A Review of Routing Protocols of Heterogeneous Networks

Samad Baseer
Telecommunication Department
Asian Institute of Technology
Bangkok, Thailand

Muhammad.Ibrahim Channa
Telecommunication Department
Asian Institute of Technology
Bangkok, Thailand

Kazi Ahmed
Telecommunication Department
Asian Institute of Technology
Bangkok, Thailand

ABSTRACT
The popularity of wireless communications systems can be seen almost everywhere in the form of cellular networks, WLANs and WPANS. In addition, small portable devices have been fully equipped with various communication interfaces building a heterogeneous environment in terms of access technologies. the future heterogeneous environments are expected to integrate wireless technologies such as WLANs, WMANs and WWANs, based on the individual network architectures. It is envisioned that the next generation wireless systems would provide convergence of various wireless network technologies so as to have architectures with global connectivity [27, 28]. We present a view of the various routing protocols present in the Mobile AdHoc Networks (MANETs) and compare them as to see the best performance oriented. The Integration of different access technologies is a very complex task and involves issues at all layers of the protocol stack.

General Terms
Security, Multiple hop Cellular Networks, Heterogeneous Networks, Mobile Ad hoc Networks

Keywords
Security, Mobile, Ad hoc Networks, Heterogeneous Networks

1. INTRODUCTION
The rapid growth of both wired and wireless technologies has made communication needs more easily available, secure, reliable and faster. The fact that anyone can be called or texted at any time and from any place around the globe has be become extremely convenient while for some it has become mandatory. The advent of the internet has made any information easily accessible and we now expect the same on the go.

Wireless communications have been in constant evolution and development for the past few years. The best example cited is the cellular networks which provide people with communication services along with the freedom of movement. Unfortunately physical constraints that arise when working with wireless technology make it difficult to provide such services especially indoors. Thus we have to work within the current environment and find solutions every where to extend coverage. [2]

In multihop networks, several important issues are how to increase coverage, capacity and reliability (self-heal, self-configure), while taking account into data transmission delay. By multihop relaying, we can enhance SNR because of the path loss reduction between a Tx node and an Rx node, and therefore we can increase data rate [1]. In addition, we can mitigate the unfairness with respect to the quality of service received by users located at different regions and enhance the cell coverage.

2. BACKGROUND
Mobile AdHoc Networks are networks where nodes function both as a host and routers. These nodes are able to move around freely easily inside the network but are also capable to enter and exit the network at any time they desire. The drawback of this mobility is that the routing algorithms become impossible to follow as all nodes are constantly moving. An important factor in the MANET's is the Transmission Power (Tx) thus if a mobile node is using its resources in forwarding data packets for other nodes its own battery life will suffer. This feature also makes the MANET very much reliable and trustworthy but at the same time also being more attacked upon also.

For mobile communications one main aspect of the communication shift paradigm is the successful development is traditional single hop cellular systems where a mobile station (MS) communicates directly with a base station (BS). The success of the second generation (2G) cellular networks and the clouds of 3G over our heads the need for higher data rates and bandwidth is an important concern for the industry. Another paradigm of the mobile communications is the multihop ad hoc networks which are infrastructureless, self organizing , rapidly deployable without any site planning unlike traditional cellular networks. Nodes can join and leave without any restriction placed on them. Thus it works on the concept of peer to peer networks. Thus every node can act as the intermediary station that relays packets of other nodes towards their destinations that otherwise cannot be reached using a single hop transmission. MANETs are easy to deploy because of their use of unlicensed spectrum of IEEE 802.11. However this architecture has its own set of drawbacks which include less reliable performance as the channel connection and interference between nodes are more difficult to predict or control. Another failure reason is the multihop paths between source destinations are more vulnerable to the node mobility and node failure.

