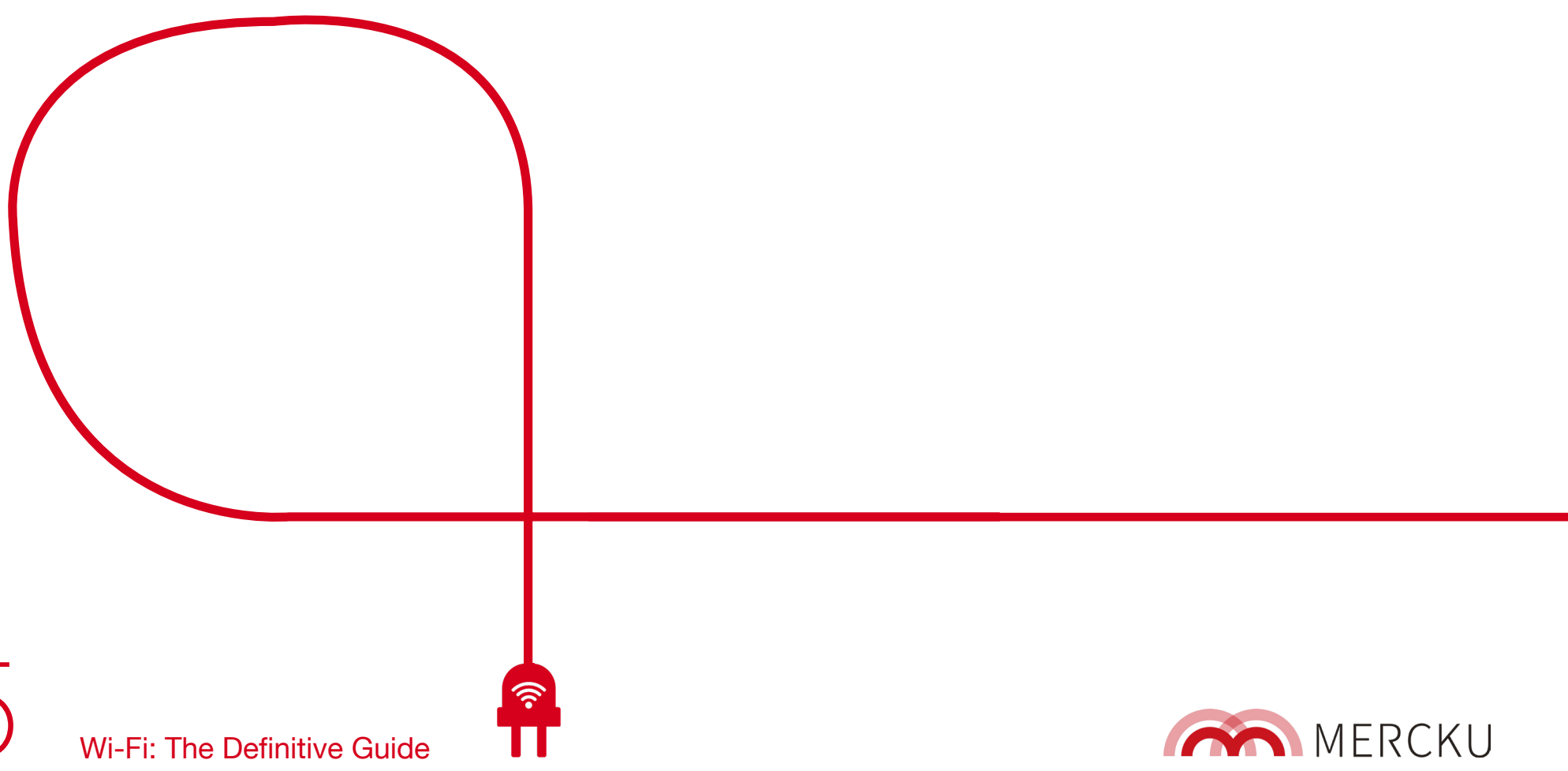
Wi-Fi 6 uses more efficient data encoding, meaning each packet of information that’s transferred in a radio wave contains more information and thus, increases throughput. To return to our highway analogy, think of it as packing more passengers into the same size car on a highway without any increased discomfort or reduction in speed. It still occupies the same volume, but there’s more data being delivered.

Wi-Fi 6 promises longer battery life for your Wi-Fi enabled devices due to the target wake time feature. Your AP can now talk to your device and tell it when to be receptive to radio waves and when to “sleep”. This will also aid IoT devices to consume less power.

Furthermore, Wi-Fi 6 will increase performance in areas with high demands for Wi-Fi. Hospitals, hotels, concert venues, and stadiums often have incredibly slow Wi-Fi because of the number of users on the network. Wi-Fi 6 should alleviate if not eliminate congestion in areas with a high density of users. Now imagine you’re a stadium manager. How can you offer event attendees a more personalized experience? Not only can you gather marketing data from having a gateway sign-on where clients enter their email or phone number, but by launching a stadium app, you can gather additional data. You can now send attendees notifications to encourage buying concessions and to make their experience more personalized.

While Wi-Fi 6 seems like an amazing improvement, most users aren’t quite ready for it yet. Remember how we thought of Wi-Fi bands like highways? Wi-Fi 6 would be like driving a rocket down the highway to get to work. Super cool, but very unnecessary. Not to mention, relatively few devices support Wi-Fi 6. To add just one more analogy, at this stage Wi-Fi 6 is like 8K TVs when there isn’t any content available in that resolution – capable of amazing performance which will be unnecessary until the rest of the industry catches up to support it.

For more on Wi-Fi 6, see Chapter 6.



RF-Sensing Systems

If you thought the new capabilities of Wi-Fi 6 are cool, wait until you get a load of Radio-Frequency (RF) sensing – one of the latest breakthroughs in wireless technology being pioneered by Mercku. Wi-Fi signals are so sensitive that they can detect subtle changes in an environment including some of the biological functions of the human body. For example, you could actually use Wi-Fi to monitor a user's heartbeat and breathing without the uses of sensors, wearables or implants. If that's not incredible enough, there are even more applications for RF-sensing:

Health monitoring:

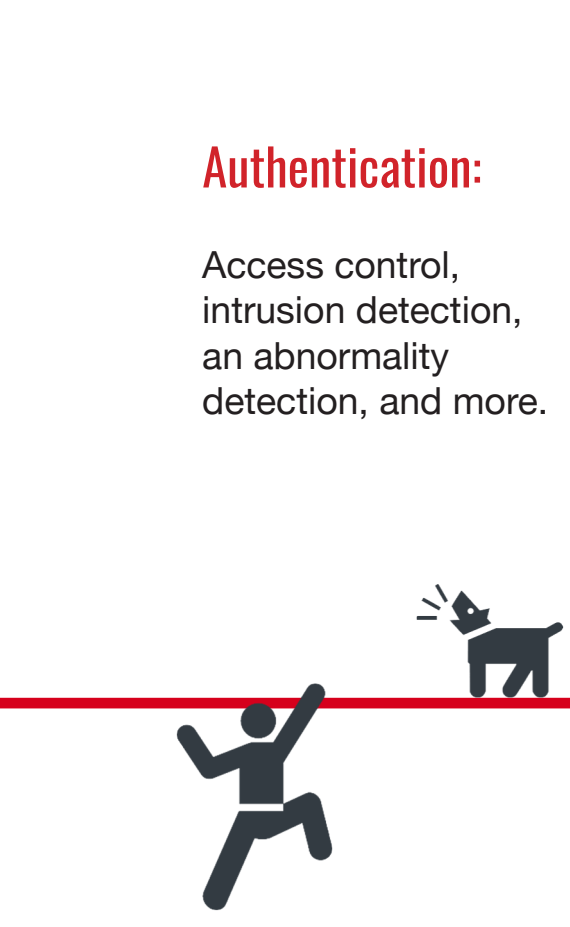
Heartbeat detection, respiration rate monitoring, sleep apnea detection, fall detection and more.

Gesture Recognition:

Human activity recognition, keystroke detection, sign language detection, lip motion recognition and more.

Authentication:

Access control, intrusion detection, an abnormality detection, and more.



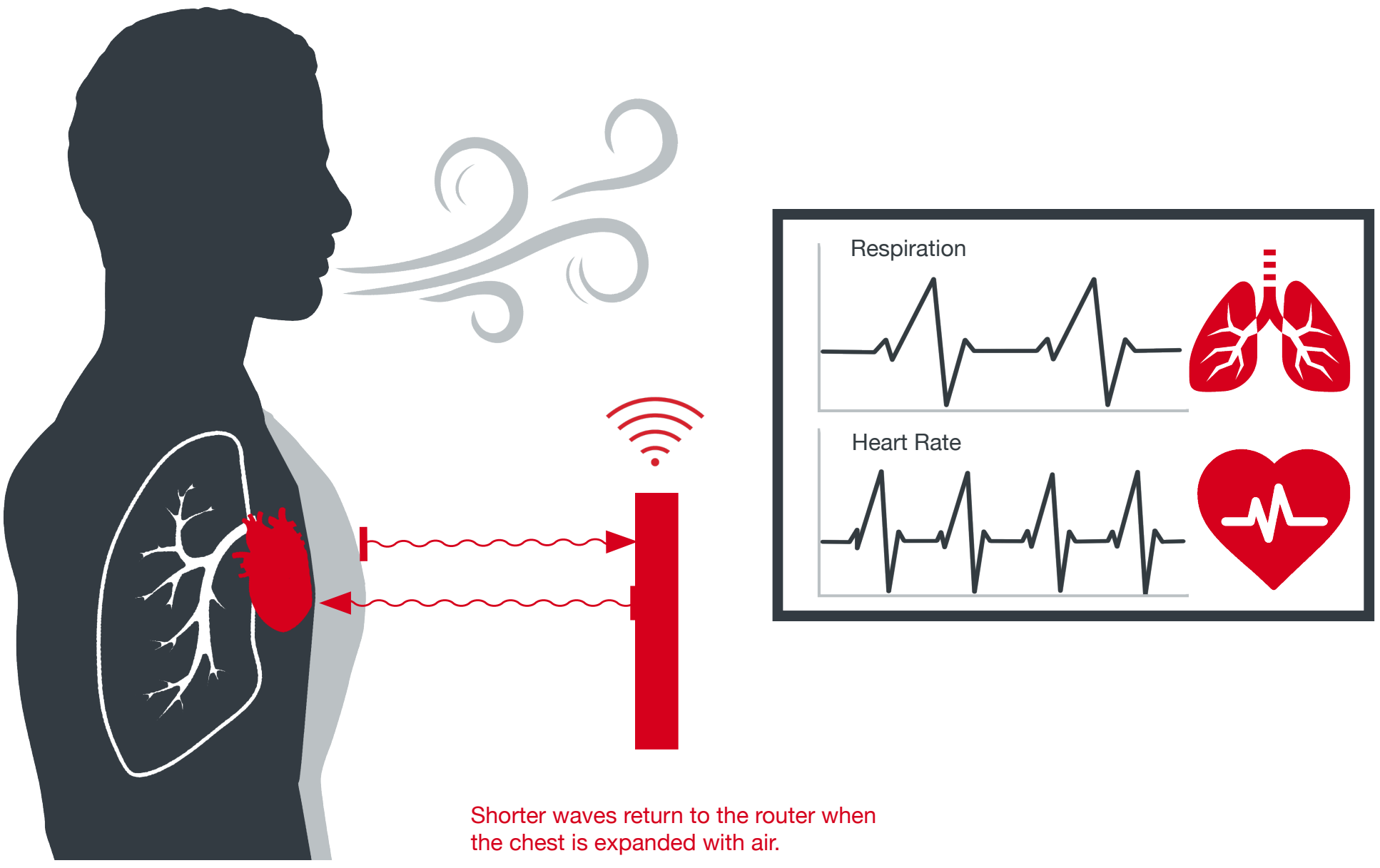
Contextual Information acquisition:

Location, direction finding, range estimation, and more.

Not only is this technology cost-effective and convenient to deploy due to the ubiquity of existing Wi-Fi infrastructure, but it is also completely non-invasive. You don't need wearables or image capturing technology to gather data. Furthermore, with the right software, an RF-Sensing system will be trained to recognize its users and to understand long-term patterns. The system can then detect and report any unusual anomalies and alert users or their medical providers. For example, if you consistently leave your home for work during the day, the RF system will learn that nobody is home from 9-5 on weekdays. If one day, someone enters your house unsuspectedly, your system can send you a notification alerting you to the possibility of an intruder. By integrating the system with your smart home technology, there are even more application possibilities.

If you're more technically minded, you may be wondering how this is even possible. Let's consider respiration rate monitoring. A radio signal is sent from your Wi-Fi device out into the environment. When you inhale, your chest inflates, making the distance from the radio signal's origin to its destination shorter. When you exhale, the radio signal needs to travel further and will experience more path loss. By monitoring these variances in the radio signal, your RF system now monitors your respiration rate. Over time, the algorithms in the system will learn what is normal for you and take motion into account (e.g. during exercise). So, if you have an allergic reaction and your respiration rate suddenly changes drastically, your RF-Sensing system could be programmed to respond by dialing 911.

