A Heterogeneous Cellular Communication System for Moving Users: A 5G Prospective

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Abstract
The Fifth Generation Communication (5G) system is has the several unique feature like: Massive Multiple Input and Multiple Output (MIMO), Device Centric Communication, Smarter Device-to-Smarter Deice, Native support for Machine-to-Machine Communication and Millimeter wave communication. The expected target for 5G network to achieve the 1000 times more system capacity, 10 times higher spectral efficiency, 100 time more energy efficiency than current network technologies, high data rate (i.e., peak data rate of 10 Gb/s for low mobility and peak data rate of 1 Gb/s for high mobility), and 25 times more average cell throughput with peak consideration of the cost and reliability of the system. The users mobility leads to the handover of device in the neighbor area, it cause the poor connection reliability and high communication cost with risk of connection loss. To address these challenges we are proposing a base station centric Device-to-Device (D2D) communication system, for overlapping area in 5G networks. The multiple signals from Base Station refers to overlapping coverage area, and user must be handover to next location area (LA). For the same we are suggesting the user centric communication (without Base Station (BS) interface) to handover the device in adjacent area, until the users finalize the communication. The suggested method will reduce the signaling cost and overheads for the communication.

Key words: 5G, Device-to-Device Communication, Signaling Cost, Overheads.

1. Introduction

The modern cellular network using the Fourth Generation (4G) and Long Term Evolution (LTE) technologies and users are demanding more attributes over them. Its looks dust around 4G begins to settle, attention is now slowly turning towards future 5G technologies. A key feature of 4G, is its ability to support high data rate (up to 1 Gbit/s) on the downlink [1-5]. There are already simmering interests in beyond 4G technologies, and the industry is starting to fund projects looking into such technologies. However, the industry's view of the future wireless standard is mostly focused on data rates and efficiency. A 5G approach must be able to efficiently support different traffic types, which all have to be part of future wireless cellular systems. The vision of a unified frame structure concept, depicted by several authors and their main aims to handle the large set of requirements in a single 5G system. The 5G of wireless/mobile broadband technology has the properties of numerous devices support, network interconnection and high traffic throughput[2-6]. The heterogeneity is a feature that is expected to characterize the emerging wireless world, as mixed usage of cells of diverse sizes and access points with different characteristics and technologies. In order to provide the new technology for 5G network we must be respect, looking forward to introduce the intelligence is major issue, and it is continuously observed by research community. Intelligence can be provide in the terms of energy and cost-efficient solutions at which a certain application/service/quality provision is achieved. Particularly, the introduction of intelligence in heterogeneous network deployments and the cloud radio-access network (RAN) is investigated by [1]. Apart of it the 5G the main attributes of 5G technologies has main contributory areas like: Massive MIMO, Device Centric Communication, Smarter Device-to-Smarter Deice, Native support for Machine-to-Machine Communication and Millimeter wave communication[2,4,7,8,9,11,12]. The massive MIMO of the key point in 5G network, for the same enormous enhancements has been made to achieve the spectral efficiency, and it was not possible without the increased BS densification. It was the possibility as is always the case of trading some of those enhancements off for power efficiency improvements. The smoothed out channel responses was mandatory, because of the vast spatial diversity, which brings about the favorable action of the law of large numbers. In this paper we are focusing about the a device centric communication to support the 5G networks and it has been derivate from Device to Device (D2D) communication. Here we addressing the D2D feature of the future communication networks. There are some technologies like: WiFi or Bluetooth used to provide some D2D communication functionality. However, they work on unlicensed band, and their interference is uncontrollable. In addition, they cannot provide security and quality of service (QoS) guarantee for PCS networks. The D2D working group don't want to lose the emerging D2D market, the cellular operators and vendors are exploring the possibilities of introducing the D2D communication capability into cellular networks, which has sparked interest in this topic. Some recent works on D2D in cellular systems have reported results on interference management issues and radio resource allocation as well as on communication session setup and management procedures [10-13].

