Original Research Paper Engineering

Implementation of Tactical Networks over Ad-Hoc Network

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ABSTRACT

In the present paperthe goal of theCBMANET program was to develop an adaptive networking capability that dramatically improved performance and reduced communication failures in complex communication networks.CBMANET was evaluated as not usable in supporting the tactical network operations infuture IT mobile services with its current coding, but it still can be useful in mobilenetworks that are not transferring time critical information. CBMANET remains apromising technology in the area of MANET improvements. Thenature of MANET, such as node mobility, unreliable transmission medium and restrictedbattery power, makes it more challenging for them to deliver the information war fightersneed on tactical missions.

KEYWORDS Manet, Tactical networks,CBMANET,Adhoc network.

Introduction

The past decades have witnessed advances in computing and communication technologies. Faster, smaller and more reliable devices enable communications with rapid, efficient information dissemination between mobile. Due to the harsh nature of the tactical environment (e.g., weather and terrain features), tactical networking challenges include low *bandwidth*, very high *latency,* and poor reliability. The Mobile Ad hoc Networks' (MANET) flexibility makes it an attractive *networking* option for tactical operations. Mobile ad hoc networks have several advantages over traditional wireless networks. These advantages are on demand setup, faulttolerance, node's increased mobility, self-organizing connectivity, adaptive, scalable ad hoc network routing. Today's tactical networks are a complex network centric system, where sensor systems, unmanned vehicle systems, and distributed systems of mobile units, transfer and analyze data while they are moving . Tactical wireless networks should provide reliable, survivable, secure and seamless communications capabilities to the tactical edge. A tactical wireless network of ten experiences connectivity problems for a variety of reasons including limited or no fixed network infrastructure, dynamically maneuvering units, challenging transmission conditions, and faulty network and collaboration schemes .

Tactical wireless networks perform significantly below the levels of connectivity, latency, and throughput that are achievable on a wired network. Tactical networks must comply with the anticipated characteristics associated with Command and Control (C2) applications in order to meet the required current and future information needs of the war fighter. Also, C2 applications should be developed comparable to the tactical network on which they effectively operate. Figure 1. shows the three problems MANET suffers from: the unsuitability of ISO-layered modularization; high protocol overhead; and the absence of adaptive cross-layer network resource allocation.

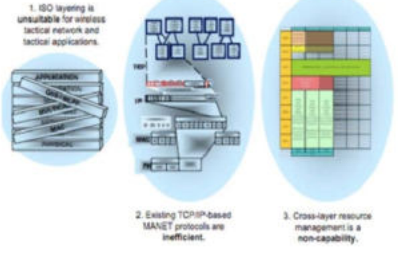

Figure 1. Challenges of MANET

Theoretical considerations

"Control-Based" is used to describe a potential for improving the performance ofMANET system architecture using distributed adaptive control mechanisms. While flexibility makes MANET an attractive networking option for tactical operations, classic networking approaches adapt poorly to the rapid network changes inherent in a battlespace environment and achieve only a fraction of the potential performance. The objective ofCBMANET contract is to research, design, develop, and evaluate a new protocol stack for MANET . Thecomplexity of this high-dimensional, adaptive, constrained, distributed networkconfiguration problem is overwhelming to human operators and designers, andhas root causes in the historically wire-line-oriented networking paradigms .Another prime objective of the CBMANET program has been to capitalize on recent theoretical advances in distributed adaptive network control to solve thedistributed resource allocation problem in tactical MANET.

There has beenimpressive growth in the field of wireless networking in the past two decades. Awireless network is a network that connects communication technologies byusing

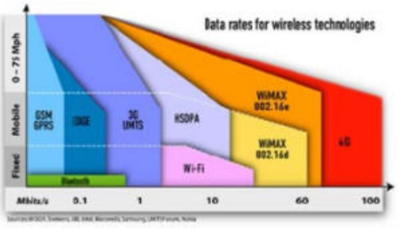

Fig 2: Data rates for wireless technologies

electromagnetic radiation to move data from one node to another. Avariety of devices and services use different methods to accomplish informationsharing among wireless networks by using radio signals. Each service has adifferent set of features, and each uses a slightly different technology. The fourmost widely used wireless technologies are Wi-Fi, WiMAX, and 3G and emerging4G cellular services. The data rates for wireless technologies and the speedcan be seen in Figure 2. Whereby 4G and WiMAX have the fastest speed.

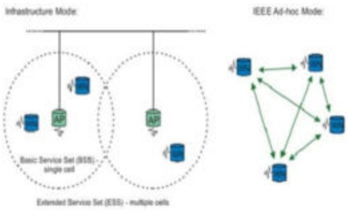

Fig 3: Infrastructure and Ad Hoc Mode of IEEE 802.11

Wi-Fi is often used in point-to-multipoint (PMP) environments to allowextended network connectivity (e.g., private/backbone network, Internet) ofmultiple

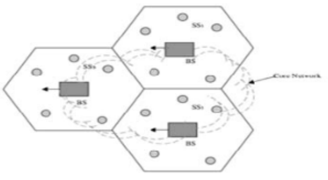

Figure 4.A Typical IEEE 802.16

Network portable devices such as laptops, PDAs, handhelds, and mobile cellularphones. Wi-Fi also allows point-to-point (P2P) connectivity, which enablesdevices to directly connect and communicate to each other. The IEEE 802.11standard defines two modes, namely Infrastructure mode and Ad-hoc mode which are depicted in Figure 3.A typical IEEE 802.16 Network is shown in Figure4.

