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Effective information transmission based on socialization nodes in opportunistic networks

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ABSTRACT

In social communication, mobile devices can be regarded as socialization nodes in social networks. Furthermore, they carry and store useful information. Mobile devices can select destination nodes and deliver messages through opportunistic networks because messages can be securely and conveniently stored, carried, and transmitted with nodes. In this study, a forwarding model in opportunistic networks is built based on socialization nodes. In accordance with a defined stop time, nodes forward messages with the maximum probability when t<h, whereas nodes stop sending messages when t>h. The proposed scheme exhibits better performance compared with classical algorithms in opportunistic networks.
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1. Introduction

A type of multi-hop wireless network, called an opportunistic network, has emerged in recent years [1]. This type of network originates from delay-tolerant networking (DTN) [2,3]. The key for distinguishing the features of opportunistic networks and DTN from ad hoc [4] is that an end-to-end path will never occur. However, the union of networks may present an end-to-end path at snapshots over time. The application areas of opportunistic networks include military communications [5], interplanetary networks [6], networks in underdeveloped areas [7], field tracking [8], and disaster rescue [9].

In opportunistic networks, the traditional algorithm paradigm for the Internet and ad hoc networks, where routing algorithms are computed based on topological information, becomes inadequate. The first approach to routing in opportunistic networks is a variation of controlled flooding. All messages are flooded and are limited by time to live, and then messages are delivered to their destination. This approach contacts the node that is receiving the message during flooding. Several advanced proposals have replaced topological information with higher-level information while attempting to limit flooding cost.

In a real social network, however, traditional opportunistic network algorithms only consider message transmission rather than the social relationship among human beings. Consequently, joining a social network is difficult for traditional opportunistic network algorithms.

This study contributes by dividing nodes in opportunistic networks into several communities. Optimized transmission nodes and control schemes can be adopted for opportunistic networks according to the established Effective Information Multi-Controlling node Transmission algorithm (EIMCT) and combined real scenarios. This algorithm is established to solve time complexity and reduce overhead costs. Compared with the traditional algorithm used in the experiment, the proposed algorithm can improve certain aspects of network communication performance.

This paper is debated some problems with information transmission based on socialization nodes in opportunistic networks. Section 2 is related works, Section 3 is system model design, Section 4 is stimulation and Section 5 is conclusion.

2. Related works

Research on opportunistic networks currently focuses on routing algorithms. Existing routing algorithms can be used in different areas through improvement. Some methods adopted in opportunistic networks are as follows.

Wu et al. [11] suggested a store-and-forward mechanism epidemic algorithm that simulated the transmission mechanism of infectious diseases. In this algorithm, two nodes exchange a message that is not stored by the other when they meet. This method is similar to exclusive or transmission and allows the nodes to

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obtain additional information. The path where a node reaches the target node and transmits the message can be guaranteed to be the shortest by increasing network bandwidth and buffering memory space. In real applications, however, congestion can occur in the message transmission network as the number of nodes included in the transmission increases, given that related resources in real networks are limited. In actual applications, this method cannot obtain good result due to the limitation of resources.

Wang et al. [12] proposed the spray and wait algorithm based on the epidemic algorithm. This algorithm consists of two phases, namely, spraying and waiting. The source node initially counts the available nodes around it for message transmission, and then transmits its message to the nodes through spraying. In the waiting phase, the message is transmitted to the target node through direct delivery to fulfill the transmission process if no available node can be found during the spraying phase. This method is a modified algorithm that improves the flood transmission feature of the original epidemic algorithm. Furthermore, the spraying phase may waste source nodes if a huge number of neighbor nodes that consume considerable space exist in the source nodes. Hence, this algorithm can cause the death of nodes by randomly overspraying source nodes in several networks.

Spyropoulos et al. [13] recommended the PRoPHET Algorithm. This algorithm improves the utilization of a network by first counting the available message transmission nodes and then calculating the appropriate transmission nodes to form message groups. Leguay et al. [14] established the MV algorithm based on the probability algorithm. This algorithm calculates transmission probability based on records and statistics in the meeting and area visiting processes of the nodes.

Burgess et al. [15] presented the MaxProp algorithm based on array setting priority. This algorithm features determining the transmission sequence according to a settled array priority when two nodes meet. This method reduces the consumption of resources and the efficiency of the algorithm is improved by arranging a reasonable sequence for message transmission. Leguay et al. [16] suggested the MobySpace algorithm. In this algorithm, node groups or pairs with high relevance form into a self-organizing transmission area to realize optimal communication among nodes.