With the above discussion we can conclude the motivation for the 5G networks as follows to achieve the high data rate refers to the total amount of data the network can serve, characterized in units of bits/s/area and we are targeting roughly 1000x more than 4G to 5G. The low edge rate (5%), is the worst data rate that a user can reasonably expect to receive when in range of the network, and it is an important metric and has a concrete significance. The objective for the 5G edge rate range from 100 Mbps to as much as 1 Gbps. The peak rate is the best-case data rate that a user can hope to achieve under any conceivable network configuration. The peak rate is a marketing number, devoid of much meaning to engineers, but in any case it will likely be in the range of tens of Gbps. To achieve the said theme, we propose a mechanisms for D2D communication session setup and management procedures in the cellular system architecture and we present numerical results based on system simulations in an interference limited local area scenario. Our results show that D2D communication can increase the total throughput over the traditional techniques.

Rest of paper has been organized as follows. In the section 2 we are discussing the proposed D2D communication system. The section 3 deals with the performance analysis of the proposed work and section 4 conclude the works and followed by list of references.

2. The Proposed Work

In this section we are a introducing a new technique D2D communication system for the 5G networks. In order to support the support 1000x higher throughput, 5G cellular networks working group are must be achieve less latencies, lower energy consumption, lower costs, and support many low-rate connections. The low energy consumption and cost can be deal by less signaling cost. In this section, we discuss important ongoing research areas that support these requirements. We begin with the most fundamental aspect of the physical layer—the waveform—and then consider the evolution of cloud-based and virtualized network architectures, latency and control signaling, and energy efficiency.

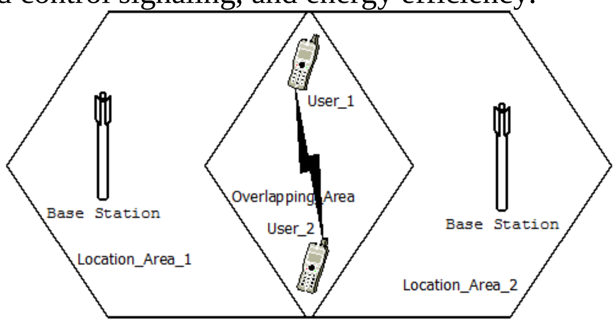

Figure 1: Device-to-Device Communication in the Overlapping cell: A 5G Approach

I order to overcome these issues we are proposing a novel technique for device centric communication in 5G paradigm, and it has following steps(as shown in Figure 1).

- The User Equipment (UE) initiates the call.
- The associated BS used to start the communication and put an effort to the request packet to Base Station Controller (BSC) or Mobile Switching Centre(MSC). The MSC/ BSC used to setup a call between the UE and Corresponding Node (CN).
- The UE starts the communication with the help of the BS.
- The network compute the position of the UE and CN.
- If the UE and CN are in the neighboring cell or the overlapping area the MSC will transfer the call to D2D communication system. In the most of the case of they must be receive the signals from multiple BS, now days cells are very small and they have radius of few meters like LTE.
- This handover will take place with respect to signal strength. It can be conclude that the proposed work will reduce the signaling overheads and cost and also lead to green communication.

3. Performance Analysis

In this section we will compute the performance of the proposed work. It is has been observed that the proposed scheme has the less signaling cost and we are evaluating the same. Here we are comparing our scheme with the traditional scheme of cellular communication like 4G and LTE scheme.

