ISSN No. 0976-5697

Volume 4, No. 6, May 2013 (Special Issue)

International Journal of Advanced Research in Computer Science

REVIEW ARTICAL

Available Online at www.ijarcs.info

Challenges and Future Directions in Ad Hoc Networking-Review

K. S. Tayde[#1]
Computer Science & Engg. , S.G.B.A.U.Amravati.
[1]kunaltayade07@gmail.com

A. M. Sahu[*2]
G.H.Raisoni College of Engg. & Magt., Amravati (MH)India.
[2]amit.3696sahu@gmail.com

Abstract— Wireless networks have become increasingly popular in the past few decades, particularly within the 1990's when they are being adapted to enable mobility and wireless devices became popular. Ad hoc networks are a key factor in the evolution of wireless communications. Self-organized ad hoc networks of PDAs or laptops are used in disaster relief, conference, and battlefield environments. An ad hoc network is a (possibly mobile) collection of communications devices (nodes) that wish to communicate, but have no fixed infrastructure available, and have no pre-determined organization of available links. This article is a survey on the current status and direction of research on ad hoc networking. We categorize the on-going research and outline the major challenges which have to be solved before widespread deployment of the technology is possible. The views presented by Perkins in [1] are used as a premise, which is then complemented with discussion and references to the latest publications. Various approaches and protocols have been proposed to address ad hoc networking problems, and multiple standardization efforts are under way within the Internet Engineering Task Force, as well as academic and industrial research projects.

Keywords— AHNs, PRNET, SURAN, ALOHA, CSMA, QoS

I. INTRODUCTION

These Ad hoc networks (AHNs) are wireless multi-hop packet networks without any fixed infrastructure. An AHN network is formed solely by its terminals so that each terminal connected to the network provides also relaying service for others i.e. acts as a router. Advantages of such system are rapid deployment, robustness, flexibility and inherent support for mobility. The wireless technology has made communication very convenient. Mobile ad hoc networking is among the recent advancements in wireless communication technology. Ad hoc networks make it possible for people to communicate using makeshift temporary networks built without any permanent infrastructure like routers, cell phone towers, land-links etc.

The mobile wireless end-hosts play the role of routers and forward data packets using peer-to-peer routing and forwarding. The quick deploy-ability of mobile ad-hoc networks makes them attractive for armies, emergency rescuers and many others. AHN can work as a stand-alone autonomous network providing internal connections for a group. Demand for such networks could arise in the contexts of shared desktop meeting, disaster recovery, or in various military applications. However, no commercial "killer applications" are known for this technology yet. In the future, ad hoc networks probably form the outermost region of the internetwork, where a wired backbone connects both the fixed local area networks and the mobile (both the fixed infrastructure and the ad hoc) networks. Whereas the base stations of a fixed infrastructure networks are directly connected to the core, an AHN is typically connected through a satellite link or a terrestrial switch (fixed wired connection point, or mobile radio link). This vision, however, requires still some further developments in ad hoc networking.

II. HISTORY

The whole life-cycle of ad-hoc networks could be categorized into the first, second, and the third generation ad-hoc networks systems. Present ad-hoc networks systems are considered the third generation. The first generation goes back to 1972. At that time, they were called PRNET (Packet Radio Networks). The history of ad-hoc networks can be dated back to the DoD1-sponsored Packet Radio Network (PRNET) research for military purpose in 1970s, which evolved into the Survivable Adaptive Radio Networks (SURAN) program in the early 1980s [1].

In conjunction with ALOHA (Areal Locations of Hazardous Atmospheres) and CSMA (Carrier Sense Medium Access), approaches for medium access control and a kind of distance-vector routing PRNET were used on a trial basis to provide different networking capabilities in a combat environment. The second generation of ad-hoc networks emerged in 1980s, when the ad-hoc network systems were further enhanced and implemented as a part of the SURAN (Survivable Adaptive Radio Networks) program. This provided a packet-switched network to the mobile battlefield in an environment without infrastructure. This program proved to be beneficial in improving the radios' performance by making them smaller, cheaper, and resilient to electronic attacks. In the 1990s, the concept of commercial ad-hoc networks arrived with notebook computers and other viable communications equipment. At the same time, the idea of a collection of mobile nodes was proposed at several research conferences.

