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Optimization Of Millimeter Wave Massive MIMO System

R.S.Mathubala[1], A.S.Asma[2], S.Divyabharathi[3], B.Lavenya[4] and V.Haripriya[5]

*[1,2,3,4,5]Department of Electronics and Communication Engineering,
Vivekananda College of Engineering for Women (Autonomous),
Elayampalayam, Tiruchengode, Namakkal-637205, Tamil Nadu, India.*

Abstract

With the explosive growth of mobile communications, the fifth generation (5G) mobile network would exploit the large amount of spectrum within the millimeter wave (mmWave) bands to greatly increase communication capacity. In terms of high propagation loss, directivity and sensitivity to blockage there are basic differences between mmWave communications and other existing communication systems.Several challenges to completely exploiting the potential of mmWave communications, including integrated circuits and system design, spatial reuse, , interference management, anti-blockage and dynamics control are the characteristics of mmWave communications. To address these challenges, we took a survey of existing system and standards and propose design guidelines in architectures and protocols for mmWave communications and ant colony algorithm. Ant colony algorithm is used to find a route from source node to receiver. The potential applications of mmWave communications in the 5G network, including the tiny cell access, the cellular access and therefore the wireless backhaul is discussed. Finally, we discuss relevant open research issues including the new physical layer technology, software defined specification , measurements of network state information, efficient control mechanisms, and heterogeneous networking, which should be further analysed to facilitate the deployment of mmWave communication systems within the ***upcoming 5Gnetworks.***

Keywords: MillimeterWave, Ant colony algorithm, efficient control mechanism and Heterogeneous networking.

INTRODUCTION

The millimeter wave (mmWave) technology is signals having wavelength in millimeters level, usually mmWave frequency ranges from 30 GHz to 300 GHz. The FCC has already assigned spectrum in millimeter wave range for both licensed and unlicensed use. 5G technology has several existing challenges like integrated circuits, system design, interference management, spatial reuse, anti-blockage, and dynamics control. There are some key factors which is to be stressed out are discussed below, which is necessarily to be satisfied simultaneously.

1) 5G technology should be capable to handle better traffic explosion than current system. In order to handle traffic caused by the user adequately, parameters like area capacity, edge rate and peak rate should be taken care.
2) Latency varies from one system to other system i.e., it is different for different system. The 4G has overall latencies about 15 ms, so in 5G, the latency should be less for faster communications. 5G aims to 1ms support round trip latency and also shrinking down the sub frame structure. Latency is the time delay of input of a system given into a system to desired outcome.
3) More cost and energy is required for the next generation based on per-link. So the foremost objective of 5G network is to provide faster data rate and more less cost bandwidth.

CHALLENGES AND EXISTING SOLUTIONS

Even with the prospective of mmWave communications, there will be number of challenges to be rectified, which are listed.

1) Integrated circuits and system design: Several technical challenges are experienced in high carrier frequency and wide bandwidth. It is observed that at 60GHz band frequency there are various nonlinear distortion of power amplifiers occurred by enormous bandwidth and high transmit power. Problems like phase noise, IQ imbalance and few other problems in radio frequency integrated circuits are also exist.

2) Spatial reuse and Interference management: By increasing the directivity of the transmission interference between the links can be reduced. The interference between nonadjacent links is neglected, and in outdoor mesh network of 60GHz band, the highly directional links are modeled as pseudo wired. The antenna beam patterns are ignored while designing the MAC protocols for mmWave mesh network. The carrier sense performed as in Wi-Fi cannot recognize in directional transmission which is also called as deafness problem. In this case, the coordination mechanism becomes the key to the MAC design and to enhance the network capacity concurrent transmission should be exploited fully.

3) Dynamics due to user mobility: One more challenge is postulated mmWave communication system is user mobility, due to which the channel state will incur significant changes. When the user movements changes that results in changes in distance between the transmitter (Tx) and the receiver (Rx), which will lead to change in channel state. By assuming LOS transmission between transmitter and receiver in Shannon's channel capacity method, the channel capacity can be calculated. Remarkably the channel capacity varies accordingly with the range between the communication devices.