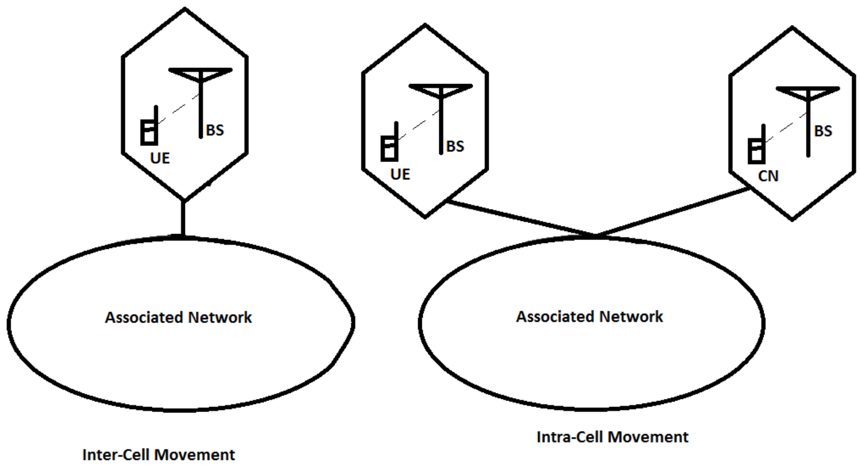

Figure 2: The User Movements

The performance analysis of the proposed work has been calculated by some mathematical symbol and they are mention in Table 1.

Symbol	Description
η	Proportionality constant
ν	Per unit per association lookup cost
χ	Liner Coefficient of LM
$\lambda_{CALL}/\lambda_{cell}$	Average number of call to a target MT per unit time in a LA/cell, is a Poission distribution random variable rate
T_C / T_P	Transmission Cost/ Processing Cost
SR_{RREQ}/SR_{RREP}	Size of Route Request and reply message for LU
ϖ / ϕ	Per hop LU/ Binding transmission cost.
d/S	Distance threshold/ Area of cell
δ	Per Location database lookup cost

Table 1: Symbol and Their Description

The signaling cost is depends on several factors and but not mainly on: hops counts, bandwidth consumption and number of active user per location area. In this paper we are considering the performance of the proposed works on the basis of said factors. The user movement can be classify in Inter cell movement and intra-cell movement (as shown in Figure 2). The signaling cost of each of them can be computed as.

Intra-cell: The total signaling cost can be classify as UE to BS, BS to MSC/BTS, MSC to MSC, MSC to BS(target), BS to CN.

Inter-cell: The total signaling cost can be classify as UE to BS, BS to MSC, MSC to BS(target), BS to CN.

The signaling cost can be computed as hop by hop of the proposed technique, and it can be calculated with every threshold distance "*d*" for the overlapping signaling strength. The signaling cost is depends on three components they are: signaling cost to travel the signal, binding cost for data packets, packets delivery cost.

The singling cost for travel incurs with the transmission cost and processing cost based on per unit of distance, and it is proportional to number of the UE. Then the cost per unit of distance can be computed as: $C_T^d = N_{UE}\frac{T_C + T_P}{d}$

It is observed, the all MSCs are interlinked with wired medium and they will follow the medium access control (MAC) protocol. So, proportionality constant, number of hops, per hop transmission cost has the dependency to calculate the T_C.

So,

$T_C = 2(h-1+\eta)\varpi$ and

$$C_T^d = N_{UE} \times \frac{2(h\text{-}1+\eta)v + T_P}{d}$$

Similarly, we can calculate the binding update cost

$$C_{BU\text{-}T}^d = N_{UE} \times N_{CN} \times \frac{B_{UC}}{d}$$

Where,

$$B_{UC} = 2(h\text{-}1+\eta)\varphi$$

So,

$$C_{BU\text{-}T}^d = N_{UE} \times N_{CN} \times \frac{2(h\text{-}1+\eta)\varphi}{d}$$

The packet delivery cost can be computed as

$$C_{PD\text{-}T}^d = N_{UE} \times N_{CN} \times \nu$$

Where,

$$\nu = \frac{\delta\lambda_{CALL}}{S} = \frac{\chi\, N_{UE}\, \lambda_{CALL}}{S}$$

So,

$$C_{PD\text{-}T}^d = N_{MT}^2 \times N_{CN} \times \frac{\chi\, \lambda_{CALL}}{S}$$

