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Intelligent Future Wireless Networks Driving Energy Efficiency

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Abstract

The advancement of wireless networking solutions represents a significant trans-formative step, as devices can now be fully networked despite the fact that they are not physically connected with cables. With the rollout of new-sophisticated radio technologies and increased data traffics, the wireless networks are consuming more energy. These networks are also becoming responsible for CO2 emissions in the ICT industry. To address this problem, this paper focuses on the necessity of considering the energy efficiency of wireless networking protocols. We have described several energy efficiency measures usually applied in wireless networking and protocols and implementing these measures according to their applications and environment would result in better throughput. Now a days the concerns regarding energy efficiency of wireless devices have become more significant than before for the users. There are ample reasons for the need of having more energy efficiency in wireless devices, but most of them are concerned about green technologies, system design, reduction in business costs and finally the satisfaction of the user. By having an intelligent wireless network which drives energy efficiency we can drastically improve the overall condition.

Keywords: Energy Efficiency; Wireless Networks; Wireless Networking Protocol; Green Technology.

1. Introduction

With the advancement in technology in the telecommunication sector the number of smart devices is increasing tremendously. The number of mobile subscribers has increased to 4.77 billion in 2017, which started off with about 34 users in 1993.It is said to reach a 5 billion mark by 2019.With the increase in such devices, there is more demand of the radio spectrum and hence the number of base stations would drastically increase. It is also difficult to meet the spectrum requirements with the ever-growing application demands of wireless sensor networks. Wireless sensor networks have become an integral part of today's world used by various organizations throughout the world. Since each sensor node is powered up by battery the main task is to reduce the energy consumption of each node. This will lead to an efficient usage of the power for various applications and thereby reducing the carbon emission levels [1]. So in this paper we have described different methods for reducing power consumption of the network there by increasing energy efficiency.

2. Heterogeneous Networks

Network planning has become very essential today. The limited radio spectrum has to cater the needs of a humungous amount of users and the traffic they carry. The shortcomings have been replaced by new antenna mechanisms and modulation techniques. The main aim is to provide the best experience to the user at any point of time while reducing the cost also. Here the capacity is also increased by introducing new bands. One way to expand an existing macro-network is by adding more sectors per eNB or deployment of many more eNBs, while maintaining it as a homogenous network. Since finding the new macro sites is quite cumbersome and expensive, reducing the site to site distance in the macro network is feasible. Another method is to introduce small cells through the addition of Remote Radio Heads (RRH) or base stations that are low powered to the already working macro-eNBs. With the use of such equipment, acquisition of sites becomes much simpler and economically viable. Small cells are primarily added at places with higher user demand to increase capacity in hot spots and to fill in areas not covered by the macro network – both outdoors and indoors. By offloading from the large macro-cells, they also improve service quality and network performance. The result is a heterogeneous network with large macro-cells in combination with small cells providing increased bitrates per unit area [2]. Operators have added small cells and have integrated them with corresponding macro networks in order to spread traffic loads, maintain service quality and enhance performance while reusing spectrum most efficiently.

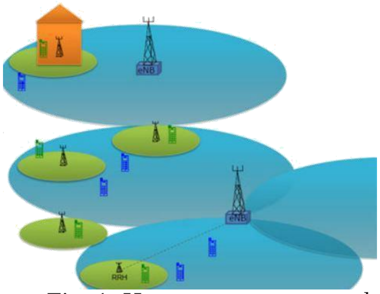

Fig. 1: Heterogeneous network

3. Cloud Ran

Cloud RAN is wireless networking solution that supports all the previous versions 2G, 3G, LTE and the future generation wireless networks [3]. China Mobile Research Institute introduced cloud radio area networks in April 2010 to maintain the growth in mobile communication. The name emphasizes on "Clean, Collaborative radio, Centralized processing and a real-time Cloud Radio Access Network ". This architecture has the ability to handle as many base stations using virtualization technique. It uses the, low cost Dense Wavelength Division Multiplexing technology, CPRI standard and mm Wave to allow broadcast of baseband signal over lengthy distance thus accomplishing large scale centralized base station deployment.

