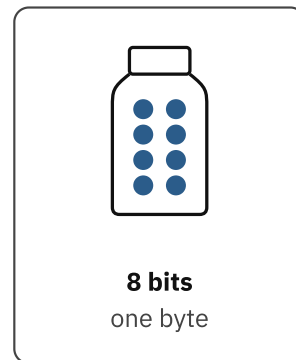
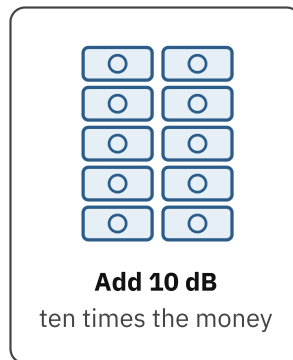
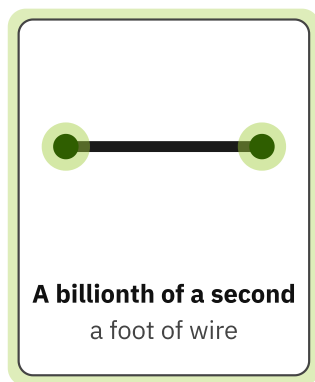

A PLAIN-ENGLISH GUIDE

Scales and Ratios, Explained

The tiny and huge numbers behind Wi-Fi, turned into things you can hold, see and picture.



The short answer

Wi-Fi runs on numbers that are too small or too big to picture. This guide turns a few of them into things you already know: a foot of wire, a stack of money, a ruler.

You don't need to do any math. Each page gives you one picture to keep.

A few words

A **nanosecond** is a billionth of a second. A **millisecond** is a thousandth of a second. A **watt** measures power, like on a light bulb. Wi-Fi uses a tiny slice of one.

What's inside

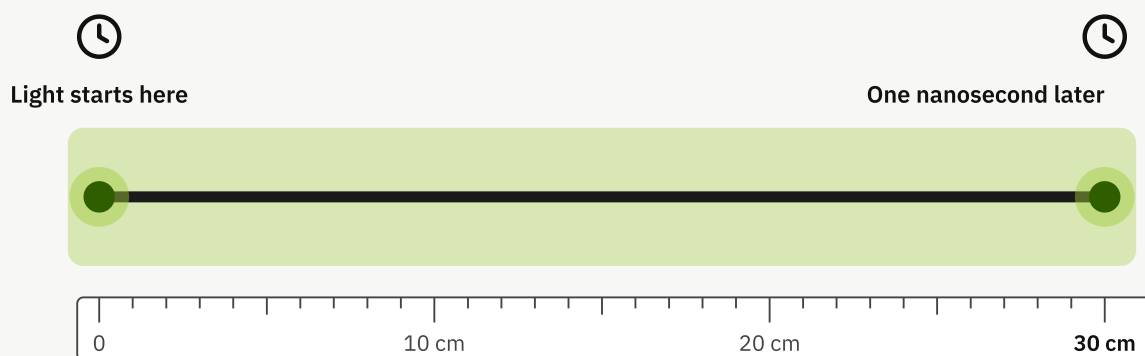
A nanosecond you can hold	3	How big is a radio wave?	10
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TIME

A nanosecond you can hold

Grace Hopper was a computer pioneer and a US Navy admiral. She used to hand out pieces of wire about 30 cm (1 foot) long.

Each piece showed how far light, or a radio wave, travels in one nanosecond. That's one billionth of a second. Fast, but not instant.



About 30 cm (1 foot) of wire: the distance light goes in one nanosecond

Figure 1. A nanosecond, as a length. Light travels about a foot in a billionth of a second. The drawing is not actual size.

GRACE HOPPER

"I had to point out that between here and the satellite were a very large number of nanoseconds."

Lecture at MIT Lincoln Laboratory, 1985.

TIME

An admiral had asked her why satellite messages took so long. Her answer was distance. A satellite is a long way up, and every foot of the trip takes time.

