COOPERATIVE NETWORKING Tutorial

AMNA, MAHAM, NARMEEN, TOOBA

COOPERATIVE NETWORKING

Abstract:

Cooperative communications enable efficient utilization of communication resources, by allowing nodes or terminals in a communication network to collaborate with each other in information transmission. It is a promising technique for future communication systems.

Networking *based on the cooperation among the involved nodes so as to achieve significant improvement in terms of the overall system capacity meeting at the same time the Quality of Service (QoS) requirements.*

Introduction:

Background

Wireless Network

- Has interference and signal loss [1]
- Has distance and signal delay
- Is unreliable due to fading
- Is vulnerable to attacks

Motivation

The presence of a few low data rate stations will have an adverse effect on the overall throughput of the network. Low throughput and reliability in wireless networks [2].

Problem Statement

Increase the performance of wireless systems.

Networking

The practice of transporting and exchanging data between nodes over a shared medium in an information system [3].

Cooperation

In cooperative endeavors the focus is primarily on sharing information and expertise [4].

Cooperative Networking

In this type of relationship participants are loosely connected so their contribution to the relationship is low [5]. Each participant remains completely independent from the others. There are only minor changes in how each participant does business, but they have the advantage of learning from others and being able to modify the way they work [6]. Cooperation is characterized by low levels of risk and reward since it emphasizes reaching agreement to adjust specific actions rather than making changes to the organization's operations.

In CoopNet [7], cooperation among peers complements traditional client-server communication rather than replace it. Specifically, CoopNet addresses the problem cases of client-server communication. It kicks in when needed and gets out of the way when normal client-server communication is working fine. Unlike some of the peer-to-peer systems [8], CoopNet does not assume that peer nodes remain available and willing to cooperate for an extended length of time. For instance, peer nodes may only be willing to cooperate for a few minutes. Hence, sole dependence on peer-to-peer communication is not an option. The specific problem case of client-server communication we focus on is flash crowds at Web sites. A flash crowd refers to a rapid and dramatic surge in the volume of requests arriving at a server, often resulting in the server being overwhelmed and response times shooting up [9].

Fig. 1 gives a preliminary explanation of the ideas behind cooperative communication [10].

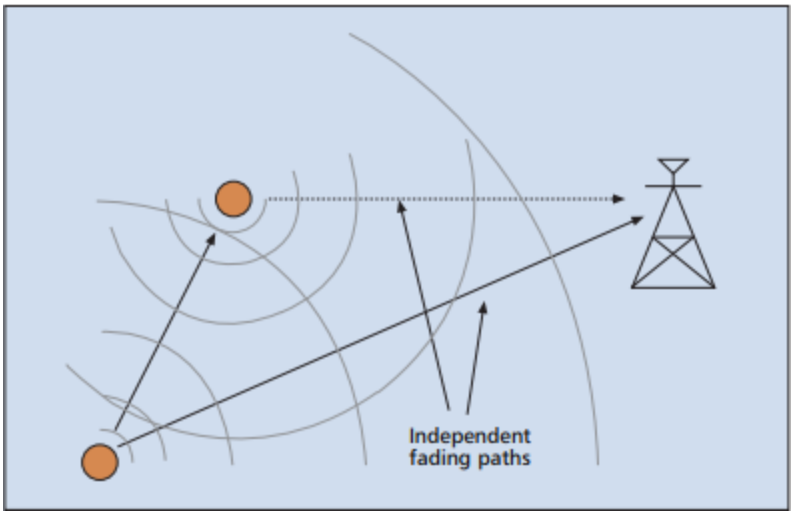

Figure 1

In cooperative wireless communication, we are concerned with a wireless network, of the cellular or ad hoc variety [11], where the wireless agents, which we call users, may increase their effective quality of service

In a cooperative communication system [12], each wireless user is assumed to transmit data as well as act as a cooperative agent for another user as shown in figure 1.

