Cooperative Cloudlet for Pervasive Networks

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Abstract – *The notion of cooperation in wireless communication has got significant attention from both academia and industrial persons towards to address the performance drawbacks of wireless sensor network due to reason of user's high mobility and lack of resources of network. The future wireless systems should be highly heterogeneous and interconnected because motivating cooperative relaying has to apply on the future mobile network for efficient results and future demand. As currently the mobile computing is facing latency and battery drainage issues which need to address and solve hence in this work we are proposed mobile-centric and opportunistic communication architecture. In this work mobile devices which are in the range of Wi-Fi of each other can create cluster with each other and can create an ad-hoc cooperative cloud using Relay Spot[1-4]. The Collaboration between these devices can enable them to resourcefully use the augmentation without any infrastructure.*

Keywords – *Cooperative relay, Opportunistic relaying, Wireless Management Resource.*

INTRODUCTION

In last decades the development of wireless networks is motivated because of its ability to provide communication anyplace and anytime. For the reason that the importance on the modern technological and communicative community different type's devices and services as like devices are mobile and cordless and services are communications and wifi are emerged due to its high proliferation of wireless. This use of trend and need is the main reason of novel wireless system development [5].

In the future generation wireless network there is +needed to provide the high quality performance with the high bandwidth. It means that the incremented wireless terminals with the higher system capacity are required for data rate levels. Instead wireless network gives easy network connectivity and deployment still present low performance and need to improve the performance levels for efficient use and results of wireless network. The main drawback in the wireless network is the use of shared medium network that is due to its limited resources and unstable wireless channels. The channels condition in the wireless network is subjected to fading variations and intrusion that influence the reliability and throughput in network. In this consequence the receiver might be possible that can acquire several copies of the transmitted signal and every copy can pass by a diverse pathway. This type of multi path fading can increase the errors rate in the transmission of data and required multi re-transmissions which can cause of low network throughput. Anyhow multipath fading's effect can alleviate with the use of cooperative communications. The main objective of the cooperative communication is to get the advantage wireless diversity and give this advantage to wired line communications and to wireless Multiple-Input Multiple-Output (MIMO) systems for all levels equally and efficiently.

The section II explains the concept of cooperative relaying and the section III elaborate the Relay Spot framework. In the last the section IV discusses the cloudlet based augmentations in Relay Spot.

COOPERATIVE RELAYING

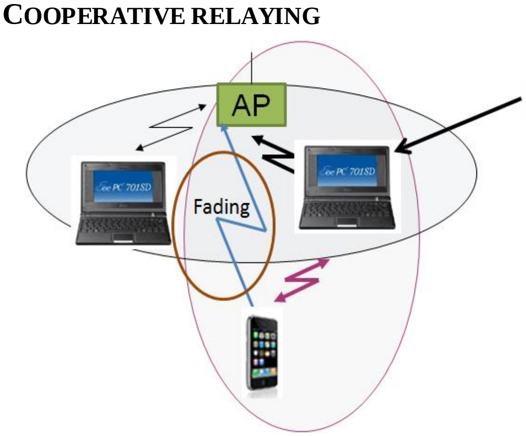

Fig. 1 relaying mitigating fading effect

Figure 1 is explaining a couple of single antenna devices that are acting as relays after sending overhead packets with its own data. It is due to statistically independence of two different devices of fading channels. It also generates spatial diversity. The figure 1 is illustrating the issues with the development of cooperative relaying systems simple scenario and several research issues. These issues also includes the network's performance impact on rely and on the whole network interference most important to a potential decrease in the network capacity and fair transmission.

Presently the utilization of link-layer diversity in cellular and multi-hop wireless networks is very vast area of research interest.

The very first step has taken in the cellular network by devise cooperative relaying systems with single-hop relays with MAC. The MAC able the system to use relays which can help in transmission from source to destination with only one re-transmission. There are normally three problems with the cellular networks interference, limited coverage and capacity scarcity. There is proposed to ease issues that communication from source to destination can be performed via relay system not only via direct transmission as shown in the Figure 2. This type of deployment yields noteworthy gains that can enhance performance of users that are capacity, coverage-limited or interference-limited [7]. Due to the networks current challenges for design of MAC protocols multi-hop network is still a complex network. The challenge for the network design and development become increase due to terminals movement in time-selective fading channels.

