How we made Bluetooth

Bluetooth allows electronic devices to communicate over short distances and is used by billions of devices worldwide. Jaap Haartsen recalls the developments that led to the establishment of the Bluetooth wireless technology standard.

Jaap Haartsen

In 1990, after completing my PhD at Delft University of Technology, I was hired by Nils Rydbeck who had just started the Ericsson-GE mobile phone division in Research Triangle Park, North Carolina, USA. Rydbeck also headed the Ericsson mobile phone division in Lund, Sweden, and had created an ideal environment for young engineers to play around with different ideas and technologies without being restricted by commercial barriers. My first manager was Paul Dent, a great inventor who taught me how to map ideas into patent applications. I initially worked on digital cellular telephony, but after a while I moved to indoor communications.

In the summer of 1994, I moved to Lund, where Rydbeck asked me to work on a new concept: a short-range radio link between a cellular phone and nearby electronic devices, supporting both voice and data. At the time, there was an ongoing project called Cornelius that investigated a wireless link between a phone and a voice headset. However, this was based on an analogue technology and did not support data. And because of the choice of spectrum, it could not be used worldwide. I started to look at other technologies, like the cordless phone standard Digital Enhanced Cordless Telecommunications (DECT) or wireless local area network (WLAN) 802.11, but none fulfilled the requirements of peer connectivity, support for voice and data, and low-power consumption.

Later in 1994, I attended an IEEE conference in The Hague, the Netherlands, that hosted symposia on both personal, indoor and mobile radio communications, and wireless computer networks, the first with focus on voice and the second on data. At the conference, I learned more about the use of the 2.4 GHz industrial, scientific and medical (ISM) radio band as a global spectrum for communications, and knew that this would be the way forward. Regulations, such as the US Federal Communications Commission (FCC) Part 15, however, put restrictions on the use of the ISM band, and, therefore, frequency hop (FH) spreading or direct-sequence (DS)

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spreading would be required. Spreading distributes the signal power over a larger part of the frequency spectrum, which can be accomplished either by jumping back and forth with a narrowband, low-rate signal (FH) or by using a wide bandwidth with a high-rate signal (DS). Furthermore, since this was a licence-free band, a radio system operating in it had to deal with interference from other users, ranging from garage door openers to baby monitors. To deal with this interference, I selected frequency hopping because, instantaneously, the radio occupies only a small part of the spectrum and nearby interferers can be suppressed by channel filtering. And at the same time, the radio, on average, hops through the entire ISM band, providing robustness against fading and static interferers.

One of the challenges in the radio system was establishing a connection quickly. For optimal robustness, the 80 MHz of the 2.4 GHz band was divided into 79 frequencies (matching the carrier plan of the WLAN 802.11 FH variant). When not connected, the device is hopping around in the spectrum, scanning at a low duty cycle for other devices that may want to connect. The other device does not know when the first device will scan and at what frequency. There is both an uncertainty in time and in frequency. How to solve this problem at low power consumption and low latency? The solution was to reduce the frequency

uncertainty by not using all 79 carriers during connection establishment, but only 32 carriers. Since this did not satisfy the FCC Part 15 requirements for FH, spreading codes were used at connection establishment to satisfy the FCC's hybrid FH/DS spreading requirements.

Early in 1995, Sven Mattisson joined the Ericsson division in Lund. An expert on radio implementations, he started to work on the hardware development of the radio. The intent was to make a low-power radio in complementary metal-oxide-semiconductor (CMOS) technology without any external components. With the hardware team, I worked on system solutions to create a full CMOS implementation. In Lund, the project was called MC Link. MC came from a multi-communicator Ericsson was developing: a small personal assistant that could be connected to the cellular phone via a wireless link.

In 1997, after nearly four years as a research project, Ericsson hired Örjan Johansson to create a business around the short-range radio concept. An ecosystem was needed, involving other industries. Intel was the first interested party. Together with key people from Intel, including Jim Kardach and Simon Ellis, other companies were approached: Nokia, Toshiba and IBM. The codename Bluetooth was used for this international project. Together, the five companies created the Bluetooth Special Interest Group in 1998. The rest is history. The technology was publicly announced in May 1999 and the first specifications were released in July 1999. In 2000, Ericsson launched its first Bluetooth product: a wireless voice headset. Interestingly, it came with an adaptor for the phone since the phones did not yet have Bluetooth embedded. □

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