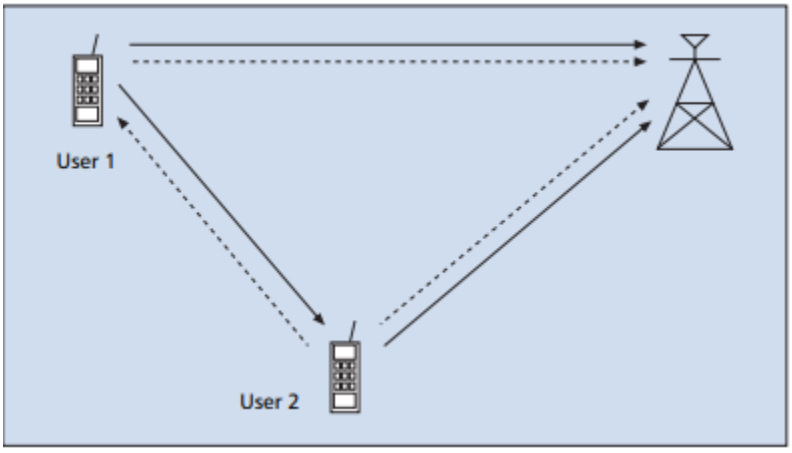

Figure 2

In cooperative communication each user transmits both his/her own bits as well as some information for his/her partner [13]; one might think this causes loss of rate in the system. However, the spectral efficiency of each user improves because, due to cooperation diversity the channel code rates can be increased.

Consider a transmitter relaying data to a receiver (Figure 1). Due to bad channel condition, the transmitter is not able to sustain high data rate with the receiver [14]. Thus it transmits in a low rate (1 Mbps in the figure). We modify this scheme by introducing another node called helper. The helper is a station that belongs to the same wireless network and is capable of supporting a higher data rate with both the transmitter and receiver [15]. In the new scheme, the transmitter instead of transmitting the packets directly to the receiver through a slow hop (1Mbps), it uses cooperation and it forwards the packets through the helper by using two fast hops: one from itself to the helper (11 Mbps in the figure) and the second one from the helper to the receiver (5.5 Mbps in the figure) [16]. The network gains benefits from spacial diversity due to the existence of the helper in the communication between the transmitter and the receiver. Simulation results as well as experiments in a real implementation show that the proposed scheme boosts the performance of the network up to 5 times comparing is with the existing technology of IEEE 802.11 [17].

Security Issues:

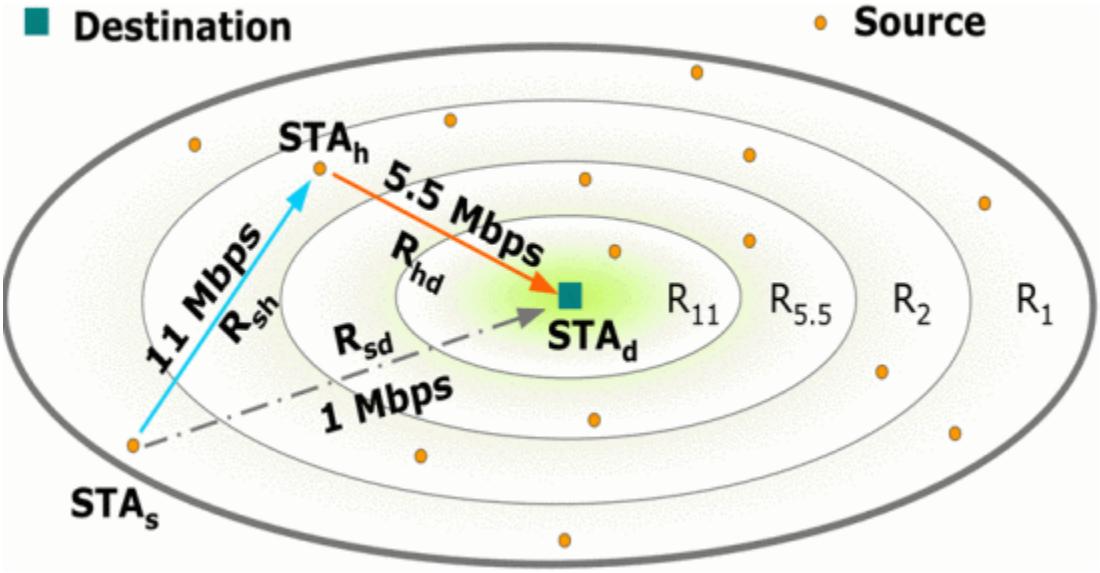

figure 3

1. The first potential security issue in the Cooperative Networking is that of the helper deliberately not forwarding frames received from the source. In this case the helper could deny service to the source by simply dropping the packets it receives [18]. It would then be up to the source to realize that this helper is unresponsive and choose another helper [19]. If another helper does not exist, it can then transmit directly to the destination, albeit at a lower rate. The source could detect the responsiveness of the helper or lack thereof, by imposing some kind of a timeout, after which if no acknowledgment from receiver is received, it would

blacklist the helper and try to retransmit via a different helper [20], if available, or directly.

