

Research on Relay Selection Scheme Based on Reduced Interference in Multi-Group Multicast

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Abstract—Based on Multi-Group Multicast transmission mechanism, the transmission of a multicast group in the process of relaying data will affect other multicast group transmission. Hence, this paper proposes a relay selection scheme based on reducing interference among groups. This scheme applies the second time slot of another generated multicast group for the factors of interference relay selection. Based on the location information of the channel state and users, this scheme studies from separate user's perspectives relay to another generated multicast group to minimize the interference probability. Simulation results show the feasibility of the proposed scheme.

Keywords—multi-group multicast; interference between groups; relay selection

I. INTRODUCTION

With the rapid growth of mobile multimedia business, the demand for spectrum resource has been increasing significant. The traditional multicast has the main disadvantage that: transmitted terminal will send information at a lower rate to ensure that each terminal can receive the business information. However, this will cause serious reduction in terms of resource utilization. Collaborative communication technology was applied to multicast transmission which is an effective method to solve this problem.

Cooperative communication can effectively improve the performance of wireless communication system by using the broadcast characteristic of wireless channel and the cooperation among users [1]. Cooperative multicast can effectively improve the throughput of the system. In the literature [2], a cooperative multicast scheduling scheme based on IEEE802.6 is proposed to improve the throughput of the system. Wang Lefei analyzed the problem of relay selection based on the minimum spanning tree in terms of the outage probability [3]. This literature [4] proposes a relay selection based on channel statistical properties that do not require knowledge of large amount of instantaneous channel information and power optimization of the source node and each relay node prior to relay selection. Currently, people spend on mobile devices on daily basis with increasing time, and some even become addicted. However, the battery capacity of the mobile terminal is limited. Therefore, it is necessary to reduce the power consumption of the mobile device terminal, thereby alleviating the problem of low power consumption. Tuan T. Tran et al proposed a cooperative multicast algorithm, which analyzes the relay selection problem of cooperative multicast [5]; Hongxiang Li proposed

a collaboration for multimedia service in the IEEE802.6 network multicast scheduling mechanism. This mechanism makes full use of cooperative communication among terminal devices and multi-channel diversity generated by different multicast groups, which improves the throughput of the system under the premise of ensuring fairness [6]. Sara Moftah Elrabiei proposed a Nearest-Neighbor Discovery Protocol (NNP), in which each user who cannot successfully receive the base station (BS) transmit signal selects a nearest neighbor as the relay from the user who successfully received the base station's transmit signal [7]. Chen Fengdie proposes a relay selection scheme based on transmission range algorithm to reduce interference [8].

Considering the above problems, this paper proposes a new relay selection scheme in Decode and Forward mode.

II. SYSTEM MODEL

We consider a cell based on the IEEE802.16 standard defined in the PMP mode of wireless multicast network, the base station in the center of the cell, all users in the radius of R cells in a random uniform distribution, as shown in Fig. 1.

Assuming that the base station is acknowledged with the location information and channel information of each user. The whole communication process is sub-divided into three stages.

In the first phase, spending time T_1 , BS transmits data x_1 for group 1. CU1,n receive x_1 and the transmission rate is R_1 . In the second stage, spending time T_2 , the CU1,n forward data x_1 to CU1,n' while BS transmits data x_2 for Group 2. Meanwhile, CU2,m receive x_2 . The transmission rate for them are R_{21} and R_{22} respectively. In the last stage, spending time T_3 , CU2,m forward data x_2 to CU2,m'. The transmission rate is R_3 . To ensure the fairness of the system, we need to guarantee that $T_1R_1 + T_2R_{21} = T_2R_{22} + T_3R_3$.

III. THE RELAY SELECTION SCHEMES

1. Placing all users in multicast group 2 in vector SS_2 ;
2. The instantaneous signal-to-noise ratio of each user in the multicast group 1 is determined and arranged in descending order and then placed in the vector $SNRI$;
3. Assuming the coverage rate of $C=50\%$, the user (CU1,n) of the first phase in multicast group 1 who successfully receives the data x_1 is the first half element of the vector $SNRI$, placing them in the vector $GCSI$; Then the user (CU1,n') of the first phase in multicast group 1 who failed

to receive the data x_1 is the second half element of the vector **SNRI** and places them in the vector **BCSI**;

4. For each element of the vector **GCSI**, calculating the number of **BCSI** elements L and the number of **SS2** elements G in the range of its transmission radius, respectively. $(L-G)$ is determined and arranged in descending order and then placed in the vector in $N1$;

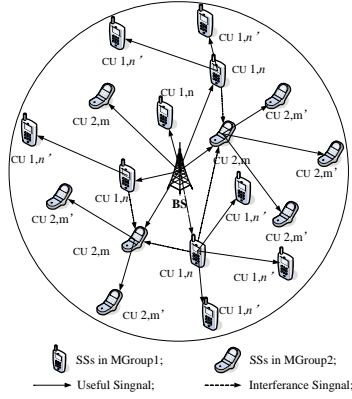


FIGURE 1. THE SYSTEM MODEL

5. Selecting the first element vector in **N1** while calculating the number of vector **BCSI** elements within the range of its transmission. If the result is 0, the $CU1,n$ is not as relay in multicast group 1. If not, the $CU1,n$ as a relay in multicast group 1;
6. The $CU1,n$ in the previous step and the $CU1,n'$ which are contained in it are removed from the vector **GCSI** and the vector **BCSI** respectively, and then the vector **GCSI** and vector **BCSI** will be updated;

Repeating the above steps until **BCSI** is empty.