Consider a scenario, in a university campus where a large number of mobile users that can act as relay MSs, are spread over the campus. At noon, the users may flock towards the cafeteria and the users in close proximity could form a multihop network. At around 2 PM, the users would leave the cafeteria and move to their offices and other locations of the university thus resulting for those people who were using their bandwidth to be completely cut off. Such a situation could bee avoided if we could form a network which is a combination of both cellular and MANETs.[27]

Thus the limitations of both the cellular networks and also the MANETs led the researchers to search for a architecture that combines both the advantages of each and present a protocol which enhances communication and reliability for the end user. Thus the traffic can be shared among the several BSs and MSs and thus all users will be able to take advantage of the bandwidth.

3. ROUTING PROTOCOLS FOR MANETS

As the mobility of the nodes is not fixed in the network so the wired networks cannot be used. Any routing algorithm has to be taken into consideration that it can appear and disappear at any time. The various routing algorithms that have been provided have both their advantages and disadvantages. In the following section we present the various routing protocols.

3.1 PROACTIVE ROUTING PROTOCOLS

These protocols will continuously try to determine the layout of the network. It achieves this by exchanging packets containing topology information between the various mobile nodes. As a result the delay in determining the route to be taken is minimal. This is very important for real time data. The major disadvantage of these routing protocols is the fact that due to the mobile nature of nodes any node can appear and then go so a lot of information will be quickly invalid. Thus resulting in many short lived routes and as soon as they appear they again disappear. Another issue which does not have good effect is the amount of node information that is being passed in the network thus creating overhead and grows exponentially when the network is of large size. A lot of battery consumption takes place due to the sending and receiving of information used for updating routes. Examples of proactive routing are Dynamic Destination Sequenced Distance Vector Routing (DSDV), this routing algorithm maintains a list of the all the destinations and number of hops to each destination. This method uses the full dump (whole routing table) or incremental packets to reduce network traffic generated by route updates. This routing algorithm also places a number of restrictions on the number of nodes that can join the network**. [3]**

Another example of proactive routing algorithm is Optimized Link State Routing Protocol (OLSR) [4], in this protocol each node send a "Hello" messages with information to specific nodes in the network. In this protocol hello packet contains nodes IP, sequence number and a list of the distance information of the nodes neighbors. Thus using this information the nodes builds itself a routing table. This protocol uses Multipoint Relays (MPR's) which forward broadcast messages during the flooding process. Only those nodes can send link state information that are selected as MP's. Thus a control messages is minimized in the network. This protocol has the advantage of minimizing the flooding messages and also control signals. This protocol is more suitable for large and dense networks.

3.2 REACTIVE ROUTING PROTOCOLS

These kinds of protocols only find a route to the destination node when there is a need to send data otherwise it does not keep routing information with itself stored. Whenever the source nodes want to transmit data it will start a route discovery procedure by transmitting route requests throughout the network. The sender will then wait for a response from the destination node or an intermediate node that can act as a relay to the destination. The main drawback of this routing algorithm is route discovery provides a significant delay before the packet can be transmitted. It also requires the transmission of a significant amount of control traffic being exchanged thus using energy resources of the mobile nodes.

The examples of such a protocol is DSR [5]**,** as this gives the concept of source routing. Mobile nodes are required to maintain route caches that contain the routes known by the node. Entries in the route cache are continually updated as new routes are learned. This protocol is mainly composed of two main mechanisms "Route Discovery" and "Route Maintenance" which work together to allow nodes to discover and maintain routes to the arbitrary destinations in the ad hoc network. To use less bandwidth the process of finding a route is done only when it is required. There are no hello messages used between nodes to notify the neighboring nodes about their presence. This protocol allows multiple routes to any destination and allows the sender to select and control the routes used in the routing its packets e.g. for use in load balancing or for increased robustness.

The major disadvantage of this routing protocol is the scalability problem due to the nature of source routing. As the network grows the control packets and the message packets also become bigger, thus gives a negative impact due to limited bandwidth. Hence this protocol is used well with networks with small diameters (between 5 & 10 hops) where the nodes move around at moderate speed.