III. QUESTIONS CONSIDERED

As we saw in the previous section, ad hoc networking has been a popular field of study during the last few years. Almost every aspect of the network has been explored in some level of detail. Yet, no ultimate resolution to any of the problems is found or, at least, agreed on. On the contrary, more questions have arisen than been answered. This section outlines the major problems remaining to be solved. The protocol dependent development possibilities are mostly omitted and the focus is on the "big picture", on the problems that stand in a way of having peer to- peer connectivity everywhere in the future. The topics are:

a. Scalability

b. Quality of Service
c. Shifting Client-server model and service location
d. Security
e. Interoperation with the Internet
f. Controlling Power
g. Node cooperation
h. Support for different routing protocols
i. Aggregation

This survey here summarizes and complements the approach presented by Perkins [1], with a few additions and several updates. The discussion attempts to sketch the following aspects for the topics: motivation, novel ideas since the publication of [1], and the still remaining problems and their relative importance.

A. *Scalability:*

Most of the visionaries depicting applications which are anticipated to benefit from the ad hoc networking technology take scalability as granted. Imagine, for example, the vision of ubiquitous computing where the networks can grow to thousands of nodes. How can be the swarm of control messages carried out in this dynamic environment? It is unclear how large an ad hoc network can actually grow. Ad hoc networks suffer, by nature, from the scalability problems in capacity. For a rough idea about this, we may look into simple interference studies. In a non-cooperative network, where Omni-directional antennas are being used, the throughput per node decreases at a rate 1= pN, where N is the number of nodes [2]. That is, in a network with 100 nodes, a single device gets approximately one tenth of the theoretical data rate of the network interface card at maximum. This problem, however, cannot be fixed except by physical layer improvements, such as smart antennas. If the available capacity sets some limits for communications, so do the protocols as well. Route acquisition, service location and encryption key exchanges are just examples of tasks that will require considerable overhead, which will grow rapidly with the network size. If the scarce resources are wasted with profuse control traffic, it is clear that ad hoc networks will see never dawn in practice. Scalability is an important research topic for the future, not only because of its necessity for ad hoc networks, but also because of the applicability of same ideas in the Internet. In the protocol design itself, several issues have to be considered with the potential applications in mind. Whereas proactive routing is not scalable in a dynamic environment as such, on-demand protocols allow deploying large networks in the expense of increased route acquisition latency.

The minimum route acquisition latency is the product of maximum network diameter and minimum node traversal time for route requests. Correspondingly, demands for short latencies for route acquisition limit the network size drastically. Can this be accepted by the applications? If not, what can be done? Traditional way of scaling the network has been hierarchical routing, the running of routing and other network functions on a several hierarchical levels. Hierarchies can be constructed by clustering algorithms which collect nodes near each other into groups. While hierarchy may not be natural for all ad hoc networks, it is one of the very few methods capable of providing any relief to the scalability problem. Mobility and dynamic hierarchy, however, need to be carefully taken into account in order to achieve any practical solutions. Several clustering solutions have already been brought forward recently, e.g. [3, 4]. Some other approaches have proposed also wide-area routing protocols [5] to complement broadcast-intensive local routing. Development of simple rules to cluster nodes and share routing information will remain actively researched. Routing simulations discussed in the literature have been very small in comparison of the futuristic idea of ubiquitous computing or sensor dust of tens of thousands of nodes. Therefore, large scale simulation studies and also trial deployment are essential to study in the future. Future research will probably develop scenarios; isolate useful applications, to optimize the trade-off between capacity and scalability in each case separately. For a general solution much remains to be done. Without development in intelligent antennas and multiuser detection, scaling AHNs to thousands of nodes seems a daunting task indeed.

B. *Quality of Service:*

The heterogeneity of existing applications in the Internet has challenged the network which is able to provide only best-effort service. Voice, live video and file transfer, to mention the common examples, all have very differing requirements what comes to delay, jitter, bandwidth, packet loss probability etc. Quality of Service (QoS) is being developed to meet the emerging requirements. QoS is a guarantee by the network to provide certain performance for a flow in terms of the quantities mentioned above. QoS routing attempts to locate routes that satisfy given performance constraints and then reserve enough capacity for the flow.

