Massive Multiple Inputs and Multiple Outputs in 5G Technology

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Abstract-In near future beyond 4G, the increasing wireless data traffic demands to have the need to explore suitable spectrum regions for meeting the requirements. To meet these demands, drastic improvement need to be made in cellular network architecture. This paper presents the result of survey on fifth generation(5G) cellular network architecture and some of key emerging technology that are helpful in meeting the needs of the user. This survey is focused on 5G cellular network architecture, Mm Wave Massive MIMO technology, Massive MIMO design and implementation using Gauss-Jordan Elimination method in SIMD processor . In appendix survey is included regarding current research project conducted in different countries by research groups on 5G technologies.

Keywords—*5G, MIMO, Mm Wave Massive MIMO, MIMO implementation, SIMD processor.*

I. INTRODUCTION

To fulfill the needs of future requirement, the wireless based network of today need to be advanced in various ways. Recent technology like high speed packet access (HSPA) and long term evolution (LTE) have been launched as symbol of advancement of wireless technology. LTE Advanced is the one of the major step in the evolution of our LTE networks towards 5G. the introduced key technologies in LTE-A are carrier aggregation, enhanced use of multiple antenna elements mapped. In the current paper, the main focus is on Multiple-input Multiple-output(MIMO) for 5G. From late 1970s, mobile wireless communication has come across from analog voice calls to current modern technology for providing high quality mobile broadband service for end user data rates of several megabits per second locally. The improvements in terms of capacity of mobile communication networks, with new mobile devices like smart phones and tablets which will result in exponential growth in traffic. This paper represents our overview of wireless network communication for 2020 and beyond. We have also described the key challenges that will be encountered in future for wireless communication while enabling the networked society. The imaginations of future networked society with unbound access to information and sharing of data which can be accessed anywhere and every time for everyone. To meet this need new technology components, need to examined for evolution of existing wireless-based technology. Present wireless based technologies are 4G and Wi-Fi, will be including new technology components that will be helping to meet the demands future users. The instigation of completely new wireless-based technology will complement the current technology which are needed for long term realization of networked society.

Massive MIMO:

MIMO can consists of a simple principle where wireless network allows the transmission and reception of multiple data signals simulation over a single radio channel as shown in figure 1. Massive MIMO uses multiple number of antennas whereas Standard MIMO networks generally use two or four antennas. These multiple antennas are located at both source and destination also it uses multiple technologies. Massive MIMO play a main role for the success of 5G cellular communications.

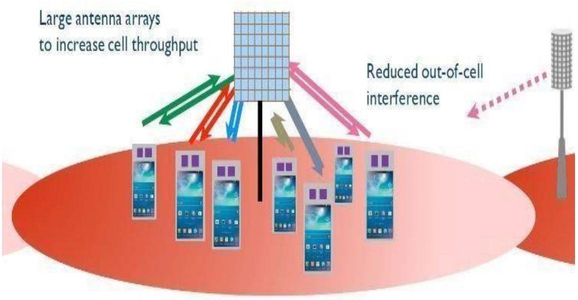

Fig.1. Massive MIMO

SIMD (Single Input and Multiple Data):

The main purpose of SIMD is to apply the sequence of data to a huge number of distinct data streams. Here every instruction uses the number of processing elements (PEs) and these SIMD is a type of parallel processing. In SIMD processors as two types one is an array processor and other is vector processor. Whereas an array works on time basedand vector works operates on multiple data elements in consecutive time steps.

II. 5G CELLULAR NETWORK ARCHITECTURE

Current technologies like OFDMA will work for next 50 years. In wireless cellular network architecture, for a mobile user to communicate inside or outside, an outside base station is present in the middle of the cell which helps in communication. If the inside users need to communicate with the outside base station, the signals will have to travel through the walls of the indoors, and this results in very high penetration loss, with high cost and reduced efficiency, data rate, energy efficiency. To overcome penetration loss through the walls of the building massive MIMO technology is used, this is implemented using multiple antennas. To construct a large MIMO network, firstly the outside base station will be fitted with large antenna and among them some are dispersed around the hexagonal cell and linked to the base station through optical fiber cables. The outside users will be fitted with certain number of antenna units which cooperate with large virtual massive MIMO links. Secondly, each building will be installed with large antenna arrays from outside to communicate with outdoor base station with the help of line of sight components. The wireless point inside the building is connected with large antenna arrays through cables in order to communicate with indoor users. This increases the energy efficiency, cell average throughput, data rate, and spectral efficiency.

