

Mobile voice quality

“After several rings, John Beerends picks up my call on his cellphone. Beerends, a senior researcher at the Netherlands Organization for Applied Scientific Research, in Delft, is one of the world’s top experts on sound perception, and I’ve called from Boston to ask his opinion on the quality of audio on mobile phones. But the connection keeps cutting out, and what I can hear is almost unintelligible. I must sound just as bad, because he asks me to dial him back on his landline. This time, his voice is much clearer. And he immediately confirms what now seems glaringly obvious: Despite their ubiquity and decades-long existence, cellphones still make for pretty poor phones.”

Mobile voice quality

- Today's cellphones are quite advanced pieces of technology
- They have the processing power of the 1980s supercomputers
- They can handle data transfers with speed on the order of tens of megabits per second

However

- The quality of mobile voice is still significantly worse than on landlines
- Even in the best conditions, including a quiet environment and a strong wireless signal, users consistently rate voice quality lower on a cellphone than on a landline. Weaken the cellular link or add background noise, such as from wind or street traffic, and callers' opinions of the experience drop dramatically.

Mobile voice quality

- In the early days of cellphones, the low quality of mobile voice was not a big issue
- Mobility was a luxury (people was willing to accept a degraded quality of voice, to have mobility)
- Today, in the United States, about 40 percent of homes rely exclusively on mobile phones for making and receiving calls
- In Africa, cellular subscriptions outnumber landlines 52 to 1

Mobile voice quality: Bottlenecks

- The first obstacle to a good-quality voice connection on today's mobile phones is their design
- Handsets have evolved considerably since Motorola debuted the original “brick” phones
- With its ear-size speaker and microphone pointed directly at his mouth, the Gekko used was clearly constructed with voice calls in mind
- Modern phone makers have taken a new tack. The smartphone's form “*is driven by industrial design and not voice quality,*” says Chris Kyriakakis, founder and chief technology officer of Audyssey, a Los Angeles–based acoustic design company.



Illustration: Serge Bloch

Bottleneck #1: Handset design

Once upon a time, cellphones were just phones. The rise of smartphones has seen microphones take a back seat to other design considerations.

Solution: Using multiple microphones can clean up a distorted voice.

Mobile voice quality: Bottlenecks

- In modern smartphones, to create an elegant, palmable chassis for watching videos and thumbing through music playlists, designers shrink and flatten speakers and sometimes even cover them in plastic
- Small, compressed speakers damp down low frequencies, degrading the quality of voice
- Smartphones use software to lessen such distortions, making voices sound more realistic



Old “brick” mobile phone

Mobile voice quality: Background noise

- The small microphone of smartphones is a problem
- The farther it is from your mouth, the more unwanted noise it picks up
- Many high-end smartphones address this problem by using multiple microphones, typically three. With one microphone situated as close as possible to the user's lips and the additional ones set farther away, a smartphone can compare the different incoming signals to better filter out background sounds
- But noise-cancellation algorithms aren't a sure-fire fix, because they can take a few seconds to recognize a noise. So while they're quite good at removing consistent sounds such as the hiss inside a passenger jet, they do a poor job of eliminating sudden or irregular disruptions, like a baby crying
- Voice echoes are especially difficult to weed out because the algorithms must also preserve speech: Too much noise suppression removes much of the natural acoustic variation in human speech, making it sound robotic
- Bluetooth ear clips or the speakerphones in cars do not help much: These setups put the microphone closer to the speaker than to your mouth, causing callers' voices or reflections within the car to echo back at them



Illustration: Serge Bloch

Bottleneck #2: Sharp background noise

Your phone can filter out background noise, such as traffic. But when it comes to sudden sounds, noise-canceling software may not be nimble enough to silence the interruption.

Solution: Specialized headsets with noise-canceling technology can silence everything but what you want to hear.

