Ad-hoc Networking Applications In Different Scenarios

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Abstract- This paper presents a significant aspect of Ad-hoc networking application based on different scenarios. In the wireless communication systems, there is a need for the rapid deployment of independent mobile users. Significant examples include establishing survivable, efficient, dynamic communication for emergency operations, disaster relief efforts, and military networks. Such network scenarios cannot rely on centralized and organized connectivity. This can be conceived as applications of MANET (Mobile Ad-Hoc Network). Most of the concerns of interest to MANETs are of interest in VANETs (Vehicular Ad-Hoc Network. Cellular ad-hoc networks also seem to be a promising solution for broadband wireless access networks in beyond 3G systems. This paper also describes the prominent future of ad-hoc networking in future wireless communication system.

Keywords – Ad-hoc network, MANET, VANET, Cellular Ad-hoc networks.

I. INTRODUCTION

This paper describes different types of ad-hoc network application based on its different scenarios. The vision with a MANET is a spontaneous network that can be established even if the local infrastructure has been destroyed. It can be used in a natural disaster area, military operation and also for educational, business purposes. VANET is used to provide communications among the nearby vehicles and between nearby fixed equipment such as traffic signal, road side alarm. In this paper we will discuss about it. This paper also discusses the role of ad-hoc networking in future wireless communications indicating that cellular ad-hoc networking seems to be a promising solution to fulfill the requirements of future wireless communication systems.

II. AD-HOC NETWORKING IN DISASTER AREA

In recent years, large scale sizes of natural disasters, such as earth quake, mountain explosion, hurricane, rain flooding and snow-slide are occurring in many countries in the world frequently. Many people by those disasters are losing their lives; huge amount of properties is being destroyed. When a disaster happens in an area where people live in and there are victims at there, rescue teams are organized and sent to save the victims. However, in many cases of disaster occurrences, the resident lives can be saved if the disaster information network system could effectively work just after disaster happened.

In typical disaster scenario emergency service teams, and relief agencies quickly mobilize to aid those affected by the disaster. The disaster zone can be large and geographically spread apart**.** Unfortunately, relief operations are often hampered due to communication system failure. Failure to communicate accurate and timely information can cost lives of the victims as well as those who are trying to assist. Under these circumstances, a reliable communications infrastructure that provides the required information in a timely manner can solve the problem.

Network establishment

In a disaster area where all communication system is fully or partly damaged, there must be an establishment of a network for relief and rescue mission. Because large disasters destroy core terrestrial communications infrastructure, and backup networks are often unable to handle the necessary traffic volumes. Relief and rescue teams may need to communicate with either the central command center, or with other teams on the disaster site.

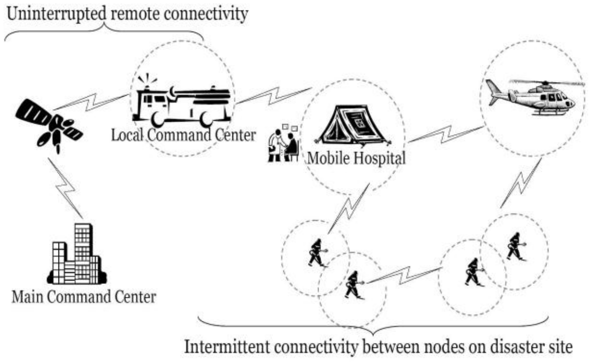

Fig: 1 A typical information sharing system in a disaster area

The Fig. 1[2] shows a typical information sharing system in a disaster area. In the first scenario, the long-distance communication link with the main command center is typically established through VSAT terminals that are mounted at selected mobile command centers. The intermittent connectivity between the mobile nodes is generated by a wireless ad-hoc network, typically a mobile ad-hoc network (MANET).

