# 6G and Beyond: A Comprehensive Study and Analysis

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**Abstract**: Recently, 5G technologies has developed in some parts of the world, enabling them to achieve high-speed internet, uninterrupted mobile communication, and the internet of things (IoT). However, it was not sufficient for industrialization, automatic driving vehicles, vehicle-to-vehicle communication, and military artificial robotics. As a result, more cutting-edge technologies, such as Terahertz frequency band spectrum, Cell-free Massive MIMO, Laser, and VLC communication, CMOS-based Gas and InP antenna design for scalable transceivers, reconfigurable intelligent surface-based multi-antenna MIMO, underwater communication, machine learning, recurrent neural networks, and satellite broadband communication, are required to cater to those high throughputs and URLL that are possible through future 6G technologies. The future 6G technologies include critical speed, security vision, and artificial intelligence-based communications based on cutting-edge technology. 6G speeds are a thousand times faster than 5G, and latency is a hundred times lower. 6G is expected to enable augmented reality and virtual reality communication across underwater, satellite, and global backhaul cloud networks. Beyond 6G, promising technologies such as the internet of Nano things, the Internet of bio-Nano things, and quantum communications, which are expected to have a significant impact on wireless communications, are expected to emerge. Above all, this paper will present issues, solutions, and future directions of 6G and beyond.

**Key word**: 6G, security vision, Terahertz frequency band spectrum, CMOS-based Gas, reconfigurable intelligent surface based multi-antenna MIMO, underwater communication, machine learning, internet of Bio-Nano things and global backhaul cloud networks.

## Introduction

Wireless communications have been a revolution in continued advancement over the past decade. It is beneficial for different stakeholders, including commercial solutions providers, research academic solutions, end-users, and stand bodies, which includes paradigm-defining networks such as softwarization and virtualization, multi-user MIMO, ultra-densifications, and new frequency bands. Many rapidly increasing applications and verticals, along with virtual and augmented reality, e-commerce, contactless payment, machine-to-machine communications, and mobile broadband communications, are all considered part of the potential of 5G. This continues to evolve and adapt to extensive variations of emergency use cases [1].

Even though there are some social aids that are often to be found, there have been numerous problems that have not been solved by fifth-generation communications, such as micro-second latency, TBPS data rate, bit error rate reduced to $10^{-10}$, industrial automation moving from industrial 4.0 to industrial X.0, and existing network management practice. In addition to increasing the connection density and coverage area, it is necessary to implement on going communication, such as intelligent reflecting surfaces, terahertz spectrum bands, autonomous networks, underwater communication, etc.

Rapidly increasing social needs, as well as technological advancements in communications, have made it possible to improve social needs. We envision 6G technology not only for secure, reliable, intelligent, scalable, terrestrial networks but also for incorporating satellite communication networks to maintain wireless networks all over the world. In this article, we are highlighting future wireless communications and their scope.

In our discussion, we introduce key performance indicators (KPI) in terms of 6G communications design. The International Telecommunication Union (ITU) is working on the official recommendation for the KPI matrix. These values appear in the public domain currently [2]. The comparison of KPI metrics for 5G and 6G communication is expressed in table-1. The table represents clearly the following KPI parameters:

**Table.1 KPI parameters with values**

| KPI | 5G wireless communication | 6G wireless communications |
|---|---|---|
| Peak data rate | 10 GBPS | 100 GBPS |
| User experience data rate | 1GBPS | >10GBPS |
| Traffic intensity | 10TBPS/KM$^2$ | 100TBPS/KM$^2$ |
| Connection intensity | 1 million | 10 million |
| Delay | 1 ms | <1ms |
| Mobility | 350km/H | 1000km/H |
| Spectrum efficiency (SE) | 3-5 times regarding 4G | 3 times regarding 5G |
| Energy efficiency (EE) | 1000 time relative to 4G | 10 times relatives to 5G |
| % Coverage | >99% | >70% |
| Reliability percentage | >99.99% | >99.999% |
| Positioning level | Meter level | Centimetre Level |
| Receiver Sensitivity | About -130dB | <-130dB |

In table-2 and 3 represents growth of the wireless communications system and 6G developing countries [3].

**Table -2. Generation deployment of wireless communications systems**

| Generation | 1G | 2G | 3G | 4G | 5G (complete world) | 6G |
|---|---|---|---|---|---|---|
| Duration | 1980-90 | 1990-2000 | 2000-10 | 2010-20 | 2020-30 | 2030-40 |
| Peak Rate | 2.5 KBPS | 144 KBPS | 2 MBPS | 1 GBPS | 35.5 GBPS | 100 GBPS |
| Optimum frequency | 890MHz | 1990MHz | 2100MHz | 6GHz | 90GHz | 10THz |
| Service Level | Voice | Text | Images | Video | 3D IOT | Sensors and industry |
| Wireless | PTT, | CDMA, | CDMA- | WiMAX, | 5G NR, | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| standards | AMPS, MTS. | GSM, IS-95 | 2000, IMT-2000, | LTE, LTE-A | WWWW. | |
| Multiplexing technique | FDMA | TDMA | CDMA | OFDMA | OFDMA, NOMA | Smart OFDMA |
| Array design | SISO | SISO | SISO | MIMO | Massive MIMO, MIMO-NOMA | Reconfigurable intelligent reflecting surface (RIS) |
| Network service | PSTN | PSTN | Packet/ NW | Internet | Internet of things (IoT) | Internet for every thing |
| Achievement | Mobility | Digitalization | Internet | Real-time streaming | Internet and cyber security | Security, privacy, Industrializations |

**Table-3. 6G technologies developing countries [4]**

| **Country** | **Innovation and implementations** | **year** |
|---|---|---|
| Finland | The 6G innovation successfully lunch in university of Oulu | 2018 |
| US | The FCC created experimental license for 95GHz to 3THz spectrum band | 2019 |
| South Korea | Collaboration of Oulu University, Samsung and Nokia has implemented and tested 6G set up in Electronics and telecommunication research institute in Finland | 2019 |
| China | The ministry of science and technologies collaboration with universities started research innovation in 6G communication | 2019 |
| Japan | This country is invested US$2 billion toward the 6G innovations | 2020 |

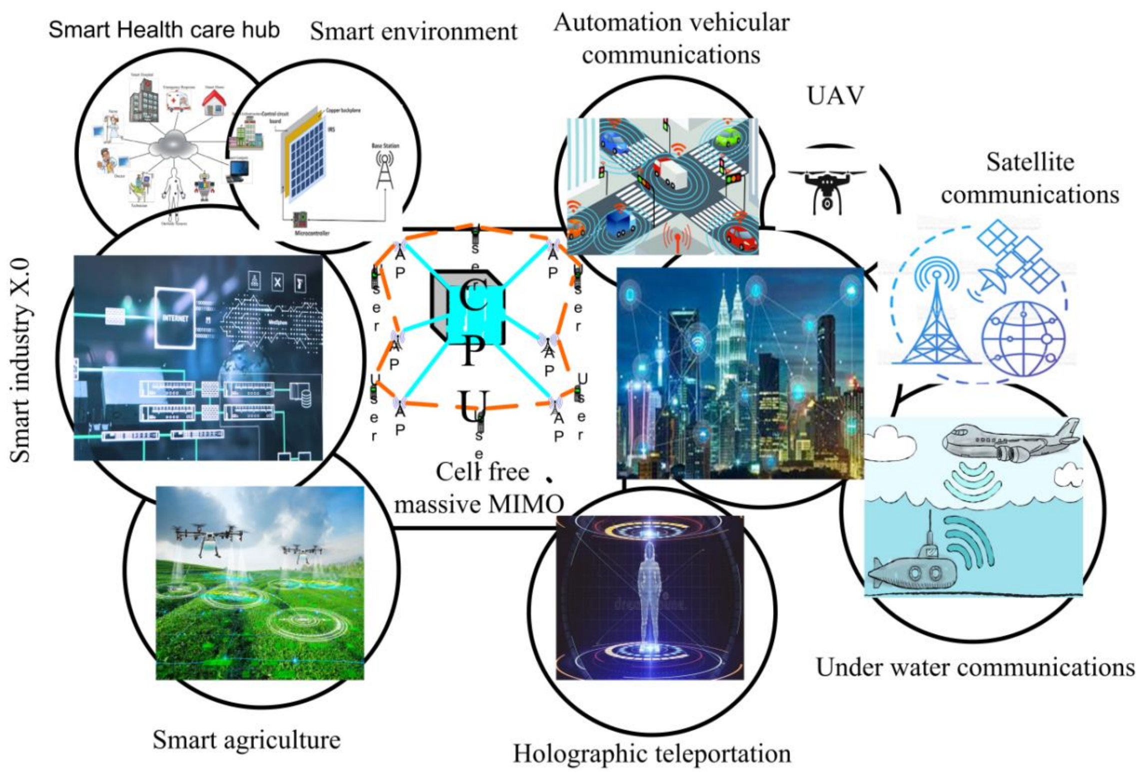



**Figure-1:** Use case of 6G wireless communication system

Figure-1 depicts the 6G applications and usage area, which include smart environment, cell-free massive MIMO, smart industrialization, smart city, smart farming, and a smart health care system.