RF Wave Path



Shorter waves return to the router when the chest is expanded with air.

Advanced Wi-Fi Functions

Another factor to consider when selecting a Wi-Fi system or router is which advanced functions are enabled in the product.

1. Does the Product Enable a Guest Wi-Fi Network?

Guest Wi-Fi is a separate Access Point (AP) on your router with a different network name and password that provides a connection to the internet, but not to your local network. If you're worried about network security, setting up a Guest Wi-Fi network is probably a wise precaution. If you're sharing your network with unfamiliar devices, any malware they contain may be capable of spreading through your local network. Connecting these devices to a Guest Wi-Fi network keeps your files, data, and personal information safe. It is also recommended to connect all smart home devices to the Guest network. In the unlikely event that any of these devices are compromised, only data on the guest network will be revealed.

2. Which Parental Controls are Included?

Parental controls include blacklisting websites or devices. Blacklisting a website makes it inaccessible to any device on the network. Blacklisting a device makes it unable to connect to the network. You can also set bandwidth limits, essentially limiting "how much" internet can be used. Often, there are options to schedule usage times or to pause the internet. There are also devices you can use as add-ons to your router to enable additional controls. For example, there are apps that allocate internet usage to kids as a reward for completing their chores.

3. How Modular is the System?

The modularity of a system determines its range, performance, and how easy it is to set up. Traditional Wi-Fi systems consist of one router which sends a signal radially outwards. Mesh systems offer an improvement as they use nodes, which are all Basic Service Sets, to expand the area covered by your network. When a user requests data from your network, the data follows the quickest path from the main router, hopping along as many nodes as it needs to reach the device. Increased modularity increases the range of your network and the number of paths available for data. It's like increasing the number of highways running through a city. Now there are more optimal paths to get from point A to point B.

4. How Easy is it to Manage Your System?

Some routers can be managed using a mobile app or a web portal. Simply signing in gives you access to all your network settings, allowing you to independently configure and control your network. Mercku's app makes setting up your system and optimizing its configuration incredibly simple.

5. Does the Product use Beamforming?

Generally, when routers send information in the form of radio waves, these waves propagate radially in all directions. However, beamforming makes the data transmission process more efficient by identifying a device's direction and focusing the wireless signal towards the specific device. This allows your Wi-Fi signal to be stronger, faster, and have a longer range.

6. Does the Router Offer Smart Connect?

Smart Connect places both the 2.4GHz and 5GHz band in the same network. By enabling Smart Connect, it's like sticking the 2.4GHz highway next to the 5GHz one, making a superhighway. You have now decreased traffic by increasing the number of lanes, and your devices don't have to change highways to switch bands; they only need to switch lanes. Sometimes it may be beneficial to disable Smart Connect to force certain devices to stay on one band and not overwhelm the other. Some smart home devices like smart plugs can only connect to the 2.4GHz band in which case you would have to disable Smart Connect to set them up.

The Merku Smart Connect function uses both 2.4 and 5GHz frequencies and combines them into a common SSID. The units automatically switch between the two bands based on your devices' need for speed. When turned on, the mesh network will decide which signal will provide a greater speed and will connect to it automatically. When disabled, the default connection band is 2.4GHz.

5G and Wi-Fi

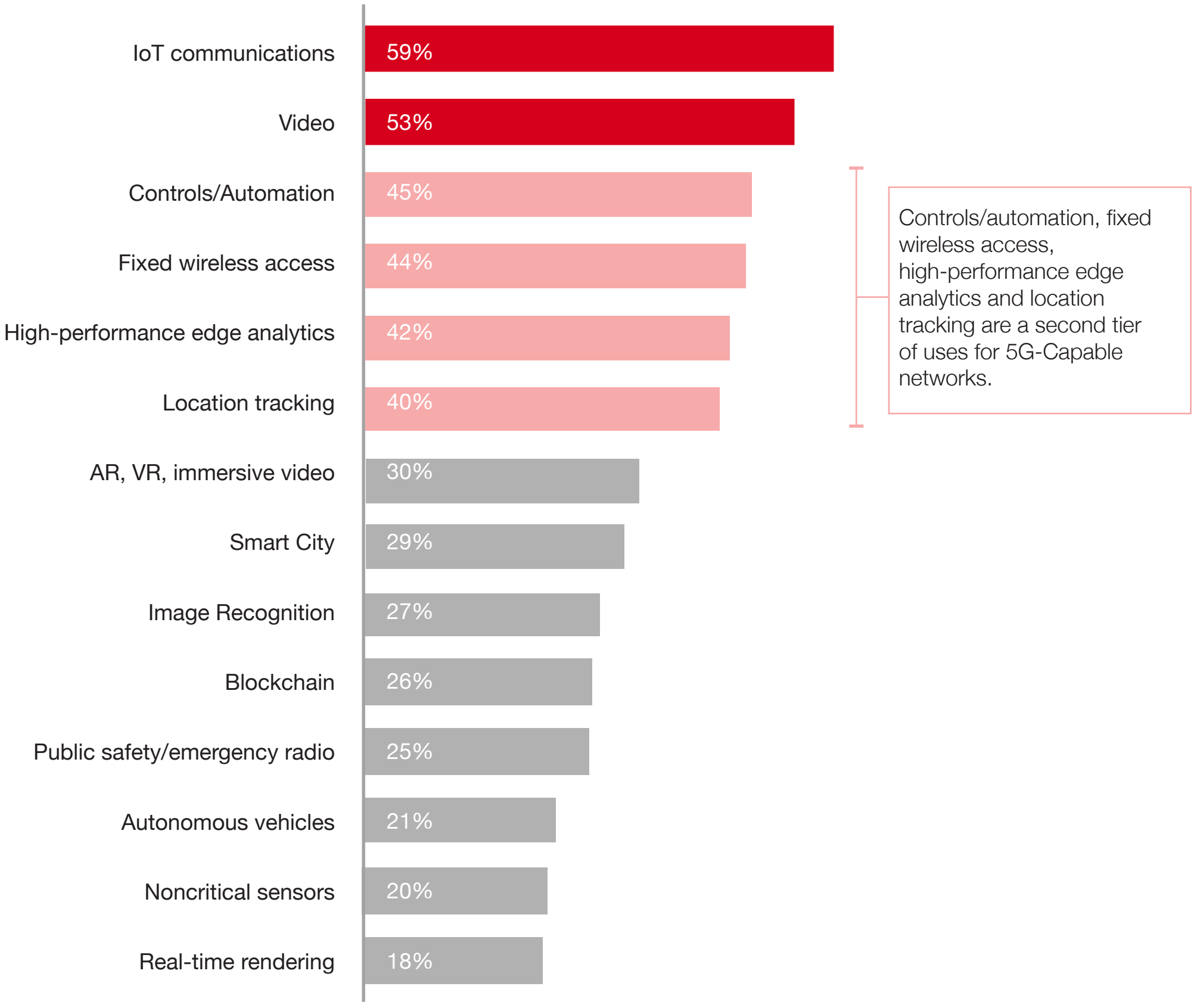
While it's often talked about in the same conversations as Wi-Fi, 5G is a cellular connectivity standard that is the successor to the 4G LTE and 3G standards. The new standard is expected to be business and enterprise-focused, enabling more business models using IoT and analytics, not to mention encouraging the development of smart cities. Despite the recent marketing pushes for new generations of 5G-enabled smartphones, the use cases for consumers are not clear other than increased speeds and better video streaming. The price of 5G network equipment and end-user devices are still being determined by the market.

Since Wi-Fi operates on the 2.4GHz and 5GHz bands, you often see networks named "John's Network" and "John's Network – 5G". The abbreviation 5G concerning Wi-Fi is a shortened way to say 5GHz and is unrelated to 5G as a cellular standard.

There is a debate as to whether 5G will replace Wi-Fi as it increases speeds and bandwidth over mobile, but Wi-Fi isn't going anywhere anytime soon. Millions of Wi-Fi-only devices will continue to exist for the foreseeable future. Furthermore, the Wi-Fi market is continuing to grow, and all the infrastructure is established. It's easier to deploy Wi-Fi and controlling or updating your network can be done independently and at a low cost. Wi-Fi and 5G will likely establish a co-existent relationship as Wi-Fi will enable more 5G use cases.

Expected Uses for 5G

Percentage of respondents



Base: n=176, Gartner Research Circle members/external sample. Excludes “don’t know”. “Other” not shown. QA07. In your opinion, how will organizations like yours potentially use 5G-capable networks? Please select all that apply. ID: 370129. Source: 2018 Gartner. Inc.

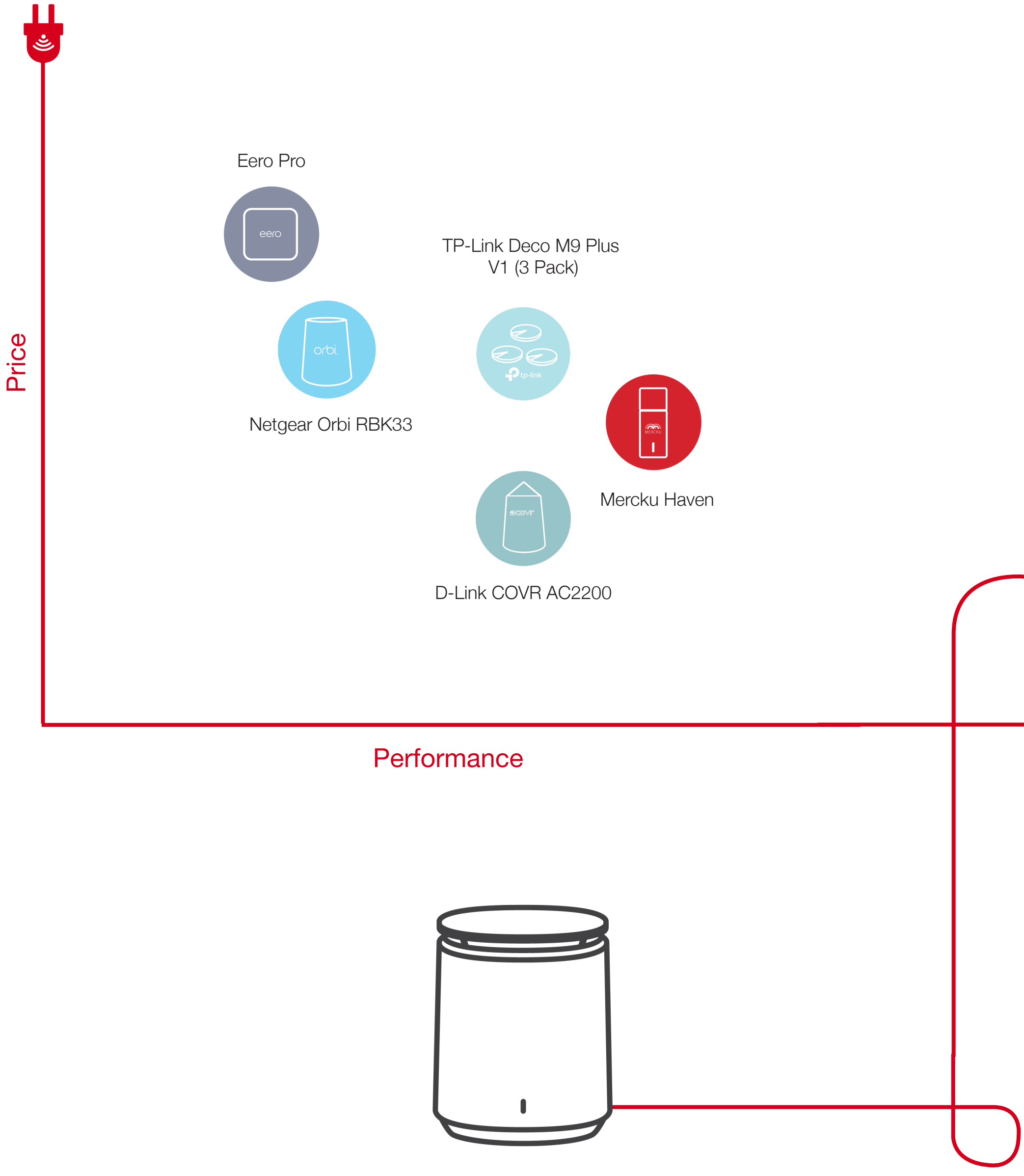
Router Comparison

Even now that we've outlined the types of systems available on the market, choosing a router can be overwhelming. In addition to price, some other factors to consider when you're deciding on a product include:

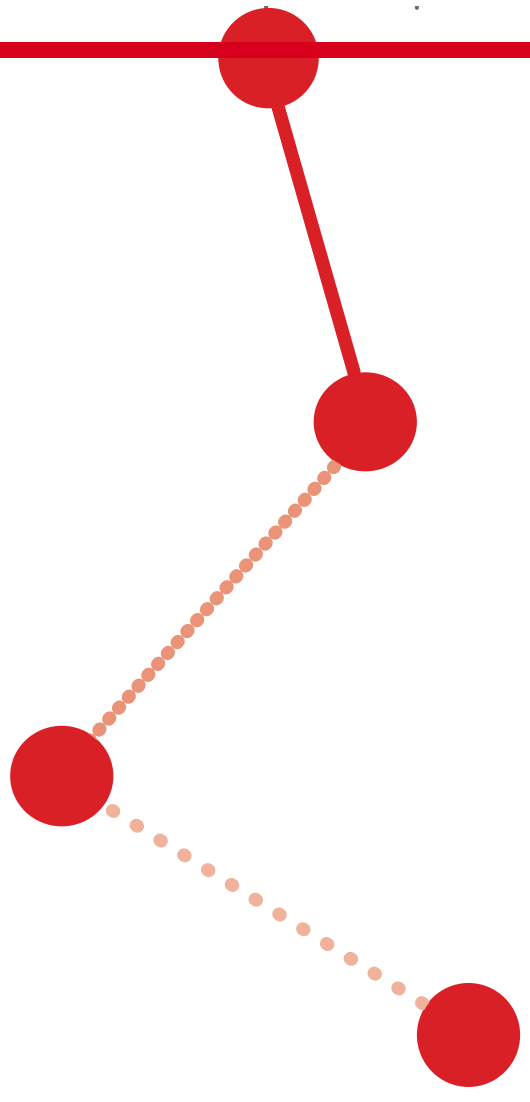
1. Promoted Wi-Fi Coverage Area
2. Available Bandwidth (Speed)
3. Mesh Versus Traditional Set-up
4. Intelligent Wi-Fi Solutions
5. Device Management

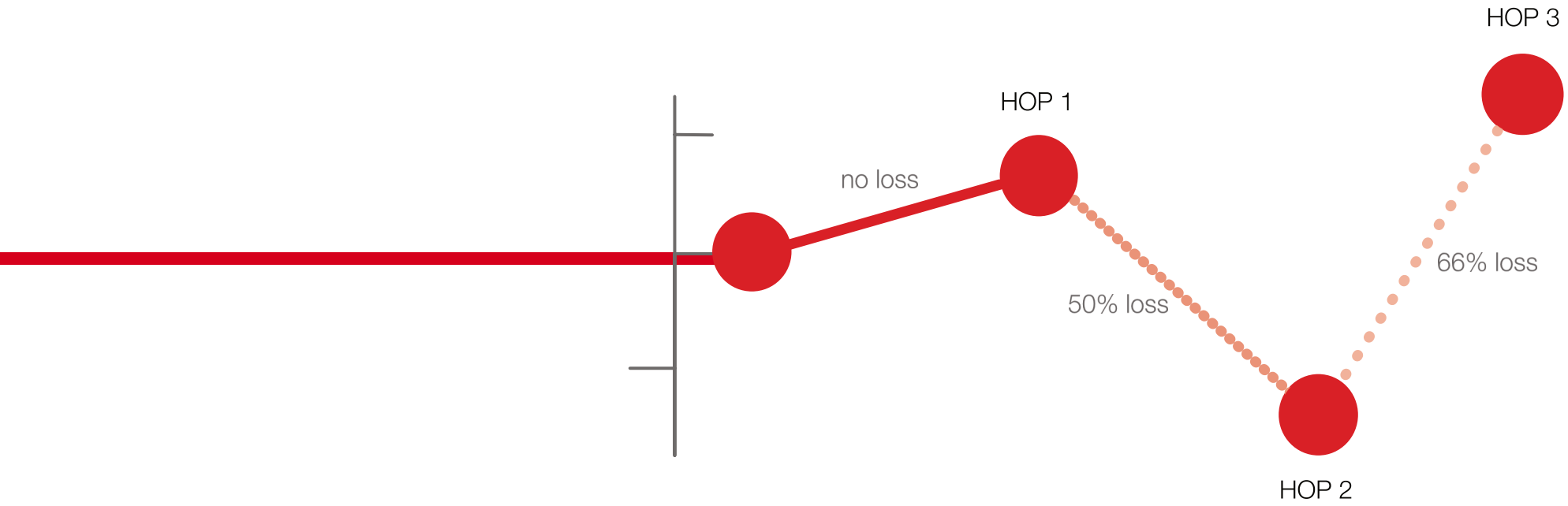
Dual Band Products

Tri Band Comparison



Chapter 4
Wi-Fi Advanced





Mesh in Depth

The Mesh Wi-Fi Standard

IEEE 802.11s is an amendment to the 802.11 Wi-Fi protocol created to enable the mesh networking standard. It defines how wireless devices can connect to create a WLAN mesh network. It is an open-source standard, which connects wireless devices without separate connectivity infrastructure. It operates on the data layer, and ensures all nodes see each other on this layer.

Deployment Considerations

To optimize the performance of a Mesh Wi-Fi system, it is important to deploy it according to the manufacturer's instructions.

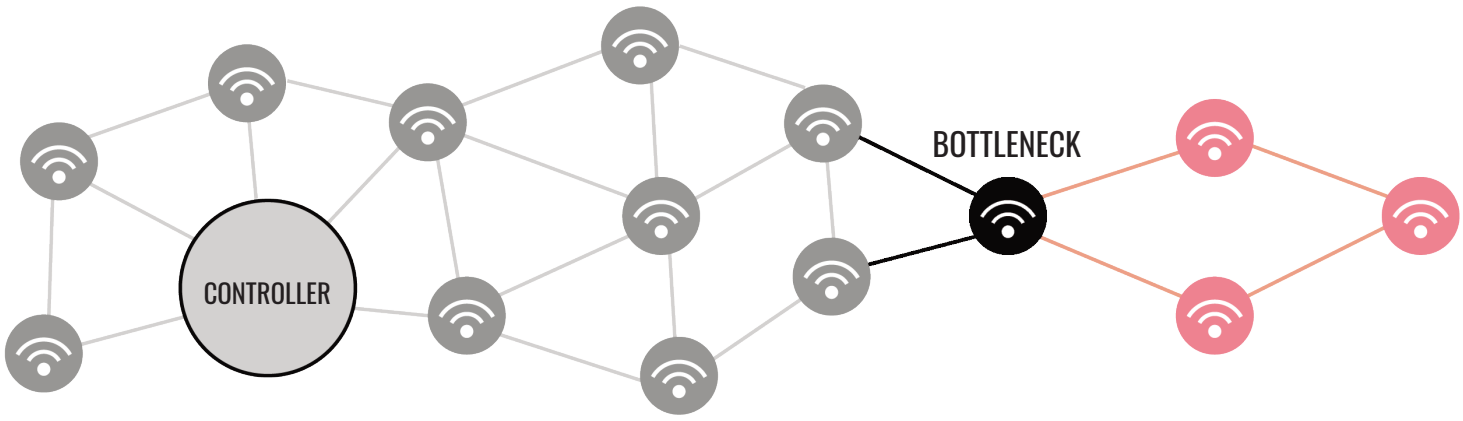
The first consideration is the number of "hops". What does that mean? When data is propagated through a network, it needs time to be transferred from node to node. Theoretically, the number of hops data can make between nodes is unlimited. In practice, if you try to make too many hops, the data transfer will be delayed. This is due to the maximum data throughput being limited by the air process in the wireless network.

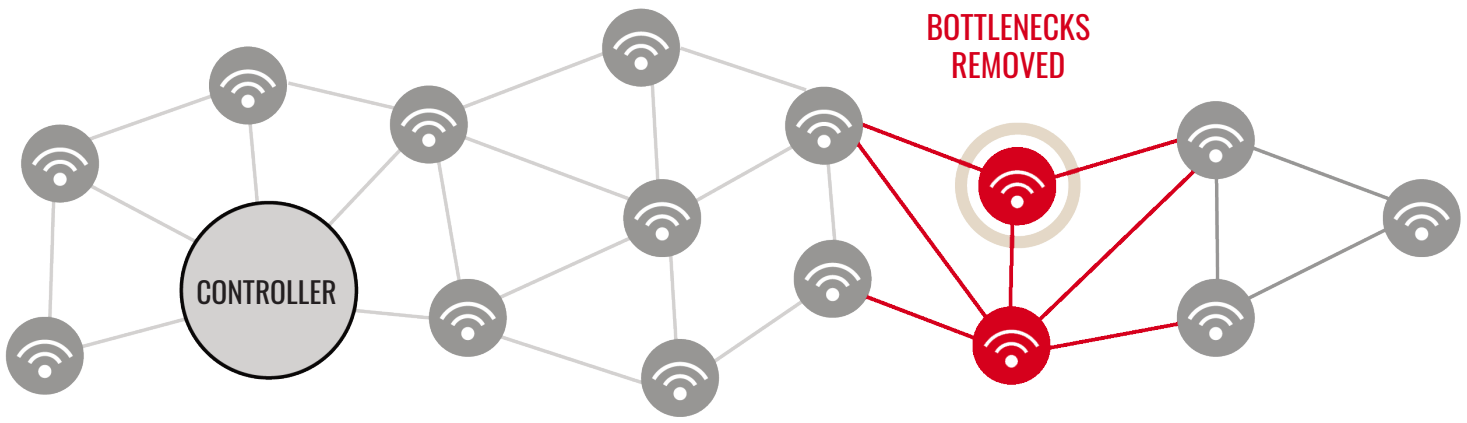
It's also important to consider the number of devices connected to your network. The total bandwidth for WLAN operation has physical limitations. The maximum bandwidth is divided between all devices connected to the network.

You may run into issues with hidden nodes when devices almost don't hear each other. These devices may still operate on the same channel and contest for access to the air.

It is important to keep in mind the connection radius that your system supports. Your wireless network permits connections between devices, even if they are located at the edge of the lowest rate of sensitivity. Placing nodes outside your connection radius significantly decreases bandwidth.

Daisy Chaining and Bottlenecks





The Anatomy of Your Wi-Fi Router

Each router is slightly different, but several components are standard among all models.

Antenna

Antennas act to improve both the transmission and reception of radio signals. There are two categories of antennas for transmission; directional and omnidirectional. Directional antennas send the signal directly to the receiver, while omnidirectional antennas send the signal in all directions. The antenna also has a “dBi value”. The higher this value, the further the signal can travel.

Mercku products use a “WHEMS” antenna, which has enhanced performance on the 2.4GHz and 5GHz bands. The antenna is high gain, ensuring consistent signal coverage, quality, and MU-MIMO throughput. It also has high isolation, low ECC and low PIM, resulting in a reduced transmission loss attributed to noise and low signal distortions.

Transceiver

Transceivers are responsible for sending and receiving signals and Mercku’s design is ground-breaking in several ways. It effectively decreases environmental noise and eliminates interference, greatly increasing data throughput and communication efficiency. It performs 100 times better than the industry average, reaching the physical limits of the chipset.

PCB design

A PCB, or printed circuit board, connects electronic components. The Canadian Academy of Engineering recognized Mercku's chief Scientist, Yihong Qi, for his PCB optimization theory, which improved upon the theory of cosmic microwave background radiation for which Arno Penzias and Robert Wilson won the 1978 Nobel Prize in Physics - a theory which is still used by all other companies in the industry.

Switch

A network switch selectively forwards packets based on the MAC address of the packet.

Amplifier

An amplifier receives a signal and outputs the same data signal at a higher power.

CPU

Essentially the "brain" of the router, the Central Processing Unit executes the operating system's instructions and determines which packets go out to which interface.

Storage / RAM

In a router, Random Access Memory, or RAM, allows more simultaneous connections and clients. Some routers have extra features such as advanced security functions that take advantage of additional RAM.

What Else Can My Router Do?

MU-MIMO

Multiple-user multiple input multiple output, or MU-MIMO, enables your router to transmit data to several devices at once by using multiple antennas. The antennas exploit a phenomenon called multipath propagation, in which radio signals reach the receiving antenna by two or more paths. This results in faster data transmission to devices, increased speeds, and increased network capacity, meaning you can use more devices simultaneously. It is important to note that both the router and the network device need to support MU-MIMO for increased download speeds. MU-MIMO is possible on the 5GHz band in Wi-Fi 5 routers, and while it increases download speeds, it does not increase upload speeds.

Smart Roaming

To further improve connectivity and data transmission, Smart Roaming may be enabled on supporting Wi-Fi routers. This feature ensures that as a device moves around, it reconnects to the node which sends it the best Wi-Fi signal. To further increase performance, band steering may be enabled to steer dual-band compatible devices (e.g. most modern smartphones) onto the less congested 5GHz network. As previously mentioned, the 5GHz band leaves less room for co-channel interference since it has more non-overlapping channels.

IP Routing

We've talked a lot about data transmission over radio waves, but how does data actually get from sender to receiver? Moreover, how does the data know where to go?

IP routing refers to the routing methodologies of Internet Protocol packets within and across IP networks. This involves not only protocols and technologies, but also the policies of the worldwide organization and configuration of internet infrastructure. When you send data across a network, your router looks up the destination IP address in a routing table. Routing tables are automatically filled with information on how to get from point A to point B. Using our highway analogy, your router's IP routing instructions are like Google Maps, giving your data directions as it travels from sender to receiver.