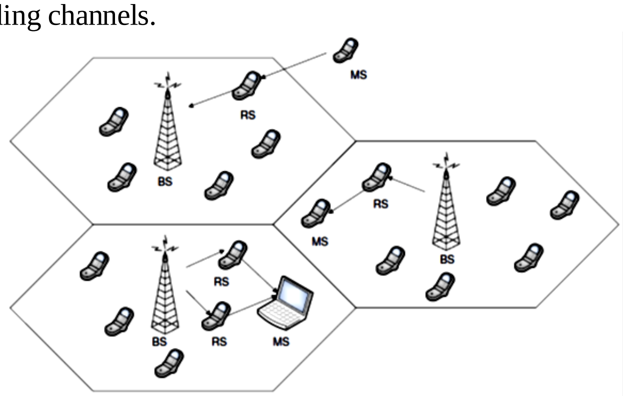

Fig. 2 Cooperative relaying in cellular networks [8]

A cooperative transmission requires unique features from MAC. These MAC Features distributes for a multipoint-to-multipoint environment. There are noteworthy issues that must be taken into account while designing cooperative diversity MAC: relay selection, cooperation decision, cooperation notification and cooperative transmission design [9]. In following section we explain the cooperative MAC protocol named Relay Spot.

A. RELAY SPOT FRAMEWORK

Relay Spot [2] is a MAC level relaying protocol comprises relay selection mechanism and cooperative transmission. Relay selection is based on local information opportunistically on spot. Cooperative transmission is further comprises of Cooperative Relay Scheduling and Chain relaying. These building blocks are described in following.

Opportunistic Relay Selection

The transfer determination handle just considers hubs that can effectively translate bundles sent by a source. This guarantees potential transfers are firmly limited with the source, with which they have great channel conditions. The capability of a hub as a hand-off relies on neighborhood data identified with hub degree, load, versatility and history of transmissions to the predetermined destination, and not to CSI.

The Equation 1 assesses the impedance level that a potential transfer is subjected to as a component of hub degree and load. Give N a chance to be the quantity of neighbors of a potential transfer, Td and Ti the engendering time of immediate and aberrant transmissions including such potential hand-off, separately, and Ni and Nd the quantity of hubs required in such roundabout and direct transmissions (circuitous transmissions are the ones caught by the potential hand-off, and coordinate transmissions are the ones completion and beginning at the potential hand-off). Adding to this, Tp is the time required for a potential hand-off to handle the consequence of an immediate transmission. The obstruction factor (I) influencing a potential hand-off has a base estimation of zero relating to no direct or indirect transmissions.

$$I = \sum_{j=1}^{N_d} (T_{dj} + T_{pj}) + \sum_{k=1}^{N_i} T_{ik}, \quad I \in [0, \infty[\qquad (1)$$

The Equation ensures that the potential transfer has a solid channel with the source and the nature of the hand-off to goal is obscure. The channel condition can likewise be assessed by the apportion of last transmission towards the goal and the present security of a potential hand-off without the estimation of CSI for the goal hand-off channel. In the condition 2 H is speaking to the history factor that assessed as proportion between the exponential moving normal of the term of effective transmissions and the most extreme span of any fruitful transmission (HM). The primary reason for the H is to illuminate that the planned transfer is probabilistically is great channel for goal without need to gauge and data of communicate channel. In the Equation 2 the M is speaking to the versatility factor that is assessed as proportion between the exponential moving normal of the delay time of the hub and the greatest recognized interruption time (MM). Here the MM is the started to a period unit. Here the M fundamental point is to choose more hubs as hand-off. The S in the condition is speaking to the determination factor for transfer as potential hub. The entire condition is utilized to choose the hub as transfer for the goal and effective transmission.

