A Transmission Probability Control Algorithm Based on Competing Node Estimation in MANET

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Abstract—Most of Transmission Probability Control Algorithms in Mobile Ad hoc Network (MANET) research are based on the assumption that the number of competing nodes is known by every node. With an increasing number of wireless devices or appliances, the number of competing node in network is changed dynamically, so the assumption that the number of competing nodes is known by every node is no longer suitable. A transmission probability control algorithm, based on competing node estimation, is proposed in this paper. The simulation results show that the protocol can estimate the number of competing node, control the transmission probability dynamically and decrease the end-to-end delay.

Keywords—transmission probability control; competing node estimation ; manet

I. INTRODUCTION

Over the past few years, research in MANET has yielded considerable advances, notably in the areas of new routing and medium access techniques. Yet, significant shortcomings of ad hoc networks remain, especially compared with wire network.

MANET suffers from fundamental capacity limitations, connectivity/survivability problems, and is prone to jamming. Attempts to surmount these problems at the medium access, network by way of innovative and often ingenious protocols have yielded only incremental success. In this paper, we consider the transmission probability control enhancement---based on the estimation of competing nodes' number to address the above problems and provide a significant improvement in network end-to-end delay.

Currently, Transmission probability control algorithms are based on prior knowledge of the number of its neighbor nodes in the network, Such as literature [1-5], CSMA/CD (Carrier Sense Multiple Access/Collision Detect) based on the transmission probability control, CSMA is divided into persistent CSMA and non - persistent CSMA. Persistent CSMA Continuously monitors the channel to channel idle, and it is also divided into 1-persistent CSMA and p-persistent CSMA. 1-persistent CSMA will not send the frame immediately until the channel is free, p-persistent CSMA sends data with the probability p, and after a period of delay with the probability of 1-p starts monitor channel, if the channel is idle, starts the sending process with probability p, until the channel is busy or frame is send successfully. With the popularity of personal intelligent mobile terminal equipment, the number of competing node in network is becoming more and more difficult to know, research in transmission probability control based on prior knowledge of the number of its neighbor nodes in the network already can't meet the needs of the reality.

II. CE-TPC ALGORITHM

In this paper, MANET is a synchronous Time Division Multiple Access network. In a slot, node obtains channel with the probability P_G , channel being idle with probability P_I , channel conflicts with probability P_C , there are k competing nodes in the network, the transmission probability is p, so P_G , P_I , P_C can be expressed as:

$$\begin{cases} P_I(k, p) = (1 - p)^k \\ P_G(k, p) = kp \cdot (1 - p)^{k-1} \\ P_C(k, p) = 1 - P_I(k, p) - P_G(k, p) = 1 - (1 - p + kp)(1 - p)^{k-1} \end{cases} \quad (1)$$

Based on Poisson theorem, formula 1 can be approximate to:

$$\begin{cases} P_I(k, p) = e^{-kp} \\ P_G(k, p) = kp \cdot e^{-kp} \\ P_C(k, p) = 1 - (1 + kp)e^{-kp} \end{cases} \quad (2)$$

The partial derivatives of formulation 2 as shown in formulation 3,

$$\begin{cases} \frac{\partial P_I(k, p)}{\partial p} = -k \cdot e^{-kp} < 0 \\ \frac{\partial P_G(k, p)}{\partial k} = -p \cdot e^{-kp} < 0 \end{cases} \quad (3)$$

$$\begin{cases} \frac{\partial P_C(k, p)}{\partial p} = k^2 p e^{-kp} > 0 \\ \frac{\partial P_C(k, p)}{\partial k} = kp^2 e^{-kp} > 0 \end{cases} \quad (4)$$

From formulation 3, free slot probability P_I is monotonically decreasing with transmission probability P and the number of competing nodes k . From formulation 4, collision slot probability P_C is monotonically increasing with transmission probability P and the number of competing nodes

k . By the opposite monotone property of transmission probability P and the number of competing nodes k , it is known that collision slot and free slot are fluctuant within a range. So the collision slot and free slot length thresholds of are set as: $Th_c = P_c \cdot F$, $Th_l = P_l \cdot F$, F is data slot length.

So, the number k_{i+1} of competing nodes in next frame is calculated as shown in formulation 5.

$$k_{i+1} = k_i - N_{Gi} + N_{Ci} - Th_c - N_{li} + Th_l \quad (5)$$

Where N_{Gi} , N_{Ci} , N_{li} are amount of obtained slot, amount of collision slot and amount of free slot respectively.

As there is one successful slot, 0 or multiple collision slots and free slots in every successful communication, the communication delay is as shown in formulation 6:

$$\begin{aligned} Delay &= T_1 \cdot \frac{P_l}{P_G} + T_c \cdot \frac{P_c}{P_G} + T_G \\ &= T_1 \left[\frac{1 - \frac{T_c}{T_l} + \frac{T_c}{T_l} \cdot e^{kp}}{np} + \left(\frac{T_G}{T_l} - \frac{T_c}{T_l} \right) \right] \end{aligned} \quad (6)$$

Where T_c is collision slot, T_l is free slot, T_G is slot of obtained channel.

The partial derivatives of formulation 6 as shown in formulation 7 and 8,

$$\frac{\partial Delay}{\partial p} = T_G e^{kp} (kp - 1) + T_G - T_l \quad (7)$$

$$\frac{\partial^2 Delay}{\partial^2 p} = k^2 T_G p e^{kp} > 0 \quad (8)$$

From formulation 8, it can be known that $Delay$ has minimum value as the function of $Delay$ is concave function, while the formulation 8 meets conditions as follows:

$$\frac{\partial Delay}{\partial p} = T_G e^{kp} (kp - 1) + T_G - T_l = 0 \quad (9)$$

From formulation 9 it can be known that,

$$e^{kp} (1 - kp) = \frac{T_c - T_l}{T_c} \quad (10)$$

In differential application area, when $|x|$ goes to zero, $e^x \approx 1 + x$. So formulation 10 can be rewritten as follows:

$$(1 - kp_1)(1 + kp_1) = \frac{T_c - T_l}{T_c} \quad (11)$$

$$p_1 = \frac{\sqrt{T_l / T_c}}{k} \quad (12)$$

From formulation 12, we can see that the transmission probability can be regulated dynamically by the amount of network competing nodes in CE-TPC algorithm.

III. ANALYSIS OF CE-TPC ALGORITHM

To validation the performance of CE-TPC algorithm, it is compared with p-CSMA/CD algorithm based on OPNET network simulation software.

TABLE I. SIMULATION PARAMETERS OF CE-TPC ALGORITHM

Parameters	Values
Number of competing node	1~20
Network range	400m × 400m
Initialization value of transmission probability	0.5
Simulation time	10 min
Speed of mobility	0~10 m/s
Duration of collision slot	200 μs

FIGURE I. END-TO-END delay

FIGURE II. RETRANSMITTING PACKET

From Figure I and Figure II, it is can be seen that the number of retransmitting packet sharply increased in p-CSMA/CD algorithm and slot utilization decreased when network competing nodes added; However, as the transmission probability can be regulated dynamically by the number of competing nodes in CE-TPC algorithm, the collision probability decreased, then the number of retransmitting packet and the increasing amplitude were both less than in p-CSMA/CD algorithm, and the end-to-end delay in CE-TPC algorithm is also less than in p-CSMA/CD algorithm.

IV. CONCLUSION

In this paper, a mobile Ad hoc network transmission probability control algorithm CE-TPC was proposed, the number of competing nodes can be calculated quickly, and the end-to-end delay can be decreased by the transmission probability regulated dynamically based on the calculated number of competing nodes.

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