Burns et al. [17] recommended the context-aware routing algorithm based on calculating the transmission probability of the source nodes reaching the target nodes. This algorithm obtains the middle node by calculating the cyclic exchange transmission probability, and then collects and groups messages to guide the middle node in transmitting messages directly to the node with higher transmission probability.

Du et al. [18] presented the message ferry algorithm, which refers to the grouping and transmission of messages. This algorithm classifies and groups the messages collected by the source nodes that are going to be transmitted, and then counts the existing transmission traces for each ferry node in the network. The movement rule of ferry nodes can be achieved. The source node will move to the ferry node automatically during message transmission. Transmission effects can be improved by predicting the node moving trace in the algorithm.

This paper discusses and demonstrates the application of opportunistic networks to social networks based on the analysis and summary of related works.

3. System model design

3.1. Transmission model design in opportunistic networks

In opportunistic networks, the data transmission of nodes is based on real social models, such as map models, car network models, and rescue sites. Lokhov [6] concluded that the distribution of the time interval of an encounter was the normal distribution of logarithmic normal distribution, and the negative exponential curve could fit the distribution well. CHEN [7] found that considering a long tail, the distribution of the tail was followed by exponential distribution. Simultaneously, a substantial number of studies [8, 9] have used this simple assumption for modeling and have obtained meaningful results. To simplify the theoretical analysis, the probability of any two nodes meeting at intervals reflects $[t, t+\triangle t]$ the probability that the time interval is the same as the negative exponential distribution.

$$p = 1 - e^{-\lambda \Delta t} \tag{1}$$

Formula (1) represents the motion model for a node, and λ denotes the parameter of the negative exponential distribution.

Literature [10] showed that social networks had unmarked features, and thus, they could be used to represent social characteristics.

$$P(k) = \begin{cases} 0, k < m \\ C(m, g)k^{-g}, m \le k \le N \end{cases} \tag{2}$$

where *P(k)* is assumed to have *k* friend proportion of the number of nodes, *N* is the total number of nodes, *m* is the minimum number of friends, *g* denotes skewness, and *C*(*m, g*) is a normalized constant.

Assume that the network contains *N* nodes, including a source node, a destination node, and mobile *N* nodes according to the negative exponential model. The social characteristics are based on the power exponent distribution among node definitions, and *S*(*k, t*) that represents *k* friend of the probability of nodes at time *t* time carries information. Given the aforementioned variables, the corresponding derivative is

$$\begin{aligned} S(k, t) &= \lambda(1 - S(k, t))p_2(t)\frac{k}{N-1}\sum_{k'=m}^{N-1} P(k')PS(k', t) \\ &\quad + \lambda(1 - S(k, t))(p_1(t) - p_2(t))\frac{k}{N-1} \\ &\quad \times \sum_{k'=m}^{N-1} P(k')PS(k', t) \end{aligned} \tag{3}$$

In this case, the range of *k* is [*m*, *N*−1]. p_1 (*t*) and p_2 (*t*) refer to between friends and the probability of passing information between friends, respectively; this study simply assumes that information is not passed between friends. For security and privacy reasons, such nodes may be unable to forward information to strangers. $p_2(t) = 0$ plug in (3).

$$S(k, t) = \lambda(1 - S(k, t))p_1(t)\frac{k}{N-1}\sum_{k'=m}^{N-1} k'P(k')PS(k', t) \tag{4}$$

With *F*(*t*), time *t* destination node receives the information of probability. With *G*(*t*), the destination node indicates the probability of not receiving information until time *t*. Evidently, $F(t) = 1 - G(t)$. Assume that all the probabilities of a node to the destination node send a message to 1. For event Θ in$[t, t+\triangle t]$, the destination node in the probability of not receiving information, the following can be obtained:

$$G(t+\triangle t) = G(t)P(\Theta) \tag{5}$$

P(Θ) can be assumed as a destination node that is unfit to carry the information of nodes in $[t, t+\triangle t]$ probability; thus, we have

$$(1 - P(\Theta)) = 1 - e^{-\lambda \sum_{k=m}^{N-1} NP(k)S(k,t)\Delta t} \tag{6}$$

From Formulas (5) and (6), the following can be obtained:

$$\begin{aligned} \lim_{\triangle t \to 0} \frac{G(t-\triangle t) - G(t)}{\triangle t} &= \lim_{\triangle t \to 0} \frac{-G(t)(1 - e^{-\lambda \sum_{k=m}^{N-1} NP(k)S(k,t)\Delta t})}{\triangle t} \\ &\Rightarrow -G(t)\lambda \sum_{k=m}^{N-1} NP(k)S(k, t) \end{aligned} \tag{7}$$

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