EBOOK

The Hitchhiker's Guide to 6G

The what, how, who, why, where and whatever...

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What do you know about 6G? Did you know it's a thing? Did you know it's not actually a thing?

Working as an instructor in the mobile telecommunication world, it's hard to overstate how much the ”generations” have coloured our view of the world. 1G wasn't really called 1G, and 2G was pretty much synonymous with ”the sequel”. But from 3G and onwards, the words themselves (3G, 4G, 5G) have taken on a life of their own.

Everyone has an opinion. Is it hype? Is it technology? Is it clever marketing? And of course, all of the above have been the correct answers, starting with ideas and visions (triggering hype) and ending with published standards, with blueprints that can be used to actually build things.

And now, 6G is making the rounds. The obvious retort to this is, ”But didn't we *just* launch 5G?” We did, you're right. And in fact, 5G is in its infancy, with thousands of unknown things to achieve in the decade to come. But that doesn't mean talking about 6G is ridiculous - although it has become an informal rule that a new generation of mobile telecommunication shall be brought to life once every ten years (2G around 1990; 3G in 2000; 4G in 2010; and 5G a year or so ago). The gestation period from conception (ideas, visions and concepts) to realization (published and finalized standards) has been longer than ten years.

There has, in essence, been parallel development with conceptual work being started on [X+1]G while [X]G still hasn't been launched. Interestingly, this period has decreased over time, being around 15 years for the creation of 3G, 12 years for 4G, and only 8 - 10 years for 5G. It's anyone's guess if this trend will continue with 6G.

6G is coming, and it is most likely going to be called just that: 6G. Some argue it will be more of a paradigm shift than any previous mobile generation transition, but they still don't seem to argue that it should be called something foundationally different. As an Apis teacher, I want to stay up-to-date with what's going on in the world of telecommunications, so I sat down to figure out what 6G is all about.

I have read a lot, and what I'm writing now could be just one more in a large (and growing) group of "So what's this 6G all about?" articles that you could find online. But I'd like to do something slightly different, and leverage the Apis skill set we use every day, to bring order and sense to any and all kinds of messy technical descriptions of things (insert your favourite technology here, and you'll agree the standardization/implementation/deployment isn't exactly straight-forward). I'll organize all the stuff I read into manageable chunks of information, with clear titles. Primarily I did this for my own understanding, but I think this structure may benefit you too.

I will begin with a bulleted list of things that have been said about 6G, but which may not all be 100% clear as to what they mean. To counterpoint that, I will summarize what I've learnt at the end of this article, with a bulleted list of things I believe *actually* describes 6G, as far as we know for now.

So, here we go. There are references at the end, and you're always welcome to contact me to discuss the things you think I have misunderstood. I love to learn!

Full Buzzword-Compatibility (FBC)

FBC is important in our world, so let's just tick off a few of the recurring wow-sounds-cool-but-what-does-it-mean terms that have been mentioned to describe 6G.

- Connecting intelligence.
- Digital twins.
- Extreme experience.
- Human-centric network.
- Truly immersive extended reality.
- Network as a sensor.
- Cloud quantum computing.
- Ultra-high resolution 4D interactions.
- Reconfigurable intelligent surface (RIS).
- Intelligent spectrum sharing.
- Very large volume and tiny instant communications (VLV & TIC).
- End-to-end mandate-driven architecture.
- Distributed MIMO with layer 1 mobility.
- Neuro-morphic compute.

Okay, are we good? Fine. Let's continue... in English.

What is the timeline for 6G?

The short answer is: 2030.

Most organizations around the world (private corporations as well as academic institutions) agree that 6G will launch publicly around the year 2030. Huawei has even promised to, and Apple is recruiting 6G engineers right now.

Before that, there will be tests. South Korea has announced a pilot set for 2026, Huawei and China Mobile have launched satellites to test high-frequency communication suitable for 6G, and researchers in Singapore and Japan have constructed a chip capable of handling terahertz waves, allowing them to transmit data at 11 gigabits per second.

Paradoxically, at this super-early time for 6G, the work being done is at both extremes of the fuzzy-to-concrete axis, but not in the middle. There are early technical tests being done (very concrete) by companies trying to make super-fast chips that will be able to handle high-frequency communication. There are also many very high-level discussions going on in a number of collaboration initiatives (essentially 6G think tanks).

The middle ground, standardization, hasn't really started yet. 3GPP, integral in the creation of 3G, 4G and 5G, currently say that "5G will remain centre stage for another two releases", and a Google search limited to 3gpp.org results only yields 398 hits for the search term "6G". As 5G (phase 2) was finalized with R16 in June 2020, and R17 (scheduled for end of 2021) includes extensions to 5G, it's unclear which two releases the 3GPP is speaking of. A qualified guess would be that it means R17 and R18, letting 6G enter stage in R19.