VPN

Now say you want to browse the internet without invasive services like Google and Facebook or a local network administrator in your office tracking your activity?

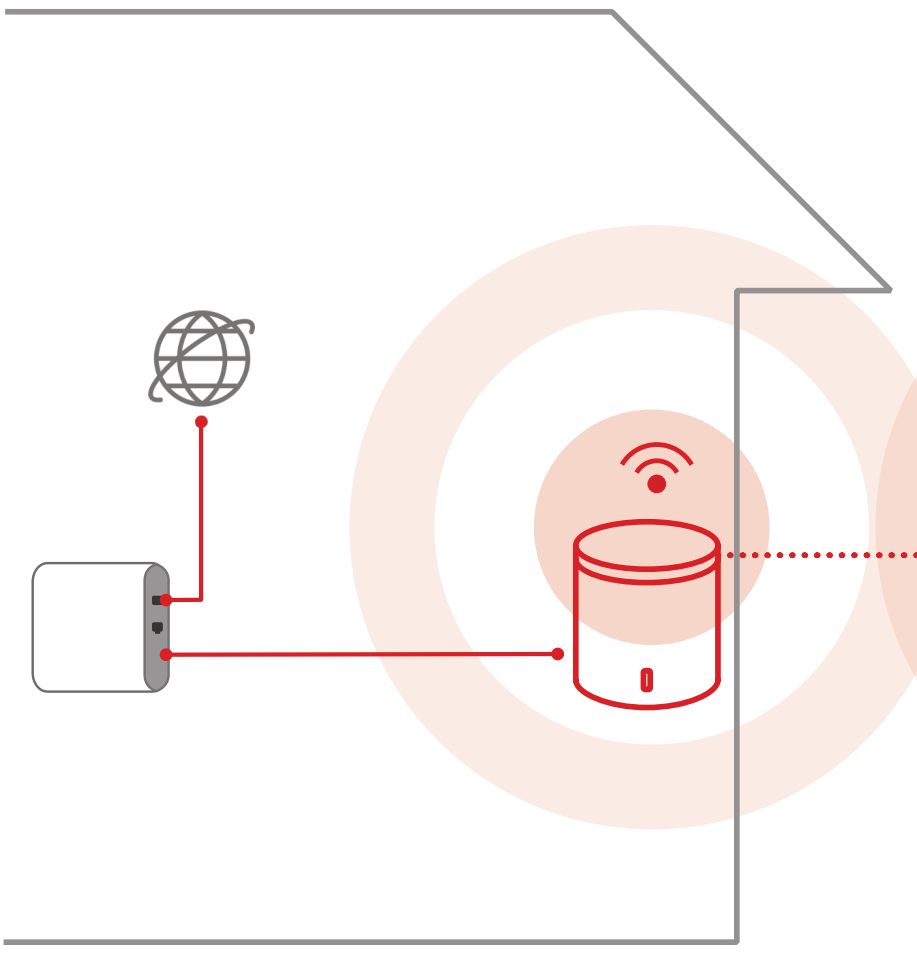
A VPN, or virtual private network, is designed to create a point-to-point private link via a shared or private network. Essentially, a VPN will create a secure connection to another network so that your browsing activity won't be publicly visible. It connects you to another computer, (actually a server), and allows you to use that computer's internet connection, which makes it seem as though you are browsing from that server's IP address. A growing number of users have started using VPN's to make it look like their system is browsing from another country to get around geographic content restrictions, or check out the Netflix selection in a different country!

Some routers have VPN passthrough as a built-in feature. VPN passthrough is exactly what it sounds like; it allows VPN traffic to travel through your router. This allows computers on a private network to establish outbound VPNs unhindered.

Network Bridging

Your router may also have the capacity to act as a network bridge, which may require you to put your router into "bridge mode". A network bridge operates at the data-link layer over Wi-Fi.

Using a network bridge, you can connect a wireless network to a wired network. For example, you can bridge the networks of two separate homes. Wireless bridging requires that access points (APs) communicate with each other and allow network traffic to flow between them. So, what's the difference between a network bridge and an AP? An AP typically connects two LANs, while bridging devices puts all devices onto a single LAN.

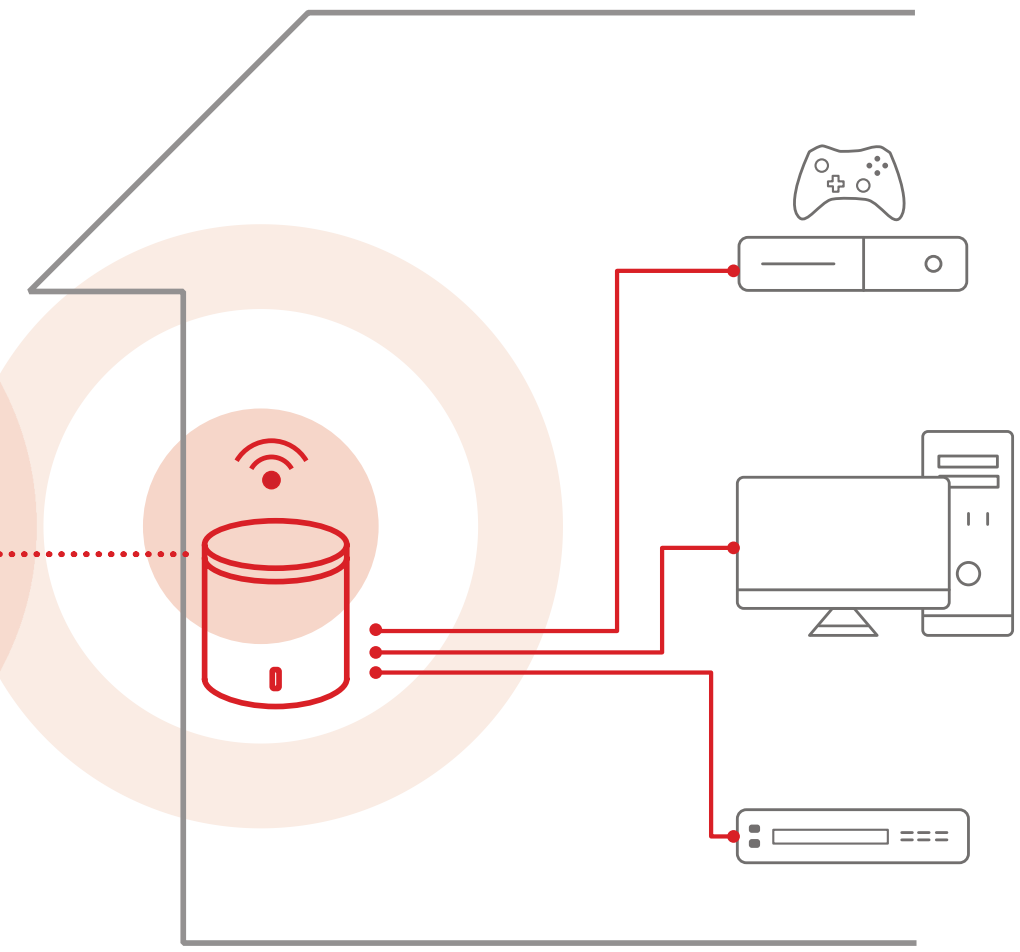


ROUTER MODE

Universal Plug and Play

UPnP is an open networking architecture that consists of services, devices, and control points. The goal is to allow data communication among all UPnP devices regardless of media, operating system, programming language, or wired vs wireless connection. It allows devices to access the network and connect to other devices as needed - an important feature if you enjoy multiplayer gaming or instant messaging.

UPnP uses standard networking protocols to connect devices to a network without requiring configuration. When a new device is connected, UPnP detects the IP address of the device and informs other devices on the network of its presence and capabilities. Similarly, UPnP informs the new device of the devices that are already on the network.



BRIDGE MODE

Quality of Service

QoS refers to any technology that manages data traffic to reduce packet loss, latency, and jitter on the network. It controls and manages network resources by setting priorities for specific types of data on the network and minimizes the impact of busy bandwidth. This is one of the reasons why some public Wi-Fi hotspots have fast browsing of text based websites but really slow video streaming, downloads or online gaming.

Backhaul

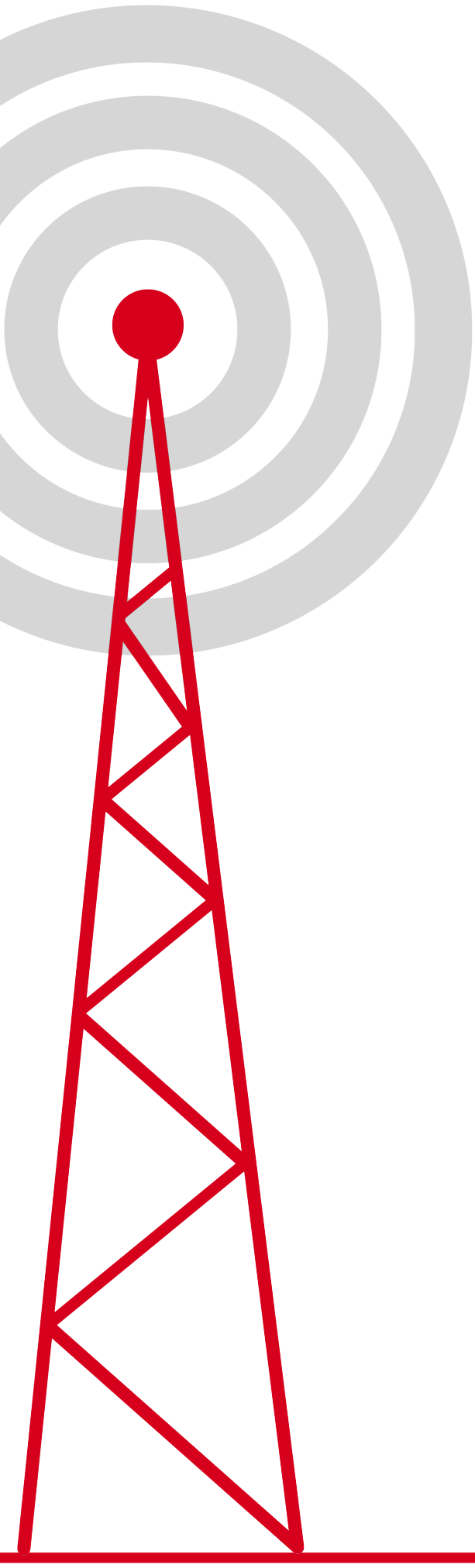
Backhaul is the backbone of any wireless network. In mesh networks, it is made of direct wireless connections between the nodes. Only one node needs to be directly connected to the internet. This connection is then shared wirelessly between nodes along with the backhaul.

The backhaul network is also used to send information back to the access point. The additional 5GHz band in tri-band routers is generally dedicated to backhaul. In larger networks, like those that span cities, certain nodes may be dedicated as backhaul nodes to increase the speed at which information is sent back to the AP.

Network Bridging

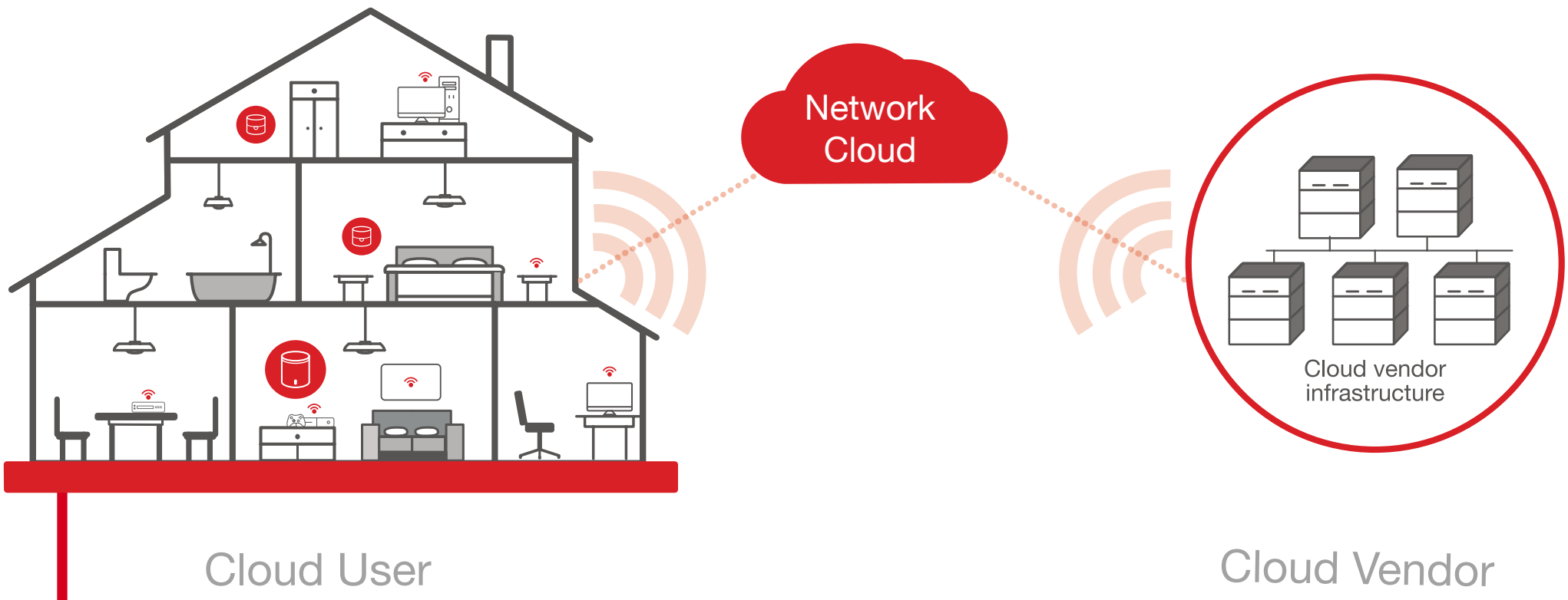
“You can use your router in bridge mode to connect multiple devices with Wi-Fi at the faster 802.11ac speed. To do this, you need two Wi-Fi routers: one set up as a router and the other set up as a bridge.”