CHALLENGES AND TECHNICAL POTENTIALS

Next, we will describe potential gains and some important from using mmWave communications in mobile networks.

a) Main Technical Challenge

Despite the theoretical potentials for extremely high data rates, there are several key technical challenges for using mmWave in mobile networks, including severe path loss, high power consumption, high penetration loss, blockage due to shadowing, hardware impairment, etc. In what follows, we will give a brief introduction to these topics.1) Path loss: In free-space transmission, the power of the received signal (outside the Kirchhoff area) can be determined by Friis transmission formula:

$$P_r(d)=P_tG_tG_r(\lambda 4\pi)2d{-}n \qquad ....(1)$$

where P_t is the transmit power and G_t and G_r are the antenna gains of the transmitter and receiver respectively. Moreover, λ is wavelength, d is the transmission distance, and the path loss exponent n equals to 2 in free space. The formula can be also used to, approximately, describe the power of the received signal in non-free-space propagation as well, by making channel measurements and then finding a suitable value of n that approximately describes the path loss measurements. The value of n is usually in the range from 2 to 6. There are also scenarios e.g., indoor environments where n can be smaller than 2 .The wavelength of mmWave signals is much shorter than conventional microwave communication signals, operating at carrier frequency below 6 GHz. Hence, the path loss of mmWave signals is much higher than that of microwave signals, if all other conditions including the antenna gains are the same. Although the path loss is quite high in mmWave, it is feasible to communicate over the distances that are common in urban mobile networks, such as a few kilometers or few hundreds of meters . By using directive antennas, it has been demonstrated that only under clean air conditions 10 km communication ranges are. The rain attenuation and atmospheric/molecular absorption limit the communication range and increase the path loss if the air is not clean.

b) Penetration Loss:

Line-of-sight (LoS) communications is assumed in path loss discussion, but the high penetration loss is compounded in non-line-of-sight (NLoS) scenarios. In indoor environments, although it is relatively low for 28GHz signals (comparable to microwave bands) penetration losses for clear glass and dry walls, the penetration losses for brick and tinted glass are high for 28 GHz signals (about 28 dB to 40 dB), which is much higher than at microwave bands. At higher frequencies the penetration losses are typically larger. Hence, it is difficult to deploy outside and cover inside with mmWave nodes and vice-versa due to high penetration loss.

c) High Power Consumption:

In addition to the challenges imposed by high path loss, shows that the transmit power needs to increase with the bandwidth if the signal-to-noise ratio (SNR) should remain intact. Alternatively, directive antennas or MIMO technology can be used to spatially direct the signal power, which leads to latter and an array gain also provides the flexibility of spatial multiplexing. MIMO/beam forming is considered essential for mmWave communications, particularly since the short wavelength at mmWave frequencies makes it

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possible to fit many half-wavelength spaced antennas into a small area. Normally MIMO arrays are fully digital for sub 6 GHz systems, where each antenna requires a dedicated radio-frequency (RF) chain, including power amplifier (PA), data converter (ADC/DACs), low noise amplifier (LNA), mixer, etc. However, it is an non-trivial task for realizing a fully digital MIMO implementation at mmWave frequencies, using current circuit design technology. For very compact circuit implementation hundreds (or even thousands) of antennas, each supported by a separate RF chain is required. Moreover, the PAs and data converters are expensive and power consuming for higher bandwidth. Hence, in a cost-efficiency perspective it appears that fully digital mmWave MIMO implementations are currently infeasible.

