SUMMARY OF PAPERS

Date: 6th July, 2007

This file contains summary of all those papers which I refer to get what is currently going on in MANET. The main purpose of this task is to know about the problems and issues researchers are currently working on. In this file I have included which problem is focused in particular paper and their approach to solve it. One can classify the following papers in one or more of the following categories: path and link availability, routing, security, multi agent systems, broadcasting problems, protocol design and Quality Of Service.

1) Title: Paths: Analysis of path duration statistics and their impact on reactive MANET protocols
Authors: Narayanan Sadagopan, Fan Bai, B Krishnamachari,
Keywords: Path duration, mobility of nodes, MANET
General Description: This paper develops a detailed study of how mobility impacts the performance of reactive MANET routing protocol. In particular this paper examines the statistics of path duration. Their results suggest that at moderate and high velocities the exponential distribution is good approximation to path duration. This paper uses the statistical analysis of simulation data to obtain detailed statistics of link and path duration. Further this paper shows using simple analytical model a strong correlation between reciprocal of average path duration and throughput and overhead of reactive protocol. In this paper, they have develop an approach that combines statistical analysis of simulation data and analytical modeling to get a deeper understanding of the protocol performance in the presence of mobility.

2) Title: A prediction based link availability estimation for routing metrics in MANETs.
Authors: Shengming Jiang, Dajiang He, J Rao
Keywords: link availability, measure of link availability, MANET
Issue: ACM digital transaction, Volume 13, issue 6
General Description: Routing is difficult in MANET since terminal mobility may cause radio links to be broken frequently. When any link of path is broken, path is repaired with new link or path is replaced with other path. To reduce rerouting operation, path reliability may be more important in selecting optimal path in MANETs than other metrics such as path cost and QoS. The reliability of path depends on reliability and availability of each link of this path. Previous study focuses mainly on procedure of information exchange for finding and/or maintaining path and often uses shortest path in terms of number of hops that a path goes through. How to measure link availability property so that it can be used as a routing metric to reflect path reliability has not addressed adequately. This paper introduces prediction based link availability estimation and uses this estimation to form routing metric.

3) Title: A Path availability model for mobile ad hoc networks.
Authors: A. Bruce McDonald and Taieb Znati
Keywords: Path availability
General Description: This paper proposes a novel routing metric, which defines a probabilistic measure of network paths that are subject to failures caused by node mobility in ad-hoc networks. It it shown that how this measure can be used to select more stable paths and reduce the routing overhead caused by node mobility. Previously mobility models have focused on a single node moving relative to a fixed base station or network of base stations. No work which addresses the two body mobility problem encountered in ad-hoc network has been published. To address this need this paper proposes a well defined mobility based routing metric for ad-hoc networks. Analytical expressions are presented for the probability that a wireless link exists between two mobility nodes at time $t_0 + t$, given that a link

exists between them at t_0. A mobility model is first proposed and used to characterize the movement of ad-hoc network nodes. This model is then used to derive expressions for link and path availability.

4) Title: Maximizing Path Durations in Mobile Ad-Hoc Networks
Authors: Yijie Han and Richard J. La
Keywords: Path durations, Path availability, Path failure
General Description: The Dynamic Source Routing (DSR) protocol selects the minimum hop path, whereas the Ad-hoc On-demand Distance Vector (AODV) routing protocol selects the first discovered path. Associativity Based Routing (ABR) protocol selects the path with maximum average age of the links. However, it is not clear how the hop count or the average age of the links along a path is related to its (expected) duration. In order to this answer this question we studied the distribution of path duration and its relation to those of the links. Our main results show that (i) when the hop count of a path is large, the distribution of path duration can be approximated by an exponential distribution, and (ii) the parameter of the exponential distribution is determined by the expected durations of the links in the path. In this paper, we propose a novel scheme that (i) maximizes the expected durations of selected paths and (ii) enables local path recovery in the event of a path failure by switching to an alternative path cached at a node, whose estimated probability of being available exceeds some threshold. The latter exploits the well known memoryless property of an exponential distribution, and the threshold value can be adjusted to carry out a trade off between routing overhead and potentially larger delays during path recovery.

5) Title: Distribution of Path Durations in Mobile Ad-Hoc networks and Path Selection
Authors: Richard J. La and Yijie Han
Keywords: Path Durations, Exponential Duration, Palm's theorem
General Description: In MANET, due to node's mobility links are set up and break down frequently. When one or more link along a path in use become unavailable, that path is no longer valid and path recovery procedure must be triggered. Detecting and recovering from path failure can take non – negligible amount of time, disrupt the on going traffic, degrades the performance and incurs additional overhead of initiating path recovering procedure. Therefor a good routing algorithm should take in to consideration expected duration as well as other requirements while selecting a path. We investigate the issue of path selection in multi-hop wireless networks with the goal of identifying a scheme that can select a path with the largest expected duration. Under a set of mild conditions, when the hop count along a path is large, the distribution of path duration can be well approximated by an exponential distribution even when the distributions of link durations are dependent and heterogeneous. Secondly, we investigate the statistical relation between a path duration and the durations of the links along the path. We prove that the parameter of the exponential distribution, which determines the expected duration of the path, is related to the link durations only through their means and is given by the sum of the inverses of the expected link durations. The application of Palm's theorem requires that the link excess lives be mutually independent. Using this we can show that distribution of path duration can indeed be approximated by exponential distribution. Two neighboring links along a path share a common node. Clearly, the excess lives of these two neighboring links depend on the mobility of the shared node, introducing some level of dependence in them. In this paper we extend above result by relaxing the independence assumption on the link excess lives. We also show that the parameter of the emerging exponential distribution is the same whether the link excess lives are mutually independent or not. In other words, the parameter of the exponential distribution is given by the sum of the inverses of the expected link durations. This suggests that for a path with a sufficiently large hop count the dependence of link excess lives does not significantly affect the path duration distribution.

