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Analysis of Delay Performance in Multicast CPC Scheme

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Abstract – **Cognitive pilot channel (CPC) can provide the necessary wireless environment information for the terminals and avoid long time- and energy- consumption for spectrum scanning. In previous researches, two different CPC information delivery modes have been proposed, i.e., broadcast CPC and on-demand CPC. However, both mechanisms exist certain advantages and disadvantages. So a novel CPC multicast mechanisms have been proposed. Although, this mechanism improving the system's access delay performance, there is still room of optimization. Because there is a limitations on research of mesh divided. This paper give a novel algorithm which make access delay of multicast CPC more optimized. Simulation results show that the proposed algorithm significantly improves the performance of multicast CPC scheme.**

***Keywords* – Multicast CPC, Mesh Size, Access Delay.**

I. Introduction

Cognitive pilot channel concept was first proposed in E^2R (End to End Reconfiguration) project [1]. Its initial purpose is to solve access problem of the terminal boot process and assist terminal spectrum sensing, choose Internet access and real-time refactor software downloads in wireless network. In 2008, E^3 project launched in-depth study about the CPC technology which support transmission of heterogeneous network information transmission based on E2 .This study made that CPC can assist terminal to cognize wireless network environment, find network , and autonomic select network. The CPC technology achieve the effective transmission of cognitive wireless networks and efficient use of information [2].Proposed CPC technology also enables accelerate the integration of heterogeneous networks [3].

In previous researches, there are two information delivery modes having been proposed, i.e., broadcast CPC and on-demand CPC. However, these two schemes both have some deficiencies in terms of delay performance. In order to overcome the defects of these two approaches, Feng et al. proposed a multicast CPC method to optimize the delay performance and information scheduling as an evolution of the on-demand mode [4].But The research still has some limitations on the further optimization of delay. The analysis is based on fixed time delay and grid size. Moreover, when the user tends uniformly distributed, the performance of the scheme did not get significantly improved. In [5], the positioning errors and the accuracy of the information were discussed , but did not consider access delay that is caused by division of the mesh. In this paper, multicast model is further analyzed and optimized. Then we propose a novel scheme on multicast CPC basis simulation results show that the proposed algorithm is largely improved delay performance of CPC multicast scheme.

II. CPC Operational Processes and Multicast Scheme

The CPC channel which carries the location information of the operator, different RAT technology and available frequency information makes user terminal avoid long time-and energy-consumption for spectrum scanning. CPC covered area is divided into a plurality of meshes. Each terminal only receives its own mesh information which is available to complete the initial access network. the basic CPC information shown in Figure1.

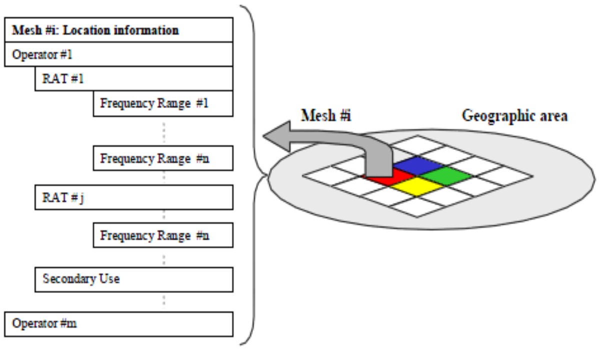

Fig.1. Information to be sent per mesh

The steps of the CPC operation procedure are shown in Figure 2. Concrete steps are as follows: After switching on, the user terminal determine its location information with a latitude and longitude to represent by using GPS or some other positioning systems. Then, the terminal starts monitor CPC message. After acquiring synchronization, the CPC terminal starts to decode CPC message. Network information of each mesh contains the location information of the mesh in coverage area. After that ,the terminal need to compare their own geographic location information with location information of each mesh in CPC message and find their own mesh ID. Then, the terminal select the appropriate mesh information to receive. Then, the terminal process received CPC messages and select the appropriate network to access.

