Overview of different wireless networking technologies

Overview of different NMS

WIRELESS NETWORKING TECHNOLOGIES

Various wireless technologies are under evaluation or are already in use by operational forces. Among these technologies are: WLAN, WiMAX, cellular-based, satellite-based, and MANET. Previous research provided an analysis of the qualities of many of these various technologies based on their ability to support ECO (McHuen and Price, 2009). Each of these technologies has unique features that allow it to fill a particular niche and each has shortcomings that require the incorporation of other technologies into the network. Because this differentiation is likely to continue, the network management system design must include the basic elements incorporated into any tactical wireless technology.

1. WiMAX

The Institute of Electric and Electrical Engineers (IEEE) 802. 16 standard defines the standards for Worldwide Interoperability for Microwave Access (WiMAX) (IEEE, 2004). WiMAX provides point to multipoint, broadband communications to areas not connected by fiber optic or copper cabling. WiMAX is capable of providing throughputs of up to 70 megabits per second and has a range of approximately 50 kilometers. WiMAX uses a multicarrier modulation scheme known as Orthogonal Frequency Division Multiplexing (OFDM). A limitation of WiMAX is that OFDM is sensitive to multipath and Doppler effects that occur in rapidly changing RF environments such as with mobile users (Fuller, 2008).

2. WLAN

The IEEE 802. 11 series defines the wireless local area network (WLAN) standards (IEEE, 2007). The most common of these standards in use today will include 802. 11g and 802. 11n. A WLAN can typically provide throughputs of 54 megabits per second and a range of 100 meters without the need for copper cabling. Most WLAN 31 implementations have the advantage of a fixed access point in order compensate for some of the effects of changing RF conditions; however, a truly mobile ad hoc network must support mobility without being tethered to a fixed infrastructure.

3. Satellite-Based Systems

Satellite-based solutions provide beyond line of sight connectivity, but the availability of satellite channels is limited for tactical users. The existing military satellite system known as the UHF Follow-on system (UFO) only provides capacity for 600 concurrent users. DoD users also have commercial services such as Iridium to fill this access gap. That is no panacea, however, since commercial satellite services may not be available when DoD needs them most (Rosenberg, 2010), and it is cost prohibitive to use satellite connectivity exclusively (U. S. Navy To Rely on Netted Iridium Service as Gap-Filler, 2010). The long-term solution in lieu of commercial satellites systems is the Mobile User Objective System (MUOS) that provides cutting edge technology based on commercial 3G cellular phone services. MUOS offers both voice and data in a converged, handheld device. However, the MUOS program has experienced several technical problems that delayed the launch of its first satellite, and there are other issues with the development of the MUOS handsets (Iannotta, 2009). It is likely to be several years before

the capabilities offered by MUOS are available to the majority of DoD’s tactical forces.

4. Commercial Cellular

The use of commercial cellular technologies on the battlefield has gained significant attention because senior military leaders recognize the potential benefits of putting these devices in the hands of a generation of soldiers and marines that have grown up using this technology. The basic requirements of any cellular network are the handsets and the cellular base stations that are typically associated with towers to increase network coverage. Current capabilities of the tactical cellular network provide throughputs of 1. 8 megabits per second while ranges are dependent on the height of the mobile cellular tower placed on a tactical vehicle such as Mine Resistant Ambush 32 Protected (MRAP) vehicle (Lowler, 2009). The current tactical cellular solution is best suited for special operations soldiers who operate in small groups. This network requires a tethered aerostat or a circling aircraft equipped with a cellular base station in order to relay the communications. Other architectural designs have focused on integrating the cellular handsets with tactical radios filling the role of the base station (Tuttle, 2010). That used the cellular handset essentially as an external computer in order to host command and control (C2) and situational awareness (SA) applications in this case. A more efficient architectural design entails developing the tactical radios to host the C2 and SA applications internally, thus eliminating the need for an external computer worn or carried by soldiers (“ New Military Radio Unveiled,” 2011). C.

