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Basic Study of Ad-Hoc Networking (A Review Paper)

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Abstract: Ad hoc networks are peer networks of mobile computational nodes. They are well explored in the contexts of sensor networks, habitat monitoring and robotic collaboration. Recently, ad hoc networks have elicited increasing interest as flexible distributed application environments. Today, many people carry numerous portable devices, such as laptops, mobile phones, PDAs (personal digital assistant) and mp3 players, for use in their professional and private lives. For the most part, these devices are used separately ie. their applications do not interact. Ad hoc wireless communication between devices might be loosely defined as a scheme, often referred to as ad hoc networking, which allows devices to establish communication, anytime and anywhere without the aid of a central infrastructure. In this article, the concept of mobile ad hoc networking along with its applications that can be envisoned are being described. Ad hoc networking covers a broad swath of situations. An ad hoc network might consist of several home-computing devices, plus a notebook computer that must exist on home and office networks without extra administrative work[I]. Such a network might also need to exist when the people and equipment in normally unrelated military units need to work together in combat.

Keywords: networking, ad hoc, bluetooth, communication, wireless, routing.

I. INTRODUCTION

Ad hoc networks are a new paradigm of wireless communication for mobile hosts (which we call nodes). In an ad hoc network, there is no fixed infrastructure such as base stations or mobile switching centers. Mobile nodes that are within each other's radio range communicate directly via wireless links, while those that are far apart rely on other nodes to relay messages as routers. As we look to the horizon, we can finally glimpse a view of truly ubiquitous computing and communication. In the near future, the role and capabilities of short-range data transaction are expected to grow, serving as a complement to traditional large-scale communication: most man machine communication as well as oral communication between human beings occurs at distances of less than 10 meters; also, as a result of this communication, the two communicating parties Military tactical operations are still the main application of ad hoc networks today. For example, military units (e.g., soldiers, tanks, or planes), equipped with wireless communication devices, could form an ad hoc network when they roam in a battlefield [VII]. Ad hoc networks can also be used for emergency, law enforcement and rescue missions. Since an ad hoc network can be deployed rapidly with relatively low cost, it becomes an attractive option for commercial uses such as sensor networks or virtual classrooms. Often have a need to exchange data. As an enabling factor, license-exempted frequency bands invite the use of developing radio technologies (such as Bluetooth) that admit effortless and inexpensive deployment of wireless communication. In terms of price, portability and usability and in the context of an ad hoc network, many computing and communication devices, such as PDAs and mobile phones, already possess the attributes that are desirable. As advances in technology continue, these attributes will be enhanced even further.

II. AD HOC NETWORK

An ad-hoc network is the cooperative engagement of a collection of mobile nodes without the required intervention of any centralized access point or existing infrastructure. We present Ad-hoc On Demand Distance Vector Routing (AODV), a novel algorithm for the operation of such ad-hoc networks. Each mobile host operates as a specialized router, and routes are obtained as needed (i.e., on-demand) with little or no reliance on periodic advertisements [V]. Our new routing algorithm is quite suitable for a dynamic self starting network, as required by users wishing to utilize ad-hoc networks. AODV provides loop-free routes even while repairing broken links. Because the protocol does not require global periodic routing advertisements, the demand on the overall bandwidth available to the mobile nodes is substantially less than in those protocols that do necessitate such advertisements. Perhaps the most widespread notion of a mobile ad hoc network is a network formed without any central administration which consists of mobile nodes that use a wireless interface to send packet data. Since the nodes in a network of this kind can serve as routers and hosts, they can forward packets on behalf of other nodes and run user applications. The roots of ad hoc networking can be traced back as far as 1968, when work on the ALOHA network was initiated (the objective of this network was to connect educational facilities in Hawaii). Although fixed stations were employed, the ALOHA

