Involvement of Mobile Adhoc Network (MANET) Technology in Pervasive Computing

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Abstract— : In future a pervasive computing environment can be expected based on the recent progresses and advances in computing and communication technologies. Next generation of mobile communications will include both prestigious infrastructured wireless networks and novel infrastructureless mobile ad hoc networks (MANETs). A MANET is a collection of wireless nodes that can dynamically set up anywhere and anytime to exchange information without using any pre-existing fixed network infrastructure. This paper describes the fundamental problems of ad hoc networking by giving its related research background including the concept, characterstics, existence, and applications of MANET. Some of the technical challenges MANET poses are also presented, based on which the paper points out some of the key research issues for ad hoc networking technology that are expected to promote the development and accelerate the commercial applications of the MANET technology. Special attention is paid on network layer routing strategy of MANET and key research issues include new X-cast routing algorithms, security & reliability schemes, QoS model, and mechanisms for interworking with outside IP networks.

Index Terms— Mobile Communications, Wireless Networks, Ad hoc Networking, Pervasive Computing, Routing Algorithm.

I. INTRODUCTION

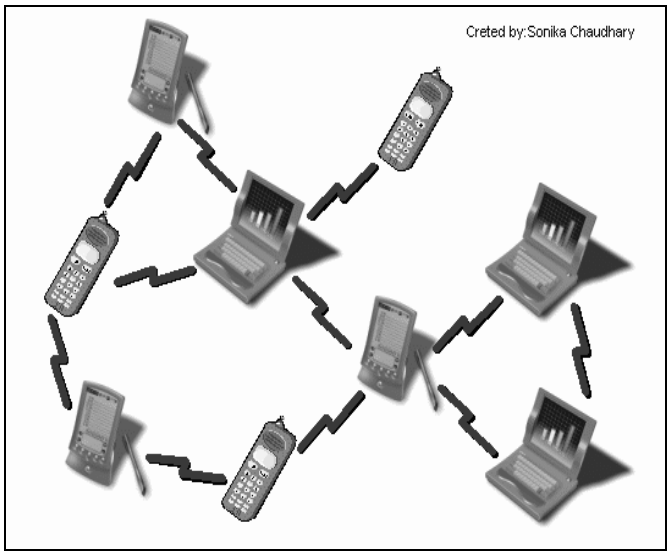
The people's future living environments are emerging based upon information resource provided by the connections of various communication networks for users. New small devices like tablet PC, Personal Digital Assistants (PDAs), mobile phones, handhelds, and wearable computers enhance information processing and accessing capabilities with mobility. Moreover, traditional home appliances, e.g. TV, digital cameras, cooking ovens, washing machines, refrigerators, vacuum cleaners, and thermostats, with computing and communicating powers attached, extend the field to a fully pervasive computing environment. Modern technologies should be formed within the new paradigm of pervasive computing, including new architectures, standards, devices, services, tools, and protocols. Mobile networking is one of the most important technologies supporting pervasive computing.. Generally there are two distinct approaches for enabling wireless mobile units to communicate with each other:

A. With Infrastructure.

Traditional Wireless mobile networks have been based on the cellular concept and relied on good infrastructure support, in which mobile devices communicate with access points like base stations connected to the fixed network infrastructure. Typical examples of this kind of wireless networks are GSM, UMTS, WLL, WLAN, etc.

B) Without Infrastructure

As to infrastructure less approach, the mobile wireless network is commonly known as a mobile ad hoc network (MANET) [1, 2]. This is a very important part of communication technology that supports truly pervasive computing, because in many contexts information exchange between mobile units cannot rely on any fixed network infrastructure, but on rapid configuration of a wireless connections on-the-fly. Wireless ad hoc networks themselves are an independent, wide area of research and applications, instead of being only just a complement of the cellular system. Some of the technical challenges MANET poses are presented, based on which the paper points out the related kernel threat. The paper is structured as follows. In Section II, the background information related to ad hoc wireless networks is Introduced the MANE Concept, characteristics, current research , and some of its applications. The technical challenges of MANET, together with relevant kernel threat, The paper is structured as follows. In Section II, the background information related to ad hoc wireless networks is Introduced the MANET concept, characterstics, current research, and some of its applications. The technical challenges of MANET, together with relevant kernel threat, are presented in Section III. Section IV mainly discusses the key research issues of MANET with the emphasis on network layer routing strategies. Finally, we summarize the paper by conclusions in Section V.



