Chapter 5

Access Control and Handover Strategy for Multiple Access Points Cooperative Communication in Vehicle Environments

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Additional information is available at the end of the chapter

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1. Introduction

Current communication technologies applied in vehicle environments meet a lot of challenges, such as larger capacity requirements, higher velocity scenarios and lower latencies. Among these challenges, higher velocity scenarios addressed most of focuses in recent years. With the worldwide rapid constructions and deployments of high-speed train transportation system, the mobile communication support for high speed vehicle environments need further improvement.

In Dec. 2004, 3GPP (3rd Generation Partner Project) launched LTE (Long Term Evolution) standard work, which improved the mobile speed support that should be up to 350km/h and even 500km/h in some frequency bands [1]. The same requirements are also included in LTE Advanced system [2]. The higher speed vehicle environments will introduce larger Doppler frequency offset which need to be coped with in physical layer techniques. Furthermore, frequent handover and access process will also occur in the high speed vehicle communication scenarios, which need the evolution of the Media Access Control (MAC) and Radio Resource Management (RRM) layer techniques.

With the research and development of mobile/vehicle communication systems, a lot of advanced physical layer technologies show their merits and are applied in next generation mobile telecommunication systems. Among these techniques, the multi-antenna techniques, such as MIMO and OFDM, show their merits in improving system capacity and coverage area [3]. In LTE Advanced system, cooperative communication is introduced with CoMP (Coordinated Multi-Point) technique [4]. CoMP implies dynamic coordination communication among multiple separated transmission points, which can improve the received signal quality and cell edge user performances.

Cooperative communication needs more than one access point to accomplish the communication process. And with the developments of communication infrastructure construction, actually we have more densely deployments of base stations or access points in next generation system now. The optical fibre enlarges the coverage and also increases the numbers of RF (radio frequency) head. For the high speed train transportation system, there will also be lots of access points deployed along the railway.

Multiple access points communication environments increase the potentiality of larger communication capacity and higher speed vehicle support. But the multiple access point communication environments also introduce the challenge for traditional access and handover strategies.

The traditional access control and handover algorithm cannot accommodate the features of multi access point communication scenarios, especially for users served by multiple distributed antennas. Therefore, this chapter will focus on the Access Control and Handover strategies for multiple access point cooperative communication in vehicle environments.

In the following parts, the research outcomes about Access Control [5,6], Slide Handover strategy [7] and corresponding performance evaluation results will be provided. Maximum Utility Principle will be proposed and applied in the Access Control and Slide Handover process.

In part 2, the MUPAC (Maximum Utility Principle Access Control) based Dijkstra's Shortest Path Algorithm for multiple access point vehicle environment will be introduced. In the accessing process, the shortest path in Dijkstra's Algorithm can be represented by the cost of accessing process, which is formed by utility function. Based on the multiple access point cooperative communication vehicle environment, the MUPAC algorithm is described in details with the utility function, Maximum Utility Principle, flow chart of accessing process. Scheduling strategy enhanced version of MUPAC and corresponding performance evaluation verify the merits of MUPAC algorithm in improving system capacity, accessing success probability and efficiency of system resources usage.

Part 3 describes the Maximum Utility Principle Slide Handover strategy for multiple access point vehicle environments. Slide Handover strategy is illustrated and its merits will be presented. Slide window is applied in the Slide Handover process, which makes users always stay in cell centre and eliminates cell-edge effect. Maximum Utility Principle is also applied in Slide Handover strategy, which can effectively solve this problem. The Utility Function in the Slide Handover and steps for handover are described and system-level performance evaluations are also provided.

Finally, there comes the summary for this chapter.

2. Maximum utility principle access control strategy for vehicle environments

In [5], we brought out a MUPAC method for multi-antenna cellular architecture with application in Group Cell architecture [8] as an example. MUPAC method can maximize the usage

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of limited system resources with guaranteeing access users' QoS requirements. Furthermore, through this method, the interference caused by access users can also be mitigated maximally and the accessing success probability can also be improved.

With MUPAC method, when the system is under heavy-load situation, MUPAC method can fully show its merits in improving resource efficiency. However if the system is relatively light loaded and the capacity is enough for most of users, MUPAC method may not fully use system capability to serve users with its best, because MUPAC cares more on the minimum QoS requirements for resource utility rather than on user better performance. So, scheduling can be used in combination with MUPAC method to solve this problem and improve user service experience after access success ratio improvements.

This part will present two improvement based on MUPAC with scheduling. One is Throughput Targeted MUPAC (TT-MUPAC) and another is Throughput and Fairness Targeted MUPAC (TFT-MUPAC) algorithm [6].

2.1. Maximum utility principle access control

Taking Group Cell architecture [8] as the typical application scenario of multiple access point communication vehicle environments, users in the system are served by more than one antenna/access point. The access control method in this situation needs to solve the problem of how to choose multiple antennas to form the serving Group Cell and allocate appropriate resources to users. The size of Group Cell can be adjustable for users by their QoS requirements. Therefore, we can add antenna with maximum utility to user's current serving Group Cell step by step and fulfil the users' QoS requirements. This solution can maximum the usage of limited system resources with guaranteeing access users' QoS requirements. Furthermore, the interference caused by new users can also be mitigated maximally and the accessing success probability can also be improved.

The steps of adding antennas with maximum utility can be accomplished based on Dijkstra's Shortest Path Algorithm [9] in Graph Theory. Based on Dijkstra's Shortest Path Algorithm, when there are new users initiate their access attempts in Group Cell architecture, the shortest path in the Dijkstra's Algorithm can be replaced by the minimal cost of accessing process. The cost of accessing process includes the interference to other users and system resources needed (antennas, channels or other resources). Furthermore, the cost can be represented by the utility functions, including the gain for the access user and deterioration to other users. Therefore, the seeking for shortest path in Dijkstra's Algorithm can be transferred to seek the antennas or resources with maximum utility. The Maximum Utility Principle can improve the system capacity and load ability. By the Dijkstra's Shortest Path Algorithm and the Maximum Utility Principle, the user accessing in multi-antenna distributed Group Cell can be effectively accomplished.