Results

The power spectral density of OFDM, multiple carriers dividing the data acrossthe available spectrum, depicted in Figure 5.

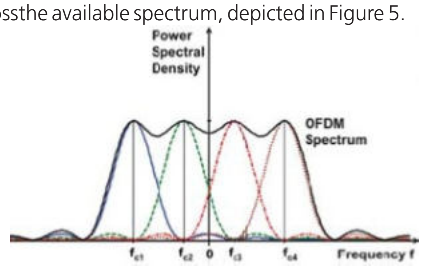

Figure 5. The Power Spectral Density of OFDM

The primary advantage of OFDM is that the multiple carrier wavesoverlap; that provides a very efficient use of the frequency bandwidth by packingmore data into the bandwidth compared to what can be achieved with a singlelarger carrier wave spread across the same spectrum. The other benefits ofOFDM are resiliency to RF interference and lower multi-path distortion. Also,OFDM eliminates crosstalk inbetween the sub-channels. Among others, theIEEE 802.11a and 802.11g Wi-Fi standards use OFDM as well as IEEE 802.16because of the inherent advantages in high-speed communication. The IEEE802.16 network also support mesh topology, where Subscriber Stations (SS) areable to communicate among themselves without the need of a Base Station (BS).CBMANET shows apparent superiority against the baseline model. In these phases, the CBMANET utility only deteriorates slightly, on the other hand, the baseline utility decreases as low as 33 percent and becomes effectively unusable. Figure 6,7and 8 illustrates the total MANET traffic diagram of the ground and air scenarios.

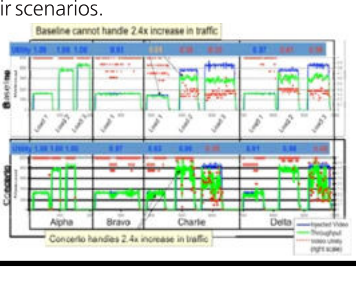

Figure 6. Ground Tactical Scenario

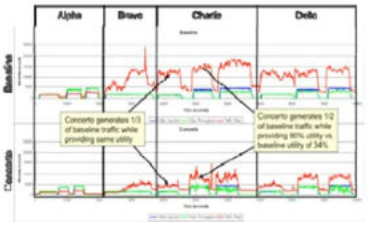

Figure 7. Ground Tactical Scenario enhanced

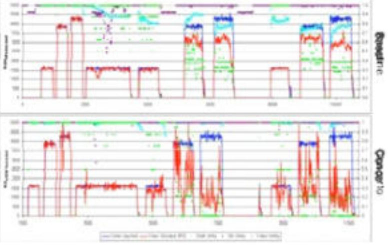

Figure 8. Air Tactical Scenario

Comparing the results it is easy to determine that it has high latency in all situations. When the actual injected video stream rate increases, latency gets higher. Although it has better goodput (i.e., application level throughput), latency can increase up to 10,000 msec.

Conclusions

Battery life in wireless communication systems has been one of the major limitations. Power consumption should be optimized in order to maximize thetotal battery life of mobile ad hoc networks. Minimum energy usage innetworking can effect important benefits (e.g., longer battery life and mitigateinterference) in the digital battlefield, especially in sensor networks. CBMANETshave inherent significant technical challenges because of the many constraintsrelated such as unreliability of wireless links, limited energy consumption anddynamic network topology. This introduces a trade-off between link maintenancein highly unreliable networks and power conservation for users with little batterypower. CBMANET was originally built on quad processor 3.0GHz Pentiums with 16 GBof RAM. The code was nearly unusable on a 750 MHz ARM processor with 256MB of RAM. Those facts imply that the computers in the radios must beupgraded to accommodate CBMANET. The new computers used approximatelytwice as much power as was previously used in battlefield computing devices. CBMANET was successful for non-interactive streaming video (e.g. YouTube); however, this type of transmission has little military utility. The otherapplications tested were chat, FTP, and blue-force tracking. In the tactical operations context, rapid deployment and self-organizationof networks are required. MANETs have the capacity and quality of servicerequired for tactical wireless networks. In terms of network capacity, lifetime, andlatency, MANETs need to be improved. Since network resources of MANET are limited due to

the multiple users sharing the same spectrum, and power resources of mobilenodes is constrained due to the energy-limited batteries, the scalability issue isone of the main research topics in developing MANET routing algorithms. It iswell known that wireless communications consume significant amounts of batteryenergy, and the limited battery lifetime imposes a constraint on networkperformance; therefore, energy efficient operations are critical to prolong thenetwork.

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