Another routing protocol of reactive protocols family is the Temporally Ordered Routing Algorithm, (TORA) [6]; this is source initiated and provides multiple routes for any desired source/destination pair. There are 3 basic functions of the protocol: route creation, route maintenance, and route erasure. As this protocol uses intermodal co ordination it exhibits instability behavior similar to "count to infinity", problem in distance vector routing protocols. As there are potential for oscillations to occur.

Ad Hoc on Demand Distance Vector Routing Protocol (AODV) [7] is one of the most commonly used routing algorithms for MANET's. It is a reactive routing protocol based on the DSDV. AODV is designed for networks with tens of thousands of mobile nodes. One feature of AODV is the use of sequence numbers in order to insure loop freedom. Sequence numbers are used by other nodes to determine the freshness of routing information. If a node has the choice between two routes to a destination a node is required to select the one with greatest sequence number.

In AODV every node has a routing table. As with DSR , the process to find a route to the destination is only executed when needed using RREQ's(Route Request) messages originating from the source node and RREP's(Route Reply) messages sent by the destination or intermediate nodes which have a route to the destination. This protocol also uses the "Route Repair" mechanism which enables a node to switch to a different path if a node along the original route goes down.

4. HETEROGENEOUS ROUTING PROTOCOLS

The future of wireless communication lies in the ubiquitous networks that will be able to provide availability anywhere. These networks will be a combination of both the wired and wireless networks. I.e. Cellular networks combined with IEEE802.XX networks where you can access both the network through access points and also through direct connection with the base station. Thus a Heterogeneous communication network provides transparent and self configuring able WLAN. The basic components are mobile stations (MS's), BS's/ APs. And a core (IP) network serving as the communication bridges for MS's. WLAN's can operate in infrastructure e.g. single hop mode where connectivity is provided by the AP or in MANET mode where devices can communicate with each other through multihop routing. A connection from a MS to a BS/AP can be established by a single hop or using multihop when the MS is out of the coverage of the corresponding BS/AP as shown in Figure.1. [8]. Although there is still a far of time to when the heterogeneous networks will be implemented there are three unique features significantly affecting the design of integrated solutions, namely , the availability of multiple interfaces for a MS, the integration of cellular networks and WLAN's and multihop communication. These issues need to be addressed to provide an integrated transparent and self configurable service**.** [11]

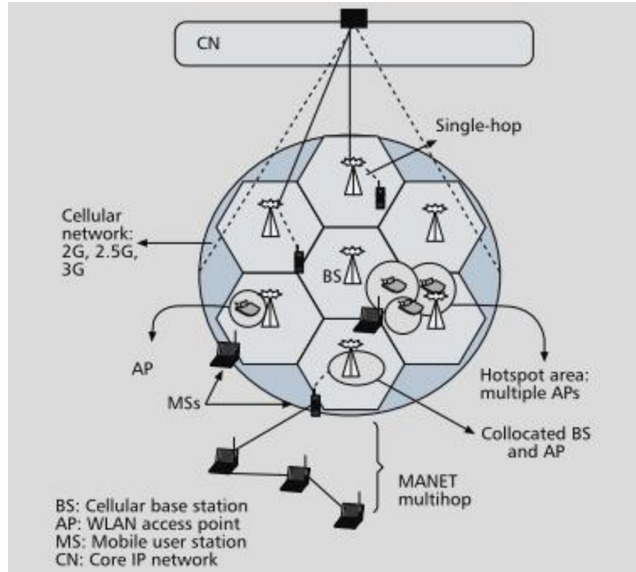

Figure 1. Heterogeneous Network Architecture [32]

Heterogeneous networks will require the maintenance and configuration of multi-hop paths and available network interfaces due to the transient nature of the networks (relay MSs). The real challenge is to devise algorithms to discover and cope up with changing topology of the network. Consider a scenario, in a university campus where a large number of mobile users that can act as relay MSs, are spread over the campus. At noon, the users may flock towards the cafeteria and users in close proximity could form a multi-hop network. At around 2 pm, the users would leave the cafeteria and move to other parts of the campus. In such a scenario, the network topology changes with the time of the day. The issue is how to recreate and reconfigure the topology of such a dynamic network. The variety of wireless access networks in a heterogeneous environment introduces a number of challenges for connection management such as maintaining valid multi-hop paths and available network interfaces. [27]

The various architectures which have been proposed are as follows.