In MUPAC method, the utility function is constructed by considering current system load, resource employment and so on. The utility function has two objectives. One is used to add antennas to current serving Group Cell with Maximum Utility Principle and the other is to select system resources allocated to the access users with Maximum Utility Principle.

The utility function has two aspects, including the gain of new antenna added in current serving Group Cell and the deterioration for the other users existed in the system.

The utility function is shown as (1).

$$U(i,\ \ldots,\ j,\ k)=\zeta_{Ck}[G_C(i,\ \ldots,\ j,\ k)-I_C(i,\ \ldots,\ j,\ k)] \\ +\beta(1-\zeta_{Ck})\max_{M\neq C}\{\zeta_{Mi}\cdot\ldots\zeta_{Mj}\cdot\zeta_{Mk}[G_M(i,\ \ldots,\ j,\ k)-I_M(i,\ \ldots,\ j,\ k)]\} \tag{1}$$

where $U(i,\ \ldots,\ j,\ k)$ denotes the utility of adding antennas k to current serving Group Cell formed by antennas $i,\ \ldots,\ j$. C and M denote the resources and C is the current resource used by serving Group Cell. ζ_{Ck} is an indicator function, which indicates the occupying information of resource C in AE (antenna element) k.

$$\zeta_{Ck}=\begin{cases}0, \text{Resource C occupied in AE k}\\ 1, \text{Resource C available in AE k}\end{cases} \tag{2}$$

where, $G_C(i,\ \ldots,\ j,\ k)$ denotes the gain achieved by adding antennas k to current Group Cell with resource C. $I_C(i,\ \ldots,\ j,\ k)$ denotes the interference to other users by adding antennas k to current serving Group Cell with C. β is a constant between 0 and 1 to introducing the penalty for coordinating current resource C and different resource (resource C') for the new serving Group Cell. β can be set according to the current system load condition. The choice of C' replacing C can also be achieved by Maximum Utility Principle with the utility function, which is:

$$C'=\arg\max_{M\neq C}\{\zeta_{Mi}\cdot\ldots\zeta_{Mj}\cdot\zeta_{Mk}[G_M(i,\ \ldots,\ j,\ k)-I_M(i,\ \ldots,\ j,\ k)]\} \tag{3}$$

Specifically, when choosing the first antennas to form the serving Group Cell, the utility for choosing the first antennas can be written as:

$$U(k)=\max_{M}\{\zeta_{Mk}[G_M(k)-I_M(k)]\} \tag{4}$$

when ζ_{Mk}, $G_C(i,\ \ldots,\ j,\ k)$ and $I_C(i,\ \ldots,\ j,\ k)$ in (1) do not exist before serving Group Cell is formed. Correspondingly, the method for choosing system resource for the new Group Cell by Maximum Utility Principle can be written as:

$$C=\arg\max_{M}\{\zeta_{Mk}[G_M(k)-I_M(k)]\} \tag{5}$$

Considering the actual mobile systems, the gain and interference in utility function are usually represented by SINR. Therefore, (1) can be revised to:

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$$
\begin{aligned}
&U(i,\ \ldots,\ j,\ k) \\
&= \zeta_{Ck}\Big[\frac{\lg_{k,i}}{\sum\limits_{n\neq i,\,j\ldots,k}(1-\zeta_{Cn})\lg_{n,i}} - \sum_{n\neq i,\ldots,\,j,k}(1-\zeta_{Cn})\frac{\lg_{n,n}}{\lg_{k,n}}\Big] \\
&+\beta(1-\zeta_{Ck})\underset{M\neq C}{\operatorname{argmax}}\left\{\begin{aligned}&\zeta_{Mi}\zeta_{Mj}\ldots\zeta_{Mk}\\ &\Big[\frac{\lg_{k,i}}{\sum\limits_{n\neq i,\ldots,\,j,k}(1-\zeta_{Mn})\lg_{n,i}} - \sum_{n\neq i,\ldots,\,j,k}(1-\zeta_{Mn})\frac{\lg_{n,n}}{\lg_{k,n}}\Big]\end{aligned}\right\}
\end{aligned}
\tag{6}
$$

And (4) can also be revised to:

$$
U(k)=\underset{C}{\operatorname{argmax}}\left\{\zeta_{Ck}\left[\frac{\lg_{k,k}}{\sum\limits_{n\neq k}(1-\zeta_{Cn})\lg_{n,k}} - \sum_{n\neq k}(1-\zeta_{Cn})\frac{\lg_{n,n}}{\lg_{k,n}}\right]\right\}
\tag{7}
$$

where $\lg_{n,k}$ denotes the path gain Between the antenna n and the access user who is currently served by the antenna k. The power for each user in (6) and (7) are equally allocated.

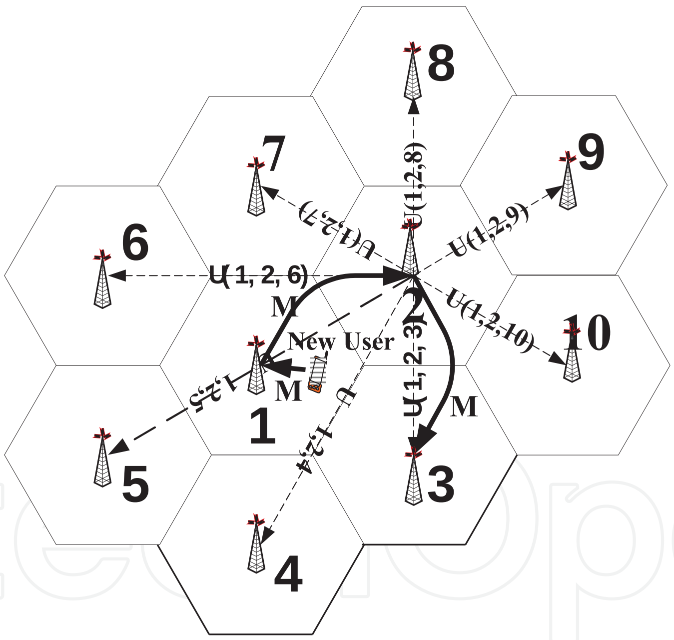

Figure 1. MUAC method in Group Cell

The application example of MUPAC in Group Cell architecture is shown as Fig. 1. The detailed implementation steps of MUPAC are shown as follows.