Chapter 5
For Internet Service Providers



Cloud-Managed Wi-Fi: How Wi-Fi Routers Enable Intelligent Deployment and Management

Not every end-user is as tech-savvy as your average network administrator, so it may get repetitive and challenging for your support team to constantly explain common troubleshooting steps. Hours can be spent on customer premises or over the phone trying to explain the steps for common fixes such as rebooting a router or upgrading the firmware for your devices.



If you’re looking for IT solutions, you’ve probably come across WLAN management through on-premises equipment or cloud-based networking. Now, if you’re a local residential ISP and want to monitor Customer Premises Equipment (CPE), installing additional on-premises equipment in people’s homes is out of the question. However, this option is viable for large enterprises to monitor their equipment. For residential internet service providers, using cloud-managed Wi-Fi networking is a wonderful solution.

Using a cloud-managed Wi-Fi system allows you as an ISP to control and manage your customers’ WLAN at specific sites. This gives your network administrators visibility into customer networks and allows for rapid troubleshooting and making remote network changes, saving you time and money.

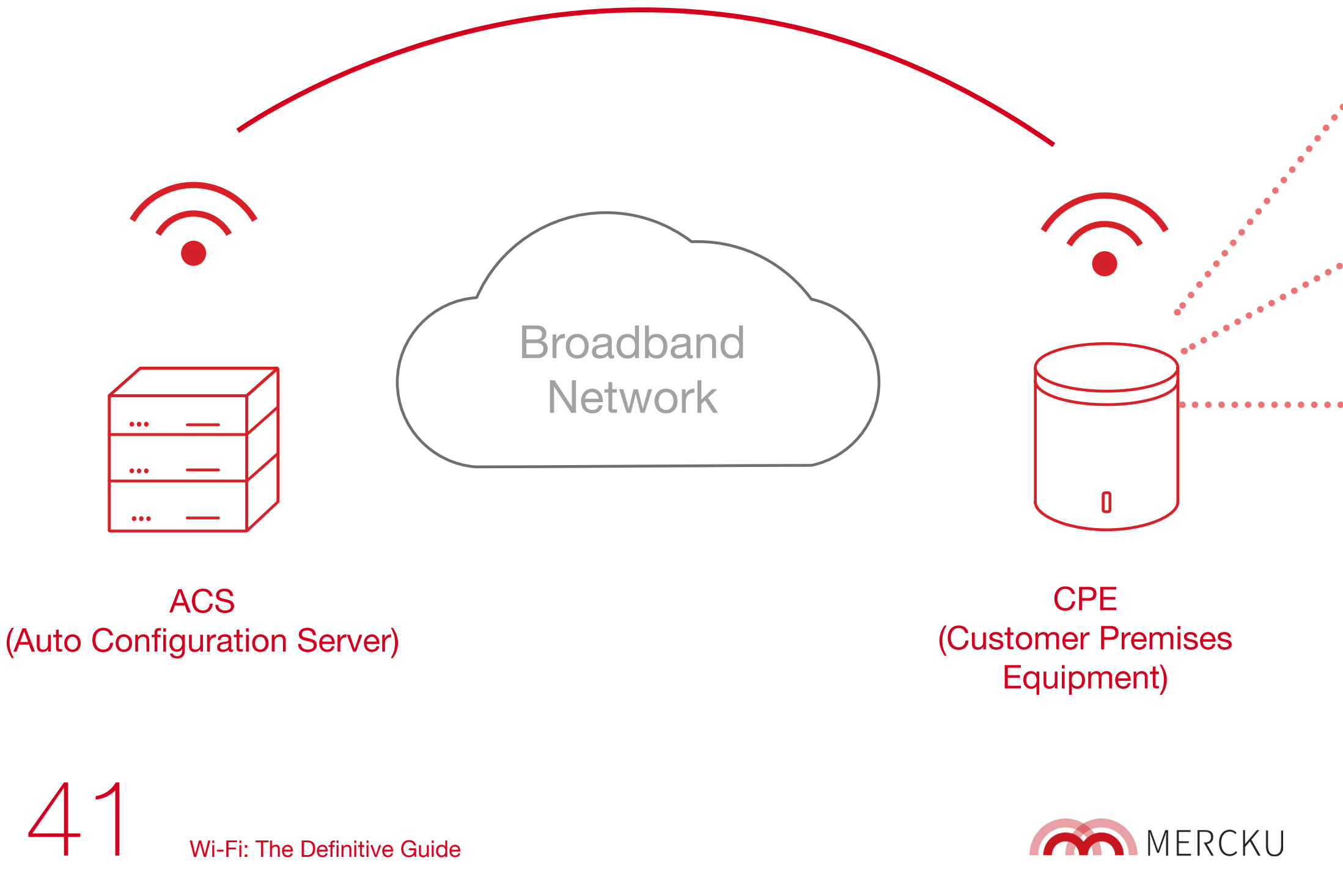
Remote control: TR-069, TR-143, ACS and other protocols

Remote access through cloud-managed Wi-Fi allows your administrators to monitor customer premises equipment (CPE) such as modems, routers, media centres, and Smart Home and IoT devices. Why spend hours of your technical support staff's time walking customers through troubleshooting their routers, when your tech support can simply access the routers remotely to run the troubleshooting themselves and thereby minimize end-user frustrations?

Technical Report 069 (TR-069) grants this functionality using the CPE WAN Management Protocol (CWMP) and supports the following:

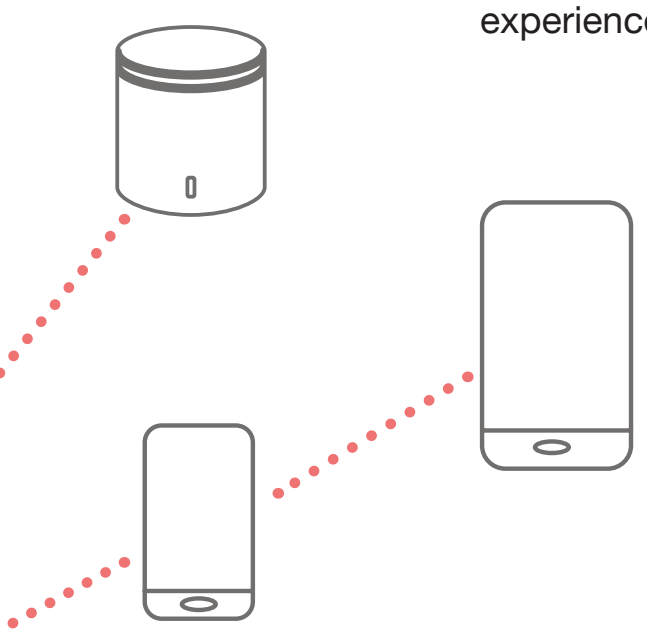
- Firmware management
- Diagnostics
- Service configuration
- Network optimization
- Monitor the state of the network

Remote CPE control via TR-069

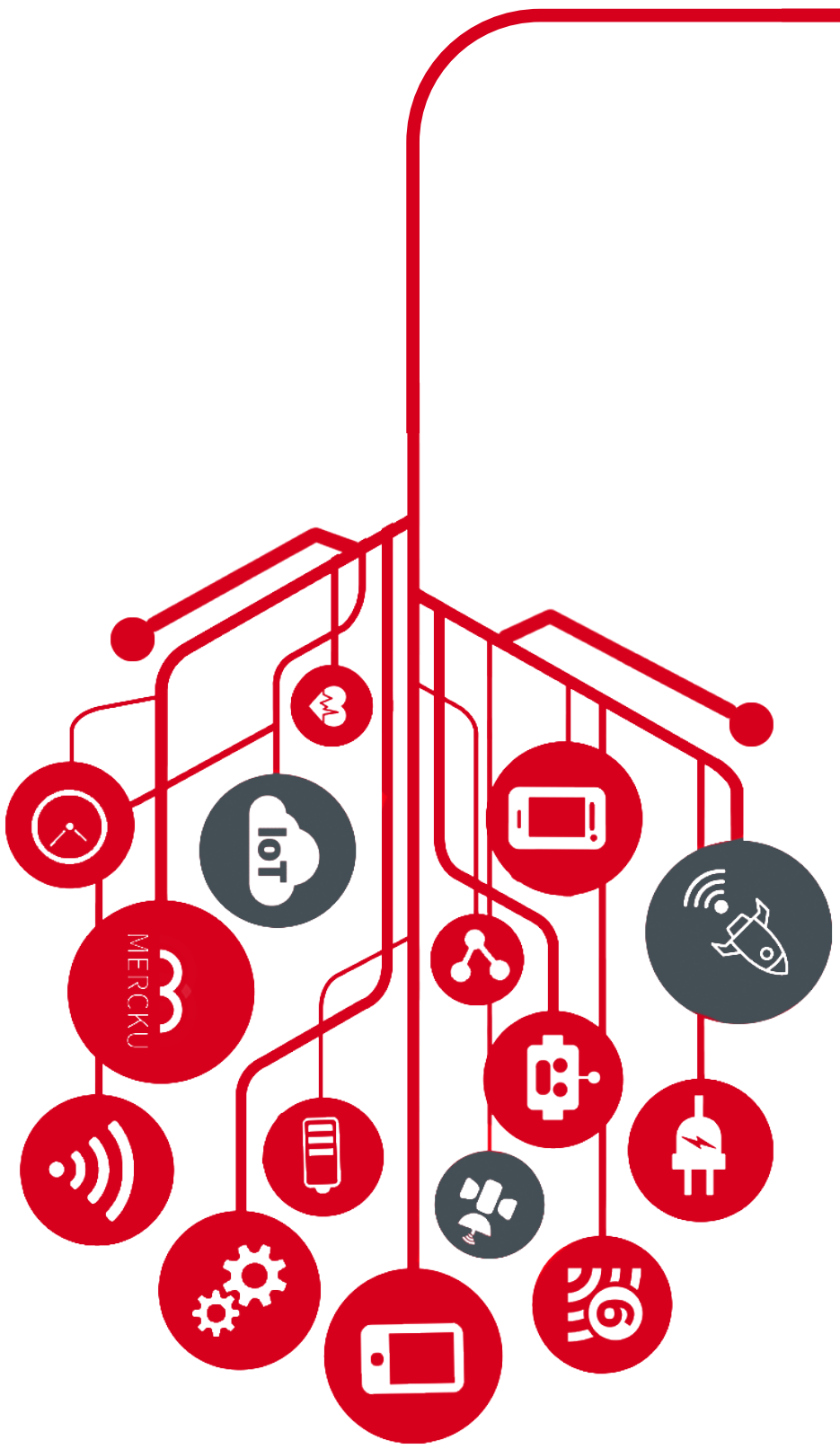


Using an Auto-Configuration Server (ACS) that is connected to a cloud, service providers can access and manage the status and performance of CPEs to gather data and remotely troubleshoot the individual and groups of devices.

Further to the TR-069 protocol, CPEs can also be managed with the high-level operations such as TR-143, allowing active throughput monitoring and enables service providers to find out if a problem is occurring on their own network, or if it's on the customer's home network. Including TR-143 allows service providers to confirm the upload, download, and latency speeds of CPEs to further analyze and verify the QoS and ultimately improve their users' quality of experience.



Chapter 6
The Future Potential of Wi-Fi



The Continuing Evolution of Wi-Fi

Now for the chapter that probably inspired you to download this book in the first place. As we have learned, Wi-Fi provides ubiquitous connectivity throughout our indoor spaces. But the full potential of Wi-Fi goes far beyond merely connecting devices with each other and enabling data transfer or access to the internet.

In this chapter, we share our crystal ball and show you what the future of Wi-Fi holds.