Challenges

To establish information sharing system for disaster response some requirements and challenges should be considered. Interoperability is one key problem that can be addressed through the use of cognitive radios. We list further requirements and challenges below [2]

- Rapid deployment: The communications infrastructure needs to be rapidly deployable. As such, it should be self organizing, and discover other nodes and communication opportunities without requiring manual intervention. This requires the capability to correctly infer the current context, determine the best sequence of actions, and then react accordingly.

- Adaptable: Network and communication characteristics can vary considerably over the course of the disaster relief operation, and thus cannot be pre-determined. This includes characteristics such as the network topology, type and size of exchanged traffic, as well as changing application service requirements, e.g., the type of data collected can range from aggregate statistics on casualty numbers, to images/video content of a specific site. This necessitates that the communication infrastructure be flexible enough to accommodate these changing requirements without sacrificing system performance or hindering other operational aspects of the network.

- Resilient and Robust: The communication infrastructure needs to be resilient and robust. This is challenging as nodes can be highly mobile, resulting in frequent disconnections and link failures. An end-to-end connection may never exist between pairs of nodes wishing to share information. This imposes challenges on both the communication protocols as well as the communications infrastructure. The communication protocols need to be designed such that they are disruption-tolerant. Similarly, the communications infrastructure needs to be modified to enable a store-and forward approach, whenever disconnections are encountered.

- Incrementally Deployable: Any feasible replacement for the current generation of disaster response communication systems must be incrementally deployable, so as not to require a complete overhauling of the existing infrastructure. It must also be backwards compatible, where new users can benefit from using the information sharing network, while also having the ability to communicate with legacy radio systems.

- Power conservation: End user devices must be small and portable, limiting their battery size. Power conservation is an important issue as teams of first responders may remain deployed at forward bases for days, or even weeks.

- Security and privacy requirements: Depending on application requirements, network security and data privacy requirements can vary significantly as well. e.g., when the network is used primarily for facilitating exchange of statistical information, data confidentiality (or anonymity) might not be particularly required, though maintaining data integrity might still be important. However, if the network is used to transmit medical files for patients undergoing treatment, then user authentication and end to- end data confidentiality may be needed, as per governmental regulations (e.g., HIPAA requirements for security and privacy of health data in the U.S. **Error! Reference source not found.**). Balancing these security issues against the requirements for timely and efficient exchange of information in life-and-death situations involves both policy and technical issues that need to be understood.

III. AD-HOC NETWORKING IN MILITARY USE

Ad-hoc networking is an enabling technology relevant to vast number scenarios. It can be a fundamental key model for future networking of the armed force in both war and peace keeping operations. The military aspects in a mobile ad hoc network are especially interesting and a bit complicated. In a military scenario with a hostile environment where more things need to consider and also it are harder constraints than in a MANET for educational or business purposes. For example, a military scenario may have higher requirements regarding the information security.

Network requirement

Military networks are probably the most difficult ad hoc network to handle when it comes to mobility management and mobile communication. There are a number of things to take into concern as shown by Hannu H. Kari in [1]

- Hostile enemy – If the enemy can get the communication in the network to stop function properly or be able to tamper with the messages, the enemy can get great advantages.

- Trust models – How to deal with the level of trust and compromised nodes.

- Quality of service control – Not all nodes and packets are equal.

- Radio power usage restrictions – Battery, reveal location, time and importance of the node.
- The need for robustness – Fault resilience, redundant routes, automatic repair after failure.
- The need for performance

Military application

For military application, the first question comes to mind is that, can mobile ad-hoc network being a reliable group communication in a military operation? To find the solution Thales Research and Technology presented a number of applications of ad-hoc networking in 2004 [2]. So, according to the research the different types of applications of MANET can be used in military operation are as follows [2]:

Unmanned vehicles

Unmanned vehicles are set to play an increasing role in the future armed force's operational missions. They can be used as individual platforms for surveillance or other purpose.