A. Base station with RRH

In Remote Radio Head architecture there are two units, a radio and a signal processing unit. The signal processing unit is called the BBU and the radio unit is called as RRH or Remote Radio Unit. RRH can performs several task such as digital to analog conversion, digital processing, analog to digital conversion, filtering, and power amplification [4]. This network architecture is used by most of the base stations. In comparison of the traditional architecture BBUs can be placed anywhere and hence RRH can be placed over places like rooftops. This helps in better cooling of RRH and hence saving energy.

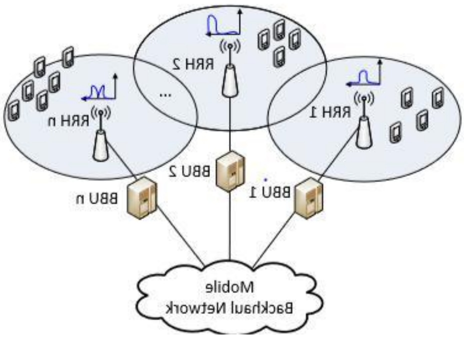

Fig. 2: Base station with RRH

B. Centralized base station architecture

In this design the optimization is done by centralizing the BBUs into one group the BBU pool/DU pool. This will cater to the efficient connectivity between lightly and heavily loaded base stations.[5]These BBU pools are shared among the cell sites and it is done using virtualization. To perform baseband processing it mainly consists of general purpose processors. Centralization allows better utilization of resources and traffic handling. Such architecture allows high reliability, low cost, high bandwidth and low latency interconnect network in the BBU pool. Since base stations will be located on the same physical device it reduces the energy and power consumption

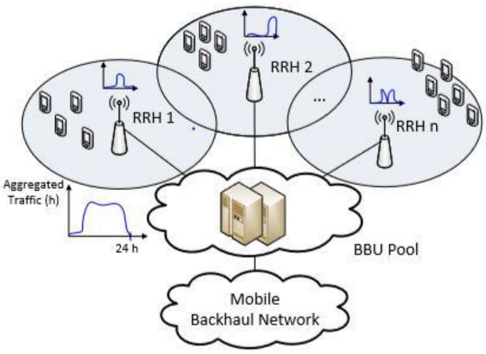

Fig. 3: Centralized base station architecture

Thus, C-RAN has become an important topic for research and development. [6] According to public information, an MoU has been signed by companies like ZTE, Intel, IBM and other companies. Consequently many companies have joined in developing CRAN systems which helps both micro and macro cells.

C. Advantages

Deployment of C-RAN has a very high potential in cost reductions of electricity as the number of BBUs are few compared to the normal RAN. Cooling of the network is an important factor that leads to about 47% of energy consumption. However, in C-RAN the usage of RRH has lead to significant decrease in cooling resources as RRH's are naturally cooled devices. China mobile has estimated about 71% of energy savings in comparison with traditional RAN. The greatness of C-RAN lies in the versatility of its architecture. LTE released by 3GPP is the current generation mobile network, which can be deployed in C-RAN architecture. The pooling of BBUs helps signal processing to be done over one pool there by reducing transmitting and processing delays. C-RAN can be deployed in metropolitan areas. The users who are continuously moving will benefit from the multiplexing gain of the network. However, the BBU pools would facilitate better for such areas. In Mobile networks small cells are employed in macro cells to increase the capacity of the network and its quality in regions where the mobile traffic is large. A user accessing a small cell coverage switches to the macro cell coverage as he moves. This involves an effective coordination between the two types of cells and energy consumption. So, if such small cells are deployed in C-RAN then it results in drastic reduction of signaling resources as they will be controlled by a single BBU pool. Thus C-RAN has the prospective to reduce operation cost and improve system, mobility and coverage performance as well as energy efficiency.