4.1 iCAR

The architecture proposed in [9], namely integrated cellular and ad hoc relaying (iCAR), features a typical example for MCNs with fixed relays, which makes use of the conventional cellular technology and ad hoc networking technology to realize the dynamic load balancing. The key idea of iCAR is to strategically locate a number of fixed relays, called ad hoc relay stations (ARSs), and use them to divert traffic from one possibly congested cell to other non-congested cells. Consequently, the congestion can be mitigated or even eliminated. Next, iCAR makes it possible to handle handover calls for MSs moving into a congested cell, or to accept new call requests originated from MSs in a congested cell. As shown in Figure.2.

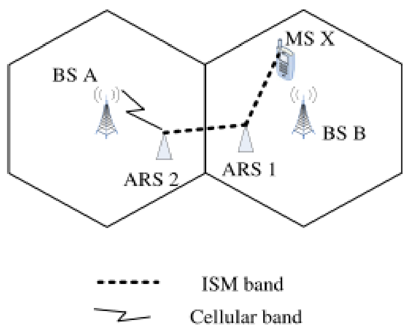

Figure 2. The Primary Relaying Strategy in iCAR[11].

If a MS X does not find a cellular frequency channel in cell B to set up a communication link with BS B, it will send the traffic to its nearest ARS, ARS 1, using frequency bands other than the cellular band, such as the ISM band. The ARS 1 will relay the traffic, using the ISM band again, to another ARS, ARS 2, in the neighboring cell, cell A. Finally, ARS 2 will forward the traffic to BS A using the cellular frequency channel. This provides a cost-effective way to overcome the congestion problem by dynamically balancing the traffic load among different cells. Besides the load balancing, iCAR is also able to extend the coverage of traditional SCNs. This is true because if a MS is out of the BSs' coverage, it can access the system by relaying its packets through ARSs. The strategy on deploying ARSs is investigated in [10] which studied how to generate a scale-free topology for ARSs so that scalability can be achieved. Subsequently, by using the scale-free topology of ARSs, they proposed a load-balancing-based routing scheme for iCAR systems so that the system is more robust to BS failures and the available resource can be used efficiently.

4.2 MCN

Lin and Hsu proposed multihop cellular network (MCN) [12] in the year 2000, which is considered as one of the few pioneer works reported in the literature using multihop transmissions in the cellular networks. They pointed out two ways to construct a MCN, which are shown in Figure. 3.

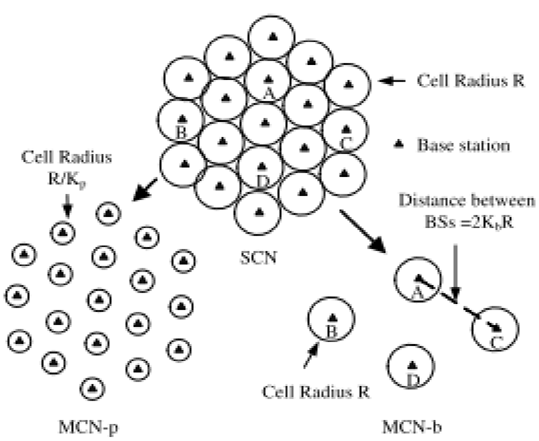

Figure 3. Two ways of Constructing MCN's[11]