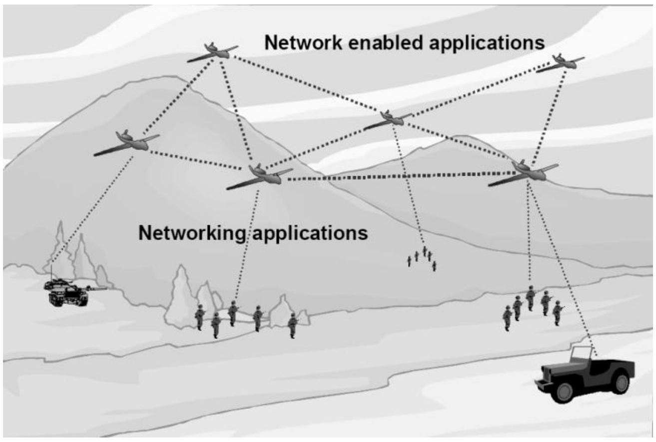

Fig. 2. Unmanned vehicles

Fig. 2 shows an example of unmanned vehicles application where a group of unmanned air vehicles (UAV) is deployed in a battle field. There are two types of applications supported by this network. Those are described below.

- Networking applications: The ad-hoc network shaped by the UAV in the sky can offer a backbone for land based stages to communicate when they are out of direct range or when obstacles prevent direct communication. The ad-hoc network therefore extends down to the land based forces and allows communication across battlefield.
- Network enabled application: the ad-hoc network also allows network enabled applications to run on the UAVs. For example, they may be able to enhance their performance by collaborating with each other over the network, for navigation, surveillance or combat purposes.

Sensor networks

Sensor networks produce a system which is more capable than the sum of its parts. There are three types of sensors are deployed in fig. 3 [2] are described below.

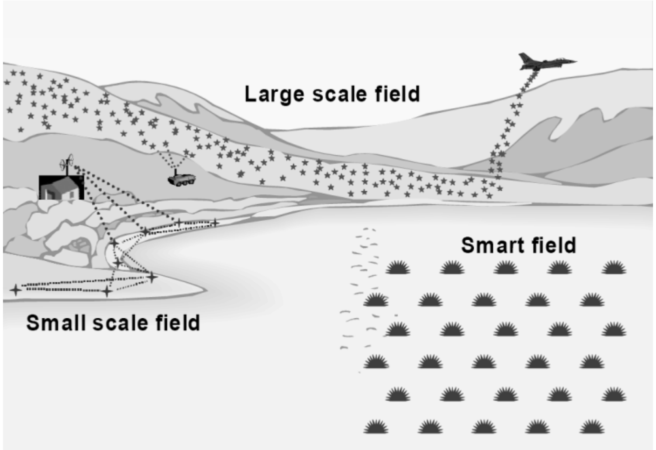

Fig. 3. Sensor networks

- Small scale fields: small scale sensor fields are deployed in strategic places. They would traditionally be individually configured and connected to a central controller. Ad-hoc technologies can simplicity the deployment load by removing the entire network configuration. The sensors only need to be positioned so that they are in range as shown in fig. 3.
- Large Scale fields: large scale fields are shown in fig. 3 as being deployed from a plane, scattering the sensors over an area of interest below. The main characteristic of this sensor is the large number of sensors deployed, making any form of manual or individual configuration not feasible. Using ad-hoc network in this scenario allows the sensors to form a network among them where they land. The field will be linked, agree to sensing data to be composed from all parts of the network by a passing vehicle.

Mobile communication

Armed forces deployed in offensive or peace keeping operations need to communicate on the move, whether between vehicles or between dismounted troops. Fig. 4 shows a convoy on the left and a dismounted section on the right.

