A Survey on the Applications of MANET

Jiazi YI
Polytech'Nantes
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Abstract

This report examined the applications of MANET nowadays. The report not only reviews the pure general-purpose MANET, but also other specified MANETs: mesh networks, opportunistic networks, vehicular ad hoc networks and wireless networks. We can see that, although pure general-purpose MANET does not yet exist in the real world, the multihop ad hoc networking paradigm was successfully applied in several classes of networks that are penetrating the mass market.

1. Pure general purpose MANET

The mostly discussed application scenario for pure general-purpose MANET is Battlefield or disaster-recovery networks. However, these kinds of networks have not yet achieved the envisaged impact in terms of real world implementation and industrial deployment.

1.1. Limits of pure general-purpose MANET research

1.1.1. USERS' PERSPECTIVE

Generally, MANET is justified by the possibility of building a network where no infrastructure exists, or to have a "free" network where users can communicate without cost, provided that the node density is sufficient. However, reports about MANET perception from the users' perspective are missing. The users' evaluation indicates the following major problems in pure general purpose MANET:

- Users' motivations for using large-scale MANET are not clear.
- Application scenarios able to attract user interest are missing.
- There is a lack of effective MANET implementations that can be used by non-expert users.
- Mesh network is a more pragmatic approach to build multihop ad hoc networks.

1.1.2. TECHNICAL PERSPECTIVE

Although MANET research has been going on for some time, there are relatively few experiences with real ad hoc networks. The lack of accuracy in most MANET simulation studies in one or more of the previous points drastically reduces the credibility of MANET research. Here are the most common issues in MANET simulation that may result in the lack of realism in simulation studies.

Simulation Modeling
Simulation Model Solution
Analysis of the Simulation Output

2. Mesh networks

Mesh networks are built upon a mix of fixed and mobile nodes interconnected via wireless links to form a multihop ad hoc network . Unlike *pure MANETs*, a mesh network introduces a *hierarchy* in the network architecture by adding dedicated nodes (called *mesh routers*) that communicate wirelessly to construct a *wireless backbone*.

MIT Roofnet provide a city such as Boston, with broadband access with an 802.11b-based wireless network backbone infrastructure.

2.1. Public Internet access.

The wireless mesh networks are the ideal solution to provide both indoor and outdoor broadband wireless connectivity in urban, suburban, and rural environments without the need for extremely costly wired network infrastructure.

Metroscale broadband city network in the city of Cerritos (California)

This network is built up with Troposbased mesh technology and covers a city area as large as eight square miles using more than 130 outdoor access points, less than 20 percent of them directly connected to a wired backhaul network.

This significant reduction of network installation costs ensures rapid deployment of a metropolitan broadband network that is cost effective even with a limited potential subscriber base, as found in rural or scarcely populated urban areas.

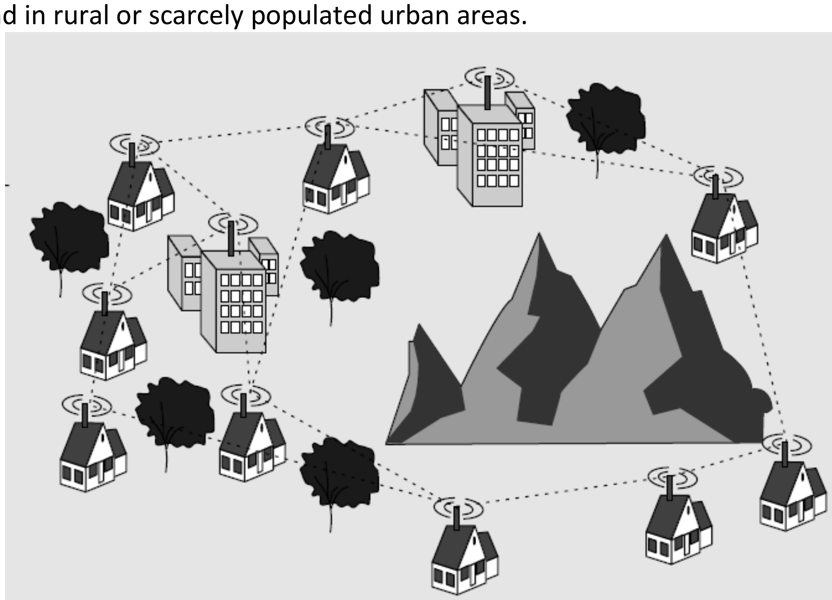

Figure 1 Residential Broadband access for hard to reach and scarcely populated areas