One is referred to as MCN-p, which reduces the transmission range of a BS (or MS) and keeps the same number of BSs in the service area. The other one, MCN-b, on the contrary, reduces the number of BSs such that the distance between two neighboring BSs becomes larger while keeping the transmission range of a BS or a MS. In both cases, the MS may not be able to reach the BS within one hop. Thus, multihop transmission through peer-to-peer communications among MSs, where some MSs act as mobile RSs, is necessary to communicate to the BSs. If a MS can not communicate to a BS due to out of the transmission range, it will reach the BS via a mobile RS. However, how to select a mobile RS is not explicitly mentioned in [12]. Consequently, the network operators could use MCNs for data services with high data rate requirements and continue with SCNs, such as GSM, for traditional voice calls. Hence, MCN does not have a problem to fit into the current state of technology. In an effort to show the advantages of MCN, Lin and Hsu have considered only intra-cell network traffic. However, under inter-cell traffic conditions, the benefits of spatial reuse through peer-to-peer communications, if any, and the effectiveness of the MCN architecture might be poor.

4.3 UCAN

In the 3G wireless data networks, channel quality usually determines the QoS of the connection from a MS to its BS. When MS's are experiencing poor channel conditions this bottleneck actually limits the aggregate throughput of a cell. Thus a multihop cellular network which was proposed in **[13]** which is a new architecture namely Unified Cellular and AdHoc Network (UCAN) by opportunistically using ad hoc network such as Industry Scientific Medical (ISM) Bandwidth. As shown in Fig 4.

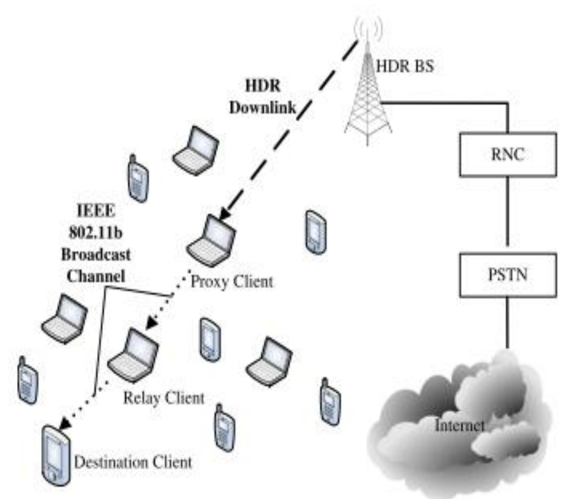

Figure 4 UCAN Architecture [11]

UCAN consists of a 3G cellular network namely CDMA 2000 Evolution-Data Only also known as High Data Rate (HDR) [14], and Wi–Fi [15] to provide high data services for any user. If the HDR BS is not able to provide a high data rate to a specified MS, the HDR BS will forward the traffic to a proxy, a Wi–Fi terminal, which will relay the traffic to that MS.

For the proxy discovery, Luo et al. proposed two algorithms greedy and on-demand proxy discovery algorithms. In general, the greedy proxy discovery protocol is proactive and the on-demand proxy discovery protocol is passive. The greedy proxy discovery requires a greedy path to reach a proxy client with high HDR downlink channel rate. A greedy path is constructed by a mobile client forwarding the route request message (RTREQ) to its neighbor client with the best HDR downlink channel rate for each hop. However, this greedy path may not always locate the proxy client with the best overall channel rate for the destination client. The on-demand proxy discovery always finds the proxy client with the best channel rate at the expense of RTREQ message flooding. The drawback encountered in UCAN is the potential stability issue related to the interference in the unlicensed ISM band.

Later, Feeney et al. [16] proposed a similar architecture that allows replacing a low data rate transmission with a two-hop sequence of shorter range, to provide higher data rate transmissions, using mobile relays. The difference from [13] is that new relay proxy discovery protocols, opportunistic relay protocol (ORP), is proposed and studied in [16]. ORP allows MSs to increase their transmission data rate using a two-hop transmission with shorter transmission range in each hop, by using an intermediate MS as a relay, such that a higher data rate can be achieved with the shorter transmission range. Furthermore, ORP differs from the proxy discovery algorithms proposed in [13] in discovering proxy experimentally by opportunistically making frames available for relaying. MSs identify them as suitable relays by forwarding these frames. Lastly, a distinct feature of ORP is that it does not rely on observations of the received signal strength to infer the availability of proxy and transmit rates.