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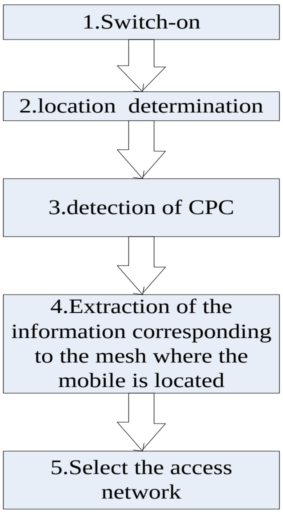

Fig.2. CPC operation procedure

In the multicast CPC scheme, CPC terminal sends a request message to the network side and the network side responds to the terminal that is same as on-demand CPC scheme. The difference is the proposed scheme adopts a point-to-multipoint information delivery approach in which the network waits for a period of time W after a user request before sending the mesh information into the scheduling system.

III. Multicast CPC Access Delay Analysis

A. System Model

We considered dividing the CPC coverage area into N_m meshes. The user distribution rate expressed by η_k in each mesh. The CPC information request rate obeys a Poisson distribution with parameter λ. User requests model shown in Figure 3.

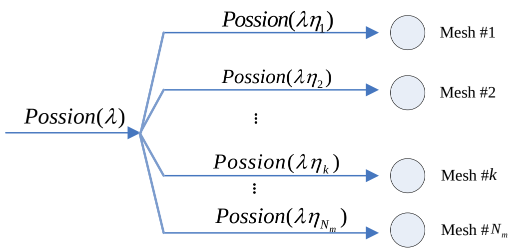

Fig.3. Multicast CPC information request model

In the multicast CPC scheme, after the network receiving the first request from a mesh, system start to wait for a period of time W.CPC multicast service model shown in Figure 4.

Because the addition of N Poisson processes is still a Poisson process, the total information input to the scheduling system has a Poisson distribution with average rate

$$\lambda' = \sum_{k=1}^{N_m} \frac{\lambda \eta_k}{(1+W\lambda\eta_k)} \quad (1)$$

λ' is determined by waiting time W, the total request rate and user distribution rate.

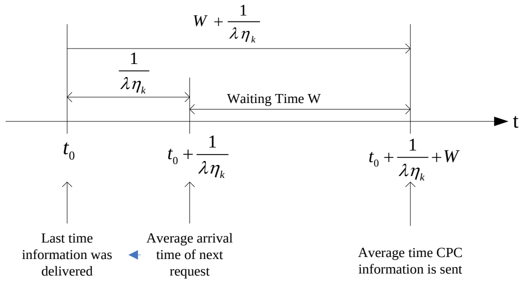

Fig.4. Multicast CPC service model for mesh k

B. Analysis and Optimization of Delay

Existing multicast scheme adopted the mechanism which each mesh had the same waiting time and did not consider the impact about delay caused by mesh size. The amount of information is processed in the same size in each mesh. In fact, in the mesh of different sizes and geographical locations, the amount of information which mesh is carrying is very different.in this paper, multicast scheme was further analyzed based on its shortcomings. We assume that CPC Operator coverage is S_{cpc} and the size of each mesh is L. There are three RAT in the entire area. When the mesh size tends to infinity ,the number of RAT tends to 0.when the mesh size is Large enough, the number of RAT tends to 3.The formula that calculate the amount of information issued is give by.

$$I_m = B_{GEO} + N_{OP}(B_{OP} + N_{RAT}(B_{RAT} + N_{FREQ}B_{FREQ})) \quad (2)$$

Parameters are defined as follows:

Table 1: Parameter definition

parameters	definitions
B_{GEO}	Geographic information:
N_{OP}	Number of operator
B_{OP}	Operator information:
N_{RAT}	Number of RAT
B_{RAT}	RAT information:
N_{FREQ}	Number of channels
B_{FREQ}	Frequency information:

The formula shows that when the mesh size from small to large, there may be have a increase about the kind of the RAT in a mesh. Each additional one RAT technology will increase the amount of information issued about 1000 bit. This will have some impact on the access delay in an unstable channel conditions in heterogeneous networks. But on the other hand, if the mesh size is too small it will increase the number of mesh. When the mesh is excessive, queuing delay will worsen. For considering delay aspects, we need to find the right size to ensure optimal delay. Specific analysis below.

