國 立 交 通 大 學

電子工程學系　　電子研究所碩士班

碩　士　論　文

第三代 cdma2000 無線系統上的接收通道效能研究

Access Channel Performance Studies for Third Generation cdma2000 Wireless Systems

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中華民國九十三年七月

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第三代cdma2000無線系統上的接收效能研究

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摘　　要

第三代無線個人通訊系統中，將會支援有更多的簡短資料。為了要避免過多的接受碰撞，和為了傳送更長的資料封包，因此cdma2000提出名叫保留模式的接收模式。本篇論文將先以由接收流量造成的接收成功率，延遲時間，接收通道干擾來研究保留模式的效能，然後與之基本接收模式作比較。最後根據分析的結果將可決定通道容量。

Access Performance Studies for Third Generation cdma2000 Wireless Systems

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Department of Electronics Engineering & Institute of Electronics

National Chiao-Tung University, HsinChu, 2004

Abstract

In the 3G wireless personal communication system, more short data burst services will be supported. To avoid excessive access collisions, a new access mode called reservation access mode (RA) is proposed in cdma2000 for transmitting longer packet data. This thesis will first study the reservation access mode performance in terms of the success rate, delay time, and the access channel interference caused by access traffic and then compare with the basic access mode. According to the analysis results the access channel capacity can be decided.

Acknowledgement

At first, I want to thank Dr. ChingYao Huang, my advisor, for sharing the research experience and knowledge. Also thanks to his proposal when I met difficulty. Then I want to thank my family for my fully supporting and encouragement. And then thank my group members 羅文嶽(Wen-Yue Lou), 高振哲(ChenTzu Kao), 莊振坤(Chen-Kun Chuang) for their discussions and research suggestions. Thank 蘇慧源(Huei-Yuan Su), 邱彥翔(Yan-Shiang Chiu), 曾勇嵐(Yung-Lan Tseng), 范裕隆(Yu-Long Fan) for their suggestions for my presentation. Thank 蔡明原(Ming-Yuan Tsai) for his helping in my rehearsal day. Thank 周建銘(Chie-Ming Chou)for my thesis suggestions. Finally I want to thank 施雲懷(Yuan-Hwai Shih), 邱大瑜(Da-Yu Chiu), 李宜鍵(Yi-Chien Li), 張正達(Cheng-Ta Chang), for their helping in lessons and homework discussions.

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Chapter 1 Introduction

1.1 Background

In a CDMA system, control channels are used to communicate the Mobile station (MS) and the Base station (BS), when a MS is not assigned the traffic channel, i.e. the MS is not busy. In IS-95 there are two control channels to communicate with the MS, paging channels and access channels. On the forward link the paging channels are used to transmit system messages from the BS to MS. The system messages include system parameters, access parameters, CDMA channel list, a neighbor list, and messages directed to the mobile stations such as general page messages , alert, abbreviated alert, release, acknowledge, and so on. On the reverse link, the access channel is used to transmit control messages from MS to BS. The messages include paging responses, service requests, short service messages (SMS), and registrations. In 3G cdma2000 the forward link control channel is divided into three channels, the quick paging channel, broadcast channel, and forward common control channel. In 3G systems, quick paging channel is used to save the battery, by reducing the mobile wake up time. The broadcast channel broadcasts the overhead messages within the cell coverage. The Forward common control channel carries acknowledges, SMS, channel assignment messages, and so on and it can operate higher data speed than paging channel in IS95.

On the reverse link, the access channel works as a bridge between the MS and the BS before the assignment of traffic channel. The access channel transmits the control messages and signaling from MS to BS. We call this action access. The importance of the access channel is that it's a bridge between the BS and the MS. In the thesis we can know the parameters to evaluate the capacity of the access channel. In other words, it shows how many attempts arrival in one second is the maximum usage which access channel can handle and provide the general quality for all users in the cell. The important signaling messages include paging response, registrations, and user requests. For a registration fails, the BS will spend more paging resource to page this MS. And similarly if the paging response fails, the BS will page the MS again by the paging strategy. In the cases BS waste too many paging messages to page the MSs and the paging channel will overload.

All the signaling messages which sent on the access channel divide into two parts according to time sensitive or not. In CDMA2000, the access channel can be operated two modes: basic access mode (BA), reservation access mode (RA). The basic mode uses forward common control channels, and the system transmits overhead messages on broadcast channels and access channels. In [1], they compare the control channels for 3G including W-CDMA and cdma2000. In the paper, the access channel in WCDMA is superior to cdma2000 access channel operating in basic access mode. There are discussions in IS95 about the paging channel and access channel they provide a paging channel model and access channel model [2]. The result is the relationship about the time delay and user arrivals. In [3-4] the paper discusses the performance of the control channel in TDMA system and the cellular network system. In [5-6], they describe the 3G system for Universal Mobile Telecommunication System (UMTS), and describe random access procedures in details. The papers discuss the access channel capacity and how to decide the performance of the access channel in IS95 [7-8]. In [9] the paper presents the control messages and makes a traffic assumption to calculate the channel occupation. In cdma2000 enhanced random access and reservation mode are writing in details [10]. In [11], the paper discusses the scenario which has single user and single base station. They discuss the message size and the probe impact to the transmission delay time during the channel variation using log-normal fading model.

1.2 Organization of this thesis

The contribution of this thesis is to analysis the performance of the access operating in basic access and reservation access mode in cdma2000 and to recommend how to decide the capacity of the access channel. We will analyze the impacts of the access traffic. There are three parameters to discuss their sensitive to the variation of the system loading. They are success rate, delay time and access channel interference.

These three performance parameters can be used to decide to critical point to the other important performance parameter: the access channel capacity.

The new proposal in cdma2000 is the reservation access mode. We will discuss it in details. The remaining chapters are organized as follow: Chapter 2 contains the description of BA and RA in the access channel and the problem statement. Chapter 3 will discuss the simulation model. Simulation results are presented in Chapter4. Chapter5 is the conclusions.

Chapter 2 The Description of cdma2000 Random Access and Problem Statement

This chapter will introduce the mobile access protocol. The MS transmits messages using the access channel by the slotted-ALOHA access method. The slotted-ALOHA method improves the original ALOHA scheme. It makes access the packets more efficiency than original ALOHA scheme. We divide the transmission time into the same slot as the packet transmission time slots. All users aim at the slots to transmit the packets.

2.1 The Description of cdma2000 Random Access

In cdma2000 it provides two random access mode, the basic access mode (BA) and reservation access mode (RA). We usually use basic access mode to transmit short data or time-sensitive signaling messages, like paging response messages and registrations. The reservation access mode is used to send long messages and non-time sensitive messages.

In wireless systems, the MS uses the power ramping scheme to do with the access process. The main reason for power ramping is the fading channel. The mobile will use the open loop power control to send its attempt because large power will cause more interference for the other users in the cell. In other words, the multiple access users may cause interference to every user. Due to this reason, power needs to increase every step. For example, in CDMA, one use get a lower power from the BS, and the MS will increase the transmitted power to the BS. Because of the reason the MS increases its power. And then the MS generates the lager noise for the other users in the same cell. The Ec/Io of the other MS becomes lower. Io means interference. The other MS need to transmit a larger power to the BS. At this time, the one gets lower Ec/Io, it should transmit larger power. We can know all users in the same cell will interfere with each other. From now on, power control is a problem, and it needs to solve. In the access channel, we use ramping power method to control the MS power in a cell.

2.1.1 Basic Access Mode (BA)

Now we discuss the basic access mode in cdma2000. The basic access mode attempt (a probe) consists of the preamble, the header and the data, as shown Figure 2-1. A probe sequence consists of many probes. The MS chooses one of the EACH and transmits its access probe. After the probe transmission finishes, the MS will wait for the acknowledgement in the FCCCH. If the MS gets the acknowledgement, it means the random access successfully. If no acknowledge the MS needs to access again. The MS will increase the power to send the next probe after the random back-off time. It is called power ramping access. The MS increases transmission power according to the power step increment, not suddenly increases a bigger power. If the MS transmits too lager power, it will interfere the other MS in talking.

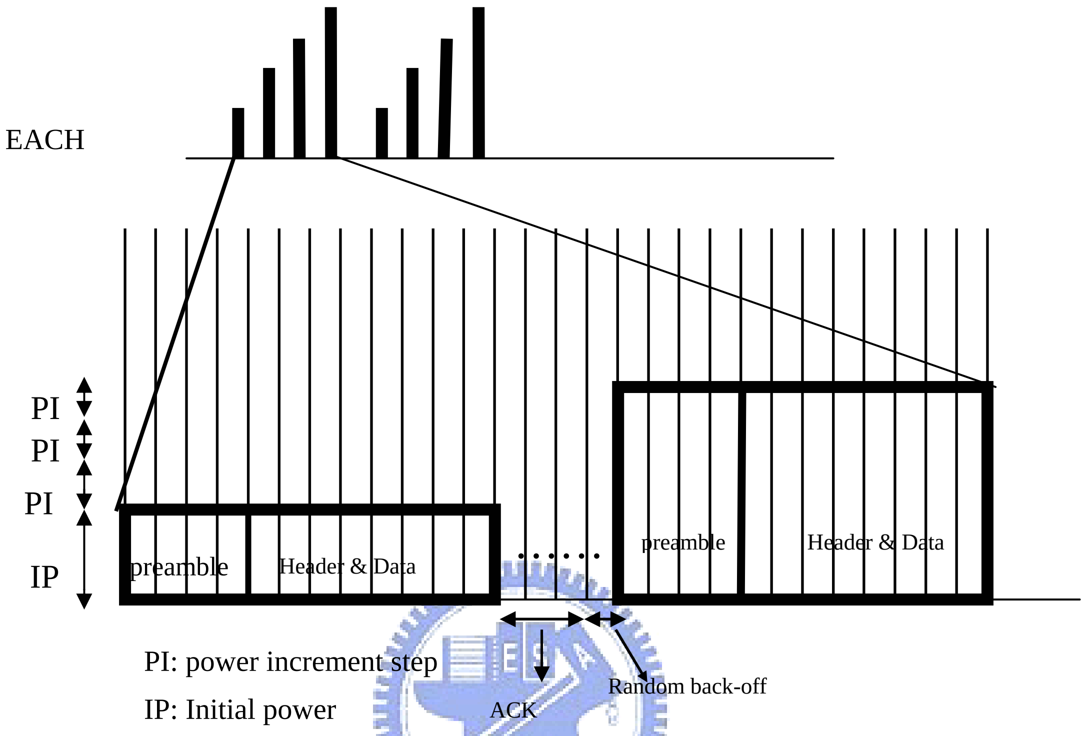

Figure 2-1 Basic access mode operation

2.1.2 Reservation Access Mode (RA)

When operating in the reservation mode, the probe which forms by a preamble and followed by a header only is sent on the enhance access channel, as shown in Figure 2-2 and Figure 2-3. Before the MS transmits its probe, the MS must read the inhibit bit on the Broadcast Channel (BCCH). The inhibit bit has two states, one is busy: the state indicates someone is using the Reverse Common Control Channel (RCCCH) to send its file. The other is idle and it means the Reverse Common Control Channel (RCCCH) is empty and the MS can send its probe. If the probe is accepted by the BS, BS will transmit the Reverse Common Control Channel (RCCCH) assignment on the Forward Common Acknowledge Channel (FCACH) and power control bit on the Forward Common Power Control Channel (FCPCH) to the MS.

The MS gets the above signaling messages, and the MS transmits its packet consisting of the preamble and the data on the Reverse Common Control Channel (RCCCH).When the data transmits completely, the BS sends access messages acknowledge to the MS and release the RCCCH. The inhibit indication turns idle. Other MS can continue process their random access procedure.