$$S = \frac{H * M}{1 + I}, \quad S \in [0, 1[\qquad (2)$$

The equation 3 is used to estimate the size of contention Window (CW). The CW_{min} and CW_{max} are representing the predefined minimum and maximum values. The selection factor (S) used to estimate the size CW after overhearing of data packet or RTS towards destination.

$$CW = CW_{\min} + (1 - S)(CW_{\max} - CW_{\min}) \qquad (3)$$

In relay group and nodes the insightful hand-off choice component offers inclination to hubs in amass give great channel condition source, low portability, low degree, low load and a decent past correspondence record from source to goal. In situations with very versatile hubs, we anticipate that astute hand-off choice will carry on superior to anything source-based transfer choice , since with the last correspondences can be upset with a likelihood relative to the portability of potential transfers, and transfers may not be accessible any longer subsequent to being chosen by the source.

a. Cooperative Relay Scheduling

In this scheduling the relays are allowed to elect them self to ignore the high interference and to make sure that the high data rates move to destination with prevention of squander of network resources. The CW processed in the above equation 3 assumes an imperative part in transfer openings scheduling.

The objective is to expand the probability of effective transmissions from relays to the destination by giving greater need to relays that are all the more firmly limited to the goal, while not disregarding the assistance that optional transfers may give. Expanding differing qualities, by enabling the destination to get numerous duplicates of a similar packet, plans to develop mistake free packets while maintaining a strategic distance from re-transmissions. In the group the next destination is estimated by receiving of more qualitative data packets from the self-elected relays.

By sending a list of need relays installed in ACKs the destination permits potential transfers to enhance the exactness of the back-off time calculation in next transmissions (relay with most astounding need sends and the other back-off however continue catching the transmission). This usefulness prompts space-time differences, which use the space assorted qualities utilized by earlier workmanship (e.g. Coop MAC). A space-time difference is accomplished by permitting the utilization of various relays after some time, helping a similar source to destination correspondence.

b. Chain Relaying

The proposed crafty relay choice and agreeable hand-off booking instruments mean to build throughput and unwavering quality, and in addition to decrease transmission delay by expanding the differing qualities changing the handing-off request. By and by, the nearness of portable hubs, and also precarious remote conditions, may require more elevated amounts of differences accomplished in view of nodes that are closed to the destination. Consequently, Relay Spot incorporates the probability of utilizing recursive hand-off determination and retransmissions if there should arise an occurrence of deprived execution. The functionality is called chain relaying (c.f. Figure 3).

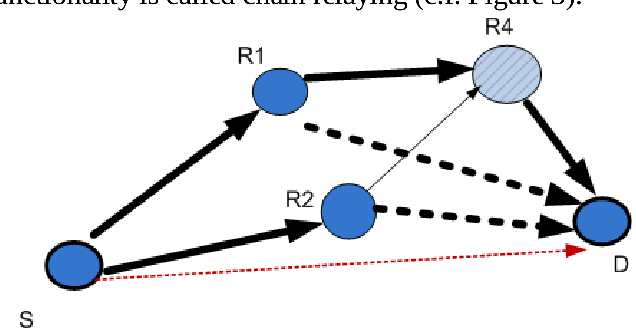

Figure 3 Chain relaying.

CLOUDLET BASED RELAY SPOT

Since the mobile cloud computing was suffering from latency and battery drainage issues due to WAN, Idea of cloudlet was proposed to overcome these issues.

Consider the scenarios like battle field where group of soldiers has mobile devices, devices need to be augmented to allow soldiers to perform compute intensive task like real time object recognition but there is no infrastructure available. Natural disaster destroys infrastructure but still people have mobile devices. If mobile devices could join together to dynamically create a cloudlet i.e. logical pool of resources, it will allow devices to perform task like map generation etc, that would not be possible otherwise. Group of hill climbers climbing together and people travelling in a place can create ad-hoc cloudlet.