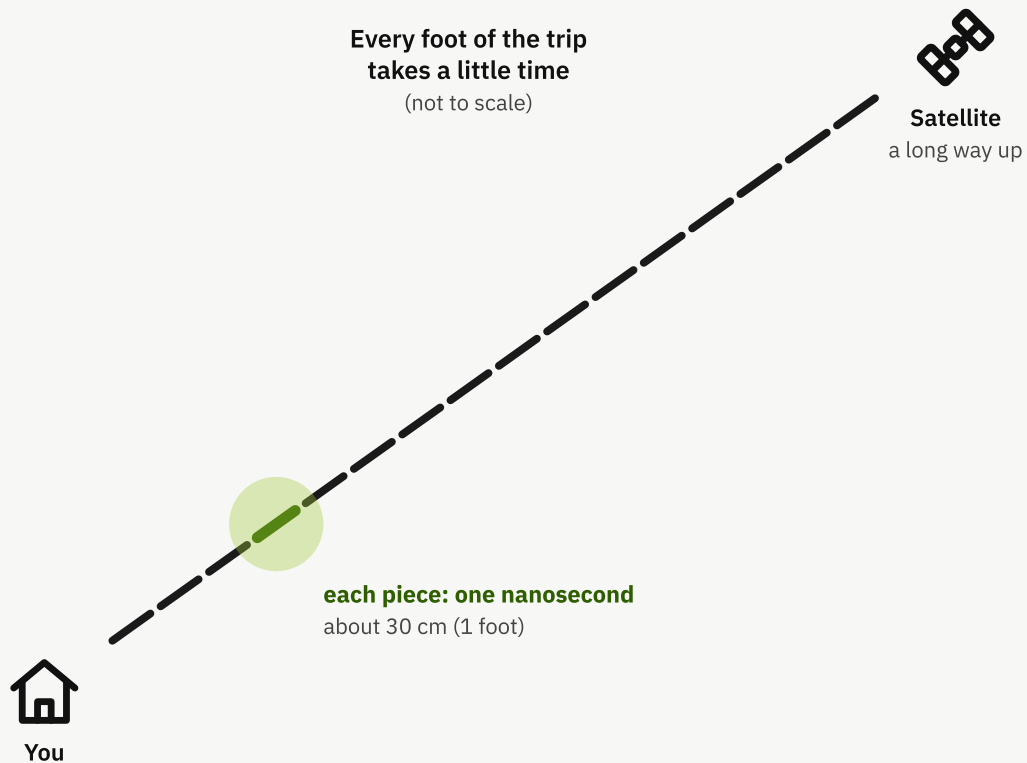


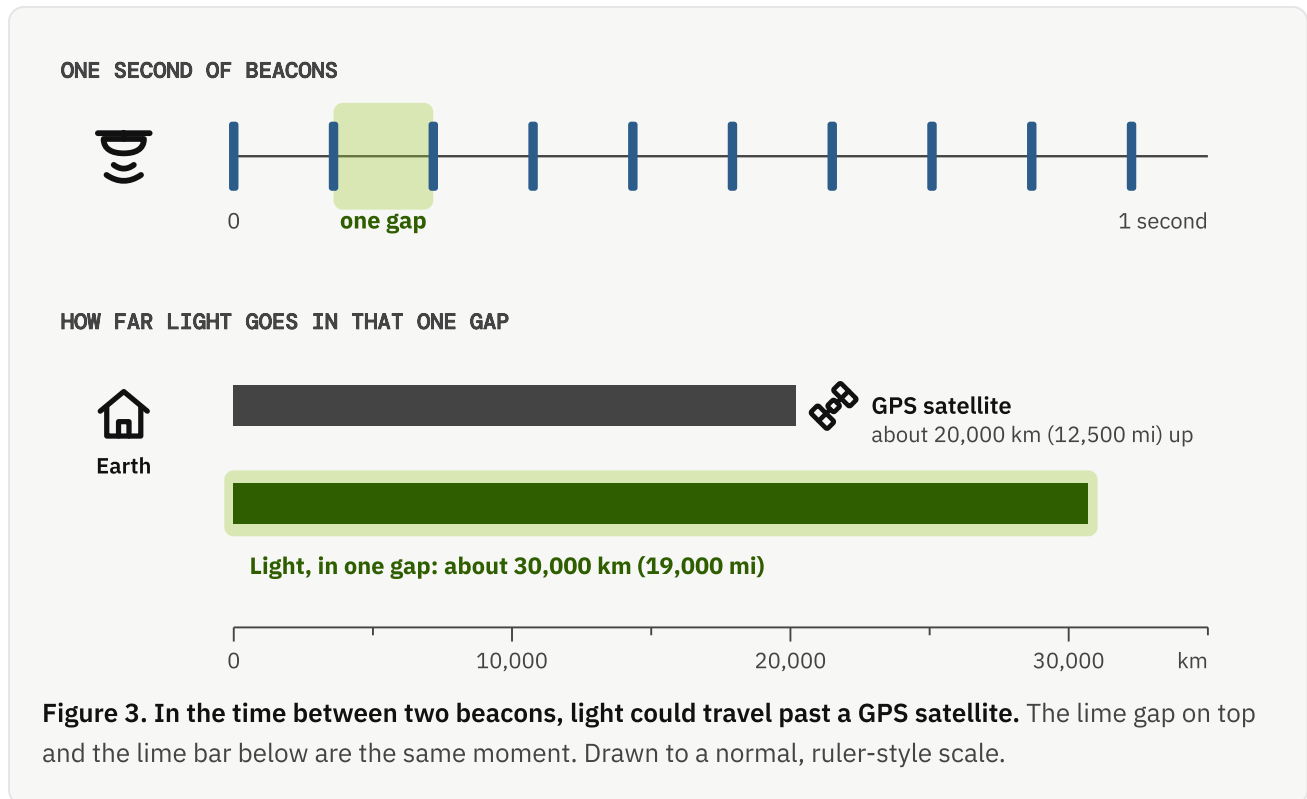
Figure 2. A long trip is a lot of nanoseconds. Lay Hopper's wires end to end up to a satellite, and each one adds a nanosecond. Not to scale.