Manuscript received on July, 2012.

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II. BRIEF DETAILS OF MANETS

MANET Concept

MANETs are often referred to as multihop wireless ad hoc networks.

1. A mobile ad hoc network is a collection of wireless nodes that can dynamically be set up anywhere and anytime Uses wireless links without existing infrastructure.
2. It is an autonomous system in which mobile hosts connected by wireless links are free to move randomly and often act as routers at the same time. The traffic types in ad hoc networks are quite different from those in an infrastructured wireless network .
3. including:
   a) *Peer-to-Peer*. Communication between two nodes which are within one hop. Network traffic (Bps) is usually consistent.
   b) *Remote-to-Remote.*Communication between two nodes beyond a single hop but which maintain a stable route between them. This may be the result of several nodes staying within communication range of each other in a single area or possibly moving as a group. The traffic is similar to standard network traffic.
   c) *Dynamic Traffic*. This occurs when nodes are dynamic and moving around. Routes must be reconstructed. This results in a poor connectivity and network activity in short bursts.

Key Elements of MANETs

- Nodes do not have any pre-specified roles
- Nodes make decision independently based on the current network situation
- Nodes are expected to behave as routers
- As routers, nodes must assist in discovery and maintenance of network routes

MANET Design complexities & Constraints

- Infrastructureless with distributed management
- Frequent and unpredictable topology changes
- Physical layer limitation
- Limited link bandwidth and quality
- Variation in node capabilities
- Energy Considerations
- Network reliability
- Network security
- Network scalability
- Quality of service

2.2 MANET Characterstics:

MANET has the following features:

1) Ad hoc wireless networks eliminate the constraints of infrastructure and enable devices to create and join networks on the fly– any time, anywhere – for virtually any application.
2) Control and management of the network is distributed among the terminals. The nodes involved in a MANET should collaborate amongst themselves and each node acts as a relay as needed, to implement functions e.g. security and routing.
3) Basic types of ad hoc routing algorithms can be single-hop and multihop, based on different link and routing protocols. Single-hop MANET is simpler than multihop in terms of structure and implementation, with the cost of lesser functionality and applicability. When delivering data packets from a source to its destination out of the direct wireless transmission range.
4) Since the nodes are mobile, the network topology may change rapidly and unpredictably and the connectivity among the terminals may vary with time. MANET should adapt to the traffic and propagation conditions as well as the mobility patterns of the mobile network nodes. The mobile nodes in the network dynamically establish routing among themselves as they move about, forming their own network on the fly. Moreover, a user in the MANET may not only operate within the ad hoc network, but may require access to a public fixed network (e.g. Internet).
5) The nature of high bit-error rates of wireless connection might be more profound in a MANET. One end-to-end path can be shared by several sessions. The channel over which the terminals communicate is subject to noise, fading, and interference, and has less bandwidth than a wired network. In some scenarios, the path between any pair of users can traverse multiple wireless links and the link themselves can be heterogeneous.
6) In most cases, the MANET nodes are mobile devices with less CPU processing capability, small memory size, and low power storage. Such devices need optimized algorithms and mechanisms that implement the computing and communicating functions.

2.3 MANET Existence

Ad hoc networking is not a new concept. As a technology for dynamic wireless networks, it has been deployed in military since 1970s. Commercial interest in such networks has recently grown due to the advances in wireless communications. A new working group for MANET has been formed within the Internet Engineering Task Force (IETF) [2], aiming to investigate and develop candidate standard Internet routing support for mobile, wireless IP

autonomous segments and develop a framework for running IP based protocols in ad hoc networks. The recent IEEE standard 802.11 [4] has increased the research interest in the field.

Many international conferences and workshops have been held by e.g. IEEE and ACM. For instance, MobiHoc (The ACM Symposium on Mobile Ad Hoc Networking & Computing) has been one of the most important conferences of ACM SIGMOBILE (Special Interest Group on Mobility of Systems, Users, Data and Computing). Research in the area of ad hoc networking is receiving more attention from academia, industry, and government. Since these networks pose many complex issues, there are many open problems for research and significant contributions.

