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MASSIVE MIMO AND MILLIMETRE WAVE COMMUNICATIONS FOR 5G CELLULAR NETWORKS

Dharmateja.Patchipulusu[1], Chaithanyakumar.Muppala[2], Neelakandan R[3]
Computer & Communication from VIT University, Vellore.
Email: pdharma.teja2016@vitstudent.ac.in

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Abstract

In this paper we discuss about 5G technologies. Due to 4G cannot be accommodated such as more energy consumption and spectrum crisis. In wireless system, the demand is enhanced for more data rates for these we introduce 5G technologies it may be implemented in 2020. If we use millimetre wave spectrum bands the capacity increases drastically. The millimetre wave communication systems and existing other communications are having some differences. The applications of millimetre wave systems in 5G technologies are seen and also discuss the wireless backhaul, cellular access and small cell access.

Keywords: Millimeter wave communication, multiple input multiple output.

I. Introduction

The demand growth is high in mobile communication traffic; bandwidth requirement is high. The millimetre wave uses huge bandwidth as millimetre wave band ranges from 30GHZ to 300GHZ, millimetre wave communication band proposed for the 5G technologies to give multi-gigabit communication applications such as HDTV and UHDV [1].

The mobile communication had a total revenue is of €174 billion by 2010 and is given by the European Mobile Observatory (EMO) [2]. Developing of wireless technologies in systems has improved, people are able to communicate and living in both social functions and business operations. The second generation (2G) mobile systems are developed in 1991. In 2001, 3G mobile systems are launched firstly, in wireless systems mobile network. The 4G mobile systems are designed for giving the requirements of International Mobile Tele-Communication-Advanced (IMT-A) using IP for all systems. The 4G systems uses the advanced radio interface along with orthogonal frequency division multiplexing (OFDM), Multiple-input multiple-output (MIMO). In 4G systems wireless networks reaches the data rates up to 1GBPS with low mobility like nomadic/local wireless access, and with high mobility reaches up to 100MBPS like mobile access.

The number ofusers are drastically increase in mobile broad-band systems per every year. Researchers are expecting the 5G mobile network in 2020. This network achieves 1000 times the capacity of system, spectral efficiency, energy efficiency is of 10 times and data rate is of 10 GBPS for low mobility, 1 GBPS for high mobility. Researches are expecting the entire world is connected to 5G mobile network, and it support communications between people to machine, people to people and machine to people, anytime, anywhere. Mainly researchers, the 5G mobile networks should support communications for some special scenarios the 4G networks should not be supported. For example, the train users in 4G networks with high-speed can give communication up to 250 KMPH but the train users in 5G network with high-speed can give up to 350-500 KMPH [3]. More smartphones and laptops are becoming more popular now-a-days. Since 2006, the European Mobile Observatory (EMO) studied that the 92 percentage of growth in mobile broad-band per every year [4]. The Wireless World Research Forum (WWRF) are expecting 7 trillion of wireless devices are using 7 billion people may be in 2017, the number of network-connected wireless devices will reach up to 1000 times the world's population[5].

The differences between millimetre wave communication systems and existing other communication systems have the microwave (μW) bands ranging 2.4GHZ to 5GHZ. We done survey on the characteristics of millimetre wave communications in 5G. The carrier frequency is high, the millimetre wave communications band suffer from high loss of propagation and for that Beam Forming (BF) process have been developed which indicates that millimetre wave communications are directionality in nature. Two standards are introduced in millimetre wave communications in the 60GHZ band, they are IEEE802.15.3c and IEEE802.11ad [6]. In 5G mobile network the applications of millimetre wave communications include wireless backhaul, cellular access small cell access. we see the techniques at millimetre wave frequency bands, the Full Duplex communication technique and New Physical Layer Technologies includes the MIMO technique [7].

II. Massive MIMO

In wireless network, the mobile devices are increasing exponentially and wireless data rate. so, operators face a major issue to offer sufficient network capacity because day by day traffic is increasing. In order to achieve increase in the traffic capacity massive MIMO is used to extend the network coverage, energy efficiency, network capacity and latency. Massive MIMO at base stations (BS) make use of tens or hundreds of antennas to increase the gain in link reliability and data rates by Adaptive Beam forming (ABF) and Direction of arrival (DOA) algorithms. The DOA provides data about the signal direction and the source location. Direction of the steering of antenna array also enabled. The Beam Division Multiple Access (BDMA), is evaluated after mobile device location allocates, beam will address the devices located at the same angle hence increasing capacity. Beam forming is used for direction of transmission or reception of signal. This is done by adding elements of phased array, so the signals at particular gives interference is experienced by others.