ITU (the International Telecommunications Union) that has also had important guiding projects for 3G (IMT-2000), 4G (IMT-Advanced) and 5G (IMT-2020), has just started talking about 6G and their group (Working Party 5D) just included "IMT of 2030 and beyond” in their list of IMTs (although it’s not a formal requirements document yet, just a term you can talk about). They plan to have a 6G vision ready by the year 2023, and a Samsung engineer is chairing the working group within ITU-R, ironing out this vision.

What are the overarching goals of 6G?

Short answer: Save the world!

There is no organization responsible for setting the goals of 6G. It’s just something that emerges, and individual groups may have their own goals, of course.

But it can be noted that although many goals I read about are technological, there is a very clear focus on environmental and societal issues as well.

Technically, there is a lot of talk about **connected machines**. By 2030 predictions by Samsung state that we will have 500 billion connected devices (at a time when the human population is around 8.5 billion). The machine will be the main user, in other words.

Openness is also a guiding light. This is already seen in technical solutions such as O-RAN and ONAP, and of course open source code has been let into the finer rooms for quite some time now.

No one would be surprised that AI is in the starting blocks to be used much more intensely than in previous generations. It can be added, however, that its job making intelligent predictions is planned to give 6G a substantially **lowered energy consumption**, which is one of the main drivers of 6G innovation.

Finally, many see future mobile communications as inextricably linked to reaching social goals. **Fighting climate change, hunger and eradicating all sorts of inequalities** is often mentioned, and formally this (at least partly) lines up with the UN Sustainable Development Goals (SDG) in their ”Agenda 2030”.

What is the philosophical change with 6G?

Short answer: Prepare to hook up the Internet as a third hemisphere of your brain.

Nikola Tesla said in 1926, ”When wireless is perfectly applied, the whole earth will be converted into a huge brain”. He even mentioned handheld devices for access to this mainframe intelligence. It's like he predicted the iPhone! Well, maybe we're currently not in total hive-mind mode, but the world-spanning brain does sound a lot like the visions incorporated in 6G.

Many texts mention different ”worlds”: the digital, the physical and the human. 6G is said to ”deepen the connection” between these worlds and even ”blur the lines” between them. A Finnish 6G group, Flagship, talks about ”ubiquitous wireless intelligence” and the EU-funded Hexa-X predicts the ”rise of the augmented human”. And it's perhaps paradoxical, given how much focus there is on AI (Artificial Intelligence) and ML (Machine Learning) in the stories told of the approaching sixth generation, that there is almost the same amount of emphasis on putting the human at the centre of 6G.

It should be noted that there is quite a divide in how visionary the technical leaders of the world allow themselves to be regarding 6G. Some just consider it (or pretend to consider it) plain technological evolution, nothing special, where others really paint a fantastic, often utopian, picture. Top executives are on the record saying things like, ”If the global industry has limited imagination and we cannot come up with compelling use cases, maybe 6G is not needed” (Huawei); ”Why do we need 6G?” (T-Mobile); and ”So far there's no clear reason to move beyond 5G” (Verizon). T-Mobile added ”I'm not sure exactly what it is”, and Verizon took it one step further informing us that ”I really don't know what the hell 6G is”.

Then again, the world is political. The statements above should be seen in context knowing that:

1. They are all in multi-billion dollar 5G network projects right now.
2. They are all members of one, or several, 6G collaboration projects.

How will I, as a user, experience 6G?

Short answer: Science fiction.

Recurring themes in the depictions of 6G are:

- Perfect hologram tele-presence.
- All surfaces can be a display.
- Constantly reachable digital assistant.
- Virtual worlds indistinguishable from the physical world.
- Completely self-driving cars.
- Sub-centimetre-scale positioning.
- Not traditional mobile devices the way we use them today, more wearables.

The ”virtual worlds” may be the ones that stand out the most, and are the foundation for the ”perfect tele-presence” where you really feel transported. 6G has been dubbed ”teleportation tech” for this very reason; it doesn’t teleport you, but it might just as well have. VR and AR (and even MR = Mixed Reality) is often replaced with XR (meaning Extended Reality), which is supposed to deliver a truly immersive experience for the user.

Ericsson has coined the phrase ”Internet of Senses”, and it has then been adopted by the 6G world at large. And they really mean the five senses; meaning they have to simulate touch, smell and taste as well. They don't really say how, but they're not backing down from the claim, at least not yet.

And just as with the previous generations, we can't expect 6G to deliver on day one. 3G and 4G both went through the same [hype] → [Initial disappointment] → [customer satisfaction] process, and 5G is sure to follow the same pattern.

Even if 6G won't start 2030 with full-size, perfect holograms, the market size for hologram displays generally is predicted to be worth 7.6 billion US dollars already in 2023, and 6G will perhaps live until 2040. That's 17 years after 2023.

The short answer could also have been: don't know. 2G promised higher-quality voice calls, but became the text messaging generation. 3G promised video calls, and became the mobile web generation. 4G promised mobile broadband, and became the streaming YouTube and Instagram generation. So who even knows what 5G will be? And then 6G?

