Minimization of Power Consumption in Mobile Ad hoc Networks

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Abstract: In ad hoc mobile wireless networks, power consumption is an important issue. As most mobile hosts operates on limited battery resource. In this paper we discuss about the power consumption which can achieved by modification of cryptographic/compression algorithms, minimizing link failures, and implementing power control algorithms. The Cryptographic / Compression algorithms consume a significant amount of computing resources such as CPU time, memory, and battery power. CPU and memory usability are increasing with a suitable rates, but battery technology is increasing at slower rate. The problem of the slower increasing battery technology forms "battery gap". The design of efficient secure protocols for wireless devices from the view of battery consumption needs to understand how encryption techniques affect the consumption of battery power with and without data transmission. Also, the link failures play a vital role in consumption of power due to high mobility of nodes. To reduce the power consumption, link failure reduction algorithms with different characteristics that reduce the link failures when nodes move fast. New performance criteria may be used to route stability despite mobility, energy consumption and many attacks in routing due to link failure.

Finally, the power consumption algorithms which have constant power drain due to the transmitter and receiver constantly, hears for signals by it. In sleep mode power consumption will use different techniques like minimizing radio power consumption, IEEE 802.11 network card.

In this paper we have proposed the data compression technique to achieve less power consumption for each node to transmit data in the network. This is achieved by transmitting the compressed data between the nodes (users) and retrieving the original data at the destination. For this, we are proposed Lempel-Ziv-Welch (LZW) compression algorithm.

Keywords: MANET, link failure, compression, decompression

I. Introduction

It is an autonomous system which comprises a collection of mobile nodes that use wireless transmission for communication is known as MANETS. Ad hoc network is a temporary network, without any form of centralized administration. Each node participating in the network acts as host, a router must therefore be willing to forward packets for other nodes. The most important characteristics are the dynamic topology, which is a consequence of node mobility. Nodes can change position quite frequently leading to packet loss. The biggest challenge in MANETs is to find a path between communicating nodes, that is, the MANET routing problem. The considerations of the MANET environment and the nature of the mobile nodes create further complications which results in the need to develop special routing algorithms to meet these challenges. MANETS are self–organized, self–configured and self-controlled infra-structure less networks.

The applications of MANETs are Personal area networking (cell phone, laptop, ear phone, wrist watch), Military environment (soldiers, tanks, planes), Civilian environments (taxi cab network, meeting rooms, sports stadiums, boats, small aircraft), Emergency operations (search-and-rescue, policing and fire fighting).

the advantages of MANET are Smaller in size, More convenient & more powerful, Support high speed multimedia services, High mobility, Device portability, Low cost.

The disadvantages of MANET are Securing data, Link failures, Power consumption, Limited transmission range, not scalable, limited resources (memory, battery power).

The power consumption can be minimized by modifying the cryptographic algorithms, or minimizing link failures or implementing power control algorithms or by compressing the text. In this paper we will discuss about the minimization of power consumption by compressing the input data.

For example, real time applications like video conferences, online banking / trading, telecommunication, etc requires more number of bits to be transmitted / received. If a single bit requires 1 watt of power to transmit / receive and it requires huge power for these applications. Since all the nodes in Ad hoc networks are wireless and battery driven, power consumption may be more if the bits are transmitted directly and the node may participate in one or two applications only. So to minimize the power consumption, the data bits can be compressed and transmitted. Therefore it is desirable to perform additional computation to reduce the number of bits transmitted. If you want to transmit a file of size n bits then if that n bits have been compressed to m bits (n > m); c is the cost of compression and decompression; and w is the cost per bit of transmission and reception; compression is energy efficient if

(C / (n-m)) < W

If the energy required to compress data is less than the energy required to send it, there is a net energy savings and consequently, a longer battery life for the nodes. If we compares total energy usage for sending/receiving the raw 1.8 Mb text data with compression + transmission method. The total bits to transmit is "n" and if we have chosen our compression algorithm then which has compression ratio of 0.56.