2.4 MANET in use:

- Tactical Networks – Military communications and operations control in battlefield environments.
- Sensor Networks – Collection of embedded sensor devices used to collect real-time data to automate everyday functions.
- Weather monitoring
- Earth activities
- Manufacturing Equipment automation

- Emergency Services–Search-and rescue operations (fire, flood.)
- Patient records retrieval at point of contact
- Loss of infrastructure due to catastrophic disaster
- Commercial Environments – electronic commerce
- Make and receive payments from anywhere
- Access customer records from the field
- Vehicular access of road conditions, weather, or local news
- Home and Enterprise Networking -
- Anywhere access for PDA
- Personal area networks
- Educational Applications – virtual classrooms or conference rooms for use during conferences, meetings or lectures.
- Entertainment – Multi-user, games, robotic pets, and outdoor Internet access.
- Location-aware Services – Follow-on services
- Call forwarding anywhere
- Transmission of actual workspace to current location
- Advertise location specific services
- Location specific travel guides
- Service availability information

The set of applications for MANETs is diverse, ranging from large-scale, mobile, highly dynamic networks, to small, static networks that are constrained by power sources. Besides the legacy applications that move from traditional infrastructured environment into the ad hoc context.

Such an ad hoc network can also extend the access to the Internet or other networks by mechanisms e.g. Wireless LAN (WLAN), GPRS, and UMTS. The PAN is potentially a promising application field of MANET in the future pervasive computing context.

2.5 MANET possible threats and challenges

Regardless of the attractive applications, the features of MANET introduce several challenges that must be studied

carefully before a wide commercial deployment can be expected.

The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger internet. Some challenge include:

1) *Routing*. Since the topology of the network is constantly changing, the issue of routing packets between any pair of nodes becomes a challenging task. Most protocols should be based on reactive routing instead of proactive. Multicast routing is another challenge because the multicast tree is no longer static due to the random movement of nodes within the network. Routes between nodes may potentially contain multiple hops, which is more complex than the single hop communication.
2) *Security and Reliability*. In addition to the common vulnerabilities of wireless connection, an ad hoc network has its particular security problems due to e.g. nasty neighbour relaying packets. The feature of distributed operation requires different schemes of authentication and key management. Further, wireless link characteristics introduce also reliability problems, because of the limited wireless transmission range, the broadcast nature of the wireless medium (e.g. hidden terminal problem), mobility-induced packet losses, and data transmission errors.
3) *Quality of Service (QoS).* Providing different quality of service levels in a constantly changing environment will be a challenge. The communications quality in a MANET makes it difficult to offer fixed guarantees on the services offered to a device. An adaptive QoS must be implemented over the traditional resource reservation to support the multimedia services.
4) *Internetworking*. In addition to the communication within an ad hoc network, internetworking between MANET and fixed networks (mainly IP based) is often expected in many cases. The coexistence of routing protocols in such a mobile device is a challenge for the harmonious mobility management.
5) *Power Consumption*. For most of the light-weight mobile terminals, the communication-related functions should be optimised for lean power consumption. Conservation of power and power-aware routing must be taken into consideration.
6) Network topology changes frequently and unpredictably.
7) Channel access/Bandwidth availability.
8) Hidden/Exposed station problem.
9) Lack of a centralized entity and symmetrical Link.

IV. RESEARCH ISSUES

This section analyses key Research issues concerning MANET network layer routing strategies, including four selected key problems in MANET: X-cast routing, security & reliability, QoS, and interworking with outside IP networks. These issues are currently main challenges of ad hoc wireless networks. The lack of robust solutions to these problems prevents MANET from wide commercial deployment.

4.1 X-cast Routing Algorithms

As in the infrastructured wireless networks, all kinds of X-cast communication schemes should be supported in an ad hoc mobile environment. These include unicast, anycast, multicast, and broadcast. MANET also brings new X-cast

modes into communications, e.g. geocast [10] and content-based. In particular, multicast is desirable to support multiparty wireless communications [11]. Since the multicast tree is no longer static (i.e. its topology is subject to change over time), the multicast routing protocol must be able to cope with mobility, including multicast membership dynamics (e.g., leave and join).

In a multihop ad hoc context, the routing problem becomes more complex because of the mobility of both hosts and routers. The random movement of the nodes and the uncertainty of path quality render the traditional routing protocols impractical. Trade-off between reactive and proactive schemes in terms of latency and overhead of route discovery and maintenance are to be considered depending on different traffic and mobility patterns. Issues to be taken into account include routing discovery and flooding, caching, data delivery, location-aided and power-aware, broadcast storm issue, route request and reverse path.

