

Bluetooth

For the Danish king, see [Harald Bluetooth](#).

Bluetooth is a short-range [wireless](#) technology standard that is used for exchanging data between fixed and mobile devices over short distances and building [personal area networks](#) (PANs). In the most widely used mode, transmission power is limited to 2.5 [milliwatts](#), giving it a very short range of up to 10 metres (33 ft). It employs [UHF radio waves](#) in the [ISM bands](#), from 2.402 [GHz](#) to 2.48 GHz.^[3] It is mainly used as an alternative to wire connections, to exchange files between nearby portable devices and connect [cell phones](#) and music players with [wireless headphones](#).

Bluetooth is managed by the [Bluetooth Special Interest Group](#) (SIG), which has more than 35,000 member companies in the areas of telecommunication, computing, networking, and consumer electronics. The [IEEE](#) standardized Bluetooth as **IEEE 802.15.1**, but no longer maintains the standard. The Bluetooth SIG oversees development of the specification, manages the qualification program, and protects the trademarks.^[4] A manufacturer must meet [Bluetooth SIG standards](#) to market it as a Bluetooth device.^[5] A network of [patents](#) apply to the technology, which are licensed to individual qualifying devices. As of 2021, 4.7 billion Bluetooth [integrated circuit](#) chips are shipped annually.^[6]

Etymology


The name "Bluetooth" was proposed in 1997 by [Jim Kardach](#) of [Intel](#), one of the founders of the Bluetooth SIG. The name was inspired by a conversation with Sven Mattisson who related Scandinavian history through tales from [Frans G. Bengtsson's](#) *[The Long Ships](#)*, a historical novel about Vikings and the 10th-century Danish king [Harald Bluetooth](#). Upon discovering a picture of the [runestone of Harald Bluetooth](#)^[7] in the book *A History of the Vikings* by [Gwyn Jones](#), Jim proposed Bluetooth as the codename for the short-range wireless program which is now called Bluetooth.^{[8][9][10]}

According to Bluetooth's official website,

Bluetooth was only intended as a placeholder until marketing could come up with something really cool.


Later, when it came time to select a serious name, Bluetooth was to be replaced with either RadioWire or PAN (Personal Area Networking). PAN was the front runner, but an exhaustive search discovered it already had tens of thousands of hits throughout the internet.

A full trademark search on RadioWire couldn't be completed in time for launch, making Bluetooth the only choice. The name caught on fast and before it could be changed, it

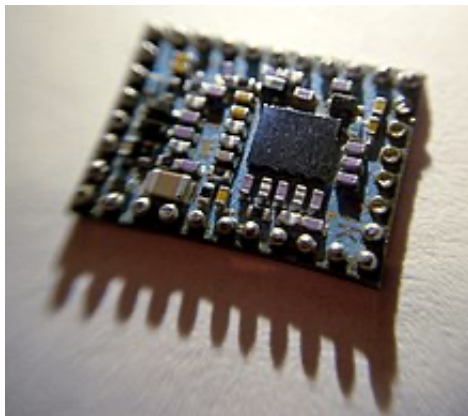
Bluetooth	
 Bluetooth[®]	
Developed by	Bluetooth Special Interest Group
Introduced	7 May 1998
Industry	Personal area networks
Compatible hardware	Personal computers Smartphones Gaming consoles Audio devices Embedded devices
Physical range	Typically less than 10 m (33 ft), up to 100 m (330 ft). Bluetooth 5.0: 40–400 m (100–1,000 ft) ^{[1][2]}
Website	www.bluetooth.com (https://www.bluetooth.com/) ↗

spread throughout the industry, becoming synonymous with short-range wireless technology.^[11]

Bluetooth is the [Anglicised](#) version of the Scandinavian *Blåtand*/*Blåtann* (or in [Old Norse](#) *blátǫnn*). It was the [epithet](#) of King Harald Bluetooth, who united the disparate Danish tribes into a single kingdom; Kardach chose the name to imply that Bluetooth similarly unites communication protocols.^[12]

The Bluetooth logo  is a [bind rune](#) merging the [Younger Futhark runes](#) ✖ (✖, [Hagall](#)) and Bj (Bj, [Bjarkan](#)), Harald's initials.^{[13][14]}

History



Ericsson Bluetooth module PBA 313 01/2S R2A manufactured in week 22, 2001.

The development of the "short-link" radio technology, later named Bluetooth, was initiated in 1989 by Nils Rydbeck, CTO at [Ericsson Mobile](#) in [Lund](#), Sweden. The purpose was to develop wireless headsets, according to two inventions by Johan Ullman, [SE 8902098-6](#) (<https://worldwide.espacenet.com/textdoc?DB=EPODOC&IDX=SE8902098-6>) [↗](#), issued 1989-06-12 and [SE 9202239](#) (<https://worldwide.espacenet.com/textdoc?DB>

=EPODOC&IDX=SE9202239) [\[15\]](#), issued 1992-07-24. Nils Rydbeck tasked Tord Wingren with specifying and Dutchman [Jaap Haartsen](#) and Sven Mattisson with developing. [\[16\]](#) Both were working for Ericsson in Lund. [\[17\]](#) Principal design and development began in 1994 and by 1997 the team had a workable solution. [\[18\]](#) From 1997 Örjan Johansson became the project leader and propelled the technology and standardization. [\[19\]](#)[\[20\]](#)[\[21\]](#)

In 1997, Adalio Sanchez, then head of [IBM ThinkPad](#) product R&D, approached Nils Rydbeck about collaborating on integrating a [mobile phone](#) into a ThinkPad notebook. The two assigned engineers from Ericsson and IBM studied the idea. The conclusion was that power consumption on cellphone technology at that time was too high to allow viable integration into a notebook and still achieve adequate battery life. Instead, the two companies agreed to integrate Ericsson's short-link technology on both a ThinkPad notebook and an Ericsson phone to accomplish the goal. Since neither IBM ThinkPad notebooks nor Ericsson phones were the market share leaders in their respective markets at that time, Adalio Sanchez and Nils Rydbeck agreed to make the short-link technology an open industry standard to permit each player maximum market access. Ericsson contributed the short-link radio technology, and IBM contributed patents around the logical layer. Adalio Sanchez of IBM then recruited Stephen Nachtsheim of Intel to join and then Intel also recruited [Toshiba](#) and [Nokia](#). In May 1998, the Bluetooth SIG was launched with IBM and Ericsson as the founding signatories and a total of five members: Ericsson, Intel, Nokia, Toshiba and IBM.

The first Bluetooth device was revealed in 1999. It was a hands-free mobile headset that earned the "Best of show Technology Award" at [COMDEX](#). The first Bluetooth mobile phone was the Ericsson T36, but it was the revised [T39](#) model that actually made it to store shelves in 2001. In parallel, IBM introduced the IBM ThinkPad A30 in October 2001 which was the first notebook with integrated Bluetooth.

Bluetooth's early incorporation into consumer electronics products continued at Vosi Technologies in Costa Mesa, California, USA, initially overseen by founding members Bejan Amini and Tom Davidson. Vosi Technologies had been created by real estate developer Ivano Stegmenga, with United States Patent 608507, for communication

between a cellular phone and a vehicle's audio system. At the time, Sony/Ericsson had only a minor market share in the cellular phone market, which was dominated in the US by Nokia and Motorola. Due to ongoing negotiations for an intended licensing agreement with Motorola beginning in the late 1990s, Vosi could not publicly disclose the intention, integration and initial development of other enabled devices which were to be the first "Smart Home" internet connected devices.

Vosi needed a means for the system to communicate without a wired connection from the vehicle to the other devices in the network. Bluetooth was chosen, since Wi-Fi was not yet readily available or supported in the public market. Vosi had begun to develop the Vosi Cello integrated vehicular system and some other internet connected devices, one of which was intended to be a table-top device named the Vosi Symphony, networked with Bluetooth. Through the negotiations with Motorola, Vosi introduced and disclosed its intent to integrate Bluetooth in its devices. In the early 2000s a [legal battle \(https://casetext.com/case/motorola-inc-v-vosi-technologies-inc\)](https://casetext.com/case/motorola-inc-v-vosi-technologies-inc) ensued between Vosi and Motorola, which indefinitely suspended release of the devices. Later, Motorola implemented it in their devices which initiated the significant propagation of Bluetooth in the public market due to its large market share at the time.

In 2012, Jaap Haartsen was nominated by the European Patent Office for the European Inventor Award.^[17]

Implementation

Bluetooth operates at frequencies between 2.402 and 2.480 GHz, or 2.400 and 2.4835 GHz, including [guard bands](#) 2 MHz wide at the bottom end and 3.5 MHz wide at the top.^[22] This is in the globally unlicensed (but not unregulated) industrial, scientific and medical (ISM) 2.4 GHz short-range radio frequency band. Bluetooth uses a radio technology called [frequency-hopping spread spectrum](#). Bluetooth divides transmitted data into packets, and transmits each packet on one of 79 designated Bluetooth channels. Each channel has a bandwidth of 1 MHz. It usually performs 1600 hops per second, with [adaptive frequency-hopping](#) (AFH) enabled.^[22] [Bluetooth Low Energy](#) uses 2 MHz spacing, which accommodates 40 channels.^[23]

Originally, [Gaussian frequency-shift keying](#) (GFSK) modulation was the only modulation scheme available. Since the introduction of Bluetooth 2.0+EDR, $\pi/4$ -[DQPSK](#) (differential quadrature phase-shift keying) and 8-DPSK modulation may also be used between compatible devices. Devices functioning with GFSK are said to be operating in basic rate (BR) mode, where an instantaneous [bit rate](#) of 1 [Mbit/s](#) is possible. The term Enhanced Data Rate (EDR) is used to describe $\pi/4$ -DPSK (EDR2) and 8-DPSK (EDR3) schemes, each giving 2 and 3 Mbit/s respectively. The combination of these (BR and EDR) modes in Bluetooth radio technology is classified as a *BR/EDR radio*.

In 2019, Apple published an extension called HDR which supports data rates of 4 (HDR4) and 8 (HDR8) Mbit/s using $\pi/4$ -[DQPSK](#) modulation on 4 MHz channels with forward error correction (FEC).^[24]

Bluetooth is a [packet-based protocol](#) with a [master/slave architecture](#). One master may communicate with up to seven slaves in a [piconet](#). All devices within a given piconet use the clock provided by the master as the base for packet exchange. The master clock ticks with a period of 312.5 μs , two clock ticks then make up a slot of 625 μs , and two slots make up a slot pair of 1250 μs . In the simple case of single-slot packets, the master transmits in even slots and receives in odd slots. The slave, conversely, receives in even slots and transmits in odd slots. Packets may be 1, 3, or 5 slots long, but in all cases, the master's transmission begins in even slots and the slave's in odd slots.

The above excludes Bluetooth Low Energy, introduced in the 4.0 specification,^[25] which [uses the same spectrum but somewhat differently](#).

Communication and connection

A master BR/EDR Bluetooth device can communicate with a maximum of seven devices in a piconet (an ad hoc computer network using Bluetooth technology), though not all devices reach this maximum. The devices can switch roles, by agreement, and the slave can become the master (for example, a headset initiating a connection to a phone necessarily begins as master—as an initiator of the connection—but may subsequently operate as the slave).

The Bluetooth Core Specification provides for the connection of two or more piconets to form a [scatternet](#), in which certain devices simultaneously play the master/leader role in one piconet and the slave role in another.

At any given time, data can be transferred between the master and one other device (except for the little-used broadcast mode). The master chooses which slave device to address; typically, it switches rapidly from one device to another in a [round-robin](#) fashion. Since it is the master that chooses which slave to address, whereas a slave is (in theory) supposed to listen in each receive slot, being a master is a lighter burden than being a slave. Being a master of seven slaves is possible; being a slave of more than one master is possible. The specification is vague as to required behavior in scatternets. ^[26]

Uses


Bluetooth is a standard wire-replacement communications protocol primarily designed for low power consumption, with a short range based on low-cost [transceiver microchips](#) in each device. ^[27] Because the devices use a radio (broadcast) communications system, they do not have to be in visual line of sight of each other; however, a [quasi optical](#) wireless path must be viable. ^[28]

Bluetooth Classes and power use

Bluetooth device power by class

Class	Max. permitted power	
	(mW)	(dBm)
1	10 — 100	+10 — +20
1.5*	2.5 — 10	+4 — +10
2	1 — 2.5	0 — +4
3	0.01 — 1	-20 — 0

* Class 1.5 included in class 1 for BR/EDR

Source: BT 5.3 Vol 6 Part A Sect 3 and V2 PA S3, [Bluetooth Technology Website \(https://www.bluetooth.com/specifications/specs/core-specification-5-3/\)](https://www.bluetooth.com/specifications/specs/core-specification-5-3/) 

Historically, the Bluetooth range was defined by the radio class, with a lower class (and higher output power) having larger range.^[2] The actual range achieved by a given link will depend on the qualities of the devices at both ends of the link, as well as the [air and obstacles in between](#). The primary hardware attributes affecting range are the data rate, protocol (Bluetooth Classic or Bluetooth Low Energy), the transmitter power, the receiver sensitivity, and the gain of both antennas.^[29]

The effective range varies depending on propagation conditions, material coverage, production sample variations, antenna configurations and battery conditions. Most Bluetooth applications are for indoor conditions, where attenuation of walls and signal fading due to signal reflections make the range far lower than specified line-of-sight ranges of the Bluetooth products.

Most Bluetooth applications are battery-powered Class 2 devices, with little difference in range whether the other end of the link is a Class 1 or Class 2 device as the lower-powered device tends to set the range limit. In some cases the effective range of the data link can be extended when a Class 2 device is connecting to a Class 1 transceiver with both higher sensitivity and transmission power than a typical Class 2 device.^[30] Mostly, however, the Class 1 devices have a similar sensitivity to Class 2 devices. Connecting two Class 1 devices with both high sensitivity and high power can allow

ranges far in excess of the typical 100m, depending on the throughput required by the application. Some such devices allow open field ranges of up to 1 km and beyond between two similar devices without exceeding legal emission limits.^{[31][32][33]}

Bluetooth profile

Main article: [List of Bluetooth profiles](#)

To use Bluetooth wireless technology, a device must be able to interpret certain Bluetooth profiles, which are definitions of possible applications and specify general behaviors that Bluetooth-enabled devices use to communicate with other Bluetooth devices. These profiles include settings to parameterize and to control the communication from the start. Adherence to profiles saves the time for transmitting the parameters anew before the bi-directional link becomes effective. There are a wide range of Bluetooth profiles that describe many different types of applications or use cases for devices.^[34]

List of applications



A typical Bluetooth mobile phone
[headset](#) from early 2000's



A handheld, waterproof
Bluetooth speaker with battery,
late 2010s

- Wireless control and communication between a mobile phone and a [handsfree headset](#). This was one of the earliest applications to become popular.^[35]
- Wireless control of audio and communication functions between a mobile phone and a Bluetooth compatible car stereo system (and sometimes [between the SIM card and the car phone](#)^{[36][37]}).
- Wireless communication between a smartphone and a [smart lock](#) for unlocking doors.
- Wireless control of and communication with iOS and Android device phones, tablets and portable [wireless speakers](#).^[38]
- Wireless [Bluetooth headset](#) and [intercom](#). Idiomatically, a headset is sometimes called "a Bluetooth".
- Wireless streaming of audio to [headphones](#) with or without communication capabilities.
- Wireless streaming of data collected by Bluetooth-enabled fitness devices to phone or PC.^[39]
- Wireless networking between PCs in a confined space and where little bandwidth is required.^[40]
- Wireless communication with PC input and output devices, the most common being the [mouse](#), [keyboard](#) and [printer](#).