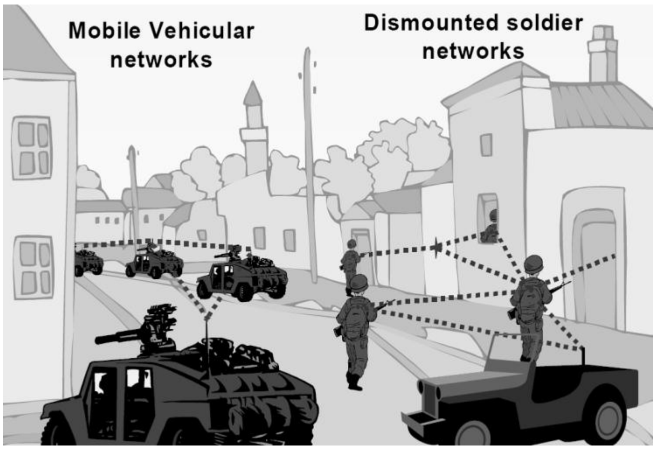

Fig. 4. Mobile Communication

There are two types of network in this system which is given bellow.

- Mobile vehicular network: on the move all the vehicles need to communicate frequently. In order to achieve all vehicles in a line the radio technology is required to have a range capable to cover the extent of the vehicle formation. Ad-hoc technologies calm down this constraint, by only requiring each vehicle to be in range of its nearby neighbors. The suitable neighbor will forward any data which is designed for a further distant vehicle. As the vehicle travel, the connectivity between then modify as they come in and out of collection of each other.

- Dismount soldier network: Correspondingly for the dismounted soldier, a dynamic network small range radio is enough to extent the entire section and provides communications beyond the each and every soldiers reach. A further feature for this is the exploit of committed relays which a soldier can leave behind him when he moves away from his section. This presents relays which strengthen the networks connectivity if the section is extend or operating in cruel condition such as pretending deep into a building.

IV. VANET APPLICATIONS

Automobile traffic is a key trouble in modern cities. Daily millions of hours and gallons of fuel are dissipated all over the world only by vehicles trapped in traffic jam. There was a study in 2005 by the Texas Transportation Institute (TTI) [4]. According to the 2005 Urban Mobility Report, traffic congestion is growing across the nation, costing Americans $63.1 billion a year. The report measured traffic congestion trends from 1982 to 2003. A system that could deliver an accurate map of traffic to drivers in real time could save huge amounts of money. If such a system could be deployed cheaply it would be very profitable and decrease the environmental impact of automobile traffic. For this reason there is a growing commercial and research interest in the development and deployment of Vehicular Ad-Hoc Network (VANET).

VANET is a special case of Mobile Ad-Hoc Network (MANET). It consists of a number of vehicles traveling on urban streets and capable of communicating with each other without a fixed communication infrastructure. VANET is expected to be of great benefit for safety applications, gathering and disseminating real-time traffic congestion and routing information, sharing of wireless channel for mobile applications etc.

Factors influence mobility in VANET:

The mobility pattern of nodes in a VANET influences the route discovery, maintenance, reconstruction, consistency. A VANET can have both static (non-moving) and dynamic (moving) nodes at any instance. The static nodes tend to dampen the changes in topology and routing by acting as stable relaying points for packets to/from the neighboring nodes. On the other hand, dynamic nodes add entropy to the system and cause frequent route setups, teardowns, and packet losses. The effects of various factors that influence the mobility pattern in VANET [6] are as follows:

- Layout of streets: Streets force nodes to confine their movements to well defined paths. The layout of the streets might be such that vehicles travel on parallel streets spaced far apart might be out of communication range. Streets can have either single or multiple lanes and can agree to either one way or two way traffic.

- The Block size: Urban areas are normally alienated into blocks of different sizes. A city block can be considered the nominal area surrounded by streets. These blocks can be of different sizes. Metropolitan areas generally have smaller city blocks than smaller towns. The block size states the density of the intersections in that particular area, which in revolve determines the frequency with which a vehicle bring to an ends. It also decides whether nodes at neighboring intersections can listen to each other's radio transmissions. Bigger blocks would enlarge the network's sensitivity to vehicles clustering at intersections and to network partitioning, and result in a mortified performance.