We assume that the bandwidth which is allocated to the CPC is B and the time that send a mesh message is

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$\tau = I_m / B$. Scheduling of CPC message obey M/D/1 queuing model. Let the system average service rate is μ which is the reciprocal of the service time τ . So the queuing delay of model is shown in Equation3.

$$D_{queuing} = \frac{1}{2(\mu - \lambda^{'})} + \frac{1}{2\mu} \quad (3)$$

We get Equation 4 when $\lambda^{'}$ and μ values are substituted into (3) of the formula

$$D_{queuing} = \frac{\tau}{2}\left(\frac{1}{1 - \sum_{k=1}^{N_m} \frac{\lambda I_m \eta_k}{B(1+W\lambda\eta_k)}} + 1 \right) \quad (4)$$

In the multicast CPC, the average waiting time of users consists of two parts. one part is the queuing delay that is generated by the delay of request message put into Scheduling systems. the other part is the average waiting time for each mesh's request into the scheduling system.

$$D_{mesh_k} = \frac{W}{2} + \frac{1}{2}\left(\frac{W}{1+W\lambda_k} \right) \quad (5)$$

Therefore, the user's overall average waiting time can be as (8) expressed.

$$D = f(W) = \frac{1}{2}\left[W + I_m / B + \sum_{k=1}^{N_m}\left(\frac{W\eta_k}{1+W\lambda\eta_k} \right) + \frac{f_{I_m}(L)}{B(1 - \sum_{k=1}^{N_m} \frac{\lambda I_m \eta_k}{B(1+W\lambda\eta_k)})} \right] \quad (6)$$

From (5) we can know that the average waiting time is determined by four factors, i.e., the total frequency of requests, user distribution rate and the amount of information mesh. Where in λ and η_k are determined by the actual system. Therefore, after determining other factors, the average waiting time for the user not only be influence by W one factor, the amount of information of each mesh also has some influence on the delay D. The amount of information each related to the current mesh size. The most important indicator is the delay of transmitted CPC messages in the using CPC auxiliary terminal access network process. Optimal delay can be expressed as:

$$(W_{opt}, L) = Arg \min_{W}\left\{ f(W) : f(W) = \frac{1}{2}\left[W + \tau + \sum_{k=1}^{N_m}\left(\frac{W\eta_k}{1+W\lambda\eta_k} \right) + \frac{\tau}{1 - \sum_{k=1}^{N_m} \frac{\lambda\tau\eta_k}{1+W\lambda\eta_k}} \right] \right\} \quad (7)$$

While taking into account the a maximum access delay which can be withstand by first random access. There should be.

We propose a new delay optimization algorithm which have considered both the mesh size and the multicast waiting time.

After selecting the mesh size, Accordance with the original multicast scheme to determine the optimal delay.

Figure 5 shows the impact of different mesh sizes and requesting frequency on time delay.

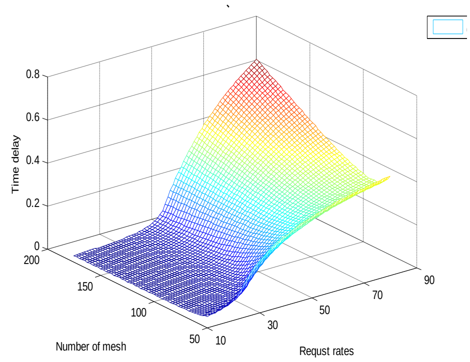

Fig.5. Delay performance of different mesh and request rate

As show in the figure 5, when requesting frequency is different, there isn't the global optimum mesh size. Therefore, we propose a mesh size adaptive algorithm based on the current network environment. On the other hand, frequent adjustment of the size of mesh is bound to bring some additional overhead of the system. Therefore, we propose an effective threshold. After the total user network frequency request changed, If the delay performance is significantly improved when the mesh size after an adjustment, we perform mesh adjustment scheme. Algorithm flow is shown in N.