4.4 MCNs with hybrid relays

MCNs with hybrid relays adopt both fixed relays and mobile relays.

4.4.1 HMCN

For MCNs with hybrid relays, Li et al. [17] proposed hierarchical multihop cellular network (HMCN). Additionally, a one-level version of HMCN was proposed in [18] and called cellular based multihop (CBM) system. As shown in Fig. 5, multihop cells are included as sub-cells in HMCN, where the multihop communication path is established through the multihop capable nodes (MHNs) as shown in Figure 5.. Note that MHNs can be fixed relaying entities deployed by the network operator or mobile nodes (MNs) with multihop communication capability; fixed MHNs or mobile MHNs. For fixed MHNs, also called extension points (EPs), they are relaying devices deployed by the network operator at strategic locations. Fixed MHNs are comparable to the ARSs in iCAR [9], but their purpose is more related to enhance coverage of high data rate access.

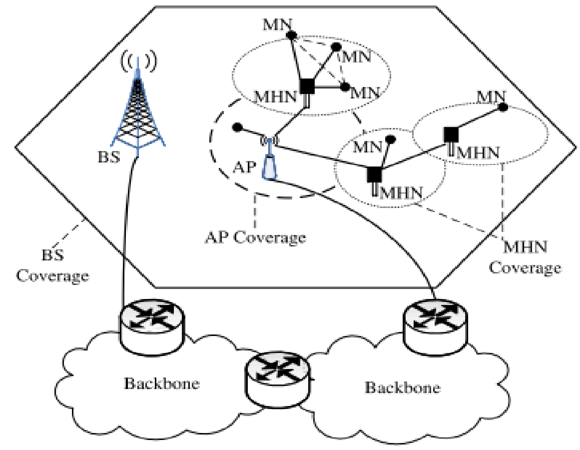

Figure 5 Cell and Multihop Cell in HMCN[11]

Mobile MHNs are actually MSs with multihop communication capability. With the aid of MHNs, multihop communication is realized in Heterogeneous Networks (HN). When fixed MHNs are used, the AP-MHN link should be known in order to optimize the overall performance of HN. In addition, a fixed MHN should have additional intelligence such as full scheduling capacity and processing the forwarding data in the baseband, instead of being a simple direct repeater. Next, the locations of fixed MHNs are pre-determined and help yield the highest benefit. Routing becomes simple if the AP knows where to find a suitable MHN. Furthermore, from the view of MSs, MHNs are equivalent to simplified APs. Finally, adaptive antennas can be equipped in fixed MHNs to further improve the data rate [19]. When mobile MHNs are used, a location controller is necessary to store the information of locality and neighborhood of each MS. Furthermore, each MS should be equipped with at least two sets of air interfaces, which operate in separate frequency bands. In this way, each MS can support multihop communication.

The range of multihop cell is dynamically changing. Several routing schemes were compared in [17] and it was found that routing with information provided by the cellular infrastructure would consume the lowest overhead and exhibit excellent scalability. To summarize, the several benefits offered by HN [17] include coverage extension, transmit power reduction, capacity gain, and low-cost deployment and optimized resource control. However, issues related to power control and resource management have not been investigated.

4.4.2 A-GSM & ODMA

The ad hoc global system for mobile communications (A-GSM) architecture [20] allows GSM dual-mode MSs to relay packets in MANET mode and provide connectivity in dead spot areas, thereby increasing system capacity and robustness against link failures. The dual-mode MSs in [20] are equipped with a GSM air interface and a MANET interface; when one interface is being used, the other can detect the availability of the alternative connectivity mode.

The MSs have an internal unit called a dual-mode identity and internetworking unit (DIMIWU), which is responsible for performing the physical and MAC layer protocol adaptation required for each air interface (i.e., GSM or MANET A-GSM). At the link layer, A-GSM mode uses an adaptation of the GSM Link Access Protocol for D channel (LAPDm) that supports the transmission of beacon signals to advertise their capabilities of serving as relay nodes. In the beacon message, a relay node can include the BS to which it can connect, as well as the respective number of hops required to reach the BS. The drawback of this proactive gateway discovery scheme is the high control overhead.