**System capacity:** In this system primarily focus on the throughput and its KPI metrics, such as peak data rate, practised data rate, peak spectral efficiency, practised spectral efficiency, optimum channel bandwidth, maximum connection density and area peak traffic density. It makes sure that the practised peak data rate and SE should reach to 95 % for all user equipment.

**System latency:** Jitter is the new KPI for 6G, which absent in 5G and beyond. It quantifies the latency of a system.

**System management:** The management of system efficiencies, such as SE, EE, mobility, and reliability, is a priority. The expected EE in the 6G system is 1 Tb/j.

**The procedure for spectrum usage and new radio design:** Adopt mm-wave spectrum in 5G, but channels require higher channel bandwidth in 6G, so use THz and sub-terahertz spectrum. And also, a new radio design is required that can simultaneously sense and communicate over the entire electromagnetic spectrum.

**Network Architecture:** The 6G communication infrastructure integrates communication infrastructure into a fabric environment. This is not possible in the classical cell-based architecture.

**Intelligence and Autonomous**: Intelligent and autonomous networks will play a significant role in assisting in the development of an enhanced automation network.

**Extend network coverage:** Through the satellite-terrestrial network and earth station communication, a large coverage extension and network for everywhere is possible.

In this paper, we are focusing on the future 6G technologies such as (i) Block chain technology in 6G (ii) smart communication environment which enable simultaneous transmission and reception environment (iii) Terahertz band complete spectrum resources utilization environment.|(iv) cell free massive MIMO communications (v) CMOS-based Gas and InP antenna design for scalable transceiver (vi) Reconfigurable Intelligent Surface (RIS) based multi-user MIMO (vii) Internet satellite communication and UAV to cover large geographical area.(viii) Machine learning and recurrent neural network (ix) Automation network (x) Internet of Nano things (xi) internet of Bio Nano things (xii) Quantum communications.

**i. Block chain technology in 6G**

Recently, the application of blockchain technology has been introduced in 6G communications, which is used in dynamic spectrum management. In addition, various applications such as data mining and spectrum sensing, spectrum lease mapping, safely recording on the blockchain, and overcoming security challenges [5, 6, and 7] have been developed. The blockchain allows users to have direct control over data management, ensuring the accuracy of the data. Television white spectrum information and spectrum utilization are recorded on the blockchain.

By effectively controlling the secondary users and varying the traffic demand for the primary user, the utilization of the spectrum is enhanced. It is assisted by the decentralized nature of the blockchain with a primary user recording data on the spectrum, which can be easily accessed by the secondary users. Furthermore, secondary users can initiate a transaction to notify other users of their arrival on the network or exit from it.

Access fairness can be achieved via blockchain-based systems that keep track of access history. Traditional Carrier Sensing Multiple Access (CSMA) methods, on the other hand, do not have their access synchronized. Users can be denied access to a specific brand for a specified amount of time if they meet the predefined access threshold, which can be regulated via the blockchain via smart contracts.

Blockchains offer a secure and reliable way to keep track of information about spectrum auctions. Spectrum auctions have been proven to be an effective method for dynamically allocating spectrum resources [8]. The following are some of the advantages of the blockchain-based approach: a) it prevents primary user fraud by providing transparency; b) it ensures that auction payments are not rejected because all transactions are verified before being recorded on the blockchain, and c) it prevents unauthorized secondary users from accessing the spectrum by allowing all secondary users to supervise and prevent such unauthorized access [9]. Figure-2: Using blockchain technology to manage spectrum resources [9].

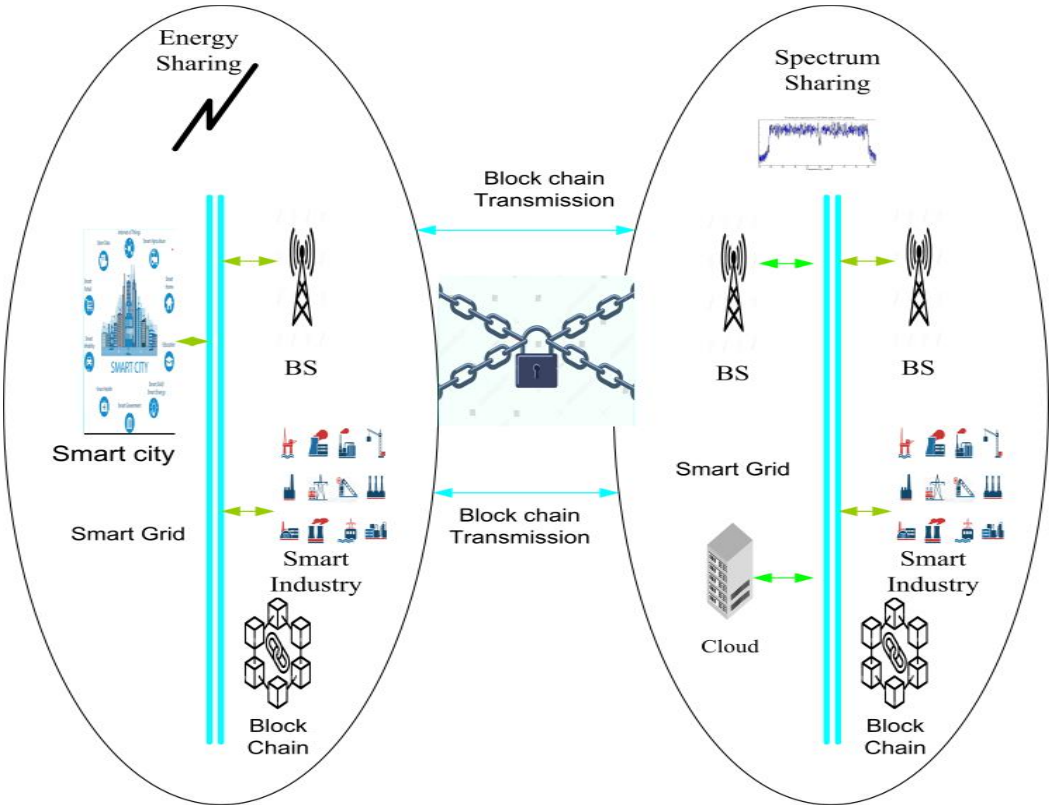



**Figure-2**: Smart and secure communication system with block chain technology

### ii. Smart Communication Environment Which Enables Simultaneous Transmission and Reception of Signal

Recent research conducted as part of the EU Research Project "Visor-Surf" revealed a structure with five main layers, which are (from top to bottom) the EM behaviour, actuation, sensing, computing, shielding, and communication layers, respectively [43]. The EM wave could be reflected by the meta-surfaces while changing phase direction and having tuneable impedance [44, 45]. A PIN is one of the actuation alternatives. Some of the actuation alternatives include diodes with programmable biassing voltage as switches in the reflect antenna array, as well as complementary metal-oxide-semiconductor (CMOS) transistors and micro-electro-mechanical (MEMS) switches for meta-surfaces. The upper layer is communication, which serves as better control toward the central controller, which processes all requests, transmits and receives messages, and performs the previously mentioned controlled wave operations. Intelligent environment design of a plasmatic reflector array able to unconventionally manipulate EM wave.