1. Access user initiates access attempt.

2. AP obtains the users' receiving pilot strength of each antenna.

3. Based on the information in step 2), AP calculates the utility of each antenna and available resource by utility function and chooses the first antenna and resource with the Maximum Utility Principle to form the serving Group Cell. If all the antennas detected by access user have no resource available, the access user will be transferred to the accessing waiting list. In Figure 1, the access user selects AE 1 as the first serving antenna with resource unit by Maximum Utility Principle.

4. AP obtains the users' receiving SINR of serving Group and compares it with user's QoS requirement. If current serving Group can provide adequate QoS to the user, the access process accomplishes successfully. Vice versa, the access user need more antennas added to the current serving Group. In Figure 1, the access user needs more antennas to get its desired QoS. So, AE 2 is chosen to be added in current serving Group Cell.

5. AP obtains the users' receiving SINR of antennas excluding current serving Group and chooses the antenna with maximum utility to add it to the serving Group Cell. This step needs to guarantee the new antenna and current serving Group Cell to use the same resource. The utility function includes the penalty of resource changing. Then, goes to step 4). In Figure 1, AE 3 is added and the serving Group Cell of AE 1, 2 and 3 has enough quality to serve the user with resource unit M.

2.2. Maximum utility principle access control with scheduling

When we are choosing the algorithms for access control, we always care about the quality of services, as well as the efficiency of resource assignment which is associated with the system capacity. Ensuring the QoS (quality of service) of access users' communications, MUPAC method gives the least sources to users to reach a minimum acceptable QoS. Considering the variable mobile communication environments and multi-user diversity, also the service experience of users, it will be helpful to implement scheduling into the process of access control.

2.2.1. Throughput Targeted-MUPAC (TT-MUPAC)

In order to make better use of the resources and reach higher system throughput, we should consider using scheduling in access control to adapt to different environments and make full use of the resources. When the system load is light, MUPAC is not good enough, especially in the condition of dealing with data services. If we make full use of system resources and increase the system throughput, it would be beneficial to either the users or the system. Throughput Targeted-Maximum Utility Principle Access Control (TT-MUPAC) brings out a good consideration on this point.

TT-MUPAC strategy gives different resources to different users in access control which depends on the system conditions. If the system is heavy-loaded with many services required, it gives the user the least resource to reach the required QoS. On the other hand, if the system is relatively light-loaded and there are many resources available, the access users will get most resource to improve system throughput.

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In TT-MUPAC strategy, MAX C/I scheduling algorithm is employed. The key point of combination of MAX C/I and MUPAC is to give some users more resource to get multi-user diversity in the system. In this way, we can improve the system throughput obviously.

2.2.2. Throughput and Fairness Targeted-MUPAC (TFT-MUPAC)

TT-MUPAC brings some advantages on system throughput, but when it comes to user fairness, the performance is decreased. Throughput and fairness are both important in access control strategy. So we should make some improvements on MUPAC and TT-MUPAC methods to reach a better performance on throughput and fairness. Throughput and Fairness Targeted-Maximum Utility Principle Access Control (TFT-MUPAC) method is proposed to achieve a balance between fairness and system throughput.

In the TFT-MUPAC strategy, the utility function should consider both system throughput and user fairness. In order to include the consideration of fairness into the access control strategy, we add a fairness factor into the utility function to present the improvement based on formula (1).

$$
\begin{aligned}
&U'(i, \ldots, j, k) = F \cdot G(i, \ldots, j, k) = \\
&\left(\frac{Raverage}{Rgenerated}\right)^{\gamma} \cdot \zeta_{Ck}[G_C(i, \ldots, j, k) - I_C(i, \ldots, j, k)] \\
&+\beta(1-\zeta_{Ck})\max_{M \neq C}\{\zeta_{Mi} \cdot \ldots \zeta_{Mj} \cdot \zeta_{Mk}[G_M(i, \ldots, j, k) - I_M(i, \ldots, j, k)]\}
\end{aligned}
\tag{8}
$$

F denotes the fairness of the service quality, which is,

$$
F = \left(\frac{Raverage}{Rgenerated}\right)^{\gamma} \tag{9}
$$

$G(i, \ldots, j, k)$ denotes the gain achieved by adding antenna k to current serving group. $R_{generated}$ is the service quality user can get with the target antennas when he is accessed. $R_{average}$ is the average service quality of the users already in the system. γ is the factor of fairness.

In the TFT-MUPAC strategy, antennas are allocated to receive a fairer QoS. At the same time the system throughput is also considered. Proportional fairness scheduling method is employed. In this way, system carries out a good performance on both system throughput and fairness.

2.3. Performance evaluation

For the performance evaluation and analyses, MUPAC method is taken for performance comparing based on Group Cell architecture. MUPAC chooses antennas and allocates resources according to the Maximum Utility Principle. The access point number of Maximum Utility Principle Access Control method is limited to 4. TT-MUPAC and TFT-MUPAC employs scheduling with MAX C/I and Proportional Fairness algorithms. System-level simulation is adopted to evaluate these three access control methods by comparing the successfully accessed user numbers with different system load (total access user number generated), system throughput and fairness. The power allocation for these three algorithms is the same as fixed power allocation scheme. The simulation parameters and setting are shown in Table 1.

Parameters	Setting
Traditional inter-site distance	$500\sqrt{3}$m
Group Cell inter-antenna distance	500m
Carrier Frequency	5.3GHz
Path gain model	25log10(d)+35.8 [10]
Shadow fading deviation	5dB
Total bandwidth	20MHz
Effective bandwidth	17.27MHz
Number of useful sub-carriers	884
Sub-carrier spacing	19.5KHz

Table 1. Simulation parameters and setting

The simulation results are shown in Figure 2, Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7.