The basic idea in A-GSM is the same as in the opportunity-driven multiple access (ODMA) scheme [20]. Both solutions integrate multiple accesses and relaying function to support multihop connections. ODMA breaks a single CDMA transmission from an MS to a BS, or vice versa, into a number of smaller radio hops by using other MSs in the same cell to relay the packets, thereby reducing the transmission power and co-channel interference. However, ODMA does not support communications for MSs outside the coverage of BSs, while A-GSM does.

4.4.3 SOPRANO - Self-Organizing Packet Radio

The Self Organizing Packet Radio Ad Hoc Network with Overlay (SOPRANO) [21] investigates some of the techniques by which the capacity of a cellular network can be enhanced, including bandwidth allocation, access control, routing, traffic control, and profile management. The SOPRANO architecture advocates six steps of self-organization for the physical, data link, and network layers to optimize the network capacity: neighbor discovery, connection setup, channel assignment, planning transmit/receive mode, mobility management and topology updating, and exchange of control and router information. Multi-user detection (MUD) is also suggested for the physical layer since MUD is an effective technique to reduce the excessive interference due to multihop relaying. In the MAC layer, if transmissions are directed to a node through several intermediate nodes by multihop, clever frequency channel assignments for each node can significantly reduce interference and could result in better performance. In the network layer, for enhancing system capacity, multihop routing strategy must take into account the traffic, interference, and energy consumption.

4.4.4 MADF

Wu et al. [22] proposed mobile-assisted data forwarding (MADF), which actually combines the characteristics of architectures proposed in iCAR [23] using fixed relays and PARCELS [24] using mobile relays. In MADF, a forwarding agent (equivalent to a relay) could be a repeater placed around the boundary of a cell or another MS. Under MADF, the cellular channels are divided into two groups fixed channels and forwarding channels, where forwarding channels will be devoted to diverting traffic from a congested cell to a non-congested cell. In this way, the system performance can be greatly improved under some delay constraint.

4.4.5 MRAC

A similar concept is proposed by Yamao et al.[25], namely Multi-hop Radio Access Cellular (MRAC)scheme. For example, two types of hop stations (equivalent to relays) are assumed in MRAC—one is a dedicated repeater installed at a good propagation location and the other is simply a MS. However, the path diversity effect is purposely employed in MRAC, which is also studied in [26]. The path diversity is very helpful to solve problems such as AP failures, hand-off procedures and weak multihop connections.

5. COMPARISON OF THE INTEGRATED ARCHITECTURES

In order to better understand the various issues in the various architectures proposed for the heterogeneous networks we show in a comparison table as to how and which one is the best in the scenarios. Table 1 shows these results.

Table 1. Comparison Table of Heterogeneous Architectures & Performances

Architecture	**Wireless technology**	**Relaying entity**	**Interface**	**Objectives**	**Implementation**
iCAR	Cellular system, WLAN	Fixed relaying devices called ad hoc relay station (ARS)	Dual interfaces	Congestion problem by diverting the traffic from hot cell to cold cell	Using fixed relaying devices i.e. ARS which are placed strategically in the network for relaying
MCN	Cellular system, WLAN	Mobile station	Dual interfaces	Solving the capacity enhancement problem by reducing the number of BS's for upgrading	Reducing the transmission power of the BS and MS thus increasing the spatial reuse of limited bandwidth