MANET SYSTEMS

MANET technologies are highly desirable in tactical environments because each node in the network is able to communicate with all other neighboring devices over one or more hops in order to extend connectivity to areas where a fixed infrastructure is not available. There are many factors that influence the performance and reliability of a MANET. Communications links within the MANET are continuously fluctuating due to the location of devices, power, or environmental factors. MANET technologies are valuable for enhancing command and control because they provide network connectivity beyond line of sight and in harsh environments where this previously was not possible. A tactical MANET provides considerable flexibility through its rapid deploy-ability to provide a wireless voice and data network without any fixed infrastructure. The general characteristics for a tactical MANET include attributes such as rapid deploy-ability, ease of use, mobility, and flexibility. These features make it very suitable for military applications in environments where setting up fixed infrastructure may not be feasible or practical. The MANET nodes also allow transmission of position location information (PLI) in real-time to increase situational awareness at the company level.

History of Wireless Networks

A wireless network consists of many types (GSM, Wi-Fi, UMTS, and WiMAX)11]. Wi-Fi technology is used in indoor environment because as for considering its accessibility and cost which is very low. Wi-Fi has its specific range in which its calculation can be made. The main goal of the project is indoor positioning system with accuracy to locate an object or target in a

room and the identifying rate must be fast that can be deployed considering real time constraints [HYPERLINK l “ FLa06” 12]. More accurate location can be achieved for mobile clients or users which are based on GSM network13]. GSM gives birth to three methods that are positioning by a cell, calculating the distance accordingly to signal strengths SS and based on time difference distance computation [HYPERLINK l “ Eve07” 14]. Positioning by a cell is located simply by using a Base Transceiver Station (BTS) it has a specific area in omnidirectional. A mobile connected to a BTS can be easily located as a BTS has its specific range (from100m to several Km) depending upon the size of the cell in which a target is located. The direction of the target is or mobile user is achieved by sect oral antenna. Positioning can also be measured by the signal strength SS, the distance between the Transmitter and Receiver is calculated through BTS. The method adopted for it is trilateration which identifies the position of a mobile phone. The accuracy obtained between the range of 50 o 500 m having great amount of errors due to structure of buildings and obstacles present there. Enhanced Observed Time Difference (EOTD) is the estimation method in which the time is noticed as it reaches from the mobile station towards the BTS. This is called timing in advance and requires the synchronization between the mobile phone and BTS. Distance is calculated by the time difference on EOTD. After that by trilateration which identifies the position of mobile phone.

These methods are not used in Wi-Fi indoor environment because of Wi-Fi limitation and short range and inside the building the signal strength SS, is weak as compared to outdoor environment15]. Accuracy and Precision are

the required main factors in indoor localization, weak signals degrade the accuracy of positioning [“ Ing06” 16]17]. Indoor positioning detection is achieved by using Wi-Fi signal strength (SS), and formulae to locate user’s position. Wi-Fi signals are of radio waves where movements of signals are dependent upon frequency [“ Mah12” 18]. Signals are transmitted by Access Point’s (APs) in all directions regarding their signal strengths. Wireless router can cover an area of about 100 feet i. e. (30. 5 m). Recent research work shows that received signal strength indicator (RSSI) localization of an object or target is achieved quite accurately. RSSI is measured in dBm. From different APs the RSSI values are observed on the basis of these values of RSSI the location can be observed between the Transmitting AP and the Receiving node. Mathematically RSSI is ten times logarithmic ratio of received power signal and reference power (i. e. 1mW)19] which has an equation of

$RSSI \alpha 10 \log P / P_{ref}$ (2. 1)

Power is dissipated from a source point by moving further, the relation between distance and power (P) is inversely proportional to square of distance (S) travelled. Mathematically

$RSSI \alpha \log (1/ S^{2})$ (2. 2)

The attraction of RSSI is that calculation and measurements are almost very simple and less time consuming rather than using other methods.