- Transfer of files, contact details, calendar appointments, and reminders between devices with [OBEX^{\[a\]}](#) and sharing directories [via FTP^{\[41\]}](#)
- Triggering the camera shutter of a [smartphone](#) using a Bluetooth controlled [selfie stick^{\[42\]}](#)
- Replacement of previous wired [RS-232](#) serial communications in test equipment, [GPS receivers](#), medical equipment, bar code scanners, and traffic control devices.
- For controls where [infrared](#) was often used.
- For low bandwidth applications where higher [USB](#) bandwidth is not required and cable-free connection desired.
- Sending small advertisements from Bluetooth-enabled advertising hoardings to other, discoverable, Bluetooth devices.^[43]
- Wireless bridge between two Industrial Ethernet (e.g., [PROFINET](#)) networks.
- Game consoles have been using Bluetooth as a wireless communications protocol for peripherals since the [seventh generation](#), including Nintendo's [Wii^{\[44\]}](#) and Sony's [PlayStation 3](#) which use Bluetooth for their respective controllers.
- Dial-up internet access on personal computers or PDAs using a data-capable mobile phone as a wireless modem.
- Short-range transmission of health sensor data from medical devices to mobile phone, [set-top box](#) or dedicated [telehealth](#) devices.^{[45][46]}
- Allowing a [DECT](#) phone to ring and answer calls on behalf of a nearby mobile phone.
- [Real-time location systems](#) (RTLS) are used to track and identify the location of objects in real time using "Nodes" or "tags" attached to, or embedded in, the objects tracked, and "Readers" that receive and process the wireless signals from these tags to determine their locations.^[47]
- Personal security application on mobile phones for prevention of theft or loss of items. The protected item has a Bluetooth marker (e.g., a tag) that is in constant communication with the phone. If the connection is broken (the marker is out of range

of the phone) then an alarm is raised. This can also be used as a [man overboard](#) alarm.

- [Calgary, Alberta](#), Canada's Roads Traffic division uses data collected from travelers' Bluetooth devices to predict travel times and road congestion for motorists.^[48]
- Wireless transmission of audio (a more reliable alternative to [FM transmitters](#))
- Live video streaming to the visual cortical implant device by Nabeel Fattah in Newcastle university 2017.^[49]
- Connection of [motion controllers](#) to a PC when using VR headsets

Bluetooth vs Wi-Fi (IEEE 802.11)

Bluetooth and [Wi-Fi](#) (Wi-Fi is the brand name for products using [IEEE 802.11](#) standards) have some similar applications: setting up networks, printing, or transferring files. Wi-Fi is intended as a replacement for high-speed cabling for general [local area network](#) access in work areas or home. This category of applications is sometimes called [wireless local area networks](#) (WLAN). Bluetooth was intended for portable equipment and its applications. The category of applications is outlined as the wireless [personal area network](#) (WPAN). Bluetooth is a replacement for cabling in various personally carried applications in any setting and also works for fixed location applications such as smart energy functionality in the home (thermostats, etc.).

Wi-Fi and Bluetooth are to some extent complementary in their applications and usage. Wi-Fi is usually access point-centered, with an asymmetrical client-server connection with all traffic routed through the access point, while Bluetooth is usually symmetrical, between two Bluetooth devices. Bluetooth serves well in simple applications where two devices need to connect with a minimal configuration like a button press, as in headsets and speakers.

Devices



A Bluetooth [USB](#) dongle with a 100 m (330 ft) range

Bluetooth exists in numerous products such as telephones, [speakers](#), tablets, media players, robotics systems, laptops, and game console equipment as well as some high definition [headsets](#), [modems](#), [hearing aids](#)^[50] and even watches.^[51] Given the variety of devices which use Bluetooth, coupled with the contemporary deprecation of headphone [jacks](#) by Apple, Google, and other companies, and the lack of regulation by the FCC, the technology is prone to interference.^[52] Nonetheless, Bluetooth is useful when transferring information between two or more devices that are near each other in low-bandwidth situations. Bluetooth is commonly used to transfer sound data with telephones (i.e., with a Bluetooth headset) or byte data with hand-held computers (transferring files).

Bluetooth protocols simplify the discovery and setup of services between devices.^[53] Bluetooth devices can advertise all of the services they provide.^[54] This makes using services easier, because more of the security, [network address](#) and permission configuration can be automated than with many other network types.^[53]

Computer requirements



A typical Bluetooth [USB](#) dongle



An internal notebook Bluetooth card
(14×36×4 mm)

A personal computer that does not have embedded Bluetooth can use a Bluetooth adapter that enables the PC to communicate with Bluetooth devices. While some [desktop computers](#) and most recent laptops come with a built-in Bluetooth radio, others require an external adapter, typically in the form of a small USB "[dongle](#)."

Unlike its predecessor, [IrDA](#), which requires a separate adapter for each device, Bluetooth lets multiple devices communicate with a computer over a single adapter.^[55]

Operating system implementation

Further information: [Bluetooth stack](#)

For [Microsoft](#) platforms, [Windows XP Service Pack 2](#) and SP3 releases work natively with Bluetooth v1.1, v2.0 and v2.0+EDR.^[56] Previous versions required users to install their Bluetooth adapter's own drivers, which were not directly supported by Microsoft.^[57] Microsoft's own Bluetooth dongles (packaged with their Bluetooth computer devices) have no external drivers and thus require at least Windows XP

Service Pack 2. Windows Vista RTM/SP1 with the Feature Pack for Wireless or Windows Vista SP2 work with Bluetooth v2.1+EDR.^[56] Windows 7 works with Bluetooth v2.1+EDR and Extended Inquiry Response (EIR).^[56] The Windows XP and Windows Vista/Windows 7 Bluetooth stacks support the following Bluetooth profiles natively: PAN, SPP, [DUN](#), HID, HCRP. The Windows XP stack can be replaced by a third party stack that supports more profiles or newer Bluetooth versions. The Windows Vista/Windows 7 Bluetooth stack supports vendor-supplied additional profiles without requiring that the Microsoft stack be replaced.^[56] Windows 8 and later support Bluetooth Low Energy (BLE). It is generally recommended to install the latest vendor driver and its associated stack to be able to use the Bluetooth device at its fullest extent.

[Apple](#) products have worked with Bluetooth since [Mac OS X v10.2](#), which was released in 2002.^[58]

[Linux](#) has two popular [Bluetooth stacks](#), BlueZ and Fluoride. The BlueZ stack is included with most Linux kernels and was originally developed by [Qualcomm](#).^[59] Fluoride, earlier known as Bluedroid is included in Android OS and was originally developed by [Broadcom](#).^[60] There is also Affix stack, developed by [Nokia](#). It was once popular, but has not been updated since 2005.^[61]

[FreeBSD](#) has included Bluetooth since its v5.0 release, implemented through [netgraph](#).^{[62][63]}

[NetBSD](#) has included Bluetooth since its v4.0 release.^{[64][65]} Its Bluetooth stack was ported to [OpenBSD](#) as well, however OpenBSD later removed it as unmaintained.^{[66][67]}

[DragonFly BSD](#) has had NetBSD's Bluetooth implementation since 1.11 (2008).^{[68][69]} A [netgraph](#)-based implementation from [FreeBSD](#) has also been available in the tree, possibly disabled until 2014-11-15, and may require more work.^{[70][71]}

Specifications and features

The specifications were formalized by the [Bluetooth Special Interest Group](#) (SIG) and formally announced on 20 May 1998.^[72] Today it has a membership of over 30,000

companies worldwide.^[73] It was established by [Ericsson](#), [IBM](#), [Intel](#), [Nokia](#) and [Toshiba](#), and later joined by many other companies.

All versions of the Bluetooth standards support [backwards compatibility](#).^[74] That lets the latest standard cover all older versions.

The Bluetooth Core Specification Working Group (CSWG) produces mainly 4 kinds of specifications:

- The Bluetooth Core Specification, release cycle is typically a few years in between
- Core Specification Addendum (CSA), release cycle can be as tight as a few times per year
- Core Specification Supplements (CSS), can be released very quickly
- Errata (Available with a user account: [Errata login \(https://www.bluetooth.com/log-in?bortorgReturnURL=/errata/index.cfm?_ga=1.184939692.467079692.1485266743\)](https://www.bluetooth.com/log-in?bortorgReturnURL=/errata/index.cfm?_ga=1.184939692.467079692.1485266743) ↗)

Bluetooth 1.0 and 1.0B

- Products weren't interoperable
- Anonymity wasn't possible, preventing certain services from using Bluetooth environments^[75]

Bluetooth 1.1

- Ratified as [IEEE Standard 802.15.1–2002](#)^[76]
- Many errors found in the v1.0B specifications were fixed.
- Added possibility of non-encrypted channels.
- Received Signal Strength Indicator ([RSSI](#)).

Bluetooth 1.2

Major enhancements include:

- Faster Connection and Discovery

- Adaptive [frequency-hopping spread spectrum \(AFH\)](#), which improves resistance to [radio frequency interference](#) by avoiding the use of crowded frequencies in the hopping sequence.
- Higher transmission speeds in practice than in v1.1, up to 721 kbit/s.^[77]
- Extended Synchronous Connections (eSCO), which improve voice quality of audio links by allowing retransmissions of corrupted packets, and may optionally increase audio latency to provide better concurrent data transfer.
- [Host Controller Interface](#) (HCI) operation with three-wire [UART](#).
- Ratified as [IEEE Standard 802.15.1–2005](#)^[78]
- Introduced Flow Control and Retransmission Modes for L2CAP.

Bluetooth 2.0 + EDR

This version of the Bluetooth Core Specification was released before 2005. The main difference is the introduction of an Enhanced Data Rate (EDR) for faster [data transfer](#). The bit rate of EDR is 3 Mbit/s, although the maximum data transfer rate (allowing for inter-packet time and acknowledgements) is 2.1 Mbit/s.^[77] EDR uses a combination of [GFSK](#) and [phase-shift keying](#) modulation (PSK) with two variants, $\pi/4$ -[DQPSK](#) and 8-[DPSK](#).^[79] EDR can provide a lower power consumption through a reduced [duty cycle](#).

The specification is published as *Bluetooth v2.0 + EDR*, which implies that EDR is an optional feature. Aside from EDR, the v2.0 specification contains other minor improvements, and products may claim compliance to "Bluetooth v2.0" without supporting the higher data rate. At least one commercial device states "Bluetooth v2.0 without EDR" on its data sheet.^[80]

Bluetooth 2.1 + EDR

Bluetooth Core Specification Version 2.1 + EDR was adopted by the Bluetooth SIG on 26 July 2007.^[79]

The headline feature of v2.1 is [secure simple pairing](#) (SSP): this improves the pairing

experience for Bluetooth devices, while increasing the use and strength of security.^[81]

Version 2.1 allows various other improvements, including *extended inquiry response* (EIR), which provides more information during the inquiry procedure to allow better filtering of devices before connection; and sniff subrating, which reduces the power consumption in low-power mode.

Bluetooth 3.0 + HS

Version 3.0 + HS of the Bluetooth Core Specification^[79] was adopted by the Bluetooth SIG on 21 April 2009. Bluetooth v3.0 + HS provides theoretical data transfer speeds of up to 24 Mbit/s, though not over the Bluetooth link itself. Instead, the Bluetooth link is used for negotiation and establishment, and the high data rate traffic is carried over a colocated [802.11](#) link.

The main new feature is AMP (Alternative MAC/PHY), the addition of [802.11](#) as a high-speed transport. The high-speed part of the specification is not mandatory, and hence only devices that display the "+HS" logo actually support Bluetooth over 802.11 high-speed data transfer. A Bluetooth v3.0 device without the "+HS" suffix is only required to support features introduced in Core Specification Version 3.0^[82] or earlier Core Specification Addendum 1.^[83]

L2CAP Enhanced modes

Enhanced Retransmission Mode (ERTM) implements reliable L2CAP channel, while Streaming Mode (SM) implements unreliable channel with no retransmission or flow control. Introduced in Core Specification Addendum 1.

Alternative MAC/PHY

Enables the use of alternative [MAC](#) and [PHYs](#) for transporting Bluetooth profile data. The Bluetooth radio is still used for device discovery, initial connection and profile configuration. However, when large quantities of data must be sent, the high-speed alternative MAC PHY 802.11 (typically associated with Wi-Fi) transports the data. This means that Bluetooth uses proven low power connection models when the system is idle, and the faster radio when it must send large quantities of data. AMP links require

enhanced L2CAP modes.

Unicast Connectionless Data

Permits sending service data without establishing an explicit L2CAP channel. It is intended for use by applications that require low latency between user action and reconnection/transmission of data. This is only appropriate for small amounts of data.

Enhanced Power Control

Updates the power control feature to remove the open loop power control, and also to clarify ambiguities in power control introduced by the new modulation schemes added for EDR. Enhanced power control removes the ambiguities by specifying the behavior that is expected. The feature also adds closed loop power control, meaning RSSI filtering can start as the response is received. Additionally, a "go straight to maximum power" request has been introduced. This is expected to deal with the headset link loss issue typically observed when a user puts their phone into a pocket on the opposite side to the headset.

Ultra-wideband

The high-speed (AMP) feature of Bluetooth v3.0 was originally intended for [UWB](#), but the WiMedia Alliance, the body responsible for the flavor of UWB intended for Bluetooth, announced in March 2009 that it was disbanding, and ultimately UWB was omitted from the Core v3.0 specification.^[84]

On 16 March 2009, the [WiMedia Alliance](#) announced it was entering into technology transfer agreements for the WiMedia [Ultra-wideband](#) (UWB) specifications. WiMedia has transferred all current and future specifications, including work on future high-speed and power-optimized implementations, to the Bluetooth Special Interest Group (SIG), [Wireless USB](#) Promoter Group and the [USB Implementers Forum](#). After successful completion of the technology transfer, marketing, and related administrative items, the WiMedia Alliance ceased operations.^{[85][86][87][88][89]}

In October 2009, the [Bluetooth Special Interest Group](#) suspended development of UWB as part of the alternative MAC/PHY, Bluetooth v3.0 + HS solution. A small, but significant, number of former [WiMedia](#) members had not and would not sign up to the necessary agreements for the [IP](#) transfer. As of 2009, the Bluetooth SIG was in the process of

evaluating other options for its longer term roadmap.^{[90][91][92]}

Bluetooth 4.0

Main article: [Bluetooth Low Energy](#)

The Bluetooth SIG completed the Bluetooth Core Specification version 4.0 (called Bluetooth Smart) and has been adopted as of 30 June 2010. It includes *Classic Bluetooth*, *Bluetooth high speed* and [Bluetooth Low Energy](#) (BLE) protocols. Bluetooth high speed is based on Wi-Fi, and Classic Bluetooth consists of legacy Bluetooth protocols.

[Bluetooth Low Energy](#), previously known as Wibree,^[93] is a subset of Bluetooth v4.0 with an entirely new protocol stack for rapid build-up of simple links. As an alternative to the Bluetooth standard protocols that were introduced in Bluetooth v1.0 to v3.0, it is aimed at very low power applications powered by a [coin cell](#). Chip designs allow for two types of implementation, dual-mode, single-mode and enhanced past versions.^[94] The provisional names *Wibree* and *Bluetooth ULP* (Ultra Low Power) were abandoned and the BLE name was used for a while. In late 2011, new logos "Bluetooth Smart Ready" for hosts and "Bluetooth Smart" for sensors were introduced as the general-public face of BLE.^[95]

Compared to *Classic Bluetooth*, Bluetooth Low Energy is intended to provide considerably reduced power consumption and cost while maintaining a [similar communication range](#). In terms of lengthening the battery life of Bluetooth devices, BLE represents a significant progression.