Current and next-generation: Wi-Fi 6, Wi-Fi 6E, Wi-Fi 7

Wi-Fi has come a long way in the last 20 years since its inception. It is de facto the standard connectivity technology in all indoor spaces, ranging from homes, public buildings, offices, shopping malls, etc. Each upgrade significantly improved the speed, range, reliability, capability, and number of supported devices.

1999
802.11b was released / “Wi-Fi 1”

2003
802.11a was released / “Wi-Fi 2”

2003
802.11g was released / “Wi-Fi 3”

2009
802.11n was released / “Wi-Fi 4”

2014
802.11ac was released / “Wi-Fi 5”

2019
802.11ax was released / “Wi-Fi 6”

2020
6GHz Wi-Fi was released / “Wi-Fi 6E”

Est. 2024
802.11be estimated release/ “Wi-Fi 7”

Clarification of Wi-Fi and 5G

In public misconceptions, Wi-Fi and 5G (cellular) are often interchangeably used when referring to mobile connectivity. It's important to note that both Wi-Fi and 5G (cellular) are fundamentally different technologies, leveraging different radio frequencies and networking technologies to provide connectivity to client devices. Where we've already explained the Wi-Fi connectivity standard, certified as 802.11x - 5G marks the 5th generation of cellular networking technology, an enhanced version of the previous LTE/4G standard. Wi-Fi and 5G technologies complement each other, enabling devices with high-speed connectivity, as users move between indoor and outdoor settings.

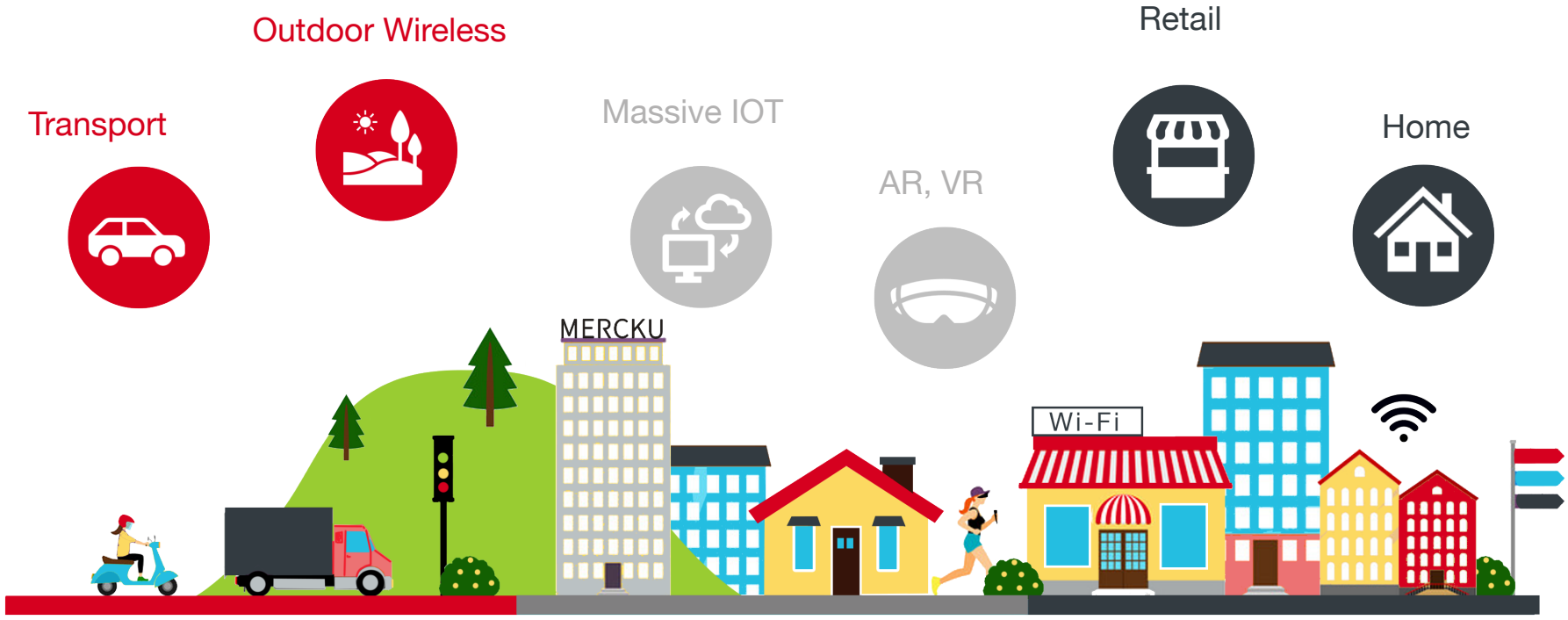
What are Wi-Fi and 5G?

	Cellular Connectivity 5G	Wi-Fi Connectivity
Underlying Tech	Cellular networking technology	Wireless networking technology
Frequencies	Up to 96GHz frequency radio waves	2.4GHz, 5GHz, 6GHz frequency radio waves
Usage	Provides wireless high-speed internet	Provides wireless high-speed internet
Name Origin	5th generation that meets the requirements of ITU IMT-2020	Trademarked phrase for IEEE 802.11x

Technology Comparison

Outdoor vs. Indoor Solution

Cellular Connectivity 5G		Wi-Fi Connectivity
OUTDOOR	OUTDOOR & INDOOR	INDOOR
Coverage	Coverage, Capacity, Density	Capacity, Density



Wi-Fi 6 and Wi-Fi 6E (802.11ax)

The global trend to introduce connectivity as a smart feature to all devices around us leads to a congestion of the network and, thus, a bad user experience. Both home and industrial applications see an increased number of devices per network, increased need for data, and super applications to provide complex services, in real-time. But also other connectivity technologies, such as Bluetooth, Zigbee, Z-Wave, or LTE, are causing increased interference in our environments. That’s why, in the year 2020, we have arrived at the standards of Wi-Fi 6, and Wi-Fi 6E (the 6GHz band). Both Wi-Fi 6 (certified Sep. 16, 2019) and 6E (certified Jan. 3, 2020) are officially known as the 802.11ax standard, enabling Wi-Fi networks to support hundreds of client devices with Gbit/s speeds.

How much better is Wi-Fi 6/6E compared to Wi-Fi 5?

Due to advanced features, the 6th standard provides four major advantages in Wi-Fi 6 networks for client devices:

- 4x better in dense environments
- Faster throughput: deliver up to 40% higher peak data rates for a single client device
- 4x increased network efficiency
- Extended battery life of client devices

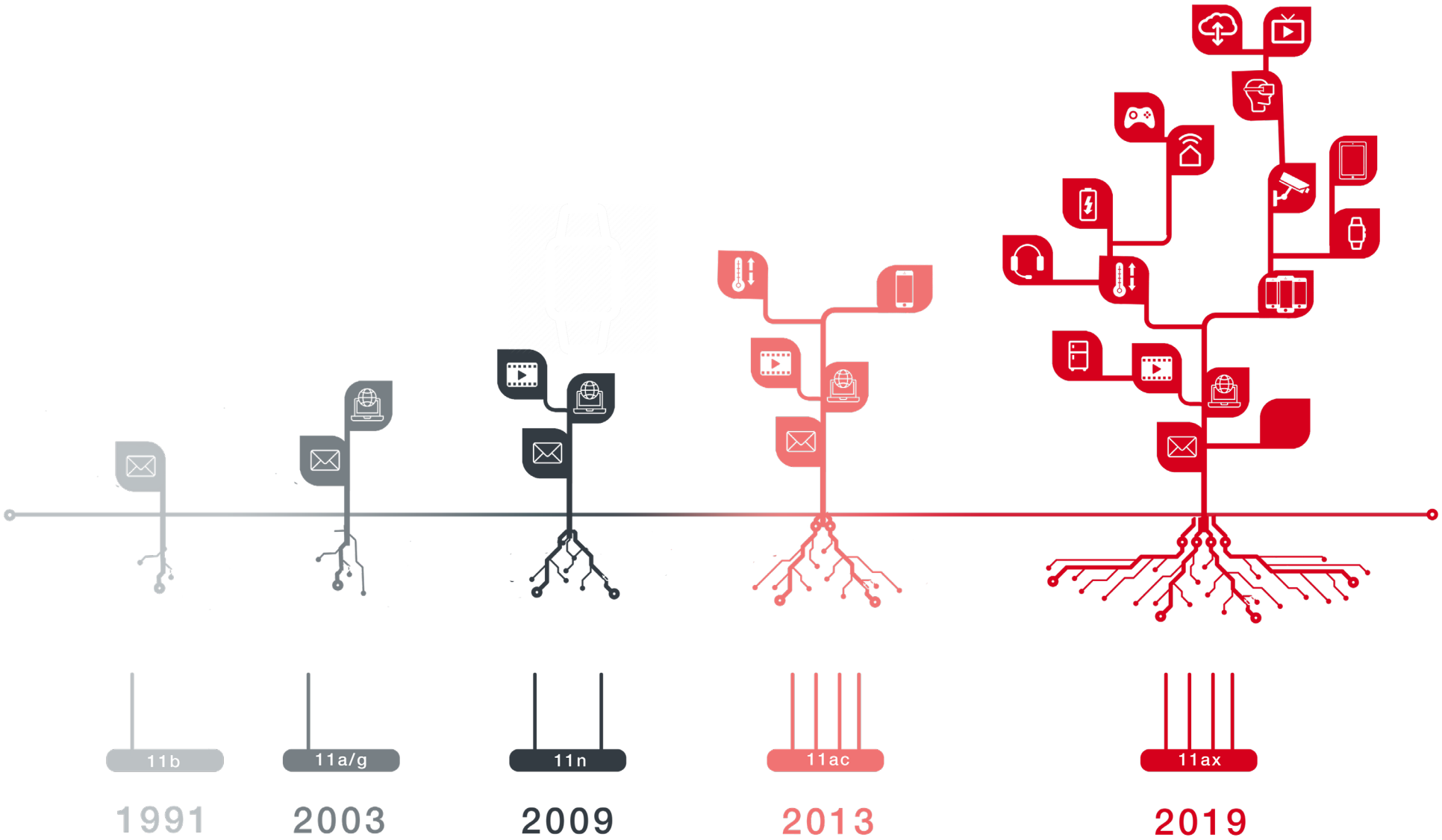
To achieve these improvements, Wi-Fi 6/6E leverages modulation schemes, spatial streams, channel bonding, airtime efficiency, BSS coloring, and target wait time, among others.

Wi-Fi 6 vs Wi-Fi 5 vs Wi-Fi 4

Parameters	802.11ax - Wi-Fi 6 (2019)	802.11ac - Wi-Fi 5 (2013)	802.11n - Wi-Fi 4 (2009)
Bandwidth (MHz)	20, 40, 80, 160	20, 40, 80, 160	20, 40
Modulation Stream	1024-QAM	256-QAM	64-QAM
Channel Bonding (MHz)	20, 40, 80+80, 160	20, 40, 80+80, 160	20, 40, 80+80, 160
Antennas	MU-MIMO (up to 12x12) - Download and Upload	MU-MIMO (up to 8x8) - Download	MU-MIMO (up to 4x4) - Download
Access Scheme	OFDMA	OFDM	OFDM
Maximum Data Rate	Up to 14.4 Gbps	Up to 6.9 Gbps	Up to 600 Mbps
Supported Bands (GHz)	2.4 GHz, 5 GHz, 6 GHz	2.4 GHz, 5 GHz	2.4 GHz, 5 GHz
Spatial Re-Use	Yes	No	No
Number of Client Devices per Access Point	200-400	50-100	< 50
Simultaneous Connections	Up to 12 Devices	Up to 8 Devices	Up to 4 Devices

Table adapted from Cisco: https://www.cisco.com/c/en_ca/products/wireless/what-is-wi-fi-6.html & Ofcom.org: https://www.ofcom.org.uk/__data/assets/pdf_file/0038/189848/consultation-spectrum-access-wifi.pdf

Wi-Fi 6
The path to truly brilliant Wi-Fi...