Problems and Degradation of Signal Strength

Indoor environment faces a lot of problems due to which weakness in the strength of the signal occurs due to path loss as it becomes weaker as the distance increases from the origin. Different barriers occur in the direction of signals such as sun or rain drops also effect the strength of the signal, even it occurs very rarely but it has its influence with signals, the structure of the building which have many walls, doors, windows, glass, concrete, shelf's and penetration from the floors, the result is in the form of attenuation. Interference is another problem with other wireless station with in an office or a building.

Signal Attenuation in Static Environment

When Electromagnetic waves strike with a wall or any other barrier as it passes through, Thus the wave becomes further weaker because of reflection that starts when it strikes the barrier. Another main factor is absorption which is converted in the form of heat and its impact is very small that it cannot be noticed by human. Loss is related to the size of material, focusing on its thickness, attenuation effect of glass is higher than brick walls. These factors have a critical impact especially by using the methods to measure distances by measuring the signal strengths.

Attenuation in Signals By User's

By experiments it is concluded that with the presence of users the signal strength is changed. The signal strength is thus weakening due to the human's in an environment. The radiations are partially absorbed as human body contains water in their bodies and this attenuation occurs in the signal

strengths. Location of a mobile device with signal strength map relates measurements with a SS map. Two approaches are for measurement matching either Deterministic or by Probabilistic.

Map-based systems are identified by signal strengths SS, in two steps i. e. (Offline step and Online step). The Offline step creates a map of signal strength. The Online step relates with the signal strength maps previously built. For both of steps, two approaches exists Offline step is achieved through measurements or with simulation. The Online approach consists of matching measurements of the signal strength SS, with the map content which was as above said that matching can be achieved either by Deterministic or probabilistic. But creating the signal strength map with simulation requires a great work for building a propagation model that computes signal strength map. Focusing on study that is simulating the signal propagation for creating signal strength map that relies on propagating based positioning techniques, but there is a difference among both systems. Positioning system using propagation based technique does not know mobile’s location; therefore it does not look into having obstacles between mobile and transmitters.

On the other hand signal strength mapping are associated with SS values for knowing its geographical coordinates. It has the ability for looking in the obstacles in models such as Motley-Kennan. With the availability of SS map, positioning mobile is built by the content of the map with signal measurements which are provided by mobile or architecture of wireless network that matching may be Deterministic or by Probabilistic approach.

Deterministic matching is a simple method for mapping SS, which has a database of all access points within its coverage area and having an average value for signal strength for every Access Point (AP). The matching may be at single point or at several points, where the average value of its coordinates are taken. Probabilistic matching is not a simple method as it required greater data for mapping the signal strength. Probability distribution is used to provide signal strength values. Matching is done by probabilistic methods which are based at Gaussian’s model i. e. CMTA.

Other models include Histogram which is done for signal strength distribution. Inconsistency is one of the properties for indoor radio wave propagation. It implies very close values of signal strength for two models in space; description is in two geographical points are opposite and very far from each other. Paramvir Bahl proposed an idea for enhancing positioning estimation considering the previous locations for eliminating the ambiguities in location which relies on Viterbi-like algorithm.

Positioning is a main factor in deploying a Wireless Local Area Network. The other hardware or technologies which are used for localization are Active Badge System which works on Infrared sensors detectors that are used to detect the signal’s from Mobile Stations (MS) Active Badge; the central unit processes the data and determine location of mobile stations. But the main drawback of infrared signals is due to its short range and interference from fluorescent light in indoor environment and from sunlight. Cricket system uses RF receivers and ultrasound to get information about time of flight and works on Multilateration for estimating location. Radio Frequency Identification (RFID) based technologies systems (i. e. SPOTON) and

LANDMARC systems are also studied. Other hybrid systems like Zigbee radios are proximity sensors, which improves accuracy in positioning system that are WLAN-based.