6) Title: Link availability Models for Mobile Ad-Hoc Networks
Authors: A. Bruce McDonald and Taieb Zanti
Keywords: Link availability, Random Ad-Hoc mobility model
General Description: The main difficulty of routing in ad-hoc networks arises because a fixed infrastructure every path consists of wireless links whose end points are moving independently of one another. Consequently node mobility causes the frequent failure and activation of links, leading to traffic backlogs at upstream nodes. Furthermore rate of node mobility is directly related to link failure. Consequently higher mobility rates increases both volume of control traffic required to maintain routes and congestion upstream of failed links. This observation suggests the need to include some notion of node mobility in the path selection process and to improve the rerouting process by attempting to find new paths prior to failure of existing path. Specifically a routing algorithms capable of choosing a path based on probabilistic availability of component links, whose status are subjected to mobility of their incident nodes, can decrease the frequency of the path failure by choosing maximum availability paths. This paper addresses this issue by proposing a model for ad-hoc node mobility which predicts the evaluation of network topology over time and provides basics for efficient ad-hoc routing strategy. By characterizing the movement of mobility nodes, analytical expressions are presented in this paper for probability that a wireless link exists between two mobile nodes at time $t_0 + t$ given that is is available at time t_0.

7) Title: Path selection in Mobile Ad-hoc networks and distribution of path duration
Authors: Yijie Han, Richard J. La and Hongqiang Zhang
Keywords: expected path duration, distribution of path duration
General Description: Authors of this paper are interested in designing a path selection algorithm that maximizes the expected duration of the selected path. They first study the distribution of the path duration and show that under the mild conditions when the hope count is large the distribution of the path duration can be well approximated by an exponential distribution even when link durations are dependent and their distributions are heterogeneous. They also investigate the relation between a path duration and duration of the link along the path. They prove that parameters of the exponential distribution, which determines the expected duration of the selected path, is related to the link duration only through their means and is given by the sum of the inverse if the expected link durations.

8) Title: Path Availability in Ad Hoc Networks
Authors: Dan Yu, Hui Li and Ingo Gruber
Keywords: Random walk mobility model, path availability
General Description: Ad hoc network has many advantages over traditional cellular wireless networks- like it does not require infrastructure, promises greater flexibility, lower operating cost, higher through put and better coverage. However, the design of ad hoc networking is difficult task because of continuous change of network topology and many network parameters that are highly random and highly dependent on each other. This paper emphasize on the analysis of the link and router availability properties of ad hoc networks. Their study shows that the relative error increases with increasing path length for small values of random length intervals, called epochs – during which mobile nodes move in constant direction in constant speed. This paper derives link and path availability models for ad hoc networks with random walk mobility model that is different from random ad-hoc mobility model. The knowledge of link availability can serve as groundwork for further analysis of network performances, as well as guide to ad hoc network protocol design. This paper presents a general ad hoc network model and derives the statistics results of link and path availability properties in ad hoc networks.

9) Title: IPv6 Auto configuration in Large Scale Mobile Ad Hoc Networks
Authors: Kilian Weniger and Martinna Zitterbart
Keywords: IPv6 Stateless Address Auto configuration and IPv6 Neighbor Discovery Protocol, leader election algorithm
General Description: In MANET, because of node mobility, the available paths to a destination change over time with a considerably higher frequency than in infrastructure networks. Furthermore, the network may partition and merge again later, dependent on the mobility patterns and transmission ranges of the mobile nodes. Consequently, enhanced requirements exist for routing protocols operating in such an environment. This has been addressed by various research efforts on mobile ad-hoc routing. Much less attention has been given to auto configuration mechanisms, such as address auto configuration. In general, the purpose of address auto configuration is the assignment of an address to an interface, which is unique and routable in the network. In ad hoc networks, this mechanism need to cope with the high dynamics within such networking environments. In this paper, we investigate the applicability of IPv6 auto configuration mechanisms to ad hoc networking. A hierarchical approach based on so-called leader nodes is proposed together with a leader election algorithm. The approach presented in this paper is based on some requirements – like the mechanism needs to cope with the network dynamics present in mobile ad-hoc networks, the mechanism shall scale to large ad-hoc networks with, e.g., thousands of nodes with multiple interfaces, because there exist many routing protocols for ad hoc networks, each optimized for special network scenarios, the mechanism shall be independent of the routing protocol, If two independently configured ad hoc networks merge, the uniqueness of the addresses shall be guaranteed afterwards, i.e. network partitioning and merging shall be supported.

10) Title: Multi hope connectivity of arbitrary networks.
Authors: L. E. Miller
Keywords: adjacency matrix, connectivity matrix
General Description: The adjacency (one hope connectivity) matrix A = { a_{ij} } for an N – node network, in which a 1 entry at (i,j) indicates a connection from node i to node j and a 0 indicates no connection, can be manipulated to obtain the (multi hope) connectivity matrix C = { c_{ij} }, for which the entry (i,j) lists the minimum number of hops needed to connect node i to node j. This letter proposes the algorithm which does above described task.

11) Title: Impact of Interferences on Connectivity in Ad Hoc Networks
Authors: Olivier Dousse, Francois Baccelli and Patrick Thiran
Keywords: percolation theory, signal to noise ratio, clusters
General Description: We study the impact of interferences on the connectivity of large-scale ad hoc networks, using percolation theory. We assume that a bi-directional connection can be set up between two nodes if the signal to noise ratio at the receiver is larger than some threshold. The noise is the sum of the contribution of interferences from all other nodes, weighted by a coefficient ´Y, and of a background noise. We find that there is a critical value of ´Y above which the network is made of disconnected clusters of nodes. We also prove that if is nonzero but small enough, there exist node spatial densities for which the network contains a large (theoretically infinite) cluster of nodes, enabling distant nodes to communicate in multiple hops. Main goal of this paper within this context is to learn whether the percolation phenomenon for the case without interference still holds within this more realistic context. This paper also introduces some orthogonality factor ´Y, which can vary from 0 to 1, and which stems from the imperfect orthogonality of the codes used in CDMA. The main result of the paper is that under attenuation functions with finite support, percolation holds under conditions similar to those of the Boolean model provided the orthogonality factor ´Y is small enough.