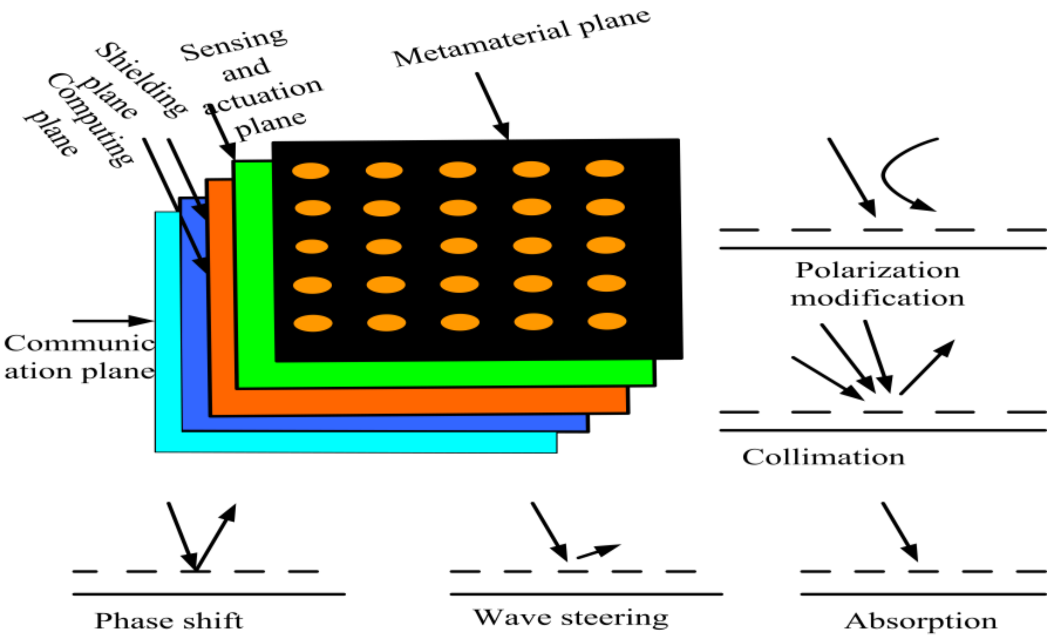



**Figure-3**: Smart communication environment using intelligent surface

Due to the obvious physics of plasmonic, plasmonic antenna arrays can have a denser element layout than metallic antenna arrays and go beyond the traditional λ/2 sampling of space to more exact space and frequency beamforming. As per previous work demonstrated, at THz frequencies, graphene can be used to make nano-transceivers and nano-antennas with a maximum dimension of λ/20 which allows for densely integrating a small footprint (1024 antennas in 1 $mm^2$), as depicted in figure-3. We can increase the operational spectrum of intelligent environments and use them in transmission and reception in a regulated manner by adding graphene-based plasmonic antenna arrays at THz bands and meta-surfaces working at mm-wave bands.

a. **Metamaterial plane:** As demonstrated in Figure-3, the metamaterial plane also serves as a surface plane. To increase valuable signals while cancelling interference, phase shifts are performed on each element in reflect array designs [46], [47]. To control operating modes such as changing polarizations, the millimeter-scale meta-surface element suggested in [48] is connected to a PIN diode with a bias voltage.
b. **Sensing and actuations plane:** Under the actual channel conditions to control the electromagnetic wave, the programmable surface is predicted to sense the propagation enrolment and actuate the above surface plane as per principle. These layers consist of hardware elements that can be controlled to achieve phase shift impedance.
c. **Computing plane:** In a controllable surface system, the computing function serves the processing function. In terms of meta-surface design [46 and 48], FPGA-based controllers are attached to the meta-surface to implement a computing function. In this layer, we can control the actuation and sense the elements. It might compute duty by mapping the local phase or impedance of the actuator state. Here, FPGA and phase shifters are used to implement a reflecting antenna array.
d. **Communication plane:** In the wireless communication plane, signals are transmitted from the processing layer to the meta surface layer and collected from the sensing and actuation plane. Communication occurs on the intelligent surface by controlling the electromagnetic waves. The signal emitted from the meta surface is a lower frequency band signal, such as signal frequency tuning using a biassing voltage PIN diode.

e. **Advantages of intelligent environment:** The communication system's efficiency improves through the good arrangement of tiles on the intelligent surface. The significant vision of the intelligent environment is to serve a large number of users and also users who are in clusters. Furthermore, it provides a physical layer of security against eavesdropping and jamming, which remains to be solved.

f. **Open problems in intelligent surface**

   i. **The trade-off between the dimension of transmission and power consumption:** The intelligent reflecting surface (RIS) is set up on the wall or surface of the building, it can ably transmit the signal long distance but power also increases due to NLOS transmission.

   ii. **Flexibility with existing applications:** Order of intelligent surfaces can support improving indoor and outdoor signal coverage.

g. **Applications:** Huge amount of IoTs operations, virtual reality video streaming, high mobility and Vehicle to vehicle to communications.

h. **Smart resources allocations:** Optimum resource allocation is a significant way to improve the communication data rate.

**iii. Terahertz band complete spectrum resources utilization environment**

The requirement for the high throughput and capacity has continues driven the wireless system for spectrum band utilizations. In the 5G communication there varies spectrum bands in different region such ranges are 3GHz to 6 GHz and 24 GHz to 50 GHz. As per author in [22] the 5G range surely included 52.4GHz and 114 GHz. The new physical layer design is with transmission to single carrier wave form could possible with high flexible 5G frame work. The significant problem is to realise the use these frequency bands in high power devices with reasonable cost. The large numbers of antennas array are used to form a narrow beam width wave to improve the effective isotropic radiated power and range [23]. The main problem in the higher frequency range is signal can be easy blocks due to short wave length, but it is flexible to coverage indoor, outdoor, reflection, LOS and NLOS communications [24]. In spite of the difficulties and peculiarities of high-band propagation, extensive research and development have resulted in feasible implementations. The spectrum representation as shown in figure-4.