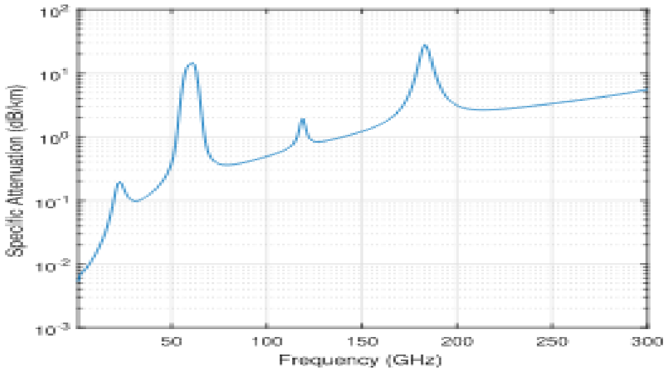
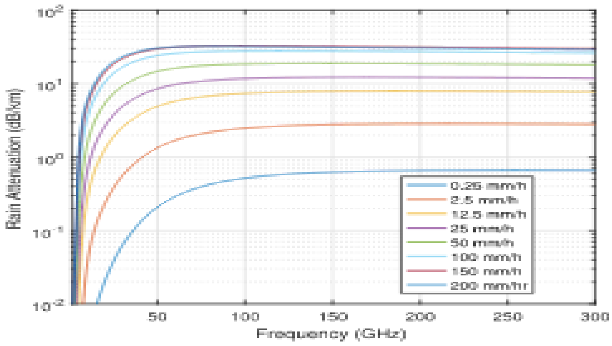


Fig. 2. Atmospheric and molecular absorption in different frequency bands [35].



This is likely to change in the future, but, in the meantime, research community had paid attention to alternative low RF-complexity architectures. In particular, the corresponding signal processing techniques must be redesigned to enable channel estimation and a good tradeoff between the energy consumption, spectral efficiency and hardware cost when hybrid analog/digital architectures are being considered.

d) Narrow Beamwidth and Side-Lobes:

For increasing the transmission distance for mmWave, by using directional antennas, MIMO, and beam-forming an array gain can be obtained. The beamwidth of mmWave signals is normally narrow. The radiation patterns are usually modeled in an idealized fashion while modeling the directivity, e.g., a constant large antenna gain within the narrow main-lobe and zero elsewhere. This idealized radiation pattern, often referred as the “flat-top model” for system-level performance analysis. However, in practice, the radiation patterns are implementation-dependent and more complicated; the main-lobe gain is not constant and the side-lobe radiation is non-zero. The ignorance of misalignment of beam caused while the effect of side-lobe radiation and the gradual reduction and of main-lobe is not possible. If the main-lobes of the transmitter and receiver are perfectly aligned then the maximum beam forming gain can be achieved, which is rare due to practical implementation constraints. In 3GPP, two-dimensional directional antenna pattern is adopted which is more practical, where the antenna gain G(θ), with respect to the relative angle θ to its boresight, is given by

$$G(\theta)=\begin{cases} G_m 10^{-\frac{3}{10}\left(\frac{2\theta}{\omega}\right)^2}, & |\theta|\le\frac{\theta_m}{2},\\ G_s, & \frac{\theta_m}{2}\le|\theta|\le\pi \end{cases}$$

where denotes the half-power (3 dB) beamwidth and θ_m is the main-lobe beamwidth. G_s and G_m represent the averaged side-lobe gain and maximum main-lobe gain, respectively. The narrow beamwidth has a impact of two-fold. For the cons, narrow beamwidth leads to higher sensitivity to misalignment between the transmitter and the receiver, especially having higher mobility which is supported, in mobile networks.

e) Hardware Impairments and Design Challenges:

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Inaddition to above challenges, practical transceiver hardware are impaired by phase noise (PN), limited ADC resolution, non-linear PAs, and I/Q imbalance. These effects limit the channel capacity, particularly when high spectral efficiency is envisioned. On the other hand, it was proved in that MIMO communication links are less affected by hardware impairments than single-antenna links. In mmWave communication systems, for signal up-conversion at the transmitter mixers are applied and down-conversion at the receiver using local oscillators to generate carrier signals operating at the desired carrier frequency. However, due to the random deviation of the output signal frequency around the carrier, that both oscillators at the transmitter and the receiver operate exactly at the same carrier frequency is infeasible.

f) Futuristic scenarios and 5G compliance

The IoT together with in-home networks and intelligent and integrated sensor systems will change the way people lead their lives. "Smart living" people will require ubiquitous and constant mobile connectivity to the network to upload their IoT control commands and activity data, thus "massive reporting" uplink data flow is generated. Critical machine to machine communication and massive machine to machine communication will play vital roles in service delivery and industry operations.