Beam forming techniques are of two types:

- Switched beam forming
- Adaptive beam forming

Switched beam forming make use of fixed set of time delays and weights from array of sensors adding the signals.

Adaptive beam forming give the response automatically to different direction.

In 5G wireless networks, the energy efficiency becomes design criterion due to it allows for operation at affordable energy consumption levels. In this we proposed a Massive multiple-input multiple-output (MIMO) technology. It is like number of base station (BS) antennas are added to a multiuser MIMO to give large energy efficiency.

Massive Multiple-Input Multiple-Output (MIMO) Systems consists of numerous antennas in transmission and reception. If we add multiple antennas, it offers more information data in wireless channels. Hence the performance will be improved in spectral efficiency, energy efficiency and reliability. In Massive MIMO systems, transmission and reception are having a large number of elements in an antenna. The antennas in the transmitter side can be distributed in many systems. The antennas in the receiver side can only one device or to many devices [8]. In Massive MIMO systems, noise and fast fading will affect and interference in intracell will be reduced by using some techniques like simple linear precoding and detection methods. In massive Multiple-input and Multiple-output (MIMO) systems, the Multi User Multiple input and Multiple output (MU-MIMO) is used to simplify the design of medium access control (MAC) layer by avoiding complicated scheduling algorithms [9]. In multiuser MIMO the Base station (BS) will separate the signals and send to the Users individually using time-frequency resource. It is the main advantage to enable massive Multiple input and Multiple output (MIMO) system in 5G wireless communications networks. Massive MIMO increases the network coverage, signal quality and capacity of wireless systems used in different systems like solar systems, spacecraft, aircraft as narrow beam in desired direction. To communicate with massive MIMO antennas used in ground station.A massive MIMO system has a large surplus of degrees of freedom. For example, with 200 antennas serving 20 terminals, 180 degrees of freedom are unused. These degrees of freedom can be used for hardware-friendly signal shaping. In particular, each antenna can transmit signals with very small peak-to-average ratio or even constant envelope at a very modest penalty in terms of increased total radiated power.

III. Characteristics of mm wave communication

The characteristics of millimetre wave Communications are:

A. Wireless channel measurement

Millimetre (mm) wave communications have high loss in propagation compared with other systems used carrier frequencies with lower values. In free space the loss of propagation is proportional to square of frequency of carrier. The wavelength is of about 5mm, the propagation loss in free space is of 60GHZ is of 28dB more near to 2.4GHZ [10]. The channel characterization lower attenuation loss in line of sight (LOS) than in non-line of sight (NLOS) communication [11]. The high antenna gain is achieved in the transmitter and receiver antennas should be directional antennas. In LOS, the direct path contains all the energy and multipath is not available. The channel is Additive White Gaussian Noise (AWGN) channel. In NLOS, there is no path directly and the energy is small in paths. The millimetre wave communication mainly used for LOS transmission to achieve high data rate and maximum power efficiency. In New York city, the millimetre wave cellular uses 28GHZ band, the transmitter and receiver distance is from 75m to 125m. For this case, in LOS, the loss exponent in a path is 2.55. whereas, in NLOS, path loss is 5.76 [12]. The coverage distance is maximum for increasing the gain of antenna and path loss will decreased. For indoor materials, the losses are low for non-tinted glass is 3.6dB and for drywall it is 6.8dB. For measurement in a reflection, the reflection coefficient is larger for outdoor materials and lower reflection coefficient for indoor materials.

B. Directivity

MM wave communication links are inherently directional. The wavelength is small, in steerable antenna arrays [13]. The signal phase is controlled and transmitted by an antenna, the beam steers the antenna towards a direction and high gain is achieved in this direction, in all other directions it offers the gain value is of very low. The beam should direct between transmission and reception; the procedure is needed for beam training and to reduce the beam time some algorithms are proposed [14].

C. Sensitivity to Blockage

The ability is weak in EM waves due to diffraction in obstacles with size greater than the wavelength. In the small wavelength, the obstacles like furniture and human bodies are sensitive to blockage for wave links in 60GHZ band. Blockage by human is of 20-30 dB [15]. In the indoor environment, the presence of human, results the blockage of channel is 1 % or 2 % time for 1-5 persons [16]. The reliable connection is maintained in sensitive applications like HDTV. It is the big challenge for millimetre wave communication.

