# Emerging Technologies for 6G Communication System

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**Abstract.** Over the past few decades, the need for wireless connectivity has increased dramatically. A new Wireless Technology known as 6th generation system developed with full AI support is expected to use between 2027 and 2030. Higher system capacity, much higher data rate, much lower latency, higher security, Network Reliability and accuracy compared to the 5G system are some basic concerns that need to be addressed beyond 5G. This article describes arising technologies which includes Scalable AI, Index Modulation, Reconfigurable Intelligence Surfaces, PHY security, and Wireless Power transfer.

**Keywords:** AI, Index Modulation, Reconfigurable Intelligence Surface, Wireless power transfer, PHY security

## 1 Introduction

This research currently focuses on the Sixth Generation (6G) wireless communication technologies. The leading-edge features of 6G systems are massive man-machine interfaces where the operator interacts with the control system, ubiquitous computing for embedding computational capability, multisensory data fusion that provides accurate basic data for feature-level and decision-level fusion to produce various mixed-reality experiences, accuracy in sensing and actuation to manage the physical environment.

The introduction of new fusions which is used for future services, includes ambient sensing intelligence to make the sensitive environments, new human-human and human-machine interaction to communicate and interact using interface, a pervasive introduction of AI that is smart devices that reacts to sights, sounds and other patterns, and the inclusion of novel technologies, including terahertz (THz) transmission for high speed wireless extension, 3-dimensional (3D) networking for interconnected services displayed as virtual worlds, quantum communications to protect information channels against eavesdropping , holographic beam forming to continuously reuse the same band of spectrum, at the same time, backscatter communication allows wireless nodes to communicate without requiring any active radiofrequency components, Intelligent Reflecting Surface (IRS) are used to enhance the performance of wireless data transmission system and proactive caching to improve the efficacy of edge caching.

According to International Telecommunication Union – Terrestrial (ITU-T) the driving characteristics based on the changes in lifestyle and society hence impact on the design are high Fidelity Holographic society: Nowadays, video is starting


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to take over the other forms of communication, particularly augmented reality (AR). Connectivity for All Things: Another aspect that will distinguish the society of the future will be a magnitude or more in terms of the number of anticipated connections using 5G as a platform, as well as its widespread use.

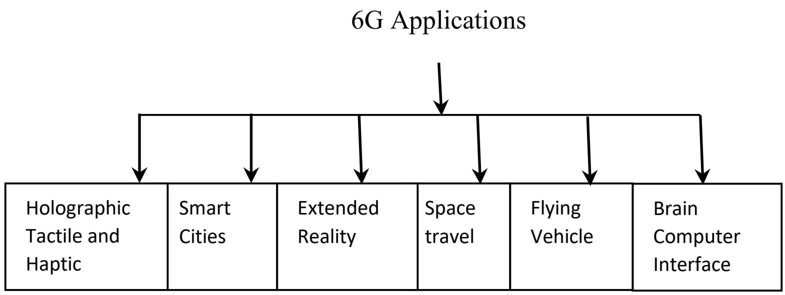


**Fig. 1.** Discuss the various applications of 6G systems.

The advancements in multimedia experiences are holographic displays, which transmit 3-D pictures from one or more sources to one or more destinations, giving the consumer a highly immersive 3-D experience. Requirements of Holograms includes, massive bandwidths from tens of Mb/s to 4.3 Tb/s for human size. The 6G standard also paves the way for several new potential application scenarios, including, human-centric services, long-distance and high mobility communications, extremely low power communications, convergence of communications, computing, control, localization, and sensing, and space-air-ground-sea integrated network. Remote holographic unmanned systems and the Internet of bio-nano-things are two examples of applications for distributed AI

## 2 Emerging Technologies for 6G

The key technology for 6G systems is as discussed below.

**Scalable Artificial Intelligence**

For 6G real-time communications, the development of machine learning will result in more intelligent networks. The real-time data flow will be streamlined and improved as AI communication advances. AI may determine utilizing a

