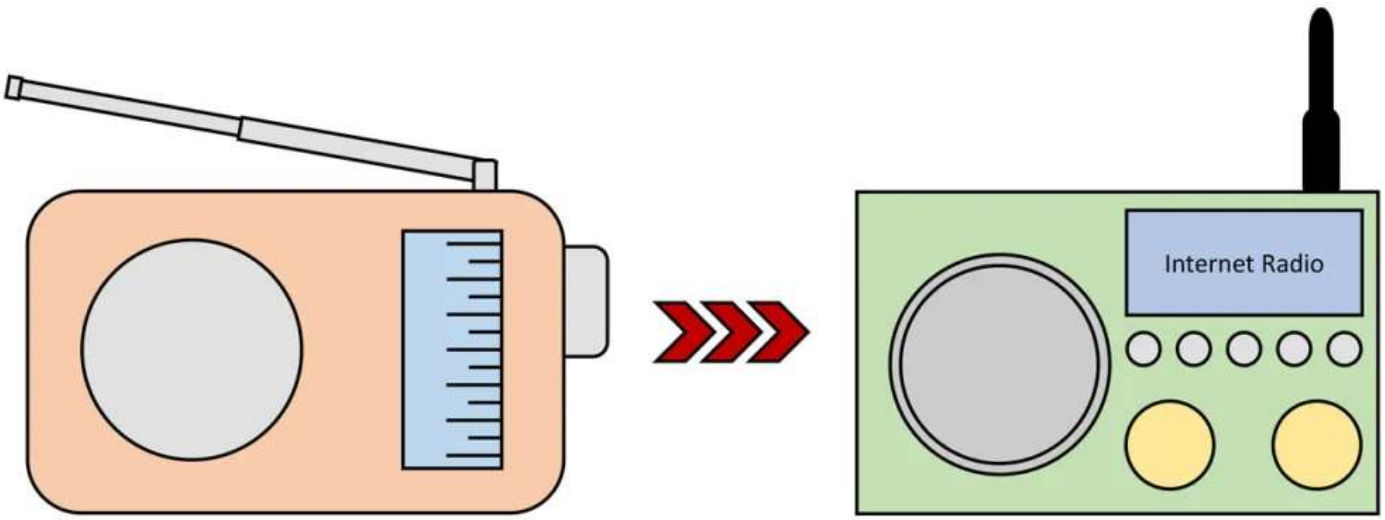


THE EVOLUTION OF RADIO RECEIVERS

14 APRIL, 2022 | EUROSCIENTIST | 3 COMMENTS

Radio receiver is one such gadget that people have been using for many generations. After the invention of radio communication by Guglielmo Marconi in 1895, the first radio receiver was also invented by Marconi. A radio receiver is an electronic device that can only receive radio signals and can convert the radio signals to audio and sound. A radio receiver can receive radio signals of various frequencies by tuning to a particular frequency. These frequencies are of two types – Amplitude Modulation (AM) and Frequency Modulation (FM). A radio receiver capable of receiving any analog audio on AM/FM frequency is called analog radio receiver and for many years people were using analog radio receivers.

Since the invention of analog radio by Marconi in 1895, many companies started manufacturing radio receivers. First came the De Forest RJ6 in 1916, and later many analog radio receivers like Sony TR-63 (1957), and H.H. Scott 350 (1961) came in the market, and they were the first analog radio receivers of that kind. After the emergence of digital electronics and digital radio transmission, digital radio receivers started to capture the market – receivers capable of receiving Digital Audio Broadcasting (DAB) – digital radio transmission. In 2003, Pure launched the PocketDAB 1000 and It was the world's first pocket digital radio capable of playing DAB radio stations. However, radio receivers became diversifying when internet technology was implemented in them, which made it possible for the companies to introduce internet radio receivers. An internet radio receiver can be either an app of a computer or can be a standalone receiver, connected to the internet to receive internet radio stations. Kerbango internet radio receiver from 3com was the first standalone internet radio receiver of 21th century. This change in the technology of radio receivers even went beyond internet radio – after the arrival of Software Defined Radio (SDR). An SDR receiver is a radio receiver which can receive both analog and digital radio transmission but can be configured and controlled using software. This became possible after the introduction of System-on-a-Chip (SoC) fabrication technology, and the first SDR receiver was made with the BCM21551 processor by Broadcom in 2007. Such SDR radio receivers became popular among the ameture radio enthusiast and the USB dongle with the Realtek RTL2832U/R820T2 demodulator chip is often used by such enthusiasts as an SDR receiver. The technology of radio receivers has changed many times since the invention of the first radio receiver, and the radio receivers are becoming smarter with the advent of various new technologies.

log category, there comes either AM or FM receiver but can also be a combo receiver. Among the digital receivers, it can be either an AM/FM HD radio receiver or a DAB/DAB+ receiver. Internet radio receivers are also digital radio receivers but can only receive radio stations when connected to the internet.