What is technically new with 6G?

Short answer: Higher bit rate, lower latency, more AI and MEC, and terahertz waves!

Bit Rate

Raising the bit rate has been a theme through all mobile generations since 2G, which was the first digital mobile technology. Strictly speaking, we could send data with modems even over 1G, so the progression of typical user data rates has been from a couple of kilobits per second in 1G, to hundreds of megabits per second in 5G. This is experienced user data throughput, the technical system limit is often much higher.

A high bit rate is needed for many of the visionary aspects of 6G. Today's 8k Augmented Reality (AR) uses around 55 Mbps, and a truly immersive AR would need 400 Mbps, according to Samsung researchers. A hand-held hologram (mobile phone sized) requires around 500 - 600 Gbps and a full human-sized one would need several Tbps.

6G is said to offer 1 terabit per second in peak data rate, which translates to 20 gigabit per second for an individual user. Since bit rate is such an easy measurement to focus on, these numbers have of course spent a lot of time in the spotlight. Well, not both actually, only one of them: the peak data rate.

It has then very popularly been:
1. Mischaracterized as user data rate.
2. Suffered confusion between bits per second and bytes per second (a byte = 8 bits).

This has resulted in many articles on the interwebs telling the story of the 1 terabyte per second capability of 6G. The popular conversion is into hours of highest-quality Netflix (4k requires 7 gigabytes per hour) and 1000 gigabytes of data then gives you 142 hours of 4k Netflix. Per second. But this requires you to first assume 1 terabit per second is user speed (it's not) and then mis-read terabit for terabyte (most articles helpfully go out of their way to explain how 1 byte = 8 bits).

The real calculation would be using 20 gigabits per second = 2.5 gigabytes per second, which gives us about a third of an hour of 4k Netflix. Still per second though, so I'd say it's good enough for my viewing habits.

These miscalculations seem to all trace back to a single Sydney-based researcher who is credited with saying 6G will give us 8000 Tbps. I can't find the claim, and I doubt he even made it. Still, Google "6G 142 hours of Netflix'' and prepare to have your mind boggled.

Latency

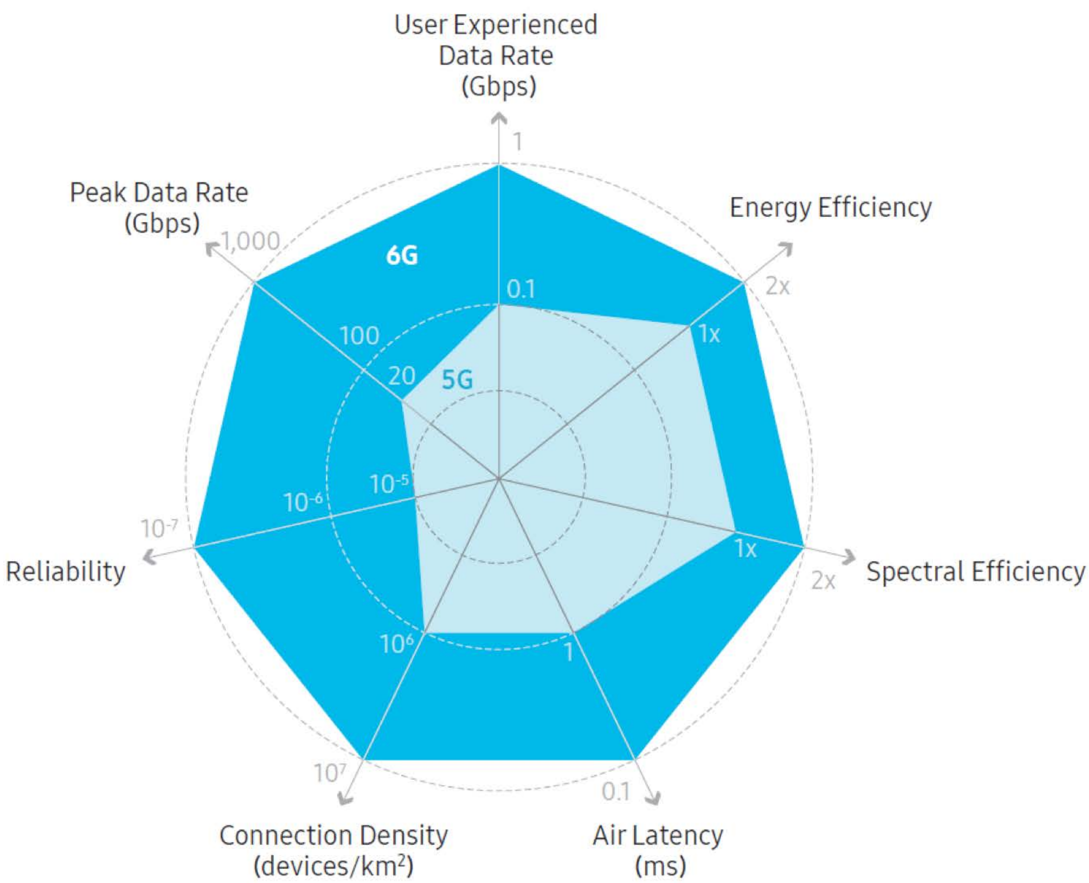
Latency is the time it takes from one thing happening until another thing happens. A delay, if you will. In telecommunications, latency is a very common term, but the points of measurement are quite often a little hazy. Is it from the mobile to the base station, from the mobile to the core network, or from the mobile to the servers and back to the mobile again?