Vehicular Ad-hoc Networks (VANETs) are constantly advancing. The offloading of networked data on unlicensed bands will play a significant role in network load balancing, reduction in control signaling and providing guaranteed bit rate services when the number of devices connected to the Internet passes tens or hundreds of billions in the decade. Hence, it is important that 5G will provide seamless compatibility with dense heterogeneous networks should be used to satisfy the high demand of real-time traffic, so that end users will experience smooth connectivity to the network.

g) Developments toward 5G technologies

Many well-known technologies or schemes, such as modulation techniques, distributed computing, or radio access techniques, could be reused in 5G with a few alterations together with many other newly developed and evolved solutions. Hence, we limited our literature review to very recent industry products, market requirements, and research papers. For example, Cisco Inc. publishes the Visual Networking Index (VNI), a white paper annually. The Cisco VNI reports forecasts global mobile data traffic, and the latest VNI report, published in February, 2015 showed interesting predictions: 24.3 Exa Bytes (EB) will be passed by the monthly global mobile data traffic, which current mobile traffic is ten times, by 2019, and the entire world population will soon be surpassed by the number of devices connected to the network.

h) Millimeter wave communication

The first step is to use the mm-wave (with a wavelength in terms of millimeters) spectrum (30–300 GHz range) as the opportunistic traffic together with carrier frequency offloading onto an unlicensed spectrum (5 GHz Wi-Fi) to achieve 1000x speed enhancement. Of the saturated 750 MHz to the 2600 Mhz spectrum spanned by the current cellular licensed carrier. Hence, the mmWave spectrum with the the design of the mostly under-utilized physical layer is required. In addition, beam forming, massive MIMO, traffic overloading on to unlicensed spectra and cloudification of radio resources will provide guaranteed availability and faster data transfer. Rappaport et al. showed the penetration characteristics, propagation behavior and path loss of 28GHz and 38GHz carriers resulting from urban structures. For designing the PHY layer of 5G deploying the mmWave data presented in this paper is certainly useful. Levanen et al. designed an ultra-low latency mm-wave communication for 5G.

DRIVERS AND CHALLENGES OF MMWAVE COMMUNICATION IN 5G NETWORKS

By targeting a design of mmWave communication for 5G networks, brings up multiple challenges to be faced. Before designing the viable technology solutions for the next generation broadband network, addressing the challenges in existing system is very important. In this section, drivers and challenges are especially discussed from mm-wave communication perspective. These challenges can be divided into several different groups namely, propagation aspects, spectrum aspects, cost aspects and energy efficiency aspects.

a) Drivers and Requirements

As discussed earlier, because of proliferation of smart devices that support a wide range of new application and services, the phenomenal growth in the volume of mobile traffic is envisioned. Some of key drivers for mobile data traffic explosion in the next generation mobile broadband networks are provided in the following:

- Uniform user experience for all users across a 5G network anywhere with the minimum of 1Gbit/s data rate.
- Support for ultra-high data rates from 5 to 50 Gbit/s for high mobility and pedestrian users.