Nortel Wireless Mesh Network

National Taiwan University - Public WLAN Trial Site in National Taiwan University

- Public WLAN: Providing campus-wide indoor and outdoor coverage to NTU’s professors, students, and staff as benchmark, leading-edge wireless mesh deployment in Taiwan
- Partner with Taiwan local companies for network build-out
- Includes a comprehensive network solution: Up to 17 Wireless AP 7220s, 1 Passport 1424 (NAP-R), 1 Optivity NMS Software, Wireless Gateway 7250, 2220/2221 WLAN Mobile Adapters

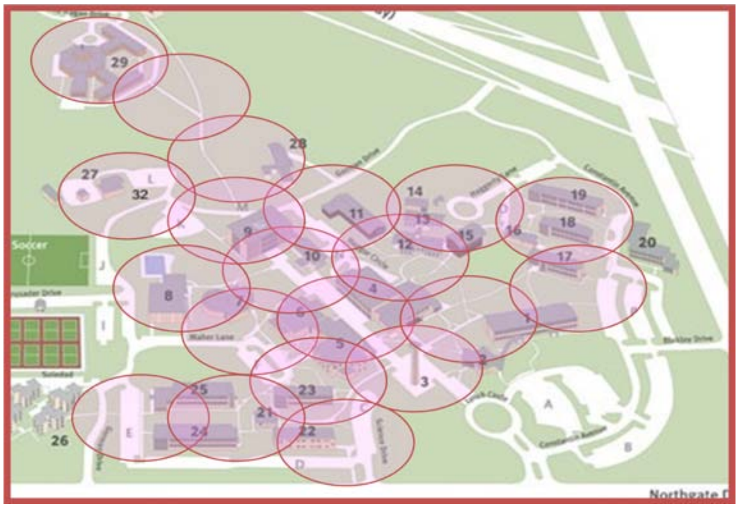

Figure 2 Wireless Mesh Network's Coverage

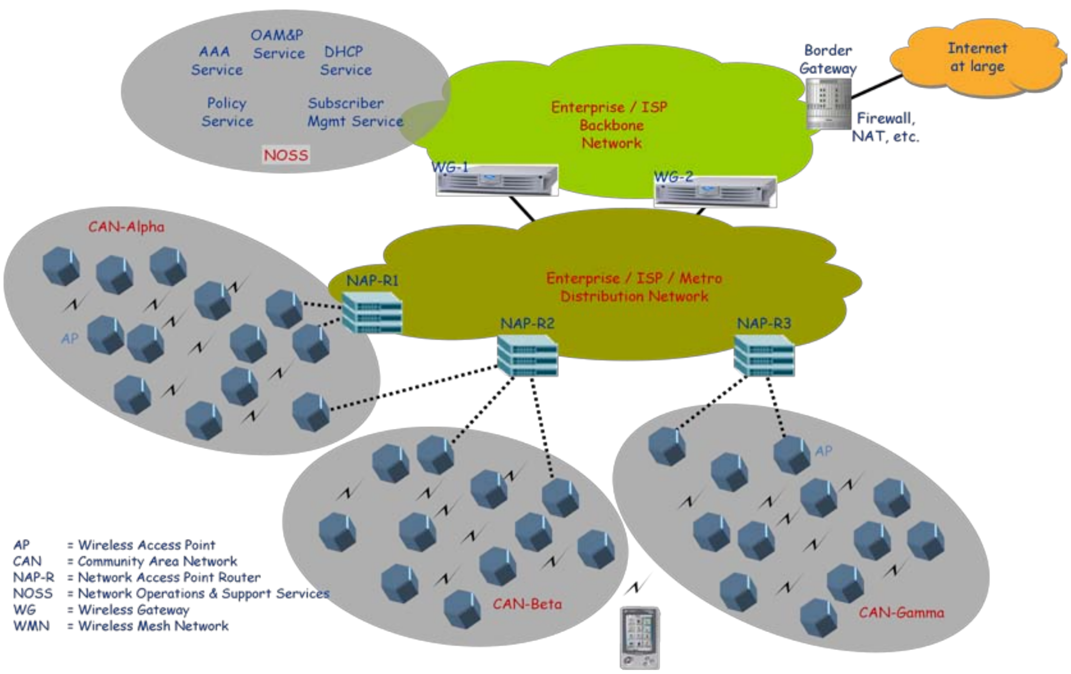

Figure 3 Nortel Wireless Mesh Network Architecture

2.2. Intelligent transportation systems

Wireless mesh could be the flexible solution to implement the information delivery system required to control transportation services.

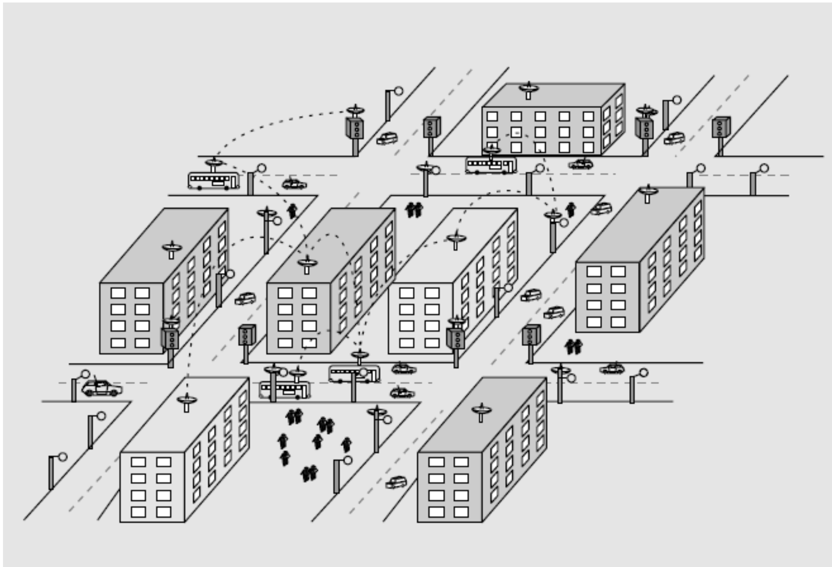

Figure 4 Intelligent Transportation System

Portsmouth Real-Time Travel Information System (PORTAL) : aimed at providing real-time travel information to bus passengers in the city of Portsmouth. This system is realized by equipping more than 300 buses with mesh technology provided by MeshNetworks Inc. The wireless mesh network allows anybody to display, at more than 40 locations throughout the city, real-time information on transportation services, such as where his/her bus is, its ultimate destination, and when it is scheduled to arrive. The same system is also expected to be used to address and alleviate transportation congestion problems, control pollution, and improve transportation safety and security.

2.3. Public Safety

Wireless mesh networks appear to be the natural solution to address the needs of law enforcement agencies and city governments. Currently, several mesh networks are operating to provide public safety applications.
The San Matteo Police Department in the San Francisco Bay Area has equipped all its patrol cars with laptops, and motorcycle and bicycle patrols with PDAs, employing standard 802.11b/g wireless cards for communications. The outdoor wireless network is built using mesh networking technology provided by Tropos Networks. More than 30 Tropos Wi-Fi access points were installed throughout downtown to provide ubiquitous coverage to the zone. Tropos proprietary software components are installed over the access points, providing self-discovery and self-configuring functionalities, communications privacy, and centralized network management and control.

2.4. Mesh community

The Champaign-Urbana Community Wireless Network (CUWiN) implementing a wireless network in the downtown area of Urbana. This is creating a community of users, who install their own nodes and participate in the mesh network that is further supported by other backbone-like nodes.

Microsoft research, Intel, Motorola, CISCO have decided to enter the wireless mesh networking.

