Expert discusses the power consumption of next-gen wireless networks

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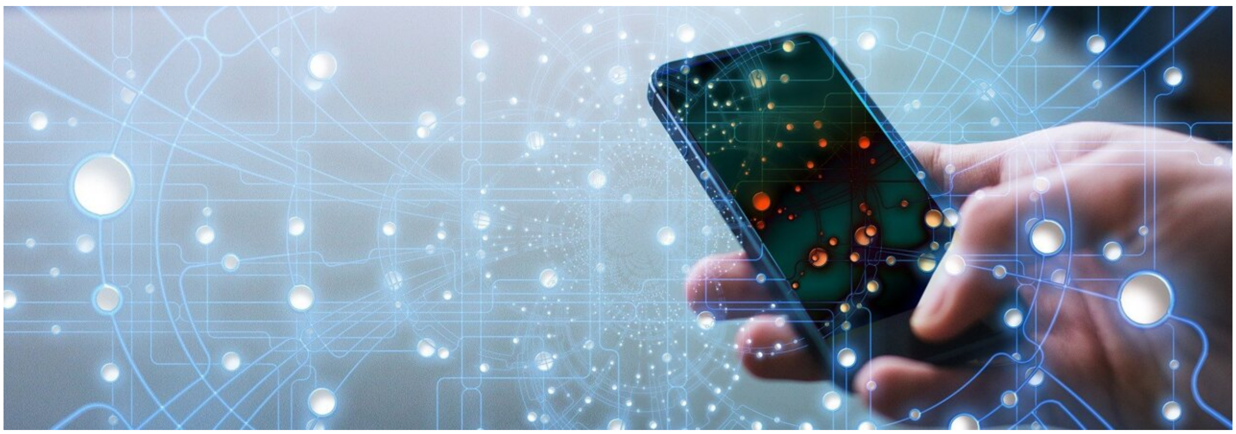

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Considering the seismic shocks that our world has endured over the last two years alone, it seems unwise to engage in predictions about what it will look like in ten years or more.

But what we can predict with certainty is that energy consumption will remain one of humanity's biggest concerns. And the urgency of the fight against climate change will be even more pressing than it is now.

Given these two truths, we can no longer rely on fossil fuels to drive economic growth.

Speaking of growth, experts predict the IT sector to keep booming. That's good news, since digital technologies contribute to greater energy efficiency and sustainability. Take telepresence, for instance, which can reduce our need for travel.

Nevertheless, the sustainability challenge is so massive that we can't afford to ignore the environmental impact of the IT infrastructure itself.

Luckily, consumers and the industry are increasingly aware of this impact. Energy efficiency is becoming a valid selling point for devices such as smartphones and laptops. And especially with the debate around the environmental cost of cryptocurrencies, nobody can claim ignorance of the potential impact of data centers on our global energy consumption.

One of the areas where awareness is comparatively lacking, is the energy cost of our wireless network infrastructure. Vendors of base stations are starting to look into the energy efficiency of their devices. But network operators are slow to consider the total energy cost of their operations.

From their viewpoint, that's understandable. The complexity of such a consideration is substantial. And when we move beyond 5G, that complexity will only increase. The good news? Our models for assessing that impact are also becoming more sophisticated.

More base stations, or more power?

Although the details are still under discussion, it's already clear that 6G will encompass several hardware innovations. Examples are sharing of spectrum and infrastructure, cell-free massive MIMO, and the convergence of communication and sensing. But, most importantly, 6G will require a shift to higher frequencies—above 100 GHz.

These factors will add to the evolution that has already started with 5G towards more complex network architectures. For one thing, a move to (much) higher frequencies will often mean that each base station's range will become (much) shorter. That generally leads to a need for more base stations to ensure complete coverage at the highest capacity.

Is that bad news from the perspective of energy consumption?

The short answer is yes. As a general rule, it's more wasteful to add base stations than to increase the output power of an existing station. There's a straightforward reason for this: adding more base stations means decoupling shared resources such as cooling, which diminishes the overall energy efficiency.

That's one of the reasons why massive MIMO is already a valuable addition to wireless connectivity technologies for 5G. It doesn't increase the power consumption per base station. Meanwhile, it expands the range at the network level, and enables faster communication towards multiple users in parallel.

So is it a good idea to increase the power levels of the base stations even further to decrease the need for additional base stations? Maybe, from a purely theoretical perspective. But in the real world, obstacles pop up frequently, such as local and international EMF regulations that limit the exposure to electro-magnetic radiation.

Another real-world consideration in designing wireless networks goes beyond the number of clients within a given area. It also takes their bandwidth needs into account. We can't forget that the bitrate also affects the power consumption of the base stations. Although 6G will be able to offer astronomical throughputs, should they be available everywhere all the time?

Models to optimize the energy efficiency of 6G networks

If we're serious about limiting the energy use of tomorrow's complex wireless network infrastructures, we can't continue being content with relatively simple and theoretical models.

The challenge lies in finding the optimal balance between the energy costs of adding more base stations, and increasing the power output levels of each base station. That's an exercise that has to be repeated for each concrete implementation. And we need to consider such factors as the physical environment, existing infrastructure, predefined installation criteria, bandwidth needs of human and non-human users, EMF guidelines, and so on.

The WAVES research group of imec at Ghent University has developed a technology- and vendor-agnostic radio access network (RAN) design tool for precisely such purposes. Creating a 3D model of the area and populating it with virtual users enables network designers to calculate the amount, locations, and power levels of base stations to ensure optimal coverage within a given area. It already supports a variety of technologies and will be continuously updated to include emerging ones such as mmWave.

The best way to boost 6G energy efficiency

The key is to use tools that can manage both the complexity of our wireless networks and that of the real world. That enables us to maximally limit energy consumption without impacting the quality of service.

These tools will help limit the chunk that wireless connectivity takes out of the world's energy budget. But it will only take us so far. At the network level, none of the technologies considered for 6G will offer us more degrees of freedom than the ones we have now. Those are: the power levels of the base stations, their locations, and smart adaptations to changing data traffic demands.

If we want to control the energy use of our wireless networks, the heavy lifting will have to be done at the device level. By exploring new materials and architectures, we should be able to disconnect a leap in performance from a commensurate rise in energy consumption. For instance, III/V technologies do not only enable more efficient power amplifiers. They also drive optimal architectures towards a reduced number of antennas and analog components.

Provided by IMEC

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