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Energy Efficient Approach for Emergency Readiness Communications in Wireless Ad-hoc Networks

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Abstract **Ad-hoc networks may exhibit varying characteristics in different environment, which may make the use of various physical layers, network topologies, and nodal mobility's. Using a simulator it is possible to model and simulate different physical layers, Link / MAC layers, and multi-routing schemes, to compare end-to-end statistics (end-to-end delay, throughput and energy efficiency), and finally to determine the most energy efficient solution. This paper analyzes the energy consumption aspect for emergency Ad-hoc networks. Hence, we propose the energy awareness scheme (Energy Efficient routing- EER) that assimilates the data link layer and physical layer for path loss, fading, ISI (Inter signal interference) at the destination receiver.**

***Index Terms*—— Energy Efficient Routing (EER), E_b/N_o , Fading, Simulation Parameters, Channel Conditions.**

I. Introduction

A wireless ad-hoc network is the collections of autonomous decentralize nodes. It has bandwidth-constrained wireless links and unpredictable network topology. Node itself acts as message transmitting and receiving station through message routing in a decentralized environment. The fluctuations and rapid mobility in forming the network topology is still a current research area. The idea is to find the shortest path in different ad-hoc networks using Dijkstra Shortest Path Algorithm based on given cost function and optimal route. The network should be able to accommodatingly alter routing paths to abate any of the effects such as path loss, fading effects, ISI, etc.

II. ROUTING STRATEGY

We implement Ad-hoc simulation framework approaches for hop-by-hop myopic routing. However, in this [1]simulation we take care of energy efficient routing strategy. In this scenario, path loss, corruption of signals at receiver level due to random attenuation, fading, ISI etc are also taken into account. Assuming buffer size of each node kept as small as possible, while taking care that each node know the identity (an intelligent node) and shortest path to route the information to the destination within the network. The main aim of energy efficient routing is to route a packet on a path that will require the minimum amount of total power consumed and for each node to transmit with just enough power to ensure that the transmission is received with an acceptable bit error rate.

In myopic routing, all nodes only determines the next hop a packet should take toward its final destination. A node must determine which nodes are within its transmission range, and then determine the nearest neighbor who can forward the packet toward the destination. While all nodes within transmission range will receive the packet, only the neighbor node must forward the packet. The selected neighbor is selected according to a given link cost metric.

In Source Routing, entire route of a packet is determined at the source node using the shortest path routing with given link cost metrics. A periodically updated table stores the routes to reach each destination. Myopic routing is a reactive, hop-by-hop routing scheme, while source routing is a proactive, end- to-end routing approach. It is interesting to study how these routing schemes will behave in our global framework and to compare their performances via different metrics. With the framework provided, it will be easy to define and test different link cost models for both approaches.

III. SIMULATION ENVIORNMENT

In this section we present the general framework developed to simulate a MANET environment. As no final standards have been chosen for the different MANET layers, this framework provides a convenient method to test and compare different layer choices.

A. Network Model

The network comprises N mobile nodes, named 0,…, N-1, which communicate over wireless links. For simplicity and to guarantee a reliable radio channel during the movement of the nodes, the topology is chosen such that nodes reside on one of three levels.

The topology is simple: 3 levels (y = 1, 3, and 5). The nodes of different level can move on straight lines (y = 1, 3 and 5 for x [0, 7]).

A variation of the moving speed implies a variation of the network topology and allows us to measure the mobility of the network. Figure 1 represents the network model.