1. **Analog radio receivers:** These types of radio receivers can receive analog radio broadcasts of AM/FM frequencies. Earlier there were only AM radio receivers and people used analog AM radio receivers for listening to news and music. The first temporary radio station and broadcast was done by Guglielmo Marconi in 1895, and after that many radio stations started broadcasting news, music, fiction readings, etc on AM frequencies. Since then people have started using AM receivers. After the invention of FM radio by Edwin Armstrong in 1933 — the company called General Electric came up with the idea of FM broadcasting in 1940 and showed that FM radio broadcast is better than AM and is less prone to elecctro-magnetic disturbances. General Electric started FM radio station (WGFM) during that time but was later sold in 1980 and now it's called WRVE (99.5 MHz) and also known as 99.5 – The River. FM broadcast can also transmit stereo music and WEFM (in the Chicago area) and WGFM (in Schenectady, New York) were reported as the first stereo FM stations. After the introduction of FM radio broadcast, FM radio receivers started to grow in the market and many receivers came with both AM/FM receiving functionality

- **AM radio receivers:**

AM radio receivers are capable of receiving only AM radio frequencies. AM radio stations broadcast radio signals using a technology called amplitude modulation and in short it's called AM. It first started with a crystal radio 1904 and then came vacuum tube radios in 1906; after the invention of vacuum tubes by Lee De Forest. Carrying a radio receiver everywhere was not easy at that time because of their bulky design but soon after the invention of the transistor in 1947, radio receivers became portable and smaller in size. An AM radio receiver is capable of receiving AM radio broadcast, which can be of Long Wave (LW), Medium Wave (MW) and Short Wave (SW) frequencies. The Long Wave (LW) frequency range is 30–300 kHz and most of the old AM radio receivers were able to receive longwave radio broadcasts. The longwave signals can travel as far as 2,000 Km but reception at a distance of 17,000 Km was also experienced. Radio Algerie/Chaine 1 (198 Khz) of Algeria, RTL (234 Khz) of France, Médi 1 (171 Khz) of Morocco and Polskie Radio (216 Khz) of Poland are some AM radio stations broadcasting in long wave frequencies with high power antennas. Medium Wave (MW) frequency range is 525 kHz – 1710 kHz and most of the world's local radio stations have

and stations can be heard from another city or country. Short Wave (SW) frequency range is 3–30 MHz and many international radio stations broadcast on shortwave frequencies because shortwave signals can be transmitted over a distance of several thousand kilometers, from one continent to another. The shortwave radio signals can travel to various parts of the world because they are reflected by the ionosphere, just like a mirror that reflects light. Among all the types of AM frequencies – only shortwave frequencies can be heard from various parts of the world using any ordinary AM radio receiver.

The first commercial AM radio was RJ6 manufactured by De Forest Radio Telephone And Telegraph Company in 1916. After the invention of Superheterodyne radio receivers by Edwin Armstrong, many companies like Zenith Electronics (USA), introduced AM radio receivers like model 12S-568 and the model 7G605 in 1942 – the first portable radio. Most of the vacuum tube radios were made to receive long wave and medium wave frequencies only because shortwave broadcast was not prevalent at that time. Philips was also one such company who started manufacturing vacuum tube radios in 1927 and became the world's largest manufacturer of AM radios.

De Forest RJ6 Radio Receiver

Credit: Lee de Forest

After the invention of the transistor (electronic component) in the early 1950s – many companies like Sony, Zenith, RCA, DeWald, and Crosley started manufacturing various types of AM radio receivers which were capable of receiving shortwave frequencies also. The Sony TR-63 released in 1957 was the first mass-produced transistor radio, leading to the mass-market penetration of transistor radios.