IV. Standardization

The millimetre wave communications have some standards. Those are IEEE 802.15.3c and IEEE 802.11ad

1. IEEE 802.11ad

In 60GHZ band, this standard specifies MAC and physical layers to support mainly the multi-gigabit applications in wireless system including wireless synchronization, wireless display of HDTV, internet access and cordless computing.

In physical layer, there are two operating modes, they are the single carrier (SC) and OFDM. Single carrier is for low complexity and power is low in implementation and OFDM for improving performance applications like data rate is high.

In IEEE 802.11ad standard, the Basic Service Set (BSS) comprises a device are AP and non-AP devices (DEVs). AP gives the timing for Basic Service Set (BSS), and medium access in basic service set to control the requests of traffic from DEVs. The channel access time is divided as the Beacon Intervals (BIs), and every Beacon Interval (BI) consists four portions they are Beacon Transmission Interval (BTI), Data Transfer Interval (DTI), Association Beam Forming Training (A-BFT) and Announcement Transmission Interval (ATI). Then Beam Form training between AP and non-AP DEVs is performed in ABFT. During ATI, Service periods (SP) and Contention-based access periods (CBAP) allocates each DTI by AP. peer to peer communication between pair of DEVs includes the AP and non-AP DEVs are performed, during DTI after completion of the beam forming training. AP sends millimetre wave frames of beacons in transmit sector in BTI.

In IEEE 802.11ad standard, is adopted for transmissions among devices of Carrier Sensing Multiple Access / Collision avoidance (CSMA/CA) and Time Division Multiple Access (TDMA). For traffic, TDMA is used for video transmission for supporting good quality of service. For High traffic, CSMA/CA is used for web browsing.

2. IEEE 802.15.3c

The MAC and physical layer in indoor WPANs (piconet) consists of wireless nodes (WNs) and a single piconet controller (PNC). The PNC gives coordinates transmission in piconet and Network synchronization.

In this standard, the time for the network is portioned a sequence of super frames. The portioned frames consist of 3 parts they are Contention Access Period (CAP), Beacon Period (BP) and Channel Time Allocation Period (CTAP). Contention Access Period (CAP) is for sending the requests for transmission to Piconet Controller (PNC). Channel Time Allocation Period (CTAP) transmits the data among devices and Beacon Period (BP) the network synchronization, messages are controlled and wide spread from piconet controller.

V. Applications of millimetre wave communications

1. *Small Cell Access*

The growth of traffic demand in a mobile communication, small cells are proposed for achieving high capacity of the network [17]. Small cells are deployed the macro cells as wireless local area networks (WLANs) is the only solution to increase the capacity of the system in 5G mobile networks. The bandwidth is high in millimetre wave band, the small cells able to give multi-gigabit rates and applications like data transfer in high-speed between devices likewise, cameras, PCs, real-time streaming of HDTVs can support.

Using millimetre wave bands, in 28GHZ, 38GHZ, 71–76GHZ, 81–86GHZ bands for enhanced local area (eLA) access in 5G. The bandwidth is high in the eLA system will able to reach the high data rates in excess of 10GBPS and edge is of higher than 100MBPS [18]. The millimetre wave band system supports HD video up to 3GBPS [19] to reach the trade-off among complexity and performance.

2. Cellular access

Using large bandwidth in millimetre wave communication band promotes the millimetre wave communications into 5G cellular network. [20]. In millimetre wave, cellular mobile networks is for coverage and capacity should be high.

The efficiency and feasibility of millimetre wave mobile communications in cellular access is of at 28GHZ and 38GHZ of cell sizes in order of 200meters. In 5G the capacity increases based on antennas directional angles it will be higher than 20 times 4G LTE mobile networks, it improves while directional antennas are placed in transmitter and receiver directions.

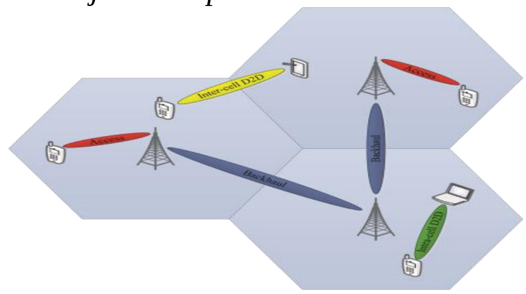

Fig.1. millimetre wave 5G cellular mobile network with Device 2 Device (D2D) communication.