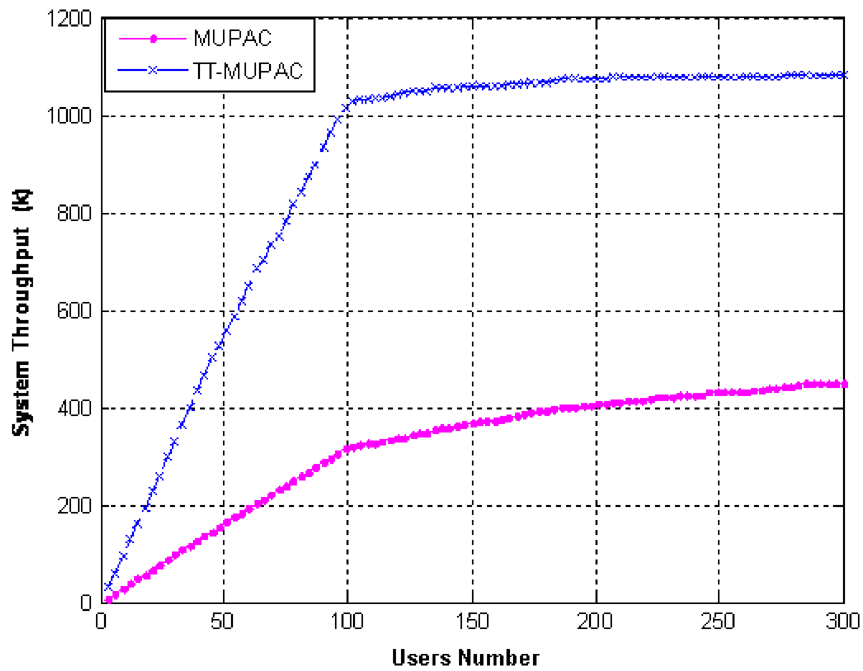

Figure 2. System Throughput of MUPAC vs. TT-MUPAC

Figure 2 shows system throughput of MUPAC and TT-MUPAC. TT-MUPAC has obvious throughput advantage over MUPAC scheme. The reason for this throughput gain mainly comes from multi-user diversity with MAX C/I scheduling. MUPAC only guarantees the minimum requirements of access users' QoS for maximum resource efficiency. By TT-MUPAC, scheduling is able to improve the throughput with light load.

Figure 3 shows access success rate of MUPAC and TT-MUPAC. MUPAC is better than TT-MUPAC, because TT-MUPAC use more resources for few users to get more throughputs. The relatively low efficiency of resource utility makes access users have less available resources and lows the access success rate.

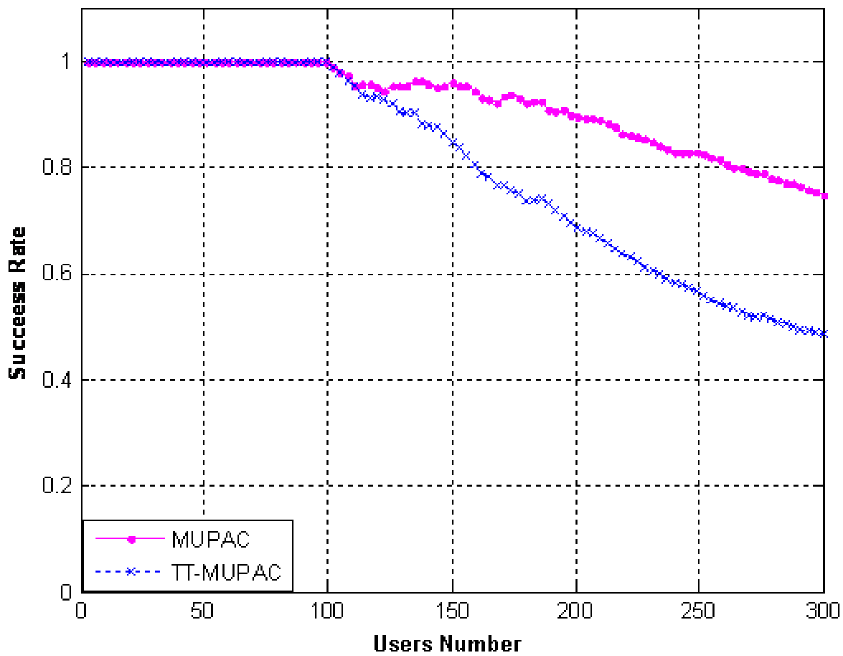

Figure 3. Access Success Rate of MUPAC vs. TT-MUPAC

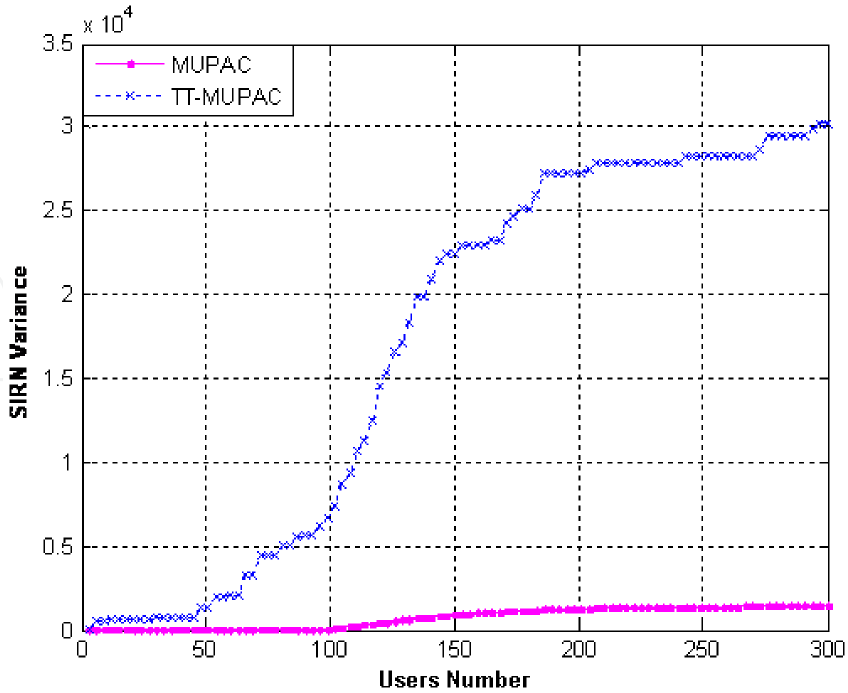

Figure 4. System Fairness of MUPAC vs. TT-MUPAC

Figure 4 shows the fairness of access users based on MUPAC and TT-MUPAC by SINR variance. From the simulation results, TT-MUPAC has worse fairness than MUPAC, which dues to the MAX C/I scheduling method.

