Ubiquity of Healthcare System

Abstract:
Healthcare systems defines the standards for health facilities to communities. Therefore, it is of equal importance to everyone. In addition, it included in every fields of technology such as Internet of Things (IoT), Body Area Networks (BANs), Big Data, Context Aware Computing as well as Machine Learning. Therefore, researchers have opportunity to contribute towards well-being smart society easily. E-health on other hand is trying to provide remote access and availability of Wireless BANs (WBANs) facilities. Since, the tiny economical sensors are attached to body (either by implant or wearable fashion) to monitor the health parameters and act accordingly. Therefore, WBAN standards need special attention for optimization. In our previous work, we have proposed relaying protocol, while in this work we aim to extend the relaying protocol to WBANs in order to achieve better performance and safeguard the Master Node (MN). In order to make ubiquity, we propose to extend this work to small world network. This document described the initial proposal in this regards.

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1. Introduction

Over the past decade, Internet access became essentially wireless, with 802.11 technologies providing a low cost broadband support for a flexible and easy deployment. However, channel conditions in wireless networks are subjected to interference and multi-path propagation, creating fading channels and decreasing the overall network performance. The broadcast nature of the radio medium may be used to improve the system performance by having a node(s), other than the source and the destination, actively help deliver data frame correctly to the destination. This practice is referred to as cooperative communications. Recently, cooperative communication in wireless networks has been of increasing interest because it promises higher rates and reliability [1].

Cooperative communications, in terms of its physical layer capabilities and characteristics, have been extensively studied, but only recently, has there been work that explores the benefits of cooperation at different protocol layers. When applied to single-hop networks, this practice can be embedded into the MAC protocol: several methods have been proposed to modify the IEEE 802.11 protocol to enable nodes to cooperate to address poor quality at the link layer. Almost all of the research in cooperative relaying focused on single-hop, where the cooperation is performed in a hop-by-hop method, and cooperation between multiple hops is not exploited..

In what concerns the operation of multiple-hop wireless networks, most of the research effort has been placed in the development of routing protocols, being scalability one of the most important open problems in large-scale wireless networks. The scalability of the wireless multi-hop routing protocols is related to whether the network routing protocols can find paths between every pair of nodes, whose lengths are bounded, with acceptable routing message overheads [2]. The performance gains of cooperative relaying make it tempting to directly apply it to multi-hop networks by finding a node that assists the transmission for every hop. Almost all of the existing research focus on path re-computations while with multi-hop cooperative relaying end-to-end long life connectivity can be provided without overhead of path re-commutation. However, cooperative communication incurs in some overhead related to relay selection and signaling for coordination. Even if these costs appear small in simple network scenarios, they will increase significantly with the size and traffic level of the network, requiring careful evaluation, or even innovative design, of cooperative protocols to ensure their usefulness in realistic networks.

When looking at the desirable self-organizing property of multi-hop networks, we have to notice that networks of coupled dynamical systems have been used to model many types of self-organizing systems. In such models connection topology is assumed to be either completely regular or completely random. But many social networks lie somewhere between these two extremes. In this project we explore simple models of networks that can be tuned through this middle ground: regular networks 'rewired' to introduce increasing amounts of disorder. These systems, called small-world networks [3] can be highly clustered, yet having small characteristic path lengths, like random graphs. Small world networks are a class of networks that behave somewhere between random and regular networks. They exhibit characteristics from both regular and random networks, e.g., a large clustering normally associated with regular networks and an average shortest path as found in random networks. According to [3], small world networks can be formed by taking a regular lattice or ring network and randomly rewiring a small portion of the links to new nodes, or by adding new links. The recent interest in small-world network effects [4] has highlighted the applicability of both graph theory [5] and scaling theory [6]. Nodes in proximity to a failed peer may be able to compensate by modifying their own behavior, acting as a router/relay or handling greater range or bandwidth to fill in the area of silence left by a failed node. Shortcuts in the network will allow linking up otherwise disparate clusters, forming a small-world network.

In this work we aim to investigate the use of cooperative relaying to improve the scalability and self-organizing properties of large dynamic networks by: i) analyzing how to improve the performance of multi-hop routing where a node can help multiple transmissions, ii) analyzing the impact on network capacity, iii) analyzing how cooperative relaying can help to create and maintain small-world networks. To the best of our knowledge it is the first work to introduce cooperative relaying as a booster of the scalability of multi-hop systems and by extension the self-organizing characteristics of small-world networks.