The Device 2 Device (D2D) Communication saves the power consumption and enhance spectral efficiency. The Fig. 1, shows millimetre wave 5G cellular mobile network with Device 2 Device (D2D) communications. with mobile cellular cells deployed, the two D2D modes are the inter-cell transmission and the intra-cell transmission. In millimetre wave, the access link, intra cell link, inter cell link and backhaul link includes the user access, controlling of power, scheduling of transmission [21].

3. *Wireless Backhaul*

The wireless backhaul in a high-speed is more cost-effective, easier to deploy and flexible. The bandwidth is high, in the available backhaul in millimetre wave bands, such as band of 60GHZ, E band of 71–76GHZ, 81–86GHZ, gives several giga bits per second of data rates and for small cells the backhaul solution is required. The Fig.2, shows E band gives the transmission between Base Stations (BSs) and gateway. we introduced Time division multiplexing (TDM) to provide point to multipoint, NLOS, Millimetre wave backhaul. In in-band backhaul, the networks and design access will reduce the resource allocation [22].

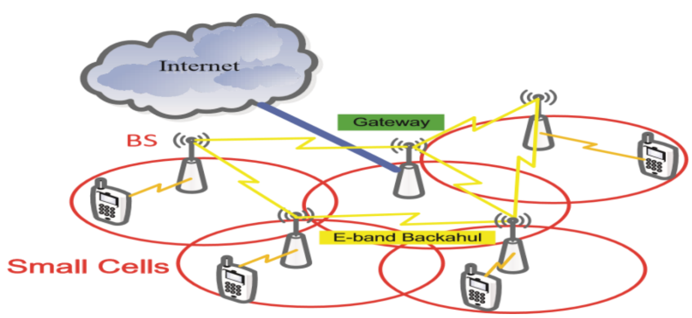

Fig2. E band backhaul.

VI. Research Issues

a. New Physical Layer Technology

The hybrid beam forming structure for the millimetre wave transmission section is shown in fig.3. The structure has data streams is of N_S is passes to base band digital precoding, output is passed via RF chains of N_{RF}. That output is passed through RF analog beam forming; the N_T antennas output is the RF signals. With $N_T \geq N_{RF}$, with this condition the required number of RF chains are reduced.

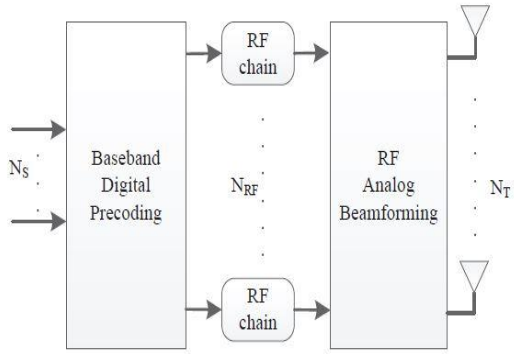

Fig.3. Hybrid structure for Beam Forming of millimetre wave transmission.

2. Full-duplex:

Now- a -days wireless systems are generally half duplex, it can transmit the signals or receive the signals, but not both simultaneously. Full-duplex communications are able to transmit the signal and receive the signal simultaneously. The designing of full-duplex communication can reduce the self-interference, because the received signal from local transmitter is stronger signal than the received signal from several nodes [23]. The methods for reducing self-interference includes antenna placement, digital cancelation and analog cancelation techniques. Firstly, antenna placement technique places another transmitting antenna as two transmitter signals interfere at receiving antenna, Analog cancellation technique has self-interference as noise, and to reduce that noise we have using noise cancelling chips. The digital cancellation removes self-interference after Analog to Digital conversion [24]. The two transmission modes exist in the full-duplex communication systems are bi-directional full duplexing and the relay full duplexing [25]. However, the current research on the full-duplex systems mainly focuses on the omnidirectional communications in the low frequency bands.

VII. Conclusions

The 5G mobile network is mainly to increase the number of users compared to current communication mobile network. Millimetre wave communication plays a major role in 5G cellular mobile network. we have seen the characteristics of millimetre wave communications to promote the redesign of architectures. In 5G systems, the efficiency increases and complexity is reduced. The millimetre wave communication applications in 5G are discussed. The New physical technology has been discussed for the development of millimetre wave communications in 5G. The Full duplex communication technology has been introduced.

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