If we consider ad hoc networks as a natural extension of the Internet at the borders where direct connections to fixed infrastructure are unavailable, these applications (voice, live video, file transfer etc.) will exist also in ad hoc networks and so there will also be naturally a demand for QoS. However, the lack of fixed infrastructure in ad hoc networks makes the QoS appear even more challenging problem than ever before. Bandwidth is seriously limited; routes are using links with differing quality and stability. Links are often asymmetrical so that, for example, QoS for telephony (2-way traffic with QoS-demands) may not be achieved by just one route. These facts are often completely ignored by the routing protocols, although the link-state algorithms could be used to find suitable routes if the links are given suitable QoS costs. Alternatively, on-demand protocols can be configured to return only communications paths that comply with the desired parameters.

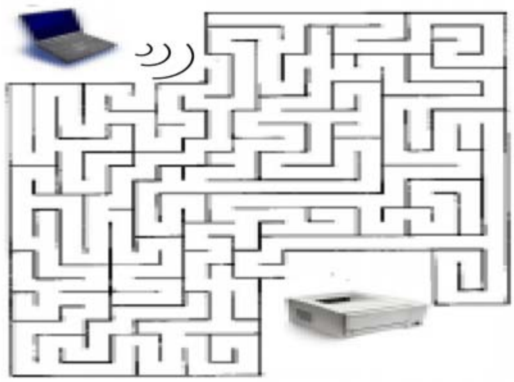

Figure 1: Services can be difficult to locate in ad hoc networks

QoS in AHNs is still largely unexplored area, a good introduction to the field of study can be found from [6].

Issues of QoS robustness, QoS routing policies, algorithms and protocols with multiple, including preemptive, priorities are to be researched in the future. It seems that in ad hoc networks end user may have to "haggle" with the network on the QoS parameters as high quality is frequently not available.

Quality of service cannot be guaranteed for a long time because of the link quality variations due to the interferences etc. Methods to detect and report changes in the connection quality should be investigated in the future. Perkins suggest an addition of a new ICMP message (QOS LOST) to be defined to inform the endpoints that a new route discovery should be initiated.

C. Shifting Client-server model and service location:

In the Internet, a network client is typically configured to use a server as its partner for network transactions. These servers can be found automatically or by static configuration. In ad hoc networks, however, the network structure cannot be defined by collecting IP-addresses into subnets. There may not be servers, but the demand for basic services still exists. Address allocation, name resolution, authentication and the service location itself are just examples of the very basic services which are needed but their location in the network is unknown and possibly even changing over time. Where do services reside (see Figure (1)? Who is administering or maintaining the services?

In ad hoc some recent proposals have considered integrating route discovery and service location tasks by allowing only particular kind of services to react to the broadcast requests. This approach, however, can be seen to have the following deficiencies:

a. Inserting application service discovery into a network layer protocol violates the modular protocol design.
b. The client may not be able to specify the required service in a way that the request can be carried on the network layer.
c. Authorization can be difficult at the network layer.

Other possibilities are, e.g., using well-known multicast addresses for very basic features, such as DNS. Also protocols for service location have been proposed. Some recent works on this field include [7, 8]. An intellectual challenge related to the service availability problems is the design of distributed network functions. It could be investigated whether and which services (or their locations) could be shared or circulated among nodes? Still the question of who is administering and ultimately responsible for the services remains unanswered.

D. Security:

Ad hoc networks are particularly prone to malicious behavior. Lack of any centralized network management or certification authority makes these dynamically changing wireless structures very vulnerable to infiltration, eavesdropping, interference etc. Security is often considered to be the major "roadblock" in commercial application of ad hoc network technology [9].

Security requirements depend naturally on the application where they are needed. In cases where all the terminals are "on the same side", such as military or emergency rescue applications, it is enough to get protection against outside interference. In civilian, especially commercial, applications even mere lack of cooperation may be enough to bring the network on its knees. The nodes enter and leave the networks as they wish and links may be using nodes that should not have access to data. How to define membership in ad hoc networks, how to classify nodes to the trusted and the not-trusted ones?

Traditional methods of protecting the data with cryptographic methods face a challenging task of key distribution and refresh. Accordingly, the research efforts on security have mostly concentrated on secure data forwarding. However, many security risks are related to the peculiar features of ad hoc networks. The most serious problem is probably the risk of a node being captured and compromised.