12) Title: Gossip Based Service Discovery in Mobile Ad Hoc Networks
Authors: Choonhwa Lee, Sumi Helal and Wonjun Lee
Keywords: Service Discovery protocols, routing in MANET
General Description: Service discovery is procedure which enable automatic detection of service available on a local network. Service in dynamic ad hoc mobile network may be discovered via multi-casts, query propagation or distributed caching scheme. Most of the service discovery protocols are based on the announce-listen model whereby the presence of services is periodically multi cast and cached by others. Study addresses the new opportunities, issues and requirements for discovery and delivery framework of device independent service in ad hoc networks. Authors believe that an ad hoc service discovery protocol should facilitate service information propagation in more efficient way. The protocol must not use too much traffic, while being able to discover services in a timely fashion. In other words, the two conflicting goals of less traffic and faster response time should be well balanced. This letter presents gossip based ad hoc service discovery protocol that uses a novel decentralized, peer to peer mechanism to provide mobile device with the ability to advertise and discover service in an efficient way.

13) Title: The Broadcast Strom Problem in a Mobile Ad Hoc Network
Authors: Sze Yao Ni, Yu Chee Tseng, Yuh Shyan and Jang Ping Sheu
Keywords: Broadcasting, redundancy, contention, collision
General Description: This paper studies the problem of sending a broadcast message in a MANET. Broadcasting is a common operation in many applications, e.g., graph-related problems and distributed computing problems. It is also widely used to resolve many network layer problems. In a MANET in particular, due to host mobility, broadcastings are expected to be performed more frequently e.g., for paging a particular host, sending an alarm signal, and finding a route to a particular host. Broadcasting may also be used in LAN emulation or serve as a last resort to provide multi-cast services in networks with rapid changing topologies. In this paper, we assume that mobile hosts in the MANET share a single common channel with carrier sense multiple access (CSMA), but no collision detection (CD), capability. Synchronization in such a network with mobility is unlikely, and global network topology information is unavailable to facilitate the scheduling of a broadcast. So one straightforward and obvious solution is broadcasting by flooding. Authors observe that serious redundancy, contention, and collision could exist if flooding is done blindly. First, because the radio propagation is omni-directional and a physical location may be covered by the transmission ranges of several hosts, many rebroadcasts are considered to be redundant. Second, heavy contention could exist because rebroadcasting hosts are probably close to each other. Third, collisions are more likely to occur because the RTS/CTS dialogue is inapplicable and the timing of rebroadcasts is highly correlated. Collectively, we refer to these problems associated with flooding as the broadcast storm problem. Two directions to alleviate this problem is to reduce the possibility of redundant rebroadcasts and differentiate the timing of rebroadcasts. Following these directions, we develop several schemes, called probabilistic, counter-based, distance-based, locution-based, and cluster-based schemes, to facilitate MANET broadcasting.

14) Title: Multi Agent Systems in Mobile Ad Hoc Networks
Authors: Joseph P. Macker, William Chao, Ranjeev Mittu, Myriam Abramson
Keywords: MANET, Multi Agent Systems (MAS)
General Description: Mobile Ad Hoc network (MANET) enables self organizing, multi hop heterogeneous network routing services and organization. Multi Agent Systems (MAS) can enable autonomous, team based problem solving under varying environmental conditions. MAS has assumed relatively benign wired network behavior and inter agent communications characteristics that may not be well supported in MANET environments. This paper describes ongoing research to improve the ability of these technologies to work in concert. MANET technology is designed to provide effective

dynamic IP routing in network environment where due to mobility of nodes topology may changes. MAS technology is well suited for dynamic, distributed problem solving in which distributed software agents are able to both sense and act within complex environments. Separately MANET and MAS encompass two challenging research areas. The focus of this paper is to begin improving the performance capability of MAS applications running in MANET environments.

15) Title: Locating Mobile Nodes With EASE: Learning Efficient Routes From Encounter Histories Alone
Authors: Matthias Grossglauser, Martin Vetterli
Keywords: Geographic routing
General Description: Routing in large scale mobile as hoc networks is challenging because all the nodes are potentially moving. Geographic routing can partially alleviate this problem, as nodes can make local routing decisions based solely on the destinations' geographic coordinates. However, geographic routing still requires an efficient location service, i.e., a distributed database recording the location of every destination node. The main purpose of this paper is to show that node mobility can be exploited to disseminate destination location information without incurring any communication overhead. This paper achieves this by letting each node maintain a local database of the time and location of its last encounter with every every other node in the network. This database is consulted by packets to obtain estimate of the destination's precise location, because node mobility has diffused estimates of that location. In this paper , the authors try to completely eliminate the cost to update location state. If nodes are not allowed to exchange any explicit location updates, then the only local information available to a node about the network topology is the history of the other nodes it has encountered in the past, i.e., that it has been directly connected to. More specially, the authors assume that every node remembers the time and location of its last encounter with every other node. If at every node along a packet's route, the next hope decision depends only on 1) the time and location of that node's last encounter with the destination and 2) auxiliary information carried by that packet, then that algorithm is called Last Encounter Routing (LER). This paper shows that depending on the mobility process it is possible for LER schemes to compute efficient route, despite the absence of a location service.