4.2 QoS Supporting Model

Just like in wired networks, QoS protocols can be used to prioritize data within ad hoc networks in order to reserve better connections for high data rate applications

while still maintaining enough bandwidth for lower bit rate communication. The support of multimedia services will most likely be required within and throughout the MANET, for which different QoS classes (e.g. voice, video, audio, web, and data stream) are needed to facilitate the use of multimedia applications.

In such environment involving dynamic nodes, hidden terminals, and fluctuating link characteristics, supporting end-to-end QoS at different levels will be a great challenge that requires in-depth investigation [12]. An adaptive QoS must be implemented over the traditional plain resource reservation to support the multimedia services. Special emphasis should be put on achieving a new QoS model for MANETs by taking into account the ad hoc features of the target networks: dynamic node roles, data flow granularity, traffic profile, etc.

4.3 Security, Reliability, and Availability Schemes

Security, reliability, and availability are three crucial aspect of MANET, especially in security-sensitive applications.
Reliability occurs by routing and forwarding packets:

- Network overload
- Misbehaving nodes
- Broken links
- No centralized management makes these problems difficult to detect and isolate.
- Reliability thus must rely on properly designed protocols. MANET Security include:
- Mobile networks are physically insecure
- Distributed management means overall security is dependent on individual node security.
- MANET security considerations:

Confidentiality – prevent eavesdropping
Access control – protecting the wireless infrastructure
Data integrity – preventing tampering of traffic
Denial of service.

Since ad hoc relies on wireless communication medium, it is important to deploy a security protocol to protect the privacy of transmissions.However, the implementation schemes of key management, authentication, and authorization are quite different because there is no aid of a trusted third-party certification authority to create trusted relationships by exchanging private/public keys [13]. Different types of threats and attacks against routing in MANET should be analysed leading to the requirement of ad hoc routing security, and advanced solutions are needed for the secure routing of MANET.

Wireless communication is subject to many types of problems due to interference and poor signals. As for reliability and availability issues, besides low level error masking and recovery mechanisms (i.e. link layer error detection and correction coding), special attention should be paid to studying fault-tolerant routing algorithm. Exploiting this property, it's possible to provide a fault-tolerant routing scheme [14], for increasing the reliability and security of the target routing algorithm.

4.4 Internetworking Mechanisms

To integrate the two mobility management schemes in the domains of both traditional infrastructured wireless networks and the new mobile ad hoc networks is an important issue. The mobility mode of an ad hoc network is quite different from that of infrastructured networks. In infrastructured networks only the nodes (terminals) at the very edges (the last hop) of fixed networks are moving, whereas an ad hoc network can be completely mobile, since a device can serve both as router and host at the same time. Consequently, in an ad hoc network mobility is handled directly by the routing algorithm.

In many cases, device accesses both within the ad hoc network and to public networks (e.g. the Internet) can be expected to form a universal communication scenario. In other words, a terminal in an ad hoc wireless network is able to connect to nodes outside the MANET while being itself also accessible by external nodes. The interworking between ad hoc and fixed networks is necessary. In particular, the coexistence and cooperation with the public IP based wireless networks is necessary to many contexts. The Mobile IP protocol for MANET should be deeply studied in order to give nodes in ad hoc networks the ability of accessing the Internet and other IP based networks to take advantage of the Services of Mobile IP.

V.CONCLUSION:

This article describes the fundamental issues and analyses key research problems of MANET. Firstly, the background information of MANET are introduced MANET concept, features, current status, and application areas.
Then the main challenges of MANET are discussed that lead to the analysis of relevant kernel barrier. Finally, four key network layer research issues of MANET routing strategies are described in detail. The novel and advanced solutions to these issues are necessary to fulfil the requirements of wide commercial deployment of MANET.Mobile ad hoc networking is one of the most important and essential technologies that support future pervasive computing scenario. The special characters of MANET bring this technology great opportunities together with severe challenges. Currently MANET is becoming more and more interesting research topic and there are many research projects employed by academic and companies all over the world. Various interesting issues are investigated that cover all aspects of ad hoc wireless networks. Meanwhile, many routing protocols designed for ad hoc networks have been proposed as Internet Draft and RFC of IETF. MANETs can be exploited in a wide area of applications, from military, emergency rescue, law enforcement, commercial, to local and personal contexts.

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