- In a single-mode implementation, only the low energy protocol stack is implemented. [Dialog Semiconductor](#),^[96] [STMicroelectronics](#),^[97] [AMICCOM](#),^[98] [CSR](#),^[99] [Nordic Semiconductor](#)^[100] and [Texas Instruments](#)^[101] have released single mode Bluetooth Low Energy solutions.
- In a dual-mode implementation, Bluetooth Smart functionality is integrated into an existing Classic Bluetooth controller. As of March 2011, the following semiconductor

companies have announced the availability of chips meeting the standard: [Qualcomm-Atheros](#), [CSR](#), [Broadcom](#)^[102]^[103] and [Texas Instruments](#). The compliant architecture shares all of Classic Bluetooth's existing radio and functionality resulting in a negligible cost increase compared to Classic Bluetooth.

Cost-reduced single-mode chips, which enable highly integrated and compact devices, feature a lightweight Link Layer providing ultra-low power idle mode operation, simple device discovery, and reliable point-to-multipoint data transfer with advanced power-save and secure encrypted connections at the lowest possible cost.

General improvements in version 4.0 include the changes necessary to facilitate BLE modes, as well the Generic Attribute Profile (GATT) and Security Manager (SM) services with [AES](#) Encryption.

Core Specification Addendum 2 was unveiled in December 2011; it contains improvements to the audio Host Controller Interface and to the High Speed (802.11) Protocol Adaptation Layer.

Core Specification Addendum 3 revision 2 has an adoption date of 24 July 2012.

Core Specification Addendum 4 has an adoption date of 12 February 2013.

Bluetooth 4.1

The Bluetooth SIG announced formal adoption of the Bluetooth v4.1 specification on 4 December 2013. This specification is an incremental software update to Bluetooth Specification v4.0, and not a hardware update. The update incorporates Bluetooth Core Specification Addenda (CSA 1, 2, 3 & 4) and adds new features that improve consumer usability. These include increased co-existence support for LTE, bulk data exchange rates—and aid developer innovation by allowing devices to support multiple roles simultaneously.^[104]

New features of this specification include:

- Mobile Wireless Service Coexistence Signaling

- Train Nudging and Generalized Interlaced Scanning
- Low Duty Cycle Directed Advertising
- L2CAP Connection Oriented and Dedicated Channels with Credit-Based Flow Control
- Dual Mode and Topology
- LE Link Layer Topology
- 802.11n PAL
- Audio Architecture Updates for Wide Band Speech
- Fast Data Advertising Interval
- Limited Discovery Time^[105]

Notice that some features were already available in a Core Specification Addendum (CSA) before the release of v4.1.

Bluetooth 4.2

Released on 2 December 2014,^[106] it introduces features for the [Internet of things](#).

The major areas of improvement are:

- [Low Energy Secure Connection](#) with [Data Packet](#) Length Extension
- [Link Layer](#) Privacy with Extended Scanner Filter Policies
- [Internet Protocol Support Profile](#) (IPSP) [version 6](#) ready for [Bluetooth Smart things](#) to support connected home

Older Bluetooth hardware may receive 4.2 features such as Data Packet Length Extension and improved privacy via firmware updates.^{[107][108]}

Bluetooth 5

The Bluetooth SIG released Bluetooth 5 on 6 December 2016.^[109] Its new features are

mainly focused on new [Internet of Things](#) technology. Sony was the first to announce Bluetooth 5.0 support with its [Xperia XZ Premium](#) in Feb 2017 during the Mobile World Congress 2017.^[110] The Samsung [Galaxy S8](#) launched with Bluetooth 5 support in April 2017. In September 2017, the [iPhone 8](#), 8 Plus and [iPhone X](#) launched with Bluetooth 5 support as well. [Apple](#) also integrated Bluetooth 5 in its new [HomePod](#) offering released on 9 February 2018.^[111] Marketing drops the point number; so that it is just "Bluetooth 5" (unlike Bluetooth 4.0);^[112] the change is for the sake of "Simplifying our marketing, communicating user benefits more effectively and making it easier to signal significant technology updates to the market."

Bluetooth 5 provides, for [BLE](#), options that can double the speed (2 Mbit/s burst) at the expense of range, or provide up to four times the range at the expense of data rate. The increase in transmissions could be important for Internet of Things devices, where many nodes connect throughout a whole house. Bluetooth 5 increases capacity of connectionless services such as location-relevant navigation^[113] of low-energy Bluetooth connections.^{[114][115][116]}

The major areas of improvement are:

- Slot Availability Mask (SAM)
- 2 Mbit/s PHY for LE
- LE Long Range
- High Duty Cycle Non-Connectable Advertising
- LE Advertising Extensions
- LE Channel Selection Algorithm #2

Features Added in CSA5 – Integrated in v5.0:

- Higher Output Power

The following features were removed in this version of the specification:

- Park State^[117]

Bluetooth 5.1

The Bluetooth SIG presented Bluetooth 5.1 on 21 January 2019.^[118]

The major areas of improvement are:

- [Angle of Arrival](#) (AoA) and Angle of Departure (AoD) which are used for locating and tracking of devices
- Advertising Channel Index
- GATT Caching
- Minor Enhancements batch 1:
 - HCI support for debug keys in LE Secure Connections
 - Sleep clock accuracy update mechanism
 - ADI field in scan response data
 - Interaction between QoS and Flow Specification
 - Block Host channel classification for secondary advertising
 - Allow the SID to appear in scan response reports
 - Specify the behavior when rules are violated
- Periodic Advertising Sync Transfer

Features Added in Core Specification Addendum (CSA) 6 – Integrated in v5.1:

- Models
- [Mesh-based model](#) hierarchy

The following features were removed in this version of the specification:

- Unit keys

Bluetooth 5.2

On 31 December 2019, the Bluetooth SIG published the Bluetooth Core Specification

Version 5.2. The new specification adds new features:^[119]

- Enhanced Attribute Protocol (EATT), an improved version of the Attribute Protocol (ATT)
- LE Power Control
- LE Isochronous Channels
- [LE Audio](#) that is built on top of the new 5.2 features. BT LE Audio was announced in January 2020 at [CES](#) by the [Bluetooth SIG](#). Compared to regular Bluetooth Audio, Bluetooth Low Energy Audio makes lower battery consumption possible and creates a standardized way of transmitting audio over BT LE. Bluetooth LE Audio also allows one-to-many and many-to-one broadcasts, allowing multiple receivers from one source or one receiver for multiple sources, known as Auracast.^{[120][121]} It uses a new [LC3 codec](#). BLE Audio will also add support for hearing aids.^[122] On 12 July 2022, the Bluetooth SIG announced the completion of Bluetooth LE Audio. The standard has a lower minimum latency claim of 20–30 ms vs Bluetooth Classic audio of 100–200 ms.^[123]

Bluetooth 5.3

The Bluetooth SIG published the Bluetooth Core Specification Version 5.3 on 13 July 2021. The feature enhancements of Bluetooth 5.3 are:^[124]

- Connection Subrating
- Periodic Advertisement Interval
- Channel Classification Enhancement
- Encryption Key Size Control Enhancements

The following features were removed in this version of the specification:

- Alternate MAC and PHY (AMP) Extension

Bluetooth 5.4

The Bluetooth SIG released the Bluetooth Core Specification Version 5.4 on 7 February

2023. This new version adds the following features:^[125]

- Periodic Advertising with Responses (PAwR)
- Encrypted Advertising Data
- LE GATT Security Levels Characteristic
- Advertising Coding Selection

Technical information

Architecture

Software

Seeking to extend the compatibility of Bluetooth devices, the devices that adhere to the standard use an interface called HCI (Host Controller Interface) between the host device (e.g. laptop, phone) and the Bluetooth device (e.g. Bluetooth wireless headset).

High-level protocols such as the SDP (Protocol used to find other Bluetooth devices within the communication range, also responsible for detecting the function of devices in range), RFCOMM (Protocol used to emulate serial port connections) and TCS (Telephony control protocol) interact with the baseband controller through the L2CAP (Logical Link Control and Adaptation Protocol). The L2CAP protocol is responsible for the segmentation and reassembly of the packets.

Hardware

The hardware that makes up the Bluetooth device is made up of, logically, two parts; which may or may not be physically separate. A radio device, responsible for modulating and transmitting the signal; and a digital controller. The digital controller is likely a CPU, one of whose functions is to run a Link Controller; and interfaces with the host device; but some functions may be delegated to hardware. The Link Controller is responsible for the processing of the baseband and the management of ARQ and physical layer FEC protocols. In addition, it handles the transfer functions (both asynchronous and

synchronous), audio coding (e.g. [SBC \(codec\)](#)) and data encryption. The CPU of the device is responsible for attending the instructions related to Bluetooth of the host device, in order to simplify its operation. To do this, the CPU runs software called Link Manager that has the function of communicating with other devices through the LMP protocol.

A Bluetooth device is a [short-range wireless](#) device. Bluetooth devices are [fabricated](#) on [RF CMOS integrated circuit \(RF circuit\)](#) chips.^{[126][127]}

Bluetooth protocol stack

Main article: [List of Bluetooth protocols](#)

Bluetooth Protocol Stack

Bluetooth is defined as a layer protocol architecture consisting of core protocols, cable replacement protocols, telephony control protocols, and adopted protocols.^[128]

Mandatory protocols for all Bluetooth stacks are LMP, L2CAP and SDP. In addition, devices that communicate with Bluetooth almost universally can use these protocols: [HCI](#) and RFCOMM.^[129]

Link Manager

The Link Manager (LM) is the system that manages establishing the connection between devices. It is responsible for the establishment, authentication and configuration of the link. The Link Manager locates other managers and communicates with them via the management protocol of the LMP link. To perform its function as a service provider, the LM uses the services included in the Link Controller (LC). The Link Manager Protocol basically consists of several PDUs (Protocol Data Units) that are sent from one device to another. The following is a list of supported services:

- Transmission and reception of data.
- Name request
- Request of the link addresses.
- Establishment of the connection.
- Authentication.
- Negotiation of link mode and connection establishment.

Host Controller Interface

The Host Controller Interface provides a command interface for the controller and for the link manager, which allows access to the hardware status and control registers. This interface provides an access layer for all Bluetooth devices. The HCI layer of the machine exchanges commands and data with the HCI firmware present in the Bluetooth device. One of the most important HCI tasks that must be performed is the automatic discovery of other Bluetooth devices that are within the coverage radius.

Logical Link Control and Adaptation Protocol

The *Logical Link Control and Adaptation Protocol* (L2CAP) is used to multiplex multiple logical connections between two devices using different higher level protocols. Provides segmentation and reassembly of on-air packets.

In *Basic* mode, L2CAP provides packets with a payload configurable up to 64 kB, with 672 bytes as the default [MTU](#), and 48 bytes as the minimum mandatory supported MTU.

In *Retransmission and Flow Control* modes, L2CAP can be configured either for isochronous data or reliable data per channel by performing retransmissions and CRC checks.

Bluetooth Core Specification Addendum 1 adds two additional L2CAP modes to the core specification. These modes effectively deprecate original Retransmission and Flow Control modes:

Enhanced Retransmission Mode (ERTM)

This mode is an improved version of the original retransmission mode. This mode provides a reliable L2CAP channel.

Streaming Mode (SM)

This is a very simple mode, with no retransmission or flow control. This mode provides an unreliable L2CAP channel.

Reliability in any of these modes is optionally and/or additionally guaranteed by the lower layer Bluetooth BDR/EDR air interface by configuring the number of retransmissions and flush timeout (time after which the radio flushes packets). In-order sequencing is guaranteed by the lower layer.

Only L2CAP channels configured in ERTM or SM may be operated over AMP logical links.

Service Discovery Protocol

The *Service Discovery Protocol* (SDP) allows a device to discover services offered by other devices, and their associated parameters. For example, when you use a mobile phone with a Bluetooth headset, the phone uses SDP to determine which [Bluetooth profiles](#) the headset can use (Headset Profile, Hands Free Profile (HFP), [Advanced Audio Distribution Profile \(A2DP\)](#) etc.) and the protocol multiplexer settings needed for the phone to connect to the headset using each of them. Each service is identified by a [Universally Unique Identifier](#) (UUID), with official services (Bluetooth profiles) assigned a short form UUID (16 bits rather than the full 128).

Radio Frequency Communications

Radio Frequency Communications (RFCOMM) is a cable replacement protocol used for generating a virtual serial data stream. RFCOMM provides for binary data transport and emulates [\[\[EIA-1325\]\]](#) (formerly RS-232) control signals over the Bluetooth baseband layer, i.e., it is a serial port emulation.

RFCOMM provides a simple, reliable, data stream to the user, similar to TCP. It is used directly by many telephony related profiles as a carrier for AT commands, as well as being a transport layer for OBEX over Bluetooth.

Many Bluetooth applications use RFCOMM because of its widespread support and publicly available API on most operating systems. Additionally, applications that used a serial port to communicate can be quickly ported to use RFCOMM.

Bluetooth Network Encapsulation Protocol

The *Bluetooth Network Encapsulation Protocol* (BNEP) is used for transferring another protocol stack's data via an L2CAP channel. Its main purpose is the transmission of IP packets in the Personal Area Networking Profile. BNEP performs a similar function to [SNAP](#) in Wireless LAN.

Audio/Video Control Transport Protocol

The *Audio/Video Control Transport Protocol* (AVCTP) is used by the remote control profile to transfer AV/C commands over an L2CAP channel. The music control buttons on a stereo headset use this protocol to control the music player.

Audio/Video Distribution Transport Protocol

The *Audio/Video Distribution Transport Protocol* (AVDTP) is used by the advanced audio distribution ([A2DP](#)) profile to stream music to stereo headsets over an [L2CAP](#) channel intended for video distribution profile in the Bluetooth transmission.

Telephony Control Protocol

The *Telephony Control Protocol – Binary* (TCS BIN) is the bit-oriented protocol that defines the call control signaling for the establishment of voice and data calls between Bluetooth devices. Additionally, "TCS BIN defines mobility management procedures for handling groups of Bluetooth TCS devices."

TCS-BIN is only used by the cordless telephony profile, which failed to attract implementers. As such it is only of historical interest.

Adopted protocols

Adopted protocols are defined by other standards-making organizations and

incorporated into Bluetooth's protocol stack, allowing Bluetooth to code protocols only when necessary. The adopted protocols include:

Point-to-Point Protocol (PPP)

Internet standard protocol for transporting [IP datagrams](#) over a point-to-point link.

TCP/IP/UDP

Foundation Protocols for TCP/IP protocol suite

Object Exchange Protocol (OBEX)

Session-layer protocol for the exchange of objects, providing a model for object and operation representation

Wireless Application Environment/Wireless Application Protocol (WAE/WAP)

WAE specifies an application framework for wireless devices and WAP is an open standard to provide mobile users access to telephony and information services.^[128]

Baseband error correction

Depending on packet type, individual packets may be protected by [error correction](#), either 1/3 rate [forward error correction](#) (FEC) or 2/3 rate. In addition, packets with CRC will be retransmitted until acknowledged by [automatic repeat request](#) (ARQ).

Setting up connections

Any Bluetooth device in *discoverable mode* transmits the following information on demand:

- Device name
- Device class
- List of services
- Technical information (for example: device features, manufacturer, Bluetooth specification used, clock offset)

Any device may perform an inquiry to find other devices to connect to, and any device can be configured to respond to such inquiries. However, if the device trying to connect

knows the address of the device, it always responds to direct connection requests and transmits the information shown in the list above if requested. Use of a device's services may require pairing or acceptance by its owner, but the connection itself can be initiated by any device and held until it goes out of range. Some devices can be connected to only one device at a time, and connecting to them prevents them from connecting to other devices and appearing in inquiries until they disconnect from the other device.

Every device has a [unique 48-bit address](#). However, these addresses are generally not shown in inquiries. Instead, friendly Bluetooth names are used, which can be set by the user. This name appears when another user scans for devices and in lists of paired devices.