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protocol lent itself to distributed channel access management and hence provided a basis for the subsequent development of distributed channel-access schemes that were suitable for ad hoc networking. The ALOHA protocol itself was a single-hop protocol ie. it did not inherently support routing. Instead every node had to be within reach of all other participating nodes. Inspired by the ALOHA network and the early development of fixed network packet switching, DARPA began work, in 1973, on the PRnet (packet radio network) a multihop network. In this context, multihopping means that nodes cooperated to relay traffic on behalf of one another to reach distant stations that would otherwise have been out of range. PRnet provided mechanisms for managing operation centrally as well as on a distributed basis. As an additional benefit, it was realized that multi hopping techniques increased network capacity, since the spatial domain could be reused for concurrent but physically separate multihop sessions. Although many experimental packet radio networks were later developed, these wireless systems did not ever really take off in the consumer segment. When developing IEEE 802.11 a standard for wireless local area networks (WLAN) the Institute of Electrical and Electronic Engineering (IEEE) replaced the term packet-radio network with ad hoc network. Packet-radio networks had come to be associated with the multihop networks of large-scale military or rescue operations, and by adopting a new name, the IEEE hoped to indicate an entirely new deployment scenario. Today, our vision of ad hoc networking includes scenarios where people carry devices that can network on an ad hoc basis. A user's devices can both interconnect with one another and connect to local information points for example, to retrieve updates on flight departures, gate changes, and so on. The ad hoc devices can also relay traffic between devices that are out of range[III]. The airport scenario thus contains a mixture of single and multiple radio hops. To put ad hoc networking in its right perspective, let us make some observations about wireless communication, beginning with present-day cellular systems, which rely heavily on infrastructure: coverage is provided by base stations, radio resources are managed from a central location, and services are integrated into the system. This lead to the good and predictable service of present-day cellular systems. As we decrease, or move away from, central management, we find ourselves moving in the direction of pure ad hoc operation, which can also be classified in terms of single or multiple hops. Without having fully relinquished control, but given the direct mode of communication in HiperLAN/2, adjacent terminals can communicate directly with one another. Thus, the transport of traffic is not entirely dependent on the coverage provided by access points. Dependency on centrally administered coverage is further reduced when end-user terminals relay traffic in a multihop fashion between other terminals and the base station (cellular multihop). A similar approach applies to commercial or residential wireless local loop (WLL) multihop access systems, primarily conceived for Internet access .Fully decentralized radio, access, and routing technologies enabled by Bluetooth, IEEE 802.11 ad hoc mode, PRnet stationless mode, mobile ad hoc network (MANET), and concepts such as the personal area network (PAN) or PAN-to-PAN Communication fit more or less entirely into the ad hoc domain. The MANET initiative by the Internet Engineering Task Force (IETF) also aims to provide services via fixed infrastructure connected to the Internet. Recent development and characteristics within this genre are the focus of this article

III. APPLICATIONS

Mobile ad hoc networks have been the focus of many recent research and development efforts. So far, ad hoc packet-radio networks have mainly been considered for military applications, where a decentralized network configuration is an operative advantage or even a necessity. In the commercial sector, equipment for wireless, mobile computing has not been available at a price attractive to large markets [II]. However, as the capacity of mobile computers increases steadily, the need for unlimited networking is also expected to rise. Commercial ad hoc networks could be used in situations where no infrastructure (fixed or cellular) is available. Examples include rescue operations in remote areas, or when local coverage must be deployed quickly at a remote construction site. Ad hoc networking could also serve as wireless public access in urban areas, providing quick deployment and extended coverage. The access points in networks of this kind could serve as stationary radio relay stations that perform ad hoc routing among themselves and between user nodes. Some of the access points would also provide gateways via which users might connect to a fixed backbone network. At the local level, ad hoc networks that link notebook or palmtop computers could be used to spread and share information among participants at a conference. They might also be appropriate for application in home networks where devices can communicate directly to exchange information, such as audio/video, alarms, and configuration updates. Perhaps the most far-reaching applications in this context are more or less autonomous networks of interconnected home robots that clean, do dishes, mow the lawn, perform security surveillance, and soon. Some people have even proposed ad hoc multihop networks (denoted sensor networks) for example, for environmental monitoring, where the networks could be used to forecast water pollution or to provide early warning of an approaching tsunami. Short-range ad hoc networks can simplify intercommunication between various mobile devices (such as a cellular phone and a PDA) by forming a PAN, and thereby eliminate the tedious need for cables. This could 250 also extend the mobility provided by the fixed network (that is, mobile IP) to nodes further out in an ad hocnetwork domain. The Bluetooth system is perhaps the most promising technology in the context of personal area networking.