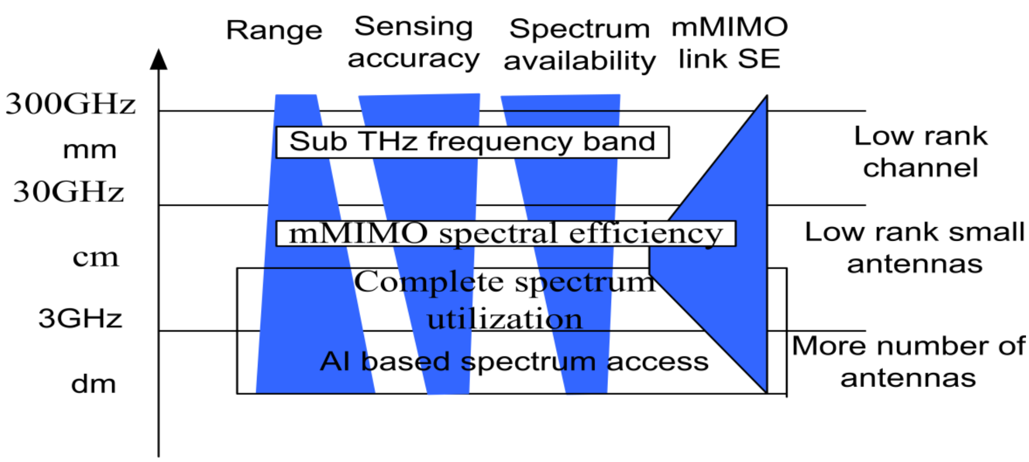



**Figure-4:** Sub THz band spectrum representations

**Table-4. mm-wave and Terahertz frequency application in 6G communications [25]**

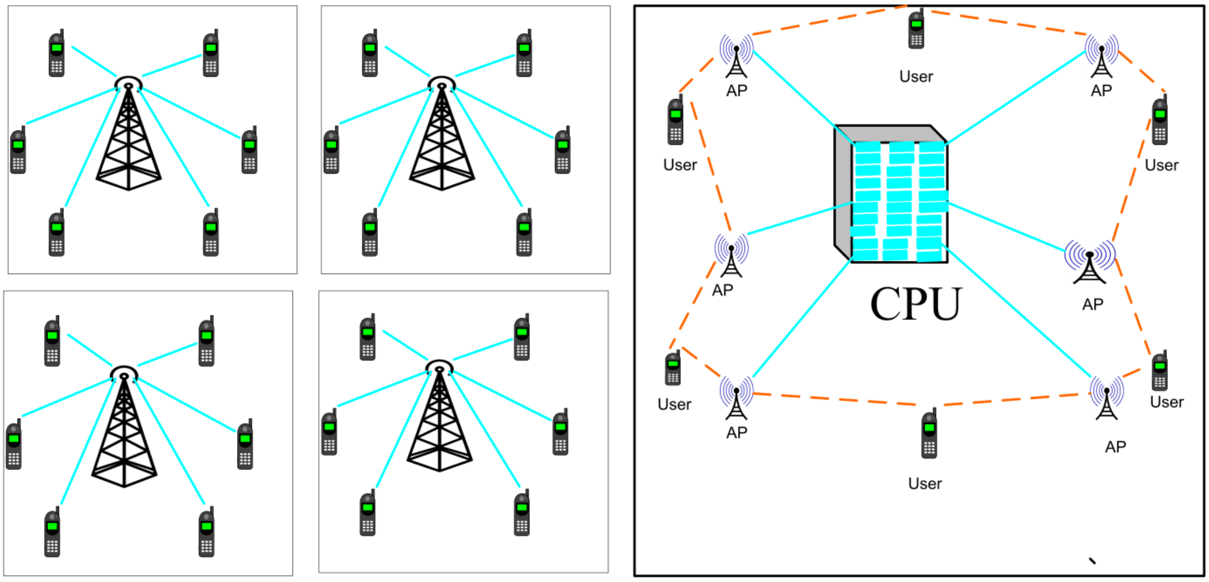
| Applications | Area of utilization |
|---|---|
| Wireless communications | Mobile wireless communication<br>Data centres<br>Intra device radio communications<br>Information shows(>100GBPS) |
| Wireless Cognitions | Autonomous vehicle control<br>UAV control<br>Robotic control |
| Sensor | Air quality testing<br>Personal health monitoring systems<br>Gesture detection<br>Gas and explosive detection |
| Imaging | Dark visible (mm-wave camera)<br>High-definition radar resolutions<br>THz security body scan |
| Positions centimetre level | Centimetre level |

The current generation's trend is to use higher frequency bands, which means that the increase in frequency bands is on-going. In the future, 6G technology is expected to use a high frequency band range from 114 GHz to 300 GHz (sub-terahertz frequency). It is already practice to use and available in the cellular system. Sub-terahertz frequency will be used in backhaul connections in the future, such as those from a cloud network to a macro base station (BS) and from a macro-BS to an access point (AP) [26]. The mm-wave and Terahertz frequency application in 6G communications is shown in table-4.

It is important to improve the mm-wave system because it is the initial approach for higher frequency utilization and it is also useful for the terahertz communication system. The initial product design of the above frequencies will follow the methods established in the mm-wave system currently. The new radio integrated circuit with an on-chip or on-board array of antennas and a phase angle shifter will be deployed [27]. The elements of manufacturing technologies such as antennas on glass can emerge to reduce the bulk of the cost. It is necessary to implement hybrid beamforming to achieve massive density connections using multi-user massive MIMO or single-user massive MIMO [28]. The receiver architecture is designed such that recombines are present before using a low-noise amplifier [26]. For reduction of power consumption, hybrid beamforming generated using AI/machine learning technologies with single-bit converters is being explored [29]. If the transmission delay over the antenna array is compared with the symbol duration with large bandwidth signals, then modern signal processing methods are required to tackle the beam sequence. In order to extend the terahertz spectrum band, the least expansive massive MIMO will be capable of better utilization of spectrum in the cm wave and mm wavebands. In 5G, mm-wave simultaneous transmission of multi-user is restricted due to analog beamforming. The massive MIMO network with mm-wave provides a widely beamformed multi-user connection density, reducing the cost and exploiting the availability of the spectrum. In the 6G prepared mid-frequency bands, they also prepared a lower frequency band such as cm wave beamforming, and the application of massive MIMO is restricted to large-sized antenna array elements. Spectrum availability is scarce, and it is also necessary to find a modern method for the utilization of spectrum resources. Visible light communication is one way of spectrum utilization, but the cheapest method is radio waves for the same data rate.

### iv. Cell free massive MIMO communications

In the conventional method, inter-cell interference occurs at the cell edge user (boundaries) in order to eliminate inter-cell interference. The combination of distributed antenna array elements and massive MIMO results in a system known as cell-free massive MIMO or distributed antenna cell-free massive MIMO [60]. Cell-free massive MIMO is a commercial technology in the current 6G of communication systems. It distributes the antennas toward the large geographical area. It is also called distrusted antenna cell-free massive MIMO, or "user-centric massive MIMO". Here, the BS at the center of all the areas is covered by the antenna points such that the number of antennas is greater than the number of users (M>K). The APs are controlled by the cloud RAN network. In massive MIMO, each AP serves a *k* number of users simultaneously. It transmits a *k* number of channels to generate *k* beamforming signals (rays), which are used to transmit or receive the *k* user signals. In this application, the resource allocation method is used to allocate the optimum power for every user in the AP. In 4G, focusing on the clustering technique, where the entire network is divided into clusters, the frequency reuse technique has been successfully achieved, but the challenge is to avoid the inter-cluster interference, hence it was not successful in the 4G network. And also, user-centric massive MIMO has given direction to the cell-free massive MIMO network.




Conventional massive MIMO Distributed antenna cell free massive MIMO

**Figure-5:** Distributed antenna cell free massive MIMO compare with conventional massive MIMO

As shown in the figure-5 the scalable dense of the antenna are arranged at the central processing unit (CPU), which is connected to the APs via fronthaul beamforming (which contains a smaller number of antennas <20) in the network. Each AP serves the multi-user simultaneously without any interference, and also, there is no inter-cell interference. In the 6G communications extension of coverage is possible through the cell free massive MIMO communications systems furthermore the user data rate is improve as compared to the multi cell conventional systems [61].

The main challenges in cell-free massive MIMO systems are (i) multiple antenna transmission and reception signals overlapped with each other (aliasing effect), (ii) massive antennas at the CPU, which causes antenna aperture increases; hence near-field slow fading increases. As the range of near-field propagation expands, a new channel model is required to characterise the large- and small-scale channel parameters.

### v. CMOS-Based Gas and InP Antenna Design for Scalable Transceiver

In the current scenario, bioimplant devices need to be implemented for the safety of the human being. It is a challenging task for the researchers to reduce the battery and the device size. In this section of the paper focuses on the on-chip antenna design in CMOS technology at 900MHz. The radio frequency energy harvesting system-on-chip antenna is also another the focus of this section of the paper. Using silterra to design a 0.13m CMOS technology approach, the CMOS approach, antenna gain, and return loss are defined based on the thickness of the SIO2 substrate [49].

The CMOS revaluation of antenna chip designs of small size and high frequency [50-54]. The issue of high frequency effect on humans and environmental changes [55]. So, it has to be designed with a minimum 1GHz frequency operation which is a big challenge for the design of the antenna [56]. It is made possible through the system-on-chip bioimplant CMOS technology [57]. The system on chip CMOS based design is limited for only millimetre wave length [58]. In order to minimise the size of the antenna at 1GHz frequency, it possible through make device electrically small and operation have to be in magnetic couple because it does not effect on human tissues [59].

The successful application of the max-well faraday equations to the design of a magnetic coupling-based loop antenna in which the number of turns in a loop varies with frequency range variation the design structure of the loop antenna is shown in the figure-6. The circuit resistor, inductor, and capacitor are connected in series and parallel combinations in the resonance circuit. The equivalent circuit of the loop antenna is shown in Figure-6.