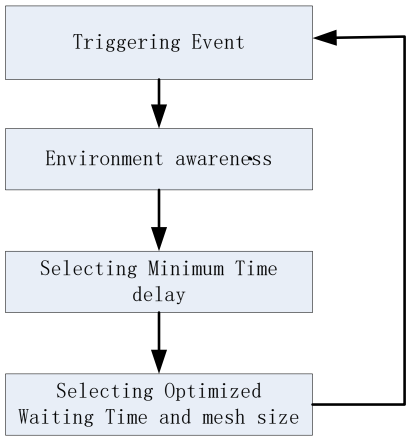

Figure.6 CPC dynamic configuration process

IV. Simulation Results and Analysis

The area covered by the CPC is divided into several meshes with 5 operators and 3 RATs in the entire region. We assume that the modulation for CPC is Binary Phase-Shift Keying (BPSK), and the bandwidth allocated to CPC is 50 kHz. If the spectrum efficiency of BPSK is 1bps/Hz, the channel capacity of CPC is 50kbs. The user distribution in the CPC coverage area can have a great effect on CPC delivery mode performance. In this paper, the user distribution follows a Double-Gaussian distribution.

$$w(x,y) = \frac{1}{2\pi\sigma_1\sigma_2} e^{-\frac{1}{2}\left(\frac{x-\mu_1}{\sigma_1}\right)^2} e^{-\frac{1}{2}\left(\frac{y-\mu_2}{\sigma_2}\right)^2} \quad (8)$$

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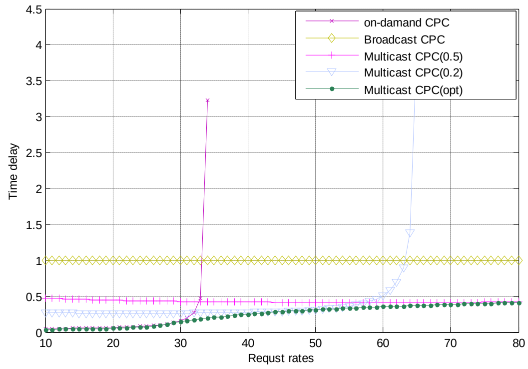

Fig.7. the performance of different scheme

Figure 7 shows several delay of existing CPC auxiliary access scheme. Figures 4 and 5 show the delay performance curve when sigma=1000.because the broadcast period only associated with the number of mesh .as shown in the simulation result, the average waiting delay only associated with the number of mesh in broadcasting CPC. The average waiting time are changing with the lambda and W. Performance curves of multicast and on-demand obviously coincides based on the optimal delay scheme when lambda value is near 10-30. This shows that when lambda is relatively small and the optimal waiting time value is 0 or very close to 0, Delay performance of the system get the best results. After separation of the performance curve of Multicast CPC scheme with different W and CPC scheme with optimal W, the average delay are sharp rise. The system can only achieve better performance when the value in a specific range. With the increase of lambda, optimized multicast CPC scheme still able to maintain optimal system time delay performance status. As shown in above simulation and analysis, optimized multicast CPC scheme can obtain a better delay performance in the user stack together scene. But there is still some delay upgrading to optimize space. we compares the performance of the proposed algorithm and the original delay scheme in figure 8.

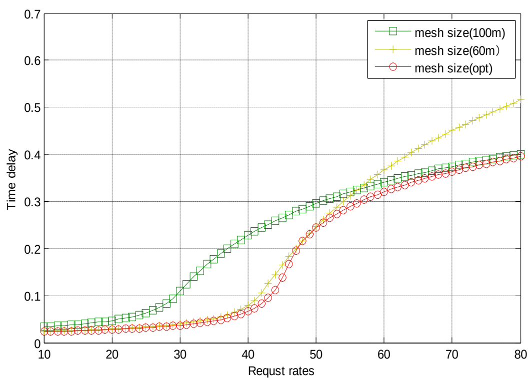

Fig.8. the performance of different mesh size

Figure 9 shows the delay performance curve of different total arrival rate in scene with $\sigma = \infty$. Note that when $\sigma = \infty$ the users are uniformly distributed. From the simulation results, when the value is close to 10-45, the multicast CPC scheme has maintained the best latency performance. However, t with the increasing there is terrible queuing delay.