IV. CHARACTERISTICS

In contrast to traditional wireline or wireless networks, an ad hoc network could be expected to operate in a network environment in which some or all the nodes are mobile. In this dynamic environment, the network functions must run

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in a distributed fashion, since nodes might suddenly disappear from, or show up in, the network. In general, however, the same basic user requirements for connectivity and traffic delivery that apply to traditional networks will apply to ad hoc networks. Below, we discuss some typical operational characteristics and how they affect the requirements for related networking functions.

- Distributed operation: a node in an ad hoc network cannot rely on a network in the background to support security and routing functions. Instead these functions must be designed so that they can operate efficiently under distributed conditions.
- Dynamic network topology: in general, the nodes will be mobile, which sooner or later will result in a varying network topology. Nonetheless, connectivity in the network should be maintained to allow applications and services to operate undisrupted.
- Fluctuating link capacity: the effects of high bit-error rates might be more profound in a multihop ad hoc network, since the aggregate of all link errors is what affects a multihop path. In addition, more than one end-to-end path can use a given link, which if the link were to break, could disrupt several sessions during periods of high bit-error transmission rates. Here, too, the routing function is affected, but efficient functions for link layer protection (such as forward error correction, FEC, and automatic repeat request, ARQ) can substantially improve the link quality.
- Low-power devices: in many cases, the network nodes will be battery-driven, which will make the power budget tight for all the power-consuming components in a device. This will affect, for instance, CPU processing, memory size/usage, signal processing, and transceiver output/input power[III]. The communication-related functions (basically the entire protocol stack below the applications) directly burden the application and services running in the device. However, the inherent stochastic communications quality in a wireless ad hoc network, as discussed above, makes it difficult to offer fixed guarantees on the services offered to a device. In networks of this kind, fixed guarantees would result in requirements for how nodes move, as well as requirements for node density, which would inherently inhibit the notion of ad hoc operation

V. ROUTING IN AD HOC NETWORKS

Routers exchange network topology informally in order to establish routes between nodes another potential target for malicious attackers who intend to bring down the network. External attackers injecting erroneous routing info, replaying old routing info or distorting routing info in order to partition a network or overloading a network with retransmissions and inefficient routing. Internal compromised nodes - more severe detection and correction more difficult Routing info signed by each node won't work since compromised nodes can generate valid signatures using their private keys. For mobile ad hoc networks, the issue of routing packets between any pair of nodes becomes a challenging task because the nodes can move randomly within the network. A path that was considered optimal at a given point in time might not work at all a few moments later. Moreover, the stochastic properties of the wireless channels add to the uncertainty of path quality. The operating environment as such might also cause problems for indoor scenarios the closing of a door might cause a path to be disrupted. Traditional routing protocols are proactive in that they maintain routes to all nodes, including nodes to which no packets are being sent. They react to any change in the topology even if no traffic is affected by the change, and they require periodic control messages to maintain routes to every node in the network. The rate at which these control messages are sent must reflect the dynamics of the network in order to maintain valid routes. Thus, scarce resources such as power and link bandwidth will be used more frequently for control traffic as node mobility increases. An alternative approach involves establishing reactive routes, which dictates that routes between nodes are determined solely when they are explicitly needed to route packets. This prevents the nodes from updating every possible route in the network, and instead allows them to focus either on routes that are being used, or on routes that are in the process of being set up.