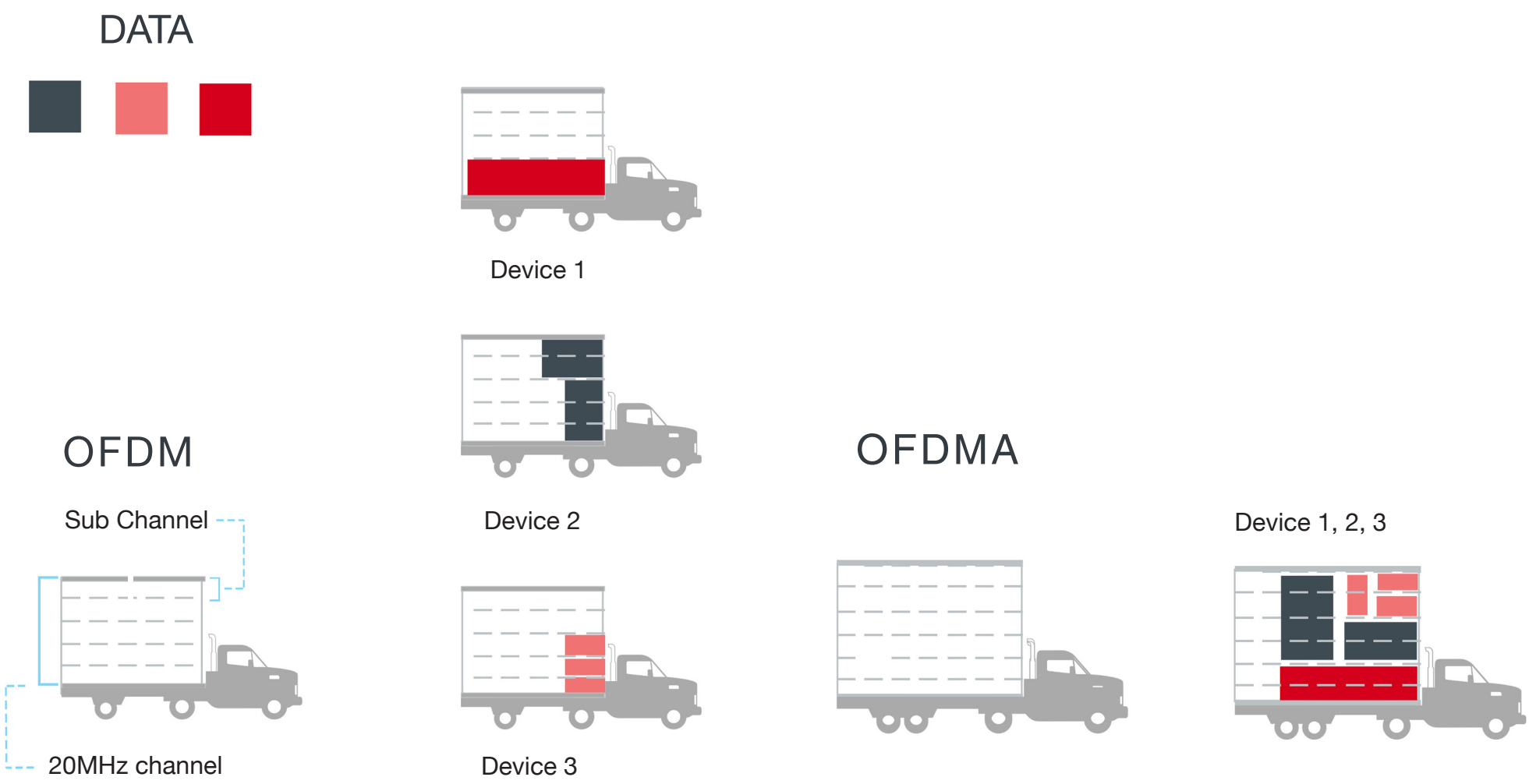


Advanced Features of Wi-Fi 6

The 6th Wi-Fi standard is equipped with five advanced features to deliver faster speeds, connect more client devices, reduce battery consumption, and reduce signal interference: OFDMA, TWT, 1024-QAM, BSS Coloring, and DL/UL MU-MIMO.

OFDMA - Orthogonal Frequency Division Multiple Access

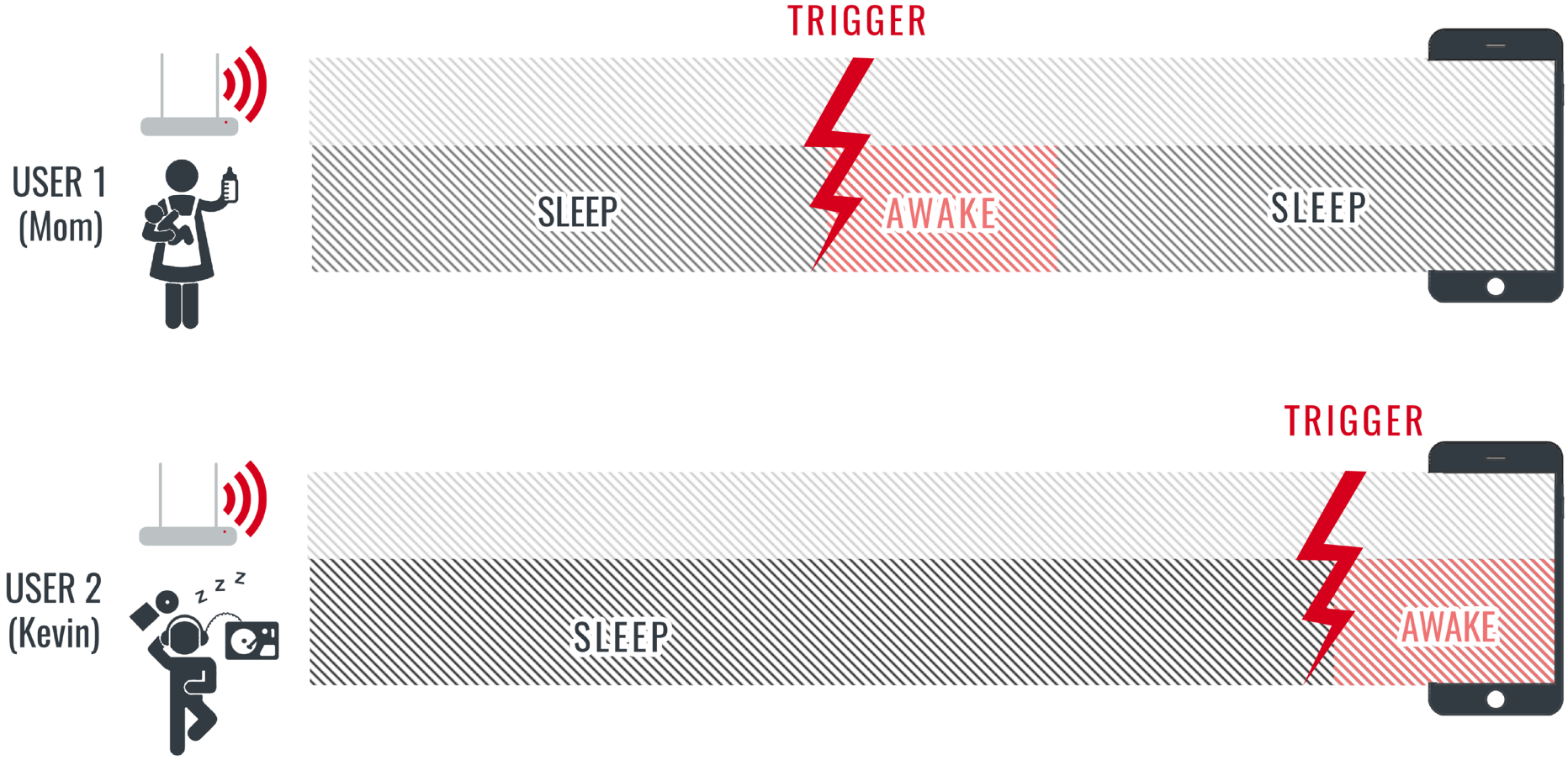
OFDMA optimizes and combines smaller data units within each transmission. This allows multiple clients to upload or download data in parallel, enhancing the device airtime efficiency and results in a more efficient use of subchannels. The optimization is achieved through the division of the allotted radio spectrum into smaller units. The feature leads to a four times stronger OFDM, which in turn creates four more subcarriers. For the end-device, it makes the connection up to 11% faster.



TWT - Target Wake Time

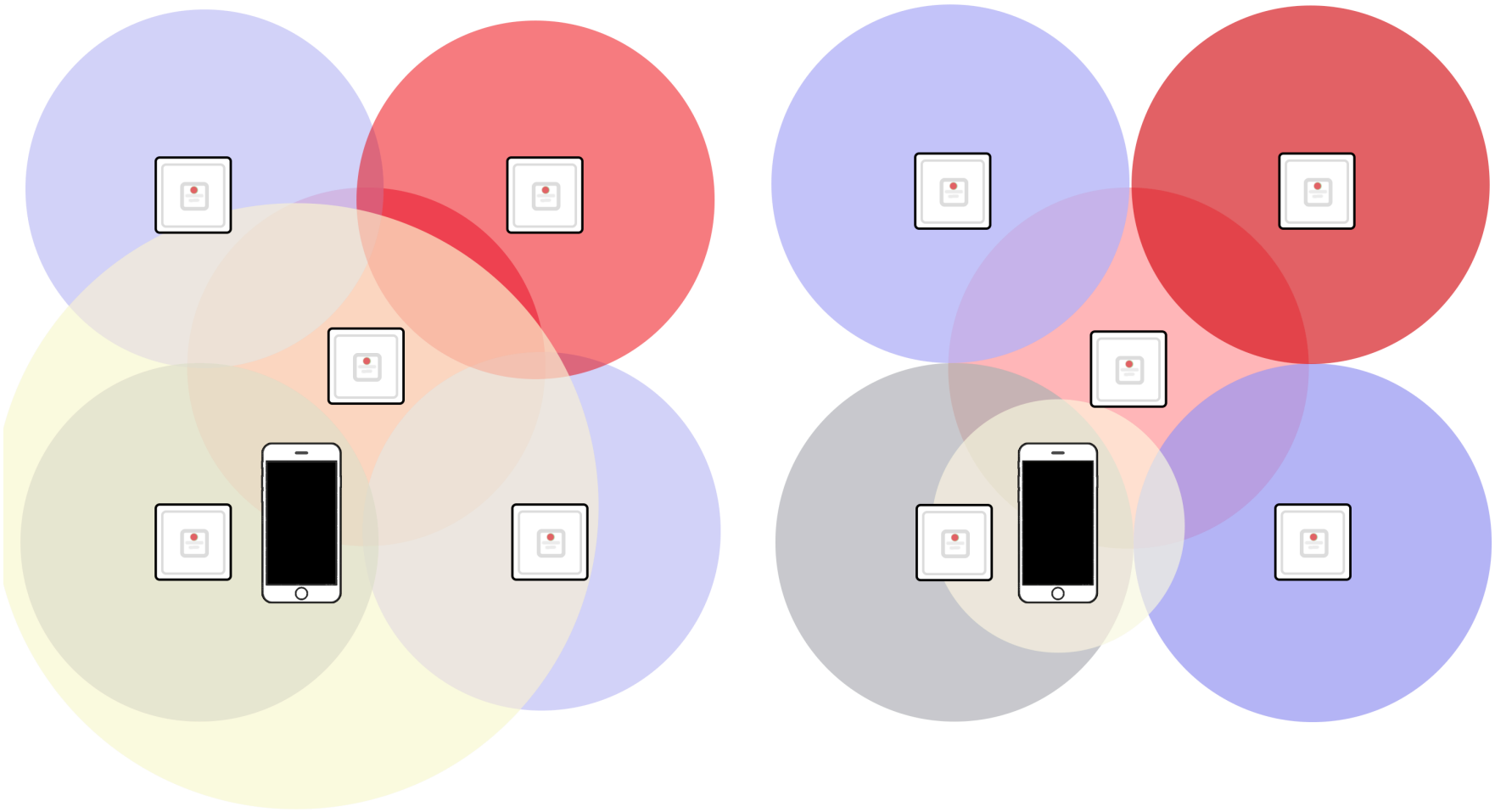
Before Wi-Fi 6, connected devices were non-stop sending radio signals to stay connected to the access point. The new TWT feature allows the access point to smart schedule different devices to wake up and send signals. This significantly reduces the radio noise on the network, as only the devices which are active and need connectivity are sending data.

The biggest benefit of TWT is significantly increased battery life and lower energy consumption for connected IoT devices, such as smart thermostats, sensors, phones, laptops, or cameras.



1024-QAM – Quadrature Amplitude Modulation

Wi-Fi 6 adds new data channels using 1024-QAM to provide a signal packed with more data and a wider 160 MHz channel. The older Wi-Fi 5 uses 256-QAM, meaning that Wi-Fi 6 has a four times longer signal.



BSS Coloring

With the BSS Coloring feature, Wi-Fi 6 can reduce co-channel interference on the network in high-density environments. The Wi-Fi access points (AP) can give color codes to devices, and then associate colored devices to the access points closest to them.

For end devices, this advanced feature helps to save battery life, as BSS Coloring adjusts and lowers the Wi-Fi power needed because non-associated access points will ignore devices of other colors.