Most cellular phones have the Bluetooth name set to the manufacturer and model of the phone by default. Most cellular phones and laptops show only the Bluetooth names and special programs are required to get additional information about remote devices. This can be confusing as, for example, there could be several cellular phones in range named [T610](#) (see [Bluejacking](#)).

Pairing and bonding

Motivation

Many services offered over Bluetooth can expose private data or let a connecting party control the Bluetooth device. Security reasons make it necessary to recognize specific devices, and thus enable control over which devices can connect to a given Bluetooth device. At the same time, it is useful for Bluetooth devices to be able to establish a connection without user intervention (for example, as soon as in range).

To resolve this conflict, Bluetooth uses a process called *bonding*, and a bond is generated through a process called *pairing*. The pairing process is triggered either by a specific request from a user to generate a bond (for example, the user explicitly requests to "Add a Bluetooth device"), or it is triggered automatically when connecting to a service where (for the first time) the identity of a device is required for security purposes. These two cases are referred to as dedicated bonding and general bonding

respectively.

Pairing often involves some level of user interaction. This user interaction confirms the identity of the devices. When pairing completes, a bond forms between the two devices, enabling those two devices to connect in the future without repeating the pairing process to confirm device identities. When desired, the user can remove the bonding relationship.

Implementation

During pairing, the two devices establish a relationship by creating a [shared secret](#) known as a *link key*. If both devices store the same link key, they are said to be *paired* or *bonded*. A device that wants to communicate only with a bonded device can [cryptographically authenticate](#) the identity of the other device, ensuring it is the same device it previously paired with. Once a link key is generated, an authenticated [ACL](#) link between the devices may be [encrypted](#) to protect exchanged data against [eavesdropping](#). Users can delete link keys from either device, which removes the bond between the devices—so it is possible for one device to have a stored link key for a device it is no longer paired with.

Bluetooth services generally require either encryption or authentication and as such require pairing before they let a remote device connect. Some services, such as the Object Push Profile, elect not to explicitly require authentication or encryption so that pairing does not interfere with the user experience associated with the service use-cases.

Pairing mechanisms

Pairing mechanisms changed significantly with the introduction of Secure Simple Pairing in Bluetooth v2.1. The following summarizes the pairing mechanisms:

- *Legacy pairing*: This is the only method available in Bluetooth v2.0 and before. Each device must enter a [PIN code](#); pairing is only successful if both devices enter the same PIN code. Any 16-byte UTF-8 string may be used as a PIN code; however, not all devices may be capable of entering all possible PIN codes.

- *Limited input devices*: The obvious example of this class of device is a Bluetooth Hands-free headset, which generally have few inputs. These devices usually have a *fixed PIN*, for example "0000" or "1234", that are hard-coded into the device.
- *Numeric input devices*: Mobile phones are classic examples of these devices. They allow a user to enter a numeric value up to 16 digits in length.
- *Alpha-numeric input devices*: PCs and smartphones are examples of these devices. They allow a user to enter full UTF-8 text as a PIN code. If pairing with a less capable device the user must be aware of the input limitations on the other device; there is no mechanism available for a capable device to determine how it should limit the available input a user may use.
- *Secure Simple Pairing (SSP)*: This is required by Bluetooth v2.1, although a Bluetooth v2.1 device may only use legacy pairing to interoperate with a v2.0 or earlier device. Secure Simple Pairing uses a form of [public-key cryptography](#), and some types can help protect against [man in the middle](#), or MITM attacks. SSP has the following authentication mechanisms:
 - *Just works*: As the name implies, this method just works, with no user interaction. However, a device may prompt the user to confirm the pairing process. This method is typically used by headsets with minimal IO capabilities, and is more secure than the fixed PIN mechanism this limited set of devices uses for legacy pairing. This method provides no man-in-the-middle (MITM) protection.
 - *Numeric comparison*: If both devices have a display, and at least one can accept a binary yes/no user input, they may use Numeric Comparison. This method displays a 6-digit numeric code on each device. The user should compare the numbers to ensure they are identical. If the comparison succeeds, the user(s) should confirm pairing on the device(s) that can accept an input. This method provides MITM protection, assuming the user confirms on both devices and actually performs the comparison properly.
 - *Passkey Entry*: This method may be used between a device with a display and a device with numeric keypad entry (such as a keyboard), or two devices with numeric keypad entry. In the first case, the display presents a 6-digit numeric

code to the user, who then enters the code on the keypad. In the second case, the user of each device enters the same 6-digit number. Both of these cases provide MITM protection.

- *Out of band* (OOB): This method uses an external means of communication, such as [near-field communication](#) (NFC) to exchange some information used in the pairing process. Pairing is completed using the Bluetooth radio, but requires information from the OOB mechanism. This provides only the level of MITM protection that is present in the OOB mechanism.

SSP is considered simple for the following reasons:

- In most cases, it does not require a user to generate a passkey.
- For use cases not requiring MITM protection, user interaction can be eliminated.
- For *numeric comparison*, MITM protection can be achieved with a simple equality comparison by the user.
- Using OOB with NFC enables pairing when devices simply get close, rather than requiring a lengthy discovery process.

Security concerns

Prior to Bluetooth v2.1, encryption is not required and can be turned off at any time. Moreover, the encryption key is only good for approximately 23.5 hours; using a single encryption key longer than this time allows simple [XOR attacks](#) to retrieve the encryption key.

- Turning off encryption is required for several normal operations, so it is problematic to detect if encryption is disabled for a valid reason or a security attack.

Bluetooth v2.1 addresses this in the following ways:

- Encryption is required for all non-SDP (Service Discovery Protocol) connections
- A new Encryption Pause and Resume feature is used for all normal operations that require that encryption be disabled. This enables easy identification of normal operation from security attacks.

- The encryption key must be refreshed before it expires.

Link keys may be stored on the device file system, not on the Bluetooth chip itself. Many Bluetooth chip manufacturers let link keys be stored on the device—however, if the device is removable, this means that the link key moves with the device.

Security

Overview

See also: [Mobile security § Attacks based on communication networks](#)

Bluetooth implements [confidentiality](#), [authentication](#) and [key](#) derivation with custom algorithms based on the [SAFER+ block cipher](#). Bluetooth key generation is generally based on a Bluetooth PIN, which must be entered into both devices. This procedure might be modified if one of the devices has a fixed PIN (e.g., for headsets or similar devices with a restricted user interface). During pairing, an initialization key or master key is generated, using the E22 algorithm.^[130] The [E0](#) stream cipher is used for encrypting packets, granting confidentiality, and is based on a shared cryptographic secret, namely a previously generated link key or master key. Those keys, used for subsequent encryption of data sent via the air interface, rely on the Bluetooth PIN, which has been entered into one or both devices.

An overview of Bluetooth vulnerabilities exploits was published in 2007 by Andreas Becker.^[131]

In September 2008, the [National Institute of Standards and Technology](#) (NIST) published a Guide to Bluetooth Security as a reference for organizations. It describes Bluetooth security capabilities and how to secure Bluetooth technologies effectively. While Bluetooth has its benefits, it is susceptible to denial-of-service attacks, eavesdropping, man-in-the-middle attacks, message modification, and resource misappropriation. Users and organizations must evaluate their acceptable level of risk and incorporate security into the lifecycle of Bluetooth devices. To help mitigate risks, included in the NIST document are security checklists with guidelines and recommendations for creating and

maintaining secure Bluetooth piconets, headsets, and smart card readers.^[132]

Bluetooth v2.1 – finalized in 2007 with consumer devices first appearing in 2009 – makes significant changes to Bluetooth's security, including pairing. See the [pairing mechanisms](#) section for more about these changes.

Bluejacking

Main article: [Bluejacking](#)

Bluejacking is the sending of either a picture or a message from one user to an unsuspecting user through Bluetooth wireless technology. Common applications include short messages, e.g., "You've just been bluejacked!"^[133] Bluejacking does not involve the removal or alteration of any data from the device.^[134]

Some form of [DoS](#) is also possible, even in modern devices, by sending unsolicited pairing requests in rapid succession; this becomes disruptive because most systems display a full screen notification for every connection request, interrupting every other activity, especially on less powerful devices.

History of security concerns

2001–2004

In 2001, Jakobsson and Wetzel from [Bell Laboratories](#) discovered flaws in the Bluetooth pairing protocol and also pointed to vulnerabilities in the encryption scheme.^[135] In 2003, Ben and Adam Laurie from A.L. Digital Ltd. discovered that serious flaws in some poor implementations of Bluetooth security may lead to disclosure of personal data.^[136] In a subsequent experiment, Martin Herfurt from the trinite.group was able to do a field-trial at the [CeBIT](#) fairgrounds, showing the importance of the problem to the world. A new attack called [BlueBug](#) was used for this experiment.^[137] In 2004 the first purported [virus](#) using Bluetooth to spread itself among mobile phones appeared on the [Symbian OS](#).^[138] The virus was first described by [Kaspersky Lab](#) and requires users to confirm the installation of unknown software before it can propagate. The virus was

written as a proof-of-concept by a group of virus writers known as "29A" and sent to anti-virus groups. Thus, it should be regarded as a potential (but not real) security threat to Bluetooth technology or [Symbian OS](#) since the virus has never spread outside of this system. In August 2004, a world-record-setting experiment (see also [Bluetooth sniping](#)) showed that the range of Class 2 Bluetooth radios could be extended to 1.78 km (1.11 mi) with directional antennas and signal amplifiers.^[139] This poses a potential security threat because it enables attackers to access vulnerable Bluetooth devices from a distance beyond expectation. The attacker must also be able to receive information from the victim to set up a connection. No attack can be made against a Bluetooth device unless the attacker knows its Bluetooth address and which channels to transmit on, although these can be deduced within a few minutes if the device is in use.^[140]

2005

In January 2005, a mobile [malware](#) worm known as Lasco surfaced. The worm began targeting mobile phones using [Symbian OS](#) ([Series 60 platform](#)) using Bluetooth enabled devices to replicate itself and spread to other devices. The worm is self-installing and begins once the mobile user approves the transfer of the file (Velasco.sis) from another device. Once installed, the worm begins looking for other Bluetooth enabled devices to infect. Additionally, the worm infects other [.SIS](#) files on the device, allowing replication to another device through the use of removable media ([Secure Digital](#), [CompactFlash](#), etc.). The worm can render the mobile device unstable.^[141]

In April 2005, [Cambridge University](#) security researchers published results of their actual implementation of passive attacks against the [PIN-based](#) pairing between commercial Bluetooth devices. They confirmed that attacks are practicably fast, and the Bluetooth symmetric key establishment method is vulnerable. To rectify this vulnerability, they designed an implementation that showed that stronger, asymmetric key establishment is feasible for certain classes of devices, such as mobile phones.^[142]

In June 2005, Yaniv Shaked^[143] and Avishai Wool^[144] published a paper describing both passive and active methods for obtaining the PIN for a Bluetooth link. The passive attack allows a suitably equipped attacker to eavesdrop on communications and spoof if the attacker was present at the time of initial pairing. The active method makes use of a

pecially constructed message that must be inserted at a specific point in the protocol, to make the master and slave repeat the pairing process. After that, the first method can be used to crack the PIN. This attack's major weakness is that it requires the user of the devices under attack to re-enter the PIN during the attack when the device prompts them to. Also, this active attack probably requires custom hardware, since most commercially available Bluetooth devices are not capable of the timing necessary.^[145]

In August 2005, police in [Cambridgeshire](#), England, issued warnings about thieves using Bluetooth enabled phones to track other devices left in cars. Police are advising users to ensure that any mobile networking connections are de-activated if laptops and other devices are left in this way.^[146]

2006

In April 2006, researchers from [Secure Network](#) and [F-Secure](#) published a report that warns of the large number of devices left in a visible state, and issued statistics on the spread of various Bluetooth services and the ease of spread of an eventual Bluetooth worm.^[147]

In October 2006, at the Luxemburgish Hack.lu Security Conference, Kevin Finistere and Thierry Zoller demonstrated and released a remote root shell via Bluetooth on Mac OS X v10.3.9 and v10.4. They also demonstrated the first Bluetooth PIN and Linkkeys cracker, which is based on the research of Wool and Shaked.^[148]

2017

In April 2017, security researchers at Armis discovered multiple exploits in the Bluetooth software in various platforms, including [Microsoft Windows](#), [Linux](#), Apple [iOS](#), and Google [Android](#). These vulnerabilities are collectively called "[BlueBorne](#)". The exploits allow an attacker to connect to devices or systems without authentication and can give them "virtually full control over the device". Armis contacted Google, Microsoft, Apple, Samsung and Linux developers allowing them to patch their software before the coordinated announcement of the vulnerabilities on 12 September 2017.^[149]

2018

In July 2018, Lior Neumann and Eli Biham, researchers at the Technion – Israel Institute of Technology identified a security vulnerability in the latest Bluetooth pairing procedures: Secure Simple Pairing and LE Secure Connections. ^{[150][151]}

Also, in October 2018, Karim Lounis, a network security researcher at Queen's University, identified a security vulnerability, called CDV (Connection Dumping Vulnerability), on various Bluetooth devices that allows an attacker to tear down an existing Bluetooth connection and cause the deauthentication and disconnection of the involved devices. The researcher demonstrated the attack on various devices of different categories and from different manufacturers. ^[152]

2019

In August 2019, security researchers at the [Singapore University of Technology and Design](#), Helmholtz Center for Information Security, and [University of Oxford](#) discovered a vulnerability, called KNOB (Key Negotiation Of Bluetooth) in the key negotiation that would "brute force the negotiated encryption keys, decrypt the eavesdropped ciphertext, and inject valid encrypted messages (in real-time)". ^{[153][154]} Google released an [Android](#) security patch on 5 August 2019, which removed this vulnerability. ^[155]

Health concerns

Main article: [Wireless device radiation and health](#)

Bluetooth uses the [radio frequency](#) spectrum in the 2.402 GHz to 2.480 GHz range, ^[156] which is non-ionizing radiation, of similar bandwidth to that used by wireless and mobile phones. No specific harm has been demonstrated, even though wireless transmission has been included by [IARC](#) in the possible [carcinogen](#) list. Maximum power output from a Bluetooth radio is 100 [mW](#) for class 1, 2.5 mW for class 2, and 1 mW for class 3 devices. Even the maximum power output of class 1 is a lower level than the lowest-powered mobile phones. ^[157] [UMTS](#) and [W-CDMA](#) output 250 mW, [GSM1800/1900](#) outputs 1000 mW, and [GSM850/900](#) outputs 2000 mW.

Award programs

The Bluetooth Innovation World Cup, a marketing initiative of the Bluetooth Special Interest Group (SIG), was an international competition that encouraged the development of innovations for applications leveraging Bluetooth technology in sports, fitness and health care products. The competition aimed to stimulate new markets.^[158]

The Bluetooth Innovation World Cup morphed into the Bluetooth Breakthrough Awards in 2013. Bluetooth SIG subsequently launched the Imagine Blue Award in 2016 at Bluetooth World.^[159] The Bluetooth Breakthrough Awards program highlights the most innovative products and applications available today, prototypes coming soon, and student-led projects in the making.^[160]

See also

- [ANT+](#)
- [Bluetooth stack](#) – building blocks that make up the various implementations of the Bluetooth protocol
- [List of Bluetooth profiles](#) – features used within the Bluetooth stack
- [Bluesniping](#)
- [BlueSoleil](#) – proprietary Bluetooth driver
- [Bluetooth Low Energy beacons](#) ([AltBeacon](#), [iBeacon](#), [Eddystone](#))
- [Bluetooth mesh networking](#)
- [Continua Health Alliance](#)
- [DASH7](#)
- [Headset \(audio\)](#)
- [Wi-Fi hotspot](#)
- [Java APIs for Bluetooth](#)

















- [Key finder](#)
- [Li-Fi](#)
- [List of Bluetooth protocols](#)
- [MyriaNed](#)
- [Near-field communication](#)
- [RuBee](#) – secure wireless protocol alternative
- [Tethering](#)
- [Thread \(network protocol\)](#)
- [Wi-Fi HaLow](#)
- [Zigbee](#) – low-power lightweight wireless protocol in the [ISM band](#) based on [IEEE 802.15.4](#)

Notes

- a. Many operating systems delete incomplete files if the file transfer has failed.

