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Modeling Based on Hidden Markovian Chain in Mobile Ad Hoc Networks

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ABSTRACT

Developing protocols in mobile ad hoc networks, requires extensive evaluation via simulation and or via testing in real world so high amount of sources should be tested in order to make pattern modeling. The results of this action leads to get experiments and acceleration in process of evaluation. In recent years using of hidden Markovian chain in mobile ad hoc to present a model, is become very popular because of relative simplicity and flexibility. In this paper we explain the concept of Markovian chain in mobile ad hoc networks modeling and then data traffic modeling for lost and received packets, connection of link between nodes, lifetime of link would be evaluated and considered.
KEYWORDS: Mobile ad hoc networks, Hidden Morkovian chain, Data traffic, Link connection, Life time.

1. INTRODUCTION

Mobile ad hoc network consist of distributed nodes which forms a temporary network without any substructure or central management. In this kind of networks, nodes connected together directly and every node cooperates in routing via sending data to other nodes [1]. In mobile ad hoc networks every node is free to move in every direction independently and as a result its link to other nodes change repeatedly [2]. For the sake of nodes movement, network topology is dynamic and variable, So it needs a routing protocol which has thae ability of adaption [3]. To study mobile ad hoc networks, modeling can be used [4]. In fact modeling is making of single sample of system which can be studied and evaluated. Generally, before making a system, a model should be made and studied its performance. Mostly modeling is done for reliability and system performance confirmation. The base of modeling in this review used hidden morkovian chain.

In this paper, we will have documents problem outline steps in section two, Markovian chain description are presented in section three, modeling of mobile ad hoc networks are described in section four and finally in section five we will have conclusion.

2. Problem outline

For studying mobile ad hoc network, modeling based on hidden markovian chain can be used. Markovian chain is a random discrete-time process with markovin chain property. In recent years because of flexibility and simplicity of markovian chain, used in almost every modeling [4]. There are some cases in mobile ad hoc network, which evaluation of this kind of networks should be considered. By presenting a model for each of these issues, the process of this evaluation for this kind of networks can be better [5]. For example data transfer should be in such a way which does not need to repetition of much data transmission [8]. In other words should there be a model for the data traffic to do evaluations better or life time should be considered. All of this issues leads us to study and improve the performance of mobile ad hoc networks [10].

3. Markovian chain description

Markovian chain is a time-discrete process of with the marovian property. This is a system which in every stage is in a certain and determined condition and is changed in every stage randomly [4].

Markovian property states that Conditional probability distributions for next system, depends on only current state the system and does not depend on previous states [6].

3.1. Hidden markovian chain

If observations are probability functions of states, then the resulting model is a random model with an underlying random process which is hidden and it can be observed just with the collection of random process which produces sequence of observations. Hidden markovian model is a statistical model where the modeled system is assumed as a Markov process with unobserved (hidden) states [4].

3.2. Determine the HiddennMarkov model parameters

A hidden Markov model can be made with the determinations of following parameters [7]:

- The number of possible states: in a hidden Markov model every state is associated with an event.
- The number of observations in every state: is equal to the number of outputs of the modeled system.
- The number of states in model N: the number of observations symbol in alphabet, if M is discrete observations, then M has an unlimited amount.

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3.3. parameters Kind of hidden Markov mode

Hidden Markov mode has different kind based on its structure and topology but due to different applications and the complexity of the process requires different structures [6]:

- Left to right model or Bakis model: is a kind of structure which is used in different applications widely. This model has left to right connections and for modeling, uses signals which their Properties changes with time. In this model there is just one input state which is the first state.
- Ergodic model: the structure of this model is like a complete graph in which vertices have also recursive connections.
- Left to right parallel model: This model has properties of two previous mentioned structures and in fact it is parallel combination of two kinds.
- Gaussian mixture model: this model is an important method of signal modeling which is like a hidden Markovian chain that its probability density function has several mixed state.

4. Modeling of mobile ad hoc networks

Developing protocols, applications, security and other issues like this in mobile ad hoc network need to evaluation via simulation or testing in real world, so more sources should be tested for pattern modeling. The result of this action leads to gain experiments and acceleration in the process of evaluation [8]. Three problems of data traffic, link connection and life time are important issues to create connection in mobile ad hoc network which performed modeling on them are evaluated and analyzed [10].

4.1. Data traffic modeling

In ad hoc network, the possibility of lost data is high because of topology dynamism and lost connection in nodes. Since all data protected by a CRC, then it is impossible to receive a fault packet. We can suppose that a packet received completely or lost. Independent of the routing mode, packet loss also has a lot of other reasons (Collision, noise, Channel noise, Drop queue and etc), So an outer observer cannot associate packet loss to any certain routing. In fact the observation a possible action relates to the state. This means that only output of system, and not state changes, can be observed by an observer which this shows using of hidden Morkovian chain. So by using the hidden Markova model, the problem of state can be solved. The most simple hidden morkovian chain is Gilbert model which has two different conditions [8]:

1. When one way to destination lost and no packet received successfully.
2. When there is one way to destination, but some packets decrease due to some reasons as Congestion, Transmission error, Buffer Overflow and so on.