m = 0.48n

And for text data of 1MB, The total compression effort would be 0.1085181 Joules. So if the total amount of data you want to transmit is x Mb then Choosing would

work, If (m * TP) + (m * 0.40TP) + x* 0.1085181*1024*1024 < (n * TP) + (n * 0.40 * TP)
Where TP is transmit power required for transmitting the data (1 bit), which can be calculated from current rate of transmission and average energy spent on transmission per/second. These readings are very well available to the sender. If this equation is satisfied then based compression is efficient.

II. Related work

In [1] Ravindra.E, VinayadattV kohir and V.D Mytri etal, proposed the mechanism of link failure prediction. This performs local route repair if the signal strength is below the threshold value. The drawback is route rebuilding time. The future work is to develop an algorithm to reduce the route rebuilding time so that real time voice and data can be transmitted in MANET.

In[2] Mr.S.A.Jain and Ms Aruna.A, Kadam, proposed different mechanisms for the link failure detection by using alternate route finding from the nearer of the faulty node resulting into improvement in throughput, and end to end delay parameters. Thus performance of MANET will be significantly increased, along with TCP throughput.

In [3] Junjun Gu,Aihong Yao, Gang Qu , Ahmed Bouridane, proposed the impact of ECC and transmission power level to the packet loss rate and transmission energy in a direct point-to-point wireless communication, and also proposes a 2-phase approach to leverage these two options to minimize the transmission energy while satisfying the transmission error requirement. The future work is energy efficient communication networks and this work is the formulation and general approach to solve this fundamental problem.

In [4] Sunil Kumar, Pankaj Negi, proposed the idea of "BACKWARD AODV (B-AODV)", which attempts backward RREQ. B-AODV route discovery succeeds in fewer tries than AODV. We conducted extensive comparison study to evaluate the performance of B-AODV and compared it with AODV. B-AODV improves the performance of AODV in most metrics, as the packet delivery ratio, end to end delay, and energy consumption. Its future work will focus on studying practical design and implementation of the B-AODV.

In [5] Weidong Cui, Ion Stoica, and Randy H. Katz EECS, UC Berkeley, proposed Probability-cost routing algorithm and single-link-failure bandwidth allocation algorithm have good performance on robustness and efficiency. Probability-cost routing algorithm is fault tolerant to noise of overlay link failure probabilities. Future Work Test the algorithms both in NIST Net emulation test bed and in a real overlay network Study how to obtain overlay link failure probabilities in real networks.

In [6] Diaa Salama, Hatem Abdual Kader, and Mohiy Hadhoud, proposed energy consumption of different common symmetric key encryptions on handheld devices. It is found that after only 600 encryptions of a 5 MB file using Triple-DES the remaining battery power is 45% and subsequent encryptions are not possible as the battery dies rapidly.

In [7] Edward Y. Hua and Zygmunt J. Haas, proposed with the range of parameters studied in this letter for the constant-velocity case, more than 80% of the RLL predictions fall within 20% of their actual values. For the G-M and G-T mobility models, the same accuracy can be achieved by 75% (for $NV\ UI$ = 20[sec]) and 70% of the RLL predictions, respectively.

In [8] Subir kumar sharkar, T.G.Basavaraju, C.Puttamadappa, proposed the advantages and disadvantages of MANETS and recent developments with applications in ad hoc networks.

In [9] Guoliang Xing, Chenyang Lu, Ying Zhang, Qingfeng Huang, Robert Pless, proposed New algorithm based on minimum Steiner tree(ISTH).in this they explain the nodes and transmission power at ideal and sleep nodes. And gives the comparison of energy in MPCP and min-power routing. Future work is to maximize system life time, reduce network contention, and estimate data rates.