III. RELATED WORK

Design of Massive MIMO Matrix Inversion Kernel Algorithm on SIMD Processor:

In this section, a fast-complex matrix inversion algorithm is proposed on SIMD instruction processor. Frist step is to select a suitable algorithm for matrix inversion, this algorithm should satisfy the SIMD architecture. Gauss- Jordan Elimination method is used as it provides the low computational complexity and exception accuracy. But at same time its data access and storage modes are quite appropriate for the parallelism of SIMD.
For 5G kernel algorithm, Gauss-Jordan Elimination method is used for performing the matrix inversion and steps are as follows:

- Find pivot, note the positioned row and column of pivot
- Exchange the column and row
- Perform the reciprocal of the pivot, and then make linear transformation of row/column
- Interchange row and column and recommence pivot location selection.

A. SIMD instruction mapping

Here, first select the pivot by determining the maximum value of complex element in each row. This can be achieved by using TMAC instruction repeatedly. Next calculate the reciprocal of the complex number using parallel polynomial estimation method also use TMAC2. Then swap the row and column by means of multiplication and subtraction of the parallel complex numbers using CMAC and CMUL instruction.

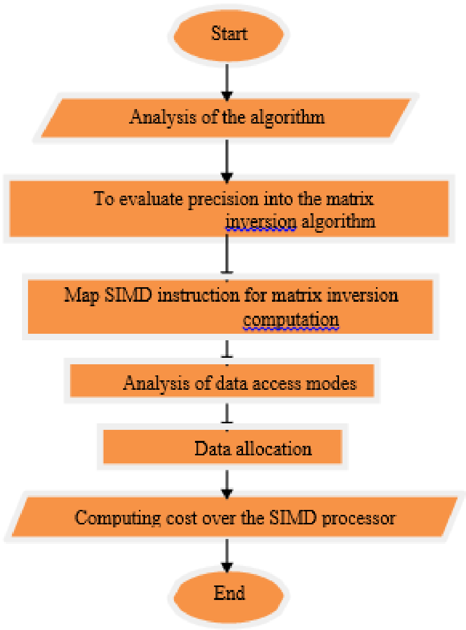

Fig.2.Flowchart of the massive MIMO matrix inversion algorithm

There are five types of accessing modes for matrix inversion. In the first mode each element from the earliest row to the last row is accessed by the processor in order to select the pivot element of each row. In the second mode, row and column will be interchanged depending on exact pivot position. In the third mode, it will not access the row of the current pivot but it will analyses the outmost loop of computation. In fourth mode it will access the column. Whereas in fifth mode data will be allocated to SIMD.

B. Data allocation in SIMD

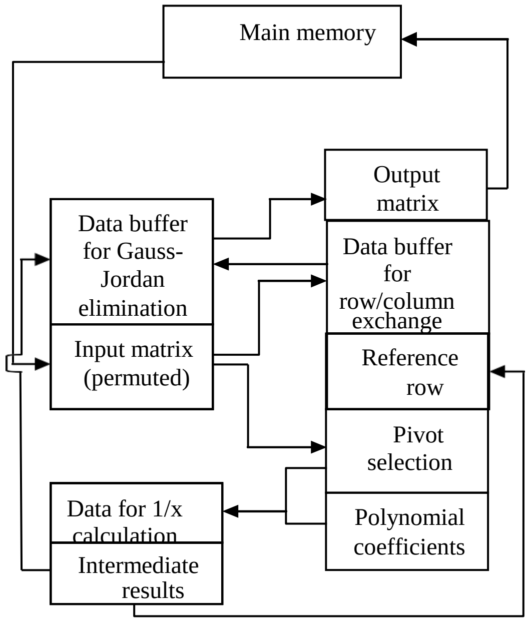

Fig.3. Data allocation in SIMD

SIMD processor allocates two vector memories for the calculation of matrix inversion. This vector registers are used to performs the complex value multiplication and subtraction also it performs the reciprocal of pivot, these all are done in intermediate steps. Here original input and output matrix is stored in main memory. Input matrix will performs some operations such that it calculates the square of the complex number, pivot selection and inverting the pivot value are stored in polynomial coefficient. To swap the row as well as column we use data buffer and register buffer as temporary storage which is used to calculate the reciprocal of complex number. In vector memory two final output result will be stored in SIMD processor also number which is eliminated in each row is stored in data buffer.

IV. MM WAVE MASSIVEMIMO

Mm Wave massive MIMO will be utilized in a technologies like machine to machine (M2M), Internet of vehicles (IoV), device to device (D2D), backhaul, small cell etc., where these technologies will be integral part of 5G wireless network. Massive MIMO provides capability for enhancing capacity, SE and energy efficiency. In the other hand the intended frequencies suffer from higher path loses. Whereas in Mm Wave massive MIMO systems, the beamforming uses a large antenna array to compensate path loses with directional transmissions. Beamforming is a procedure, which steers, the majority of signals generated from an array of transmit antennas to an intended angular direction. In pure digital beamforming, the processing for beamforming is done using a digital signal processor, which provides greater flexibility with more degrees of freedom. Also these requires a separate RF chain for each antenna element, which results in a complex architecture and high power consumption. In analog beamforming, the antenna weights can either be applied using time delay elements or shifting the signal before RF up-conversion or after the up-conversion stage. Based on advantages and disadvantages of analog beamforming and digital beamforming, there is a growing interest that hybrid beamforming is a suitable architecture which can exploit large mm wave antenna array with reduced architecture.