References

1. "Bluetooth Range: 100m, 1km, or 10km?" (<https://web.archive.org/web/20150613072937/http://www.bluaiir.pl/bluetooth-range>) [↗](#). *bluaiir.pl*. Archived from the original (<http://www.bluaiir.pl/bluetooth-range>) [↗](#) on 13 June 2015. Retrieved 4 June 2015.
2. "Basics | Bluetooth Technology Website" (<http://www.bluetooth.com/Pages/Basics.aspx>) [↗](#). Bluetooth.com. 23 May 2010. Archived (<https://web.archive.org/web/20121028194747/http://www.bluetooth.com/Pages/basics.aspx>) [↗](#) from the original on 28 October 2012. Retrieved 16 October 2012.
3. Muller, Nathan J. (2002). *Networking A to Z* (<https://books.google.com/books?id=0qv4KbasX7wC&q=bluetooth&pg=PA45>) [↗](#). McGraw-Hill Professional. pp. 45–47. ISBN 9780071429139. Archived (<https://web.archive.org/web/20210624205933/https://books.google.com/books?id=0qv4KbasX7wC&q=bluetooth&pg=PA45>) [↗](#) from the original on 24 June 2021. Retrieved 14 June 2021.










4. "About us - Bluetooth Technology Website" (<https://www.bluetooth.com/about-us/>) . Bluetooth.com. Archived (<https://web.archive.org/web/20190426192848/https://www.bluetooth.com/about-us/>)  from the original on 26 April 2019. Retrieved 8 May 2019.
5. "Brand Enforcement Program" (<https://www.bluetooth.com/develop-with-bluetooth/marketing-branding/brand-enforcement-program/>) . Bluetooth.com. Archived (<https://web.archive.org/web/20180220182035/https://www.bluetooth.com/develop-with-bluetooth/marketing-branding/brand-enforcement-program/>)  from the original on 20 February 2018. Retrieved 8 May 2019.
6. Federica Laricchia (31 March 2022). "Global Bluetooth device shipments 2022" (<https://www.statista.com/statistics/1220933/global-bluetooth-device-shipment-forecast/>) . Statista. Retrieved 7 August 2022.
7. "Harald Bluetooth's rune stone" (<http://jelling.natmus.dk/en/about-jelling/the-rune-stones/harald-bluetooths-rune-stone>) . National Museum of Denmark. Archived (<https://web.archive.org/web/20211026032119/http://jelling.natmus.dk/en/about-jelling/the-rune-stones/harald-bluetooths-rune-stone/>)  from the original on 26 October 2021. Retrieved 22 October 2021.
8. Kardach, Jim (5 March 2008). "Tech History: How Bluetooth got its name" (<https://www.eetimes.com/tech-history-how-bluetooth-got-its-name>) . *eetimes*. Archived (<https://web.archive.org/web/20191205132704/https://www.eetimes.com/tech-history-how-bluetooth-got-its-name/>)  from the original on 5 December 2019. Retrieved 11 June 2013.
9. Forsyth, Mark (2011). *The Etymologicon* (https://archive.org/details/etymologiconcirc00fors_748) . London: Icon Books Ltd. p. 139 (https://archive.org/details/etymologiconcirc00fors_748/page/n138) . ISBN 9781848313071.
10. Kardach, Jim. "The Naming of a Technology" (<https://www.kardach.com/bluetooth/naming-bluetooth>) . kardach.com. Archived (<https://web.archive.org/web/20211022195739/https://www.kardach.com/bluetooth/naming-bluetooth>)  from the original on 22 October 2021. Retrieved 22 October 2021.
11. "Origin of the Name" (<https://www.bluetooth.com/about-us/bluetooth-origin/>) . *Bluetooth® Technology Website*. Archived (<https://web.archive.org/web/20201228185749/https://www.bluetooth.com/about-us/bluetooth-origin/>)  from the original on 28 December 2020. Retrieved 10 November 2021.
12. "Milestones in the Bluetooth advance" (<https://web.archive.org/web/20040620150507/http://www.ericsson.com/bluetooth/companvove/history-bl/>) . Ericsson Technology Licensing. 22

<http://www.ericsson.com/bluetooth/companyove/history-bl/>) [\[1\]](#), [\[2\]](#). Ericsson Technology Licensing. 22 March 2004. Archived from the original (<http://www.ericsson.com/bluetooth/companyove/history-bl/>) [\[3\]](#) on 20 June 2004.

13. "Bluetooth on Twitter" (<https://twitter.com/BluetoothSIG/status/704694301201043456>) [\[4\]](#). Archived (<https://web.archive.org/web/20181230095911/https://twitter.com/BluetoothSIG/status/704694301201043456>) [\[5\]](#) from the original on 30 December 2018. Retrieved 2 March 2016.
14. "Bluetooth Experience Icons" (https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=46091) [\[6\]](#) (PDF). Bluetooth Special Interest Group. Archived (https://web.archive.org/web/20181223163534/https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=46091) [\[7\]](#) from the original on 23 December 2018. Retrieved 21 October 2016.
"Bluetooth Experience Icons borrow two of these three features: the blue color and the rune-inspired symbol."
15. Nguyen, Tuan C. "Who Invented Bluetooth?" (<https://www.thoughtco.com/who-invented-bluetooth-4038864>) [\[8\]](#). *ThoughtCo*. Archived (<https://web.archive.org/web/20191011191850/https://www.thoughtco.com/who-invented-bluetooth-4038864>) [\[9\]](#) from the original on 11 October 2019. Retrieved 11 October 2019.
16. "The Bluetooth" (https://web.archive.org/web/20071222231740/http://www.information-age.com/article/2001/may/the_bluetooth_blues) [\[10\]](#). Information Age. 24 May 2001. Archived from the original (http://www.information-age.com/article/2001/may/the_bluetooth_blues) [\[11\]](#) on 22 December 2007. Retrieved 1 February 2008.
17. "Presenting the (economic) value of patents nominated for the European Inventor Award 2012" (http://documents.epo.org/projects/babylon/eponet.nsf/0/39F611EACF119B21C12579F30036D7E4/%24File/haartsen_en.pdf) [\[12\]](#) (PDF). Technopolis Group. 30 March 2012. Archived (https://web.archive.org/web/20210703142518/http://documents.epo.org/projects/babylon/eponet.nsf/0/39F611EACF119B21C12579F30036D7E4/%24File/haartsen_en.pdf) [\[13\]](#) (PDF) from the original on 3 July 2021. Retrieved 28 September 2021.
18. "Grattis Bluetooth, 10 år" (<http://etn.se/index.php/nyheter/45972-grattis-bluetooth-10-ar>) [\[14\]](#). *etn.se*. Archived (<https://web.archive.org/web/20191029131527/http://etn.se/index.php/nyheter/45972-grattis-bluetooth-10-ar>) [\[15\]](#) from the original on 29 October 2019. Retrieved 29 October 2019.
19. "Sveriges 20 främsta innovationer de senaste 35 åren" (<http://www.va.se/nyheter/2015/06/24/sveriges-20-framsta-innovationer-de-senaste-35-aren/>) [\[16\]](#). *Veckans affärer*. Archived (<https://web.archive.org/web/20191029174607/https://www.va.se/nyheter/2015/06/24/sveriges-20-framsta-innovationer-de-senaste-35-aren/>) [\[17\]](#) from the original on 29 October 2019.

[20-tramsta-innovationer-de-senaste-35-aren/](#)) [↗](#) from the original on 29 October 2019. Retrieved 29 October 2019.

20. "122 Nobel prize candidates" (https://stik.se/122nobelkandidater_sv.pdf) [↗](#) (PDF). Archived (https://web.archive.org/web/20191029174558/https://stik.se/122nobelkandidater_sv.pdf) [↗](#) (PDF) from the original on 29 October 2019. Retrieved 29 October 2019.
21. "De största innovationerna i modern tid" (<https://web.archive.org/web/20190517151629/http://innovatorsradet.se/innovationer.htm>) [↗](#). *innovatorsradet.se*. Archived from the original (<https://innovatorsradet.se/innovationer.htm>) [↗](#) on 17 May 2019. Retrieved 29 October 2019.
22. "Bluetooth Radio Interface, Modulation & Channels" (<http://www.radio-electronics.com/info/wireless/bluetooth/radio-interface-modulation.php>) [↗](#). Radio-Electronics.com. Archived (<https://web.archive.org/web/20120102064023/http://www.radio-electronics.com/info/wireless/bluetooth/radio-interface-modulation.php>) [↗](#) from the original on 2 January 2012. Retrieved 24 March 2012.
23. "Bluetooth Specification Version 5.0" (https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=421043) [↗](#). *Bluetooth Special Interest Group*. Archived (https://web.archive.org/web/20181223163509/https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=421043) [↗](#) from the original on 23 December 2018. Retrieved 8 December 2016.
24. "Ultra-Low Latency Audio Over Bluetooth - Apple Inc" (<http://www.freepatentsonline.com/y2019/0104424.html>) [↗](#). Freepatentsonline.com. Retrieved 21 July 2022.
25. Gomez, Carles; Oller, Joaquim; Paradells, Josep (29 August 2012). "Overview and Evaluation of Bluetooth Low Energy: An Emerging Low-Power Wireless Technology" (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3478807>) [↗](#). *Sensors*. **12** (9): 11734–11753. Bibcode:2012Senso..1211734G (<https://ui.adsabs.harvard.edu/abs/2012Senso..1211734G>) [↗](#). doi:10.3390/s120911734 (<https://doi.org/10.3390/s120911734>) [↗](#). ISSN 1424-8220 (<https://www.worldcat.org/issn/1424-8220>) [↗](#). PMC 3478807 (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3478807>) [↗](#).
26. Kurawar, Arwa; Koul, Ayushi; Patil, Viki Tukaram (August 2014). "Survey of Bluetooth and Applications". *International Journal of Advanced Research in Computer Engineering & Technology*. **3**: 2832–2837. ISSN 2278-1323 (<https://www.worldcat.org/issn/2278-1323>) [↗](#).
27. "How Bluetooth Technology Works" (<https://web.archive.org/web/20080117000828/http://bluetooth.com/Bluetooth/Technology/Works/>) [↗](#). Bluetooth SIG. Archived from the original (<http://www.bluetooth.com/Bluetooth/Technology/Works/>) [↗](#) on 17 January 2008. Retrieved 1 February 2008.

28. Newton, Harold (2007). *Newton's telecom dictionary*. New York: Flatiron Publishing. ISBN 9780979387364.
29. "Understanding Bluetooth Range" (<https://www.bluetooth.com/learn-about-bluetooth/key-attributes/range/>) . Bluetooth SIG. Retrieved 29 June 2022.
30. "Class 1 Bluetooth Dongle Test" (<https://web.archive.org/web/20211010085437/https://inventionduniya.in/what-is-bluetooth-and-how-to-use-bluetooth/>) . Amperordirect.com. Archived from the original (<https://inventionduniya.in/what-is-bluetooth-and-how-to-use-bluetooth/>)  on 10 October 2021. Retrieved 4 September 2010.
31. "WT41 Long Range Bluetooth Module" (http://www.bluegiga.com/WT41_Long_Range_Bluetooth_Module) . Archived (https://web.archive.org/web/20130703045646/http://www.bluegiga.com/WT41_Long_Range_Bluetooth_Module)  from the original on 3 July 2013. Retrieved 28 August 2013.
32. "BluBear Industrial Long Range Bluetooth 2.1 Module with EDR" (<https://web.archive.org/web/20130717051641/http://www.lesswire.com/en/products/embedded-wireless-modules/bluetooth/bluebear/overview/>) . Archived from the original (<http://www.lesswire.com/en/products/embedded-wireless-modules/bluetooth/bluebear/overview/>)  on 17 July 2013.
33. "OEM Bluetooth Serial Port Module OBS433" (<http://www.connectblue.com/products/classic-bluetooth-products/classic-bluetooth-modules/bluetooth-serial-port-module-obs433/>) . Archived (<https://web.archive.org/web/20130716065225/http://www.connectblue.com/products/classic-bluetooth-products/classic-bluetooth-modules/bluetooth-serial-port-module-obs433/>)  from the original on 16 July 2013. Retrieved 28 August 2013.
34. "Traditional Profile Specifications" (<https://www.bluetooth.com/specifications/profiles-overview/>) . Bluetooth.com. Archived (<https://web.archive.org/web/20200311022237/https://www.bluetooth.com/specifications/profiles-overview/>)  from the original on 11 March 2020. Retrieved 28 October 2019.
35. "History of the Bluetooth Special Interest Group" (<http://www.bluetooth.com/Pages/History-of-Bluetooth.aspx>) . Bluetooth.com. Archived (<https://web.archive.org/web/20150701073626/http://www.bluetooth.com/Pages/History-of-Bluetooth.aspx>)  from the original on 1 July 2015. Retrieved 15 May 2015.
36. Sauter, Martin (2 August 2017). *From GSM to LTE-Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband* (<https://books.google.com/books?id=aEewDwAAQBAJ&pg=PA491>) . John Wiley & Sons. p. 491. ISBN 978-1-119-34690-6. Archived (<https://web.archive.org/web/20210414135830/https://books.google.com/books?id=aEewDwAAQBAJ&pg=PA491>)  from the original on 14 April 2021. Retrieved 13 September 2020.

















[xpg-FA431](#)) from the original on 14 April 2021. Retrieved 13 September 2020.

37. Penttinen, Jyrki T. J. (16 March 2015). *The Telecommunications Handbook: Engineering Guidelines for Fixed, Mobile and Satellite Systems* (<https://books.google.com/books?id=HRQmBgAAQBAJ&pg=PA129>) [↗](#). John Wiley & Sons. p. 129. ISBN 978-1-119-94488-1. Archived (<https://web.archive.org/web/20210125202158/https://books.google.com/books?id=HRQmBgAAQBAJ&pg=PA129>) [↗](#) from the original on 25 January 2021. Retrieved 13 September 2020.
38. "Portable Wireless Bluetooth Compatible Speakers" (<https://web.archive.org/web/20160418105028/https://www.trusoundaudio.com/collections/all>) [↗](#). Trusound Audio. Archived from the original (<https://www.trusoundaudio.com/collections/all>) [↗](#) on 18 April 2016. Retrieved 7 April 2016.
39. "Bluetooth Revisited" (<https://web.archive.org/web/20160603110522/https://techpayout.com/blog/bluetooth-revisited/>) [↗](#). *www.techpayout.com*. 27 March 2014. Archived from the original (<https://techpayout.com/blog/bluetooth-revisited/>) [↗](#) on 3 June 2016. Retrieved 10 May 2016.
40. "Bluetooth Technology" (<http://www.mobileinfo.com/Bluetooth/applic.htm>) [↗](#). mobileinfo.com. Archived (<https://web.archive.org/web/20181223163529/http://www.mobileinfo.com/Bluetooth/applic.htm>) [↗](#) from the original on 23 December 2018. Retrieved 11 May 2015.
41. "Samsung Omnia II: How to Transfer Files with Bluetooth FTP" (<https://www.youtube.com/watch?v=3BdT1DGyGT4>) [↗](#). *YouTube*. 11 December 2009. Archived (<https://ghostarchive.org/archive/youtube/20211123/3BdT1DGyGT4>) [↗](#) from the original on 23 November 2021.
42. Mattei, Giovanni. "Selfie stick: i migliori modelli per foto e video eccellenti" (<https://www.telefonino.net/guide/selfie-stick/>) [↗](#). *telefonino.net* (in Italian). Retrieved 31 October 2022.
43. John Fuller (28 July 2008). "How Bluetooth Surveillance Works" (<http://electronics.howstuffworks.com/bluetooth-surveillance1.htm>) [↗](#). *howstuffworks*. Archived (<https://web.archive.org/web/20150526093443/http://electronics.howstuffworks.com/bluetooth-surveillance1.htm>) [↗](#) from the original on 26 May 2015. Retrieved 26 May 2015.
44. "Wii Controller" (https://web.archive.org/web/20080220080315/http://bluetooth.com/Bluetooth/Products/Products/Product_Details.htm?ProductID=2951) [↗](#). Bluetooth SIG. Archived from the original (http://bluetooth.com/Bluetooth/Products/Products/Product_Details.htm?ProductID=2951) [↗](#) on 20 February 2008. Retrieved 1 February 2008.
45. "Telemedicine.jp" (<http://www.telemedicine.jp/>) [↗](#). Telemedicine.jp. Archived (<https://web.archive.org/web/20181223163529/http://www.telemedicine.jp/>) [↗](#) from the original on 23 December 2018. Retrieved 11 May 2015.

nive.org/web/20181223163413/http://www.telemedicine.jp/) from the original on 23 December 2018. Retrieved 4 September 2010.