III. Analysis of existing algorithms:

A. Minimizing link failure

In MANET high speed of mobility or continuously changing network topology causes link breakage and invalidation of end-to-end route. The link failure will indicated by the absence of hello message. To reduce the link failure we retransmit the messages. By retransmitting the messages the routes or system consume more energy and its system life time will be less. We must minimize radio power consumption to extend system lifetime. Under radio power cost the IEEE802.11 network card has the radio power cost of TX=1400, Rx=1000, idle=830, sleeping=120. Transmission consumes more power than receiver. Sleeping consumes much less power than idle. The idle power of non-communicating nodes is reduced by sending it into the sleeping. To save the power there are three types:

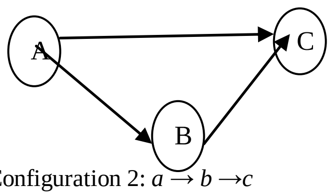
- Topology control reduces per node transmission power.
- Minimum power routing reduces per packet transmission power.
- Sleep management reduces idle power through duty cycle.
- None of above scheme minimizes both idle and transmission power.

$$P(a \to c) = rP_{tx}(a,c) + rP_{rx} + 2(1-r)P_{idle} + P_{sleep}$$

For example

A sends to c at normalized rate r = $\frac{R}{BW}$

Configuration 1: a →c, b sleeps



Configuration 2: $a \to b \to c$

$$P(a \to b \to c) = r\left(P_{tx}(a,b) + P_{tx}(b,c)\right) + 2rP_{rx} + (3-4r)P_{idle}$$

P_{tx} (a, c) = 80mW, P_{tx} (a, b) = P_{tx} (b, c) = P_{rx} = P_{idle} = 24mw

Security attacks in MANET routing can be divided in two main types, passive attacks and active attacks. An active attack is performed by a malicious node with the intention to interrupt the routing functionality of a MANET. Common attack occurred in link failures are

- Modification attack
- Selfish behavior
- Hostile attack

i. Selfish Behavior

This refers to a node which does not cooperate in any routing. For example, the node wishes to save energy and so switches to a “sleep mode” whenever it is not taking part in any network communication. While such an attack may not be launched with explicitly bad intentions, it can lead to serious disruptions in network communications such as high route discovery delays and dropped data packets. The selfish node also happens to be the only communication link between two MANET end points and communications between these endpoints will become unavailable.

ii. Modification attack

A modification attack is typically launched by a malicious node with the deliberate intention of Redirecting routing packets.

iii. Hostile attack

Any type of misbehaving nodes can create the hostile attacks. These types of attack can seriously damage basic aspects of security such as integrity, confidentiality, and privacy of the nodes.

B. Power control algorithm

Energy is a source and non-renewable in wireless ad hoc network, energy-efficient protocol design is a key concern. The design and performance analysis of such protocols require proper modeling for the measurement of energy consumption. Feeney et al presents some results of measuring energy consumption of various network interfaces. The four possible energy consumption states are identified: transmit, receive, idle and sleep. The first two states are when the node is transmitting and receiving the packets respectively, the idle state is when node is waiting for any packet transfers, and the sleep state is a very low power state where the node can neither receive nor transmit.

The cost associated with each packet at a node is represented as the total of incremental cost m proportional to the packet size and a fixed cost b associated with channel acquisition

Cost=m*size+ b

Thus the cost of a broadcast packet will be of the form

Costbroadcast=m send*size+ b send+ $\sum_{n\in s}(m\, recv * size + b\, recev)$

Where

s=set of nodes with in transmission range of transmitting node

m send, b send=incremental and fixed cost for sending the broadcast packet

m recev, b recev=incremental and fixed cost for receiving the broadcast packet

Similarly the cost of point-to-point traffic at the sender and receiver while considering presence of $\frac{RTS}{CTS}$control messages in 802.11 based networks can be respectively represented by the following equation:-

Cost unicast -sender=b send ctl + b recvctl + m send*size+ b send + b recev ctl

Cost unicast - receiver=b recev ctl + b send ctl+ m recv*size+ b recv+ b send ctl

Where

b send ctl =fixed cost for sending a control packet

b recev ctl = fixed cost for receiving a control packet

Beside this model for energy costs, it was also shown that the energy consumed by an idle network interface dominates the total energy consumption (about a magnitude more than sleep mode).