This node would then have access to structural information on the network, relayed data, but it can also send false routing information which would paralyze the entire network very quickly. In [10] the authors discussed the security problems in general and proposed a self-organized public-key infrastructure for ad hoc network cryptography. Key exchanging, however, raise again the scalability issues. Furthermore, defining keys for multicast transmission seems even tougher challenge.

Secure routing was considered in [11], which had an appealing idea of dividing the data on N pieces which are send along separate routes and, at the destination, the original message is reconstructed out of any (M−out−of −N) pieces of the message.

Security is indeed one of the most difficult problems to be solved, but it has received only modest attention so far. The "golden age" of this research field can be expected to dawn only after the functional problems on the underlying layers have been agreed on.

E. Interoperation with the Internet:

It seems very likely that one of the most common applications of ad hoc networks require a connection to the Internet. By ad hoc network technology the coverage of wireless LAN systems can be expanded and complemented. However, the issue of defining the interface between the two very different networks is not straight forward. If a node in ad hoc network has an Internet connection, it could offer Internet connectivity to the other nodes. The node could define itself as a default router and the whole ad hoc network could be considered to be "single-hop" from the Internet perspective although the connections are physically over several hop links. Recently a practical solution for this problem was suggested in [12]. The idea was to combine the Mobile-IP technology with ad hoc routing [12] so that the gateway node can be considered to be foreign agent for Mobile IP.

F. Controlling Power:

Power-aware networks are currently being extremely popular within the ad hoc networking research. The motivation for power-aware thinking for wireless communications is obvious, as summarized in [13]:

a. ***Functional utility –*** New features and functionality usually costs additional energy. By increasing energy efficiency, devices may meet new user demands without reduced useful lifetime.

b. ***Size and weight –*** Increased power efficiency can allow smaller and lighter power source.

c. ***Maintenance –*** Power sources will always need to be replaced or recharged at some point, and the cost for this can vary from inconvenient to prohibitive.

d. ***Environmental –*** Battery designs contain acids and heavy metals, which must be disposed of properly.

There are two research topics which are partially similar: the maximization of lifetime of a single battery and the maximization of the lifetime of the whole network. The former is related to commercial applications and node cooperation issues whereas the latter is especially of military etc. interest, where the node cooperation is already assumed.

The goals can be achieved either by developing better batteries, or by making the network terminals' operation more power efficient. The first approach is likely to give a 40% increase in battery life in near future (with Li-Polymer batteries) [13]. As to the device power consumption, the primary aspect are achieving energy savings is through the low power hardware development using techniques such as variable clock speed CPUs, flash memory, and disk spin down [14]. However, from the networking point of view our interest naturally focuses on the device's network interface, which is often the single largest consumer of power.

Energy efficiency at the network interface can be improved by developing transmission/reception technologies on the physical layer and by sensing inactivity on the application layer, but especially with certain networking algorithms; MAC, routing and handling of end-to-end connections. In all these approaches, savings are based on intelligently turning off the interface when it is not needed.

Medium Access Control - protocols can be made power-aware by simple rules: when the node has nothing to send or receive, or it overhears a transmission (i.e. the radio channel is busy) it can power off the network interface and wake again after a while to see is there anything to do. This has significant advantages as receiving unnecessary data is surprisingly expensive in terms of energy consumption. One such protocol, PAMAS, is introduced in [15], for which the authors reported up to 70% energy savings.

Just above the MAC-layer reside different topology reduction algorithms. Their premise is that if the network is dense enough, only a subset of nodes is required to be relaying nodes to maintain full connectivity. This means that some of the nodes can be put to a sleep state (such as provided by IEEE 802.11 [16]) only to wake up periodically to see whether there are incoming traffic directly to them. Active nodes form a forwarding backbone in the network, which can be found distributed as discussed in [17]. This problem is closely related to (minimum) dominating set problem in graph theory.

In routing, one usually tries to maximize the network lifetime. In other words, routes are selected by their transmission energy cost giving the priority to the nodes with full batteries. This way the time to network partition can be maximized distributedly [18]. Furthermore, unicast and multicast routing should be considered separately when considering energy-efficiency due to the broadcast nature of the transmission [19].