- Traffic control mechanisms: The most common traffic control mechanisms at intersections are stop signs and traffic lights. A vehicle requires stop at a red light until it turns green. A vehicle also needs to stop at a stop sign for a few seconds before moving onward. These mechanisms cause the formation of clusters and queues of vehicles at intersections, consequently reducing their average speed. Reduced mobility implies more static nodes and slower rates of route changes in the network. Alternatively, cluster arrangement can also adversely influence network performance with increased wireless channel argument and rise network partitioning.

- Interdependent vehicular motion: Vehicles cannot disregard physical constraints posed by the presence of streets and nearby vehicles. Every vehicle's movement is influenced by the movement pattern of its surrounding vehicles. For example, a vehicle needs to maintain a minimum safe distance from the one in front of it, increase or decrease its speed, or change to another lane to avoid congestion.

- Average speed: The speed of the vehicle determines how quickly its position changes, which in turn determines the rate of network topology change. The speed limit of each road determines the average speed of vehicles and how often the existing routes are broken or new routes are established. Additionally, vehicles' acceleration / deceleration and the map's topology also affect their average speed - if a map has fewer intersections, it implies that its roads are longer, allowing vehicles to move at higher speeds for longer periods of time.

VANET system design

VANET is designed to be a useful system to drivers. In this system design the driver can not only exchange information on every section of road but also it can exchange information between the vehicles on areas of unexpected traffic.

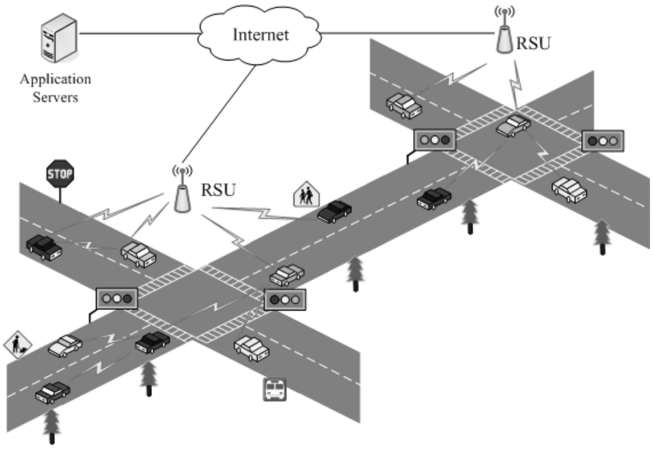

Fig. 5. An example of VANET architecture

Fig. 5 defines a simple VANET architecture. Vehicular Ad-hoc Networks (VANET) can be built by equipping vehicles with onboard sensing devices. Every corner of streets there is a RSU (road side unit) which contains all the information about traffic sign and different stop signals. Each vehicle is connected with RSU and as well as with the other vehicle which are within the communication range. In the system design of VANET there are some key factors [7] **Error! Reference source not found.**need to be considered those are as follows:

- Posted speed limit: The first factor is then posted speed limit. One needs to communicate any information if any vehicle is traveling above the posted speed limit. Drivers do not need be noticed if the road is clear. They can only communicate if the traffic is busy.

- Expected speed: It is possible to extend the idea of expected speed beyond the posted speed limit. Traffic congestion has very predictable trends which can be exploited. For example, major commuter routes will be slow during rush hour. If this information is available to all of the nodes of the network then each node only needs to communicate when the recorded speed is outside the variance of expected speed. This would reduce the communication significantly without any difference in information available to the end user.

- System adoption: This system does not expect that all drivers adopt it. In fact it can be designed to work with only a small fraction of total drivers participating in the network. While it might be desirable that all cars use VANET it is highly unlikely that will happen in the near future. It is far more acceptable that drivers from higher economic classes and professional drivers will be the first adopters.

- Serendipitous exchange: In the system each vehicle collects, stores and exchanges all traffic information that is made available to it. The nodes in the network do not differentiate between information that might be useful to the driver and information that will be of little use to the driver. By cooperating nodes will construct a more exact global model of the road network. While information held by one vehicle of may be of no use to that car, it may serendipitously exchange that information to another car that values that information.