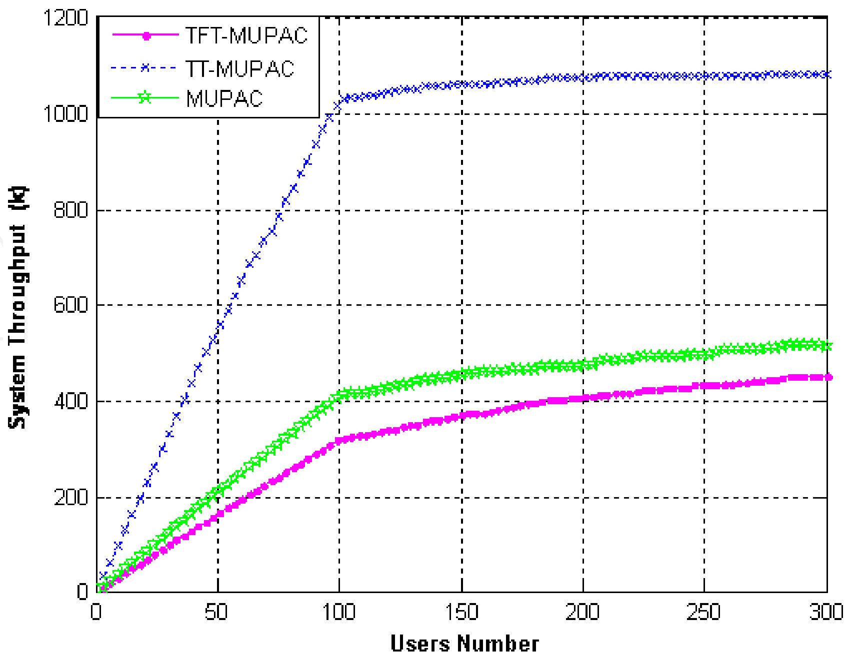

Figure 5. System Throughput of MUPAC, TT-MUPAC and TFT-MUPAC

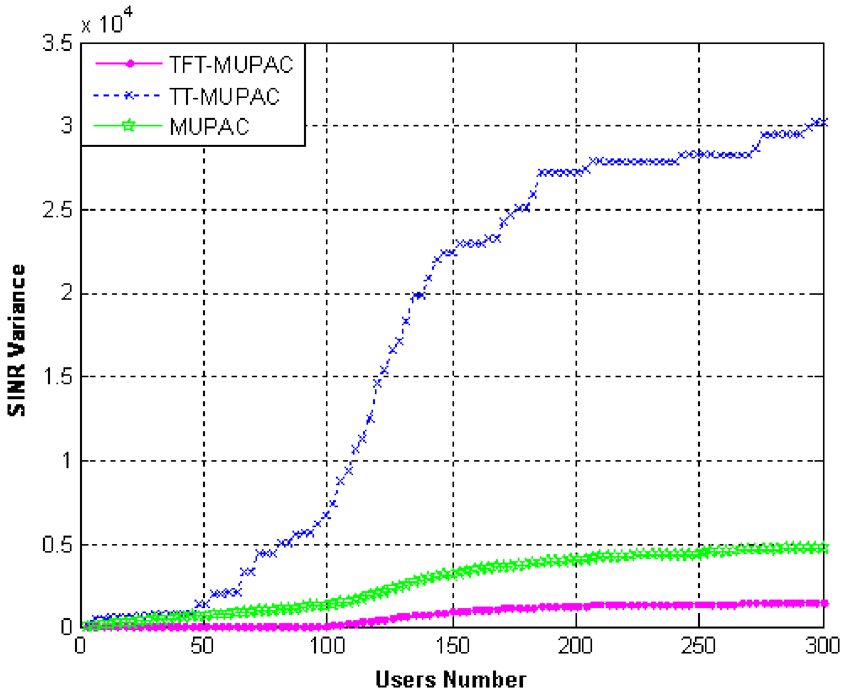

Figure 6. User Fairness of MUPAC, TT-MUPAC and TFT-MUPAC

Figure 5 and figure 6 show the performance of MUPAC, TT-MUPAC and TFT-MUPAC, including system throughput and user fairness. Figure 5 shows the throughput performance of MUPAC, TT-MUPAC and TFT-MUPAC. TT-MUPAC has the best performance and TFT-MUPAC has the worst performance with the features of scheduling methods. Figure 6 shows the user fairness of these three methods. TFT-MUPAC has better fairness performance than MUPAC and TT-MUPAC.

3. Maximum utility principle slide handover for vehicle environments

3.1. Slide handover strategy

Based on Group Cell architecture [8], Slide Handover strategy is proposed with multi-antenna slide windows [11]. Slide Handover makes user always in the centre of its corresponding serving Group Cell by adaptive changing the antennas to form the serving Group Cell. So, cell-edge effect is terminated to enhance the performance of cell-edge and guarantee cell-edge user data rate. This is also the basic requirement of 3GPP LTE and IMT-Advanced. For the user, the handover by Slide Handover strategy is not the user handover among antennas, but antenna choosing for always best user experience through the adaptive change of serving Group Cell.

But for Slide Handover, the handover rules or principles of adding new antennas and replacing or releasing existing antennas are based only on the pilot strength of each antenna. This will constrain the performance of Slide Handover, so, the principle and rule need to be proposed.

In [5, 6], Maximum Utility Principle Access Control method is proposed for multiple access point distributed network architecture, which can maximize the usage of limited system resources with guaranteeing access users' QoS requirements. MUPAC use Dijkstra's Shortest Path Algorithm and Maximum Utility Principle to represent the cost and utility in access control process. For Slide Handover, the Maximum Utility Principle can also be deployed with adaptive revisions.