Sony TR-63

Source:
https://m.facebook.com/ilmagicobox/photos/a.1916934968546200/2730037630569259/?type=3

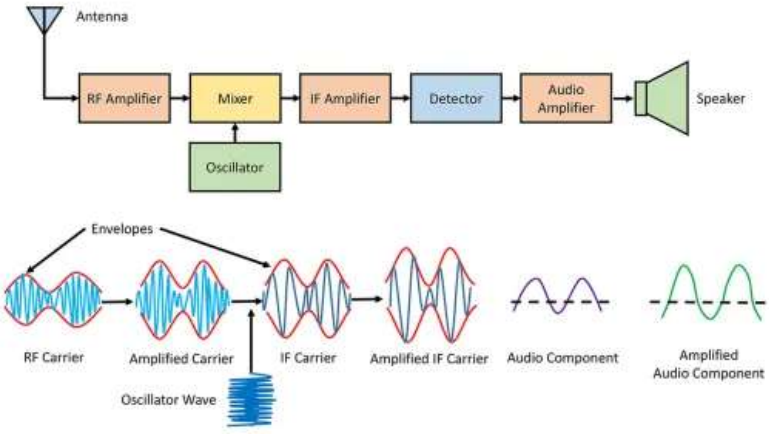
After the golden age of radio during the 1950s and due to the increase of international radio stations – many companies started manufacturing world band receivers. A world band receiver is capable of receiving any AM radio station, broadcasted in longwave, medium wave or shortwave frequencies. Many companies like Sony, Sangean, Grundig, and Philips, manufactured transistor based world band receivers.

- **FM radio receivers:** FM radio receivers are able to receive only FM radio stations. FM radio stations broadcast radio signals through a technology called frequency modulation and in short it's called FM. This technology was invented by Edwin Armstrong in 1933 and was verified by a company called General Electric in 1940. General Electric also started the world's first FM radio station called WGFM/WRVE – 99.5 The River 1939 and it was also the world's first stereo FM broadcasting station in the world. After this many FM radio stations started broadcasting around the world and FM radio receivers started to become popular among the listeners. Many companies started manufacturing FM radio receivers and the company called H. H. Scott (USA) manufactured and sold the first FM radio receiver – Model 350 in 1961.

H. H. Scott 350 FM Stereo Multiplex Tuner

Source: https://i.pinimg.com/736x/4e/ea/63/4eea631f46545c1eb4dfab4816220570–lwren-scott-vinyl-records.jpg

Later companies started manufacturing radio receivers with both AM and FM modes, and today most of the radio receivers can receiver AM and FM frequencies. AM/FM receivers became so popular that many products like alarm clocks, CD/MP3 players, walkmans, portable speakers, etc were manufactured with integrated AM/FM radio. Sony Walkman was one such popular product that came with an AM/FM receiver. However, many radio receivers, manufactured today, also come without AM mode. Due to the decline of AM listeners, many companies now-a-days don't integrate AM receivers with FM radio receivers. Today, only selected radio models have both AM/FM modes and world band receivers manufactured by companies like Degen and Tecsun have such features. However, due to the rise of smartphone users and the integration of FM receivers in smartphones, the number of AM listeners have reduced overtime.



Analog Radio Receiver Technology

Credits: Debojit Acharjee

sends the amplified signals to the detector, which detects the audio and feeds it to the audio amplifier. The audio amplifier finally amplifies the audio and makes it audible with the help of a speaker.

The radio broadcasting frequencies and the radio receiver manufacturing standards are regulated by the Federal Communications Commission (FCC) of the USA and companies must follow the standards regulated by FCC. Because of this reason almost all radio receivers manufactured by branded companies can only receive frequencies of commercial radio stations but can't receive any other kind of communication frequencies like Air or Police band frequencies.