G. Node cooperation:

Closely related to the security issues, the node cooperation stands in the way of commercial application of the technology. The fundamental question is: Why should anyone relay others data? The answer is simple: to receive the corresponding service from the others. However, when differences in amount and priority of the data are existing, the situation is more complex. Surely, a critical fire alarm box should not waste its batteries for relaying gaming data, nor should it deny access because of this behavior.

Encouraging nodes to cooperate may lead to the introduction of billing in ad hoc networks, with a similar idea which was suggested for Internet congestion control in [20]. Well-behaving network members could be rewarded for the relaying and selfish or malicious users could be charged. Implementation of any kind of billing mechanism, however, is very challenging. These issues are still wide open.

H. Support for different routing protocols:

If energy costs or other dynamic quantities are to be tracked, there may be significant differences between routing algorithm performances. For certain sensor networks, static node-state based algorithms enable route optimization especially in multicast case, whereas such algorithm would be too cumbersome for networks with mobility.

Dozens of routing protocols have be introduced, all of which typically perform well in some situations while having significant weaknesses in other cases. Question is, can the heterogeneity of the ad hoc networks be covered by any single routing algorithm?

If no all-round routing protocol can be found or agreed on, the networks have to be capable of supporting several protocols. This can happen so that as a certain number of network nodes detect that their routing is not optimal the network switches to another protocol. When a protocol ceases to be optimal and how can the change is implemented?

Another option is that the network is able to simultaneously support several routing methods. How to define the interfaces and self-awareness?

I. Aggregation:

Finally, there is the question of rationalizing and collecting the research results. Research has been extremely active during the past few years. The pace has been so fast that the big picture is somewhat blurred. That is why there is a need for summarizing research efforts to combine, not just compare, different approaches. The trend is towards more complete ad hoc networking solutions instead of specific protocols in the near future. The first works on this field has been conducted for energy conserving purposes because of its inherent "multilayer"-structure that provides a natural environment for combining different ideas.

There is work to be done to find best possible combinations of MAC, topology reduction, and routing protocols. There is also work to be done in combining preferable properties of different protocols. This will naturally lead to discussion on specific networks, application tailored solutions, as the ultimate ad hoc networking solution is still far away, if it even can be found.

IV. RESEARCH STATUS

This section attempts to summarize the current research that is being conducted on ad hoc networks. Due to the vast amount of the material about the topic, we chose to take a representative sample of the most recent research results and to categorize them to get a rough overview on the situation. For this purpose we will look into the publishing activity of the IEEE (publications are available at [21]). It is sometimes useful to try to predict the future to get new ideas and see the present day in a more appropriate context on larger scale. Future is unknown, but it is, after all, the result of the actions we take now. In this Section we look into the crystal ball and give scenarios on the future development. How do ad hoc networks evolve? What are the enabling technologies? What kind of applications we are going to see in the near future?

A. Overview:

The classification, shown in Table (1) and Figure (2), was done for all the ad hoc networking related publications, conference and journal articles without distinguishing them, published within the IEEE organization in 2001. Categories were selected so that they would describe their contents unambiguously, but still provide detailed and informative knowledge on large scale (i.e. the number of classes was tried to keep as small as possible). Power aware protocols were counted twice, once into the Power awareness category and once into the corresponding category in where the protocol or algorithm was considered. For example, a publication with the topic "A power-aware routing protocol" would be counted into both Routing and

Table 1: Publications on ad hoc networks within IEEE during 2001 see Figure 2 for illustration

Sr. No	Publications
1	Routing
2	MAC, scheduling
3	Special AHNs-Bluetooth
4	Applications-Multimedia
5	Clustering, organization
6	Technology, physical layer
7	General overviews
8	Internet Protocols on AHNs
9	Network management
10	Quality of service, service differentiation
11	New network concepts
12	Service Availability
13	Positioning, situation awareness
14	Topology studies
15	Practical studies
16	Transport issues
17	Security
18	Mobility
19	Cooperation
	Power-awareness

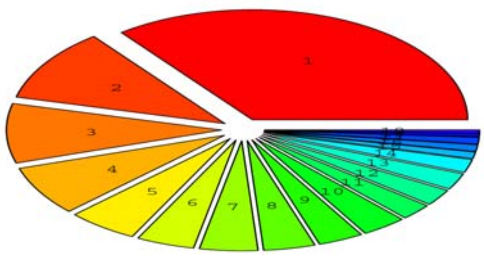

Figure 2: Publications on ad hoc networks within IEEE during 2001, see Table 1 for key.