46. "Tai nghe bluetooth nokia" (<http://tainghebluetooth.com/tai-nghe-bluetooth-nokia>) from the original on 21 September 2016. Retrieved 6 September 2016.
47. "Real Time Location Systems" (http://www.clarinox.com/docs/whitepapers/RealTime_main.pdf) (PDF). clarinox. Archived (https://web.archive.org/web/20191228211943/https://www.clarinox.com/docs/whitepapers/RealTime_main.pdf) (PDF) from the original on 28 December 2019. Retrieved 4 August 2010.
48. "Wireless waves used to track travel times" (<http://calgary.ctvnews.ca/wireless-waves-used-to-track-travel-times-1.1054731>) from the original on 1 July 2013. Retrieved 11 July 2013.
49. "Wireless Data and Power Transfer of an Optogenetic Implantable Visual Cortex Stimulator (PDF Download Available)" (<https://www.researchgate.net/publication/284639806>) from the original on 12 February 2022. Retrieved 20 September 2017.
50. Mroz, Mandy (21 May 2018). "Bluetooth hearing aids: Hearing aids with Bluetooth technology use today's wireless technology to help you easily stay connected to iOS and Android phones, televisions, tablets and other favorite audio devices" (<https://www.healthyhearing.com/help/hearing-aids/bluetooth>) from the original on 25 May 2019. Retrieved 15 July 2018.
51. "Watch" (<https://web.archive.org/web/20100918122452/http://www.bluetooth.com/English/Products/pages/watch.aspx>) on 18 September 2010. Retrieved 4 September 2010.
52. Eizikowitz, Grant (5 March 2018). "Why does Bluetooth still suck?" (<http://www.businessinsider.com/why-bluetooth-sucks-bad-problems-issues-disconnects-2018-2>) from the original

on 15 July 2018. Retrieved 15 July 2018.

53. "How Bluetooth Works" (<http://www.howstuffworks.com/bluetooth.htm>) . How Stuff Works. 30 June 2010. Archived (<https://web.archive.org/web/20120404182314/http://www.howstuffworks.com/bluetooth.htm>)  from the original on 4 April 2012. Retrieved 12 April 2012.
54. "Specification Documents" (<https://www.bluetooth.com/specifications>) . Bluetooth.com. 30 June 2010. Archived (<https://web.archive.org/web/20170912191437/https://www.bluetooth.com/specifications>)  from the original on 12 September 2017. Retrieved 12 September 2017.
55. "Bluetooth for Programmers" (<http://people.csail.mit.edu/rudolph/Teaching/Articles/PartOfBTBook.pdf>)  (PDF). MIT Computer Science And Artificial Intelligence Laboratory. Archived (<https://web.archive.org/web/20181223163532/http://people.csail.mit.edu/rudolph/Teaching/Articles/PartOfBTBook.pdf>)  (PDF) from the original on 23 December 2018. Retrieved 11 May 2015.
56. "Bluetooth Wireless Technology FAQ – 2010" (http://download.microsoft.com/download/9/c/5/9c5b2167-8017-4bae-9fde-d599bac8184a/Bth_FAQ.docx) . Archived (https://web.archive.org/web/20181223163558/http://download.microsoft.com/download/9/c/5/9c5b2167-8017-4bae-9fde-d599bac8184a/Bth_FAQ.docx)  from the original on 23 December 2018. Retrieved 4 September 2010.
57. "Network Protection Technologie" (<https://web.archive.org/web/20080101194700/http://www.microsoft.com/technet/prodtechnol/winxppro/maintain/sp2netwk.msp>) . *Changes to Functionality in Microsoft Windows XP Service Pack 2*. Microsoft Technet. Archived from the original (<http://www.microsoft.com/technet/prodtechnol/winxppro/maintain/sp2netwk.msp>)  on 1 January 2008. Retrieved 1 February 2008.
58. "Apple Introduces "Jaguar," the Next Major Release of Mac OS X" (<https://web.archive.org/web/20080218140207/http://www.apple.com/pr/library/2002/jul/17jaguar.html>)  (Press release). Apple. 17 July 2002. Archived from the original (<https://www.apple.com/pr/library/2002/jul/17jaguar.html>)  on 18 February 2008. Retrieved 4 February 2008.
59. "Official Linux Bluetooth protocol stack" (<http://www.bluez.org/>) . BlueZ. Archived (<https://web.archive.org/web/20190522085659/http://www.bluez.org/>)  from the original on 22 May 2019. Retrieved 4 September 2010.
60. "Bluedroid stack in android" (<https://medium.com/@zpcat/bluedroid-stack-in-android-564c58b451f4>) . Jacob su. 10 May 2016. Archived (<https://web.archive.org/web/20190619145347/http://medium.com/@zpcat/bluedroid-stack-in-android-564c58b451f4>)  from the

47/<https://medium.com/@zpcat/bluetooth-stack-in-android-564c58d45114>) from the original on 19 June 2019. Retrieved 19 June 2019.

61. "Affix Bluetooth Protocol Stack for Linux" (<http://affix.sourceforge.net/>) from the original on 5 November 2018. Retrieved 19 June 2019.
62. Maksim Yevmenkin (2002). "ng_bluetooth.4 — placeholder for global Bluetooth variables" (http://bxr.su/f/share/man/man4/ng_bluetooth.4) from the original on 12 February 2022. Retrieved 10 April 2019.
63. "ng_bluetooth" (https://www.freebsd.org/cgi/man.cgi?query=ng_bluetooth&sektion=4) from the original on 12 February 2022. Retrieved 10 April 2019.
64. Iain Hibbert; Itronix Inc (2006). "bluetooth.4 — Bluetooth Protocol Family" (<http://bxr.su/n/share/man/man4/bluetooth.4>) from the original on 12 February 2022. Retrieved 10 April 2019.
65. "bluetooth(4)" (<https://web.archive.org/web/20210313080003/http://man.netbsd.org/bluetooth.4>) on 13 March 2021.
66. Ted Unangst (11 July 2014). "CVS: cvs.openbsd.org: src" (<https://marc.info/?l=openbsd-cvs&m=140511572108715&w=2>) from the original on 19 January 2019. Retrieved 10 April 2019. "bluetooth support doesn't work and isn't going anywhere."
67. tbert, ed. (29 July 2014). "g2k14: Ted Unangst on the Art of the Tedu" (<https://undeadly.org/cgi?action=article&sid=20140729070721>) from the original on 24 March 2019. Retrieved 10 April 2019. "Of these, you may possibly miss bluetooth support. Unfortunately, the current code doesn't work and isn't structured properly to encourage much future development."
68. Hasso Tepper, ed. (2008). "bluetooth.4 — Bluetooth Protocol Family" (<http://bxr.su/d/share/man/man4/bluetooth.4>) from the original on 12 February 2022. Retrieved 10 April 2019.

69. "bluetooth" (<https://www.dragonflybsd.org/cgi/web-man?command=bluetooth§ion=4>) . *DragonFly On-Line Manual Pages*. DragonFly.
70. "sys/netgraph7/bluetooth/common/ng_bluetooth.c" (http://bxe.su/d/sys/netgraph7/bluetooth/common/ng_bluetooth.c) . *BSD Cross Reference*. DragonFly BSD. Archived (https://web.archive.org/web/20220212024952/http://bxe.su/DragonFly/sys/netgraph7/bluetooth/common/ng_bluetooth.c)  from the original on 12 February 2022. Retrieved 10 April 2019.
71. Sascha Wildner (15 November 2014). "kernel/netgraph7: Port the kernel part of the netgraph7 bluetooth stack" (<https://github.com/DragonFlyBSD/DragonFlyBSD/commit/e85b99abf6da4a83a7dc495b0ef37ce19864149f>) . DragonFly BSD. Archived (<https://web.archive.org/web/20190430044658/https://github.com/DragonFlyBSD/DragonFlyBSD/commit/e85b99abf6da4a83a7dc495b0ef37ce19864149f>)  from the original on 30 April 2019. Retrieved 10 April 2019.
72. "Our History" (<https://web.archive.org/web/20180525083558/https://www.bluetooth.com/about-us/our-history>) . Bluetooth.com. Archived from the original (<https://www.bluetooth.com/about-us/our-history>)  on 25 May 2018. Retrieved 24 August 2018.
73. "English Introduction to Membership" (<https://web.archive.org/web/20140626122249/https://www.bluetooth.org/en-us/members/introduction-to-membership>) . *Bluetooth.org*. Archived from the original (<https://www.bluetooth.org/en-us/members/introduction-to-membership>)  on 26 June 2014. Retrieved 13 May 2014.
74. "Compatibility guide" (https://www.kohls.com/media/digital/ecom/pdfs/pdf/Bluetooth_Compatibility_Guide_May_2015.pdf)  (PDF). 2016. Archived (https://web.archive.org/web/20191228212138/https://www.kohls.com/media/digital/ecom/pdfs/pdf/Bluetooth_Compatibility_Guide_May_2015.pdf)  (PDF) from the original on 28 December 2019. Retrieved 18 December 2019.
75. "BlueTooth" (http://blue-tooth.50webs.com/bluetooth1_and_1.0b.html) . *BlueTooth*. 2007. Archived (https://web.archive.org/web/20200214234923/http://blue-tooth.50webs.com/bluetooth1_and_1.0b.html)  from the original on 14 February 2020. Retrieved 25 October 2021.
76. *IEEE Std 802.15.1–2002 – IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements Part 15.1: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs)*. 2002. doi:10.1109/IEEESTD.2002.93621 (<https://doi.org/10.1109%2FIEEESTD.2002.93621>) . ISBN 978-0-7381-3335-5.
77. Guv Kewnev (16 November 2004). "High speed Bluetooth comes a step closer: enhanced















77. Guy Rowley (10 November 2007). "High speed Bluetooth comes a step closer: Enhanced data rate approved" (<https://web.archive.org/web/20180115173504/http://www.newswireless.net/index.cfm/article/629>) . Newswireless.net. Archived from the original (<http://www.newswireless.net/index.cfm/article/629>)  on 15 January 2018. Retrieved 4 February 2008.
78. *IEEE Std 802.15.1–2005 – IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements Part 15.1: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs)*. doi:10.1109/IEEESTD.2005.96290 (<https://doi.org/10.1109%2FIEEESTD.2005.96290>) . ISBN 978-0-7381-4708-6.
79. "Specification Documents" (http://www.bluetooth.org/docman/handlers/DownloadDoc.ashx?doc_id=40560&ei=25GiT8L3CuTa0QGnmqDVDA&usg=AFQjCNGXY5pm4Tkju1KGs4dYRJLtd03FEg) . Bluetooth SIG. Archived (https://web.archive.org/web/20181223163507/https://www.bluetooth.org/docman/handlers/DownloadDoc.ashx?doc_id=40560&ei=25GiT8L3CuTa0QGnmqDVDA&usg=AFQjCNGXY5pm4Tkju1KGs4dYRJLtd03FEg)  from the original on 23 December 2018. Retrieved 3 May 2012.
80. "HTC TyTN Specification" (https://web.archive.org/web/20061012113727/http://www.europe.htc.com/z/pdf/products/1766_TyTN_LFLT_OUT.PDF)  (PDF). HTC. Archived from the original (http://www.europe.htc.com/z/pdf/products/1766_TyTN_LFLT_OUT.PDF)  (PDF) on 12 October 2006. Retrieved 4 February 2008.
81. "Simple Pairing Whitepaper" (https://web.archive.org/web/20061018032605/http://www.bluetooth.com/NR/rdonlyres/0A0B3F36-D15F-4470-85A6-F2CCFA26F70F/0/SimplePairing_WP_V10r00.pdf)  (PDF). Version V10r00. Bluetooth SIG. 3 August 2006. Archived from the original (http://bluetooth.com/NR/rdonlyres/0A0B3F36-D15F-4470-85A6-F2CCFA26F70F/0/SimplePairing_WP_V10r00.pdf)  (PDF) on 18 October 2006. Retrieved 1 February 2007.
82. "Bluetooth Core Version 3.0 + HS specification" (https://www.bluetooth.org/docman/handlers/DownloadDoc.ashx?doc_id=40560) . Archived (https://web.archive.org/web/20181223163602/https://www.bluetooth.org/docman/handlers/DownloadDoc.ashx?doc_id=40560)  from the original on 23 December 2018. Retrieved 8 May 2011.
83. "Bluetooth Core Specification Addendum (CSA) 1" (https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=174214) . Archived (https://web.archive.org/web/20181223163555/https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=174214)  from the original on 23 December 2018. Retrieved 11 April 2018.
84. David Meyer (22 April 2009). "Bluetooth 3.0 released without ultrawideband" (https://web.archive.org/web/20090422100000/http://www.bluetooth.com/press/press_releases/2009/04/22/) 

cnive.org/web/20110919213421/http://www.zdnet.co.uk/news/networking/2009/04/22/bluetooth-30-released-without-ultrawideband-39643174/) [↗](#). zdnet.co.uk. Archived from the original (<http://news.zdnet.co.uk/communications/0,1000000085,39643174,00.htm>) [↗](#) on 19 September 2011. Retrieved 22 April 2009.