2. Digital radio receivers: Digital radio receivers work only with digital radio transmission or internet broadcast, and a digital radio receiver converts the digital audio signals received from the digital radio signals to analog audio. This analog audio is then converted to sound using an analog audio amplifier. The digital radio signals can be either compressed or uncompressed but are usually compressed in MP2 format. Various types of digital radio receivers include: Digital Audio Broadcasting (DAB), HD Radio and Internet Radio receivers. First came the Digital Audio Broadcasting (DAB) receivers during the 90s and The Norwegian Broadcasting Corporation (NRK) launched the first DAB channel in the world on 1 June 1995 (NRK Klassisk). Many DAB receivers came in the market, and PocketDAB 1000 was the world's first pocket DAB receiver launched by Pure International in 2003. Few years after the rise of DAB receivers, the HD radio receivers were introduced in the market by many companies like Sangean, Sony, TEAC, Yamaha, JVC, Kenwood and Pioneer. Such an HD radio receiver was capable of receiving digital AM/FM radio signals. As the HD radio broadcasting stations were running only in some countries like the USA and Canada, such HD radio receivers couldn't hit the international market abundantly. Later in the aughts, internet radio receivers became popular among the internet users, and such a radio receiver requires internet connection to play any internet radio station. It was either an app used on a computer or a standalone receiver connected to the internet. Kerbango internet radio receiver from 3com was the first standalone internet radio receiver, but the standalone receivers couldn't dominate the market because of the easy availability of internet radio apps which were able to play internet radio stations when used on a computer (connected to the internet). But the story doesn't end here – after the rise of System-on-a-Chip (SoC) processors, the working of a Software Defined Radio (SDR) receiver became possible. An SDR receiver is a radio receiver that can be used to receive radio signals with the help of a computer, and it's controlled using software. The BCM21551 processor from Broadcom was first SoC used in an SDR receiver in 2007. Since then many companies have launched many types of SDR receivers in the market

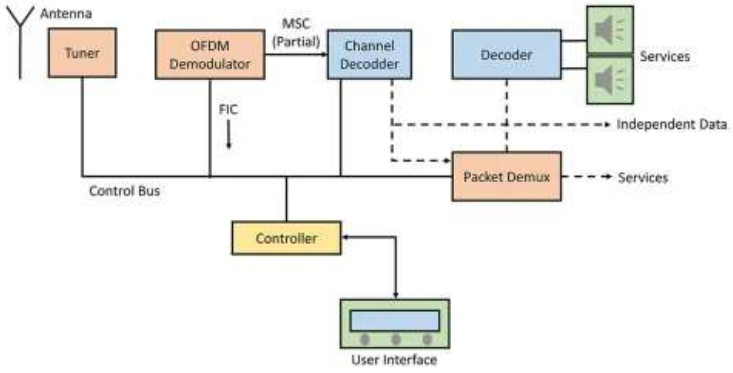
Now-a-days many companies like Yaesu (USA) manufactures radio transceivers with inbuilt SDR functionality.

- **Digital Audio Broadcasting (DAB):** A Digital Audio Broadcasting (DAB) receiver can only receive a DAB/DAB+ radio broadcast. A DAB broadcast uses digital radio signals to broadcast audio and can offer more radio stations for the same bandwidth.That's why it is better than the analog FM, but the audio quality is poor if the bandwidth is less than 192kbps. Moreover, the reception quality of DAB receivers degrades, if the signal strength falls below a critical threshold, whereas FM reception quality degrades slowly with the decreasing signal, providing effective coverage over a larger area. The Norwegian Broadcasting Corporation (NRK) launched the first DAB channel in the world on 1 June 1995 (NRK Klassisk). The BBC and Swedish Radio (SR) also launched their first DAB digital radio broadcasts on 27 September 1995. DAB. Since then many companies have already started manufacturing DAB receivers. Gradually many countries switched to DAB and DAB receivers became popular in the world. Companies like Pure International Ltd (UK), started manufacturing DAB receivers and it was the world's first company to manufacture DAB receivers for the first time. In 2003, Pure launched the PocketDAB 1000 and It was the world's first pocket digital radio.

Pure PocketDAB 1000 Digital Radio

Source: https://mans.io/images/1125470/1306145.jpg

Many other companies like Pioneer, Tecsun, Revo, Tivoli, Geneva, etc manufacture DAB radio receivers. A newer version of DAB broadcast called the DAB+ has started in many countries and many new DAB receivers are manufactured to work with DAB+ but the older ones can't. However the newer DAB+ receivers are backward compatible and can receive DAB broadcast also. Because of many good features of DAB technology, many AM/FM radio stations have switched to DAB completely, but this isn't the case for the USA, because in North America most of the radio stations are using HD radio technology instead of DAB for digital radio broadcasting.