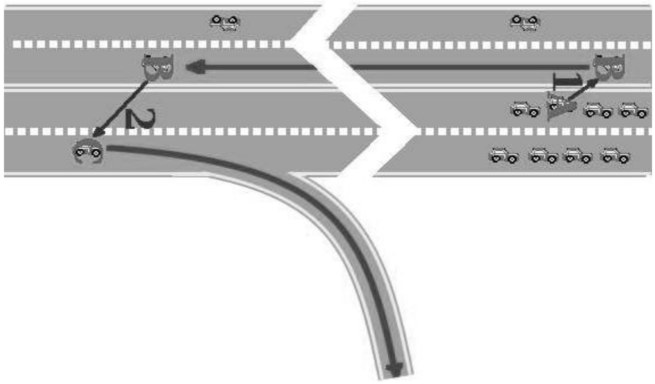

Fig. 6. An example of Serendipitous Exchange

An example for this system of information exchange is shown in fig. 6. Car A is trapped in traffic and drives a message to car B. That information is of little value to car B since the congestion is on the other side of the road. However a little downs the road B relays the information to car C. With that new information car C leaves the road for a better route.

V. CELLULAR AD-HOC NETWORKS

Cellular ad hoc networks are self-organizing multi-hop networks with multiple access points that are connected with a broadband core network. The difference of a cellular ad hoc network from an isolated ad hoc network is that most of the traffic in the cellular ad hoc network is to/from access points. After the standardization of the 3G (3rd generation) systems lMT-2000/UMTS, researchers are beginning to develop concepts and technologies for wireless beyond 3G systems. Higher transmission rate and lower system cost are regarded as the key requirements of the beyond 3G systems. A new air interface concept to form a W-CHAMl3 network that is suited for the wireless multimedia communications beyond 3G is presented in [8]. Its main features are self-organizing, multi-hop transmission and QoS (Quality of Service) guarantee. As major applications of beyond 3G systems will require a transmission rate 10 times higher than that of 3G, the beyond 3G systems must use frequency bands over 3GHz in the view of availability and feasibility of frequency spectrum to support high rate services. The respective frequencies have very limited ability to penetrate obstructions and have very irregular propagation characteristics *so* that frequency planning is very difficult there. In addition, higher transmission rates and higher frequency bands result in a very limited communication range and irregular radio coverage. Two approaches might be used to achieve reasonable radio coverage. One is to increase the number of base stations and the output poker. This method might increase the system cost significantly. The other one uses cellular ad hoc networks with multi-hop transmissions to extend the radio coverage and realize a cost-effective solution.

VI. OTHER APPLICATIONS

One of many possible uses of mobile ad-hoc networks is in some business environments, where the need for collaborative computing might be more important outside the office environment than inside, such as in a business meeting outside the office to brief clients on a given assignment. Wireless ad-hoc network is also very effective in class room where students and teachers can communicate with each other without involving the main network. Fig. 7 shows a wireless ad-hoc networking in a class room. In this environment students can download desired content, review lecture notes and begin their work on assignment.

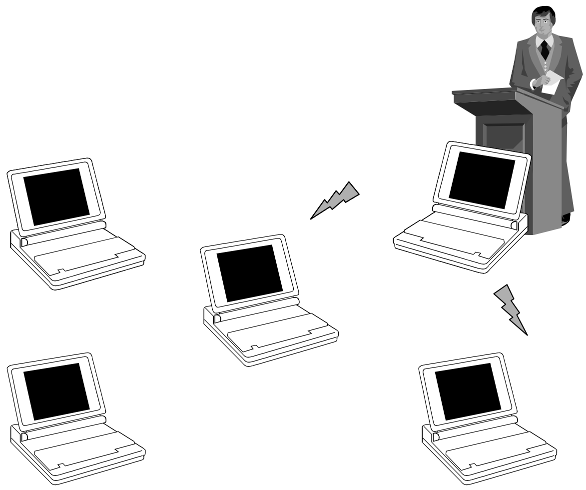

Fig. 7. Wireless ad-hoc networking in class room

A commercial application, such as Bluetooth, is one of the recent developments utilizing the concept of mobile ad-hoc networking. Bluetooth was first introduced in 1998. Bluetooth uses radio waves to transmit wireless data over short distances. It can support many users in any environment. Eight devices can communicate with each other in a small network known as Pico-net. At one time, ten of these Pico-nets can coexist in the same coverage range of the Bluetooth radio. A Bluetooth device can act both as a client and a server. A connection must be established to exchange data between any two Bluetooth devices. In order to establish a connection a device must request a connection with the other device.