3. Opportunistic Networking (Delay Tolerant Networking)

3.1. Pocket Switched Networks in the Haggle Project

The Haggle Project (http://www.haggleproject.org) is a 4-year project, started in January 2006, funded by the European Commission in the framework of the FET-SAC initiative (http://cordis.europa.eu/ist/fet/comms-sy.htm). It targets solutions for communication in autonomic/opportunistic networks. In this framework, researchers are studying the properties of Pocket Switched Networks (PSNs), i.e., opportunistic networks that can exploit any possible encountered device (e.g., cell phones and PDAs that users carry in their pockets) to forward messages.

3.2. Wildlife monitoring

Wildlife monitoring is an interesting application field for opportunistic networks. It focuses on tracking wild species to deeply investigate their behavior and understand the interactions and influences on each other, as well as their reaction to the ecosystem changes caused by human activities. Researchers use opportunistic networks as a reliable, cost-effective, and not intrusive means to monitor large populations roaming in vast areas. Systems for wildlife monitoring generally include special tags with sensing capacity to be carried by the animals under study, and one or more base stations to collect the data from the tags and send them to the destination processing centre. A network protocol is also comprised to percolate the data from the tags towards the base station(s). Base stations can be fixed or mobile, however, in both cases data collection from all the deployed tags is quite challenging. Therefore, it is generally advisable to exploit pair-wise contacts between the animals to let them exchange the information already collected. As a consequence, each animal eventually carries the information collected by its own together with the information collected by the animals it has encountered.
The realistic projects include ZebraNet at Princeton University which is used for tracking zebras wearing special collars and SWIM (Shared Wireless Infostation Model) which is used to monitor whales.

3.3. Opportunistic networks for developing areas

Opportunistic networks can provide intermittent Internet connectivity to rural and developing areas where they typically represent the only affordable way to help bridging the digital divide. One such example is the DakNet Project aimed at realizing a very low-cost asynchronous ICT infrastructure to provide connectivity to rural villages in India, where it is not cost-effective to deploy standard Internet access.
Another interesting opportunistic application scenario has been investigated in the framework of the Saami Network Connectivity (SNC) project [6] aimed at providing network connectivity to the nomadic Saami population of the reindeer herders. In its initial stage, the SNC project has only focused on providing email, file transfer, and cached web services to the Saami people. Reindeer herd telemetry is also going to be provided to support the herding activity itself.

4. Vehicular ad hoc networks

VANETs use ad hoc communications for performing efficient driver assistance and car safety. The communications include data from the roadside and from other cars. VANET research aims to supply drivers with information regarding obstacles on the road and emergency events, mainly due to line-of-sight limitations and large processing delays. VANET can be used to communicate premonitions, notification of emergencies, and warnings about traffic conditions.

It can be used for distributing information about road conditions and maintenance, weather forecasts, or other relevant data distribution requirements between vehicles.
VANET enable the use of advanced driver assistance systems (ADAS) and vehicular-tovehicular (V2V) communications, also called inter-vehicular communications (IVC), as well as communication with roadside infrastructure. VANET have an advantage compared to traditional MANET. They rarely have constraints related to the capacities of the devices.

Association of Electronic Technology for Automobile Traffic and Driving (JSK), Japan in the early eighties is considered the initiator of the research in the IVC area.

European FleetNet project aims at the development and demonstration of a wireless ad-hoc network for inter-vehicle communications. Key design factors for FleetNet are the capability to distribute locally relevant data where generated and/or needed and to satisfy the vehicle drivers' and passengers' needs for location-dependent information and services.

California PATH seeks to learn how traffic information can positively impact the environment, traffic safety and traffic congestion. It will synthesize data and research in the areas of traffic data collection, emissions- and fuel-consumption-based navigation and "smart engine" controls to turn an Audi vehicle into a working prototype of the ultimate traffic- and fuel-smart car. The project incorporates data on traffic signals, road conditions, vehicle velocity, terrain grade and traffic congestion conditions, creating a composite of information from which smart engine controls can choose the safest, most fuel-efficient speeds and routes.