2. The second potential issue is more serious. The malicious helper may try to deny service to the source by failing to forward data and spoofing an ACK on behalf of the destination, thereby making the source think that the data was received. Here, we may try to combat this problem via the aid of RTS/CTS. Cooperative Networking uses some variant of the RTS/CTS scheme. This means that the destination sends the CTS, and is aware that it is an intended recipient of a future frame [21]. Thus, if it does not receive this frame in the allocated NAV period, (due to the fact that the helper did not send it and spoofed an ACK to the source) it can send a NACK or negative acknowledgment to the source, alerting the source that it did not receive the frame. Alternatively, the transmitter can simply listen to the second hop transmission, and if the correct second hop packet is not heard, then blacklist the helper to avoid using it in the future [22].

3. The third and the most important potential security issue is a scenario where the helper modifies the payload and then forwards it . The receiver will typically not come to know of this, so it will think that it is only communicating with the genuine sender and may end up voluntarily with replying with privileged information, such as username and passwords [23]. This type of an attack is possible when changes made in the payload will not lead to corruption of the packet, i.e. when no wireless encryption scheme is used. If no wireless encryption scheme is employed, then it is obvious that no mechanism exists to detect the alteration of the payload. Such an attack cannot be easily avoided unless the transmitter and receiver can themselves find that there is an unusually large delay in the received packets, which will be due to calculations of CRC. etc, at the helper. At that point they may choose to use some other helper. However if we implement Cooperative Networking according to the protocol which requires the retransmission of the packet by the helper in a SIFS interval this type of attack will not be possible as the SIFS duration is very small to perform any kind of complex calculations and manipulation of the packet [24].
Finally, 802.11i security protocols are not vulnerable to the modification of payload unless the exact key is known to the helper [25].

Future of Cooperative Networking

Cooperative networking is becoming the key components of the concept referred to as the Future Internet [26].

Cooperative Communication Systems Driven by Social Mobile Networks

The assumption of this work is that future mobile communication systems will incorporate user cooperation, i.e. a combination of cellular access in parallel with ongoing short range links to the neighboring devices. It has been shown that user cooperation enables higher data rates, better spectral efficiencies, and reduces the energy consumption of the mobile unit.

Cooperative Techniques and Principles Enabling Future 4G Wireless Networks

Future 4G wireless networks starting from the convergence idea and adopting cooperative techniques and principles [28]. The later will allow novel services at low power consumptions avoiding the problems associated with the linear extension of existing wireless networks [29]. An architecture for mobile terminals supporting cooperation is presented [27].

References:

[1] T Jamal, P Amaral, A Khan, SAB, Kiramat, "Denial of Service Attack in Wireless LAN", in Proc of 12th ICDS 2018, Rome Italy.

[2] T. Jamal and P. Mendes, “Relay Selection Approaches for Wireless Cooperative Networks,” in Proc. of IEEE WiMob, Niagara Falls, Canada, Oct. 2010.

[3] T. Jamal, P. Mendes, and A. Zúquete, “Opportunistic Relay Selection for Wireless Cooperative Network,” in Proc. of IEEE IFIP NTMS, Istanbul, Turkey, May 2012.

[4] T. Jamal and P. Mendes, “Cooperative relaying in user-centric networking under interference conditions,” IEEE Communications Magazine, vol. 52, no. 12, pp. 18–24, dec 2014

[5] P. Mendes,W. Moreira, T. Jamal and Huiling Zhu, “Cooperative Networking In User-Centric Wireless Networks”, Springer Lecture Notes in Social Networks, User-Centric Networking: Future Perspectives, ISBN 978-3-319- 05217-5, May 2014.

[6] T. Jamal, P. Mendes, and A. Zúquete, “Relayspot: A Framework for Opportunistic Cooperative Relaying,” in Proc. of IARIA ACCESS, Luxembourg, June 2011.

[7] T. Jamal, SA Butt, "Malicious node analysis in MANETS", International Journal of Information Technology, Springer Publisher 2018.

[8] T. Jamal and P. Mendes. “Cooperative Relaying for Dynamic Networks”, EU Patent, (EP13182366.8), August 2013.