VI. BLUETOOTH NETWORKING

Bluetooth technology was designed primarily to support simple wireless networking of personal consumer devices and peripherals, including cell phones, PDAs, and wireless headsets. Wireless signals transmitted with Bluetooth cover short distances, typically up to 30 feet (10 meters). Bluetooth devices generally communicate at less than 1 Mbps. Bluetooth networks feature a dynamic topology called a *piconet* or *PAN*. Piconets contain a minimum of two and a maximum of eight Bluetooth peer devices [VI]. Devices communicate using protocols that are part of the Bluetooth Specification. Definitions for multiple versions of the Bluetooth specification exist including versions 1.1, 1.2 and 2.0. Although the Bluetooth standard utilizes the same 2.4 Ghz range as 802.11b and 802.11g, Bluetooth technology is not a suitable Wi-Fi replacement. Compared to Wi-Fi, Bluetooth networking is much slower, a bit more limited in range, and supports many fewer devices. Concerns with Bluetooth technology include security and interoperability with other networking standards. Worldwide, the industry has shown a tremendous interest in techniques that provide short-range wireless connectivity. In this context, Bluetooth technology is seen as the key component. However, Bluetooth technology must be able to operate in ad hoc networks that can be stand-alone, or part of the IP-networked world, or a combination of the two. The main purpose of Bluetooth is to replace cables between electronic devices, such as telephones, PDAs, laptop computers, digital cameras, printers, and fax machines, by using a low-cost radio chip. Short-range connectivity also fits nicely into the widearea context, in that it can extend IP networking into the personal-area network domain, as discussed earlier. Bluetooth must be able to carry IP efficiently in a PAN, since PANs will be connected to the Internet via UMTS or

corporate LANs, and will contain IP-enabled hosts. Generally speaking, a good capacity for carrying IP would give Bluetooth networks a wider and more open interface, which would most certainly boost the development of new applications for Bluetooth.

VIII. CONCLUSION

Adhoc networking is still a raw area of research as can be seen with the problems that exist in these networks and the emerging solutions .In this article I have tried to survey ad hoc networking mainly from a technical point of view. I have also made an attempt to clarify what an ad hoc network actually is and found that the definitions vary. However , by proceeding from familiar wireless network architectures, we have allowed the level of independent operation of the network nodes to define the notion of ad hoc networking. Typically, these networks operate with distributed functions and allow traffic to pass over multiple radio hops between source and destination. Furthermore, I have discussed some of the typical properties of ad hoc networks, such as routing algorithms and the implications of radio layers. The inherent unpredictability in a network whose nodes move poses a challenge to routing and mobility functions if they are to deliver data consistently between the network nodes. Nonetheless, multihop radio systems also make it possible to save battery capacity while retaining, or even improving, performance. In any case, the most attractive property of an ad hoc networking model is perhaps its independence from centralized control and, thus, the increased freedom and flexibility it gives the user. Ad hoc networks have mostly been used in the military sector, where being able to establish ad hoc communication is often a necessity. On the other hand, in the commercial sector, successful examples of ad hoc radio networks are few so far, if any. However, instead of looking at large-scale networks we turned to the small-scale personal area networks that are emerging in response to the introduction of short-range radio technologies, such as Bluetooth. Here, ease of use and flexibility are fueling the demand for ad hoc operation. In addition, a centralized network architecture would have serious problems trying to control all PAN devices. In particular, ad hoc Bluetooth networks scatternets will give rise to a whole new set of business and consumer applications for small, battery-driven user devices, such as mobile phones, PDAs, and notebook computers. The combination of wide-area IP connectivity via UMTS (mobile phone) access, and personal area connectivity in the PAN presents new opportunities for the user on the go. Thus, the current development of IP support in Bluetooth networks is crucial. Due to its inherent flexibility, ad hoc networking is easy to deploy and would fit nicely into, say, an office setting, where users could set up ad hoc networking groups using fewer LAN access points and potentially less transmitting power. However, the products that apply the concepts of ad hoc networking will most likely see its light in the short, personal area range. These products will mainly focus on facilitating communication between a user's personal devices either for local traffic or as gateways to the Internet. The ad hoc network functionality will also enable the interconnection of different. User's devices for instance, to facilitate larger ad hoc working groups. The intrinsic ability to create generic, small-scale, ad hoc networks in portable devices represents an entirely new area for future ad hoc-based applications.

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