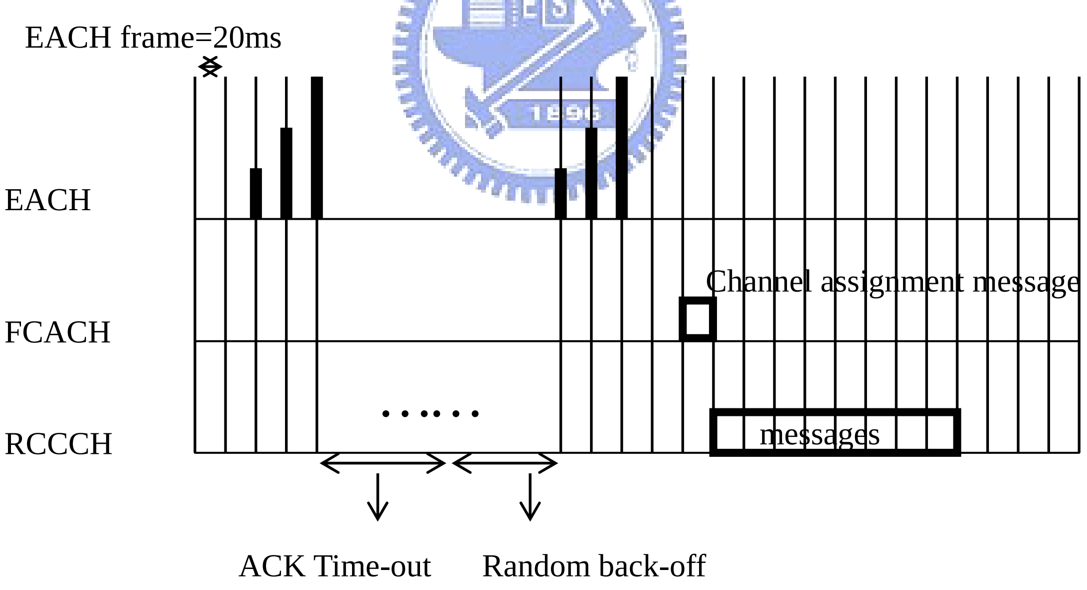

Figure 2-2 The Reservation access mode operation

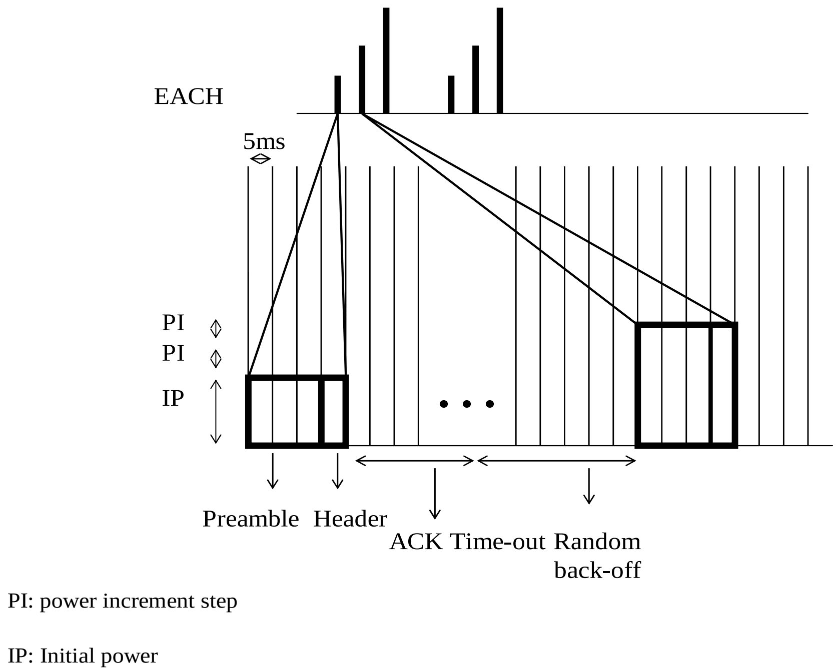

Figure 2-3 the access probe describes in details

2.2 Access channel problem statement

Because of long packet data applications the conventional random access scheme i.e. basic access mode in cdma2000 might not be able efficiently to process the packet data. If a lager packet wants to be sent, the MS will choose the reservation access mode to send this packet. A larger packet often spans over several frames. If the basic access mode is used to transmit the packet, the collision probability will be high and result in more probes MS should be used. More probes will have long latency. In other words the efficiency of the access process becomes low. When the load of the system is getting higher, due to the collisions the success rate is getter worse. Due to collisions the delay of the mobiles operating in cdma2000 is much longer than the mobiles operating in IS-95. The capacity of the access channel will be defined by several parameters including delay, success rate, etc. There is long latency and it will reduce the capacity of the access channel. For above reasons the new access scheme is proposal in cdma2000 to solve these problems. We can have the delay and success rate which we can endure.

2.3 The access channel performance and the channel capacity definition

We will discuss the performance of the access channel. At first, we use the access channel to transmit the registrations, paging responses, paging requests, and short message services. So we think the capacity of the access channel is one of the performances to evaluate the quality of the channel. Secondly, we also can compute the access delay to evaluate the access channel. The time from the completion of the transmission of the first probe until the time the mobile station receives an acknowledgement defines the delay. For users' viewpoints the delay time is important. No one wants to wait long call setup time or SMS transmission time.

Access channel interference is also important. We use the common power control channel and help MS save battery and the MS can be used longer. The power control and hand off algorithm will help the system to arrive the target. For example the proper power control algorithm can improve the signal to interference ratio.

Although we use probe ramping scheme the power will interfere the traffic channel. In other words, the access channel will interfere with the users who are chatting or discuss their business. We say that the system must avoid disturbing these users. If the transmission power is too large, the soft capacity of the system decreases. Due to the capacity of the system is inversely proportional to Io. Io means interference. If the MS uses the lower Io, the system can support more MSs in the cell. For the reason signal to interference ratio is the important parameters to evaluate if the access design is good or bad.

The final parameter is the success rate. For the system point of view, we want good success rate. The high success rate means the system can service the more users in the cell. For example, if a MS is paged. But the random access process fails, the MS will be paged again by the general paging messages, it cannot transmit a paging response to the BS. In this case, depending on the paging strategy, the system uses the paging channel to page the MS again or more. It wastes a lot of paging resource to page the MS. In other words, more paging actions will cause the paging channel or the forward common control overload.

According to the delay, success rate, and interference, the plots could be found out the channel engineering limit. The curves may increase nonlinearly when the arrival rate grows up. Totally considering the three we can choose the high success rate, linear delay time, and linear access channel interference to decide the capacity of the access channel.

Chapter 3 Simulation Flow

Chapter 3 will provide the simulation flow of the program including RA and BA. It includes random access procedures, power ramping and we execute the simulation programs and plot the performance curves. The input parameters are arrival rate, PI, and initial SIR to do the sensitivity analysis. The power of the MS goes through fading and multiple access interference and accepted by the BS. The BS detects success or fail according to the collisions and enough power. Finally we can calculate the overall MSs and their performance parameters to plot the graphs to analyze.

3.1 Simulation environment setup

First we see our access simulation flow charts.

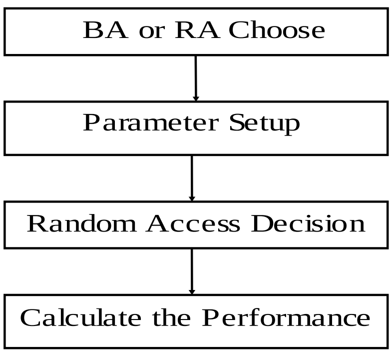

Figure 3-1 Configuration flow graph

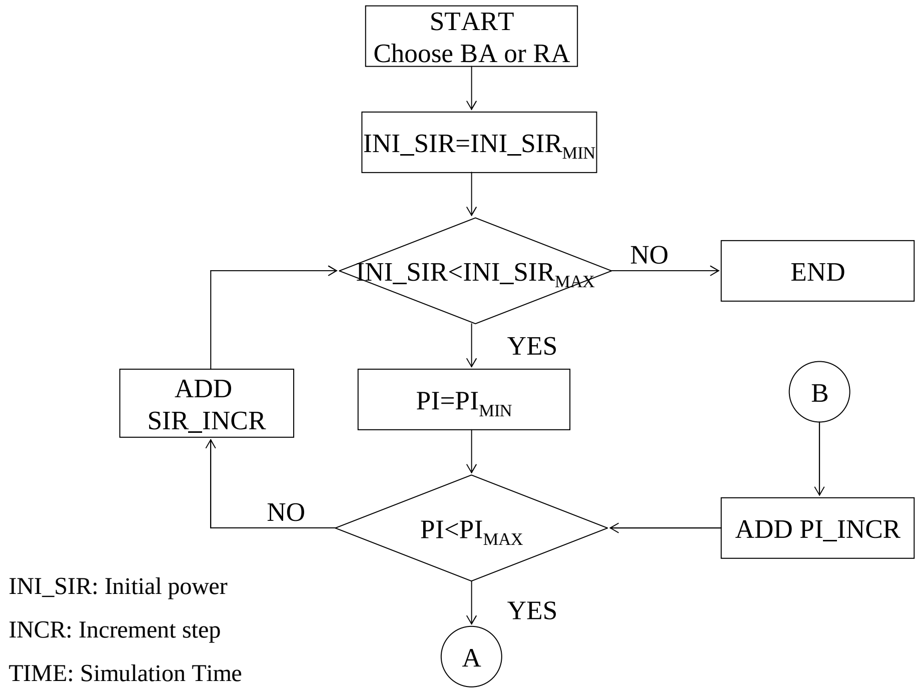

Figure 3-2 initial condition setup

Here are four parameters about the simulation condition: initial signal to interference (SIR) ratio, power increment value (PI), arrival rate (ARR), simulation time. In the Figure 3-2, the MSs must choose the BA or RA and we will have the ini_SIR and PI value. In Figure 3-3, according to the arrival rate we put the mobiles in the queue and assign the same SIR value, the same power increment (PI) value, and different arrival time offset for all mobiles in this cell. We give the initial condition and start the timer and then execute the random access process. If a mobile access successfully by the BS the timer adds one slot or assigned slot by using BA or RA and go back to the queue to random access the mobiles which are not access successfully. When the timer expires, we clear all MSs in the queue and add arrival rate according to the arrival rate

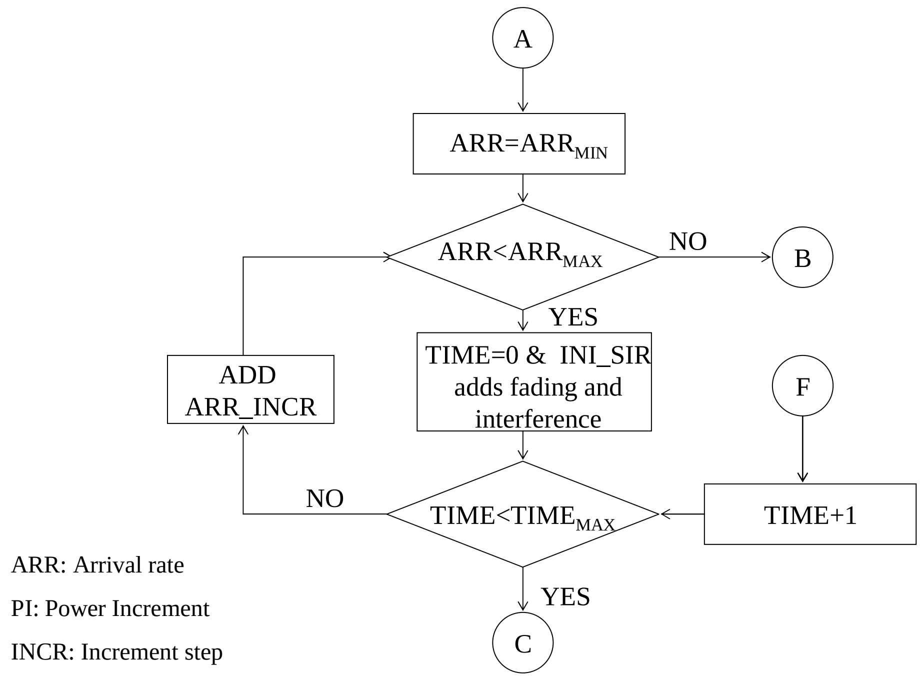

Figure 3-3 Initial condition setup

increment step (ARR_INCR).We can get a new arrival rate. This arrival rate is sum of the previous arrival rate and the arrival rate increment step. Again put the MSs in the queue according to the new arrival rate. The SIR and PI are the same as pervious cycle and then run the random access process again. This cycle is repeated by only changing the arrival rate until the new arrival rate lager than the arrival rate maximum we define. When the condition happens, we go back to change the power increment step. The new power increment step is the sum of the old power increment step and PI increment (PI_INCR). Here we increase the PI and we run the cycle again from the minimum arrival rate to maximum arrival rate. It means we have the same ini_SIR but different PI to run the random access again. When the PI value gets to the maximum value, the cycle will go back to set the initial SIR. The new initial SIR is sum of the old initial SIR and SIR_INCR. When we have new ini_SIR, do the above process again.

3.2 Random access process details in Reservation Mode (RA) and Basic Mode (BA)

In the random access process (Figure 3-4), if the signal to interference (SIR) of the mobiles is higher than the SIR of the BS predefined, the BS will check whether the mobile collision or not. If the SIR of the mobile is not, the access process fails and this mobile needs to reschedule. When the mobile collides, the access process fails and the mobile needs to reschedule. Neither collides nor the lower SIR than the BS, the mobile access successfully by the BS.

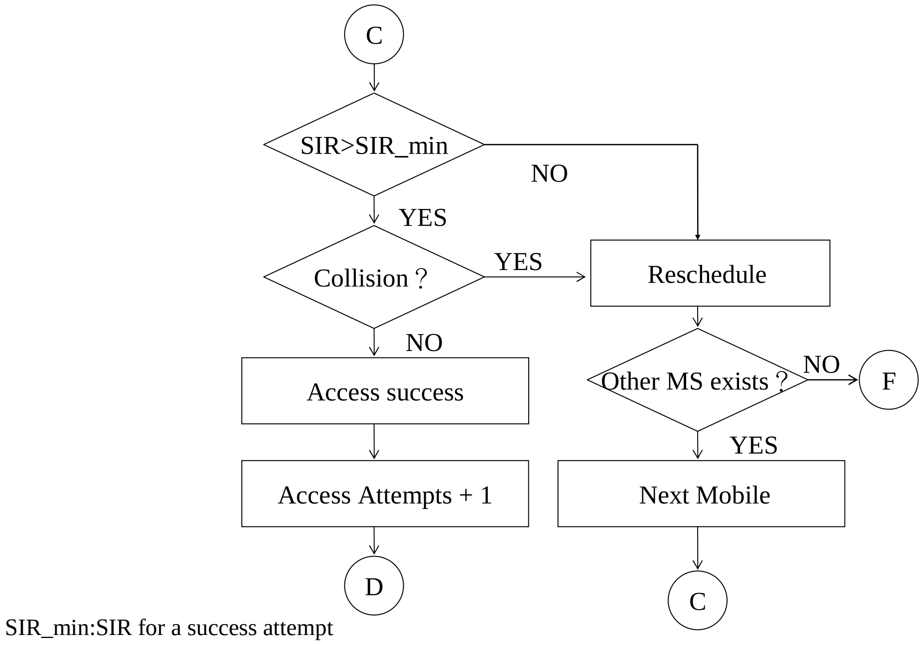

Figure 3-4 Random access flow

In BA (Figure 3-5) the others mobiles which don't get the acknowledgement will go back to the queue and then retransmit the probes by using power ramping method and back-off strategy. Here we say that all fail MSs will be rescheduled. The mobile which is accepted by the BS will record its SIR, delay time, and the total number of the success mobiles adds one, and we calculate the performance about the access channel. Finally remove the successful mobile from the queue.

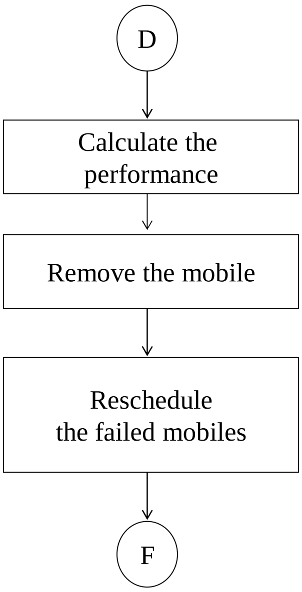

Figure 3-5 BA MODE

In RA (Figure 3-6) the MS is successfully accepted by BS. The BS sends the channel assignment messages to the successful MS and the MS can upload its messages during the reserve time which the BS will tell the other users who are in this cell. The BS will broadcast the inhibit bit to tell all the other MSs. The other MSs cannot send their probe until the BS turns off the inhibit bit. The MS which accesses successfully will record its performance parameters and then remove it from the access queue. During the reserved time, the queue still adds the new MSs according to the arrival rate. But new arrival MSs and the fail MSs only permit to transmit their probes when the inhibit bit is off.