This handover process is Slide Handover, as detailed shown in Figure 7 with highway environment [11], by which the users are always staying in the centre of Group Cell and the cell-edge effect can be eliminated. When the mobile moves at rapid speed, the size of the slide window will become larger so as to keep up with the movement of the MT and decrease the number of handover times. When the speed of mobile is relatively slow, the size of the slide window will become smaller to reduce the waste of resource. If the MT changes its moving direction, the direction of slide window would change at the same time.

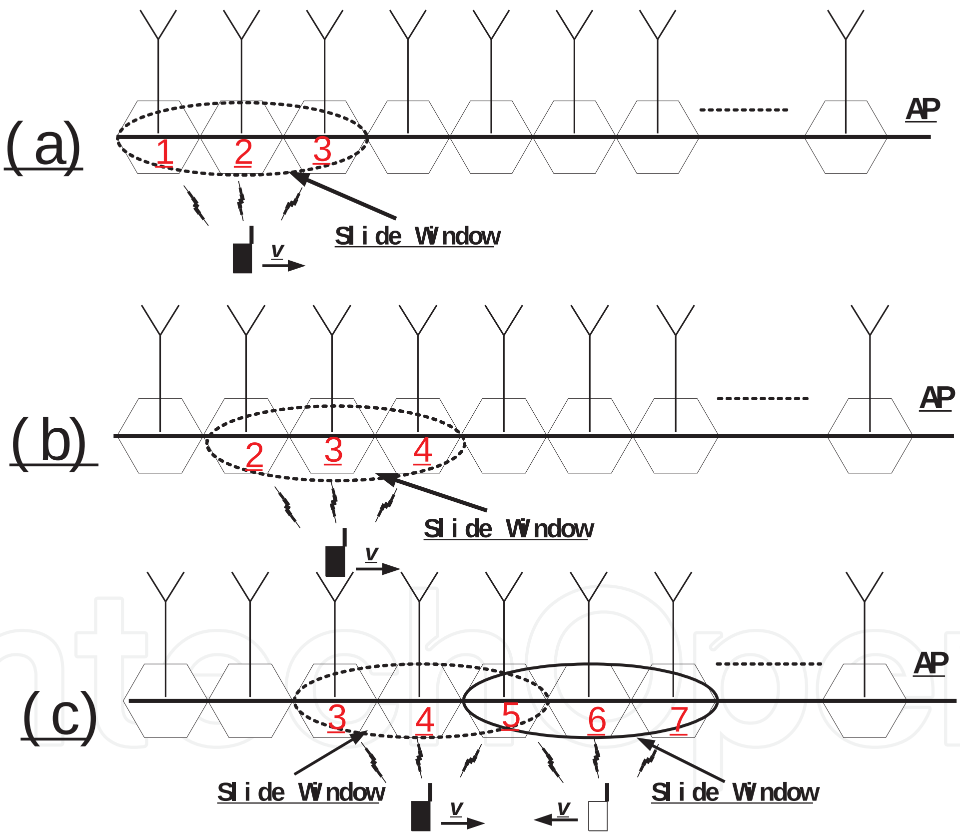

Figure 7. Slide Handover process in highway environment

Slide Handover strategy can complement the handover mainly in physical layer adaptively as AE updated, while the resources will be reserved and signalling in Layer 2 and Layer 3 will not be involved. After the handover, the handover result will be sent to the Layer 3. Slide Handover in Group Cell could be seen as only Layer 1 handover or AE scheduling, where AE is just a kind of radio resource in the multiple access point communication system.

Therefore, Slide Handover can effectively avoid the complicated interchanges of Layer 3 signalling among antennas inside APs and the latency of handover inside APs will be decreased dramatically.

3.2. Maximum utility principle slide handover strategy

Maximum Utility Principle Slide Handover strategy deploys the Maximum Utility Principle into the handover as the rule for adding, replacing and releasing AEs. The principle for adding, replacing and releasing AEs is determined by the utility of each AE to the users. The utility is defined with consideration of both the gain for handover user and the influence to the other users already in the system. Based on Dijkstra’s Shortest Path Algorithm, the construction of current serving Group Cell of AEs guarantee the users’ QoS requirements with the least numbers of AEs to improve system resource efficiency. Suitable AEs are chosen to form the serving Group Cell by their utility with Maximum Utility Principle. In fact, the Maximum Utility Principle corresponds to the shortest path in Dijkstra’s Shortest Path Algorithm. In the process of accessing new user and allocation resources, the optimal choosing multi-AEs to serve one user can be accomplished by adding AEs to user’s current serving Group Cell step by step to fulfil the users’ QoS requirements. Dijkstra’s Shortest Path Algorithm is used in the choosing of AEs by its nature of finding the “shortest path”. In this process, the “shortest path” represents the least cost in the access, which is also the maximum utility of adding AEs. This is the key points of Maximum Utility Principle Access Control method.

In Slide Handover strategy, we can still use the Maximum Utility Principle as the rule for adding, replacing and releasing AEs by appropriate definition of Utility Function. The Utility Function in Slide Handover is constructed with considering current system load, resource occupying and so on. The Utility Function has two objectives. One is used to add new AEs to current serving Group Cell with Maximum Utility Principle. The second is to releasing existing AEs in current serving Group Cell because their relatively lower utility. And the third is to select or negotiate resources allocated to the handover users with Maximum Utility Principle.

The utility function has two aspects, including the gain of AEs added in current serving Group Cell and the deterioration for other users in the system. Formula (6) and (7) can still be used in the Slide Handover process.

The detailed implementation steps of Maximum Utility Principle Slide Handover are shown as follows.

1. User initiates handover attempt when its receiving SINR of current Group is below the handover threshold.

2. AP obtains the users’ receiving pilot strength of current serving Group and other AEs.

3. Based on the information in step 2), AP calculates the utility of each AE and available resource by utility function and chooses the strongest new AE with the Maximum Utility Principle to add in the serving Group Cell. And the weakest existing AE with the Maximum Utility Principle is replaced and released. This step needs to guarantee the new AE and current serving Group Cell to use the same resources.