Mobile voice quality: Compression

- Unlike landlines, which provide each caller with a dedicated, full-capacity channel, cellphones must share a limited amount of wireless spectrum
- So they compress the voice data to let more users connect
- Standard compression rates vary from 12.2 kb/s to 4.75 kb/s, depending on the volume of voice traffic and the strength of the wireless signal
- Calls compressed to speeds as low as 7.95 kb/s can still sound almost as good as a landline connection. But beyond that, you start to hear compression artifacts, including missing syllables and distortions such as ringing or warbling
- If you're making a local call to a mobile user on your own carrier network, the compressed data will likely travel to the receiving cellphone without further manipulation
- But if you're talking to someone across the country or on a different carrier, your local network will typically direct the call into the backbone telephone network, which was designed to carry landline traffic at 64 kb/s. So transcoding equipment at the exchange point must convert the mobile voice data to the higher wire-line rate.
- A standard landline phone can decode that signal without losing more information. But if your call is sent to another cellphone, voice quality will take another nosedive when the base station serving the phone recompresses the data to fit into a cramped wireless channel.



Illustration: Serge Bloch

Bottleneck #3: Phone-to-tower connection

Distance from a cellular tower can degrade the quality of a voice call or result in the conversation being dropped altogether.

Solution: Cellular providers offer signal boosters that can improve call quality if you're not near a tower.

Mobile voice quality: Solutions?

- Other parts of the telephone network may require additional conversions, which can further degrade quality. For instance, international carriers sometimes compress voice data to stuff more calls through subsea cables rather than pay for additional capacity. The extra compression cycles can explain the very poor international voice call quality that we sometimes experience
- A couple of technologies already exist that can circumvent these choke points—or at least lessen the damage. Many new smartphones have one or both built in. But for you to use these enhancements to their full potential, carriers will have to make major network upgrades, which will take time and money.
- One solution is HD voice. This transmission standard more than doubles the range of audio frequencies that represent speech, letting phone systems collect and relay signals from 50 to 7,000 Hz. At their healthiest, normal human ears can perceive frequencies as low as 20 Hz and as high as 20,000 Hz. But early telephone networks had limited bandwidth, and engineers decided that frequencies between 300 and 3,400 Hz would be adequate for conveying intelligible speech.

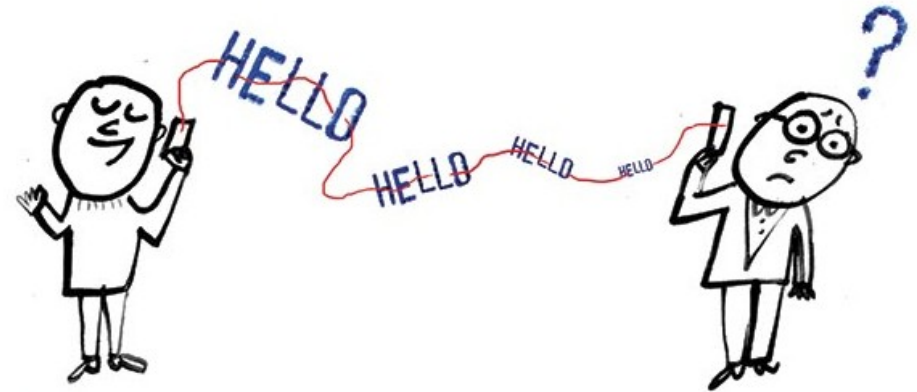


Illustration: Serge Bloch

Bottleneck #4: Voice-data conversion

Cellular voice calls can be compressed multiple times and get unpacked at their destination, garbling the speakers' words.

Solution: VoLTE technology can ensure your call has to be compressed only once, minimizing voice degradation.