Wi-Fi keeps time in tiny steps

Wi-Fi devices take turns to talk. Each turn is timed in millionths of a second.

Your access point also sends out a short "here I am" message, called a beacon. It sends about ten of them every second.

That gap between beacons feels like nothing to you. For light, it's a long trip.

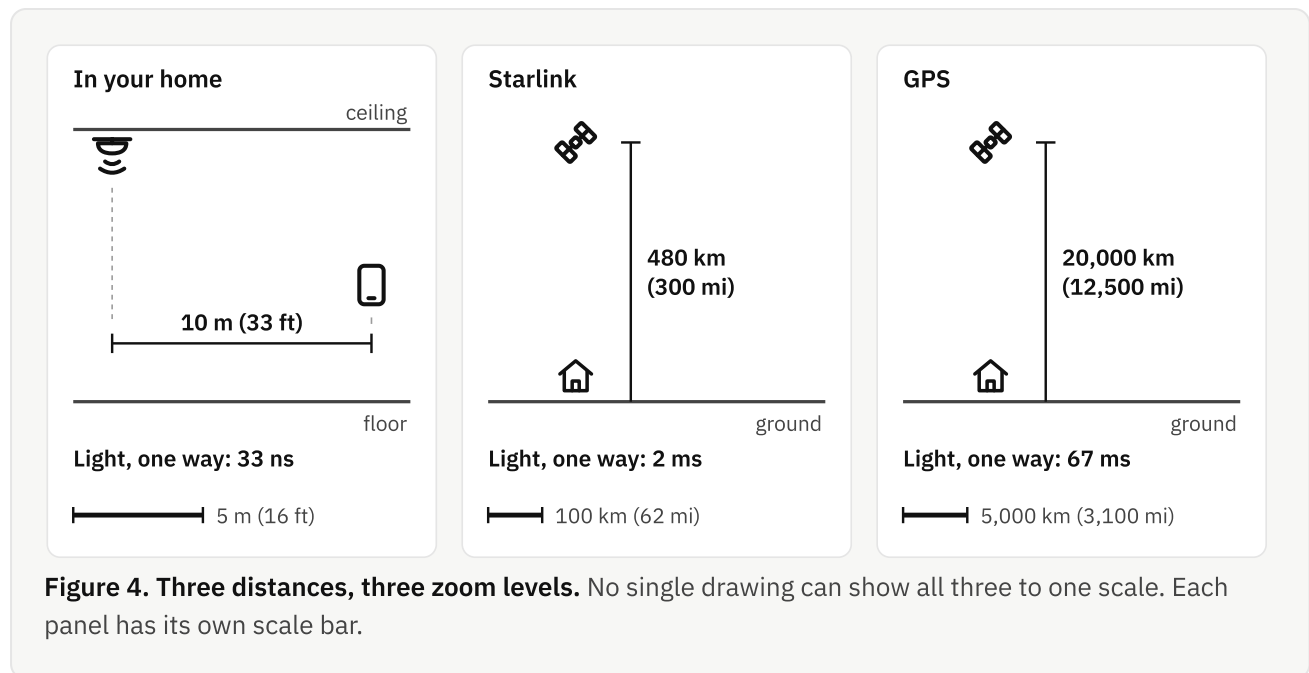


DISTANCE

Near and far

Your Wi-Fi signal crosses a room. A GPS signal falls from high in space. Both travel at the speed of light.

The access point on your ceiling is a few meters away. A Starlink satellite is about 480 km (300 