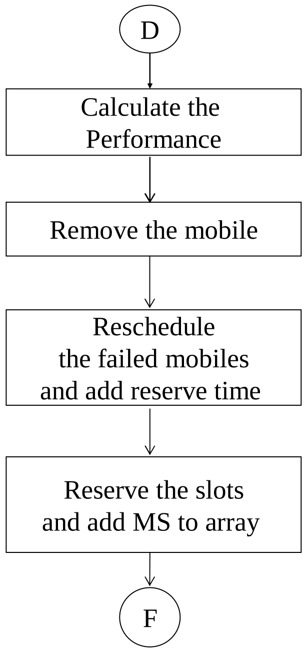

Figure 3-6 RA MODE

3.3 Simulation Model

This section will present the simulation model and use the parameters we defined to evaluate the access channel and finally we can decide the channel capacity. In Figure 3-7 the all input parameters, the system mode, and the output performance parameters are showed .Here we have one BS which has one enhance access channel (EACH) and one Reverse Common Control Channel (RCCCH) only. If the MS access successfully, the other MSs cannot send their probes during the time which the successful MS gets its channel assignment and transmits the messages. All the new MS should transmit their probes in the time slot which is right after the previous successful MS complete their data messages.

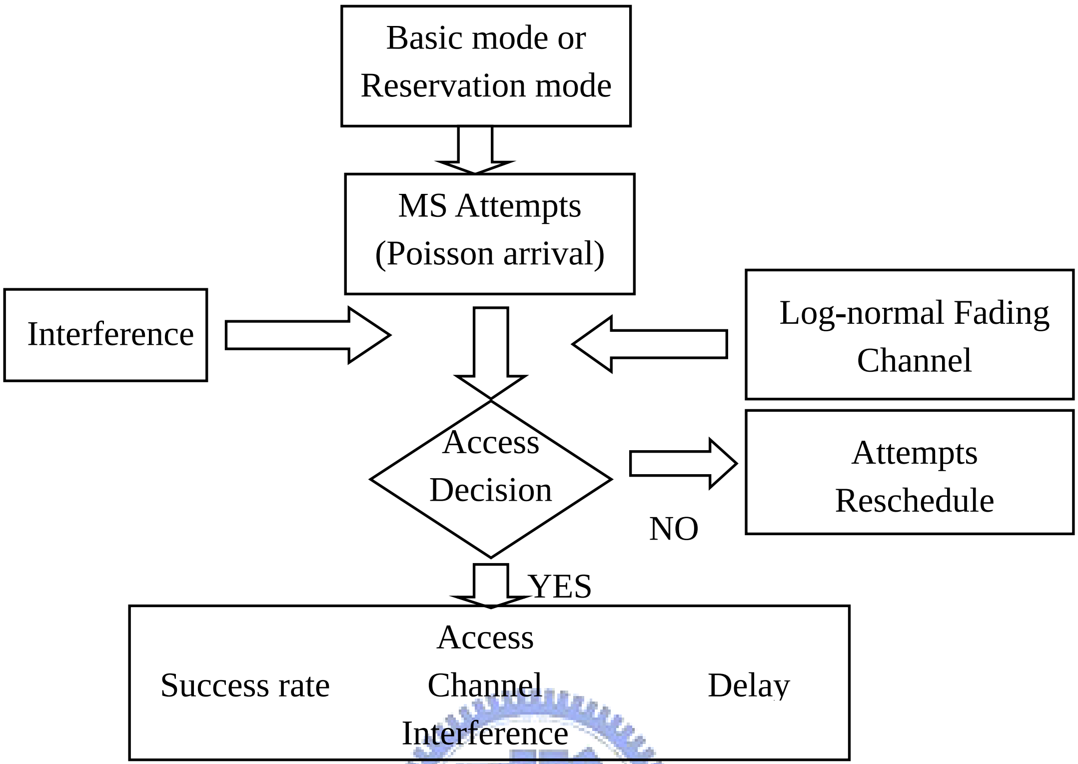

Figure 3-7 Simulation model

We fix 20ms frame size to be the unit of the header and preamble. The header size is 5ms and the preamble part is 15 milliseconds. In real system the preamble size would be variable [11]. The total time including channel assignment delay and reservation slot is multiples of 20ms.The fading channel between the BS and the MS is the log-normal fading channel with zero mean and 8dB deviation.

Later, we discuss the random access flow and the condition of the random access success or not. At first the MS uses open loop control mechanism to set the initial power. If a probe goes through the fading channel and arrive the BS, the SIR of the probe is over the threshold and the BS can detect the MS. But there are more than two probes arrive at the same time the BS can't detect the MS. Here the collisions happen if two MSs arrive within 2 chips. We call these MSs collide. They need to back off and increase power to retransmission. For the messages part, this work does not use the close loop control algorithm. In every access channel slot, the MSs arrive according to the Poisson distribution given the mean. The mean we give the Poisson distribution presents how many attempts (MSs) arrive per hour. We change the mean to execute the access process to observe the traffic density impact to the success rate, delay time and the access channel interference to the traffic channel.

Now we give the definition of the performance parameters.

The success rate is defined the successful MS over the all arrival MSs

$$success\_rate = \frac{success\_MSs}{all\_arrival\_MSs}$$

(5.1)

Here "all_arrival_MSs" means all the mobiles arrives in the simulation time, and "success_MSs" means the MSs which accesses successfully by the BS.

The access channel interference to the traffic channel ratio is

$$Access\ channel\ interference\ ratio = \frac{sum\_access\_channel\_power}{traffic\_power * sim\_TIME}$$

(5.2)

Traffic power means the power of the dedicate channels, and we assume it is constant and the system loading is 50%. In general we keep the interference margin below ten percent of the traffic channel loading [7].

Delay time = random access process time + message size

(5.3)

Here the unit of the process time and message size is millisecond (ms).

To understand the effect caused by various parameters, a sensitive study including initial signal to interference ratio, power increment step, arrival rate, reservation slot length, attempt probe numbers and probe sequence numbers are investigated.

Chapter 4 Simulation Assumptions and Simulation Results

In this chapter, the assumptions are given and the final simulation results are created under the assumptions. There are three parameters, ini_SIR, PI, arrival rate to plot the simulation graphs. In the graphs, we can decide to define the channel capacity in the performance study. In the other words, we can decide the channel capacity from the trade-off between the success rate, delay and interference.

4.1 Simulation Assumptions

The previous chapter present the simulation flows. Here the assumptions are displayed.

Table 4-1 Assumptions

Full name	Value
Initial SIR range	-18,-14,-10 dB
Power step range	1,3,5,7 dB
Arrival rate range	0.1 ~5.1 attempts/sec
SIR for a success attempt	-12 dB
(Max sequence ,Max number)	(1,8) , (2,4)

Collision interval	2 chips
Simulation time	300000 slots

Here the probe number is 4.Besides first probe, the MS can increase 3times.For example, if PI=1 the final power increases 3dB than the original. In other words, the final power is twice than the original power.

4.2 Simulation results

4.2.1 The performance analysis of the Reservation Mode

We will show the simulation results according to the above simulation model and simulation flow. Here are the graphs about the success rate when the MS is operating in the reservation access mode. We set the different initial signal to interference ratio to observe the performance issue.

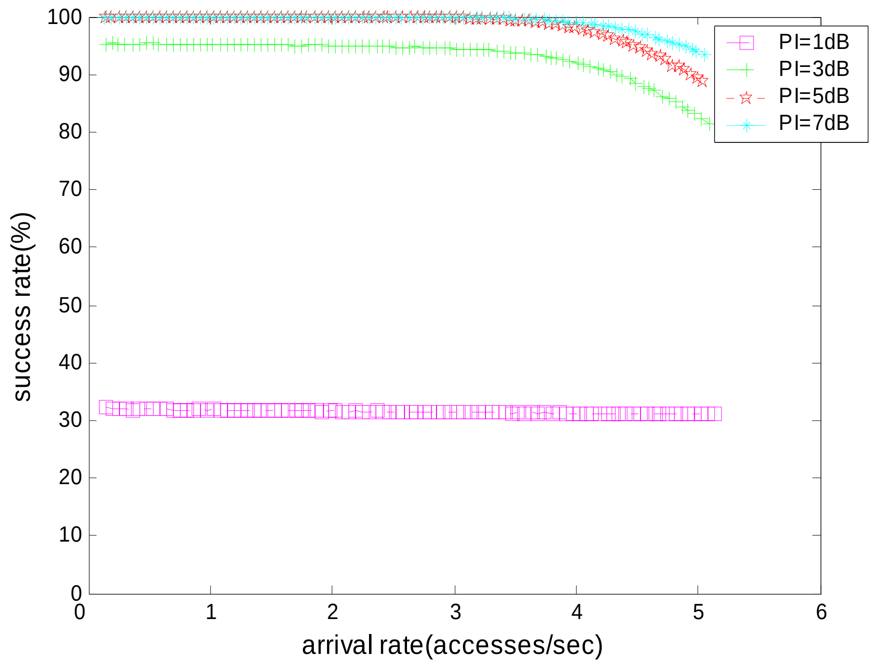

Figure 4-1 RA: success rate in the initial SIR is -18dB (2, 4)

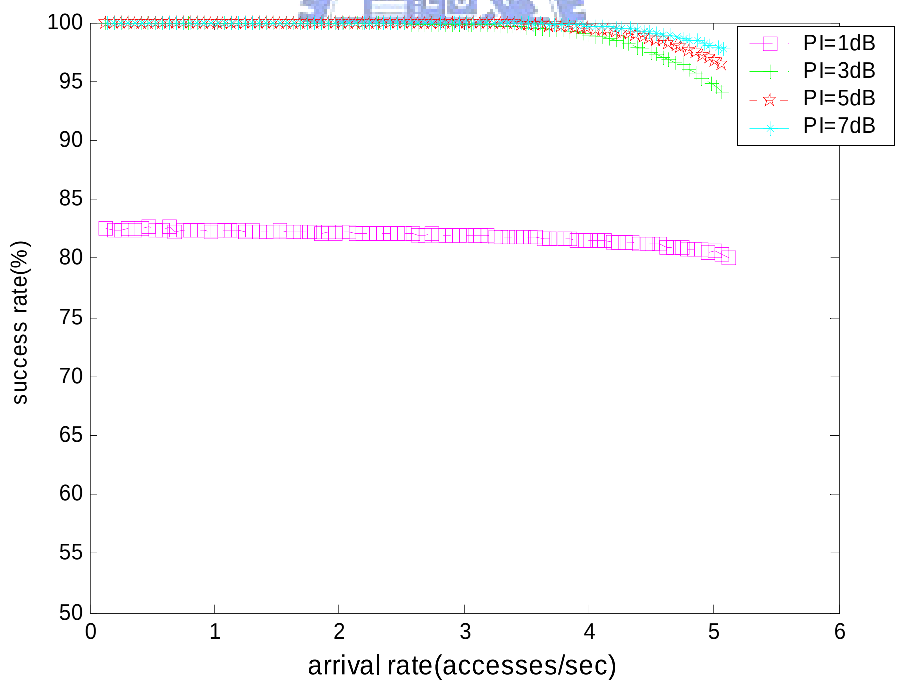

Figure 4-2 RA: success rate in the initial SIR is -14dB (2, 4)

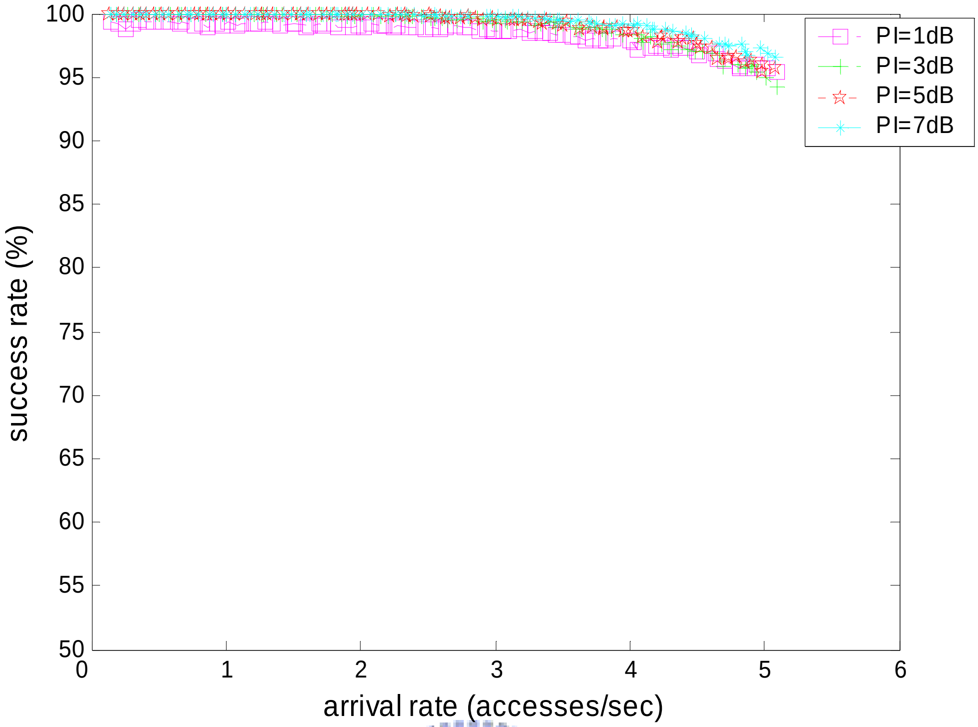

Figure 4-3 RA: success rate in the initial SIR is -10dB (2, 4)

The threshold which is accepted by BS is -12 dB. In this condition the energy to noise ratio is about 8dB after dispreading. Under this energy to noise ratio the MS has low bit error rate.