DAB Radio Receiver Technology

Credit: Debojit Acharjee

DAB radio receivers use technology for decoding digital radio signals to play the radio station. The tuner digitally tunes the radio frequency and Orthogonal Frequency Division Multiplexing (OFDM) signals are demodulated by the OFDM demodulator. The demodulated signals are used by the channel detector and the digital signals of the tuned station are used by the packet demux and decoder to make use of the digital signals by different services and audio playback. Each of these components of the receiver are controlled by the controller through a control bus, and user inputs are also used by the controller through the user interface.

- **HD radio receiver:** This type of radio receiver can only receive digital AM/FM radio signals which is also known as In-band on-channel (IBOC). HD radio is only a trademark given to the IBOC technology that uses standard radio frequency to transmit audio and data. The digital data is transmitted just above and below the analog audio of the radio signal, so that the audio can be listened in either digital HD mode or as normal analog audio. HD radio broadcast is mostly available in the United States, Canada and Mexico. It was selected by the U.S. Federal Communications Commission (FCC) in 2002 as a digital audio broadcasting method for the United States, and is the only digital system approved by the FCC for digital AM/FM broadcasts in the United States. Since then many HD radio receivers are available in the market. Sangean, Sony, TEAC, Yamaha, JVC, Kenwood and Pioneer are some popular companies that manufacture HD radio receivers. Sangean HDR-16 and Sparc SHD-BT1 are some HD radio receivers available in the market and on online stores like Amazon.

- **Internet radio receivers:** Internet radio receivers work by encoding the streaming audio broadcast over the internet and converting it to audio signal. An Internet ra-

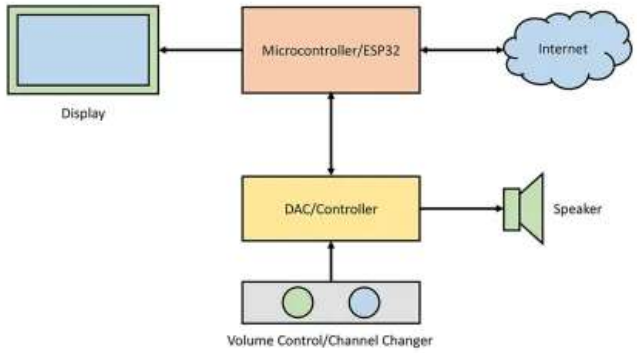
which was the "first computer-radio talk show, each week interviewing a computer expert". Since then many internet radio stations started broadcasting online, and international stations like BBC World Service also started broadcasting online. Many standalone internet radios are available in the market and Kerbango internet radio receiver from 3com was the first standalone internet radio receiver that let people listen to internet radio stations without any PC.

Kerbango Internet Radio

Source: https://techland.time.com/wp-content/uploads/sites/15/2011/08/kerbango.jpg?w=586

It's also possible to listen to any online radio station using any internet radio station using any mobile app or PC software. PC software like Scream Radio from Steamcore (https://www.screamer-radio.com/) is an internet radio software that can be used on Windows PC for listening to online radio stations. In order to listen to any online radio station using the internet radio receiver, one must get the streaming URL link. Many websites like https://www.internet-radio.com/ hosts online radio stations but to get the streaming link, you have to download the M3U playlist file and open it using a text editor like notepad. After opening the playlist file in notepad you will see the streaming URL as a web address with a port number (example: http://us4.internet-radio.com:8266/). You need to copy that URL link and use it with your internet radio receiver to play that radio station.

This seems a very easy way of listening to online radio stations but there are many radio stations that don't use a static URL link for streaming their radio stations and it's always encrypted. Such radio stations can only be played on their official website or using their mobile app. Many international radio stations like Voice of America and China Radio International use encrypted radio streams.



Internet Radio Player Using Microcontroller

Credit: Debojit Acharjee

Internet radio receivers can also work using a microcontroller like ESP32 and a Digital to Analog Converter (DAC). The microcontroller needs to be programmed to decode internet radio packets. When connected to the internet using WiFi, the user can tune to an internet station using the controller interface and the station information is displayed on the

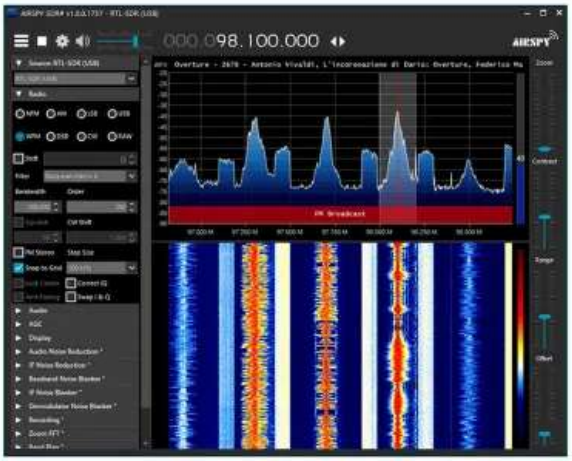
display device connected to the microcontroller. The decoded signals are fed to DAC and converted to analog audio, which is played using a connected speaker.