2. Literature Review

The basic ideas behind cooperative communication can be traced back to the relay channel model in information theory extensively studied in the 1970s by Cover and El Gamal [7]. Recent research on cooperative communication [8, 9, 10] demonstrates the benefits of cooperative relaying in a wireless environment by achieving spatial diversity. Although previous work shows the benefit of cooperation in wireless networks, it does not define medium access methods that would support new cooperative schemes. To take full advantage of physical layer cooperative techniques, new MAC schemes must change the transmitter-receiver communication model to include a transmitter-relay(s)-receiver model.

Common examples of MAC source-based cooperative relaying schemes are the ones that use one relay [11, 12] or two relays in parallel [13]. Source-based relaying approaches require the sources to maintain a table of CSI that is updated by potential relays based upon periodic broadcasts. As an example, with CoopMAC [11], the source can use an intermediate node (called helper) that experiences relatively good channel with the source and the destination. Source-based approaches undergo two main problems: channel estimation and periodic broadcasts, which introduce overhead.

While source-based proposals follow a proactive approach, reactive cooperative methods [14, 15, 16] rely on relays to re-transmit on behalf of the source when the direct transmission fails. Reactive approaches face the same challenges of source-based methods. N. Marchenko et al. propose a mechanism [17] where all overhearing nodes estimate the Signal-to-Noise Ratio (SNR) for both source-relay and relay-destination channels, based on which they can select a slot in the contention window, and the destination selects a most suitable relay among all the nominated nodes. This proposal has several drawback: i) geographic position of nodes is assumed to be known; ii) the size of the contention window has great influence in selecting the best relay; iii) the destination node is not aware of the number of nominated relays.

In the case of multi-hop networks the performance gain of cooperative relaying may be exploited by finding a node that assists the transmission for every hop. Although the gain achieved through cooperative diversity increases robustness, it requires retransmissions reducing network capacity. Such a hop base cooperation scheme neglects a crucial evidence: not only the destination of a packet might be in need of help but also the next hop. An alternative approach may be to use two-in-one cooperation [15], in which a single retransmission can improve the success probability of two ordinary transmissions (source to next-hop and next-hop to destination), leading to a better usage of the network capacity. In two-in-one cooperation all potential relays react after detecting a missing Acknowledgment (ACK) from the destination. Although two-in-one cooperation can achieve a diversity gain of three, the most suitable relay selection scheme is not investigated.

In a clear contrast to the prior art Jamal et al. proposed a new type of cooperative relaying scheme [18] based upon local decisions that do not rely on unstable information (e.g., CSI) collected over multiple links. Such proposal describe an 802.11 backward compatible cooperative relaying framework, called RelaySpot, which aims to ensure accurate and fast relay selection, posing minimum overhead and reducing the dependency upon CSI estimations, which is essential to increase system performance in scenarios with mobile nodes. The basic characteristic of any RelaySpot-based solution is the capability to perform local relaying decisions at potential relay nodes (can be more than one), based on a combination of opportunistic relay selection and cooperative relay scheduling. Intermediate nodes take the opportunity to relay in the presence of local favorable conditions (e.g., no concurrent traffic). Cooperative scheduling is used to compensate unsuccessful relay transmissions. The proposed opportunistic relay selection and cooperative relay scheduling mechanisms aim to increase throughput and reliability, as well as to reduce transmission delay by increasing the diversity adjusting the relaying order. Nevertheless, the presence of mobile nodes, as well as unstable wireless conditions, may require higher levels of diversity achieved based on nodes that are closed to the destination (higher probability of successful transmissions). Hence, RelaySpot includes the concept of chain relaying: the possibility of using recursive relay selection and retransmissions in case of poor performance. This functionality represents a starting point for the work to be done in this project in what concerns the usage of cooperative relaying in large dynamic networks, where multi-hop communications can be used.

In what concern the relaying in large networks, S. Min et al.[2] proposed a Small-World based cooperative routing protocol , where a routing protocol is proposed with the combination of small-world and cooperative relaying. In this proposal each node should select shortcut nodes and record it into routing table. The shortcut nodes are regards as next hop. If the short cut node is several hops away than forwarding node, relaying is used to help. In this proposal, all nodes are involved to find relays, which leads to unnecessary cooperation, while L2 cooperation has not been investigated.

3. Chain Relaying

Jamal et al. previous work, entitled RelaySpot, have proposed a recursive relaying mechanism, which aims to use multiple relays in sequence. The starting point of this project is to extend the concept of chain relaying and analyze its impact on network performance. Chain relaying aims to minimize the outage and to increase the range of transmission. Nodes that are able to successfully decode packets sent by a relay to a destination may trigger the RelaySpot operation on that relay-destination channel in case the channel conditions are so bad that source and /or relay node do not have connectivity with destination [18]. Therefore, we will start our project by studying chain relaying in order to understand how one relay can help multiple transmissions and how multiple relays can help one transmission to occur.