16) Title: Hop by Hop Congestion Control Over a Wireless Multi Hop Network
Authors: Yung Yi, Sanjay Shakkottai
Keywords: MAC, spatial spreading, Congestion control
General Description: In a wireless context, an important resource constrain that arises is that due to the MAC. To address this, we consider a wireless system, where multiple frequencies / codes are available for transmission, and enables parallel communication in a neighborhood using such orthogonal channels. The wireless MAC in such a system use a time – division strategy for channel access, where at any point in space, the physical channel can be addressed by a single use at each instant of time. This paper develops a distributed, hop by hop congestion control scheme, which is shown to be stable in the absence of the propagation delays, and allocates bandwidth to various users in proportionally fair manner. In the presence of delay, this paper shows that it has the property of spatial spreading. In other words, focused loads at a particular spatial location in the network get smoothed over space. While end to end control scheme could result in large transient overloads at a single node, a hop by hop scheme will “push back” and cause congestion to occur over space, resulting in smaller peak overloads. Thus, even if the bottleneck node is very close to the receiver, there are potential gains to be had due to spatial spreading. Hence, even if the total buffer requirement over the network is the same, the hop by hop scheme ensures that the buffers required are spatially spread.

17) Title: An Approach to Mobile Ad hoc Network Protocol Kernel Design
Authors: Lusheng Ji, Mary Ishibashi, M. Scott Corson
Keywords: Kernel construction
General Description: The resource constraints of the fixed Internet have naturally led to a protocol design approach that favors expenditure of bandwidth while minimizing, to the greatest extent possible, the need for processing or storage in routers. This design approach relies on "horizontal" peer to peer communication between peer protocol layers on neighboring routers, while minimizing the amount of interlayer communication within protocol stack. This is sometimes referred to as the principle of "strict protocol layer separation". This approach has the added benefit in that it minimizes the degree of fate sharing between adjacent protocol layers, and reduces the complexity of protocol design. The resource constraints in MANETs (bandwidth and sometimes energy) are essentially the opposite of those in the fixed Internet, and this argues for a different design approach-one which minimizes horizontal communication and increases interlayer communication within the protocol stack. Protocol stacks designed in this fashion become more "logically-coupled" , with increased two-way interlayer communication sufficient to permit upper layer protocols to bind more closely with lower layer protocols, thereby removing inefficiencies that might result from additional horizontal communication. This approach can have the added benefit of reduced energy expenditure-often the primary design objective in low power systems. Following this approach, upper layer protocols will likely become dependent on lower layer protocols for protocol-specific functionalities. Following this latter design approach has been the usual practice in mobile packet radio systems, which have traditionally been known **as** "stove-pipe" systems because of their use of proprietary, highly vertically-integrated technology at all levels of network control. As underlying technologies change, it is necessary that the protocol stack changes with them. Such flexibility is greatly facilitated by the use of a modular kernel – one composed of multiple protocols (i.e. processes) which communicate through well-known interfaces via message passing. Such a kernel can be physically loosely-coupled, but vertically logically-coupled. The former attribute renders the kernel's composition flexible, while the latter preserves its efficiency. A kernel composed in this fashion can be more easily extended and reconfigured than one where the protocol stack has a tightly-bound, monolithic implementation, **as** communication through well-known interfaces explicitly defines adjacent protocol interactions.

18) Title: Quality of Service for Mobile Ad Hoc Networks (Diploma Thesis)
Authors: Patrick Studi
Keywords: QoS, DeffServ, IntServ, RSVP, ASAP
General Description: Traditional internet QoS protocols like RSVP cannot be easily migrated to the wireless environment due to the error-prone nature of wireless links and the high mobility of mobile devices. This is specially true for Mobile Ad Hoc Networks (MANETs) where every node moves arbitrarily causing the multi-hop network topology to change randomly and at unpredictable times. In this thesis an existing QoS framework is extended to be suitable for MANETs. This thesis studies the special issues and difficulties when applying different QoS models designed for Internet in MANET. The ad hoc extension to ASAP is proposed.

19) Title: Quality of Service and Mobility for Wireless Internet
Authors: J Antonio garcia-macias, Franck Rousseau, Gilles Berger- Sabbatel, Leyla Toumi and Andrzej Duda
Keywords: QoS, DiffServ, Micro mobility scheme of IPv6.
General Description: This paper explores the issue of how to provide appropriate quality of service mechanisms closely integrated with flexible mobility management in wireless local area networks. Authors consider them as access networks of choice for the high performance Wireless Mobile Internet. This paper presents a hierarchical QoS architecture that extends *Differentiated Services*

(DiffServ) to mobile hosts in a wireless environment. The approach of this paper is based on controlling several parameters of a wireless LAN cell: the limited geographical span to ensure the same high bit rate for all hosts, the constrained rate of traffic sources to limit the use of the channel in function of the required QoS and the limited number of active hosts to keep the load sufficiently low. The QoS management is coupled with mobility management at the IP level. Authors use a micro-mobility scheme implemented in the IPv6 layer with fast hand-offs between adjacent cells. Micro-mobility avoids address translation, traffic tunneling, and enables fast hand-offs.

20) Title: Secure Multipath Routing for Mobile Ad Hoc Networks
Authors: Panayiotis Kotzanikolaou, Rosa Mavropodi, Christos Douligeris
Keywords: Denial Of Service attack, Security issues in MANET
General Description: Security is a major concern in MANET. Several security issues have been examined such as node authentication and trust establishment , key agreement and intrusion detection . Of particular interest is routing security, since the lack of fixed infrastructure makes routing an obvious target for malicious nodes. With single path protocols it is trivial for an adversary to launch a DoS attack, even if security measures are taken. A malicious node controlled by the adversary may participate passively in the routing path between two end nodes and may behave as a legitimate intermediate node. The malicious node can stop the communication at any time it seems most advantageous to the adversary. Indeed, if there exist k node-disjoint paths between two end nodes, the adversary should compromise at least *k* nodes - and more particularly at least one node in each path - in order to control their communication. A secure multipath routing protocol must be node-disjoint. Otherwise, a malicious node would be allowed to participate and consequently control more than one paths. By employing *k* node-disjoint routing paths between two communicating nodes, the integrity and availability of the communication is guaranteed against DoS attacks of an adversary that controls less than *k* malicious nodes. This paper proposes a complete on-demand multipath routing protocol, the Secure Multipath Routing (SecMR) protocol, which provides protection against DoS attacks from a bounded number of collaborating malicious nodes.