Since mobile devices today are rich in their resources, proximate mobile devices can cluster together to work cooperatively as cloudlet. Devices form an ad-hoc network and then cooperate with each other to create cloudlet. Each device sees a logical pool of resources just like in traditional cloud and can offload compute intensive task to that pool. This logical pool of resources i.e. ad-hoc cloudlet is self-managed with minimum interaction from user.

In this section we describe the algorithm developed for incorporating cloudlet into Relay Spot. Relay Spot protocol is used in creation, maintenance of and executing tasks cooperatively in Cloudlet. Important points used in our system are following:

- To create Cloudlet, i.e., when to initiate cooperation.
- Periodically probe Cloudlet controller (i.e., Source node) and if it fails then switch other node to take its responsibility.
- To keep updated information about state of all devices in Cloudlet.
- To distribute tasks among devices participating in Cloudlet and gathering results.

Figure 4 Picture used for evaluation

Dynamic creation of ad-hoc Cloudlet and maintenance is achieved by allowing nearby mobile devices to connect to each other and negotiate the creation of Cloudlet. Mobile device that is resource rich is selected as Cloudlet-controller (in this paper we used source node as controller) while the relay nodes act as Cloudlet nodes.

We used actual mobile devices to implement our Relay Spot Cloudlet design for experimentation. Mobile devices with different operating systems are available in market but we chose Android devices (i.e., Samsung Galaxy Tab 3) for our implementation. For coding we used APIs provided by JAVA for application development on android. To evaluate to performance of our proposed framework we carried out many experimentations. Face recognition is used as compute intensive task to evaluate performance of Cloud-let. We used the picture shown in Figure 4 to extract and recognize faces. In our experimentation, recognition of a single face is considered one task.

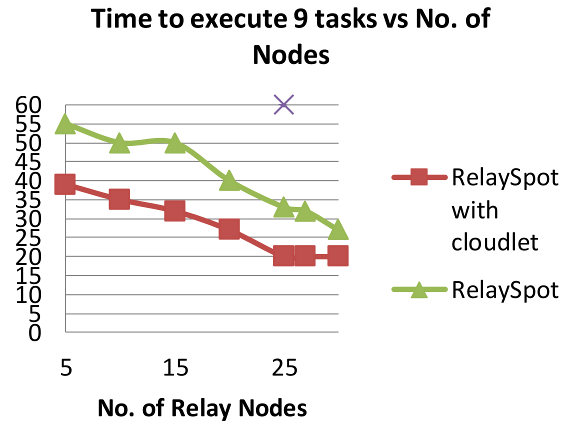

Figure 5. Task Execution time vs. No. of Relays

The results in Figure 5 clearly show that significant gain can be achieved by Relay Spot using cloudlet cooperation as compared to Relay Spot without cloudlet.

CONCLUSION

In this work we have designed a system for mobile device augmentation that is scalable, fault tolerant and independent of infrastructure and addressed the topic of cooperation in wireless network, where nodes can offer cooperation to specific source-destination pairs. As discussed, mobile cloud computing suffering from latency and battery drainage issues, while with cooperation these issues can be mitigated. Results show that we can achieve performance gain using cooperation in cloudlet, as well as we can achieve pervasiveness by providing connectivity to end user even if there is no infrastructure.

Our solution is suitable for any scenario in which users are moving together in form of a group e.g. hill-climbers or group of soldiers in battle field. Implementation of system does not need expensive hardware and is thus usable. Design of system is such that it needs minimal user interaction and is completely autonomous. System can be easily updated to support more services due to its flexible design. For the purpose of analysis, multiple face recognition problems is executed on ad-hoc cloudlet and it is shown that significant performance gain can be achieved. Experimentation and analysis shows that communication overhead due to control messaging is minimal and does not deteriorate task execution.

For now our implementation only supports single-hop communication which can be extended to multi-hop communication in future. In the future security and privacy issues can be addressed so that the data of confidential nature can also be processed on ad-hoc cloudlet. Our implementation uses only Wi-Fi for wireless communication and one of the improvements in future is to make system support multiple modes of wireless communication e.g. a mobile device falls back to Bluetooth if Wi-Fi fails.

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