A user is randomly selected in Multicast 1 as relay the probability of that is

$$P_{RA}(SS1_i) = P_1 \times P_2 \times P_3 \quad (1)$$

Where P_1 represents the probability that the user receives data at the first time slot,

$$P_2 = \left(1 - \sum_{k=0}^{N_1-1} P(\sum_k^1 < b_n N_o) \right) \quad (2)$$

Where $N1$ represents the number of users in multicast groups 1, P_2 indicates the probability that at least one user cannot receive data in the first slot in multicast group 1. In this paper, the coverage ratio C is set to 50%, thereby $P_2=1$. P_3 stands for the probability that $(L-G)$ the maximum and $L \neq 0$.

The probability that the area of A contains k users is:

$$P_4 = e^{-\lambda A} \cdot \frac{(\lambda A)^k}{k!} \quad (3)$$

Where λ represents the density of Poisson point processes.

Since the coverage ratio C is equal to 50%, the average number of $CU1,n$ and the number of **SS2** in the cell area per unit area can be shown as:

$$\lambda_1 = \frac{N_1 / 2}{\pi R^2} \quad (4)$$

$$\lambda_2 = \frac{N_2 / 2}{\pi R^2} \quad (5)$$

The transmission range of $CU1,n$ is A_j . The probability that A_j contains the $CU1,n'$ number is L and the probability that A_j contains the **SS2** number is G which can be shown as:

$$P_5 = e^{-\lambda_1 A_j} \frac{(\lambda_1 A_j)^L}{L!} \quad (6)$$

$$P_6 = e^{-\lambda_2 A_j} \frac{(\lambda_2 A_j)^G}{G!} \quad (7)$$

Hence, the transmission range in the area inside the expression is shown in (8)

$$A = \begin{cases} r^2 ar \cos\left(\frac{d^2 + r^2 - R^2}{2dr}\right) + R^2 ar \cos\left(\frac{d^2 + R^2 - r^2}{2dR}\right) \\ - \frac{1}{2} \sqrt{(-d + r + R)(d + r - R)(d - r + R)(d + r + R)}; d \in [(R - r), R] \\ \pi r^2; d < (R - r) \end{cases} \quad (8)$$

Where r represents the user transmission radius; R represents the radius of the cell; d represents the distance between the base station and the **SS1i**.

The probability that $(L-G)$ the maximum and $L \neq 0$ is shown in (9)

$$P_3 = \sum_{m=1-N_2}^{N_1/2} \left[\left(\prod_{L-G=m, L \in [1, N_1/2], G \in [0, N_2]} e^{-\lambda_1(A(x,y))} \frac{(\lambda_1(A(x,y)))^L}{L!} e^{-\lambda_2(A(x,y))} \frac{(\lambda_2(A(x,y)))^G}{G!} \right) \right. \\ \left. \prod_{SS1_M \in MGroup1, M=1}^{N_1/2} \left(\sum_{m=1-N_2}^m \left(\prod_{L-G=m, L \in [1, N_1/2], G \in [0, N_2]} e^{-\lambda_1 A_j} \frac{(\lambda_1 A_M)^L}{L!} e^{-\lambda_2 A_j} \frac{(\lambda_2 A_M)^G}{G!} \right) \right) \right] \quad (9)$$

Therefore, the probability that each user in the multicast group 1 which is selected as a relay is:

$$P_{RA}(SS1_i) = C \times P_3 \quad (10)$$

IV. SIMULATION RESULTS AND ANALYSIS

In this paper, the transmission range algorithm, the NNP protocol, the FenHou scheme and the relay selection scheme based on the reduction of inter group interference are studied

in the first place and compared with the number of relays in the four scenarios. Then we studied the effects of the above schemes on the multicast group 2 users and made the comparison. There is a base station located in the center of the system and N1+N2 users located in the cell, of which N1 is equal to N2, and the user is randomly distributed in a circle with a radius of 2.5 km. The Multi-Group multicast system consists of two multicast groups. The multicast group 1 contains N1 users, and the multicast group 2 contains N2 users.