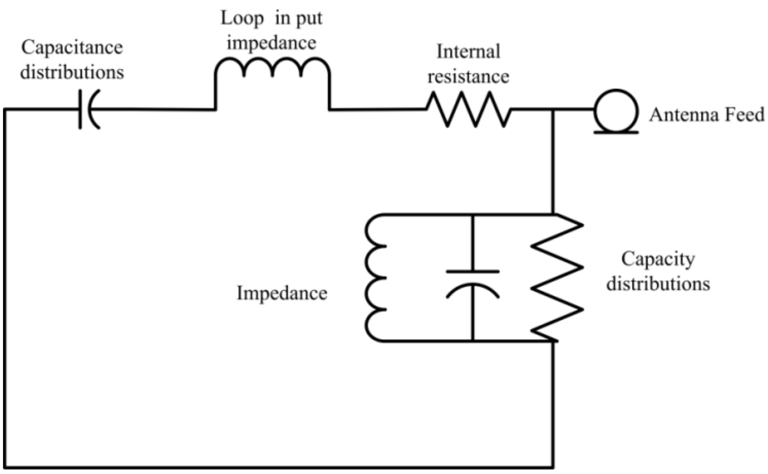



**Figure-6:** Equivalent circuit of single loop antenna design

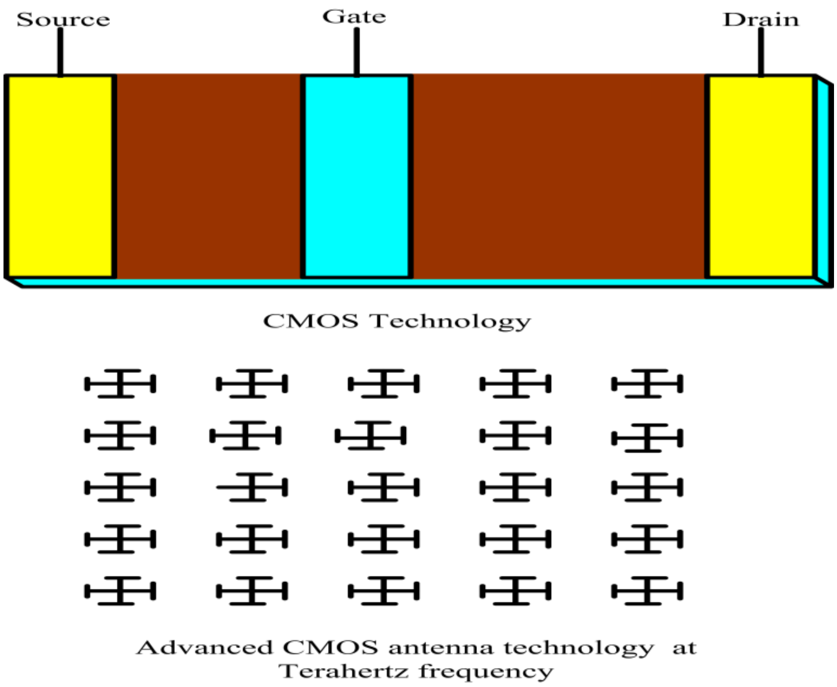



**Figure-7.** CMOS based antenna design technology

The fundament structure of CMOS circuit with advanced CMOS antenna technology is shown in figure-7. It assists to lower frequency band and also large power gains furthermore extension of coverage is more. It achieves the advantage of multi-scalable antennas design in a single chip.

### vii. Internet satellite communication and UAV to cover large geographical area

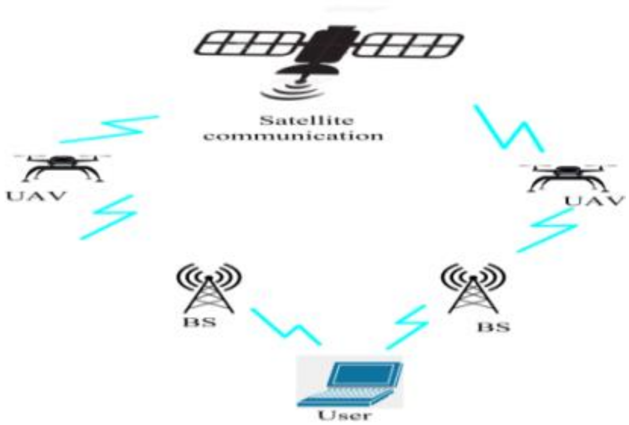



**Figure-3**: Satellite with UAV communication

Wireless communication is used in industrial development. The Third Generation Partnership Endeavour (3GPP) has pushed the convergence of non-terrestrial networks (NTNs) with terrestrial 5G as a joint project for terrestrial communications. This can serve as a foundation for future satellite-based IoT development. The coverage extension of satellite communication is shown in figure.3.

Table.4. Comparison between satellite and terrestrial communications

| Main factors | Satellite communications | Terrestrial communications |
|---|---|---|
| Type of link | Both feeder link and service link | Service link |
| Transmission distance | About 600km | About 1km |
| Transmission Delay | 10 to 100 ms | ms |
| Frequency band | Ka, ku, q bands | 6GHz |
| Path loss | 180dB | 140dB |
| Doppler shift | 100kHz | kHz |
| BS radius | About km | 300-500m |
| Mobility | Inter-gateway | Inter cells |
| Frequency reuse factor | Re-used 4 | Re-use factor 1 |

In the present scenario, medium and lower orbits are focused on industrial satellite communication to provide IoT and broadband communication. The lower orbit outperforms the geostationary orbit in terms of propagation loss and delay. This is active conductive and enables the maximum number of IoT terminals. The comparison of emerging satellite-based communication systems such as Iridium, fiber band, keplar, and astronaut shows that these systems provide satellite communications.

In a few countries, openly permitted LEO satellite construction, along with commercial satellite communications, has been proposed to accommodate both broadband transmissions and IoT enterprises, such as Hongyan, Hongyun, Ladybug, and Apocalypse. The above-mentioned satellites are practically highlighted. The processes demonstrate how satellite mobile communication has significant advantages over terrestrial mobile communication. Existing satellite constellation systems, on the other hand, mostly use time-based or code-division-based multiple accesses. This will continue to change with the situation [10].

**Table.4. The representation of LEO satellite [10]**

| **parameter** | **One web** | **Star link band** | **Indium** | **Asro cast** | **Keplar** | **Hiber band** |
|---|---|---|---|---|---|---|
| Frequency band | Ka/ku | ku | L/k band | L/S band | k/ku/s band | ka/ku |
| Maximum data rate | 50 MBPS | 1GBPS | L to 1.5 GBPS | _ | 1MBPS | _ |
| Latency(ms) | 20-30 | 20-30 | <30 | _ | _ | _ |
| Maximum Number of satellites | 720 | 4425 | 75 | 80 | 140 | 24 |
| Service type | Broadband | Broadband | Broadband /IOT | IOT | IOT | IOT |
| Inter satellite link | NO | YES | YES | _ | YES | _ |

For instance, we look at some of the most promising multiple access methods for satellite-based IoT in the 6G era. The authors then suggest a practical method that takes advantage of the combined benefits of RA and NOMA to address huge access requirements in satellite-based IoT while maintaining reduced signalling overhead. In the future, we'll concentrate on waveform design, transceiver design, allocating resources, and AI-assisted design for satellite-based IoT in the 6G era.

At present, artificial intelligence has the ability to solve difficult problems and also adopt new technological enrolment. It is a new setup for optimum internet communications. AI is promising for air interfacing and the future internet of things-based satellite communication. AI techniques can be used to create waveforms, transceivers, and resource allocation algorithms, as well as to optimize the entire process. To dynamically change the transmission and reception environment, one needs to adopt satellite-based technology. In addition, add online learning technologies such as Meta-learning and transfer learning.

## vi. Viii. Machine learning and recurrent neural network

In this section, we are focusing on reinforcement learning and deep learning. These methods are already successfully implemented in image processing and speech processing [11-14]. These methods are implemented by QUALCOMM and Huawei.

## Deep learning

The main idea of the deep learning is a merging of perception in a brain with deep neural network [15, 16, and 17]. The structure of deep learning is a combination of three layers which are input, hidden and output layer. Input is applied to the input layer, which transfer input information to the hidden layer, through the hidden layer information to the output layer. In the hidden layer is applicable activation function such as rectified leaner unit (Relu), tangential function (tanh), SoftMax function, and sigmoid function but at the out maximum prepare linear activation only because it's out either 0 or 1.