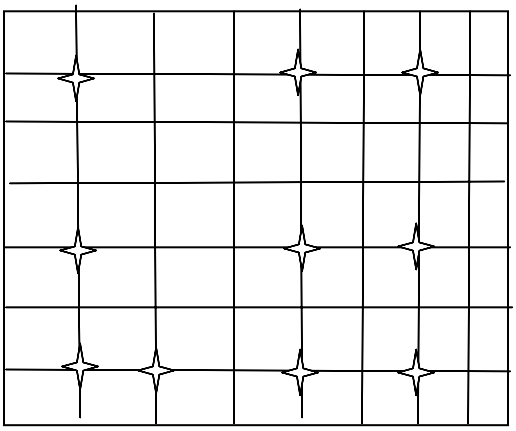

Fig 1. Network model with unit scale in kilometers the transmission range is chosen and depends on the network topology.

B. Node Model

Each of the 10 nodes has the structure given in Figure 2 and is uniquely identified by its user ID.

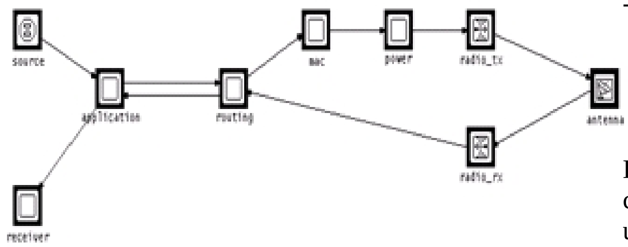

Fig 2. Mobile Node Model

The *source* module generates packets according to an inter-arrival exponential distribution. This inter-arrival time can be chosen during the simulation. The packet size is 100 bits and the packet format has six fields as shown in Figure 3: destination and next node address which contain the destination name and next node name respectively, power field which stores the transmitted power, hop field which memorizes the path of the packet, fading field which depends on the fading factor of the link, and the data field.

Destination	Next node	Power
Hop	Fading	Data

Fig 3. Data Packet Fields

The *application* module sets a random destination address to the incoming packet and measures the number of total packets transmitted.

- The *routing* module executes both routing approaches, myopic and source routing. Various link cost metrics can be tested and compared for both routing approaches.
- The *MAC* module is used to simulate the random access channel protocol. In this simulation, a simple ALOHA has been used. Other MAC layer protocols such as CSMA/CD, 802.11 or FAMA can be tested.
- The *power* module processes the spreading code allocation and estimates an optimum transmission power for each new packet. This module illustrates simulation of the physical layer and is described in more detail in the remainder of the paper.
- The *radio_tx* module sends the packets on the radio channel through the antenna. The modulation is BPSK with spread spectrum.
- The *antenna* module sends and receives packets from the defined channel. The antenna is an isotropic pattern.
- The *radio_rx* module receives packets from the antenna.
- The *receiver* module records various end-to-end statistics and destroys the packets.

IV. Direct-Sequence Spread-Spectrum

Before transmitting a packet, we determine the spreading code of the intended receiver and transmit the packet using this code. Even if the intended node receives a packet, multi-user interference is created on the channel.

This spread-spectrum effect is not simulated in this simple model.

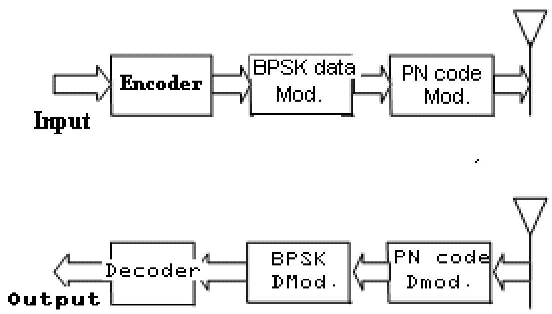

Fig 4. Physical layer scheme

Consider the physical layer design shown in Figure 4. It is important to understand the different pipeline stages of the channel simulation in order to choose a « level » of simulation. Since the default OPNET model does not allow us to simulate the whole modulation process, we have chosen to simulate the channel at the chip level. Consequently, the channel characteristics are set up at the chip level. The chip rate (9.6Gchip/s) is the inverse of the bandwidth, e.g., packet size of 100 bits is equal to 100 K-chips. The processing gain is set to 30 dB. With the characteristics chosen in this manner, the SNR at the receiver is then at the *chip* level. However, the requirements are at the *bit* level for the bit-error rate. Consequently, we must determine how to compute the bit error rate knowing the SNR at the chip level.