Then the per unit signaling coat can be computed as

$$C_{Signal} = \left(C_T^d + C_{BU\text{-}T}^d + C_{PD\text{-}T}^d\right) \times \left(SR_{RREQ} + SR_{RREP}\right)$$

$$C_{signal} = \left(N_{MT} \times \frac{2(h\text{-}1+\eta)v + T_P}{d} + N_{UE} \times N_{CN} \times \frac{2(h\text{-}1+\eta)\phi}{d} + N_{UE}^2 \times N_{CN} \times \frac{\chi\, \lambda_{CALL}}{S} \right)$$
$$\times \left(SR_{RREQ} + SR_{RREP}\right)$$

Here the C_{signal} represents the per hop signaling cost and we are assuming that the intra-cell and inter-cell has at least 4 and 5 unit of signaling cost respectively. Now we are taking the average of the duration of the transmission of data packets is 2 minutes. So the signaling cost of the network can be computed as

$$C_{\text{Signal}}^{\text{Traditional}} = \left(N_{MT} \times \frac{2(h\text{-}1+\eta)v+T_P}{d} + N_{UE} \times N_{CN} \times \frac{2(h\text{-}1+\eta)\phi}{d} + N_{UE}^2 \times N_{CN} \times \frac{\chi \ \lambda_{CALL}}{S} \right)$$
$$\times \left(SR_{RREQ} + SR_{RREP} \right) \times \left(D_p \times 120 \right)$$

In our proposed scheme the first data packet will follows the same path as the traditional scheme later, later it will be setup a D2D communication path so we can compute the same equation as follows. The most remarkable point is that it is a one to one communication and it will refers the $N_{UE} = N_{CN} = 1$.

$$C_{\text{Proposed}} = \left(N_{UE} \times \frac{2(h\text{-}1+\eta)v+T_P}{d} + N_{UE} \times N_{CN} \times \frac{2(h\text{-}1+\eta)\phi}{d} + N_{UE}^2 \times N_{CN} \times \frac{\chi \ \lambda_{CALL}}{S} \right)$$
$$\times \left(SR_{RREQ} + SR_{RREP} \right) \times \left(D_p \right) + \left(\frac{2(h\text{-}1+\eta)v+T_P}{d} + \frac{2(h\text{-}1+\eta)\phi}{d} + \frac{\chi \ \lambda_{CALL}}{S} \right)$$
$$\times \left(SR_{RREQ} + SR_{RREP} \right) \times \left(D_p \times 119 \right)$$

Now we will check the efficiency and effectiveness of the proposed work in simulation. For the same we has been create a simulation setup using MatlabR2014a. The initial parameters set are as follows. There are 5 users in the cell and they are communication to CN. The average hop distance between the caller and called users is 5. The minimum threshold value of handover is 50 meters. The transition probability constant is 0.02. size of route request and route reply packet size is 256 byte, and size of data packet has also same size. Initial transmission and processing cost is assumed as 0.02 units. The area of the each cell is 500 m^2.

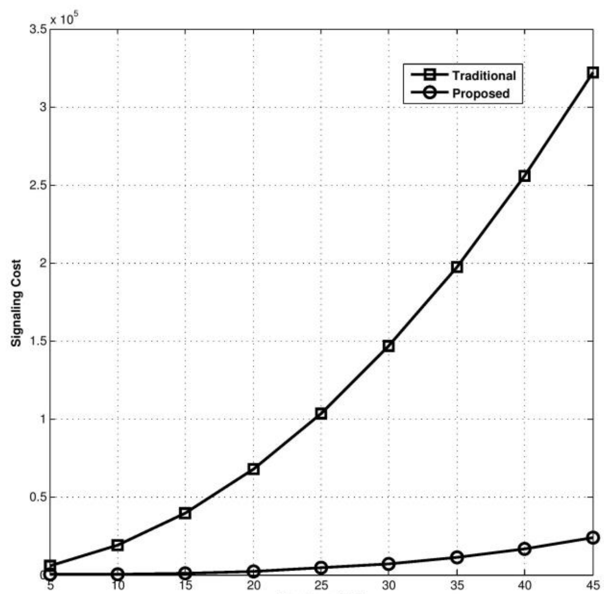

Figure 3: Signaling Cost Vs Number of UE in a cell

Figure 3 shows the effect of number of mobile user in a cell and they are varying to communicate the corresponding nodes. Here the number of UE are varying from 5 to 45, and same refers to number of CN. It has been observed that the once the user are increasing the overall cost will be increases but in the proposed work it will be very less. Because the first packet will routed via BS rest of the data packet will move through D2D system.