6G will attempt to deliver a mobile-to-service (wherever that is located) latency of 1 ms, with an air latency (mobile to base station) of a tenth of that, 100 microseconds. Most of this latency is not wave propagation, but handling of the signal. Light travels in fibre 200 kilometres (124 miles) in a millisecond, and electromagnetic waves outrun that with 300 kilometres (186 miles) in the same time.

Why is this important? Have you noticed all the talk about XR, VR, AR and ”virtual worlds”? In VR, the motion-to-photon latency rules supreme, and is a brutal master. If you wear a VR headset and it takes more than around 20 ms between the moment you move your head or your hand, until that is represented to your eyes in the display, you lose immersion (and quite possibly lunch). Samsung says this limit is 10 ms for XR. In an Augmented Reality system, often referred to as OST (Optical See-Through) where you see a digital image overlaid on the physical world around you, the latency requirement shrinks to just 5 ms. This is because you won’t just see one world, but two (the digital and the real), and your brain can discern timing discrepancies down to single-digit milliseconds. Which is cool, but is also a technical hurdle.

Jitter is also an aspect to consider, as it measures the variability in the latency, how much the latency changes over time. 6G is proposed to deliver a jitter in the range of microseconds in the end-to-end latency, which is truly astounding.

The image below is a Samsung white paper comparison between 5G and expected values for 6G.



AI

Artificial Intelligence is of course already all the rage, and 6G will, simply put, be using more of it. AI is built-in from the beginning and depending on the reach of a particular AI system, the terms local, joint and end-to-end AI are used.

It can be noted that often when AI is mentioned, it is to provide predictions that can be used to fine-tune the behaviour of the system, or even switch parts of it off to conserve energy. The air interface (radio waves) is sometimes described as an AI/ML air interface, and is meant to use AI and ML (machine learning) to predict the radio environment.

Descriptions of AI in 6G even go so far as to sometimes invoke the concept of the ”precog” individuals from the film ”Minority Report”: people whose job it is to live constantly predicting (and experiencing) the near future.

MEC

MEC stands for Multi-Access Edge Computing and is already an established technology. It means moving computational power closer to the user, instead of running all services in data centres far from the consumer, with delays and lowered throughput as a side effect.

The flip side of this is moving computations from the local devices, to somewhere on the other side of the radio link, so as not to burden small wearable devices with heavy computations (e.g. VR and AR). You could say that it will be a more flexible landscape, where computation is done where and when it suits the application best. This is sometimes called ”split computing” and Ericsson talks about the ”Network Compute Fabric”, meaning the collection of all processing capabilities, from the users’ devices, all the way through the network to the core data centres.

New IP

One prominent think tank suggests we may have come to the end-of-life of our beloved IP protocol. Finnish 6G Flagship says MPLS and GTP are sub-optimal for our current needs, and that we need BBE (Beyond Best Effort) delivery.

In their minds the future holds not just one Internet, but many private and public networks, requiring an ability to handle what’s called ”ManyNets”. In this, a ”contract” is inserted between header and payload, containing promises about latency, packet loss and other QoS (Quality of Service) parameters. The header itself may also be transformed into something called a ”shipping directive” to further support ManyNet routing.

In other protocol news, HTTP/3 could be an important player in 6G. This is not entirely new technology, and HTTP/3 using QUIC (Quick UDP Internet Connections) has already been supported by some browsers since mid-2020. For a long time HTTP/2 has been the obvious and only option, but 6G Flagship say HTTP/3 could provide a smooth evolution towards ”True End-to-End Service-Based Architecture (SBA)”.

Digital Twins

The term ”Digital Twin” is bandied about a lot when discussing 6G characteristics. It's difficult to know where to put this - in this section about technology, or the previous section about user experience. But I put it in the technological one, for a specific reason - I think the term is misleading. I'm not sure about you, but the first ten times I read ”Digital Twin” I thought of a person. A duplicate of me, for instance. Although this could possibly be part of the concept as well, I don't think this is the main meaning of a 6G ”Digital Twin” anymore.

What is duplicated is the environment, not people. It's roads, buildings, cars, lamp posts etc. In this duplicate world, which is supposed to be kept really up-to-date with millisecond latency technology, you can manipulate data, make measurements, and finally deliver predictions that is impossible to do with just a small set of point-like measurements.