85. "Wimedia.org" (<https://web.archive.org/web/20020426095418/http://www.wimedia.org/>) [↗](#). Wimedia.org. 4 January 2010. Archived from the original (<http://www.wimedia.org/>) [↗](#) on 26 April 2002. Retrieved 4 September 2010.
86. "Wimedia.org" (<https://web.archive.org/web/20090323120814/http://www.wimedia.org/imwp/download.asp?ContentID=15506>) [↗](#). Archived from the original (<http://www.wimedia.org/imwp/download.asp?ContentID=15506>) [↗](#) on 23 March 2009. Retrieved 4 September 2010.
87. "bluetooth.com" (<http://www.bluetooth.com/Pages/Press-Releases-Detail.aspx?ItemID=4>) [↗](#). Archived (<https://web.archive.org/web/20150208013350/http://www.bluetooth.com/Pages/Press-Releases-Detail.aspx?ItemID=4>) [↗](#) from the original on 8 February 2015. Retrieved 29 January 2015.
88. "USB.org" (https://web.archive.org/web/20110610211240/http://www.usb.org/press/WiMedia_Tech_Transfer/) [↗](#). USB.org. 16 March 2009. Archived from the original (http://www.usb.org/press/WiMedia_Tech_Transfer/) [↗](#) on 10 June 2011. Retrieved 4 September 2010.
89. "Incisor.tv" (<https://web.archive.org/web/20180916054407/http://www.incisor.tv/2009/03/what-to-make-of-bluetooth-sig-wimedia.html>) [↗](#). Incisor.tv. 16 March 2009. Archived from the original (<http://www.incisor.tv/2009/03/what-to-make-of-bluetooth-sig-wimedia.html>) [↗](#) on 16 September 2018. Retrieved 4 September 2010.
90. "Bluetooth group drops ultrawideband, eyes 60 GHz" (<https://www.eetimes.com/bluetooth-group-drops-ultrawideband-eyes-60-ghz/>) [↗](#). *EETimes*. 29 October 2009. Archived (<https://web.archive.org/web/20210612021636/https://www.eetimes.com/bluetooth-group-drops-ultrawideband-eyes-60-ghz/>) [↗](#) from the original on 12 June 2021. Retrieved 17 June 2021.
91. "Report: Ultrawideband dies by 2013" (<https://www.eetimes.com/report-ultrawideband-dies-by-2013/>) [↗](#). *EETimes*. 4 May 2009. Archived (<https://web.archive.org/web/20210612021648/https://www.eetimes.com/report-ultrawideband-dies-by-2013/>) [↗](#) from the original on 12 June 2021. Retrieved 17 June 2021.
92. "Simon Stenhouse - Leech Attempt" (<https://web.archive.org/web/20150924034305/http://www.incisor.tv/download.php?file=140november2009.pdf>) [↗](#) (PDF). *incisor.tv*. November 2009. Archived from the original (<http://www.incisor.tv/download.php?file=140november2009.pdf>) [↗](#) (PDF) on 24 September 2015. Retrieved 4 June 2015.

93. "Wibree forum merges with Bluetooth SIG" (https://web.archive.org/web/20141229073516/http://www.wibree.com/press/Wibree_pressrelease_final_1206.pdf)  (PDF) (Press release). Nokia. 12 June 2007. Archived from the original (http://www.wibree.com/press/Wibree_pressrelease_final_1206.pdf)  (PDF) on 29 December 2014. Retrieved 4 February 2008.
94. "Bluetooth.com" (https://web.archive.org/web/20091221175650/http://www.bluetooth.com/Bluetooth/Press/SIG/SIG_INTRODUCES_BLUETOOTH_LOW_ENERGY_WIRELESS_TECHNOLOGY_THE_NEXT_GENERATION_OF_BLUETOOTH_WIRELESS_TE.htm) . Bluetooth.com. Archived from the original (http://www.bluetooth.com/Bluetooth/Press/SIG/SIG_INTRODUCES_BLUETOOTH_LOW_ENERGY_WIRELESS_TECHNOLOGY_THE_NEXT_GENERATION_OF_BLUETOOTH_WIRELESS_TE.htm)  on 21 December 2009. Retrieved 4 September 2010.
95. "Bluetooth SIG unveils Smart Marks, explains v4.0 compatibility with unnecessary complexity" (<https://www.engadget.com/2011/10/25/bluetooth-sig-unveils-smart-marks-explains-v4-0-compatibility-w/>) . Engadget. Archived (<https://web.archive.org/web/20181230095852/https://www.engadget.com/2011/10/25/bluetooth-sig-unveils-smart-marks-explains-v4-0-compatibility-w/>)  from the original on 30 December 2018. Retrieved 24 August 2017.
96. "Dialog Semiconductor" (<https://www.dialog-semiconductor.com/bluetooth-low-energy>) . Archived (<https://web.archive.org/web/20181223163430/https://www.dialog-semiconductor.com/bluetooth-low-energy>)  from the original on 23 December 2018. Retrieved 1 February 2018.
97. "BlueNRG-1 - Programmable Bluetooth LE 5.2 Wireless SoC" (<https://www.st.com/en/wireless-connectivity/bluenrg-1.html>) . STMicroelectronics. Retrieved 24 March 2022.
98. ":::矽科電子-Amiccom" (<https://web.archive.org/web/20130825161057/http://www.amiccom.com.tw/>) . Archived from the original (<http://www.amiccom.com.tw/>)  on 25 August 2013.
99. "CSR.com" (<https://archive.today/20120628214525/http://www.csr.com/products/45/csr-energy>) . CSR. Archived from the original (<http://www.csr.com/products/45/csr-energy>)  on 28 June 2012. Retrieved 7 April 2011.
100. "Nordicsemi.com" (<https://web.archive.org/web/20110402173736/http://www.nordicsemi.com/eng/Products/Bluetooth-R-low-energy/nRF8001>) . Nordic Semiconductor. Archived from the original (<https://www.nordicsemi.com/eng/Products/Bluetooth-R-low-energy/nRF8001>)  on 2 April 2011. Retrieved 7 April 2011.
101. "TI.com" (<http://focus.ti.com/docs/prod/folders/print/cc2540.html>) . Texas Instruments. Archived (<https://web.archive.org/web/20110721114918/http://focus.ti.com/docs/prod/folders/print/cc2540.html>)  from the original on 21 July 2011. Retrieved 7 April 2011.


102. "iFixit MacBook Air 13" Mid 2011 Teardown" (<http://www.ifixit.com/Teardown/MacBook-Air-13-Inch-Mid-2011-Teardown/6130/1>) [↗](#). iFixit.com. 21 July 2011. Archived (<https://web.archive.org/web/20110724072433/http://www.ifixit.com/Teardown/MacBook-Air-13-Inch-Mid-2011-Teardown/6130/1>) [↗](#) from the original on 24 July 2011. Retrieved 27 July 2011.
103. "Broadcom.com – BCM20702 – Single-Chip Bluetooth® 4.0 HCI Solution with Bluetooth Low Energy (BLE) Support" (<https://web.archive.org/web/20110811125845/http://www.broadcom.com/products/Bluetooth/Bluetooth-RF-Silicon-and-Software-Solutions/BCM20702>) [↗](#). Broadcom. Archived from the original (<http://www.broadcom.com/products/Bluetooth/Bluetooth-RF-Silicon-and-Software-Solutions/BCM20702>) [↗](#) on 11 August 2011. Retrieved 27 July 2011.
104. "Press Releases Detail | Bluetooth Technology Website" (<https://web.archive.org/web/20140623092659/http://www.bluetooth.com/pages/press-releases-detail.aspx?itemid=197>) [↗](#). Bluetooth.com. 4 December 2013. Archived from the original (<http://www.bluetooth.com/Pages/Press-Releases-Detail.aspx?ItemID=197>) [↗](#) on 23 June 2014. Retrieved 13 May 2014.
105. "Adopted Specification; Bluetooth Technology Website" (<https://web.archive.org/web/20151003173654/https://www.bluetooth.org/en-us/specification/adopted-specifications>) [↗](#). Bluetooth.com. 4 December 2013. Archived from the original (<https://www.bluetooth.org/en-us/specification/adopted-specifications>) [↗](#) on 3 October 2015. Retrieved 14 May 2014.
106. "Specification of the Bluetooth® System" (https://www.bluetooth.org/docman/handlers/downloaddoc.ashx?doc_id=441541) [↗](#). *bluetooth.com*. 2 December 2014. Retrieved 23 February 2023.
107. "Redmondpie" (<http://www.redmondpie.com/bluetooth-4.2-announced-heres-what-is-new/>) [↗](#). 3 December 2014. Archived (<https://web.archive.org/web/20141213015652/http://www.redmondpie.com/bluetooth-4.2-announced-heres-what-is-new/>) [↗](#) from the original on 13 December 2014. Retrieved 11 December 2014.
108. "DailyTech" (<https://web.archive.org/web/20141207093853/http://www.dailytech.com/Bluetooth+42+Promises+Faster+Connections+Better+Security+to+Stop+Snooping/article36960.htm>) [↗](#). Archived from the original (<http://www.dailytech.com/Bluetooth+42+Promises+Faster+Connections+Better+Security+to+Stop+Snooping/article36960.htm>) [↗](#) on 7 December 2014.
109. Woolley, Martin (26 October 2017). "Bluetooth® Core Specification Version 5.0 Feature Enhancements" (https://www.bluetooth.com/wp-content/uploads/2019/03/Bluetooth_5-FINAL.pdf) [↗](#) (PDF). *bluetooth.com* (1.1.0 ed.). Retrieved 23 February 2023.
110. "MWC 2017: Sony launches new 5G-ready Xperia XZ series with top notch camera" (<https://www.sony.com/europe/news-events/sony-launches-xperia-xz-series>) [↗](#). Sony. 26 September 2017. Archived (<https://web.archive.org/web/20170926120000/https://www.sony.com/europe/news-events/sony-launches-xperia-xz-series>) [↗](#) from the original on 26 September 2017. Retrieved 23 February 2023.

110. "MWC 2017: Sony launches new 5G-ready xperia xz series with top-notch camera" (<https://www.ibtimes.co.in/mwc-2017-sony-launches-new-5g-ready-xperia-xz-series-top-notch-camera-717581>) . *IBT*. 27 February 2017. Archived (<https://web.archive.org/web/20191003065556/https://www.ibtimes.co.in/mwc-2017-sony-launches-new-5g-ready-xperia-xz-series-top-notch-camera-717581>)  from the original on 3 October 2019. Retrieved 3 October 2019.
111. "HomePod - Technical Specifications" (<https://www.apple.com/homepod/specs/>) . *Apple*. Archived (<https://web.archive.org/web/20190513062322/https://www.apple.com/homepod/specs/>)  from the original on 13 May 2019. Retrieved 29 January 2018.
112. cnxsoft (10 June 2016). "Bluetooth 5 Promises Four times the Range, Twice the Speed of Bluetooth 4.0 LE Transmissions" (<https://www.cnx-software.com/2016/06/10/bluetooth-5-promises-four-times-the-speed-twice-the-range-of-bluetooth-4-0-le-transmissions/>) . Archived (<https://web.archive.org/web/20190512044135/https://www.cnx-software.com/2016/06/10/bluetooth-5-promises-four-times-the-speed-twice-the-range-of-bluetooth-4-0-le-transmissions/>)  from the original on 12 May 2019. Retrieved 12 December 2018.
113. "Bluetooth 5 standard brings range, speed and capacity boost for IoT" (<http://www.computerweekly.com/news/450298598/Bluetooth-5-standard-brings-range-speed-and-capacity-boost-for-IoT>) . Archived (<https://web.archive.org/web/20160618143744/http://www.computerweekly.com/news/450298598/Bluetooth-5-standard-brings-range-speed-and-capacity-boost-for-IoT>)  from the original on 18 June 2016. Retrieved 18 June 2016.
114. "Bluetooth® 5 Quadruples Range, Doubles Speed, Increases Data Broadcasting Capacity by 800% - Bluetooth Technology Website" (<https://web.archive.org/web/20181209055417/http://www.bluetooth.com/news/pressreleases/2016/06/16/-bluetooth-5-quadruples-rangedoubles-speedincreases-data-broadcasting-capacity-by-800>) . *www.bluetooth.com*. Archived from the original (<https://www.bluetooth.com/news/pressreleases/2016/06/16/-bluetooth-5-quadruples-rangedoubles-speedincreases-data-broadcasting-capacity-by-800>)  on 9 December 2018. Retrieved 12 December 2018.
115. " "Bluetooth 5" spec coming next week with 4x more range and 2x better speed [Updated]" (<https://arstechnica.com/gadgets/2016/06/bluetooth-5-spec-coming-next-week-with-2x-more-range-and-4x-better-speed/>) . 10 June 2016. Archived (<https://web.archive.org/web/20190610041359/https://arstechnica.com/gadgets/2016/06/bluetooth-5-spec-coming-next-week-with-2x-more-range-and-4x-better-speed/>)  from the original on 10 June 2019. Retrieved 14 June 2017.
116. "Bluetooth 5: everything you need to know" (<http://www.techradar.com/news/networking/bluetooth-5-everything-you-need-to-know-1323060>) . 10 June 2016. Archived (<https://web.archive.org/web/20190610041359/https://www.techradar.com/news/networking/bluetooth-5-everything-you-need-to-know-1323060>)  from the original on 10 June 2019. Retrieved 14 June 2017.

















Bluetooth & everything you need to know 1323060) [↗] from the original on 5 May 2021. Retrieved 11 June 2016.


117. "Bluetooth Core Specification v5.0" (https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=421043) [↗] (PDF download). *www.bluetooth.org*. Archived (https://web.archive.org/web/20181223163509/https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=421043) [↗] from the original on 23 December 2018. Retrieved 8 December 2016.
118. Woolley, Martin (28 January 2019). "Bluetooth Core Specification v5.1" (https://www.bluetooth.com/wp-content/uploads/Files/Specification/1901_Feature_Overview_Brief_FINAL.pdf) [↗] (PDF). *bluetooth.com* (1.0.1 ed.). Retrieved 23 February 2023.
119. Woolley, Martin (9 December 2020). "Bluetooth Core Specification Version 5.2 Feature Overview" (https://www.bluetooth.com/wp-content/uploads/2020/01/Bluetooth_5.2_Feature_Overview.pdf) [↗] (PDF). *bluetooth.com*. Archived (https://web.archive.org/web/20200108105207/https://www.bluetooth.com/wp-content/uploads/2020/01/Bluetooth_5.2_Feature_Overview.pdf) [↗] (PDF) from the original on 8 January 2020. Retrieved 8 January 2020.
120. "The New Version of Bluetooth Is Here to Fix Your Headphones" (<https://www.wired.com/story/bluetooth-le-audio/>) [↗]. *Wired*. ISSN 1059-1028 (<https://www.worldcat.org/issn/1059-1028>) [↗]. Archived (<https://web.archive.org/web/20200426154948/https://www.wired.com/story/bluetooth-le-audio/>) [↗] from the original on 26 April 2020. Retrieved 3 February 2020.
121. Clover, Juli. "Bluetooth SIG Announces 'LE Audio' With Audio Sharing, Lower Data Consumption, Hearing Aid Support and More" (<https://www.macrumors.com/2020/01/06/bluetooth-sig-debuts-le-audio/>) [↗]. *www.macrumors.com*. Archived (<https://web.archive.org/web/20200220134827/https://www.macrumors.com/2020/01/06/bluetooth-sig-debuts-le-audio/>) [↗] from the original on 20 February 2020. Retrieved 3 February 2020.
122. "Hearing Aid Audio Support Using Bluetooth LE" (<https://source.android.com/devices/bluetooth/asha>) [↗]. *Android Open Source Project*. Archived (<https://web.archive.org/web/20200220152923/https://source.android.com/devices/bluetooth/asha>) [↗] from the original on 20 February 2020. Retrieved 3 February 2020.
123. Scharon Harding (12 July 2022). "What's Bluetooth LE Audio? Explaining the spec and what it means for wireless sound" (<https://arstechnica.com/gadgets/2022/07/whats-bluetooth-le-audio-explaining-the-latest-wireless-tech-standard/>) [↗]. *Ars Technica*. Retrieved 21 July 2022.