In next step we will analyze the effect of chain relaying over the overall network. In a large network with multiple source destination pairs using cooperative relaying, we will study how concurrent cooperation affects the network capacity, and to study the effect of cooperation over non cooperative nodes.

Finally we will extend our analysis to small-world networks, and will study how the cooperative relaying provides the needed long-link connectivity required to create small-world networks. We'll investigate how our cooperative relaying (single-hop or multi-hop) can be used to create such long-links and how such cooperation can be triggered (analysis of random vs controlled schemes).

4. Challenges towards ubiquity

The major challenges to be addressed are related to:

- Study the best way to apply cooperative relaying in order to augment the performance of multi-hop routing.
- Analyze the impact of cooperative relaying (single-hop and multiple-hop) in the transmission capacity of large dynamic networks.
- Analyze our cooperative relaying can be used to ensure the creation and maintenance of small-world networks.

a. Innovative Aspects

In comparison with the described state-of-the-art, the major innovation aspects are:

- Perform multi-hop relaying without use of routing information.
- Establish a L2 routing without L3 path re-computations.
- Method to select the best chain of cooperative relay nodes which can be applied in sequence or in parallel.
- Ensure the creation of small-worlds with higher probability, based on a selective usage of cooperative relaying.

b. Methodology

As mentioned before, the project aims to exploit the usage of cooperative relaying in three complementary areas: to augment multi-hop communications; to increase the capacity of dynamic networks; to improve the self-organizing characteristic of small-work networks. Hence, this project is divided into three exploratory phases, which corresponds to three different work-packages (WPs): WP1 - Multi-hop relaying; WP2 - Network capacity; WP3 – Small-world Networks.

Each of the three WPs are organized into the following phases:

- **Setup phase**: includes Problem Space Definition and choice of technical scenarios for each task.

- **Implementation and Validation**: includes the development of novel concepts and their evaluation by means of simulators and

5. Experimental Tools

Matlab is the tool of choice to validate aspects that relates to algorithms and metrics, such as in the case of the evaluation of machine learning strategies. Matlab offers a large number of functionalities to process network data and to test the algorithms.

In what concerns the evaluation of cooperative communication systems, the OMNET++ simulator is the tool of choice to evaluate global performance aspects of the networking platform.

For WP1 and WP2 we will use OMNET++ and MiXIM framework, which are already been used to analyze the performance of RelaySpot. The implementation of the latter can be easily extended to include all the modules needed to conduct the study related to multi-hop communications based on the concept of chain relaying to be developed in WP1. For WP3, Matlab will be used due to the support that it already has for the study of small-world networks.

This WP aims to investigate the usage of chain relaying in a cooperative networking system. The aim is to investigate when chain relaying is required and when it would be useful, as well as investigate the overhead due to usage of multiple relays. At set-up phase of this task, technical scenarios, comparison towards related work and website establishment will also be performed.

Some research questions that will be tackle are:

- Could cooperative MAC protocol improve performance (throughput and latency) in multi-hop network?
- Will it be able to enlarge transmission range, and extending the network coverage?

- Would cooperative relaying allow the reduction of path re-computations?

The evaluation of the devised algorithms and systems will be based on OMNet++ simulator using MiXim platform.

This WP aims to analyze relaying over large-scale dynamic networks in scenarios with various direct and relay links. In the past Jamal et al [19, 20] proposed an Interference-aware relay selection, which will be extend in this WP, together with the chain-relaying mechanism analysed in WP1, in order to investigate its scalability properties of large networks in the presence of several potential relays and several concurrent transmissions.

Some topics to be considered are:

- Handling of concurrent transmissions over the same set of relays.
- Rate maximization and interference minimization trade-off.
- Increasing the transmission rate, and decreasing communication delay across the network.

a. Small-world Relaying Networks

We aim to extend studies and outcome from RelaySpot and Cooperation to the best way to use cooperative relaying to create and maintain small-world network in dynamic and large-scale scenarios. In small-world network most of the nodes are clustered and few are neighbours of each other in different clusters (thought random links). The aim of this is to study how to provide connectivity between isolated networks via cooperative relaying, in order to ensure the creation of a small-world network. As a start-up phase of this work, choice of relaying protocol, identification of most useful scenarios and system model will be studied, based on WBAN protocols, such as:

- Probability of cooperative relaying of providing useful links (able to connect networks with the smallest latency.
- Selectiveness of cooperative relaying in provided the needed inter-network links (random process vs selective process).

Small-world networks analysis corresponds to the goal of ubiquity. It relates to the result of the analysis work done in order to evaluate the proposed relaying strategies in small-world networks [21].

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