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- Support for real-time services, for example, tactile network, UHD/3D video streaming, tactile network, leading to stringent latency requirements, i.e., round-trip-time requirement to be 1ms.
- Support for cloud based services.
- Support for proximity based services. mmWave communication looks promising technology ground for further development and research in the framework of 5G networks by looking at above drivers.

b) Spectrum Aspects

There is an additional 200 GHz of spectrum in the so-called mmWave frequency range that today is mainly under-utilized beyond the traditional sweetspot of spectrum for wireless communications which ends at around 6GHz. This spectrum band has channel size with the capablity of supporting wireless data speeds of 10-50 Gbps. Within the next 5 years for 5G cellular and Wi-Fi communications for the significant proportion of this enormous radio spectrum could be unlocked. The target is above 6GHz for the field of 5G research, and the research in this field should look to link budgets, Electromagnetic field (EMF) aspects, channel model description and propagation issues. A low millimeter band and high millimeter bands within the range of 20 to 90 GHz are briefly discussed in the following. A contiguous bandwidth up to 2 GHz can be found in the frequency range. It is worth nothing that ITU co-primary service bands for mobile systems has been marked with green color. Currently, 20-50 GHz range of ITU co-primary mobile bands have been used also for other services, e.g. fixed navigation and satellite services. Therefore, the consideration of co-existence of mmWave communication with other existing systems needs to be carefully done. There is also 7GHz unlicensed spectrum surrounding 60GHz for higher part of mmWave band. ITU has allocated lightly licensed 5GHz bandwidths for both 81-86 GHz and 71-76 GHz bands for establishing high bandwidth wireless links additionally. The band 92-95GHz has been allocated for high bandwidth wireless links similarly.

c) Propagation Channel Aspects

For designing efficient wireless solutions for next generation mobile broadband systems, through understanding of radio channel is an fundamental requirement. The characteristics of radio channel are reflected to the network architecture and air interface design. Therefore, for designing of future mobile broadband systems, supported by simulation, theoretical and measurement efforts, the need of accurate channel model play a key role. As discussed earlier, mm-wave bands around 30 GHz are attractive options for cellular communication in next generation mobile broadband systems due to availability of large contiguous chunk of spectrum. In contrast to the common understanding, atmospheric absorption, snow, rain or fog are the various attenuation are not serious but even negligible in the case of propagation distances and the frequency bands of our interest. Of course, there is an path-loss in mmWave frequency bands with respect to the frequency bands of conventional cellular systems additionally. However, additional path loss can be compensated by exploiting antenna array either at the transmitter or the receiver.

d) Energy Efficiency and Cost Aspects:

Recently, for a green wireless communication in the fourth generation(4G) networks, the large volume of research and development efforts in academia and industry has been dedicated. Clearly, in the context of 5G networks, the importance of green communication will become even more important with respect to existing systems. Novel energy efficient and cost-efficient multi-antenna transceiver architectures and mechanism to access large continuous chunks of spectrum are under interest from the mmWave perspective. The minimization of installation and operation costs of wireless backhaul are under high interests additionally while deploying of scalable ultra-dense mmWave small cell networks.

EXISTING SYSTEM

An overview of research challenges and opportunities in the fifth generation (5G) mobile broadband networks with mmWave communication are provided in this paper. More specifically, propagation channel, spectrum, energy and cost efficient aspects, are the different challenges from the perspective of mmWave communication are discussed. Insights on research opportunities of mmWave communication in heterogeneous networks and multi-antenna transceiver technologies are provided further. Based on the provided overview, it can be concluded that mmWave communication is a promising framework which can be forwarded to next generation mobile broadband communication systems with further research and development.

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a) DRAWBACKS OF EXISTING SYSTEM

- Becomes overcrowding of existing spectrum for new mobile services. On contrary, mmWave spectrum with the frequency range of 30-300 GHz, opens up an attractive opportunity to harvest large continuous chunks of spectrum with emerging mmWave technologies for ultra-high data rate wireless communication.
- Up to today, mmWave spectrum has not been effectively leveraged for the use of mobile broadband systems.