Calculation of energy required for transmitter and reception of a single packet

i. for data packets

Packet length=1500 bytes.

Bit rate=250 kbps (48ms/packet or 20.8 packets/sec)

Total packet size=size of (preamble +PLCP header + IP header +data)

= (144+48+28*8+20*8+1500*8) bits

Although the preamble and PLCP header are transmitted at 1mbps while the rest are sent at 11mbps.thus we have 144+48 bits sent at 1mbps,with a transmission time for single packet=0.19ms

Hence the total transmission time for a single packet=1.128+0.19=1.318ms

ii. for acknowledgement packets:

Packet length=14bytes, bit rate=250kbps.

Total packet size=size of (preamble +PLCP header+ ACK) = (144+48+14*8) bits

So, transmission time for single packet=0.304ms

C. Modification of cryptographic/compression algorithm.

Cryptographic algorithm plays vital roles for information system security. These algorithms consume a significant amount of computing resources such as CPU time, memory, and battery power. CPU and memory usability are increasing with a suitable rates, but battery technology is increasing at slower rate. The problem of the slower is increasing battery technology forms “battery gap”. The design of efficient secure protocols for wireless devices from the view of battery consumption needs to understand how encryption techniques affect the consumption of battery power with and without data transmission. The first method is

The battery life consumed in percentage for one run $=\frac{\text{Change in battery life}}{\text{the number of runs}}$ (1)

Average battery Consumed per iteration$=\frac{\sum_1^n BatteryConsumedPer\ iteration}{N}$ (2)

The second method of security primitives can also be measured by counting the amount of computing cycles which are used in computations related to cryptographic operations. For computation of the energy cost of encryption, we use the same techniques as described using the following equations.

B cost _ encryption (ampere-cycle) = τ * I (3)

Tenergy_cost (ampere seconds) $=\frac{\text{B cost \_ encryption (ampere-cycle)}}{\text{F (cycles/sec)}}$ (4)

E cost (Joule) = T energy _cost (ampere-seconds)*V (5)

Where

B cost _encryption: a basic cost of encryption (Ampere -cycle).

τ: the total number of clock cycles.

I: the average current drawn by each CPU clock cycle.

T energy _ cost: the total energy cost (ampere seconds).

F: clock frequency (cycles/sec).

E cost (Joule): the energy cost (consumed).

IV. Proposed work

4.1 DATA COMPRESSION

A compression algorithm is used to convert data from an easy-to-use format to one optimized for compactness. Likewise, a decompression program returns the information to its original form.

The compression methods have been classified as either lossless or lossy. A lossless technique means that the restored data file is identical to the original. This is absolutely necessary for many types of data, for example: executable code, word processing files, tabulated numbers, etc. The compression methods used for images and sounds are lossy, as they will be degraded in comparison with the original files.

When comparing the lossless compression algorithms, we found that the LZW compression algorithm is more advantageous than other compression algorithms as shown in table 1.

Table 1: Comparison of lossless compression techniques

Types of file	Huffman Encoding	LZW Compression	Run Length Encoding
Text file	66%	44%	75%
Speech file	65%	64%	73%
Image file	94%	88%	97%
Size of compressed file as percentage of the original file			

The LZW compression algorithm in its simplest form is shown in figure1. A quick examination of the algorithm shows that LZW is always trying to output codes for strings that are already known. And each time a new code is output, a new string is added to the string table.