Consider the input vector X= $(x_0, x_1, x_2\ldots, x_n)^T$, it passing through the weight matrix W=$(w_0,w_1,w_2\ldots w_n)^T$ the order of the weight matrix is (first layer ,input ),(second layer ,first layer )… respectively. The output function is represented as $y = \sigma(W^T X)$. Each neuron is multiplied with the weight matrix construction as shown in **figure-4.**

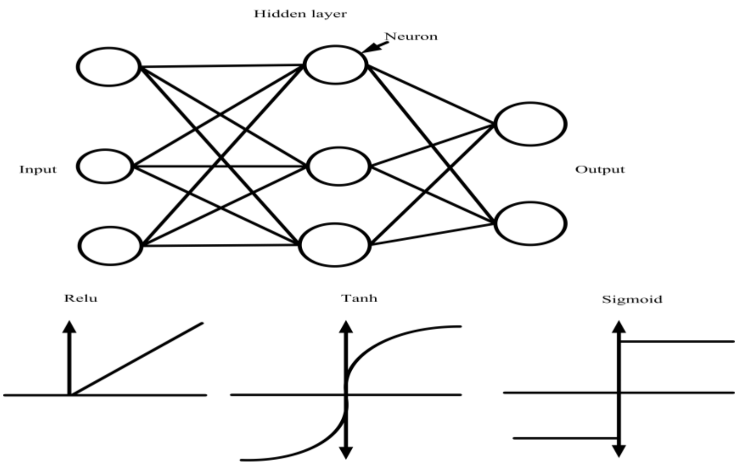


**Figure.4:** Deep neural network with activation functions

The deep learning can be implemented in two scenarios such as training and testing e.i off line training and online executions. In term of training stage, the label data is represented as $(X_N^L, Y_N^L)$, it represents the input, output belonging layer and node number (ex: $X_2^1$ in put layer one with second node, similar $Y_2^1$ output layer one with second node). It is used the minimise mean square error as we well as the cross entropy. Especially label date will come either simulation or manual design depending on practical simulations.

In deep learning data propagation has done in two ways forward propagation and back ford propagation method using stochastic grading function. The key significant challenge in the deep learning is wireless communication structure design for the deep learning varies cases, such as the wireless network trained in the off-line stage and executed in the online practical method. Design of communication system deep neural network can be divided two categories such as model free and model driven [18]. The model is represented as the mathematical relation and decision making factors, in the model free network decision making is consider as the wireless communication end to end is presented as a black box (ex : automatic encoding communication system) [19]. This uses a deep neural network to encode the input data into a specific signal at the transmitter side and a deep neural network at the receiver side to retrieve the received signal. In a model-driven approach, the decision-making component (or learning agent) in wireless communication technology uses the domain-knowledge method to enhance efficiency. The end-to-end communication using deep neural network as shown in in figure.5.

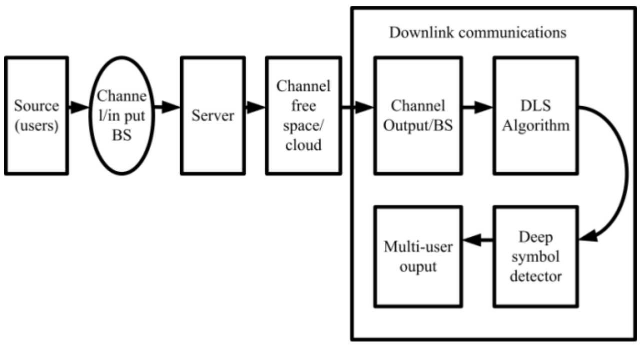



**Figure-5**: End to end 6G wireless communication using deep learning

Lot of advanced method have been introduced and proved although some are simplified and inefficiency. Model-driven deep learning can correct for the faults of domain-knowledge models by incorporating deep learning's training power into the domain knowledge model. The radio transformer network [20] and the OFDM-auto encoder [21] are two good examples.

## Recurrent neural network

Recurrent neural network is used to sequential of data in language processing such as in a language sequential of grammatical error corrections, speech conversations. Long short term memory (LSTM) and gated recurrent unit (GRU).which can be used in the communication for channel estimation and resource allocations.

LSTM

RNN includes long-short term memory, which is capable of resolving long-term dependencies. It can anticipate the current CSI using CSI previews. Consider the current state N+1 and the preview state N. In this case, the LSTM data set is utilised to preview channel state data before updating the current channel state data. The LSTM network may find out which users have the poorest channel strength and allocate the most power to them.

From **Figure.6.** The input gate, forget gate, and output gate are the three gates in an LSTM network. Here, the input gate is used to receive the previous state's information, the forget gate is used to forget the stronger channel strength state user, and the output gate is used to obtain the weakest channel strength state users and assign maximum power to those channels. For vast volumes of data samples, LSTM can also deliver accurate results.

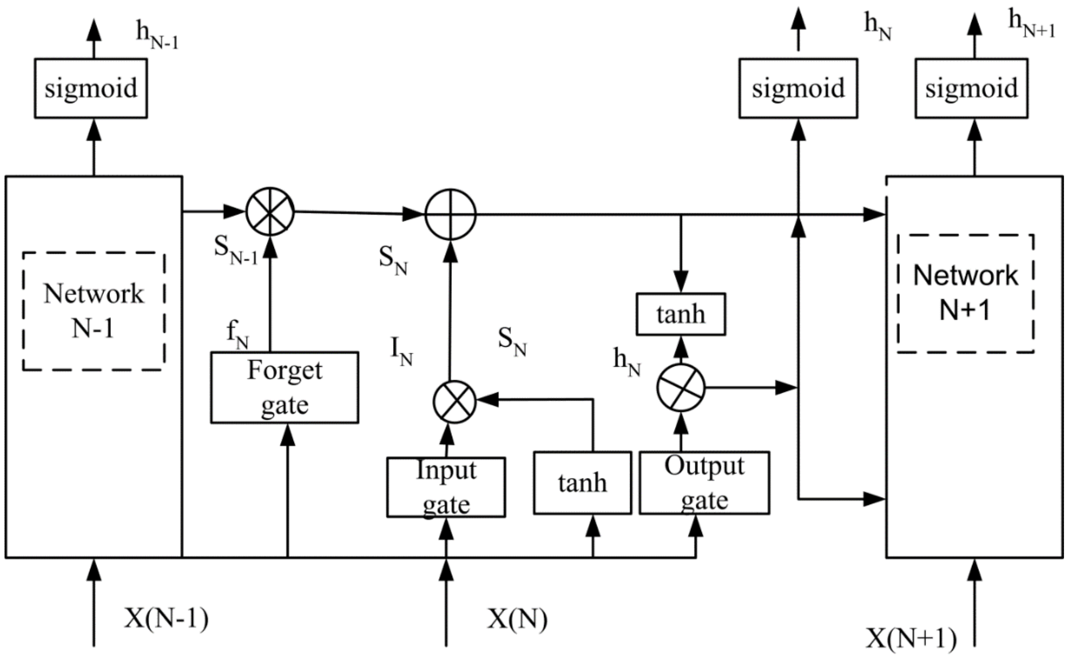



**Figure .6.** LSTM network operations

We compute the state SN at time N, then add additional information x (N) to it and compute the new state $S_N$+1.

Only channel state information is maintained in $S_N$+1 thanks to selective read, writes, and forgets. Figure 4 shows a diagram. Using "Lagrange's multiplier," estimates the channel and power allocation. The base station first generates a superimposed signal using the NOMA concept, then assigns a power coefficient and transmits the signal across the channel. As a result, each user receives a super positioning signal. We utilise an LSTM network to assess channel strength at the receiver. The input gate, which is utilised to receive the current input signals, sends a signal to the LSTM network. The threshold SINR can be used by LSTM to evaluate channel strength. If the SINR is greater than the threshold, the signals are routed to the output gate. As a result, utilising successive interference cancellation, all users may decode their original signal. Signals with a SINR less than the threshold are retained in memory and are unable to decipher their original signal. Through the feedback route, the complete estimated signal is delivered to the base station. The channel gain is received by the base station via feedback channel gain information, and then "Lagrange's multiplier" is used to give the greatest power to the weaker channel gain user, and the gain is sent to the receiver. The signal is predicted by the LSTM network using the previews channel, current channel, and memory state channel SINR. Repeat the same method as with the previews until all of the weaker channels have a SINR over the threshold. The complete procedure as shown in the figure.7.