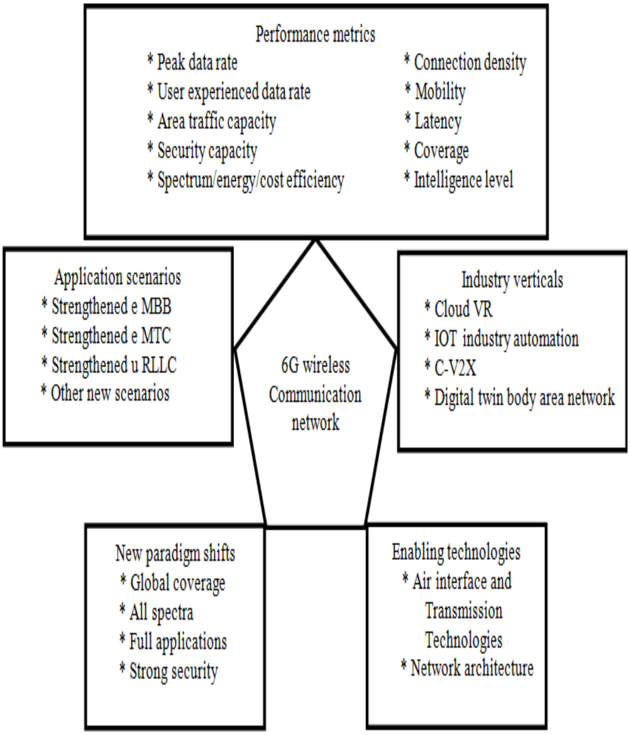


**Fig. 2. 6G** wireless networks

range of analytics, how a challenging objective task is completed. AI will shorten the processing time and quicken the communication phases. Meta-materials especially used in negative refractive index, smart Structures that is able to sense pressure, velocity and many more parameters, Multidisciplinary methodologies that are included in AI are as given below.

Supervised Learning: Supervised learning builds the learning approach that is widely separated into classification and regression subfields, using a collection of unique labelled data. Every input sample in a classification analysis is given a categorical label, which contains K-nearest neighbors (KNN), support vector machines and decision trees (DT). Support vector regression (SVR) to predict discrete values and the Gaussian process are two components of regression analysis. Using differential parallax regression (DPR) techniques, continuous values are estimated or predicted features of statistics.

Unsupervised learning: which can be categorized as either clustering or dimension reduction, aims to identify hidden patterns and extract meaningful characteristics from unlabeled data.

## Index Modulation

Spectral Efficiency (SE) and Energy Efficiency (EE) requirements are becoming more demanding, Orthogonal Frequency-Division Multiplexing with Index Modulation (OFDM-IM), which adds a second modulation domain and the third degree of freedom, was proposed to satisfy these two needs. In contrast to traditional Amplitude Phase Modulation (APM) methods, OFDM-IM uses a three-dimensional modulation approach that in the correct system configurations significantly enhances the SE. For example, by using the inverse fast Fourier transform and subcarrier grouping, OFDM-IM will only activate to produce a distinctive subcarrier activation pattern (SAP), a section of orthogonal subcarriers (IFFT) [10]. Relay(s) receive a subset of subcarriers and transmit them to the destination.

## Reconfigurable Intelligent Surfaces (RIS)

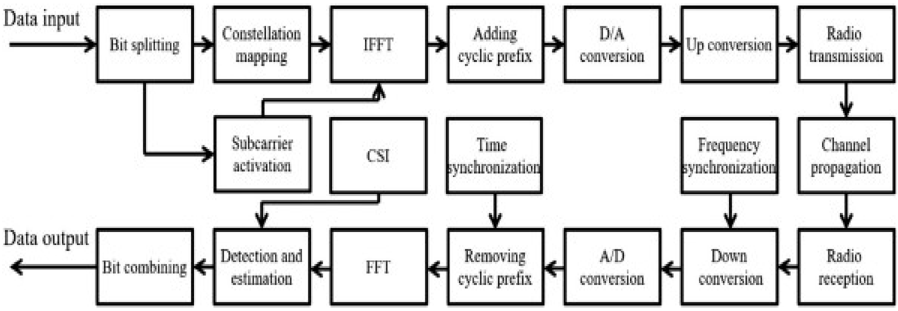


**Fig. 3** Block diagram of reconfigurable intelligent surfaces

The usage of Reconfigurable Intelligent Surface (RISs) or Intelligent Reflecting Surfaces (IRSs) is one of the foremost innovative and ground-breaking methods to extend the energy efficiency of wireless systems. Each reflecting element's construction, which includes an embedded positive-intrinsic negative (PIN) diode, as depicted in Fig. 3. The corresponding circuit of Fig. 3 illustrates how the PIN can switch between the "On" and "Off" modes by adjusting the voltage across the biasing line, realizing a difference in radians for the phase shift.

Some of the main PHY security techniques consist of:

i) Iterative signal processing
ii) Joint source channel coding
iii) Artificial noise injection to improve secrecy
iv) MIMO/IRS to increase energy efficiency

v) Het Nets (user/BS association to provide a larger area of security) that uses different cells and different technologies.
vi) Visible Light Communications (VLC) that uses LED to deliver to the network and
vii) Cipher-Key generation.

**Wireless power transfer**

According to predictions, emerging wireless communication technologies will make the Internet of Everything (IOE) a reality, where over a wireless network, numerous different devices communicate. One such technique, on which more study is being conducted is WPT (wireless power transfer). Current RF research in WPT primarily concentrates on microwave-operated systems, employing relatively tiny antenna arrays in the sub-6 GHz band that a practical distance.

**Molecular Communication**

Standard wireless communication using electromagnetic (EM) waves are neither feasible nor beneficial in some situations, such as inside the human body. Molecular Communications (MC), which transmits information through chemical signals, has been suggested as a promising solution [13]. Due to its distinctive qualities, interest in MC has been rapidly increasing over the past ten years.

In MC, the concentration, release rate, and kind of molecules are used to encode the information. There are two types of propagation: passive (just involves molecule diffusion) and active (diffusion-advection, molecular motors).