21) Title: Gossip Based Ad Hoc Routing
Authors: Zygmunt J. Haas, Joseph Y. Halpern and Li (Erran) Li
Keywords: flooding, routing, optimization
General Description: Despite the optimizations, in routing protocols that use flooding, many routing messages are propagated unnecessarily. In this paper, authors show that *gossiping*—essentially, tossing a coin to randomly decide whether or not to forward a message— can be used to significantly reduce the number of routing messages sent. It follows from results in percolation theory that gossiping exhibits a certain type of bimodal behavior. In almost all executions of the Gossip based routing algorithm, either hardly any nodes receive the message, or most of them do. Ideally, we could make the fraction of executions where the gossip dies out relatively low while also keeping the gossip probability low, to reduce the message overhead. The goal of this paper is to investigate the extent to which this can be done. This paper shows that, by using appropriate heuristics, we can save up to 35% message overhead compared to flooding. Furthermore, adding gossiping to a protocol such as AODV not only reduces the number of messages sent, but also results in improved network performance in terms of end-to-end latency and throughput. In an ad hoc network, if a message is transmitted by a node, it is in fact usually sent as a broadcast rather than a point-to-point communication, and thus is received by all the nodes one hop away from the sender. Because of the fact that wireless resources are expensive, it makes sense to take advantage of this physical-layer broadcasting feature of the radio transmission. In our gossiping protocol, authors control the probability with which this physical-layer broadcast is sent.

22) Title: Optimal Tradeoffs for Location Based Routing in Large Scale Ad Hoc Networks
Authors: Taejoon Park, Kang G. Shin
Keywords: location based routing, proactive and reactive routing protocols
General Description: Existing location-based routing protocols are not versatile enough for a large-scale ad hoc environment to simultaneously meet all of the requirements of scalability, bandwidth efficiency, energy efficiency, and quality-of-service routing. Discovering and maintaining a route under the energy or QoS constraints is challenging, especially in a large-scale, mobile network. A location-based routing protocol must have the following salient features: 1) scalability to a large number of nodes; 2) support for discovery/recovery of minimum-cost2 routes for *any* destinations; and 3) bandwidth- and energy-efficiency in terms of minimizing the amount of routing overhead and prolonging the lifetime of each node. There exists a tension between keeping accurate location information and avoiding excessive overhead. The location- update overhead would increase with the frequency of location update, while the route-discovery overhead gets smaller as the frequency of location update is raised. On the other hand, the larger the update interval, the smaller the location-update overhead gets, while the more obsolete the cached location information becomes, thus increasing the route-discovery overhead. Hence, the thresholds should be so chosen as to keep the location-update overhead reasonably low while maintaining location information up-to-date enough to determine the asymptotic direction to each destination. This paper studies how to achieve *optimal* location management and efficient route discovery on top of location-basd routing; This paper proposes a tradeoff-based approach that: 1) combines several useful schemes to our advantage, and 2) optimally adjusts the relevant thresholds to minimize the routing overhead. In particular, the two main contributions of this paper are: 1) development of a routing protocol as a hybrid of existing location-based schemes, that addresses the above requirements, and 2) derivation of optimality conditions for the proposed location- update scheme, that enables each node to determine when to update its location.

23) Title: RDMAR: A bandwidth efficient Routing protocol for Mobile Ad Hoc Networks
Authors: George Aggelou and Rahim Tafazolli
Keywords: Relative Distance Micro discovery (RDM), routing
General Description: This paper proposes a new routing protocol for ad hoc wireless networks which addresses some of the problems with existing approaches. The objective of design of this protocol is to keep the routing overhead low while contributing to high overall throughput. In this routing scheme, an optimized route discovery mechanism, called Relative Distance Micro-discovery (RDM), is introduced. According to this mechanism, the routing protocol limits the range of route searching in order to save the cost of flooding a route request message into the entire wireless area. The protocol is highly adaptive, efficient and scalable; and is well-suited in large mobile networks whose rate of topological changes is moderate. A key concept in its design is that protocol reaction to link failures is typically localized to a very small region of the network near the change. The concept behind *RDM* is that a query flood can be localized by knowing the relative distance (RD) between two terminals. To accomplish this, every time a route search between the two terminals is triggered, an iterative algorithm calculates an estimate of their RD, given an average nodal mobility and information about the elapsed time since they last communicated and their previous RD. Based on the newly calculated RD, the query flood is then localized to a limited region of the network centered at the source node of the route discovery and with maximum propagation radius that equals to the estimated relative distance. This ability to localize query flooding into a limited area of the network serves to minimize routing overhead and overall network congestion. Thus, in contrast to pure flooding mechanism where a route query would reach every node that is reachable in the wireless network, in our scheme a query is propagated only to a limited region of the network for the successful discovery of the destination terminal. Due to the significant impact of the *RDM* algorithm on our routing scheme, authors name it *Relative Distance Micro-discovery Ad Hoc Routing Protocol* (RDMAR).

24) Title: DART: Dynamic Address RouTing for Scalable Ad Hoc and Mesh Networks
Authors: Jakob Eriksson, Michalis Faloutsos and Srikant V. Krishnamuthy
Keywords: Dynamic addressing, routing
General Description: It is well known that the current ad hoc protocol suites do not scale to work efficiently in networks of more than a few hundred nodes. In this paper,authors argue that the use of dynamic addressing can enable scalable routing in ad hoc networks. This paper provides an initial design of a routing layer based on dynamic addressing, and evaluate its performance. Each node has a unique permanent identifier and a transient routing address, which indicates its location in the network at any given time. We propose mechanisms to implement dynamic addressing efficiently. With dynamic addressing, nodes change addresses as they move, so that their addresses have a topological meaning. Dynamic addressing simplifies routing but introduces two new problems: address allocation and address lookup. Authors identify a set of properties that a scalable and efficient solution must have: Localization of overhead, Lightweight, decentralized protocols, Zero-configuration, Minimal restrictions on hardware. First, authors develop a dynamic addressing scheme, which has the necessary properties mentioned above. Our scheme separates node identity from node address, and uses the address to indicate the node's current location in the network. Second, authors study the performance of a new routing protocol, based on dynamic addressing, through analysis and simulations. In more detail, this paper leads to the following results. 1) address allocation scheme uses the address space efficiently on topologies of randomly and uniformly distributed nodes, empirically resulting in average routing table sizes of less than 2log n, where n is the number of nodes in the network. 2) Authors compare our protocol to reactive protocols (AODV, DSR) and a proactive protocol (DSDV). This results suggest that dynamic addressing and proactive routing together provide significant scalability advantages.