miles) up. A GPS satellite is about 480 km (300 miles) up. A GPS satellite is much farther again.



That's why GPS signals arrive so weak. They have come a long way.

POWER

Power: the rule of 3s and 10s

Wi-Fi engineers measure signal strength in decibels, or dB. You only need two facts.

Add 3 dB and the power about doubles. Add 10 dB and it's ten times bigger. Going down works the same way. Think of it as money:

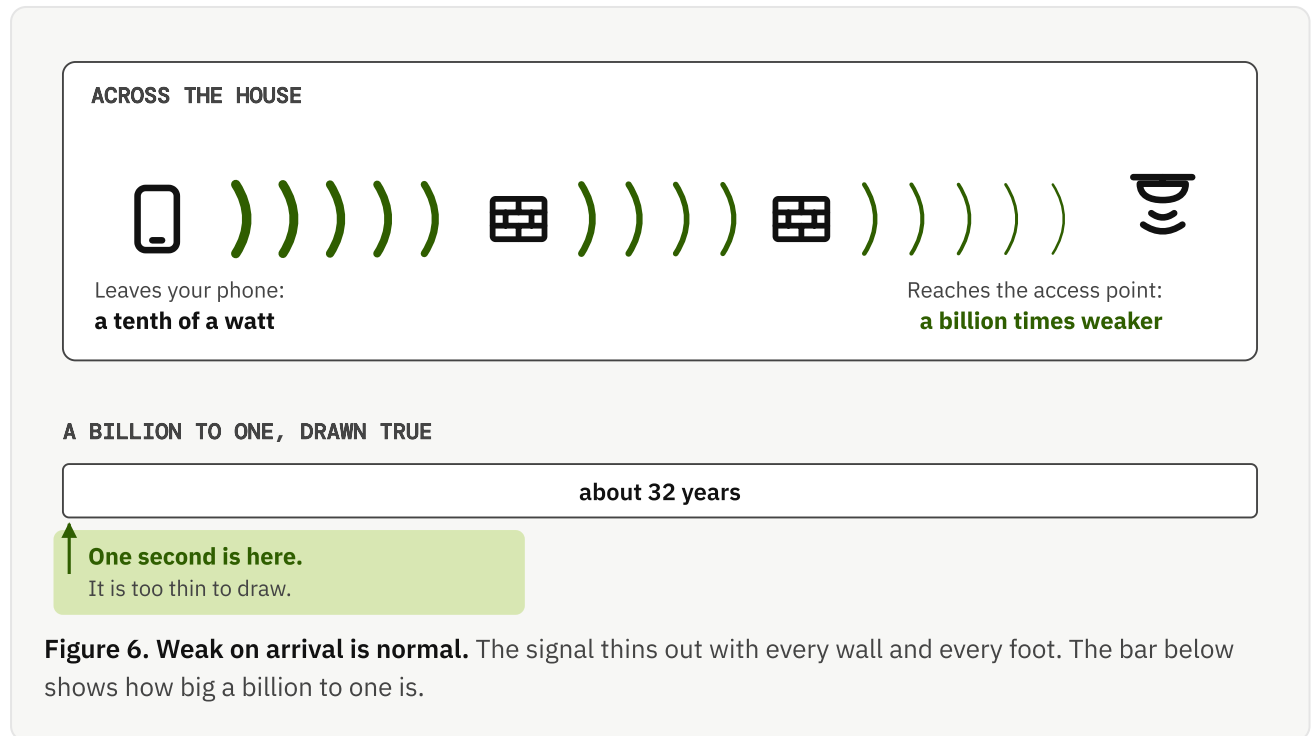


Figure 5. Decibels as money, starting from \$100. Add 3 dB and your money about doubles. Add 10 dB and it grows ten times.