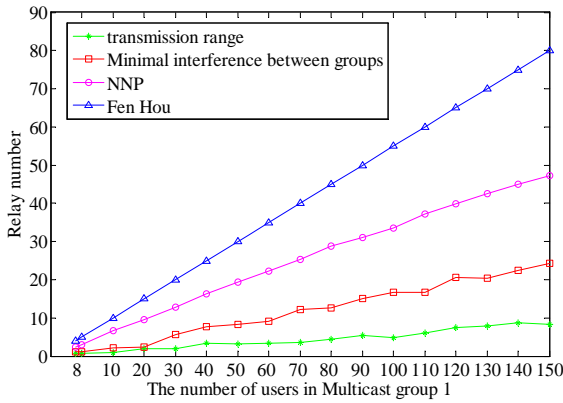


FIGURE II. THE AVERAGE PROBABILITY

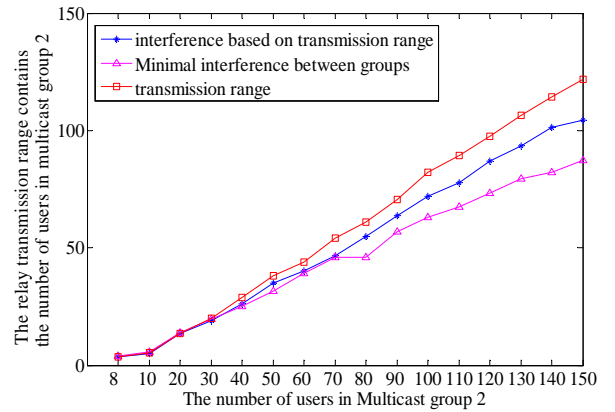


FIGURE IV. THE NUMBER OF USERS IN GROUP2

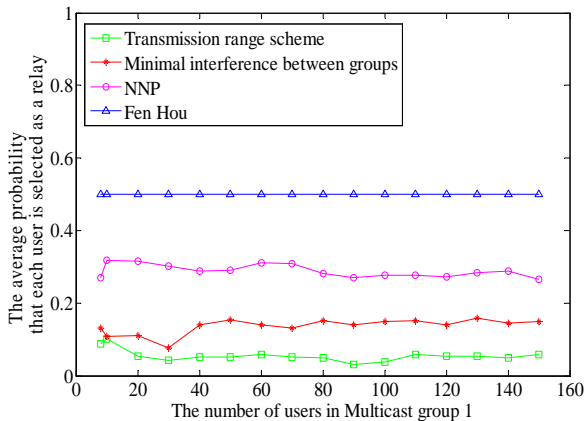


FIGURE III. RELAY NUMBERS

Figure 2 shows the compared the number of relay in multicast group 1 of the four schemes. In the case of the same number of users in the multicast group 1, the number of relays with minimal interference between two groups is less than NNP protocol and FenHou scheme, but more than transmission rang scheme. In the FenHou scheme, the users that receive data successfully in the first phase are relayed. The transmission range algorithm reduces the probability that each user who can receive data successful in the first phase in the case of data forwarding.

Figure 3 shows the average probability that each user is selected as a relay. P is getting closer and closer to a stable value with the increasing number of users.

In figure 4, the number of users of the multicast group 2 within the transmission relay range is illustrated. The scheme of this paper contains the minimum number of multicast groups 2.

Combining figure 2 and figure 4, it can be seen that the scheme raised by this paper could greatly reduces the impact on multicast group 2. This is under the circumstance of small increase in the number of relays.

V. CONCLUSION

In this paper, we propose a relay selection algorithm based on the reduction of the inter group interference in a mode, combining with the transmission range algorithm in the DF mode. Under the same conditions, the performance of the proposed algorithm is better than the other algorithms mentioned in this paper. It can effectively reduce the interference between the two multicast groups and significantly improve the system performance and power efficiency.

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REFERENCES

- [1] Chen Yali, Wang Mei and Wang Junyi. Energy efficiency optimization of cooperative multicast based on relay selection[J]. Journal of Guilin University of Electronic Technology, 2014,(4):259-263.
- [2] Hou F, Cai L X, Ho P H, et al. A cooperative multicast scheduling scheme for multimedia services in IEEE 802.16 networks[J]. Wireless Communications IEEE Transactions on, 2009, 8(3):1508-1519.
- [3] WANG Le-fei, ZHANG Li, PENG Tao and WANG Wen-bo. Multi-Hop Route Selection of D2D Communication under Analysis of Outage Probability [J]. Journal of Beijing University of Posts and Telecommunications. 2015(10):23-27
- [4] SUN Li-yue;ZHAO Xiao-hui, and GUO Ming. Outage probability based power allocation and relay selection algorithm in cooperative communication [J]. Journal on Communications.2013(10):84-91
- [5] Tran T T, Li H, Liu L, et al. Secure Network-Coded Wireless Multicast for Delay-Sensitive Data[J], IEEE ICC 2012, 11(18):1943-1947.
- [6] Li H, Liu S, Gudaitis M S. Optimal interference pre-cancellation order in DPC-based broadcast and unicast hybrid network[C]. Information Sciences and Systems. 2013:1-6.
- [7] Elrabiei S M, Habaebi M H. Energy efficient cooperative communication in single frequency networks[C]. Personal Indoor and Mobile Radio Communications (PIMRC), 2010 IEEE 21st International Symposium on. IEEE, 2010:1719-1724.
- [8] Chen Fengdie. Relay Location and Relay Selection in Cooperative Multicast Networks [D]. Zhengzhou University, 2016.