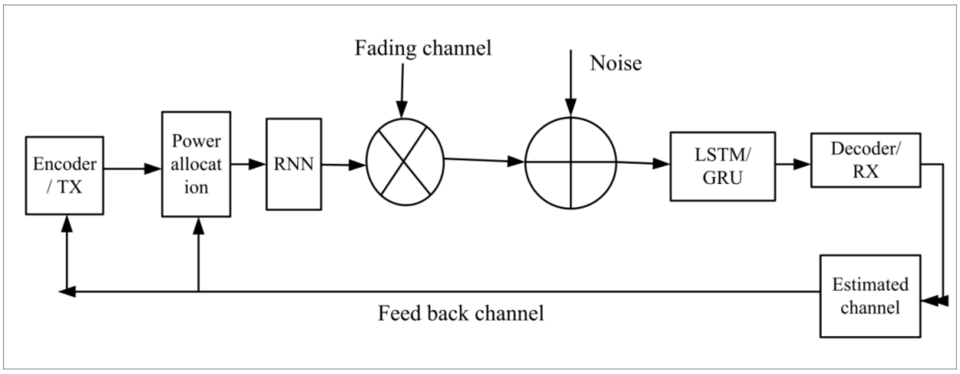



**Figure.7**. End to end wireless communication using LSTM network

### vii. Vi. Reconfigurable intelligent surface based multi-user MIMO

An intelligent reflecting surface (RIS) is presently a two-dimensional surface of engineered materials with configurable qualities rather than static features. RIS is a new technique that allows incident electromagnetic waves to be reflected and modulated [30-33]. It provides the best conditions for active control propagation and gives wireless networks the most dimensions. The primary applications are to improve received power over the RIS and extend coverage [34].

The current wireless network is unable to control the signals that are broadcast. As a result, antenna array technology allows electromagnetic waves to be received and sent for wireless communications, sensing, and localization. To increase the signal-to-noise ratio, arrays are used to produce beams in the desired direction, suppress interference with sophisticated filtering, and multiplex the data stream using unique procedures [35]. These antennas are used for localization to preserve SNR while operating over a larger bandwidth, to estimate angle arrival, and to distinguish multi-sources and scatter [36]. Each element's RIS signal amplitude and phase can be adjusted to improve signal quality at the receiver. The complete procedure is shown in figure 9.

The RIS was designed to gather signal energy proportional to its coverage area and re-radiate it to the receiver in the form of a beamform. The RIS must be programmable and controllable to ensure that the beam focuses on the receiver anytime it is in the room. The signal to interference noise ratio can be improved in this arrangement by employing a RIS [37]. RIS is a thin surface made up of N elements, each with its own scattering configuration. A tiny antenna that can receive and re-radiate a signal without amplification, but with a delay period that can be adjusted [38].

To discover the field of each RIS element, we must first utilize the green function of signal sources and then apply the superposition technique to obtain the field at the receiver. Because the elements are brief, the re-radiated field can be predicted by treating each one as a point source, with the received signal being a superposition of the phase shift and amplitude-scaled source signals [39].

The primary advantage of employing the RIS antenna array is that SNR increases correspondingly as N increases. This means that when reached, the transmitted power decreases by 1/N time; this is known as an asymptotic power scaling law. When employing the RIS optimal setups, the SNR grows appropriately to $N^2$. As power was reduced to 1/N2, a more aggressive power scaling law was proposed [40 and 41]. The intelligent aided reflecting surface is likewise a relay configuration, so the system model looks like a half-duplex, mMIMO relay scenario, with the important feature that each element in the IRS scatters the incoming signals with a configurable phase shift without requiring a separate transmission power [42].

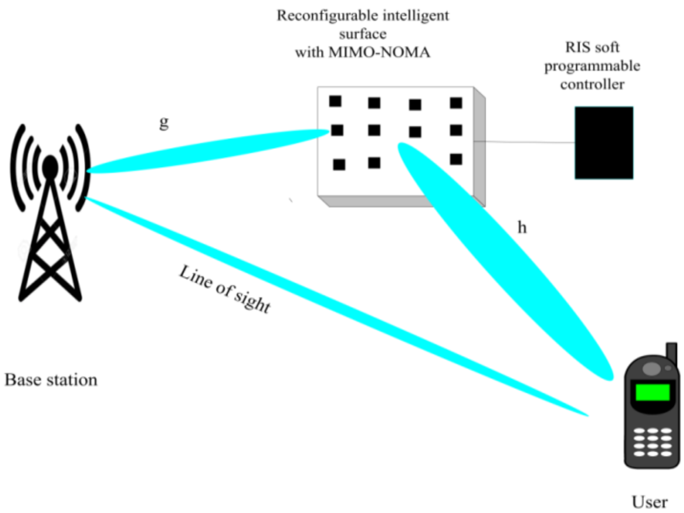



**Figure.9**.RIS based massive MIMO-NOMA system

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## Automation network

The 6G focuses on industrial-oriented communication, such as automatic vehicle driving, industrial production, and agriculture. Network automation aims to increase the speed with which network services are delivered while maintaining a dynamic and reliable service level agreement (SLA) and lowering the risk of errors by reducing the need for manual involvement.

In 3GPP releases 15 and 16, the standard effort on automation resulted in the introduction of the network data analytics function in the data management service and control panel to increase data collection and analysis [62,63]. Network automation functions form a significant sector of the service-based agriculture in 5G, representing the increasing importance of network automation. The automatic driving network is the holy grail of automation, which does not require manual interventions.

A comprehensive, broad-based description of the state, as well as abstractions that expose this information, is required. A state consistency method is required because packet-level state maintenance will be handled by distributed switching devices. To prevent competing forwarding actions, a mechanism like this may be implemented by the controller. The challenge is the security aspect. As data switches based on the packet metadata, malformed packets could readily be used by a malicious attacker to cause state transitions. For protection, you need to Packet integrity verification will necessitate ultra-lightweight techniques.

The network operator plays a significant role in serving the network operations, even though real-time network management is really impossible for human operators because of the increase in complexity of communication networks along with the over-increasing of multiple connected devices. Hence, it required a transition from an operator-driven network to a self-driven network. Such as the self-driving network, this requires minimum latency, high data rates, error-free transmissions, prompt and targeted security responses, and more active than reactive service handling [64].

To get knowledge about automation network management, self-driving is defined as a network. Network measurements are task-driven and tightly combined with the control of network management. (ii) A network model for individual protocols is defined by the large volume of data analysis and machine learning models used in monitoring [65]. Self-driving networks should be a high-level goal. It should be manual control, analysis, measurement, and calibration done by it [66]. The self-driving network should follow the given steps, such as (i) performing perfect measurements (ii) learning from the corresponding interference (iii) based on the input content and taking necessary action. The architecture of the network is self-driving, as depicted in **figure 14.** [1]. Real-time flow, analysis, and calibration are described.