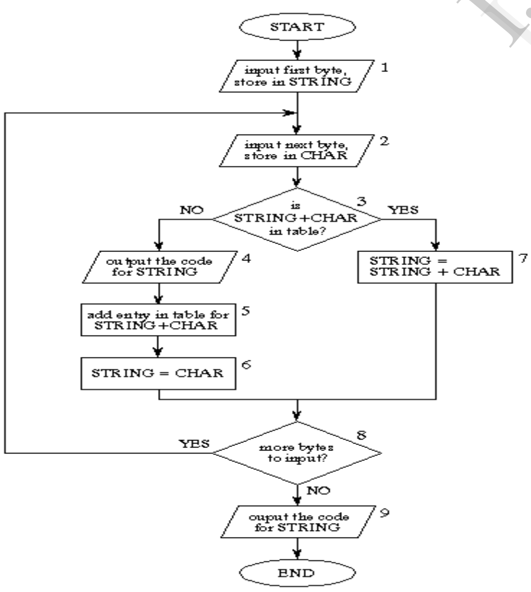


Figure 1. Compression Flowchart

The decompression algorithm needs to be able to take the stream of codes output from the compression algorithm, and use them to exactly recreate the input stream shown in figure 2. One reason for the efficiency of the LZW algorithm is that it does not need to pass the string table to the decompression code. The table can be built exactly as it was during compression, using the input stream as data. This is possible because the compression algorithm always outputs the STRING and CHARACTER components of a code before it uses it in the output stream. This means that the compressed data is not burdened with carrying a large string translation table.

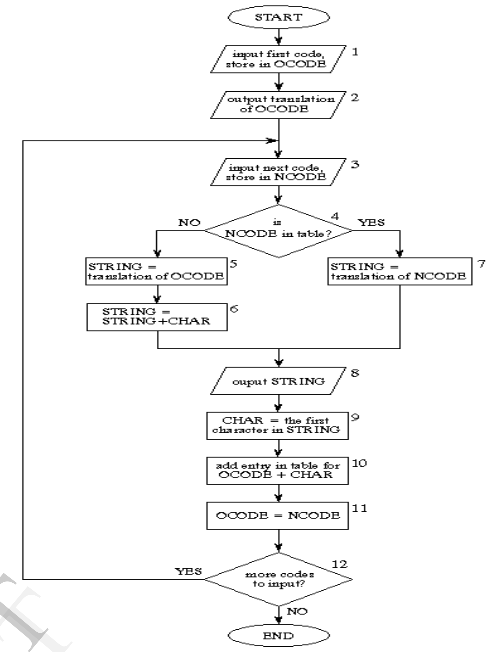


Figure 2. Decompression Flowchart

V. Implementation and Expected Results

The LZW algorithm is going to implement in the Glomosim with the following metrics to evaluate the efficiency in addition to the effectiveness of the algorithm.

(i) **Average throughput**: Measured as the ratio of data packets delivered to the destinations to data packets originated by the sources. This number presents the routing efficiency of the protocol.

(ii) **Packet delivery ratio**: Measured as the ratio of the data packets delivered to the receivers to those data packets expected to be delivered.

(iii) **End-to-end delay:** Measured as the time interval from the moment that the source node sends a first message until the moment that the destination node in the network receives this last message. It also includes all possible delays caused by queuing at the interface, retransmission delays, and propagation and transfer times.

VI. CONCLUSION & FUTURE WORK

Since the power consumption is an important issue for MANETS, we propose a compression technique which is simple to implement rather than using complex algorithms. Here we are going to implement LZW algorithm in GLOMOSIM with expectation of high compression ratio, so that the power required for data transmission / reception can be minimized.

This work can be extended for implementing

- Authentication when introduced before the encryption and decryption process will make a more complete security model.
- Power control protocols to reduce the power, which in turn increases the battery life.
- Image compression can also be implemented in Mobile Ad hoc Networks to save the bandwidth.
- Reduce Network contention
- QoS Topology Control in Ad Hoc Wireless Networks

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