Take traffic, for instance. The digitally twinned world could be used to see exactly what's going on, on all roads, for all vehicles, making it possible to pick low-hanging fruit such as much better congestion management, but also more science fiction-like applications - like statistically predicting an accident about to happen in 35 seconds and taking measures to avoid it.

New Use Cases

5G has a well-known trio of use cases:
- Ultra-Reliable Low-Latency Communication (URLLC).
- Massive Machine-Type Communication (mMTC).
- Enhanced Mobile Broadband (eMBB).

Within the framework of 6G, three new use cases have been presented, which almost perfectly just combines the existing three into new pairs:
- Real-Time Broadband Communication (RTBC) = eMBB + URLLC.
- Harmonized Communication and Sensing (HCS) = mMTC + URLLC.
- Uplink-Centric Broadband Communication (UCBC) = mMTC + eMBB.

Note that these use cases, just like any other statement about what 6G ”is”, is not official and is not part of any actual standardization. It's still mostly visions and white papers.

New Places for Base Stations

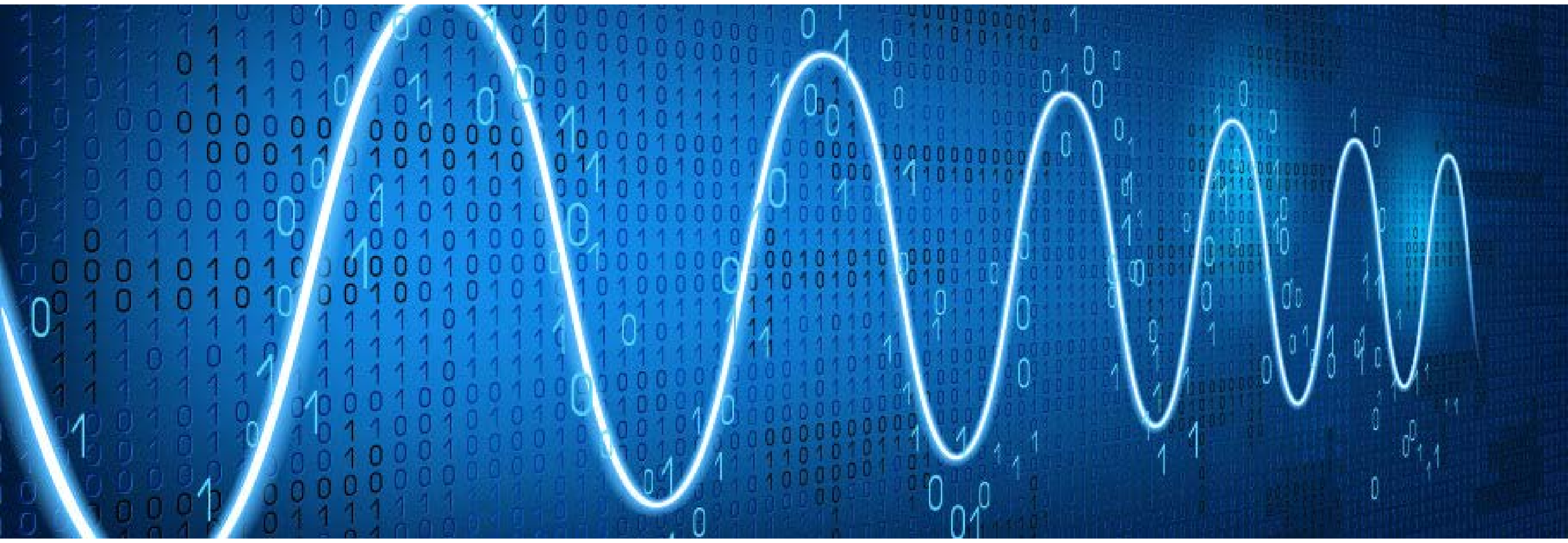
6G is probably going to support more locations for communication nodes than previous generations. Terrestrial components are not new (fixed or moving base stations), but UAM (Urban Air Mobility) systems are; this is your classic flying car. Going higher up we have HAPS (High Altitude Platform Stations) which could be blimps, and even higher we get Low Earth Orbit (LEO), and finally Geostationary (GEO) satellites.

Less Energy Consumption

One of the major goals of 6G is to reduce energy consumption, specifically to meet the Sustainable Development Goals (SDG) set by the United Nations in their ”Agenda 2030”. 6G addresses this mainly with the same energy consumption techniques used in 5G, namely NFV, SDN and network slicing, just more precisely, supported by the infinite and precognisant wisdom of AI and ML.

Terahertz Waves

This is such a big subject, it requires a section of its own. Follow me and I’ll unpack this.



Terahertz you say, tell me more

Short answer: This is unused greenfield spectrum, if you’re right next to the base station, within line-of-sight and the sun is shining.