This is a two-state hidden Markova model based on Markovian chain which is shown in fig. 1.

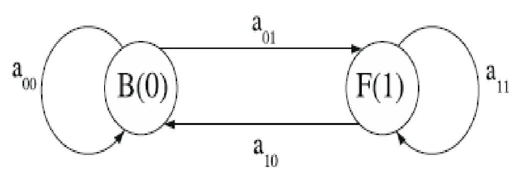

Fig. 1. Two- state markovian chain model [8].

State B models a condition which lost way to destination. The possibility of going a packet to destination successfully is zero. In state F, packets lost according to determination of h(s) in which s is the amount of packet. With routing state B to zero, and state F to one, Transition probability matrix can be get from this relation [4].

$$A_2 = \begin{bmatrix} a_{00} & a_{01} \\ a_{10} & a_{11} \end{bmatrix} \qquad (1)$$

Essentially losing of one packet is independent from size of packet. So possibility function relates to state F and in constant value. The amount of performing of state B and F have an average amount $\frac{1}{a_{10}}$ and $\frac{1}{a_{01}}$, so we have [8]:

$$\widehat{a_{10}} = \frac{1}{\mu_{CPA}} \quad \widehat{a_{01}} = \frac{1}{\mu_b} \qquad (2)$$

We can find the possibility of stable state π for all states. For this, first we do Flow equations of every state. With Simplifying the Flow equation, π_b and π_f is given by Equation (3) [6]:

$$\pi_b = \frac{a_{10}}{a_{01}} \pi_f \, , \pi_f = \frac{a_{01}}{a_{10}} \pi_b \qquad (3)$$

By knowing $\pi_b + \pi_f = 1$, we have Equation (4):

$$\pi_b = \frac{a_{10}}{a_{01} + a_{10}} \, , \pi_f = \frac{a_{01}}{a_{01} + a_{10}} \qquad (4)$$

By finding π, we can determine the exact possibility of getting packets to destination by using Equation (5) [8].

$$P_{arrival} = \hat{h} . \pi_1 = \hat{h} . \frac{\widehat{a_{01}}}{a_{01} + a_{10}} \quad (5)$$

4.2 connecting link Modeling

A link in ad hoc network can have active connection, if the signal strength threshold related to system gained powerfully, then gained signal power relates to close distance to source node, obstacles, fading effect and more other factors [12].

The time of connection link can be predicated in a limited condition, for example Constant speed of nodes, and random behavior in path changing. McDonald and Znati present a mathematical model to cover the distribution of the total distance and on the covered direction which can be formulated by using speeds and non-random direction [11].

Two nodes connections is a random process without memory. This means that next two nodes connections are without background and relates only to current connection state. In other words connection in time t+Δt relates to link state in time t. but we describe two nodes connections and transition probability, independent from state in period [0,t] in fig. 2.

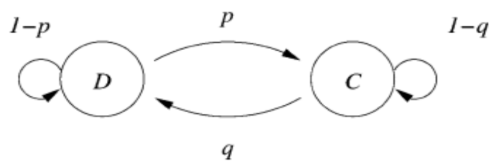

Fig. 2. The state of connection and transition betweentwo nodes [11].

Markovian chain has space state S={D,C} which in state D shows two nodes disconnections and C shows that two nodes are connected with a two-state wireless channel. Connection state in the next time, with the probability of p is done from D to C and probability q is obtained for transition from C to D, So transition probability matrix of state P is according to equation (6) [12].

$$P = \begin{bmatrix} 1-p & q \\ p & 1-q \end{bmatrix} \quad (6)$$

In fact matrix p is a general form for a two–state Markovian chain transfer matrix, now for description Long-term behavior of connections, the behavior of P_n should be calculated, for large values of n. Eigen values of matrix p is one and is 1-p-q if p>0 and q<1. Because |1-p-q|<1, so stable probability of transfer matrix is [11]:

$$\lim_{n\to\infty} P^n = \begin{bmatrix} q/(p+q) & q/(p+q) \\ p/(p+q) & p/(p+q) \end{bmatrix} \quad (7)$$

By considering equation, we know that connection state remains with the rate $p/(p+q)$ and it goes to disconnected state with rate $q/(p+q)$. We define a space S , such that S={C,D} and define a process X_t such that has Markova property. Like equation (8):

$$P\{Xt = c \mid Xr , 0 \le r \le s\} = P\{Xt = C \mid Xs\} \quad (8)$$

In this process time is homogeneous, so equation (9) can be obtained:

$$P\{Xt = C \mid Xs = D\} = P\{Xt\text{-}s = C \mid X0 = D\} \quad (9)$$

μ and λ are the transmission rate from $D \rightarrow C$ and $C \rightarrow D$ for time-continues Markova chain. With μ and λ we define a random process by the equation (10) and (11):

$$P\{Xt+\Delta t = C \mid Xt = C\} = 1- \Delta\mu \quad (10)$$

$$P\{Xt+\Delta t = C \mid Xt = D\} = \Delta\lambda \quad (11)$$

By defining P(t) which shows P{$X_t = s$ } such that s $\in$ {C,D}, we have equation (12):

$$\lambda\, pD\,(t) - \mu\, pc(t) \quad (12)$$

By using of probability vector P(t) as $[P_D(t), P_C(t)]^t$, the system is showed in equation 12 can be simplified as equation (13):

$$\lambda P'(t) = Ap(t), \text{and } A = \begin{bmatrix} -\lambda & \mu \\ \lambda & -\mu \end{bmatrix} \quad (13)$$