- **Software Defined Radio (SDR):** A SDR radio receiver works with the help of a software to complete various radio processing tasks like tuning and filtering of radio signals. Unlike a traditional radio receiver, in which various electronic components like filters, fixers, amplifiers, modulators/demodulators, detectors, etc., are implemented in the hardware, in a SDR receiver, such components are also implemented in the software and can be controlled with the help of a computer/embedded systems.

The first SDR was developed by the research team of an American entrepreneur and scientist called Ulrich L. Rohde, While working under a US Department of Defense contract at RCA in 1982, and it used the COSMAC (Complementary Symmetry Monolithic Array Computer) chip. However, the practical commercial application of SDR was made possible by a company called Broadcom, with the help of RF CMOS technology. The company demonstrated this by integrating a SDR on a single mixed-signal System-on-a-Chip (SoC) with the BCM21551 processor in 2007.

RTL-SDR USB Stick With R820T2

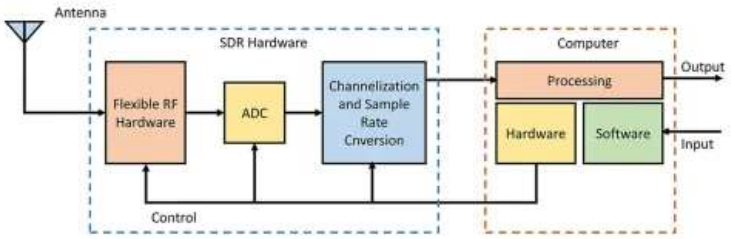
Source: https://www.passion-radio.com/668-large_default/rtl-sdr-r820t2.jpg



Airplay SDR# Software

Source: http://sandsoftwaresound.net/wp-content/uploads/2020/09/Airspy-sdr-sharp.jpg

Since then many companies have introduced SDR receivers in the market for ameture use. Any USB dongle with the Realtek RTL2832U/R820T2 demodulator chip can be used as a SDR receiver with the help of a computer and SDR software like SDRSharp. It has a frequency range of 25MHz up to 1800MHz and supports both analog (AM/FM) and digital (DAB) radio reception. More information is available at https://www.rtl-sdr.com/.



SDR Receiver Technology

Credit: Bebojit Acharjee

The SDR receiver hardware works along with the hardware of the connected computer. Various components of the receiver are controlled by the computer hardware according to the software configuration. The radio signals received by the antenna connected with the SDR hardware is used by the flexible RF hardware of the SDR. Only the flexibility of the RF hardware makes it possible to work in many different modes with the help of a software. The filtered radio signals are converted to digital data and are used for channelization and sample rate conversion. This data is then used by the computer for further processing to output the data for audio.

Many AM/FM radio stations have resorted to digital transmission, and are also running internet radio channels. Even though the audio quality of digital radio transmission is of superior quality, digital transmission is still having some disadvantages when compared with the traditional analog transmission. And one of the biggest disadvantages is that digital transmissions like DAB have limited coverage range. AM analog radio signals (especially SW) can be transmitted to thousands of miles from one country to another, but that's not possible with digital radio transmissions like DAB. Moreover, to use an internet radio receiver, one must have an active high speed internet connection, which is not free.

Therefore, analog radio technology has some good features that makes it a winner in some worst case scenarios like network failure (for internet radio) and electromagnetic interference (that causes data loss for digital transmissions), and it's one of the best technologies ever made.

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The author is a software engineer and likes to geek about various software technologies

knowledge about various software technologies like Robot Process Automation (RPA), Artificial Intelligence (AI) & Machine Learning (ML), blockchain, DevOps, database management, and also knows many programming languages. Besides that, he also knows about various multimedia software used for audio/video editing and production purposes. His passion for computers makes him work hard, and he believes that success comes in life only through hard work and good skills.

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