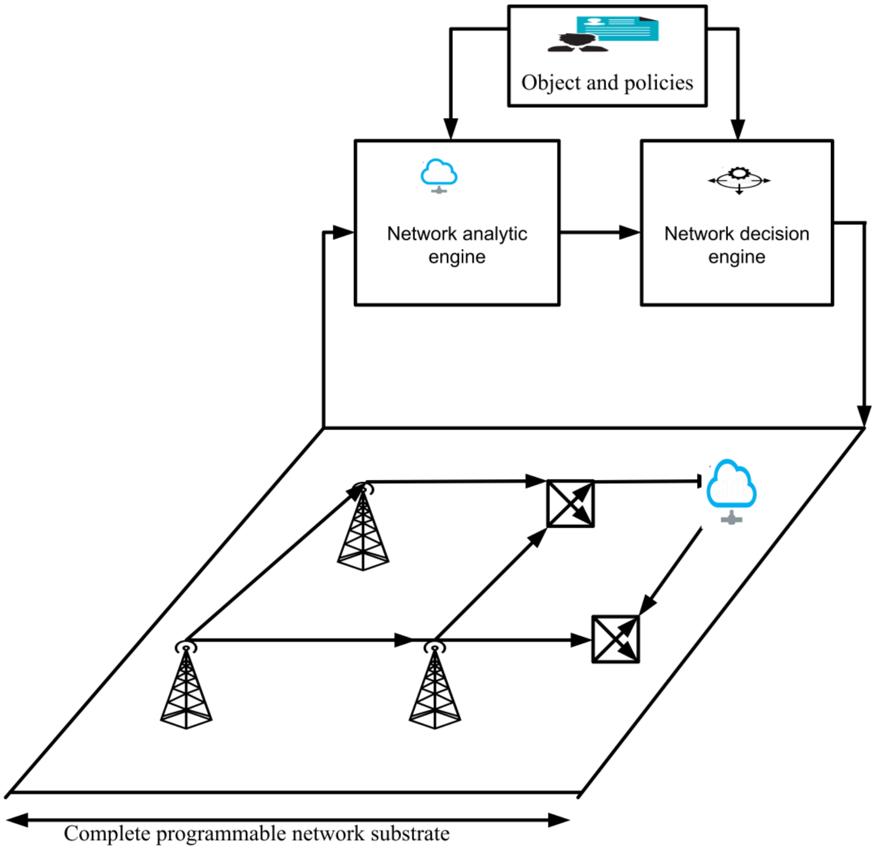


**Figure.14.** Architecture of self-driving network

### Real time automation using machine learning

Machine learning is important in real-time self-driving, estimating interference, and correcting errors in real-time. Make a decision based on the control provided by high data communications and ultra-reliable low latency.

### Internet of Nano-things

In order to use the spectrum resources to serve a large number of wireless devices and services, a variety of transceiver methods are required to become a reality in near-future wireless networks. However, it is noted that EM waves do not have acceptable performance or lock reliability due to hard limitations, such as in high salinity water or intravascular channels where the transmission range is extremely low. All applications based on higher frequency ranges, such as the EM wave's wavelength, fall down to a nanometre (imagine a nanometre) [67,68]. These are distinct from conventional communications systems.

In communication, nanotechnology depends on the following: (i) encodes data bits and carries them out with molecules under a mechanism. (ii) plasmonic radiation on a metamaterial-based antenna element design based on carbon nanotubes and graphene operating at sub-THz frequencies. The plasmonic antennas influence the physical surface plasmon polarisation (SPS) waves [69-71]. The EM wave is radiated by the oscillation of electrons in the conducting and dielectric material towards the targeted resonance frequency while being shorter than the corresponding wavelength. The wavelength ratio is the plasmonic confinement factor. For the larger value confinement factor, smaller arrays and high density will be integrated. The significant components in Nano meter waves are follows.

**Nano nodes**

The Nano nodes range from 1 to 100 metres and create conditions for the transmission and reception of the signals. The Nano processor basically operates in the 1 THz band, which includes Nano-attenuators, Nano-sensors, gas molecules, Nano-memories (storing bits of signal in a single atom), and energy Nano-harvesters, which transfer energy to other elements [72,73].

**Nano-routers**

Nano-routers are used to transmit signals between routers; its behavioural characteristics make obtain an optimum path to forwarding signals.

**Gateways**

It can serve as a controller for Nano-things and provide a connection over the internet service provider. This is a smart Nano device, including smart phones, tablets, etc.

**Nano comers** are based on nano photo-sensing while electrical signals are received and decoded using nano photodetectors. Oil pipeline leak detection and intravascular imaging are two major applications.

**Important application of Nano-things**

**Internet of bio Nano-things**

The Internet of bio-Nano Things (IoBNT) is a unique communication model where little, biocompatible, and non-intrusive devices gather and sense biological signals from the atmosphere and send them to data centers for processing over the internet. The IOBNT has gathered for important transactions on its effort to synergistically combine telecommunication with care health centres [74].

The IOBNT applications relating to the health care, it has more unique challenges and opportunities. Especially interdisciplinary research on both research on including healthcare data analysis and communications, cancer cell identifications, diseases effective control measures. Also, expression on generic cell codes and organ level balancing, analog to varies data applications in wireless communications. The communication model can be deployed and exploited to conceive a generally applicable health monitoring systems [75].

The main difference between conventional and molecular communication is that in conventional communications the EM wave transmit through the channel but in molecular communications system, molecular movement on the rely channels. Molecular have different medium such blood vessels, plasma number of neurons and several chemical compositions. The Nano device is used to transmit the encoded molecules through the wireless molecular channel, it decodes at the receiver, which are not receive properly received consider as noise signals [76].

IONBT can give solution to the virus-related problem such as covid-19, Ebola virus, severe acute respiratory syndrome (SARS) and few seasonal diseases. To developed the antivirus and preventive solutions, research led to create a bio-sensor which control the cleavages of protease with in the infected cell. Proteases are generated as a result of the cell being infected by the genome of coronavirus, which is a type of RNA virus [77] and [79].

**Quantum communications**

The conventional communication beyond 6G is a more computational complexity system, and then quantum communications are flexible for solving the complexity optimization problems. For, examples in the maximum routing problem with multiple objectives, traditional methods, geographic routing algorithm and less complexity ones often sacrifices the optimality [80]. It has been expressed that using quantum computing for such difficulties can efficiently reduce complication while achieving maximum [79]. On the other hand, such computationally expensive activities frequently necessitate hundreds of thousands or millions of interconnected quantum bits and thus cannot be completed on a single quantum chip. The requirement for interconnection several chips of this type have spawned the idea of as a result, quantum communications are now possible. Its must-have for running large-scale quantum systems.

We note that the following physical entities constitute the quantum network as shown in figure.15.

**Quantum nodes:** these are used to interconnect the quantum devices

**Wireless communication link:** these are quantum links which interconnect the quantum nodes

**Entangled pair:** this device is responsible for the entangled pairs that are spread the quantum nodes are separated by a quantum of space.

**Quantum memories:** for the communication purpose storing the quantum states.

**Quantum measurement device:** maintain the assessment of the generated entangled states.

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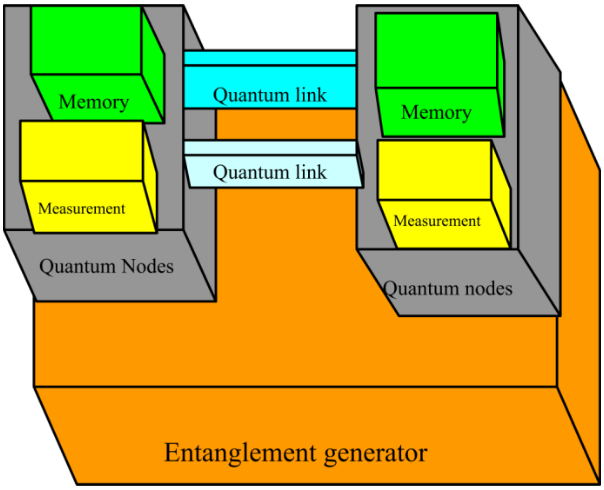


**Figure-15**: Quantum communications transmission and receptions

## Conclusion

The revolution of the communication system has been continuing from 1980 to still onwards. In 2020 the 5G communication system model successfully launched many areas.5G, however, is not just about data as the previews generation is also about connecting everywhere and everything is about the machine-to-machine communications, automation networks used in a more instructive manner and improve the network around us. In 6G vast connection, increase data rate over the 5G up to 10 times but also cyber security.6G has to be driven by the industries hub. In the standard alone sub 6GHz and millimetre wave communication implemented more practical aspects. Next releases 16 and 17 going to introduce ultra-reliable low latency communications, high reliable, point to point communication it going to be industrial automation, automation vehicle communications, and density of connectivity .6G really combination of communicating, sensing, computing, imaging and network security. 6G really makes possible on the food managing products, semiconductor manufacturing and thought about health care sectors, smart device, and smart watches.

## Declaration

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**Availability of data and material (data transparency)**: No

**Code availability (software application or custom code)**: Custom code.

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