PROPOSED SYSTEM

The paper discusses fifth generation mobile communication and upcoming technologies for satisfying the customers need and changes in the network architecture. The main concern will be on 5G network architecture, along with the exploitation of higher frequencies, mainly millimeter wave (mmwave), one of the promising technologies for future 5G cellular networks. In comparison to existing communication technology, millimeter wave communication is different in terms of directivity, high propagation loss, sensitivity to blockage. To fully employ the characteristics of mmwave it has several technical challenges. Further research is to be done for 28GHz and 38 GHz band and above 60 GHz band. This paper, we propose a multi-path wireless sensor network routing Ant Colony algorithm based on energy equalization. The algorithm uses forward ants to find the path from the source node to the destination node, and uses backward ants to update the pheromone on the path. In the route selection, we use the energy of the neighboring nodes as the parameter of the heuristic function.

a) ADVANTAGES OF PROPOSED SYSTEM

For next generation networks and devices, new challenging requirements, e.g., in terms of throughputs, latencies and reliability, will be imposed for a entire system design.

LITERATURE SURVEY

AUTHOR	TITLE	DESCRIPTION
C. H. Doan, S. Emami, D. A. Sobel, A. M. Niknejad, and R. W. Brodersen	"Design considerations for 60 GHz cmos radios,"	With the availability of 7 GHz of unlicensed spectrum around 60 GHz, there is a growing interest in using this resource for new consumer applications requiring very high-data-rate wireless transmission. Historically, the cost of the 60 GHz electronics, implemented in the compound semiconductor technology, has been prohibitively expensive.
P. Pietraski, D. Britz, A. Roy, R. Pragada, and G. Charlton,	"Millimeter wave and terahertz communications: feasibility and challenges,"	Fifth-generation (5G) cellular networks will almost certainly operate in the high-bandwidth, underutilized millimeter-wave (mmWave) frequency spectrum, which offers the potentiality of high capacity wireless transmission of multi-gigabit-per-second (Gbps) data rates.
F. Khan and Z. Pi,	"An introduction to millimeter wave mobile broadband systems,"	The global bandwidth shortage facing wireless carriers has motivated the exploration of the underutilized millimeter wave (mm-wave) frequency spectrum for future broadband cellular communication networks.

FEASIBILITY STUDY

The feasibility analysis is an analytical program through project manager determines the project success ratio and through feasibility study project manager able to see either project. The different feasibility analysis which is to be considered are:

- Economic Feasibility

- Technical Feasibility
- Operational Feasibility
- Environmental Feasibility

a) ECONOMICAL FEASIBILITY

Hence this project is economically feasible there is no need to involve any cost for this project.

b) TECHNICAL FEASIBILITY

Software Technologies used are PHP and MySQL. In the educational institutions, it is possible to update the system in future. No special hardware is required for the purpose of using this system. Hence it is declared that this project is technically feasible.

c) OPERATIONAL FEASIBILITY

As the admin work mainly to maintain the Patient and Doctor. Doctor will predict patient cancer disease. Hence it is easy to operate with training. Therefore it is operationally feasible for implementation.

d) ENVIRONMENTAL FEASIBILITY

This project environment is correct as a admin has developed this system and no expenditure is involved under any head and this process is part of admin document management, this project environment is accessible.

SYSTEM REQUIREMENTS

a) HARDWARE REQUIREMENTS Input Devices, Storage Devices, Processing & Control units and Output Devices are the hardware components consists in the computer. Computer may also use external storage unit to store data in programs.

The Hardware Configuration involved in this project

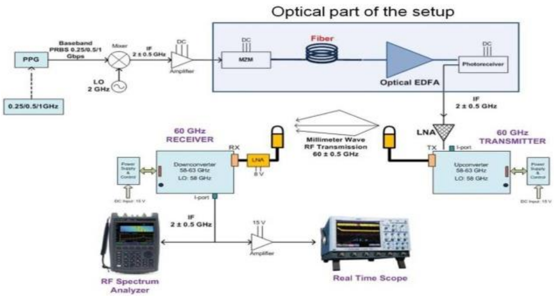
- Personal Laptop: Windows 7
- Processor : 64 bit

b) SOFTWARE REQUIREMENTS

Software is a group of programs in which each program does a particular task in computers. It is an essential requirement of Computer System. The Software used to develop the project is