B. Power-awareness categories:

Four clear facts can be immediately extracted from the data:

a. Routing protocols are being studied extensively
b. Overall volume of the research effort on AHNs is high (>200 publications a year just in this organization!)
c. The spectrum of the topics is wide; ad hoc networking has brought together protocol engineers and mathematicians
d. Based on the status of the research projects conducting this work, further rapid development is to be expected at all fronts during the next few years.

V. THE FUTURE

Imagine the following scenarios: a wireless mesh of rooftop-mounted ad hoc routers; an ad hoc network of cars for instant traffic and other information; sensors and robots forming a multimedia network that allows remote visualization and control; multiple airborne routers (from tiny robots to blimps) automatically providing connectivity and capacity where needed (e.g., at a football game); an ad hoc network of spacecraft around and in transit between the Earth and Mars.

A. Future going Ad Hoc:

There are many open questions related to ad hoc networks applications. Before a public demand for any set of applications can be found, these networks will be deployed in various specialized cases. In the first phase, which can be already foreseen we will have autonomous military and public authority ad hoc networks, which can be used for a very specific purposes. For the most part the networks will be quite small except for the sensor applications, including the millimeter sized sensing networks.

In the second phase, the future cellular infrastructure extensions could be implemented so that ad hoc networking would act as a basis of the whole 4th generation wireless technology. An image of completely unrestricted "anytime, anywhere" communications using this technology seems, however, to belong to the more distant future. Problems with security, authorization and management are daunting indeed in large scale networks. Hence, it is more likely that the technology will be used to augment wireless LAN technology with the limited network size or hops in connections.

B. The Future Revolution:

Assume that most of the problems discussed in this paper are solved and there is a possibility to deploy secure broadband self-organizing ad hoc networks with hundreds or thousands of nodes. What will happen?

The general trend is towards low-level infrastructure and increased end-user responsibility. Being able to freely communicate transfer information with close-by people is, of course, convenient, but it may even have larger societal effects. On a larger scale, ad hoc networking can very well be the next revolution in the world of communications. It enables local communities to manage their own need for connectivity using their own local resources. The control of the local network will be hence again where it belongs and the ISP era might be coming to a turning point. Why to a call a taxi if you are visiting your next door neighbor or the shop around the corner? The telecommunications business would experience shift from the operators towards both device manufacturers and end-users themselves. Are the operators going to allow this development? Can it be done without their support?

In this local community networking view can be the seed of a completely new approach to communicating with people and henceforth to understanding what it means to be a part of a community. In these local networks many services, such as local web pages, e-mail and telephony would be free from charge and jurisdiction by remote administrations. Naturally, there would be some privacy concerns in the beginning, but trust inside the community should provide the necessary umbrella for the privacy.Ad hoc networks have indeed the potential to change how we see the communications world today. For alternativescenarios of the wireless future, where the services stay centralized, interested reader should consult e.g. [22].

VI. CONCLUSIONS

In this paper we summarize recent advances in mobility modeling for mobile ad hoc networks. The main focus is on the analysis of mobility models, mobility influence on routing protocols and mobility metrics used to measure mobility patterns. These helps researchers obtain an in depth understanding of the mobility models and realize their importance in the research of mobile ad hoc networks.

Whereas ad hoc networks will become widely used in military contexts in near future, the corporate world has to continue the daunting search for profitable commercial applications and possibilities of the technology. Meanwhile, the academic community has adopted the new field as a playground to apply their ideas to create something completely new. In all, although the widespread deployment of ad hoc networks is still years away, the research in this field will continue being very active and imaginative.

VII. REFERENCES

[1] Charles E. Perkins (Ed.). Ad Hoc Networking. Addison-Wesley, December 2000.

[2] Piyush Gupta and P. R. Kumar. The capacity of wireless networks. IEEE Transactions on Information Theory, 46(2):388–404, March 2000.

[3] S. Basagni. Distributed clustering for ad hoc networks. In Proceedings of the 1999 International Symposium on Parallel Architectures, Algorithms, and Networks (I-SPAN'99), pages 310–315, June 1999.

[4] P. Basu, N. Khan, and T.D.C. Little. A mobility based metric for clustering in mobile ad hoc networks. In Proceedings of Distributed Computing Systems Workshop 2001, pages 413–418, 2001.