[9] T. Jamal and P. Mendes, “802.11 Medium Access Control In MiXiM,” Tech Rep. SITILabs-TR-13-02, University Lusófona, Mar. 2013.

[10] T Jamal, M Alam, MM Umair, "Detection and prevention against RTS attacks in wireless LANs", in Proc of IEEE C-CODE, Mar 2017.

[11] L. Lopes, T. Jamal & P. Mendes, "Towards Implementing Cooperative Relaying" In Technical Report COPE-TR13-06, CopeLabs University Lusofona Portugal, Jan 2013.

[12] T. Jamal, P. Mendes, and A. Zúquete, “Interference-aware opportunistic relay selection”, In Proceedings of The ACM CoNEXT Student Workshop, Tokyo, Japan, 2011.

[13] T. Jamal, "Cooperative MAC for Wireless Network" In 1st MAP tele Workshop, Porto, Portugal, 2010.

[14] T. Jamal and P. Mendes. Analysis of Hybrid Relaying in Cooperative WLAN. In Proc. of IFIP WirelessDays, Valencia, Spain, November 2013.

[15] T. Jamal and P. Mendes, “Cooperative Relaying for Dynamic WLAN,” Chapter WiNeMO Book (Springer LNCS Editor), Feb. 2014.

[16] T. Jamal, and SA Butt, “Cooperative Cloudlet for Pervasive Networks”, in proc. of Asia Pacific Journal of Multidisciplinary Research, vol 5, issue 3, Aug 2017.

[17] T. Jamal, P. Mendes, and A. Zúquete, “Wireless Cooperative Relaying Based on Opportunistic Relay Selection,” International Journal on Advances in Networks and Services, vol. 05, no. 2, pp. 116-127, Jun. 2012.

[18] T. Jamal, P. Amaral, and SA Butt, “Denial of Service Attack in Wireless LAN”, in proc. of IARIA ICDS, Rome, Italy, Mar. 2018.

[19] T. Jamal, and P. Amaral, “Flow Table Congestion in Software Defined Networks”, in proc. of IARIA ICDS, Rome, Italy, Mar. 2018.

[20] R. Sofia, P. Mendes, W. Moreira, A. Ribeiro, S. Queiroz, A. Junior, T. Jamal, N. Chama, and L. Carvalho, “Upns: User provided networks, technical report: Living-examples, challenges, advantages”, Tech. Rep. SITI-TR-11- 03, Research Unit in Informatics Systems and Technologies (SITI), University Lusofona, Mar. 2011.

[21] T. Jamal, and P. Mendes, “Cooperative relaying in wireless user-centric networks”, In: Aldini, A., Bogliolo, A. (eds.) User Centric Networking - Future Perspectives. LNSN, pp. 171–195. Springer, Heidelberg (2014).

[22] T. Jamal and P. Mendes, “Cooperative relaying for Wireless Local Area Networks”, In proc. of Wireless Networks Moving Objects, Springer LNCS WiNeMo, March 2014.

[23] T. Jamal, P. Mendes, and A. Zuquete, “RelaySpot: Cooperative Wireless Relaying”, in proc. of MAP-Tele Workshop, Aveiro, Portugal, May 2011.

[24] T. Jamal and P. Mendes, “Cooperative Wireless Relaying, Key Factors for Relay Selection”, in MAP-Tele Workshop, Porto, Portugal, Dec. 2009.

[25] SA Butt, T. Jamal, “Study of Black Hole Attack in AODV”, in Proc of International Journal of Future Generation Communication and Networking, Vol.10, No.9 (2017), pp.37-48.

[26] T. Jamal and SA Butt, Low-Energy Adaptive Clustering Hierarchy (LEACH) Enhancement for Military Security Operations, ISSN 2090-4304 Journal of Basic and Applied Scientific Research, 2017.

[27] T. Jamal, and P. Mendes, “RelaySpot, OMNET++ module”, In COPE-SW-13-05, 2013.

[28] T. Jamal, P. Mendes, and A. Zúquete, “Design and Performance of Wireless Cooperative Relaying”, PhD Thesis MAP Tele, University of Aveiro, 2013.

[29] SA Butt, T. Jamal, “Frequent Change Request From User to Handle Cost on Project in Agile Model” in Proc. of Asia Pacific Journal of Multidisciplinary Research 5 (2), 26-42.