New things are coming in the radio world. It’s likely that the networks will be more mesh-like, letting devices contact the network through each other (this is today often called D2D, or device-to-device functionality), giving much better range and fewer ”blind spots”.

It’s also not unlikely that it will be possible to use the same frequency spectrum, at the same time, for both uplink and downlink. In Code-Division Multiple Access (CDMA), classically used in 2G and 3G, different users can connect to the network at the same time, using the same frequency, cleverly separated by something called a ”code”. Some say this can be extended in 6G to allow for simultaneous uplink and downlink on the same frequency. But fancy as this is, it’s still not the big radio thing everyone is talking about. The big thing is: terahertz waves.

What’s a Terahertz?

On the surface it’s not complicated, but exactly what it sounds like. It’s waves in the terahertz spectrum of electromagnetic radiation. Traditional mobile telecommunications have used spectrum from hundreds of megahertz up to, most recently, 5G which has used ”mmWave” as a big poster word. mmWave is EM radiation with waves between 1 and 10 millimetres long, corresponding to frequencies between 300 and 30 gigahertz. Although frequencies up to 100 GHz is on the table for 5G, so far practicalities have only allowed for frequencies up to 39 GHz.

Above that is what many have thought of as “useless spectrum”. Useless because it’s difficult to use. But it also means it’s unused, which is tempting. If we go to 1000 gigahertz = 1 terahertz, there is a lot of unused spectrum up there, which has made many label the THz spectrum interesting, important and even inevitable for 6G.

The US regulatory authority FCC has made the spectrum from 95 GHz to 3 THz available as an experimental resource for innovators. This was done in 2019, and organizations are given a 10 year licence to experiment. FCC calls this the ”Spectrum Horizons Experimental Radio Licence”.

Of course things don’t happen overnight, and many believe initial rollout will start around 275 GHz, and then the frequencies will rise up above the THz mark. ITU is one of the most important global standardizing bodies for mobile telecommunications (they’re part of the UN), and they have World Radio Congresses (WRC) every three to four years. The next one will be in 2023 and will more than likely include the terahertz question, and probably offer some guidance.

So What’s the Problem?

Why is all this spectrum unused, or even ”useless”? It turns out that as the frequency is raised, the propagation of the radio wave becomes more and more difficult. Lower frequencies (hundreds of megahertz) can travel many kilometres, go through walls and around buildings. Higher frequencies, and this is true even for the ones in the high end of the 5G span (up to 100 GHz), are much harder to keep alive, as they fly away from the antenna. Path loss, how much the radiated power is attenuated over distance, increases. The radio waves in the millimetre wave spectrum can't penetrate walls or go around corners.

One reason for this path loss is absorption by molecules in the atmosphere. Below 10 GHz it's fairly unhindered, but both free oxygen (O2) and water vapor (H2O) in the air have multiple resonance frequencies, the first at 22 GHz (water) and the next at 63 GHz (oxygen). At these frequencies they absorb the energy of the radio emission, draining it from power. This also means that rain, leaves, and even fog, disturbs the signals.

Although this is a problem, there is hope. It seems it could be possible to modulate the signal in such a clever way (think crazy, complex math) that the water and oxygen don't start resonating and let the signal through.

Will Things Only Get Worse Then?

The interesting thing is that the terahertz wave spectrum is kind of the most difficult part of the spectrum, and is sometimes referred to as the ”terahertz gap”. That's partly because the increase in path loss is not linear, and doesn't get a lot worse with higher frequencies. Partly it's because it's difficult to generate the terahertz waves. Longer waves (lower frequencies) we can do, that's what we have in our good old walkie-talkies and 1G, 2G, 3G and so on. But distinctly higher frequencies are also quite easy to generate. For instance, the range from 400 - 800 terahertz is quite easy to generate, because that's visible light, and the electromagnetic wave transmitter used for that is called…a lamp.

So What Will 6G Terahertz Base Stations Look Like?

They will quite likely not look like anything you'd call a ”base station”, because they will be really small. They will constitute an infrastructure, the likes of which we haven't come close to yet, with transmitters and receivers possibly in every room.

This sounds very dangerous of course, and you can imagine the protests from the 5G fear-mongers when they hear this. But it will probably, in reality, result in a measurably lower exposure to radiation. All transmission will be short-range, dedicated to fill a specific purpose, not use more energy than needed, and use highly directed beamforming to concentrate the energy only in the direction needed. (And just to be clear, no generation of mobile communications has been shown to have any detrimental effects on human health.)

This is incidentally also the reason positioning could get so precise, as an effect of very local low-power base stations, and pencil-thin transmission beams.

It has also been suggested that the terahertz era will bring with it more satellite technology (as mentioned, test satellites with terahertz chips have already been tested), as well as ”intelligent surfaces” capable of reflecting EM radiation in such a way that it will be easier to reach all users.

Which collaboration projects exist?

Short answer: Quite a few, with a messy funding structure in Europe.