European Project CarTALK 2000. The European Project CarTALK 2000 is focussing on new driver assistance systems which are based upon inter-vehicle communication. The main objectives are the development of co-operative driver assistance systems and the development of a self-organising ad-hoc radio network as a communication basis with the aim of preparing a future standard.
As for the assistance system, the main issues are:

- assessment of today's and future applications for co-operative driver assistance systems,
- development of software structures and algorithms, i.e. new fusion techniques,
- testing and demonstrating assistance functions in probe vehicles in real or reconstructed traffic scenarios.

To achieve a suitable communication system, algorithms for radio ad-hoc networks with extremely high dynamic network topologies are developed and prototypes are tested in probe vehicles.
Apart from the technological goals, CarTALK 2000 actively addresses market introduction strategies including cost/ benefit analyses and legal aspects, and eventually aims at the standardisation to bring these systems to the European market.

LaRA, France is to assist the drivers in order to improve safety, comfort and efficiency of road transport. The ultimate goal is to remove completely the driver from the control loop, at least in particular situations such as dedicated freeways and at low speed in urban situations.

5. Wireless sensor networks

WSN benefit from the advances in computing technology, which led to the production of small, wireless, battery powered, smart sensor nodes. These nodes are active devices with computing and communication capabilities that not only sample real world phenomena but also can filter, share, combine, and operate on the data they sense.

5.1. Habitat and Environmental Monitoring for Scientific Applications

The periodic information retrieval required by most of the habitat and environmental applications can be performed, in most of the cases, only by means of WSN. WSN enable regular observation of the environment without invading the environment of plants and animals and make possible a 24-hour monitoring.

The ***PODS project*** developed a sensor-network to study the biology of typical rare plant species and the habitats they occupy in Volcanoes National Park in Hawaii. The WSN is used to collect measurements of the temperature, humidity, rainfall, wind, and solar radiation in the habitat of the rare species.

The ***Great Duck Island Habitat Monitoring project*** is a pilot application for monitoring migratory seabirds (Leach's Storm Petrel) on Great Duck Island, Maine. The WSN was used to monitor the microclimates in and around nesting burrows. Eventually, data is transferred via satellite to the database at the University of California at Berkeley. Intel and the University at Berkeley proposed WSN for creating a macroscope (sensor nodes strapped at different elevations on a redwood tree) to study the microclimate around redwoods.

The ***Envisense GlacsWeb project*** uses WSN for monitoring the glacial environment to study sub glacial bed deformations by collecting measurement samples via pressure, temperature, and orientation sensors and delivering them to a base station located on the glacier surface, from which they are delivered to the sink.

5.2. Monitoring for Civilian Applications

Forest fire detection, flood detection, and precision agriculture. Alarms, propagated by multihop through the WSN, enable a quick reaction before the fire becomes uncontrollable.

Health monitoring. WSN can be used as part of a health monitoring system that can be worn by the patient. CodeBlue system developed at Harvard University exploits a WSN to raise an alert when vital signs fall outside of the normal parameters. The system monitors heart rate, oxygen saturation, and EKG data and relays the data over a short-range wireless network to a set of devices, including ambulance-based terminals.

Tracking applications. Instead of sensing environmental data, sensor nodes are deployed to sense the presence of persons and objects. In the simplest case, objects can be tracked by tagging them with a small sensor node. The sensor node is tracked as it moves through a field of sensor nodes that are deployed in the environment at known locations. The sensor nodes can be used as active tags that announce the presence of a device.

Intelligent home environment. The smart home can communicate with the environment and people through the use of sensors and can act upon the environment through the use of actuators.

Localization applications. For example, detecting and locating snipers is a challenging goal for armed forces and law enforcement agencies. Most successful sniper-detecting systems are based on exploiting a WSN that takes easurements of the acoustic events generated by a shot: the spherical wave (traveling at the speed of sound) produced by the muzzle blast and the shock wave generated by the supersonic projectile. By exploiting the measurements of acoustic events taken by the sensor network nodes, it is possible to determine the sniper's location and the bullet's trajectory.

Monitoring the aquatic environment. The underwater wireless sensor network have applications including the scientific (e.g., oceanographic data collection for scientific exploration, pollution control, or climate monitoring), military (e.g., tactical surveillance), and civilian fields (e.g., tsunami warnings).

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