DL/UL MU-MIMO – Download & Upload Multiple User Multiple-Input-Multiple-Output

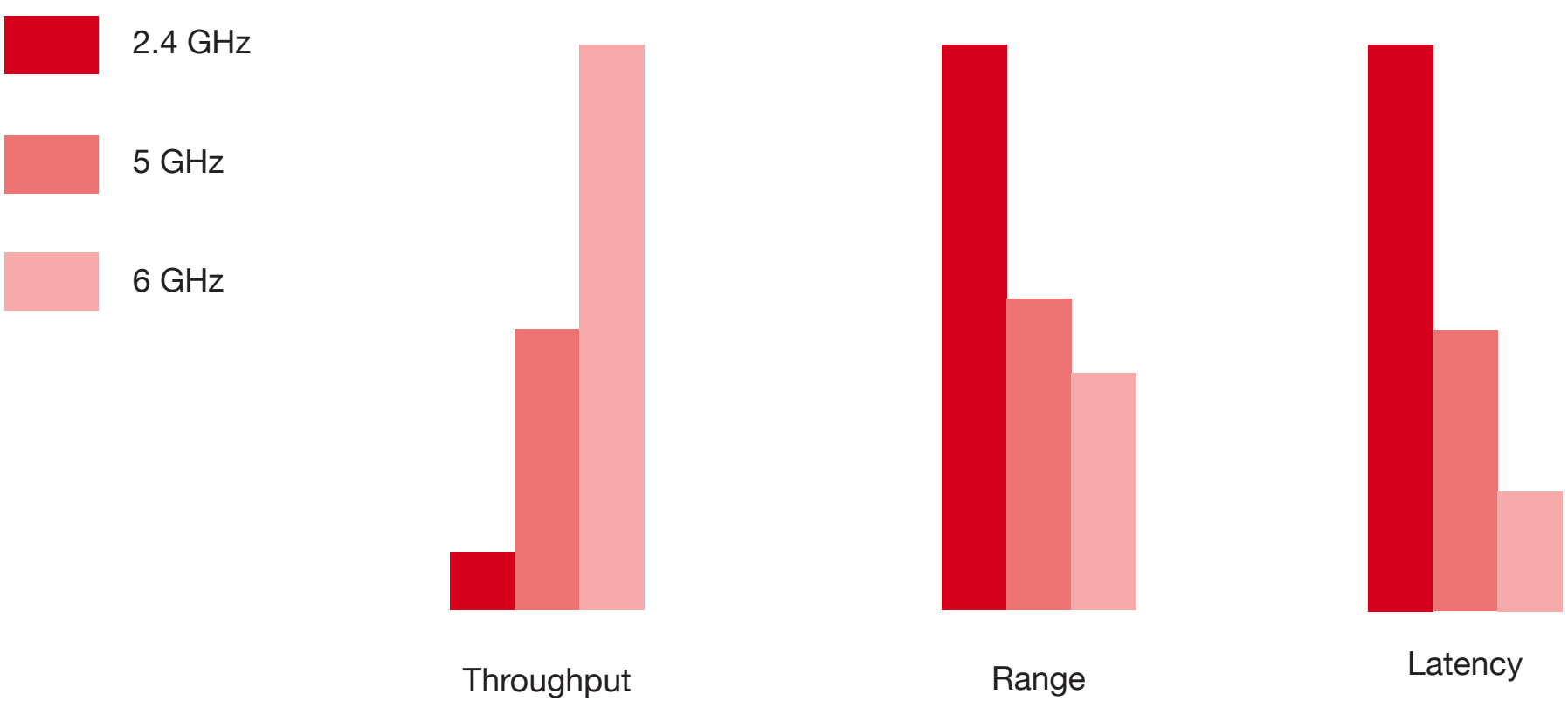
MIMO is a commonly used bandwidth-enhancement feature for radio frequencies. It allows the access point to simultaneously connect to multiple devices without any noticeable decrease in bandwidth quality. The enhancement of MIMO in Wi-Fi 6 adds support to upload data, not just download as in previous versions. The full 8x8 DL/UL MU-MIMO is a powerful feature, as it provides eight available streams for devices to choose from. In combination, the Wi-Fi 6 MU-MIMO, OFDMA, and BSS Coloring lead to four times larger capacity.

Adding the 6GHz band to Wi-Fi (Wi-Fi 6E)

Shortly after certifying Wi-Fi 6, the Wi-Fi Alliance announced the addition of Wi-Fi 6E (extended).
The E symbolizes the new unlicensed 6 GHz band that is added to the frequency spectrum that Wi-Fi access points and devices can use. The details of Wi-Fi 6E are still in discussion between different government bodies, associations, and the Wi-Fi Alliance.

Comparison of Wi-Fi Standards

Boost Wi-Fi Performance with 6 GHz

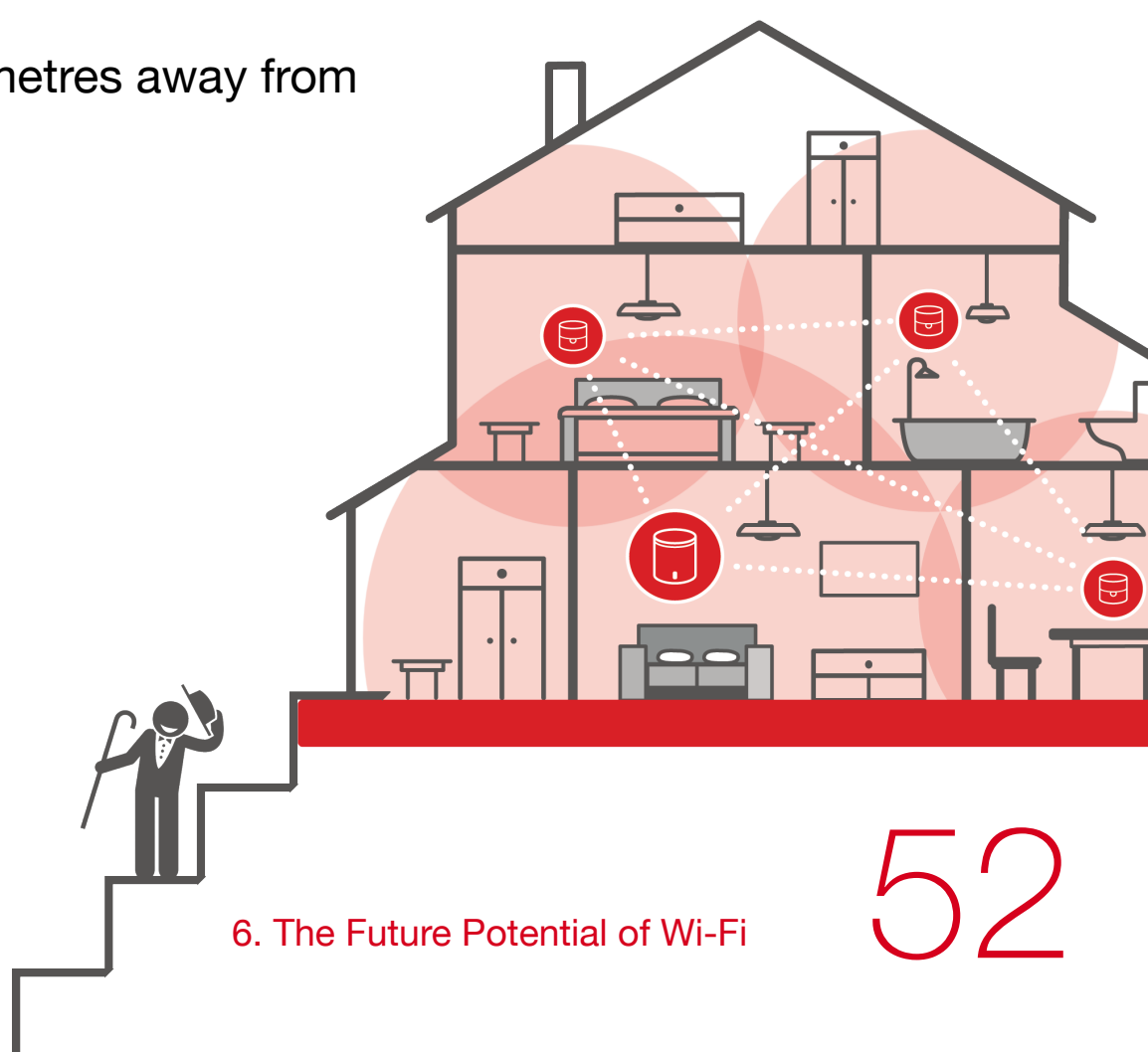


Use cases of 6GHz Wi-Fi at home

6GHz Wi-Fi delivers 1.2 Gbps at even 7 metres away from an access point with obstructions.

Use Cases:

- Residential Multi-AP/mesh networks
- Multiple dwelling unit (MDU) Single-AP networks
- High-density enterprise networks
- Indoor public venues
- Industrial IoT



The Implications of Wi-Fi 6/6E

Wi-Fi 6/6E were developed to deliver considerable increases in network efficiency and capacity for dense population centers. Wi-Fi 6 will have an immediate impact on the performance of networks in crowded places such as stadiums or apartment buildings. With the global increase in fiber internet coverage, the necessity of Wi-Fi 6 will increase to leverage the full 1Gbps or 10Gbps broadband connections.

The biggest issue with purchasing Wi-Fi 6 routers right now is that there are only very few devices on the market capable of using the Wi-Fi 6 features. (The analogy we used earlier was like buying an 8K TV when there is no content available in that resolution.) The few devices available now are using a prototype version of the new standard, which will be updated later in 2020. By the end of 2020, estimates suggest that enabled devices will be more available, and thus the transition towards Wi-Fi 6 is expected to happen on a larger scale. Wi-Fi 6E is still waiting for commercial device announcements.

The next generation: Wi-Fi 7 (802.11be)

The Institute of Electrical and Electronics Engineers (IEEE) has already started defining the seventh generation of Wi-Fi, dubbed the “EHT” Extremely High Throughput Wi-Fi. This generation is expected to have a breadth of enhanced Wi-Fi features, such as CMU-MIMO, Multi-band data management, better modulation and compression, 320 MHz bandwidth and more efficient utilization of non-contiguous spectrum, Multi-band/ multi-channel aggregation and operation, 16 spatial streams and Multiple Input Multiple Output (MIMO) protocols enhancements, Multi-Access Point (AP) Coordination, and many others.

The explanation of each advanced feature would go beyond the scope of this eBook and will be explored further in additional resources. Please see the sources appendix.

Glossary of Terms

Abbreviation	Explanation
IEEE	Institute of Electrical and Electronics Engineers
AP	Access Point
WAN	Wide Area Network
LAN	Local Area Network
WLAN	Wireless Local Area Network
IP	Internet Protocol
MAC	Media Access Control
ISP	Internet Service Provider
RF	Radiofrequency
GHz	Gigahertz
RF-sensing	Radiofrequency sensing
ACS	Auto-Configuration Server
IPS	Indoor Positioning System
UHF	Ultra High Frequency
MU-MIMO	Multiple User Multiple Input Multiple Output
DHCP	Dynamic Host Configuration Protocol
DSL	Digital Subscriber Line
PPPoE	Point-to-Point Protocol over Ethernet
WAP	Wireless Access Point
SSID	Service Set Identifier. The SSID of your router is also known as the network name, which is the name you see in the list of wireless options when you turn Wi-Fi on for your device.
BSS	Base Service Set
IoT	Internet of Things
PCB	Printed Circuit Board
CPU	Central Processing Unit
RAM	Random Access Memory
VPN	Virtual Private Network

UPnP	Universal Plug and Play
QoS	Quality of Service
CPE	Customer Premises Equipment
CWMP	CPE WAN Management Protocol
Zigbee	ZigBee is a low-cost, low-power, wireless mesh network standard targeted at battery-powered devices in wireless control and monitoring applications.
Z-wave	Z-Wave is a wireless communications protocol used primarily for home automation.
LTE	Long-Term Evolution, is a standard for wireless broadband communication for mobile devices and data terminals,
OFDMA	Orthogonal Frequency Division Multiple Access
OFDM	Orthogonal Frequency-Division Multiplexing, is a type of digital modulation, a method of encoding digital data on multiple carrier frequencies.
TWT	Target Wake Time
EHT	Extremely High Throughput
GPS	Global Positioning Systems
UWB	Ultra-wideband, is a radio technology that can use a very low energy level for short-range, high-bandwidth communications over a large portion of the radio spectrum.
B2B	Business-to-business
B2C	Business-to-consumer
API	Application Programming Interface
SDK	Software Development Kit

Sources

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See chapter.

2 Wi-Fi: The Basics

See chapter.

3 Wi-Fi System Solutions

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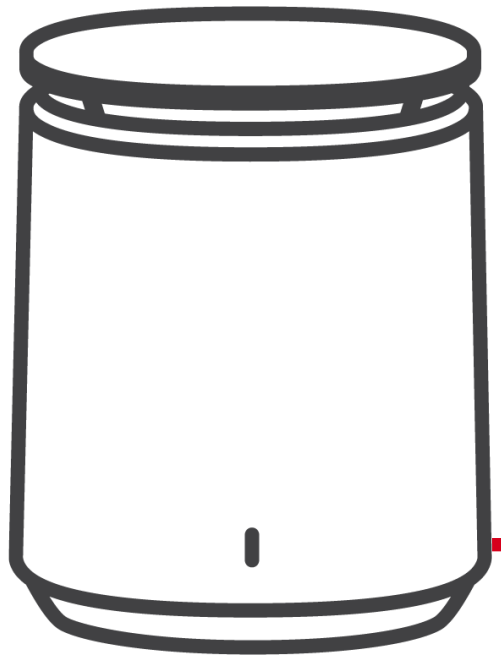

6 The Future Potential of Wi-Fi

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