25) Title: Database and Location Management Schemes for Mobile Communications
Authors: Anna Hac and Bo Liu
Keywords: tracking mobile users, database and location management
General Description: In tracking mobile users and delivering enhanced services causes an additional load in service network by incurring more signaling traffic. To meet the challenges from high density and mobility of users and the challenges from various service features, an efficient database and location management schemes are needed. The system needs to update and provide, upon request, information about the location of mobile users. Queries can be formulated by both the users and the network resource management facility. The criterion for efficient update is low signaling cost incurred by relocation of users between cells. The cost should be kept small enough not to affect network performance. The signaling load for location updates is higher due to more frequent relocation for small cells. Providing information about user location is coupled with updating. Because of frequent relocation of mobile users, especially for small cells, it is impractical to keep track of their exact locations at all times. The more general approach is to keep the location information updated upon query, which requires extra search work. Keeping more complete information updated requires higher signaling cost, while less search work is needed upon query. Finding efficient methods or schemes can balance the effects of these factors and achieve optimal overall performance.

26) Title: Ad Hoc Mobility Management with Uniform Quorum Systems
(Meaning of quorum: a gathering of the minimal number of members of an organization to conduct business)
Authors: Zygmunt J. hadd, Ben Liang
Keywords: Mobility management, uniform quorum systems, balanced incomplete block designs
General Description: In a mobile communication network, mobile hosts move freely from place to place. The location of a mobile host must be identified before a call to the mobile host can be

established. Mobility management deals with the storage, maintenance, and retrieval of the mobile host location information. In *ad hoc* network architecture, however, there is no preexisting fixed-network infrastructure. Nodes of an *ad hoc* network are mobile hosts with similar transmission power and computation capabilities. Direct communication between any two nodes is allowed when adequate radio propagation conditions and network channel assignment exist, in which case we say that these two nodes are neighbors. Otherwise, the nodes communicate through multihop routing. The lack of fixed infrastructure suggests that some network functions otherwise handled by the wireline backbone must now be maintained by the nomadic nodes in the *ad hoc* network. Most of the proposed and existing systems directly send data packets to a destination node through pre-determined routes without using any specialized databases to store the mobile nodes' location. To achieve this, the initiating node must either already have an up-to-date routing table to all the nodes in the network (proactive routing) or try to determine the route on demand (reactive). In this work, we propose an *ad hoc* mobility-management scheme that utilizes location databases which form a *virtual backbone* that is dynamically distributed among the network nodes. A distributed mobility-management scheme using a class of uniform quorum systems (UQS) is proposed for *ad hoc* networks. In the proposed scheme, location databases are stored in the network nodes themselves, which form a selforganizing virtual backbone within the flat network structure. The databases are dynamically organized into quorums, every two of which intersect at a constant number of databases. Upon location update or call arrival, a mobile's location information is written to or read from all the databases of a quorum, chosen in a nondeterministic manner. These databases serve only as containers for location storage and retrieval. Routing is carried out in the flat network structure involving every node in the network. That is, the routes do not necessarily go through the databases. However, the node location provided by the databases can provide vital information to the routing protocol so that route searching is more localized. Moreover, the location of a mobile host is defined in terms of the positional relationships between the mobile host and the other nodes. The identity of the neighboring nodes of a mobile host can provide an indication of how a message could be routed to the mobile host. In particular, we will define the location of a mobile host as the ID number of its nearest location database.

27) Title: A Mobility Transparent Deterministic Broadcast Mechanism for Ad Hoc Networks
Authors: Stefano Basagni, Danilo Bruschi, Imrich Chlamtac
Keywords: broadcasting
General Description: Broadcast (distributing a message from a source node to all other nodes) is a fundamental problem in distributed computing. Several solutions for solving this problem in mobile wireless networks are available, in which mobility is dealt with either by the use of randomized retransmissions or, in the case of deterministic delivery protocols, by using conflict-free transmission schedules. Randomized solutions can be used only when unbounded delays can be tolerated. Deterministic conflict free solutions require schedule recomputation when topology changes, thus becoming unstable when the topology rate of change exceeds the schedule recomputation rate. The deterministic broadcast protocols authors have introduced in this paper overcome the above limitations by using a novel mobility-transparent schedule, thus providing a delivery (time) guarantee without the need to recompute the schedules when topology changes. This paper shows that the proposed protocol is simple and easy to implement, and that it is optimal in networks in which assumptions on the maximum number of the neighbors of a node can be made. This paper presents a general algorithmic scheme for devising broadcast protocols. In particular, this paper introduces a new broadcast protocol in which each node computes its own transmission schedule *once and for all* at network initialization depending only on global network parameters, such as n and the *degree* of the network, namely, the maximum number of neighbors that a node can have. Thus, the proposed protocol is mobility independent in the sense defined above. Moreover, solution presented in this paper completes the broadcast of a message in polylogarithmic time.