124. Woolley, Martin (24 June 2021). "Bluetooth Core Specification Version 5.3 Feature Enhancements" (https://www.bluetooth.com/wp-content/uploads/2021/01/Bluetooth_5.3_Feature_Enhancements_Update.pdf) (PDF). *bluetooth.com*. Archived (https://web.archive.org/web/20210730064958/https://www.bluetooth.com/wp-content/uploads/2021/01/Bluetooth_5.3_Feature_Enhancements_Update.pdf) (PDF) from the original on 30 July 2021. Retrieved 17 September 2021.
125. Woolley, Martin (7 February 2023). "Bluetooth® Core Specification Version 5.4" (https://www.bluetooth.com/wp-content/uploads/2023/02/2301_5.4_Tech_Overview_FINAL.pdf) (PDF). *bluetooth.com*. Archived (https://web.archive.org/web/20230209191214/https://www.bluetooth.com/wp-content/uploads/2023/02/2301_5.4_Tech_Overview_FINAL.pdf) (PDF) from the original on 9 February 2023. Retrieved 23 February 2023.
126. Happich, Julien (24 February 2010). "Global shipments of short range wireless ICs to exceed 2 billion units in 2010" (https://www.eetimes.com/document.asp?doc_id=1254987) (PDF). *EE Times*. Archived (<https://web.archive.org/web/20220212025004/https://www.eetimes.com/global-shipments-of-short-range-wireless-ics-to-exceed-2-billion-units-in-2010/>) (PDF) from the original on 12 February 2022. Retrieved 25 October 2019.
127. Veendrick, Harry J. M. (2017). *Nanometer CMOS ICs: From Basics to ASICs* (https://books.google.com/books?id=Lv_EDgAAQBAJ&pg=PA243) (PDF). Springer. p. 243. ISBN 9783319475974. Archived (https://web.archive.org/web/20200505161843/https://books.google.com/books?id=Lv_EDgAAQBAJ&pg=PA243) (PDF) from the original on 5 May 2020. Retrieved 26 October 2019.
128. Stallings, William (2005). *Wireless communications & networks*. Upper Saddle River, NJ: Pearson Prentice Hall. ISBN 9788132231561.
129. "Bluetooth protocol (RFCOMM, L2CAP and ACL)" (<https://stackoverflow.com/questions/20868038/bluetooth-protocol-rfcomm-l2cap-and-acl>) (PDF). *Stack Overflow*. Archived (<https://web.archive.org/web/20211202234531/https://stackoverflow.com/questions/20868038/bluetooth-protocol-rfcomm-l2cap-and-acl>) (PDF) from the original on 2 December 2021. Retrieved 2 December 2021.
130. Juha T. Vainio (25 May 2000). "Bluetooth Security" (<http://www.iki.fi/jiitv/bluesec.pdf>) (PDF). Helsinki University of Technology. Archived (<https://web.archive.org/web/20200925110917/http://www.yuuhaw.com/bluesec.pdf>) (PDF) from the original on 25 September 2020. Retrieved 1 January 2009.
131. Andreas Becker (16 August 2007). "Bluetooth Security & Hacks" (https://web.archive.org/web/20160321205619/http://asvc.es/~anto/ubicuos2/bluetooth_security_and_hacks.pdf) (PDF) from the original on 16 August 2007. Retrieved 1 January 2009.

- http://gsyc.es/~anto/ubicuos2/bluetooth_security_and_hacks.pdf (PDF). Ruhr-Universität Bochum. Archived from the original (http://gsyc.es/~anto/ubicuos2/bluetooth_security_and_hacks.pdf) (PDF) on 21 March 2016. Retrieved 10 October 2007.
132. Scarfone, K. & Padgett, J. (September 2008). "Guide to Bluetooth Security" (http://csrc.nist.gov/publications/nistpubs/800-121-rev1/sp800-121_rev1.pdf) (PDF). National Institute of Standards and Technology. Archived (https://web.archive.org/web/20170611040534/http://csrc.nist.gov/publications/nistpubs/800-121-rev1/sp800-121_rev1.pdf) (PDF) from the original on 11 June 2017. Retrieved 3 July 2013.
 133. John Fuller. "What is bluejacking?" (<http://electronics.howstuffworks.com/bluejacking.htm>) (PDF). howstuffworks. Archived (<https://web.archive.org/web/20150520035211/http://electronics.howstuffworks.com/bluejacking.htm>) (PDF) from the original on 20 May 2015. Retrieved 26 May 2015.
 134. Kaviarasu, S., & Muthupandian, P. (2016). Bluejacking Technology: A Review. International Journal of Trend in Research and Development, 3(6), 1. Retrieved October 2018, from https://www.researchgate.net/publication/314233155_Bluejacking_Technology_A_Review Archived (https://web.archive.org/web/20200302061045/https://www.researchgate.net/publication/314233155_Bluejacking_Technology_A_Review) 2 March 2020 at the Wayback Machine
 135. "Security Weaknesses in Bluetooth". RSA Security Conf. – Cryptographer's Track. CiteSeerX 10.1.1.23.7357 (<https://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.23.7357>) .
 136. "Bluetooth" (<https://web.archive.org/web/20070126012417/http://www.thebunker.net/resources/bluetooth>) (PDF). The Bunker. Archived from the original (<http://www.thebunker.net/resources/bluetooth>) (PDF) on 26 January 2007. Retrieved 1 February 2007.
 137. "BlueBug" (http://trifinite.org/trifinite_stuff_bluebug.html) (PDF). Trifinite.org. Archived (https://web.archive.org/web/20181223163514/https://trifinite.org/trifinite_stuff_bluebug.html) (PDF) from the original on 23 December 2018. Retrieved 1 February 2007.
 138. John Oates (15 June 2004). "Virus attacks mobiles via Bluetooth" (https://www.theregister.co.uk/2004/06/15/symbian_virus/) (PDF). *The Register*. Archived (https://web.archive.org/web/20181223163603/https://www.theregister.co.uk/2004/06/15/symbian_virus/) (PDF) from the original on 23 December 2018. Retrieved 1 February 2007.
 139. "Long Distance Snarf" (http://trifinite.org/trifinite_stuff_ids.html) (PDF). Trifinite.org. Archived (https://web.archive.org/web/20181223163536/https://trifinite.org/trifinite_stuff_ids.html) (PDF) from the original on 23 December 2018. Retrieved 1 February 2007.

140. "Dispelling Common Bluetooth Misconceptions" (<https://web.archive.org/web/20140714150109/http://www.sans.edu/research/security-laboratory/article/bluetooth>) . SANS. Archived from the original (<http://www.sans.edu/research/security-laboratory/article/bluetooth>)  on 14 July 2014. Retrieved 9 July 2014.
141. "F-Secure Malware Information Pages: Lasco.A" (https://web.archive.org/web/20080517091014/http://www.f-secure.com/v-descs/lasco_a.shtml) . F-Secure.com. Archived from the original (http://www.f-secure.com/v-descs/lasco_a.shtml)  on 17 May 2008. Retrieved 5 May 2008.
142. Ford-Long Wong; Frank Stajano; Jolyon Clulow (April 2005). "Repairing the Bluetooth pairing protocol" (<https://web.archive.org/web/20070616082657/http://www.cl.cam.ac.uk/~fw242/publications/2005-WongStaClu-bluetooth.pdf>)  (PDF). University of Cambridge Computer Laboratory. Archived from the original (<http://www.cl.cam.ac.uk/~fw242/publications/2005-WongStaClu-bluetooth.pdf>)  (PDF) on 16 June 2007. Retrieved 1 February 2007.
143. "Yaniv Shaked's Homepage" (<https://web.archive.org/web/20071109192150/http://www.eng.tau.ac.il/~shakedy/>) . Archived from the original (<http://www.eng.tau.ac.il/~shakedy/>)  on 9 November 2007. Retrieved 6 November 2007.
144. "Avishai Wool – אבישי וול" (<http://www.eng.tau.ac.il/~yash/>) . *tau.ac.il*. Archived (<https://web.archive.org/web/20181223163419/http://www.eng.tau.ac.il/~yash/>)  from the original on 23 December 2018. Retrieved 4 June 2015.
145. Yaniv Shaked; Avishai Wool (2 May 2005). "Cracking the Bluetooth PIN" (<http://www.eng.tau.ac.il/~yash/shaked-wool-mobisys05/>) . School of Electrical Engineering Systems, Tel Aviv University. Archived (<https://web.archive.org/web/20181223163532/http://www.eng.tau.ac.il/~yash/shaked-wool-mobisys05/>)  from the original on 23 December 2018. Retrieved 1 February 2007.
146. "Phone pirates in seek and steal mission" (https://web.archive.org/web/20070717035938/http://www.cambridge-news.co.uk/news/region_wide/2005/08/17/06967453-8002-45f8-b520-66b9bed6f29f.lpf) . *Cambridge Evening News*. Archived from the original (http://www.cambridge-news.co.uk/news/region_wide/2005/08/17/06967453-8002-45f8-b520-66b9bed6f29f.lpf)  on 17 July 2007. Retrieved 4 February 2008.
147. "Going Around with Bluetooth in Full Safety" (https://web.archive.org/web/20060610072813/http://www.securenetwork.it/bluebag_brochure.pdf)  (PDF). F-Secure. May 2006. Archived from the original (http://www.securenetwork.it/bluebag_brochure.pdf)  (PDF) on 10 June 2006. Retrieved 4 February 2008.

148. Finistere & Zoller. "All your Bluetooth is belong to us" (http://archive.hack.lu/2006/Zoller_hack_lu_2006.pdf)  (PDF). *archive.hack.lu*. Archived (https://web.archive.org/web/20181223163448/http://archive.hack.lu/2006/Zoller_hack_lu_2006.pdf)  (PDF) from the original on 23 December 2018. Retrieved 20 September 2017.
149. "BlueBorne Information from the Research Team – Armis Labs" (<https://www.armis.com/blueborne/#/technical>) . *armis*. Archived (<https://web.archive.org/web/20170921075121/https://www.armis.com/blueborne/#/technical>)  from the original on 21 September 2017. Retrieved 20 September 2017.
150. "Update Your iPhones And Androids Now If You Don't Want Your Bluetooth Hacked" (<https://www.forbes.com/sites/thomasbrewster/2018/07/24/bluetooth-hack-warning-for-iphone-and-roid-and-windows>) . *Forbes*. 24 July 2019. Archived (<https://web.archive.org/web/20190926093726/https://www.forbes.com/sites/thomasbrewster/2018/07/24/bluetooth-hack-warning-for-iphone-and-roid-and-windows>)  from the original on 26 September 2019. Retrieved 26 September 2019.
151. Neumann, Lior; Biham, Eli (2020). "Breaking the Bluetooth Pairing – The Fixed Coordinate Invalid Curve Attack" (<https://eprint.iacr.org/2019/1043>) . *Selected Areas in Cryptography – SAC 2019*. Lecture Notes in Computer Science. Vol. 11959. Technion – Israel Institute of Technology. pp. 250–273. doi:10.1007/978-3-030-38471-5_11 (https://doi.org/10.1007%2F978-3-030-38471-5_11) . ISBN 978-3-030-38470-8. S2CID 51757249 (<https://api.semanticscholar.org/CorpusID:51757249>) . Archived (<https://web.archive.org/web/20190918215324/https://eprint.iacr.org/2019/1043>)  from the original on 18 September 2019. Retrieved 26 September 2019.
152. Lounis, Karim; Zulkernine, Mohammad (2019). "Connection Dumping Vulnerability Affecting Bluetooth Availability" (https://link.springer.com/chapter/10.1007/978-3-030-12143-3_16) . *13th International Conference on Risks and Security of Internet and Systems – CRiSIS 2018*. Lecture Notes in Computer Science. Vol. 11391. Springer. pp. 188–204. doi:10.1007/978-3-030-12143-3_16 (https://doi.org/10.1007%2F978-3-030-12143-3_16) . ISBN 978-3-030-12142-6. S2CID 59248863 (<https://api.semanticscholar.org/CorpusID:59248863>) . Archived (https://web.archive.org/web/20210830005951/https://link.springer.com/chapter/10.1007/978-3-030-12143-3_16)  from the original on 30 August 2021. Retrieved 30 August 2021.
153. "New Critical Bluetooth Security Issue Exposes Millions Of Devices To Attack" (<https://www.forbes.com/sites/zakdoffman/2019/08/15/critical-new-bluetooth-security-issue-leaves-your-devices-and-data-open-to-attack>) . *Forbes*. 15 August 2019. Archived (<https://web.archive.org/web/20190815000000/https://www.forbes.com/sites/zakdoffman/2019/08/15/critical-new-bluetooth-security-issue-leaves-your-devices-and-data-open-to-attack>) 

[.org/web/20190820200938/https://www.torpedes.com/sites/zakdortman/2019/08/15/critical-new-bluetooth-security-issue-leaves-your-devices-and-data-open-to-attack](https://www.torpedes.com/sites/zakdortman/2019/08/15/critical-new-bluetooth-security-issue-leaves-your-devices-and-data-open-to-attack))  from the original on 20 August 2019. Retrieved 20 August 2019.

154. Antonioli, Daniele; Tippenhauer, Nils Ole; Rasmussen, Kasper B. (15 August 2019). *The KNOB is Broken: Exploiting Low Entropy in the Encryption Key Negotiation Of Bluetooth BR/EDR* (<https://www.usenix.org/system/files/sec19-antonioli.pdf>)  (PDF). Santa Clara: University of Oxford. ISBN 9781939133069. Archived (<https://web.archive.org/web/20210416163953/https://www.usenix.org/system/files/sec19-antonioli.pdf>)  (PDF) from the original on 16 April 2021. Retrieved 14 June 2021.
155. "Android Security Bulletin—August 2019" (<https://source.android.com/security/bulletin/2019-08-01.html>) . Retrieved 5 June 2022.
156. D. Chomienne; M. Eftimakis (20 October 2010). "Bluetooth Tutorial" (<https://web.archive.org/web/20161212135324/http://floatingbluetoothspeakerpro.com/>) . Archived from the original (<http://floatingbluetoothspeakerpro.com/>)  (PDF) on 12 December 2016. Retrieved 11 December 2009.
157. M. Hietanen; T. Alanko (October 2005). "Occupational Exposure Related to Radiofrequency Fields from Wireless Communication Systems" (<https://web.archive.org/web/20061006124651/http://www.ursi.org/Proceedings/ProcGA05/pdf/K03.7%2801682%29.pdf>)  (PDF). *XXVIIIth General Assembly of URSI – Proceedings*. Union Radio-Scientifique Internationale. Archived from the original ([http://www.ursi.org/Proceedings/ProcGA05/pdf/K03.7\(01682\).pdf](http://www.ursi.org/Proceedings/ProcGA05/pdf/K03.7(01682).pdf))  (PDF) on 6 October 2006. Retrieved 19 April 2007.
158. "Bluetooth Innovation World Cup" (http://www.bluetooth.com/Bluetooth/Press/Bluetooth_World_Innovation_Cup.htm) . Bluetooth.com. Archived (https://web.archive.org/web/20090823092414/http://www.bluetooth.com/Bluetooth/Press/Bluetooth_World_Innovation_Cup.htm)  from the original on 23 August 2009. Retrieved 4 September 2010.
159. "Bluetooth SIG announces winners of Imagine Blue Awards at Bluetooth World" (<https://www.bluetooth.com/news/pressreleases/2017/03/bluetooth-sig-announces-winners-of-imagine-blue-awards-at-bluetooth-world-2017>) . *Bluetooth.com*. Retrieved 29 March 2017.
160. "Bluetooth Breakthrough Awards" (<https://web.archive.org/web/20150715025823/https://www.bluetooth.org/en-us/news-events/bluetooth-breakthrough-awards>) . *bluetooth.org*. Archived from the original (<https://www.bluetooth.org/en-us/news-events/bluetooth-breakthrough-awards>)  on 15 July 2015. Retrieved 4 June 2015.

External links

- [Official website \(https://www.bluetooth.com\)](https://www.bluetooth.com) ↗
- [Specifications \(https://www.bluetooth.org/en-us/specification/adopted-specifications\)](https://www.bluetooth.org/en-us/specification/adopted-specifications) ↗ at Bluetooth SIG

Wikimedia Commons has media related to ***Bluetooth***.