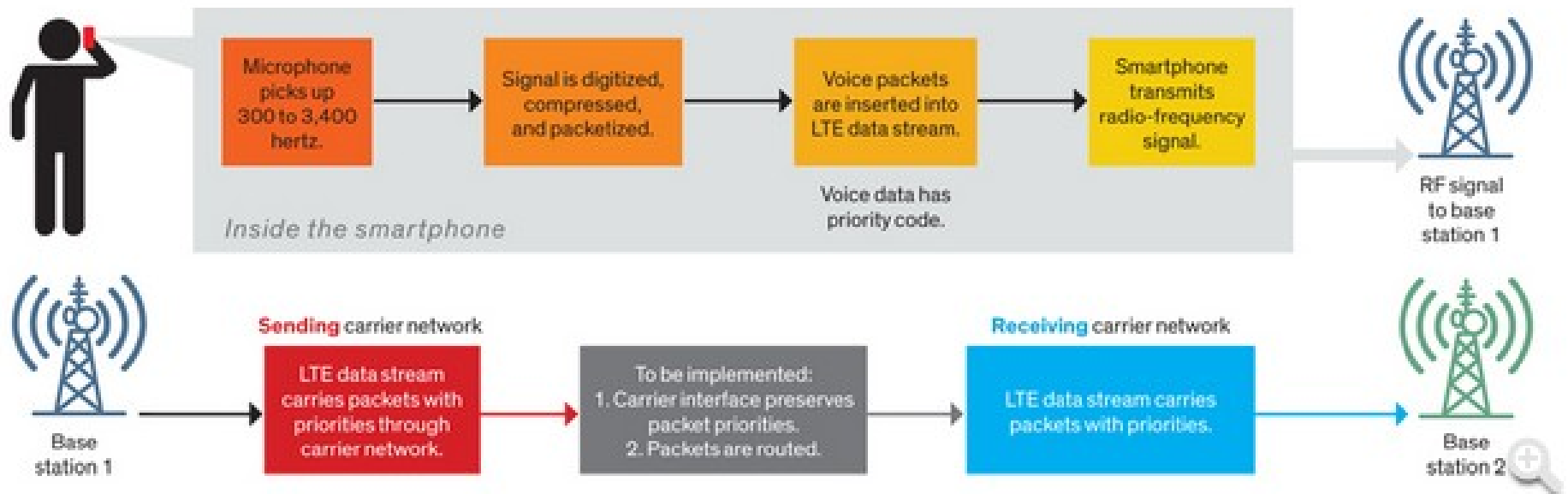
Mobile voice quality: HD voice

- By the 1980s, however, acoustic researchers had demonstrated that people need to hear a wider range of wavelengths to fully understand speech. Frequencies above 3,400 Hz, for example, help listeners distinguish between some consonants. “If I said ‘fox’ and ‘socks’ in isolation, you couldn’t tell them apart over standard telephone bandwidth,” says Mark Clements, a signal-processing expert at Georgia Tech. Likewise, names like Jeff and Jess sound the same on the phone.
- After the International Telecommunications Union standardized HD voice more than a quarter century ago, radio broadcasters were among the first adopters. Today, they still use the technology to transmit remote interviews from a sports stadium or another studio over high-speed digital telephone lines. The improvement in sound quality is significant.
- In September 2009, in an unlikely test ground sandwiched between Romania and Ukraine, the wireless carrier Orange became the first company to launch HD voice on a cellular network. The technology has since spread around the world. According to the latest count, 329 smartphone models support the standard, and 109 mobile operators offer service in 73 countries.
- If you’re wondering why you haven’t noticed these changes, that’s because HD voice equipment still typically defaults to standard “narrowband” service. Even if your phone is HD compatible, for instance, you won’t hear an improvement unless the person you’re talking with is also on an HD phone and all of the networking equipment in between supports the technology. But that situation almost never happens because the circuit-switched backbone still uses standard voice technology. Until it’s upgraded, you won’t be able to roam among different HD networks or place an HD call to someone on a different carrier.

Mobile voice quality: VoLTE

- A promising fix for this problem is the second technology capable of boosting cellular voice quality: Voice over LTE (VoLTE). Today, the majority of mobile calls, including HD traffic, are carried on a 2G or 3G network despite the widespread deployment of LTE technology.
- VoLTE lets mobile carriers deliver voice traffic just like regular data. By compressing a voice call into a series of standardized packets that can travel between carriers and across national borders over an IP backbone, VoLTE eliminates the need to convert the data into different formats for different parts of the system. “The same bits that leave one phone will enter the other phone without any changes,” Ericsson’s Derksen explains. And because LTE is designed to deliver any data packet regardless of its content, VoLTE networks can support HD voice right out of the box.
- But most LTE carriers don’t yet offer VoLTE. “LTE was originally designed without a native voice service,” says Peter Carson, senior director of technical marketing at Qualcomm. That’s because traditional packet switching doesn’t ensure good voice quality. By treating all packets on a first-come, first-served basis, LTE carriers can’t guarantee that voice packets will arrive at their destination in a timely manner. Packets can be lost or delayed, for example, when a network is busy, creating unintentional silences that can garble speech or cause callers to talk over one another. This unreliability helps explain why VoIP calls can sometimes sound great one minute and poor the next.