From above three graphs the initial condition is better the success rate is better and the MS chooses the bigger power increment step the higher success rate. When PI is 1dB the success rate is very low in Figure 4-1 only 30%.Because 1dB is too small and is not enough to overcome the fading channel especially in bad SIR. In Figure 4-2 the success rate curve of the 1dB improve more than 80% because of the good SIR condition. In Figure 4-3 all curves are almost to the 100% in light and middle access traffic. But in the heavy traffic the more MSs arrive during the same time and result in more collisions, finally the success rate decreases. In Figure 4-1 the curve of the 1dB is almost flat even in the heavy condition. The reason is the power of the arrival MSs is not all large enough to collide with each other.

The important issue is the delay time because it is directly relative to the wait time. We assume channel assignment delay and reservation slots are total 200ms. The messages are 140ms.

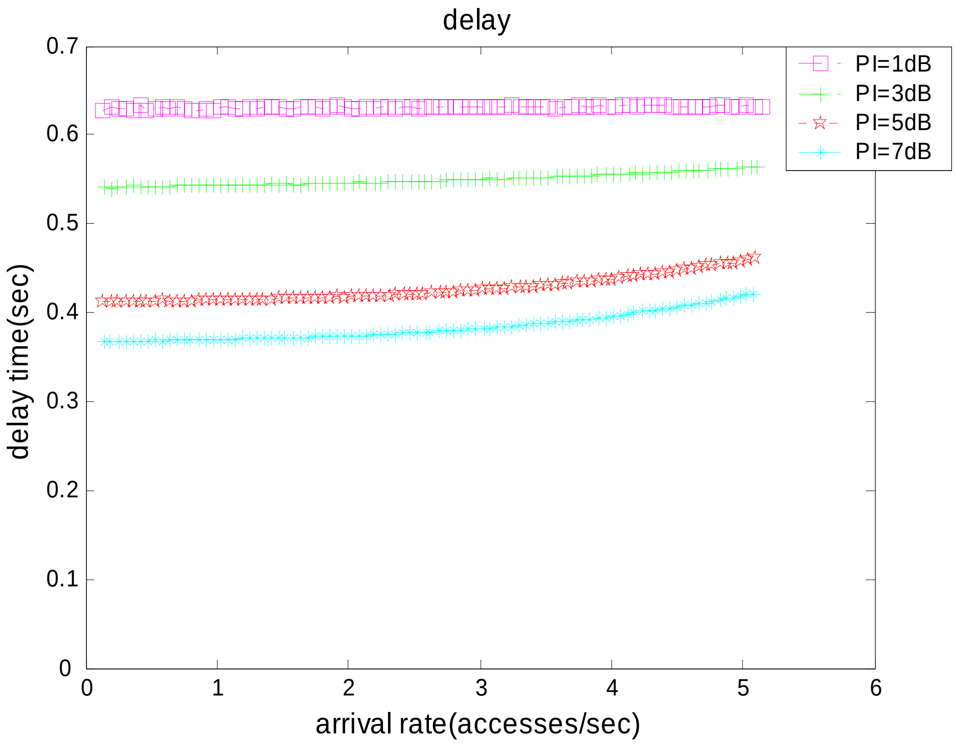

Figure 4-4 RA: delay in the initial SIR is -18dB (2, 4)

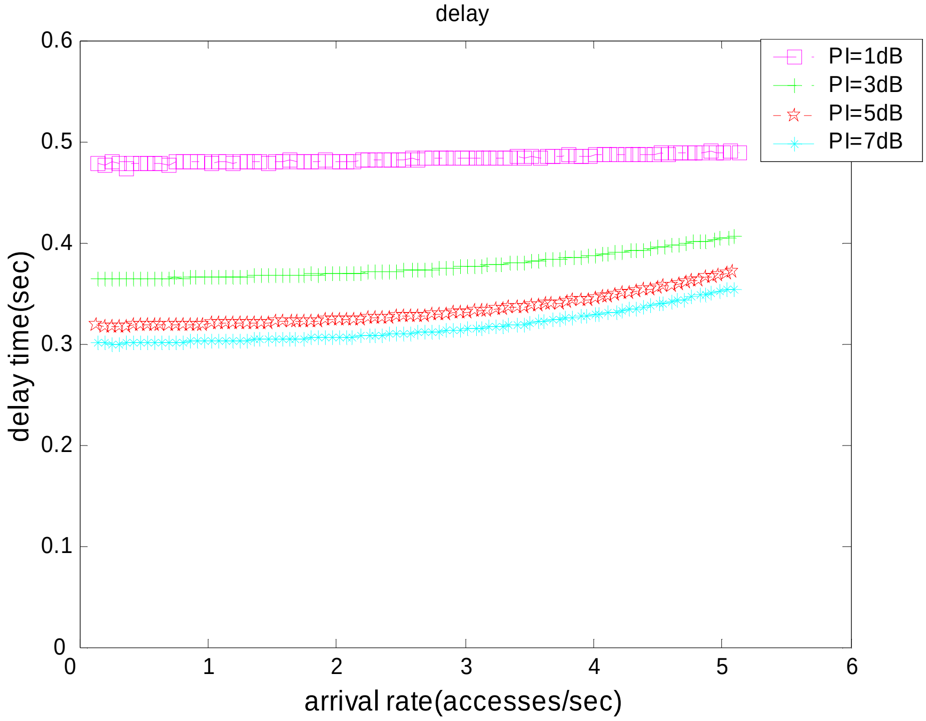

Figure 4-5 RA: delay in the initial SIR is -14dB (2, 4)

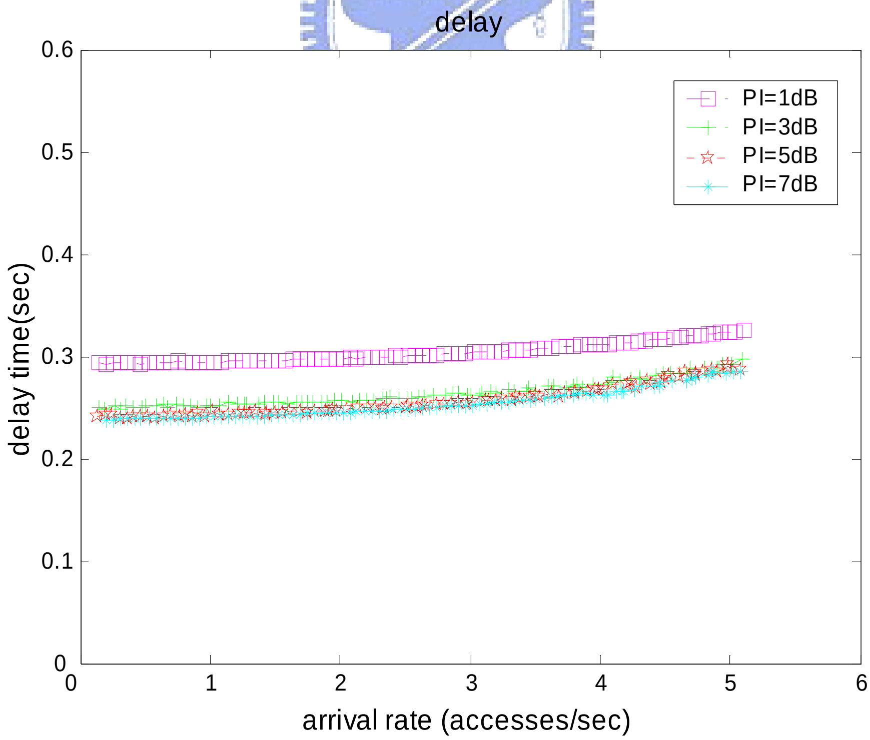

Figure 4-6 RA: delay in the initial SIR is -10dB (2, 4)

In the better initial SIR we have less delay due to the good initial near the success SIR threshold. In Figure 4-6 1dB also faces the more collisions than Figure 4-4 and Figure 4-5 and the delay curve increases. The same condition happens to the 3dB curve but in Figure 4-5 and Figure 4-6 the curves raise than Figure 4-4, and the reason is that for the attempt the good SIR will cause more effective collisions. The effective collisions mean the power of the probe is more than the success threshold SIR and more than two probes arrive within 2 chips. Obviously the 5dB and 7dB nonlinearly increase because of the efficient collisions in Figure 4-4, Figure 4-5, and Figure 4-6. When the arrival rate raises the high traffic density causes the collisions, and the delay time increases accordingly. In Figure 4-4, Figure 4-5 the curve of 1dB is flat and this is because the collisions don't happen very often in heavy access traffic. But the other curves all meet the collisions in high arrival rate. The RA mode uses small probe to reduce the collision probability in the Reverse Enhance Access Channel. And the small probe can save the time waiting for the acknowledgement. The only cost is that RA needs to wait for the channel assignment messages.

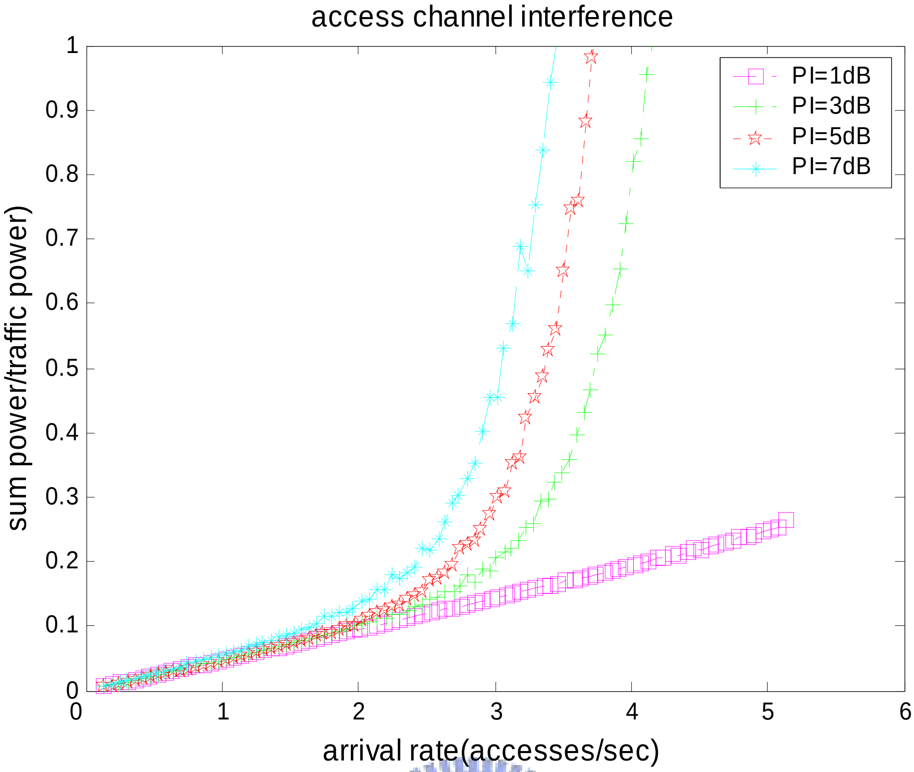

Figure 4-7 RA: interference in the initial SIR is -18dB (2, 4)

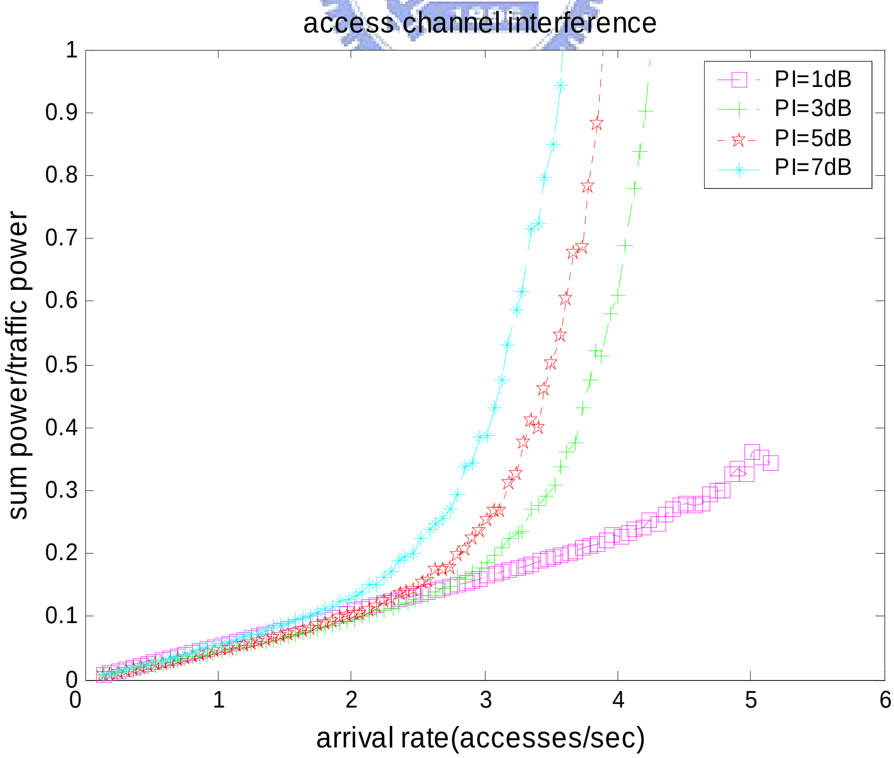

Figure 4-8 RA: interference in the initial SIR is -14dB (2, 4)

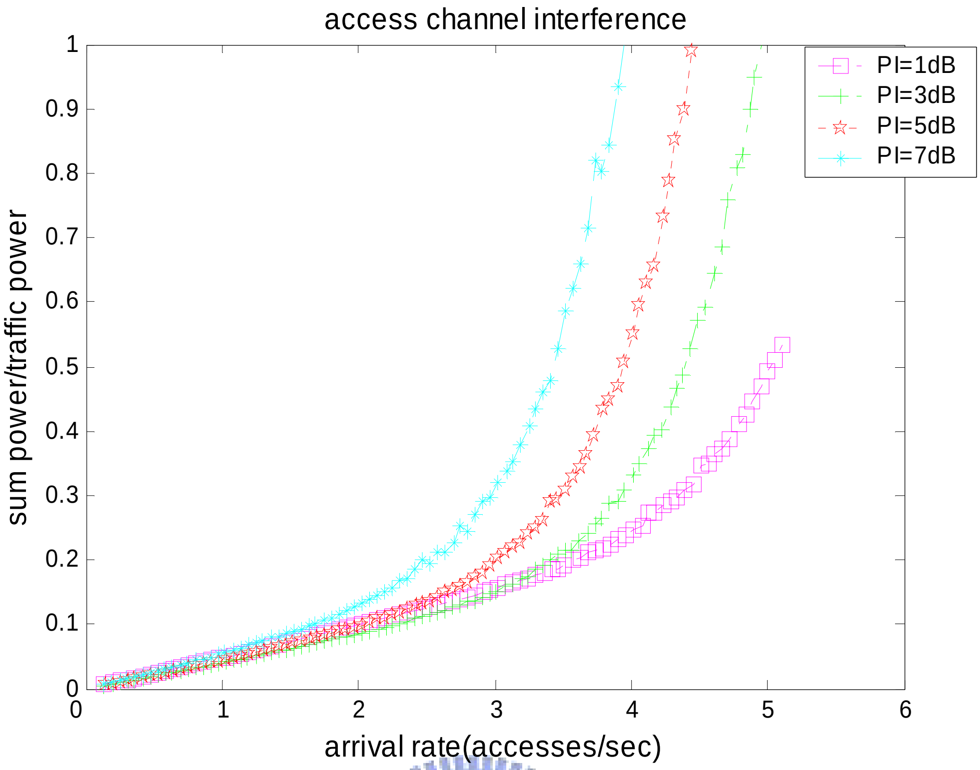

Figure 4-9 RA: interference in the initial SIR is -10dB (2, 4)

We discuss the access channel interference to the traffic channel ratio. When many mobiles arrive in the fixed duration condition, the interference grows up very rapidly, especially in high PI for example 7dB. We can keep the ratio below 10%. For this reason we can decide the channel capacity by this parameter. If the initial SIR is better the curve will increase nonlinearly in higher traffic arrival rate. In Figure 4-9, 1 dB curve is also nonlinear. But in Figure 4-7 Figure 4-8 1dB is not obviously increase nonlinearly.