28) Title: A Dynamic Call Admission Policy With Precision QoS Guarantee Using Stochastic Control for Mobile Wireless Networks
Authors: Si Wu, K. Y. Michael Wong, Bo Li
Keywords: Call admission control, call dropping probability, new call blocking probability
Call Admission control: The purpose of an admission control algorithm is to decide , at the time of call, whether or not a new call should be admitted into the network. A new call is admitted if and only if its QoS constraints can be satisfied without temporizing the QoS constraints of the existing calls in the network.
General Description: Call admission control is one of the key elements in ensuring the quality of service in mobile wireless networks. The traditional trunk reservation policy and its numerous variants give preferential treatment to the handoff calls over new arrivals by reserving a number of radio channels exclusively for handoffs. Such schemes, however, cannot adapt to changes in traffic pattern due to the static nature. This paper deals with admission control related to the radio channel assignment. When a mobile moves across cells during its lifetime, dropping is primarily caused by the unavailability of the channels in the new cell. One of the key design goals is to minimize the call dropping probability, which is precisely the objectives of most existing proposals on call admission control. This, however, usually comes at the expense of potentially poor channel utilization by admitting fewer new calls. Given that radio channels are considered to be the primary scarce resource in mobile wireless networks, the *main challenge* in the design of an efficient admission control scheme is to balance these two conflicting requirements. Hence the major performance parameters of interest in this paper are the *call dropping probability*, *channel utilization*, and *new call blocking probability.* This paper introduces a novel *stable dynamic call admission control mechanism* (SDCA) that aims to maximize the radio channel utilization while satisfying a predetermined bound on the call dropping probability. The novelties of the proposed mechanism are: 1) it is adaptive to wide range of system parameters and traffic conditions due to its dynamic nature; 2) the control is stable under overloading traffic conditions, thus can effectively deal with sudden traffic surges; 3) the admission policy is stochastic, thus spreading new arrivals evenly over a control period, and resulting in more effective and accurate control; and 4) the model takes into account the effects of limited channel capacity and time dependence on the call dropping probability, and the influences from nearest and next-nearest neighboring cells, which greatly improve the control precision. In addition, this paper also introduces local control algorithms based on strictly local estimations of the needed traffic parameters, without requiring the status information exchange among different cells.

29) Title: Mobility Incerases the Capacity of Ad Hoc Wireless Networks
Authors: Matthias Grossglauser and Davic N. C. Tse
Keywords: multiuser diversity, loose delay constraints
General Description: The capacity of ad hoc wireless networks is constrained by the mutual interference of concurrent transmissions between nodes. This paper studies a model of an ad hoc network where nodes communicate in random source–destination pairs. These nodes are assumed to be mobile. This paper examines the per-session throughput for applications with loose delay constraints, such that the topology changes over the time-scale of packet delivery. Under this assumption, the per-user throughput can increase dramatically when nodes are mobile rather than fixed. This improvement can be achieved by exploiting a form of *multiuser diversity* via packet relaying. This paper focuses on mobile ad hoc networks that have no fixed base stations and with multiple pairs of users wanting to communicate with each other. A model for studying the capacity of *fixed* ad hoc networks, where nodes are randomly located but are immobile, was proposed in P. Gupta and P. R. Kumar, "The capacity of wireless networks," *IEEE Trans. Inform. Theory*, vol. 46, pp. 388–404, Mar. 2000. Each source node has a random destination in the network to which it wants to communicate. Every node in the network acts simultaneously as a source, a destination for some other node, as well as relays for others' packets.

The main result shows that as the number of nodes per unit area N increases, the throughput per source-to-destination (S–D) pair decreases approximately like $1/\sqrt{N}$. This paper introduces mobility into the model and consider the situation when users move independently around the network. The main result of this paper shows that the average long-term throughput per S–D pair can be kept *constant* even as the number of nodes per unit area N increases.

30) Title: Independent Zone Routing: An Adaptive hybrid Routing Framework for Ad Hoc Wireless Networks
Authors: Prince Samar, Marc R. Pearlman and Zygmunt J. Haas
Keywords: Proactive routing, Reactive routing, Zone routing
Proactive or table driven protocols continuously evaluate the routes within the network, so that when a packet needs to be forwarded, the route is already known and can be immediately used.
Reactive or on-demand protocols invoke a route determination procedure on an on-demand basis by flooding the network with the route query.
General Description: To effectively support communication in such a dynamic networking environment as the *ad hoc networks*, the routing framework has to be adaptable to the spatial and temporal changes in the characteristics of the network, such as traffic and mobility patterns. Multiscoping, as is provided through the concept of the Zone Routing Protocol (ZRP) for example, can serve as a basis for such an adaptive behavior. The Zone Routing framework implements hybrid routing by every network node proactively maintaining routing information about its local neighborhood called the routing zone, while reactively acquiring routes to destinations beyond the routing zone. This paper proposes the Independent Zone Routing (IZR) framework, an enhancement of the Zone Routing framework, which allows adaptive and distributed configuration for the optimal size of each node's routing zone, on the per-node basis. Authors demonstrate that the performance of IZR is significantly improved by its ability to automatically and dynamically tune the network routing operation, so as to flexibly and robustly support changes in the network characteristics and operational conditions. The on-demand discovery of routes can result in much less traffic than the proactive schemes, especially when innovative route maintenance schemes are employed. However, the reliance on flooding of the reactive schemes may still lead to a considerable volume of control traffic in the highly versatile ad hoc networking environment. Moreover, because this control traffic is concentrated during the periods of route discovery, the route acquisition delay can be significant. This paper explores the third class of routing protocols—the hybrid protocols.