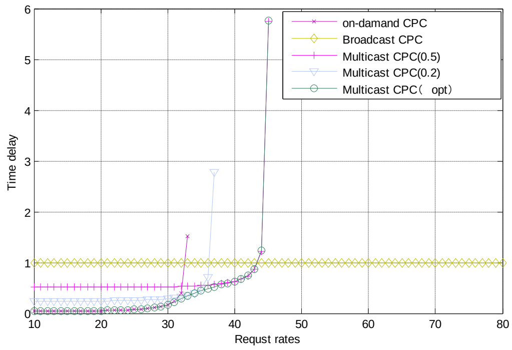

Fig.9. The performance of different scheme with a uniform user distribution

Although the queuing delay of proposed scheme is still rapidly increases with the arrival rate in uniformly scene . But the threshold of total arrival rate which leads to deterioration of the queuing delay. This means that the system can accommodate more users in this optimization scheme ,that has some practical significance.

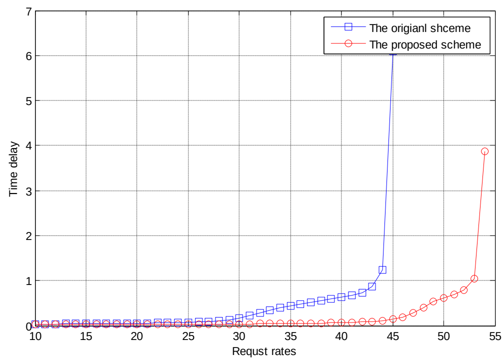

Fig.10. The performance of proposed scheme

V. Conclusion

In this paper, the CPC request message and response message correspond to the client's arrival and services in queuing theory. We modeled the multicast CPC message transmission model and analyzed the delay in this model. For the original multicast CPC limitations in the analysis of delay, we got further analysis of the impact of the delay caused by the division of the mesh and propose a new algorithm for optimizing access delay. Proposed scheme accord the current network environments to adaptive adjust mesh size. The simulation results show that the time delay performance of multicast CPC scheme is optimized.

References

[1] P. Cordier, P. Houze, S. Ben Jemaa, O. Simon, D. Bourse, D. Grandblaise, K. Moessner, J. Luo, C. Kloeck, K. Tsagkaris, R. Agusti, N. Olaziregi, Z. Boufidis, E. Buracchini, P. Goria, A. Trogolo. E2R Cognitive Pilot Channel concept. Proc. IST Mobile and Wireless Commun. Summit, June.2006.

International Journal of Electronics Communication and Computer Engineering
Volume 5, Issue 4, ISSN (Online): 2249–071X, ISSN (Print): 2278–4209

[2] https://ict-e3.eu/project/
[3] Mueck M, Haustein T. Demand driven evolution of the cognitive pilot channel[C]//Cognitive Radio Oriented Wireless Networks & Communications (CROWNCOM), 2010 Proceedings of the Fifth International Conference on. IEEE, 2010: 1-5.
[4] Feng Z, Zhang Q, Tian F, et al. Novel research on cognitive pilot channel in cognitive wireless network [J]. Wireless Personal Communications, 2012, 62(2): 455-478.
[5] Zhang Q, Feng Z, Zhang G, et al. Efficient mesh division and differential information coding schemes in broadcast cognitive pilot channel[J]. Wireless Personal Communications, 2012, 63(2): 363-392.
[6] Pérez-Romero J, Salient O, Agustí R, et al. A novel on-demand cognitive pilot channel enabling dynamic spectrum allocation[C]//New Frontiers in Dynamic Spectrum Access Networks, 2007. DySPAN 2007. 2nd IEEE International Symposium on. IEEE, 2007: 46-54.
[7] ITU-R Document 5D/929-E, Annex 9 - Working Document towards a preliminary draft new report ITU-R [LMS.CRS2] - Cognitive radio systems [(CRS) applications] in the land mobile service . 8th meeting of Working Party 5A, Geneva, Nov.8-17,2011.
[8] Dang jianwu, Li cuiran, Xie jianli. Cognitive radio technology and applications [M]. Bei Jing: Tsinghua University, 2012.

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