There are currently a number of projects running to outline, and eventually ease into existence, the 6G era. Here are some of the more prominent ones I found.

Horizon 2020

This is a research and innovation programme within the European Commission (the executive arm of the European Union), aimed at boosting European innovation and competitiveness. It houses a number of projects and funds a lot of independent research on the European continent.

Horizon 2020 has a budget of 900 million Euro up until the year 2027, but this is not a 6G-exclusive initiative. A lot of interesting 6G projects in Europe do seem to get funding from here, though, once you start looking.

Hexa-X

This is a project within the 5GPPP, an EU research group created to establish guidelines for 5G. The name stuck and 5GPPP does 6G things, just as 3GPP has done 3G, 4G and 5G things (and will get into 6G as well).

Hexa-X gets funding from Horizon 2020, which started on the 1st of January 2021 and will run for an estimated 2.5 years. It is led by Nokia (formal project lead) and co-piloted (formally technical management) by Ericsson. Along with lots of European universities, the group also comprises Intel, Orange, Qualcomm, Siemens, TIM and Telefonica.

6G Flagship

This has a slightly confusing name, as many of these projects are informally considered and called ”flagship” projects for this or that organization or part of the world. This one is named ”6G Flagship” though.

It is run by the university of Oulu, which is in Finland (homeland of Nokia). This is more of a research centre than one specific project, it seems. It has gathered 300 researchers, has a budget of a quarter of a billion Euro, roughly, and is set to run for 8 years.

Even though it is run from Europe, it has lots of non-European members participating in its work, primarily from Asia. The list of companies taking part in the 6G Flagship programme includes Orange, NEC, Microsoft, Huawei, TIM and ZTE.

One neat thing about 6G Flagship, is that they have written and published a number (a dozen, to be precise) of high-quality 6G white papers. These can be downloaded from their website, and is a great resource to start unpacking the subject of 6G.

The topics of these 12 white papers are:

- 6G Drivers and UN SDGs.
- Business of 6G.
- 6G Validation and Trials.
- 6G Connectivity for Remote Areas.
- 6G Networking.
- Machine Learning in 6G.
- Edge Intelligence in 6G.
- Trust, Security and Privacy in 6G.
- 6G Broadband Connectivity.
- Critical and Massive Machine Type Communication in 6G.
- 6G Localization and Sensing.
- RF Opportunities and Challenges in 6G.

It seems this project has its roots in something called 6Genesis, which existed in 2018 and is still mentioned here and there on the Internet. Today the 6Genesis domain points at the 6G Flagship website.

Next-G Alliance

This is not European, but North American. It is an initiative within ATIS (Alliance for Telecommunications Industry Solutions).

Next-G started in 2020, and its purpose is to promote 6G research in North America, with a prestigious list of members: AT&T, Ericsson, Telus, Verizon, T-Mobile, Microsoft, Samsung, Nokia, Facebook, Qualcomm, Apple, Google, Bell Canada, Ciena, InterDigital, JMA Wireless, Telnyx, Cisco and VMware. It is chaired by AT&T and the vice chair is Ericsson.

RINGS

This acronym stands for ”Resilient and Intelligent Next-Generation Systems programme”. It is run out of NSF (National Science Foundation, the National here being the United States) and plans to hand out around 40 million US dollars to projects and research teams in the 6G area.

It is an American-run programme, and its members include Apple, Google, IBM, Intel, Microsoft, Nokia, Qualcomm, VMware and Ericsson.

REINDEER

This is one of those projects where you wonder if the name or the acronym came first, as REINDEER stands for ”REsilient INteractive applications through hyper-Diversity in Energy-Efficient Radiowaves technology”.

It is a 5GPPP project and gets funding from EU’s Horizon 2020. It started on the first day of 2021 and is scheduled to run for 3.5 years.

It may seem very niche and is, in essence, a collaboration group for leading multi-antenna technology manufacturers. But as mm Wave and terahertz technology is such a deeply rooted part of the magic of 6G, antenna technology may represent the part of 6G that experiences the most actual technical innovation.

6GIC

IC stands for ”Innovation Centre” and 6GIC is a UK-based research centre. It is run by the University of Surrey and aims to be a ”UK-based hub for global innovation and collaboration on 6G”.

Are there anti-collaboration projects?

Short answer: Yes.

Well, there are no projects with the explicit intention of ruining the plans of others. Kind of. But also, there kind of are.

Let's back up. In the good old days of 1G it was every man, woman and non-binary for him-, her- and their self. The world was covered with different, completely non-interoperable, mobile telephony systems. As we then progressed through the generations, adding technical requirements for bit rates and latency and other easily measurable things, there was also a drive towards unity. The world didn't want a million different mobile systems.