31) Title: The Predictive User Mobility Profile Framework for Wireless Multimedia Networks
Authors: Ian F. Akyildiz and Wenye Wang
Keywords: QoS, User Mobility Profile (UMP)
General Description: User mobility profile (UMP) is a combination of historic records and predictive patterns of mobile terminals, which serve as fundamental information for mobility management and enhancement of quality of service (QoS) in wireless multimedia networks. Since mobility and resource management are critical to supporting mobility and providing QoS in wireless networks, it is very important to describe movement patterns of mobile objects accurately. most of the existing methods are aimed at finding the most probable cell. However, when an MT moves quickly in micro-cell networks, the short residence time in a cell may not allow computations in every cell, i.e., next-cell prediction. Also, there are very limited efforts on estimating a group of probable cells or a cluster of cells without considering the historical records. Often, the demand for multimedia services is not taken into account, which is critical for efficient resource management. Furthermore,UMP is not well defined, which should consider the characteristics of users' mobility and service patterns. In this paper, a UMP framework is developed for estimating service patterns and tracking mobile users, including descriptions of location, mobility, and service requirements. For each mobile user, the service

requirement is estimated using a mean-square error method. Moreover, a new mobility model is designed to characterize not only stochastic behaviors, but historical records and predictive future locations of mobile users as well. Therefore, approach of this paper incorporates aggregate history and current system parameters to acquire UMP. In particular, an adaptive algorithm is designed to predict the future positions of mobile terminals in terms of location probabilities based on moving directions and residence time in a cell.

32) Title: Modeling and Performance Analysis for Wireless Mobile Networks: A New Analytical Approach
Authors: Yuguang Fang
Keywords: call dropping probability, handoff probability, handoff rate, and the actual call holding times
An incomplete call a call which is prematurely terminated due to the lack of resource when it roams.
Call dropping probability is the probability that a call is immaturely terminated due to lack of resources (channels) in the network.
General Description: To evaluate the performance of a wireless network, the following performance metrics are of great importance: call dropping probability, handoff probability, handoff rate, and the actual call holding times for a complete call and an incomplete call. Call dropping probability is closely related to handoff blocking probability. The handoff rate is used to find the handoff traffic arrival rate, which is needed to find the call blocking probability and handoff blocking probability. The handoff probability can be used to design channel reservation schemes, and the actual call holding times can be used to design service charging rate. In the study of these quantities for the traditional cellular networks and PCS networks, the following assumptions are commonly used in order to obtain some analytical results: the interarrival time of cell traffic, the call holding time, and the channel holding time are all assumed to be exponentially distributed. However, field data and simulation study showed that these classical assumptions are not appropriate. In this paper, we relax the classical exponential assumption for the call holding time and cell residence time and develop an analytical approach for the study of the following performance metrics: call dropping probability, handoff probability, handoff rate, and the actual call holding times for a complete call and an incomplete call. It turns out that many interesting performance quantities can be completely determined by a single probability result.We will present analytical formulas for the above performance metrics for the cases when the Laplace transforms of pdfs of call holding time and cell residence time are rational functions.

33) Title: Link Availability Models for Mobile Ad Hoc Networks
Authors: A Bruce McDonald and Taieb Znati
Keywords: Link availability, rerouting process
General Description: An ad hoc network is comprised of wireless nodes and requires no fixed infrastructure. It becomes crucial to design scalable routing strategies for ad hoc networks which are capable of responding rapidly to node mobility without over utilizing network resources. Knowledge of node mobility can be used to help achieve this objective. Consequently analytical models are needed which characterizes link availability between mobile nodes in ad hoc networks. The mobility problem in an ad hoc mobile network is more complex because both ends of each wireless links are mobile. The main difficulty in routing in ad hoc networks arises because without a fixed infrastructure every path consists of exclusively of wireless links whose end points are moving independently of one another. Consequently, node mobility causes the frequent failure and activation of links. These observations suggest the need to include some notion of node mobility in the path selection process and to improve rerouting process by attempting to find new paths prior to the failure of existing ones. A routing algorithm capable of choosing paths based upon probabilistic availability of the component links can decrease the frequency of path failure by choosing maximum availability paths. The purpose of this

paper is to address these issues by proposing a model for ad hoc node mobility which predicts the evaluation of a network's topology over time and provides the basis for an efficient ad hoc network routing strategy.

34) Title: A mobility based framework for adaptive clustering in wireless ad hoc networks
Authors: A. Bruce McDonald and Taieb F. Znati
Keywords: dynamic clustering,routing
General Description: Existing schemes for routing in ad hoc networks can be classified according to four broad categories, namely, proactive routing, flooding, reactive routing, and dynamic cluster-based routing. Proactive routing protocols periodically distribute routing information throughout the network in order to precompute paths to all possible destinations. Although this approach can ensure higher quality routes in a static topology, it does not scale well to large highly dynamic networks. By contrast, flooding-based routing requires no knowledge of network topology. Packets are broadcast to all destinations with the expectation that they will eventually reach their intended target. it generates an excessive amount of traffic in large networks, and it is difficult to achieve flooding reliably [30] when the topology is highly dynamic. In a reactive routing strategy, the design objective is accomplished by maintaining paths on a demand-basis using a query–response mechanism. This limits the total number of destinations to which routing information must be maintained, and consequently, the volume of control traffic required to achieve routing. The shortcomings of this approach include the possibility of significant delay at route setup time, the large volume of far-reaching control traffic required to support the route query mechanism, and lower path quality relative to proactive routing. In dynamic cluster-based routing, the network is dynamically organized into partitions called clusters, with the objective of maintaining a relatively stable effective topology. The membership in each cluster changes over time in response to node mobility and is determined by the criteria specified in the clustering algorithm. In order to limit far-reaching reactions to topology dynamics, complete routing information is maintained only for intra-cluster routing. Inter-cluster routing is achieved by hiding the topology details within a cluster from external nodes and using hierarchical aggregation, reactive routing, or a combination of both techniques. The argument made against dynamic clustering is that the rearrangement of the clusters and the assignment of nodes to clusters may require excessive processing and communications overhead, which outweigh its potential benefits. The purpose of this paper is to present the (α,t) cluster framework, which defines a strategy for dynamically organizing the topology of an ad hoc network in order to adaptively balance the tradeoff between proactive and demand-based routing by clustering nodes according to node mobility. Based on the (α,t) cluster framework, intra-cluster routing requires a proactive strategy, whereas inter-cluster routing is demand-based.

By
Sapan Shah
200611048
M.Tech. (2nd Year)