4.2.1.1 The Capacity of the Access Channel

Here we show the parameters which can evaluate the performance of the access channel. In the simulation the loading of the access channel defines the numbers of the arrivals in a unit time. The system success rate is the number of the successful probe in the specified time. The delay is defined as sum the delay time of all successful mobiles over the numbers of all successful mobiles. The interference to the traffic is defined sum all the power of the mobiles over the traffic channel power. Here the traffic channel power is assumed constant [7].

We show the simulation results about the success rate. The SIR_ini defines the initial power of the mobile. If the initial power is lager the MS would access more easily.

This bottleneck in the access channel is defined the capacity of the access channel. When the initial SIR is -14dB and power increment step is 3dB, we can say that 3MSs per second is the capacity of the access channel. In the bad initial condition the MS uses the small power increment (PI) step, and we get the low collisions events and success rate. For example PI is 1dB, the success rate is the lower than the others. 5dB and 7dB have too much interference to the traffic channel.

4.2.2 Change the attempt probe sequences and probe numbers to analysis the performance

Later we change the probe number and probe sequence to observe the performance variation. We set the probe sequence is 1 and the probe number is 8. In 4.2.1 the sequence is 2 and the probe number is 4. In order to compare with pervious section condition we assume when the probe number is 5, the probe will face new fading condition. Because in every first probe of the sequence, the MS will use open loop power control to retransmit the initial power again, i.e. the probe will not go through the same fading channel with the first probe of the first sequence.

First we show the success rate plots.

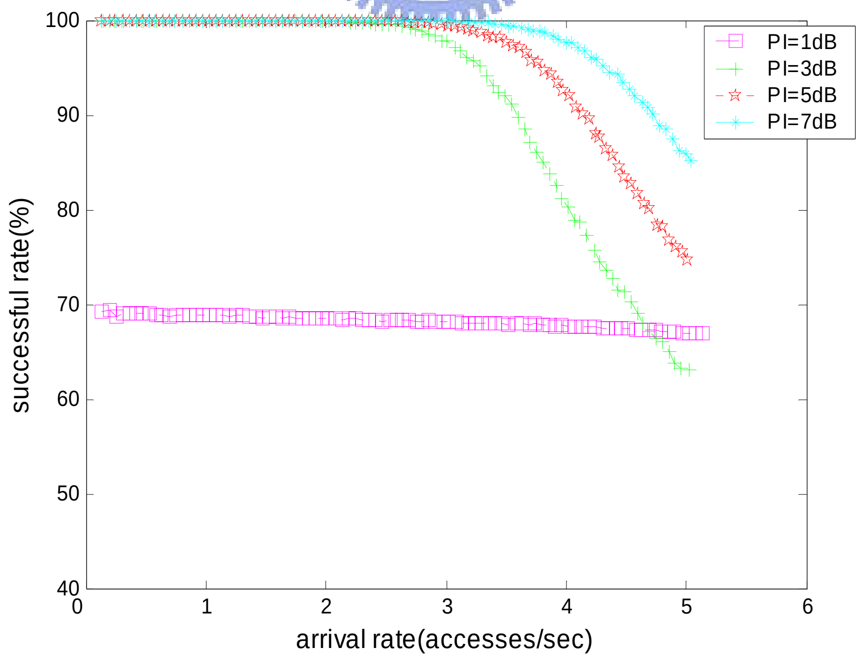

Figure 4-10 RA: success rate in the initial SIR is -18dB (1, 8)

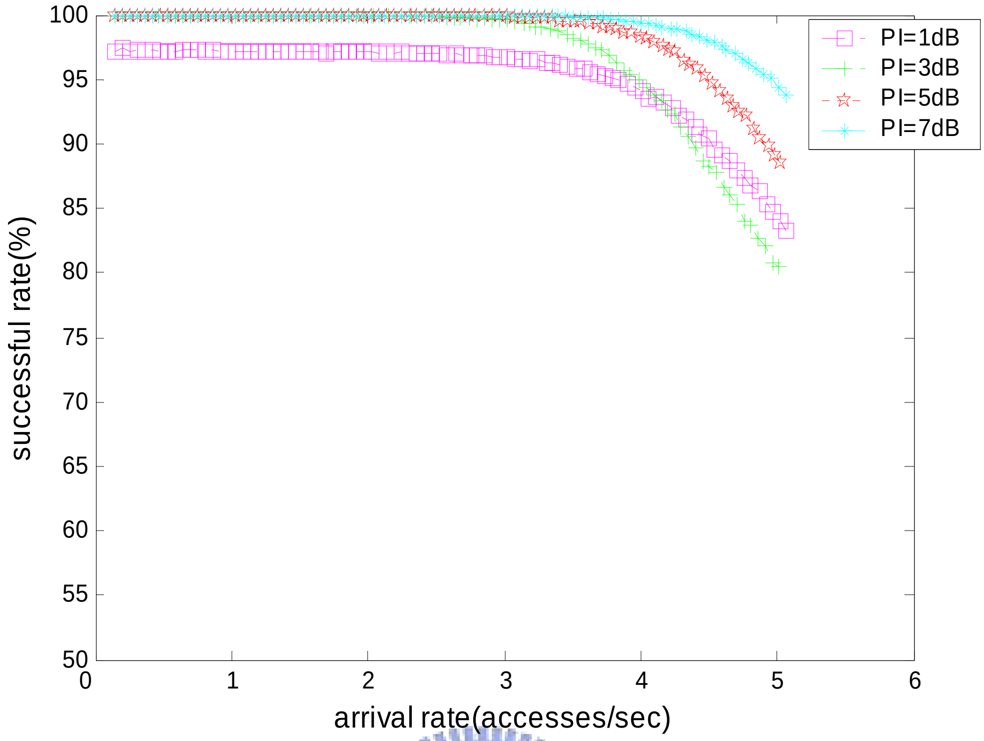

Figure 4-11 RA: success rate in the initial SIR is -14dB (1, 8)

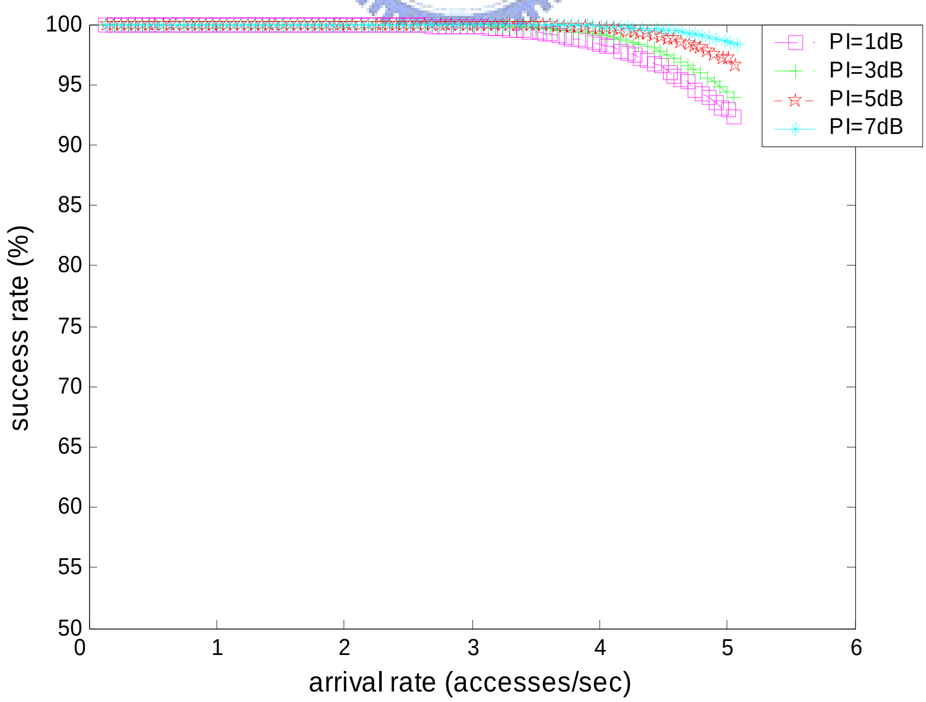

Figure 4-12 RA: success rate in the initial SIR is -10dB (1, 8)

From Figure 4-10, Figure 4-11, and Figure 4-12 the better SIR will get the better SIR, because the good SIR is nearer the success threshold than the poor SIR. In Figure 4-10 curve of 1dB has 70% success rate. It presents the 8 probe number can overcome many bad SIR and the fading channel impact. In Figure 4-11 and Figure 4-12 the four curves improve to 98%. The 8 probe number method works efficiently. In Figure 4-11, the high collisions the 3dB is worse than 1dB when the arrival rate reaches about 4 accesses per second about arrival rate. Of course the curves fall down in high arrival rate because of the high collisions in Figure 4-10, Figure 4-11, and Figure 4-12.

More probes in a sequence will get high success rate in the initial low SIR than two sequences which have four probes respectively. When the arrival rate is light the success rate is very high especially in 1dB. But in Figure 4-11and Figure 4-11 the access success rate curves fall down very fast. In the bad ini_SIR and high traffic condition, using the more probe numbers in a probe sequence is very sensitive. Compare to the Figure 4-1, Figure 4-2, and Figure 4-3 the line 1dB here is better. But using the other PI will fall faster than Figure 4-1, Figure 4-2, and Figure 4-3 in the high arrival rate. When the MS uses PI=1dB the 8 probe number in 1 probe sequence is good. If the MS uses the other PI, 2 probe sequence, 4 probe number every sequence will recommend.

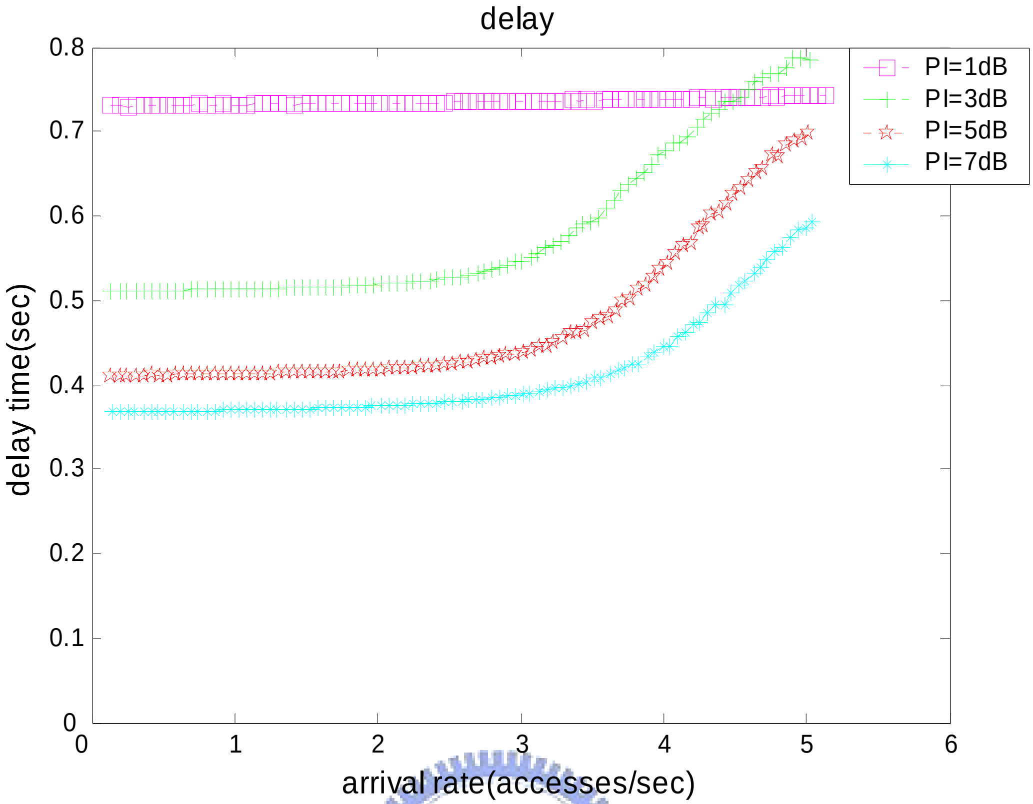

Figure 4-13 RA: delay in the initial SIR is -18dB (1, 8)