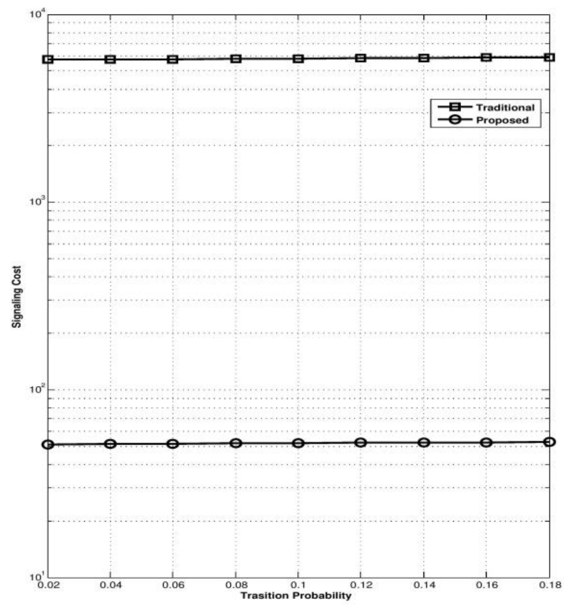

Figure 4: Signaling Cost Vs Transition Probability of UE in a cell.

Figure 4 refers the effect of transition probability (user mobility) of the mobile user in a cell and they are varying from 0.02 to 0.18. Here the number of UE is 5, and same number of CN. The effect of user mobility is almost independent to the overall signaling cost because, if there is a user with network coverage it lead to singling cost.

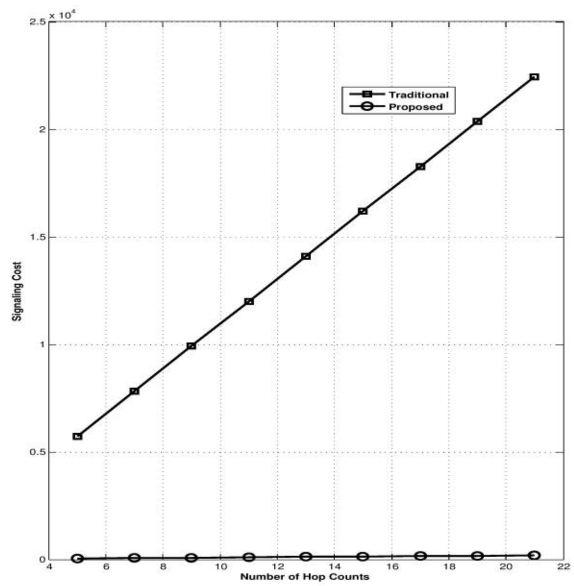

Figure 5: Signaling Cost Vs Number of Hop counts for the CN

Figure 5 shows the effect of hop count between the UE and CN. Here the hops counts varying from 5 to 21. Here the number of UE is 5, and same number of CN. It has been observed that the once the user are increasing the overall cost will be increases but in the proposed work it will be very less. Because the first hops towards the call will lead to signaling cost rest packet will not affect the same.

4. Conclusions

In this paper we have proposed a device to device communication system for 5G communication system. When a mobile user used to receive the multiple signals for multiple cells then the user should be handover to adjacent or neighbor cell, and this process lead to signaling overheads. To overcome the same issue we are suggesting to start the device to device communication in the overlapping area. The initial phase of the communication is network centric communication and after that it will handover to user centric mode. The performance analysis of the proposed work shows the effectiveness and efficiency of the work and it has been observed it has significant improvement over the traditional system.

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