4. Energy efficient wireless sensor networks based on beacon synchronization

The wireless sensor networks (WSNs) uses a number of nodes deployed at the area of interest to get the desired result. All these nodes are often required to synchronize with the clock. It is unavoidable in some cases to synchronize clocks with nodes and also it is important for efficient channel access. There are several efficient synchronization schemes available which roots for the clock precision. Guard Beacon is one such synchronization scheme which focuses on optimization of clock synchronization instead of clock precision. Guard beacon is not just about synchronization but also helps reduce the idle listening window. This is done by sending the beacon signals in an optimal time period. This arrangement saves up to 40% of synchronization power consumption. But there are other asynchronous events which are needed to be carried out such as alarm. Alarms are detected by listening to the idle channel all the time Alternatively, wake up radio can be used. An inexpensive radio is always listening to the propagation of alarm. One drawback of such method is short range of radio signal.

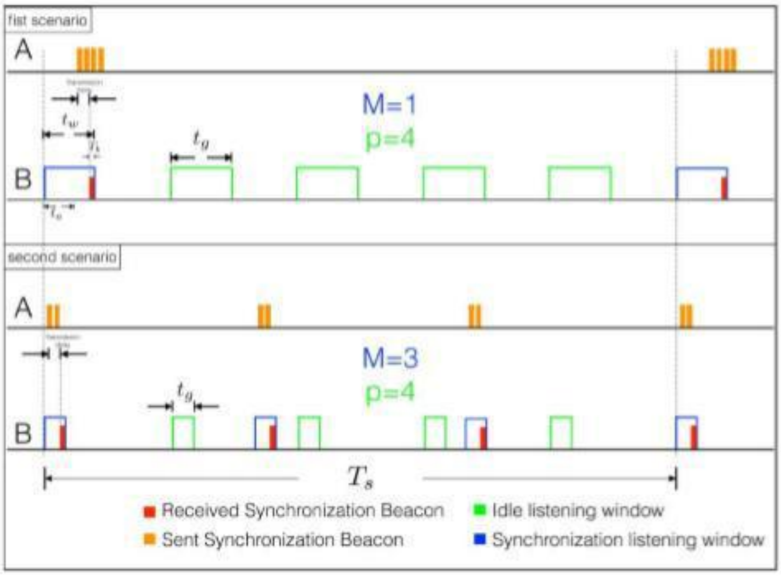

Fig. 4: Scheme of increasing the synchronizations

5. Wireless Sensor Networks Driving Energy Efficient Routing

The sensor nodes require continuous power sources which cannot be replaced or recharged. So, many cluster base energy conservation techniques have been used to optimize the energy usage. The main concern is the data aggregation and energy conservation in making clusters. EER (Energy Efficient Routing) is the technique to estimate the optimal size of the cluster and data aggregation along with routing in an efficient manner. In the proposed method each network node is identical in structure. These nodes have to be energy efficient and hence various energy conservation techniques are used. One such technique is Cellular Automata. This maximizes the lifespan of a node. This can be achieved by keeping some nodes in active while some nodes in standby mode**.** The dynamic nodes make cluster with the aid of CA scheme without signal passing. Productive routing technique is employed here.

6. Bluetooth Protocol

In numerous wireless networking applications mainly in communication, we want the devices to have the ability to obtain some genuine information. However, amid utmost time, we needn't bother about devices to work at full capacity. Therefore, the devices just needs to communicate very little information during rest/sleep mode and might require communicating substantial information during active mode. If there are demands of transmission, the communicating protocols can intelligently change into active/sleep modes and use energy wisely, we can save substantial amount of energy since the devices which operate under sleep mode, usually requires very less amount of energy compared to the active mode. This is possible because in rest mode the device only maintains some basic communications that is required and turns off other applications that are not required. This can be accomplished by utilizing Bluetooth protocol. Since Bluetooth's main concern is the battery life of the peripheral devices, this protocol consists of many rest modes than active/rest modes. The connected mode which is Bluetooth protocol, is the same as active mode in different protocol. [7] It can transmit both in synchronous and asynchronous connections and has a 3 bit dynamic part address. There are 3 sorts of rest/sleep modes in Bluetooth

Park mode:- In this the device surrenders its 3 bits active part address and gets 8 bits park address, and wakes up and tunes in to signals of beacons.