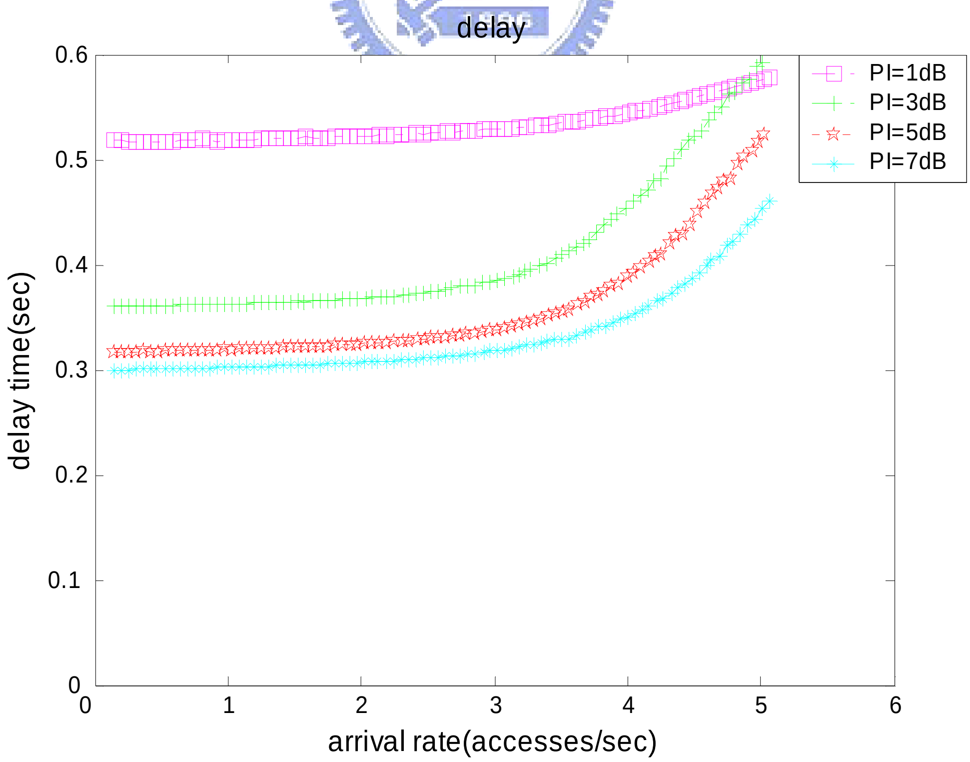

Figure 4-14 RA: delay in the initial SIR is -14dB (1, 8)

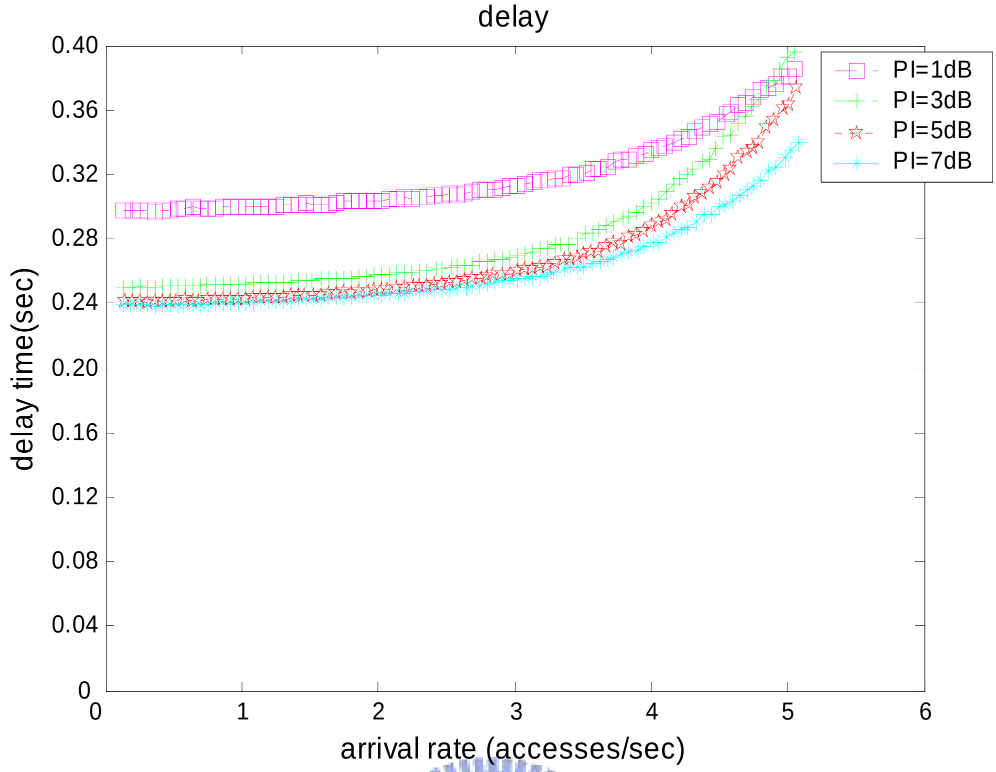

Figure 4-15 RA: delay in the initial SIR is -10dB (1, 8)

In Figure 4-13, Figure 4-14, and Figure 4-15 all delay time grow up rapidly when the arrival rate increases. If the initial SIR is better, we can have the better delay. In the high arrival rate the line 1dB is cross over 3dB and 5dB in Figure 4-15 because of the high collisions. Compare to the Figure 4-4, Figure 4-5, and the curves here are much sharper in the heavy traffic. In the light traffic, both sides are very close. Due to the comparisons the 2 probe sequence 4 probe numbers every sequence will recommend to use in delay time and channel interference ratio viewpoints.

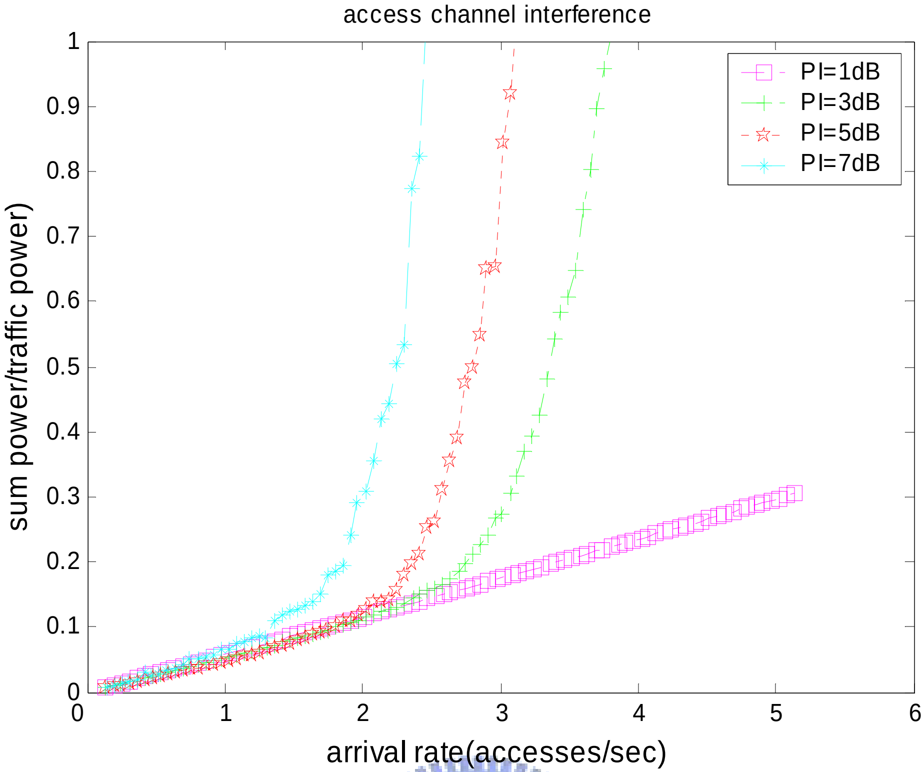

Figure 4-16 RA: interference in the initial SIR is -18dB (1, 8)

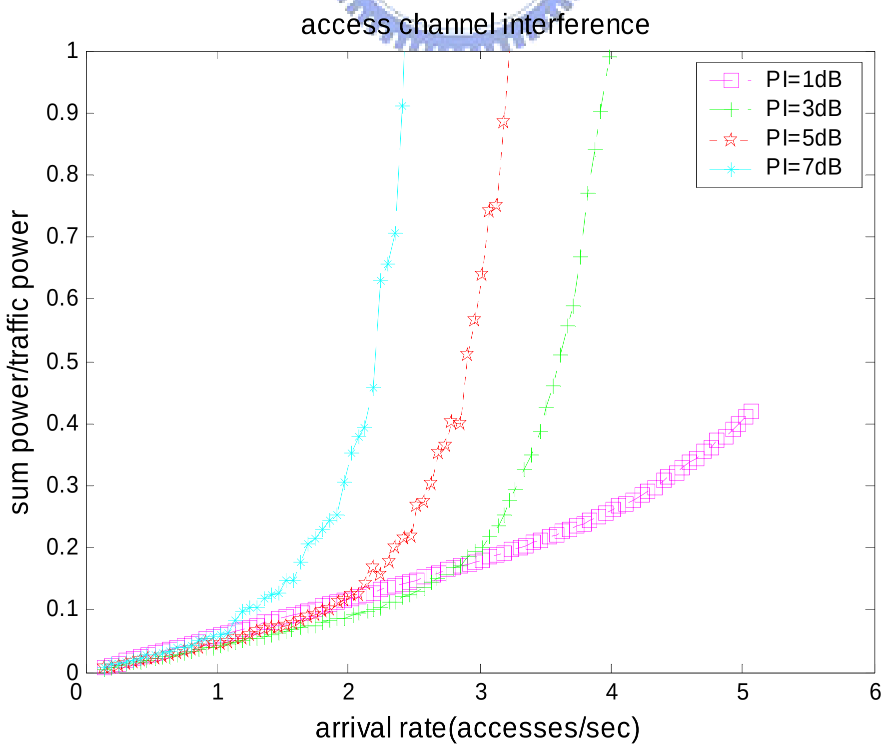

Figure 4-17 RA: interference in the initial SIR is -14dB (1, 8)

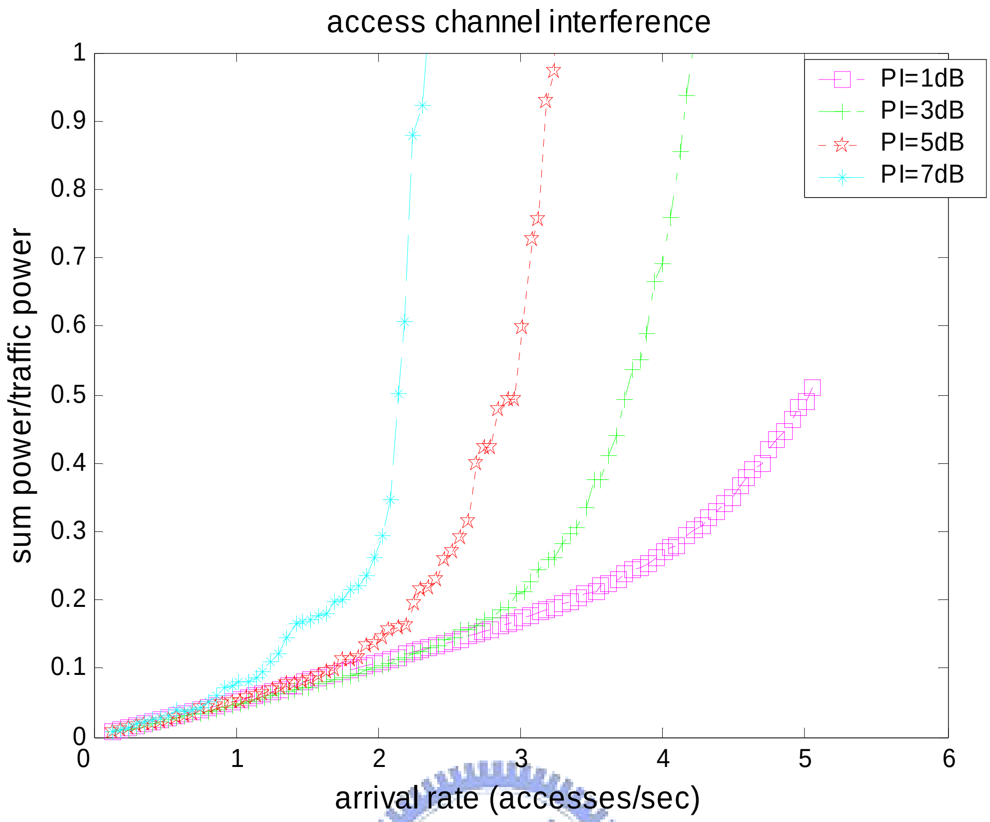

Figure 4-18 RA: interference in the initial SIR is -10dB (1, 8)

In Figure 4-16, Figure 4-17, and Figure 4-18 the interference much worse than the Figure 4-7, Figure 4-8, and Figure 4-9. The 1 probe sequence brings too much interference to the traffic channel. Excluding the channel fading and the first probe we increase 3 power increments to transmit the access probe power. For example we choose the smallest PI 1dB and after 3 increments step, the power increases 3dB i.e. The power of the fourth probe is twice than the original first probe. If 7dB is chosen, the power of the fourth power is 128 times than the original first probe. In these observations the 1 probe sequence including 8 probe numbers will not suit to use. Because the interference is too much the system cannot endure and could be unstable.

In most cases the original scheme, 2 probe sequence 4 probe numbers, is much better than the 1 probe sequence 6 probe numbers scheme. The 1 probe sequence 6 probe numbers scheme only works efficiently in PI=1 in bad initial SIR condition. But it cause more interference and has a sharper delay time curve and falls down rapidly than the original scheme. So we conclude to recommend the original scheme.

4.2.3 The performance analysis of the Basic Mode

The access attempts are firstly considered below Figure 4-19, Figure 4-20, and Figure 4-21.