4. AP obtains the users' receiving SINR of new serving Group and compares it with the handover threshold. If current serving Group can provide adequate QoS to the user, the handover process accomplishes successfully. Vice verse, the handover users need more AEs added to the current serving Group.
5. AP obtains the users' receiving SINR of AEs excluding current serving Group and chooses new AE with maximum utility to add it into the serving Group or replacing existing AEs. This step also needs to guarantee the new AE and current serving Group Cell to use the same resource. The utility function includes the penalty of resource changing. Then, goes to step 4.

With the Utility Function defined above and Maximum Utility Principle, the Slide Handover can solve the problem of how to choose AEs in the handover process with suitable AE numbers and efficient QoS guarantee. Maximum Utility Principle Slide Handover can maximum the usage of limited system resource and guarantee the handover users QoS. With the advantages of Slide Handover in the physical layer exchanging signalling as AE selection inside AP, Maximum Utility Principle based Slide Handover will get further performance improvement.

3.3. Performance evaluation of slide handover strategy

For the performance evaluation and analyses, traditional Slide Handover strategy with only pilot strength or SINR threshold as the handover rule is taken for performance comparing with Maximum Utility Principle Slide Handover based on Group Cell architecture. Maximum Utility Principle Slide Handover chooses AEs and replaces or releasing AEs according to the Maximum Utility Principle. System-level simulation is adopted to evaluate these two methods by comparing the handover success rate, drop times and throughput in handover. The simulation parameters and setting are shown in Table 2.

Parameters	Setting
Traditional inter-site distance	$500\sqrt{3}$ m
Group Cell inter-antenna distance	500m
Carrier Frequency	5.3GHz
Path gain model	25log10(d)+35.8
Shadow fading deviation	5dB
Total bandwidth	20MHz
Effective bandwidth	17.27MHz
Number of useful sub-carriers	884
Sub-carrier spacing	19.5KHz

Table 2. Simulation parameters and setting

In the simulations, the traditional Slide Handover strategy is denoted as SWHO, the Maximum Utility Principle Slide Handover strategy is denoted as MU-SWHO. The simulation results are shown in Figure 8, Figure 9, Figure 10 and Figure 11.

Figure 8 shows the handover success rate of these two Slide Handover strategies. From the simulation results, Maximum Utility Principle Slide Handover strategy has obvious improvement over traditional strategy because of the rules presented by utility rather than the pilot strength of AEs only. The utility not only contains the gain to the handover users, but also the influence to other users in the system, which makes AEs and resource use more effectively. In some extent, Maximum Utility Principle Slide Handover strategy has the effect of interference mitigation. So, the handover success rate of new strategy is further better.

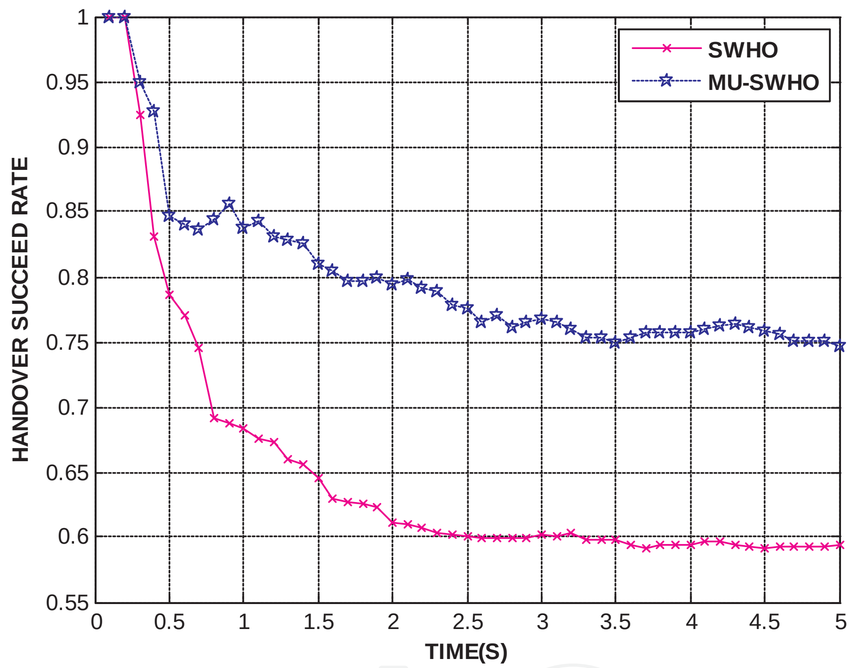

Figure 8. Handover success rate

Figure 9 shows the system throughput of these two Slide Handover strategies. Maximum Utility Principle Slide Handover strategy also has improvement at system throughput in handover process. The reason is that the users in handover choose the best AEs by Maximum Utility Principle, which improves system throughput and also mitigates the interference. The system can achieve optimization.

Figure 10 shows the drop rates of these two Slide Handover strategies. Maximum Utility Principle Slide Handover strategy still has improvement over traditional strategy. Because Maximum Utility Principle Slide Handover strategy chooses AEs based on the users' QoS guarantees and always tries to use as little as AEs to accomplish handover. This will avoid users drop in handover process and improve the resource efficiency with more resources saved for the other users.