According to our model, OPNET provides the SNR at the *chip* error rate: $\frac{E_{ch}}{N_o}$ We have the following relation between the SNR at the chip level and the SNR at the channel level:

$$\frac{E_{ch}}{N_o} * R_{ch} \equiv \frac{E_c}{N_o} * R_c$$

We can say,

$R = \frac{\kappa}{n} * R_c / R_{ch} = G * \frac{\kappa}{n} * R_c$, where G= R_c / R_{ch}

This deduces the desired relation of the SNR at the channel level:

$$\frac{E_c}{N_o} = \frac{E_{ch}}{N_o} * G * \frac{\kappa}{n} \qquad (1)$$

With this relation, it is then possible to use OPNET's modulation table for BPSK to determine the channel bit error probability p_c:

$$P_c = Q^t \sqrt{\frac{2E_c}{N_o}} \qquad (2)$$

Where t is the number of recoverable errors, e.g., t=2 for a (61,53) code.

Implementation

With the aforementioned modifications, it is now possible to pass from the chip SNR to the max BER threshold called "ECC threshold" in OPNET. We modified the BER pipeline stage according to Equation (1) in order to obtain the channel bit error probability as an output. We modified the « dra_ber » pipeline stage file by adding the term *k/n* in the effective SNR. Then we recompiled the new file « ber_bpsk » using the op_mko OPNET command.

The ECC threshold should then be chosen at the channel level, and the computation from equation (2) performed by the user. In this case, the code allows t=2 errors every 63 bits, which means 3% errors at the bit level.

The HF channel is modeled as a tapped delay line, with one tap for each resolvable mode (or path) in time. The delayed signal is modulated in amplitude, and phase, by a complex random tap-gain time-dependent function that is defined by:

$$G_i(t) = G_{ia}(t)\exp\left(j.2\pi.f_{ia}.t\right) + G_{ib}(t)\exp\left(j2\pi.f_{ib}.t\right)$$

Where a and b subscripts denote the i-th element in a time series representation for two magnetoionic path components. In this context, $G_{ia}(t)$ and $G_{ib}(t)$ represents two independent complex bivariate Gaussian ergodic random processes, each with zero mean and independent real and imaginary components with equal RMS values that produce Rayleigh fading. The exponentials provide frequency shifts f_{ia} and f_{ib} for the magnetoionic components in the tap-gain spectrum. Each tap gain has a spectrum $H_i(\lambda)$ that, in general, consists of the sum of two magnetoionic components, each of which is a Gaussian function of frequency, as specified by:

$$H(\lambda) = \frac{1}{\left(A_{ia}.\sqrt{2\pi.\sigma_{ia}}\right)}.\exp\left(\frac{-(\lambda-\lambda_{ia})}{\left(2\sigma_{ia}^2\right)}\right) + \frac{1}{\left(A_{ib}.\sqrt{2\pi.\sigma_{ib}}\right)}.\exp\left(\frac{-(\lambda-\lambda_{ib})}{\left(2\sigma_{ia}^2\right)}\right)$$