Bluetooth was based on the idea of advancing wireless interactions with various electronic devices. Devices like mobile phones, personal digital assistants, and laptops with the right chips could all communicate wirelessly with each other. However, later it was realized that a lot more is possible. At present, Bluetooth technology is in used in a variety of different places. Not long ago, in May 2004, a service knows as BEDD was launched in Singapore **Error! Reference source not found.**. BEDD uses Bluetooth wireless communications to scan strangers' phones for their personal profiles. Once the software is downloaded into a compatible phone, it automatically starts searches for and exchanges profiles with other phones that come within a 20-meter radius.

Underwater Networking is also an important application of wireless ad-hoc networking. The main goal of underwater ad-hoc networking is to allow divers/sensors to know where other divers/sensors, dive vessel are located, providing the ability for short communications between all the equipments, informing others if any emergency situation occurs. Fig. 8 shows an example of underwater ad-hoc networking.

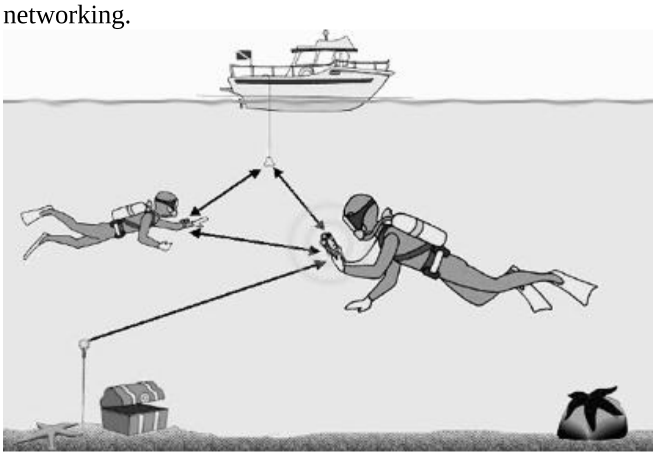

Fig. 8. Underwater Ad-hoc Networking

VII. CONCLUDING REMARKS

In conclusion, wireless ad-hoc networks allow the construction of flexible and adaptive networks with no fixed infrastructure. These networks are expected to play an important role in the future wireless generation. Future wireless technology will require highly-adaptive mobile networking technology to effectively manage multi-hop ad-hoc network clusters, which will not only operate autonomously but also will be able to attach at some point to the fixed networks. To meet the need of a member of ad-hoc group to access the global internet or to be reached over the global Internet, various ad-hoc gateways can be used to integrate ad-hoc networks with the global Internet. In cellular ad-hoc networks can improve the system performance as the bottleneck effect in the AP (Access Point) is reduced because of the reduced interference. The radio coverage of APs can be enlarged using multi-hop transmissions without the need of increasing transmission power so that the system cost can keep very low. The organization remains simple by limitation of the transmission hops. Frequency planning that is very difficult in the frequency range above 3G Hz can be avoided by self-organization of APs and mobile nodes. Cellular ad hoc networks seem to be a promising solution for broadband wireless access networks in beyond 3G systems.

The goal of this paper was to provide insight into the understanding of ad-hoc networking aspects and its applications based on different scenarios in a wireless environment. This was not geared toward any system in particular. No system specific protocols, parameters or standard were discussed in this work. Wireless systems engineers, in their research of wireless data communication, can use this paper as a tool for understanding the application of ad-hoc networking.

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