A billion to one

Your phone sends its Wi-Fi signal with up to about a tenth of a watt. By the time it reaches the access point across the house, it can be a billion times weaker.

That sounds broken, but it's normal. A billion to one is like one second out of about 32 years. Wi-Fi radios are built to hear signals that faint.



Why distance costs so much

A signal spreads out as it travels, like paint from a spray can. The farther it goes, the thinner it gets.

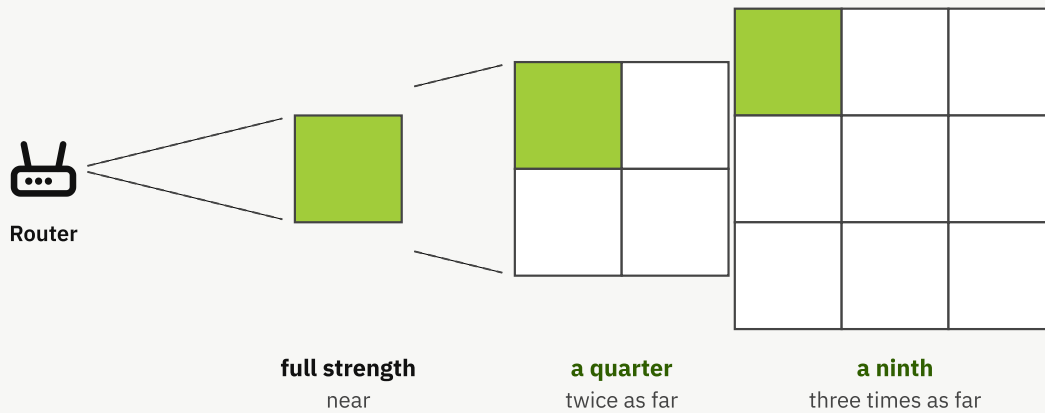
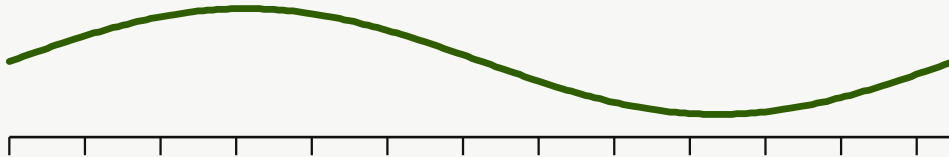


Figure 7. The same power, spread over more area. Double the distance and the signal covers four times the area. Each spot gets a quarter as much.

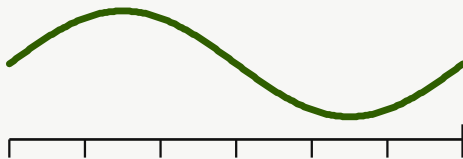
How big is a radio wave?

Wi-Fi waves are small enough to hold. A 2.4 GHz wave is about 12 cm (5 inches) long; the figure shows it at actual size. A 5 or 6 GHz wave is about 5 to 6 cm (2 inches) long.

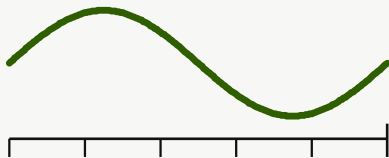
2.4 GHz Wi-Fi: about 12 cm (5 in)



5 GHz Wi-Fi: about 6 cm (2 in)



6 GHz Wi-Fi: about 5 cm (2 in)



One wave of each, at actual size when printed at 100%. Ticks are 1 cm apart.

Figure 8. One wave from each Wi-Fi band. The bands with smaller waves have more room for data, but they fade faster through walls.

Bits and bytes

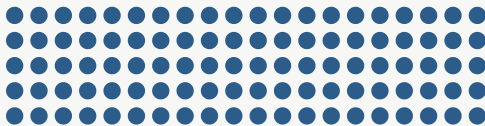
Internet speed is sold in megabits. File sizes are counted in megabytes. They are not the same thing.

A byte is eight bits. So to turn a speed in Mbps into megabytes each second, divide by 8.