In which transfer matrix A, is called Infinitesimal chain generator and its deferential equation has a solution like equation (14):

$$\begin{bmatrix} \frac{\mu}{\lambda+\mu} + \frac{\lambda}{\lambda+\mu} e^{-(\lambda+\mu)t} & \frac{\mu}{\lambda+\mu} - \frac{\mu}{\lambda+\mu} e^{-(\lambda+\mu)t} \\ \frac{\lambda}{\lambda+\mu} - \frac{\lambda}{\lambda+\mu} e^{-(\lambda+\mu)t} & \frac{\lambda}{\lambda+\mu} + \frac{\mu}{\lambda+\mu} e^{-(\lambda+\mu)t} \end{bmatrix} \quad (14)$$

4.3 Link life time Modeling

The link life time is a period of time which two nodes are connected and can make connection. In the case of connection between two nodes in different times, network can send data actively and communication between nodes is established [12].

Wireless connection between two nodes a and b is broken when distance between two nodes is greater than R. When the data packet send in time t_1, the position of node b can be defined in anywhere in connection circle by range of transitions a. B is packet transmissionrate L_p is the size of packet data and t1+Tl is the time when node b goes out of connection circle, so we can define $\frac{L_p}{B} \leq T_L$ for node b, starting random point in connection circle is equal with the probability of being constantly in connection circlebefore leaving it So we define cumulativedistribution function CCDF as equation (15) [13]:

$$F_L(t) = P(T_L \geq t) \quad (15)$$

Probability of link failure, PLp is related with the packet size L_p and we can show this in equation (16):

$$P_{Lp} = P\left(T_L < \frac{L_p}{B}\right) = 1 - F_L\left(\frac{L_p}{B}\right) \quad (16)$$

Node a moves by the speed of V_a and direction θ_a and node b also moves by the speed of V_b and direction θ_b. We suppose that node a is stable and b is in movement state with relative speed V_r and direction θ_c . By moving node b with specified speed and direction and by considering θ_a and θ_b are between $[0,2\pi]$ as non-uniform distribution, we can direction movement as $\theta_c = \theta_b - \theta_a$. The average speed can be gained by this equation (17) [14]:

$$v_r = \sqrt{v_a^2 + v_b^2 - 2v_a v_b \cos\theta_c} \quad (17)$$

As it is showed in fig. 3, evaluation of link life time can be showed in a two- state Markova process.

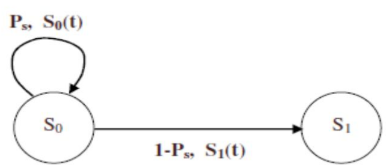

Fig. 3. Two- state Markova model for link life time evaluation [13].

State s_0 shows that b is in connection circle and state s_1 shows that b is out of connection area. Inhabitancy probability is P_S, It means that the possibility that b is in the connection circle. Probability distribution function PDF, $s_0(t)$ is the distribution of resident time movement period when a node remains in state s_0 and $s_0(t)$ is measure of the distribution of the exit time for a node when exits from communication range and goes to s_1. Also N_i is an integer variable counter. Conditional life time T_l(Ni) and P(Ni = k) is calculated by the equation (18) [13]:

$$T_L(N_i) = \sum_{i=0}^{N_i-1} s_{0,i} + s_1, \qquad P(N_i = K) = P_s^K \quad (18)$$

Characteristic function $U_{T_l}(\theta)$ for link life time T_l can be evaluated as equation (19).

$$T_L(N_i) = \sum_{i=0}^{N_i-1} s_{0,i} + s_1, \qquad P(N_i = K) = P_s^K \quad (19)$$

In which $U_0(\theta)$ and $U_1(\theta)$ are the characteristic function of $S_0(t)$ and $S_1(t)$, respectively. Depending on the size and speed of network nodes maybe communication circleis small So p_s<< 1. In this case, $U_0(\theta)$ as the characteristic function of $S_0(t)$, is equal to $|U_0(\theta)| \leq 1$. Finally $U_0(\theta)p_s$<<1. So the equation (19) is as the equation (20) [13]:

$$U_{T_l}(\theta) \approx U_1(\theta) \tag{20}$$

5. CONCLUSION

Modeling can evaluate and analyze different aspects of mobile ad hoc network. Hidden markovan model can be used in most mobile ad hoc network. Because of adjustment most of property of ad hoc networks and Markovian chain, most of this modeling in this kind of networks are based on Markovian chain. It is tried to gather issues which are important and necessary challenges for ad hoc networks, such that evaluation of this challenge scan be better. In the end, we can evaluate and study presented models to understand the mentioned points.

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