2G was better than 1G. You could travel around Europe with the same GSM phone, and if you went to the US, you didn't need a conceptually different phone, just a GSM one that could handle the frequencies used in America. Same technology, other frequencies. There were triple-band phones that could be used on both continents. Yes, there were other 2G systems as well, like CDMA, but baby steps were bringing us closer to a global mobile communications community.

The stated intention from the ITU when outlining the requirements on 3G (IMT-2000), was to have just one standard. They got two, UMTS and cdma2000, but still much better than 2G.

As the cdma2000 path eventually closed, 4G was the first standard to be truly global. Whether you call it LTE or EPS or something else, we have only one 4G. The same thing applies for 5G. It is standardized by 3GPP, which truly brings under one roof, people from around the whole world.

Here comes the 6G twist. Quite a few of the most prominent 6G initiatives today, including Hexa-X from Europe and Next-G from North America, have the stated mission to make ”their” continent the leader in the 6G race. And in fact, just calling it a ”race” gives the game away a little bit, doesn’t it?

Huawei is not in Next-G. NSF is American, so Huawei is not in RINGS either. Not surprising after the recent rise of US-China conflict-oriented sentiments.

As we become a more digitized society, wireless standards emerge as a foundational cornerstone, giving stability to the wellbeing of the national economy and security. And who wouldn’t want to be in total control of that? So it’s currently a bit up in the air how joined our forces will be in the creation of 6G. Will we finally join hands and walk together, or will, as some predict, the 6G race give rise to a new technological cold war between the EU, US and China?

Summary

I started working in this business in the year 2000. I worked at the Swedish (formerly national) operator Telia, specifically in their research department. It was in the budding 3G era - everyone talked about it, but no one really knew what to do with it. We even got direct orders from management: ”Now that we have this 3G licence, could you please tell us what we got it for?” It was weird.

We conducted a lot of focus groups exploring the concept ”always on”, and showed people visionary films about what the future could hold for us if we got 3G. The cool thing, looking back at those films, is that even with 4G, every single thing in those films became everyday parts of my life. Everything except video calls. That doesn’t seem to ever really play well with the human psyche. We've had the technology for a long time, but not a lot of people I see on the bus are engaged in video calls.

So historically, and statistically, there is precedent for science fiction-like visionary concept films to become real in a decade. Perhaps it will be true with 6G as well. Granted, the films I've seen so far about 6G are quite far out there, but then again, that was my exact feeling about the 3G films twenty years ago!

Think about it this way: 6G is going to be in the spotlight somewhere between 2030 and 2040. It will begin its life after a decade shaped by 5G (who knows where that will lead us), and then continue to develop for ten more years (4G is very different now compared to when it was first launched a decade ago).

I promised a technical summary, to bring balance to the buzzword beginning of this article, and here it comes.

This is my summary of what I believe describes 6G, as far as we know now:

- It will be much faster than 4G (perhaps 1 Gbps user bit rate).
- It will have lower latency than 4G (perhaps sub-millisecond).
- It will use very high frequencies (hundreds of GHz and up into THz territory).
- Radio infrastructure will be much more built into things, as "base stations" will need to be small, close to the users, and often with direct line-of-sight.
- There will be holograms. There just will be. That's cool!
- The current trend of virtualization, NFV and SDN will continue and be more heavily used.
- The current trend of MEC will continue and be more heavily used.
- We as humans will be much more hooked-up to the global information systems.
- Autonomous vehicles will be everywhere, and will in some way use 6G.
- The main use case of 6G is probably still completely unknown to us (which is likely the case even for 5G).
- Even though there is contention right now, I'm willing to bet that there will be an essentially global 6G standard, and that 3GPP will have something to do with it.

If you have comments about what I've written, or thoughts you want to discuss, don't hesitate to get in touch with us. We love to discuss technology! And until we can offer you 6G training, why not start out with some 5G courses?

Take care, and keep a look out for those 6G holograms!

Further reading

Here are places you can go and read more about 6G for yourself. Be aware that not all of the reporting in the articles is necessarily 100% reliable. Remember the 142 Netflix hours.

Organizations

- https://hexa-x.eu/
- https://5g-ppp.eu/hexa-x/
- https://nextgalliance.org/
- https://www.oulu.fi/6gflagship/
- https://www.oulu.fi/6gflagship/6g-white-papers
- http://jultika.oulu.fi/files/isbn9789526228419.pdf
- https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505904
- https://cordis.europa.eu/project/id/101015956
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Film

- https://www.youtube.com/watch?v=T6ubRoZCeVw&list=PLbmmrgFBOMouFA9JFgVeV9iOoFWCCnxua
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From companies

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In the news

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- https://interestingengineering.com/6g-what-why-when
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- https://www.lightreading.com/cloud-nativenfv/verizons-cto-i-dont-know-what-hell-6g-is/d/d-id/766270
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- https://www.lightreading.com/6g/6g-could-be-worlds-first-teleportation-tech/d/d-id/766395
- https://www.lightreading.com/6g/huawei-and-great-6g-schism/a/d-id/768733
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