8 BITS MAKE 1 BYTE



A 100 MBPS PLAN, EACH SECOND



divide by 8



Figure 9. Eight bits fill one byte. Pour a second of a 100 Mbps plan into byte jars and you fill about 12 of them.

The letter A, stored as 1 byte



Time to download a 4 GB movie

What people expect at 100 Mbps

40 s

Real, at 100 Mbps (at least)

5 min 20 s

Real, at 1 Gbps (at least)

32 s

0 1 min 2 min 3 min 4 min 5 min 6 min

Figure 10. Why a download takes longer than you think. A 100 Mbps plan moves a movie in minutes, not seconds. Drawn to a normal, ruler-style scale.

Real downloads are slower still. Other devices share the connection, and every message carries a little extra.

STRAIGHT FACTS

Four things people get wrong

Each myth is followed by what's true.

MYTH A nanosecond is too short to matter.

FACT Light only goes about a foot in one. Wi-Fi times its turns in millionths of a second, so nanoseconds add up fast.

MYTH Adding 3 dB doubles the power exactly.

FACT It's close to double. That's close enough for any Wi-Fi math you'll ever do.

MYTH A 100 Mbps plan downloads 100 megabytes a second.

FACT Mbps means megabits. Divide by 8. At best, that's about 12 megabytes a second.

MYTH A weak signal means something is broken.

FACT A signal can arrive a billion times weaker than it left and still work. Wi-Fi is built for that.

Pictures to keep

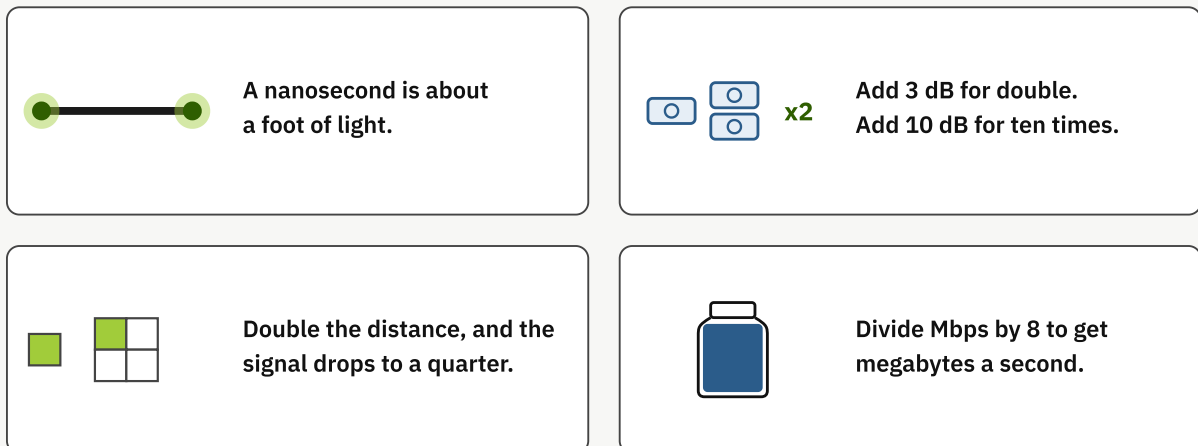


Figure 11. Four pictures to keep. The four ideas from this guide worth remembering.

SOURCES

Where these facts come from

Gathered 28 September 2026.

- NIST SP 330, The International System of Units (SI): the speed of light and the metric prefixes
- Grace Hopper, lecture at MIT Lincoln Laboratory, 25 April 1985, transcript published by Speakola
- Smithsonian National Museum of American History, object record for Hopper's nanosecond wires
- CWNP, "802.11 Beacon Intervals", quoting IEEE 802.11 (the beacon interval)
- GPS.gov, Space Segment (GPS satellite height); Starlink Space Safety, "Constellation altitudes" (about 480 km)
- HyperPhysics, Georgia State University, Inverse square law
- IEC, Prefixes for binary multiples; FCC, Broadband Speed Guide

About this guide

Written for anyone who wants Wi-Fi's numbers to mean something. Companion guides: *How GPS Works, Explained*; *Analog vs Digital, Explained*; *Starlink, Explained*. Keith Parsons, CWNE #3, Wireless LAN Professionals.