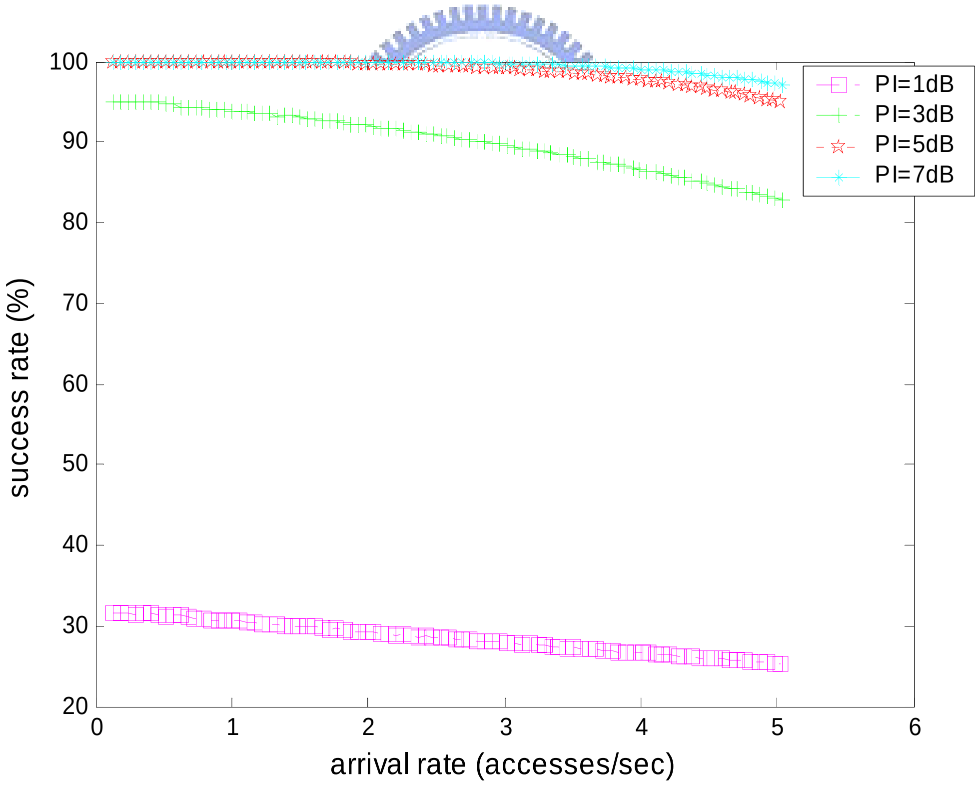

Figure 4-19 BA: success rate in the initial SIR is -18dB (2, 4)

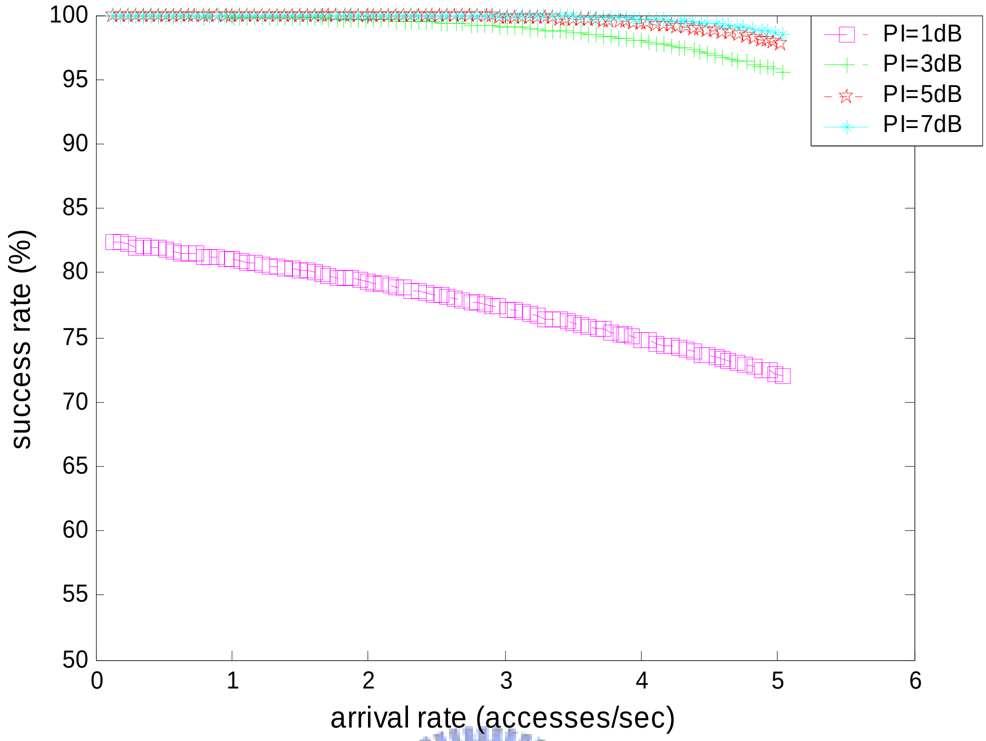

Figure 4-20 BA: success rate in the initial SIR is -14dB (2, 4)

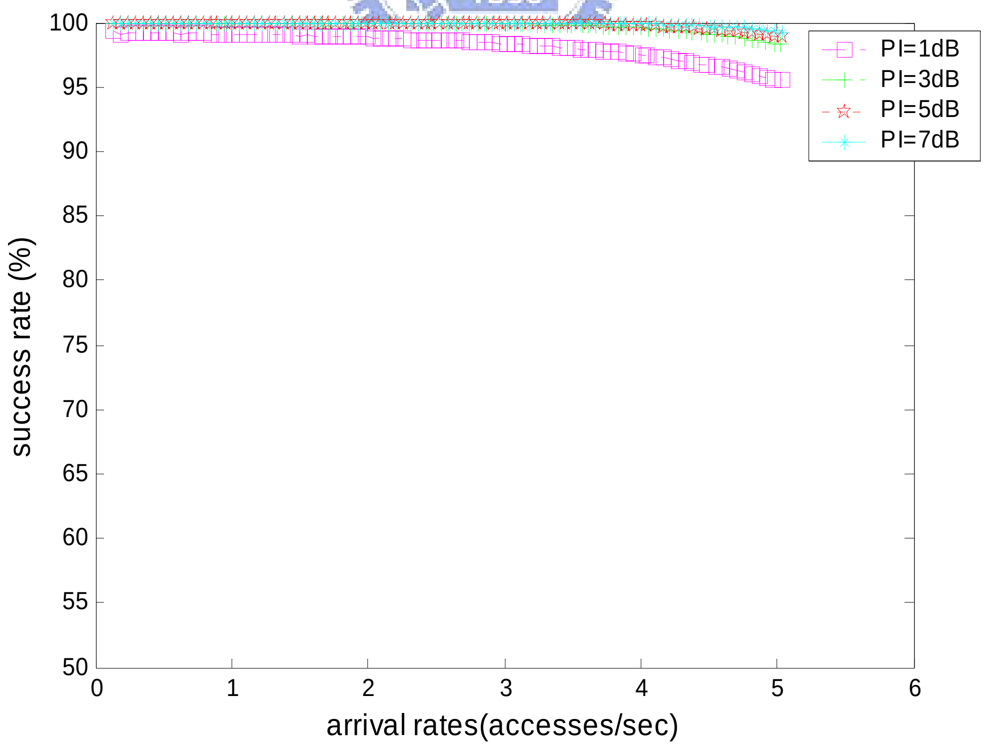

Figure 4-21 BA: success rate in the initial SIR is -10dB (2, 4)

In the different initial SIR environment, we can get the better environment, i.e. the higher initial SIR the success rate is better. The best condition is one MS accesses and it is successfully detected by the BS. We can see the more power increment step (PI) and the better SIR (signal to interference ratio) the success rate is better.

We take three graphs to compare the delay time in the different initial SIR and different power increment step. The initial SIR include -18dB, -14dB, and -10dB. The PI values are 1dB, 3dB, 5dB, and 7dB.

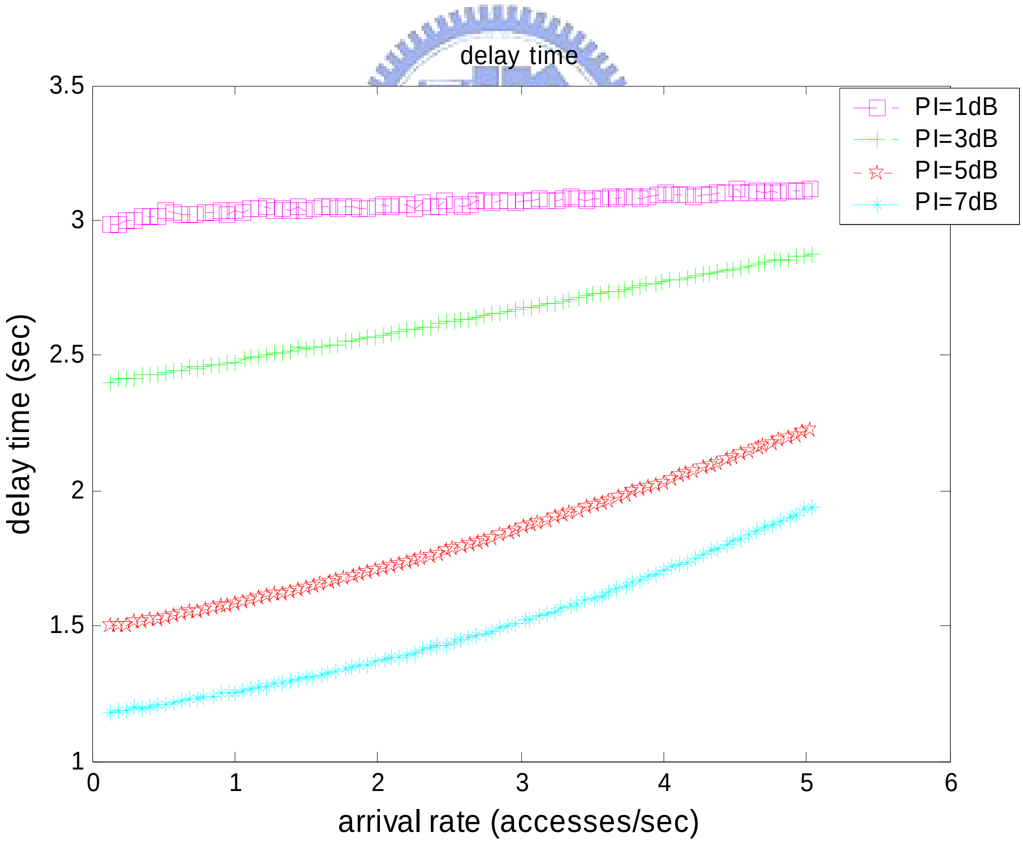

Figure 4-22 BA: delay in the initial SIR is -18dB (2, 4)

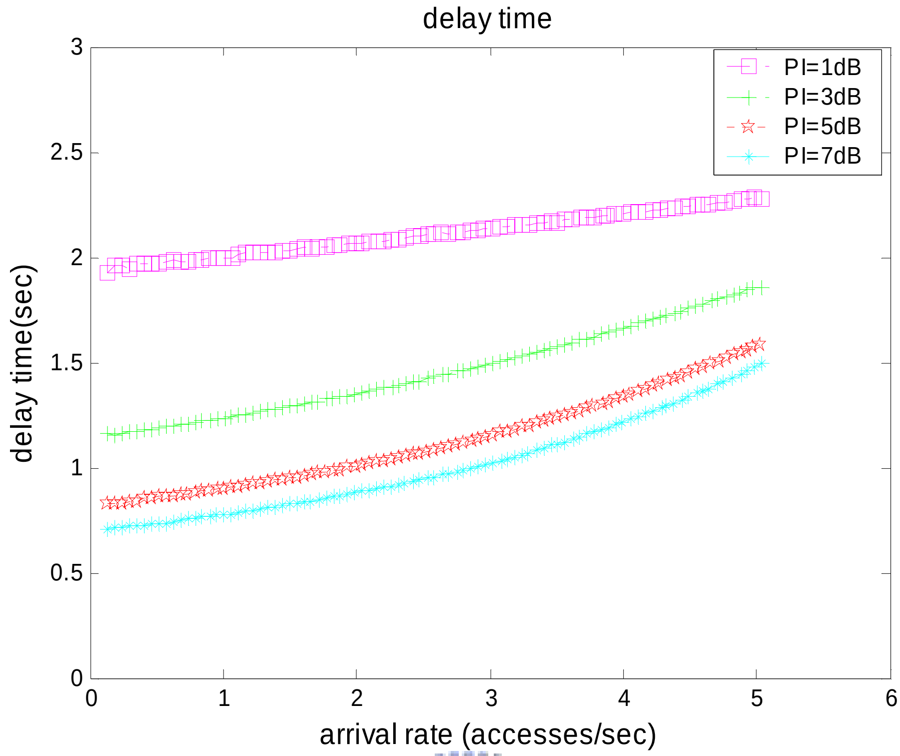

Figure 4-23 BA: delay in the initial SIR is -14dB (2, 4)

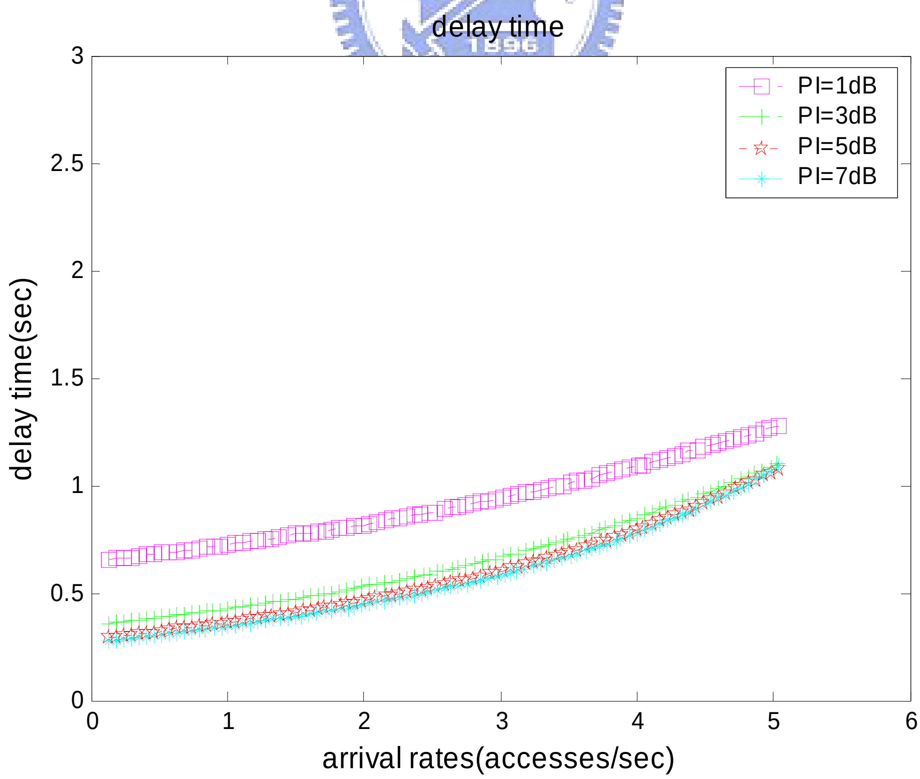

Figure 4-24 BA: delay in the initial SIR is -10dB (2, 4)

The smaller power increment step the MS chooses the more time the MS should spend. If the initial SIR is good, the MS takes lower time delay than bad initial SIR. From the above graphs, when the SIR gets good the delay time all decrease and the gaps between every curve will be close. In Figure 4-23 1dB is almost a flat line, and it means the collisions happen few and will not cause the delay up. In Figure 4-23 and Figure 4-24 the collisions effect reflects on the 1dB curves and the delay curves up. In Figure 4-24 due to the good SIR, the difference of using 3dB, 5dB, 7dB will be not clear.