Mobile voice quality: VoLTE



Voice over LTE (VoLTE) lets cellular carriers send voice calls the same way they send other data, like bits of a streaming video. As VoIP services do, VoLTE compresses and digitizes your voice, sending it as packets of data over the LTE network. The packets are sent with priority codes to ensure they arrive in order and don't garble your message. LTE is now widely available, but carriers still have work to do to ensure that all networks respect one another's priority codes.

Mobile voice quality: Traffic management

- In general, the quality of VoIP services has gotten better in recent years as broadband speeds have increased. But when VoIP packets enter the Internet or a cellular network, they're handled as "best-effort traffic" along with other data. So VoIP providers can't promise that sound quality will always be adequate.
- VoLTE lets LTE carriers manage voice traffic using a software platform called the IP Multimedia Subsystem, or IMS. This control layer essentially acts as a traffic cop, opening fast lanes for voice data and other time-sensitive streams, such as video calls and online gaming.
- The IMS prioritizes some types of traffic over others by assigning each data connection a single-digit code, called the QoS (quality-of-service) class identifier, or QCI. This number, which is stored in a routing table, describes the transmission requirements for the link, including the maximum packet latency, acceptable number of losses, and whether the network will guarantee a given bit rate. Voice calls, for example, get a QCI of 1, which ensures that 99.99 percent of packets will arrive at their destination within 100 milliseconds, even during peak use times. By comparison, typical Internet traffic, such as e-mail and browsing data, receives the lowest-priority QCIs: 8 and 9. Each router along the way can now usher packets into different transmission queues depending on their QCIs, preventing VoLTE packets, for example, from getting stuck in a Netflix traffic jam.

Mobile voice quality: Current evolution

- For years, VoLTE deployments lagged far behind HD voice over 2G and 3G networks. But now, carriers are finally committing to the upgrade. More than 100 smartphone models include the technology, and although the service is currently available from only 10 carriers, in Hong Kong, Japan, Singapore, South Korea, and the United States, others are quickly getting on board. As of July, 56 more operators had announced plans to test or commercialize VoLTE in 35 countries around the globe.
- Meanwhile, carriers are expanding their IP infrastructures, including backbone networks and local broadband links, which will let VoLTE packets flow seamlessly between mobile handsets and other IP phones, including computers and landlines. Voice quality should continue to improve as more networks support priority protocols and callers move onto the same packet-based system.
- Eventually, if the carriers get their way, the old circuit-switched networks will go dark. But that transition will take time as companies invest in new equipment and regulators work to ensure that some customers aren't left with shoddy voice service—or none at all.

Mobile voice quality: Current evolution

- There was a time when telephone operators took pride in their voice networks. When Sprint built the first nationwide fiber footprint in the late 1980s, for example, it ran commercials boasting that the system was “so incredibly quiet that you could actually hear a pin drop.”
- But since the arrival of the smartphone era, carriers have been strangely mum about sound quality. Could the tide be turning at last? Even the second-, third-, and fourth-largest U.S. carriers—AT&T, Sprint, and T-Mobile—which long shied away from discussing voice quality with the public, announced plans for VoLTE rollouts this year. Verizon, the top U.S. carrier, which plans to start deploying the technology before year’s end, calls it “the next evolution in wireless calling.”
- *“If that’s really true, it’s reason for me and other voice customers to be optimistic. But I’ve experienced too many lousy connections to take these promises at face value: I’ll believe it when I hear it.”* (says Jeff Hecht)