- Operating System : Ubunto
- Software Used : NS2 Stimulator
- Programming : C++

SYSTEM DESIGN AND DEVELOPEMENT



a) DATA FLOW DIAGRAM

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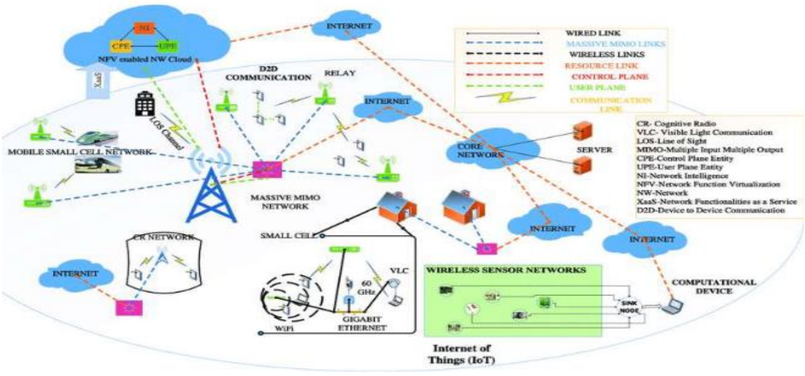
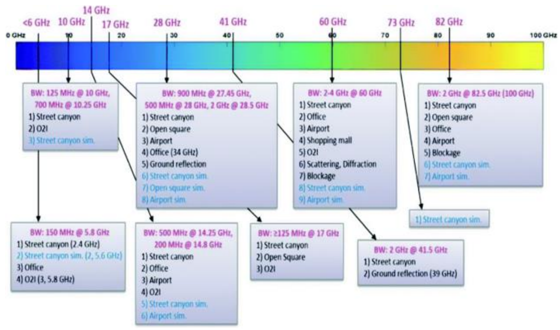


SYSTEM ARCHITECTURE UML DIAGRAM



TESTING AND IMPLEMENTATION

a) TESTING

The project when the theoretical design is turned into a working system is ready for implementation. This is the final and important phase in the system life cycle. It is the process of converting the new system into a operational one.

b) Unit Testing

Comprising the set of tests performed by an individual programmer prior to integration of the unit into a larger system is said to be unit testing. For ensuring that the information properly flows into and out of the program unit, the module interface is tested. For ensuring that the data stored temporarily maintains its integrity during all steps in an algorithm's execution, the local data is examined. For ensuring that the module operates properly at boundaries established to limit or restrict processing, boundary conditions are tested. All independent paths through the control structure are tested. All error-handling paths are tested.

c) Black Box Testing

An method of software testing that examines the functionality of an application without peering into its internal structures or workings is said to be black-box testing. At every level of software testing this method of test can be applied: unit, integration, system and acceptance. It is sometimes referred to as specification-based testing.

d) SYSTEM IMPLEMENTATION

For ensuring that the system is operational and used, information system should be built which is said to be system implementation. This is the final and important phase in the system life cycle.

CONCLUSION

Nowadays, dramatically the number of mobile users has been increased and they want more reliable service and high speed data rate. Faster data rate will be delivered in 5G networks with assurance. Companies and industry people are working together in overall development of 5G technology though it is still under research stage. Ant colony algorithm is mainly used to find a route with the forward ants from transmitter to receiver and the backward ants to update the pheromene on the path. Handling more traffic and to provide faster data rate existing technology is the main goal of 5G technology. A survey of mmWave communications used in 5G technology has been discussed. Operators of satellites, radar systems and other real-time applications in which mmWave communications is used become a promising candidate in implementing 5G technology. It is concluded, by clearing that mmWave communications has potential to provide better performance in cellular communication.

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