Sniff mode: - In this the device will not talk but only attends to the master for each fixed internal of time.

Hold mode: - In this the device retains 3 bit dynamic part address and expresses just in synchronous association arranged and not the asynchronous association.

Modes	Address	Communication	Max sleep period
Connected	3 bits Active member address	Both synchronous and asynchronous	NA
Hold	3 bits Active member address	Only synchronous	500ms
Sniff	3 bits Active member address	Only listen after a fixed Sniff interval	50ms
Park	8 bits Park address	Only listen to beacon after a period	10s

Table 1: Modes in Bluetooth.

Thus the device can save a lot of energy by utilizing distinctive sleep modes in Bluetooth protocol, accordingly to the demands of communication.

7. Cooperative Mimo

To increase the throughput and the efficiency of the energy, one powerful way is the cooperative MIMO. This is achieved by the collaboration of the antennas which works individually together which forms as a multi antenna system. CMIMO, otherwise called virtual MIMO/distributed MIMO/network MIMO gives noteworthy gains in terms of flexibility. It additionally gives higher bit rates and energy gains. In the traditional point to point MIMO, each wireless device needs to have multiple antennas at the transmitter and multiple antennas at the receivers. But because of cost, equipment restrictions and little size of the sensor devices, referred to as a node, it can be hard to incorporate multiple antennas in such nodes. Because of this restriction, conventional MIMO frameworks can't deliver the expected performance, and hence the concept of cooperative multiple input multiple output (CMIMO) implemented by cooperation of individual antennas, takes care of the size confinement issue. [8, 9] In cooperative MIMO each node will have only one antenna and each of these antennas are located in the different areas. These distributed nodes achieve higher spatial diversity gain by forming virtual antenna array. The communication between the transmitter and receiver proceeds in three phases, the first stage is about data sharing and cooperative transmission. Enabling of the individual data transmission is done by collecting the information from the others. In the second phase, all the nodes or selected nodes cooperate together to form a computer-generated MIMO system over different techniques such as distributed space time block coding or repetition. Then synchronously they transmit towards the destination group. In the third phase the receiver nodes will send the signals to the destination which combines the entire signal. In this way, through distributed algorithms without an inherent infrastructure, the antennas can handle the controls that are necessary. They perform the communication tasks by their own [10]. An example of the cooperative MIMO transmission is shown.

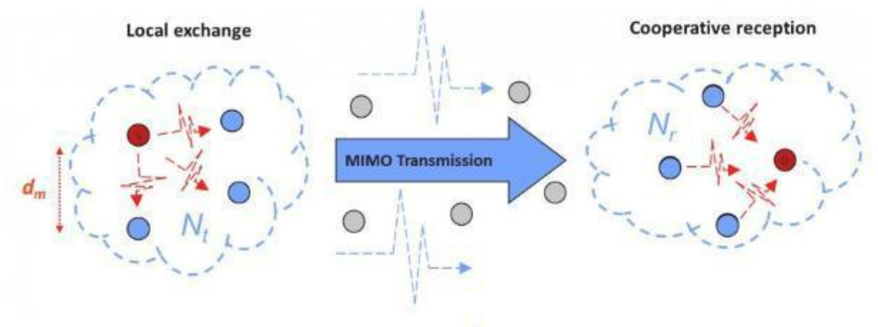

Fig. 5: CMIMO transmission

Thus by using Cooperative MIMO system, entire energy depletion and the total delay can be reduced significantly compared to the single input single output system.

8. Conclusion

In this paper, we have researched about various methods in wireless technology, which are efficient for current day networks. We feel that the above methods described are very efficient. Since current day network has some major drawbacks, by using these methods we can effectively improve the efficiency of the network. Each method has its own advantages and disadvantages, so when we consider the combination of different such methods then the power consumption reduces and thus increases the efficiency.

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