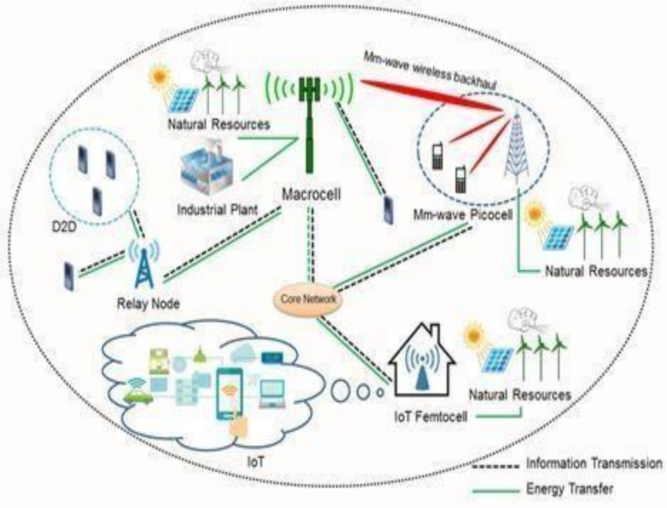

Fig.4. Mm Wave massive MIMO beamforming applications

V. SURVEY

However, with an explosion of wireless mobile devices and services, there are still some challenges that cannot be accommodated even by 4G, such as the spectrum crisis and high energy consumption Wireless system designers have been facing the continuously increasing demand for high data rates and mobility required by new wireless application and therefore have started research on fifth generation that are expected to be deployed beyond 2020. Massive multiple inputs and multiple output (MIMO) is a technology for sustaining evolution towards 5G because it provides multiple orders of spectral efficiency gains over current LTE technology. 5G technologies are likely to appear in the market in 2020. It is expected to significantly improve customers Quality of Service in the context of increasing growth of data volume in mobile networks and the growth of wireless devices with variety of services provided. Some general trends related to 5G can be explained in terms of machine to machine traffic and number of machine to machine connections in mobile . Based on the projections as shown in Fig. below, in 2018 the number of machine to machine (M2M) connections in the networks of mobile operators will surpass 15 billion , which is 2 times more than the present rate, and in 2022 mobile operators will have more than 26 billion machine to machine connections.

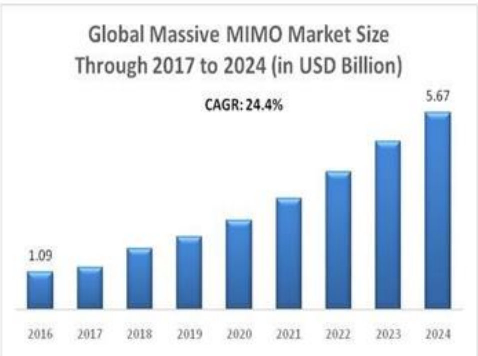

Fig.5. Evolution Speed of Massive MIMO

The more the BS antennas used, the more the data streams can be released to serve more terminals, reducing the radiated power, while boosting the data rate. This will also improve link reliability through spatial diversity and, provide more degrees of freedom in the spatial domain, and improve the performance irrespective of the noisiness of the measurements. In addition, because massive MIMO systems have a broad range of states of freedom, and greater selectivity in transmitting and receiving the data streams, interference cancellation is enhanced. BSs can relatively easily avert transmission into undesired directions to alleviate harmful interference which, leads to low latency as well. In addition, massive MIMO makes a proper use of beamforming techniques to reduce fading drops; this further boosts signal-to-noise-ratio (SNR), bit rate and reduces latency.

VI. CONCLUSION

This paper presents the results of a detailed survey on the 5G cellular network architecture and performance requirements of 5G wireless cellular communication systems that have been defined in terms of capacity. Massive MIMO is an innovative technology that helps in the achievement of higher system throughput and reliable transmission for 5G and beyond wireless networks. In this paper, we discussed major elements of massive MIMO networks There are many interconnected design issues that need to be properly understood and solved before widespread deployment of the massive MIMO technology. Several open research challenges are still facing the progress and development of this emerging technology. As detection becomes harder when the number of BS antennas increases, more advanced signal processing methods are required for better detection and are associated with introducing low complexity optimum and nonlinear detectors, and precoders to improve the performance and reduce the computational complexity.

VI. REFERENCES

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