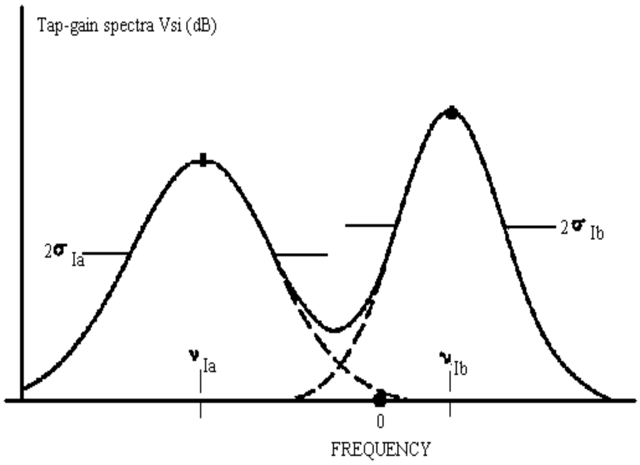

Fig.1 **Tap gain distributions for a two-ray model**

Where A_{ia} and A_{ib} are component attenuations and the frequency spread on each component is determined by $2\sigma_{ia}$ and $2\sigma_{ib}$.The frequency shift on the two components are given by λ_{ia} and λ_{ib}.

The tap gain distributions for two ray model are shown in the figure 1.

According to equation (2), this corresponds to 5% errors at the channel level. Hence, we set the OPNET ECC threshold to 0.05.

This is the solution we use to simulate direct-sequence spread-spectrum at the channel level. In the simulation section, we compare the characteristics of this channel with a channel without direct-sequence spread-spectrum modulation.

V. Fading Simulation

In this section, we present a simple way to simulate a fading effect in a MANET as shown in Figure 5. We assume that each wireless link has the same fading factor for a period seconds, which depends on how fast the fading is changing.
To implement this phenomenon, we define a fading table of size (N*N), where N is the number of nodes in the network. Each entry (i, j) represents the fading factor between node i and node j. In the Initialization State, we compute a random fading factor according to the Rayleigh distribution for each link. The table is updated every seconds by re-computing new fading factors.

For every packet, the "fading field" is set to the value corresponding to the wireless link on which it will be transmitted. We modified the power pipeline stage so that the received power is multiplied by the fading factor retrieved from the packet header. The interval time and the variance of the Rayleigh fading process can be chosen at the beginning of the simulation according to the type of fading to be simulated (slow or fast fading).

Implementation of SNR calculation in C.

```
Float snr(int sum, int sum2, int samples)
{
float mx, mx2, mi2, sx2;
        mx = ((float)sum)/samples;
        mx2=mx*mx;
        mi2=((float)sum2)/samples;
        sx2 = mi2 - mx2;
        return mx2/sx2;

}
```

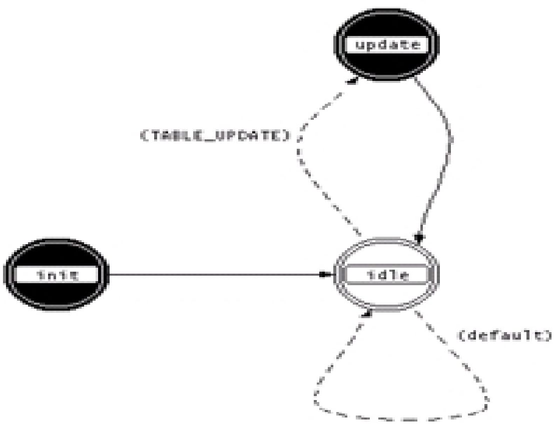

Fig 5. Fading process

VI. Performance Metrics And Simulation Results

In order to evaluate the performance of different routing protocols for MANET, we need to consider different quantitative metrics. Indeed the characteristics of a MANET imply that we have to take into account more factors. In this global simulation framework, we compute the following statistics:

- end -to-end delay
- end-to-end throughput
- efficiency
- mean transmitted power per packet
- mean transmitted power per hop
- number of hops in the packet path
- distance of the packet path
- amount of overhead

Conclusions

In myopic routing, a routing decision is made by each node along a path to the final destination. In contrast, in source routing all routing decisions are made at the source node and the entire path is stored in the header of the packet. The type of routing that is more suitable for a given network depends on the dynamic network conditions.
It is possible to design different physical layers, MAC layers, and routing schemes, to compare end-to-end statistics (end-to-end delay, throughput and power consumption), and finally to determine the most efficient solution.

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BIOGRAPHIES

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