**Free-space Optical Communication (FSO)**

Managing with society's insatiable demand for high data rates and massive 6G connectivity has become a crucial challenge. Free-space optical (FSO) communication is a breakthrough innovation. FSO communication provides an incredible opportunity to develop ultrafast data links that can be used in a variety of 6G applications, including heterogeneous networks with enormous connectivity and wireless backhauls for cellular systems. Controlling the Doppler Effect for satellites and varying user equipment (UE) delays in the domain of satellite communications are the two key issues in FSO. The key 6G technologies, including Scalable AI, IM, cell free massive MIMO, RIS, wireless power transfer, molecular communication, and FSO, are summarized in Table 2 along with the challenges and prospects they present.

## 3 Channel Estimation

To achieve the potential performance, the accurate channel estimation is to be obtained. The main objective of channel estimation algorithms is to minimize mean squared error while exploiting minimal computational resources in the estimation process. The channel estimation algorithms are classified as training-based, semi-blind channel estimation and blind channel estimation. Convolutional Neural Network with Auto Encoder (CNNAE) algorithm for Channel Estimation in MIMO-

OFDM system for channel model performance metrics improvement is designed and is compared to Least Square estimation (LS), Linear Minimum Mean Squared Error (LMMSE) and Deep Neural Network (DNN) for fading environments such as Rician distribution. Equation (1) gives the channel estimation equation for LS estimation.

$$\hat{h}_{LS} = \frac{1}{\tau} X_o = h + \frac{1}{\tau} n \tag{1}$$

Equation (2) gives the channel estimation equation for LMMSE estimation

$$\hat{h}_{LMMSE} = R(R + \sigma_n^2 I_{\tau_0})^{-1} x_0 \tag{2}$$

The CNNAE estimator P with an N-layer fully-connected Leaky Rectified Linear Unit (LReLU) CNN. denotes the input of P; indicates the output of P, in which and H signify input space and the output space. Consider f(x0,ɵ) as the function that is denoted by P, in which all the parameters of P are indicated by ɵ, and the estimated

$$L(x_{0,} h) = \frac{1}{2} \sum_{i=1}^{m} \left\| x_{0,i} - h_{0,i} \right\|^2 + \frac{\lambda}{2} \left\| W_{0,\tau} \right\|^2 \tag{3}$$

channel of the CNNAE estimator is notated by f(x0,ɵ).Consider Z= x H as the sample space of training. A set of training samples drawn from the joint distribution of x0 and Zm={zi}m ={(x0,I,hi)}m represents h, in which the number of training samples is signified by m. Auto Encoder (AE) denotes the symmetrical CNN that is architecturally referred to by three layers, namely input layer, hidden layer and output layer.

The squared error function or loss function is given by equation (4).

$$J_{emp} = \frac{1}{m} \sum_{Z_i \in Z_m} \xi(f(x_o, \theta), h_i) = \frac{1}{m} \sum_{Z_i \in Z_m} \left\| h_i - f(x_{o,i}, \theta) \right\|_2^2 \tag{4}$$

BER and SNR values have been associated for Rician fading channels by applying the existing channel estimation methods like LS, LMMSE, DNN, FCDNN and the proposed CNNAE method to evaluate their performance as shown in figure 4. The CNNAE algorithm delivers the BER of 0.0005324 for Rician Channel in SNR at 20 dB. Whereas, the existing LS, LMMSE, DNN and FCDNN (Fully Connected DNN) approaches provide 0.011475, 0.0094, 0.00095822 and 0.0007405 respectively which are considered on the higher side of BER.

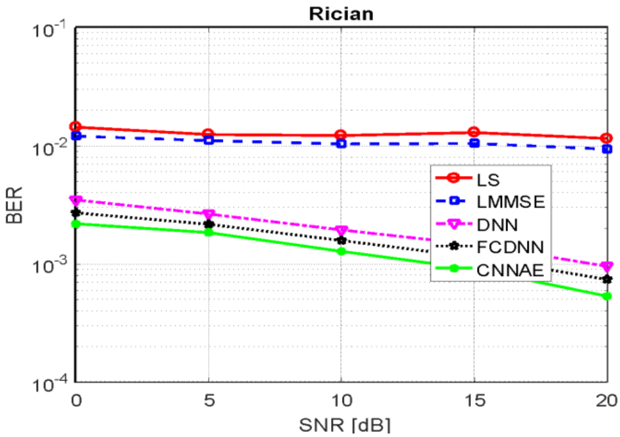


**Fig. 4** Plot of BER vs SNR for LS, LMMSE, DNN, FCDNN and CNNAE

## 4 Conclusion

Successive and fascinating features are added to communication systems with each new iteration. With its global deployment, the 5G communication technology has some amazing features. However, 5G won't be able to completely satisfy the growing demand for wireless connectivity by 2030, 6G must be put into use as a result. The potential paths and plans for reaching the 6G communication objective are envisioned in this study. Following the examination of numerous system components and potential solutions, it is concluded that the future is intriguing.

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