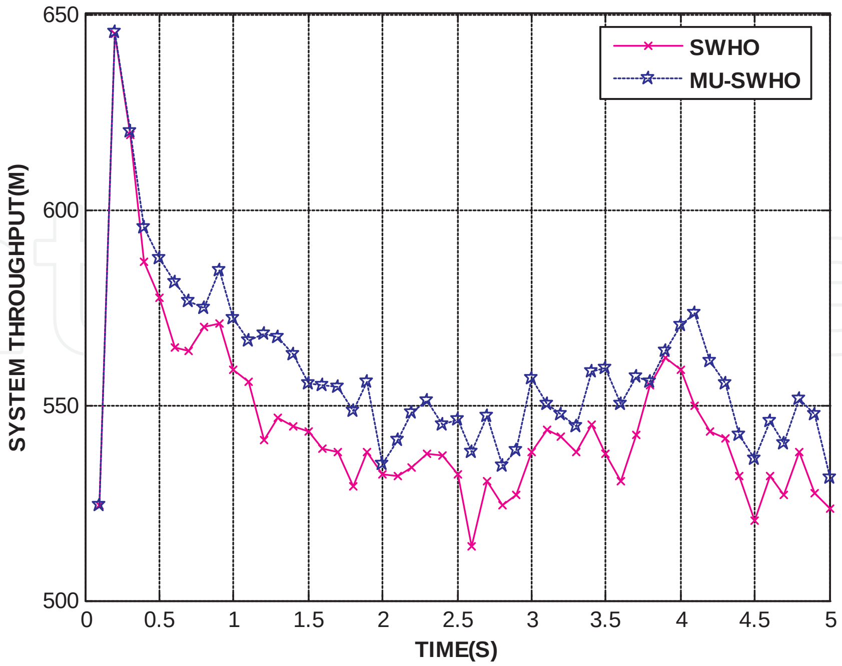

Figure 9. System throughput

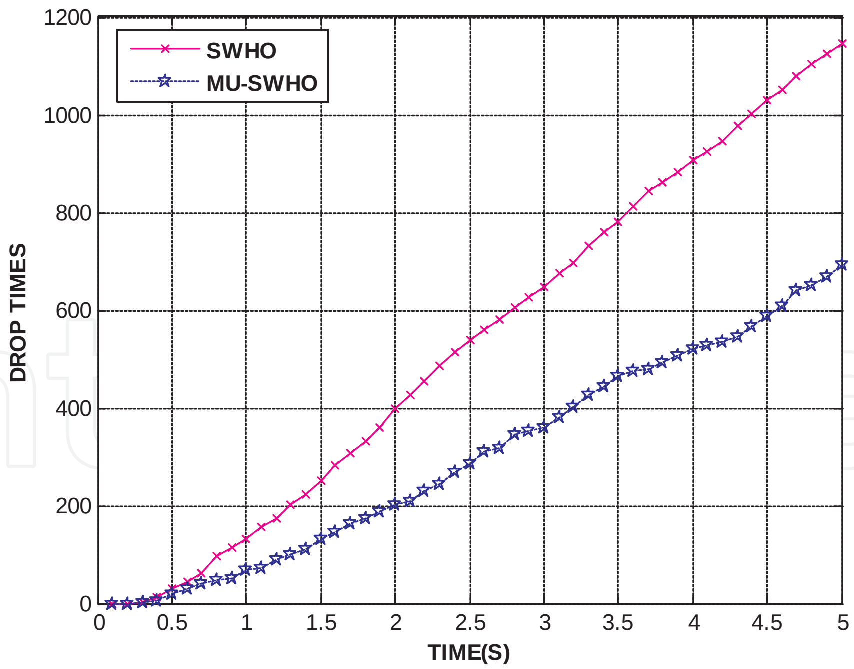

Figure 10. Drop times in handover process

Figure 11 shows the average SINR of AEs inside handover serving Group Cell by these two Slide Handover strategies. By Maximum Utility Principle Slide Handover strategy, the antennas in the serving Group has better utility than traditional strategy because Maximum Utility Principle only chooses the antennas which have the maximum utility to add in the Group. This will further improve the resource efficiency with more resources saved for the other users.

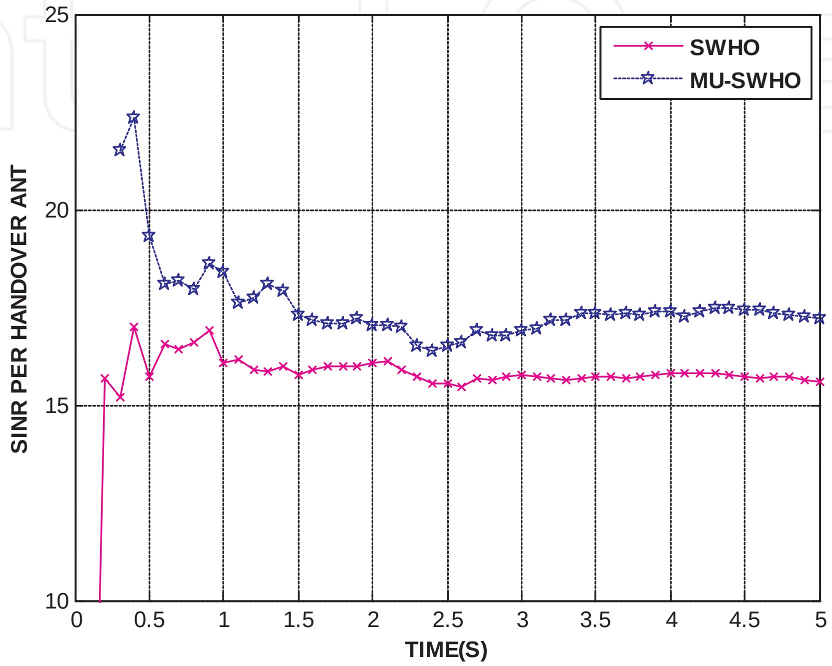

Figure 11. SINR per AE in handover process

4. Summary

Maximum Utility Principle was proposed for multiple access point cooperative communication in vehicle environments based on Dijkstra's Shortest Path Algorithm, which is applied in Access Control method and Slide Handover strategy to improve the performance of mobile communication especially for high speed mobility scenario.

For Maximum Utility Principle Access Control scheme, this chapter presented two improvements for MUPAC with scheduling algorithms. With combination of scheduling and access control strategy, Throughput Targeted-MUPAC and Throughput and Fairness Targeted-MUPAC can get better performance of system throughput and user fairness with appropriate resource utility efficiency to accommodating different situation of system load and access users. Performance evaluation and analyses verify the merits of TT-MUPAC and TFT-MUPAC algorithms in improving system throughput, accessing success rate and user fairness.

For Maximum Utility Principle Slide Handover scheme, this chapter introduced new rules of adding new access points and replacing or releasing existing access points. The Utility Function in the Slide Handover and steps for handover were described in this chapter and system-level performance evaluation was provided to verify the merits of handover successful rate, drop times and so on.

There will still be more challenges for higher mobility vehicle environments, such as the user QoS guarantee and optimal resource allocation and scheduling. More research outcomes need to be achieved.

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