[5] Ljubica Blazevic, Levente Buttyan, Srdjan Capkun, Silvia Giordano, Jean-Pierre Hubaux, and Jean-Yves Le Boudec. Self-organization in mobile ad-hoc networks: the approach of terminodes. IEEE Communications Magazine, pages 166–174, June 2001.

[6] Satyabrata Chakrabarti and Amitabh Mishra. Qos issues in ad hoc wireless networks. IEEE Communications Magazine, 39(2):142–148, February 2001.

[7] L.M. Feeney, B. Ahlgren, and A. Westerlund. Spontaneous networking: an application oriented approach to ad hoc networking. IEEE Communications Magazine, 39(6):176–181, June 2001.

[8] H. Koubaa and E. Fleury. A fully distributed mediator based service location protocol in ad hoc networks. In Proc. of Global Telecommunications Conference (GLOBECOM), 2001, volume 5, pages 2949–2953. IEEE, 2001.

[9] Zygmunt J. Haas, Jing Deng, Ben Liang, Panagiotis Papadimitatos, and S. Sajama. Wireless ad hoc networks. In John Proakis, editor, Encyclopedia of Telecommunications (to appear). John Wiley, December 2002.

[10] Jean-Pierre Hubaux, Levente Buttyan, and Srdjan Capkun. The quest for security in mobile ad hoc networks. Proc. of MobiHOC 2001, pages 146–155, October 2001.

[11] P. Papadimitratos and Z.J. Haas. Secure routing for mobile ad hoc networks. In SCS Communication Networks and Distributed Systems Modeling and Simulation Conference (CNDS 2002), San Antonio, TX, January 2002.

[12] Yuan Sun, Elizabeth M. Belding-Royer, and Charles E. Perkins. Internet connectivity for ad hoc mobile networks. International Journal of Wireless Information Networks, special issue on Mobile Ad hoc Networks (to appear), 2002.

[13] Chiara Petrioli, Ramesh R. Rao, and Jason Redi. Guest editorial: Energy conserving protocols. ACM Mobile Networks and Applications, 6(3):207–209, June 2001.

[14] Christine E. Jones, Krishna M. Sivalingam, Prathima Agrawal, and Jyh Cheng Chen. A survey of energy efficient network protocols for wireless networks. Wireless Networks, 7(4):343–358, September 2001.

[15] Suresh Singh and C. Raghavendra. Pamas: Power aware multi-access protocol with signalling for ad hoc networks. ACM SIGCOMM Computer Communication.

[16] IEEE Computer Society LAN MAN Standards Committee. Wireless LAN medium access control and physical layer specifications, IEEE 802.11 standard, August 1999.

[17] Benjie Chen, Kyle Jamieson, Hari Balakrishnan, and Robert Morris. Span: an energy-efficient coordination algorithm for topology maintenance in ad hoc wireless networks. ACM Wireless Networks Journal (to appear), 8(5), September 2002.

[18] Jae-Hwan Chang and Leandros Tassiulas. Energy conserving routing in wireless ad-hoc networks. In INFOCOM, volume 1, pages 22–31, 2000.

[19] J.E. Wieselthier, G.D. Nguyen, and A. Ephremides. Algorithms for energy-efficient multicasting in ad hoc wireless networks. In Military Communications Conference Proceedings, 1999. IEEE MILCOM 1999., volume 2, pages 1414–1418, 1999.

CONFERENCE PAPER
"A National Level Conference on Recent Trends in Information Technology and Technical Symposium" On 09th March 2013
Organized by
Dept. of IT, Jawaharlal Darda Inst. Of Eng. & Tech., Yavatmal (MS), India

[20] Jeffrey K. MacKie-Mason and Hal R. Varian. Pricing the internet. In B. Kahin and J. Keller, editors, Public Access to the Internet. Prentice-Hall, New Jersey, 1994

[21] IEEE. IEEE/IEE electronic library. http://ieeexplore.ieee.org.

[22] Aurelian Bria, Fredrik Gessler, Olav Queseth, Rickard Stridh, Matthias Unbehaun, Jiang Wu, and Jens Zander. 4th-Generation wireless infrastructures: Scenarios and research challenges. IEEE Personal Communications, pages 25–31, December 2001.