UCAN	3G Cellular system, WLAN	Mobile client	Dual interfaces	Increases the downlink throughput of cellular system by opportunistic use of IEEE 802.11 based ad hoc networks. It also maintains throughput gain fairness by refining 3G BS scheduling algorithm	Relaying traffic in HDR downlink to the proxy client, then forwarding it through several intermediate clients before Finally the traffic arriving at the destination client. The route request message is initiated by the destination client and it also acts as a route establishment.
HMCN	GSM, UMTS, WLAN	Multihop capable node (MHN). It can be fixed relaying devices (extension points) or mobile stations	Dual interfaces	Providing high data rate services for cellular system user through the possible use of WLAN access and high mobility Internet access for WLAN user by allowing vertical handover to cellular system	Introducing a layered architecture of several wireless systems with overlapped coverage. Multihop communication is mostly performed in the WLAN layer
A -GSM	Cellular, MANETs	Gateway Nodes send beacon messages (Proactive Scheme)	Dual Mode	Providing coverage Transmission power reduction and capacity	The reduction in transmission power from MS away from the BS is a big advantage.
MADF	Cellular, MANETs	Ad Hoc routing protocol for routing discovery	Single mode	Load balancing between BS's	Forward parts of the traffic in an overcrowded cell to some free cells.
SOPRANO	Cellular, MANET	Routing decision is based on minimu	Single mode	Base station capacity	Using different layers to optimize the network capacity,

		m interference and energy			neighbor capacity , connection setup channel assignment

6. PROBLEMS IN THE ROUTING PROTOCOLS

In this section we give an overview of the problems that exist in the various routing protocols and their problems. All the above architectures consider specific networking scenarios and have specific optimization goals such as increasing the system capacity [29, 30] and providing a good load balance [31]. A detailed comparison of these architectures can be found in [32]. MCN, ICAR, SOPRANO, ODMA, MADF and UCAN do not support MSs that are out of coverage of the BS/AP. These schemes improve the throughput between the BS/AP and the MS but do not provide extended coverage. MCN, SOPRANO and MADF assume single-mode MSs. Two-hop relay supports out of coverage MSs, but does not provide dynamic topology discovery in the event of relay MSs move away. These schemes do not consider selection of alternative routing paths based on user requirements in case multiple routing paths are available to the BS/AP. These architectures do not consider generic combinations of network architectures that support the best connectivity to the user and increase the network capacity. Also, these architectures do not take node cooperation into account and why an MS should relay packet destined to another MS? Therefore, existing inter-domain multi-hop connection management protocols do not cater to the requirements of Heterogeneous Networks.

7. NODE COOPERATION

It is considered in the most of the literature that all nodes existing in the network will be trustworthy and not selfish nor having any malicious nature in them but in a real world this is not the case. Last, but not the least, node cooperation is required for the viability of HNs. For the proper operation of a multi-hop network, the MSs are required to collaborate with each other. This collaboration or the willingness of a MS to participate in the relaying or packet forwarding process cannot be taken for granted because each user wants to maximize his or her gains, with minimal dissipation of his or her resources. The packet forwarding process consumes the battery life of the relaying MS. A selfish user may turn off his MS to avoid dissipation of resources [33, 34]. Therefore, a fundamental question is why a user would forward packet for someone else• Protocols fostering node cooperation or collaboration such as rewarding a relaying MS could encourage users to participate in packet relaying. Two important issues in developing protocols for fostering node cooperation are resource constraints of the MSs in implementing complex algorithm and additional control overhead associated with the protocol. The existing approaches for node cooperation in ad hoc networks are listed in [35]. We can see that the authors of these architectures did not show any incentive to the users as to why they should forward someone else's data and use their battery power consumption. Security architectures are not present in the protocols and most of them consider the network trustworthy which is not the case in a real world.

8. CONCLUSIONS AND FINDINGS

The continued research in the field of mobile wireless communication will always give us alternatives as to how to remain connected always. Although most of the architectures have shown how to increase network capacity and increase throughput and how to reduce delay still there is more work to be done. As the future will be heterogeneous thus the mobility protocol being selected should be able to adapt to different network topologies and various possible scenarios. More incentives need to be given to the end user as to why he should be wiling to help a customer located outside the cellular coverage. More security protocols also need to be introduced to enhance the effectiveness against any kind of attack by a user.

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