Later, we discuss the access channel interference to the traffic channel ratio. In basically the ratio is lower, the interference condition is better.

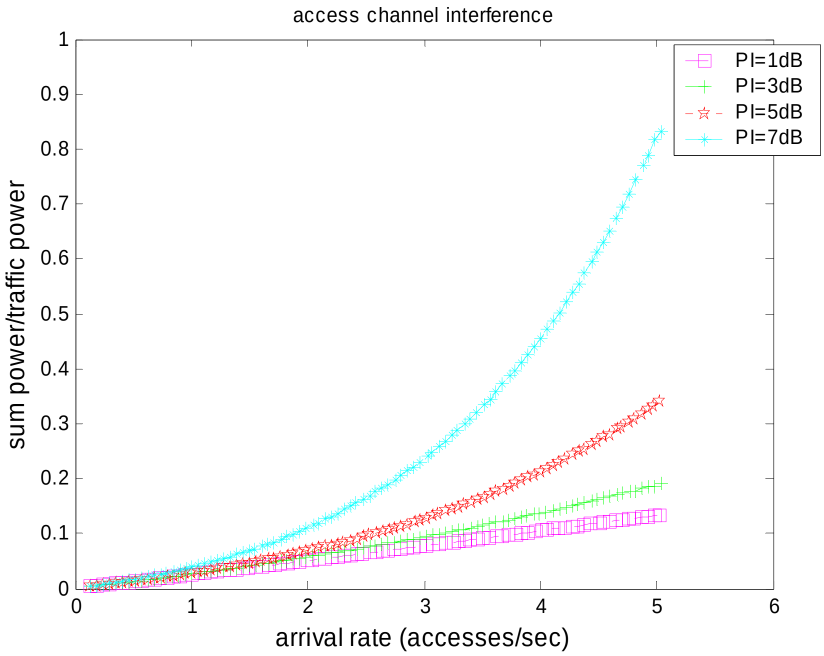

Figure 4-25 BA: interference in the initial SIR is -18dB (2, 4)

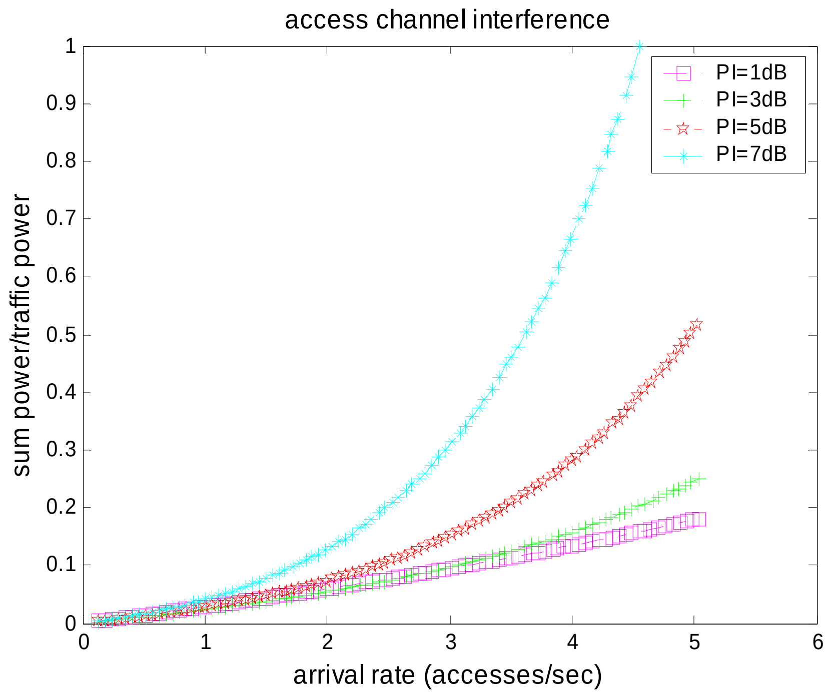

Figure 4-26 BA: interference in the initial SIR is -14dB (2, 4)

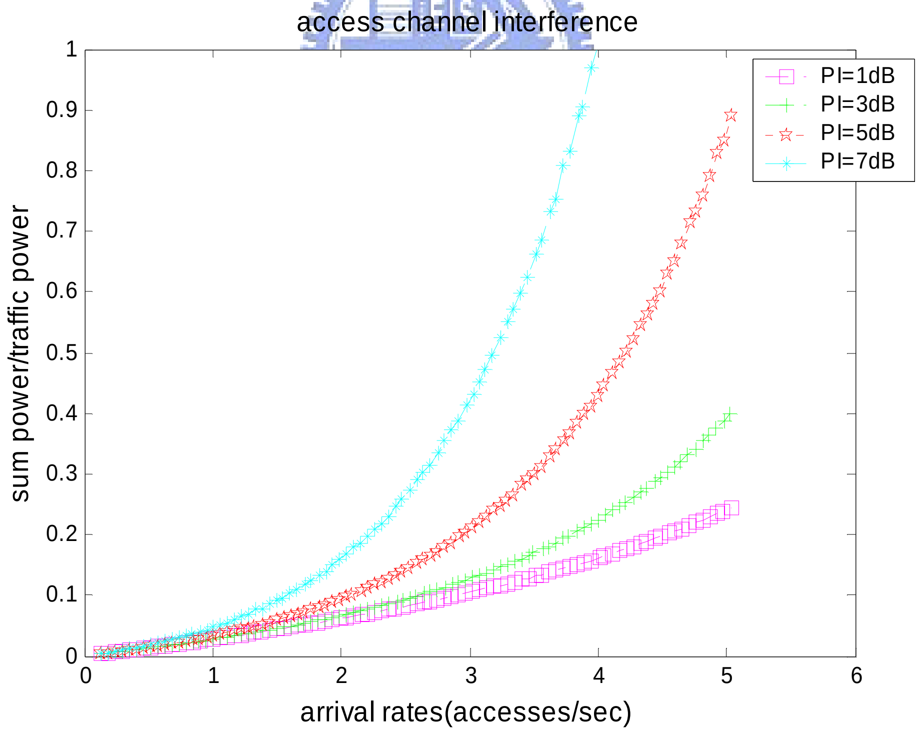

Figure 4-27 BA: interference in the initial SIR is -10dB (2, 4)

The simulation environment sets on the different signal to interference ratio. In

Figure 4-25, Figure 4-26, and Figure 4-27, the interference to traffic ratio curves are nonlinear when loading is larger. Choose a larger PI we get the sharper curve. We usually keep the noise margin about 10% of the traffic power. In Figure 4-25, 1dB and 3dB are much smoother than 7dB. In Figure 4-26 and Figure 4-27 5dB and 7dB rapidly grow up. According to the noise margin requirement, in Figure 4-25 the 1dB and 3dB curves can support 3 accesses per second, 5dB only can support 2 accesses per second, but 7dB support less than 2 accesses second. In Figure 4-27 because the good SIR the curves grow up faster than Figure 4-26 for the same arrival rate. 1dB is almost a straight line, and 3dB curve becomes nonlinear in the high arrival rate because of high arrival and high collisions. Although high PI gets less delay and good success rate, in the interference aspect the high PI is not a good method. From above three graphs we can conclude the better SIR the high interference and the high PI will cause the curves nonlinearly increase. Finally in interference viewpoint we can suggest 1dB and 3dB are good values to use.

So far choose a larger PI and we have better delay time and better success rate, but the strategy brings more interference to the other channels and users in the system. We can conclude that it should trade-off among interference, success rate and delay time. Finally the capacity of the access channel can be defined among the above three performance parameters.

4.3 The comparison of BA and RA in delay time

In first two sections of this chapter we show the BA and RA performance in details. In the section the BA and RA will take to compare the access channel interference ratio and change the initial SIR and message size. And the different PI step will be discussed together. We discuss three parameters respectively.

Here we discuss the message size and delay time relationship between BA and RA. In the simulation environment, the PI is all 3dB but use the different initial SIR and different arrival rate. The best initial SIR, light traffic and the worst initial SIR, heavy traffic are considered. First the RA and BA are all operating in initial SIR -10dB and -14dB to compare the relationship between message size and delay time. In this initial SIR condition, the delay performance is under the same success rate (over 96%) to be considered.

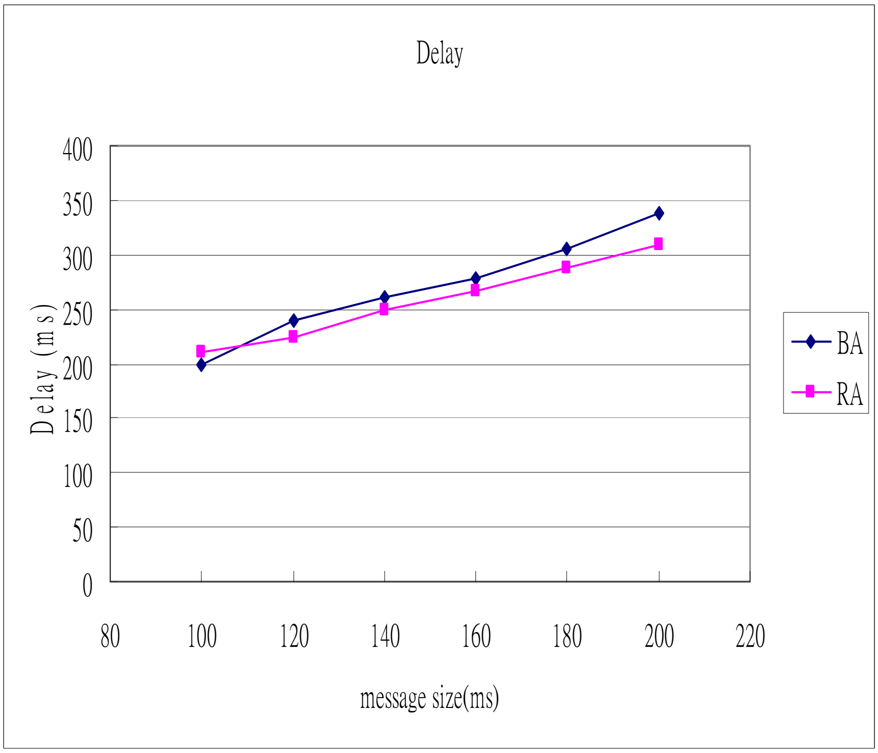

Figure 4-28 delay comparison in the initial SIR is -10dB, 0.2 attempts/sec

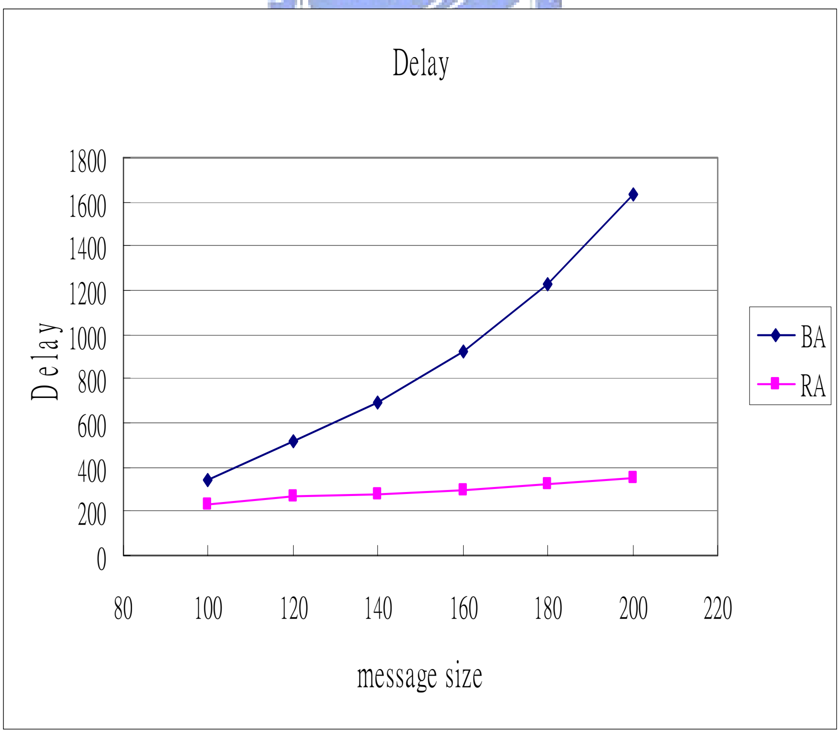

Figure 4-29 delay comparison in the initial SIR is -10dB, 4.6 attempts/sec

In Figure 4-28 delay comparison in the initial SIR is -10dB, 0.2 attempts/and Figure 4-29 delay comparison in the initial SIR is -10dB, 4.6 attempts/the different is the traffic. Figure 4-28 delay comparison in the initial SIR is -10dB, 0.2 attempts/is in light traffic the BA works efficiently in small attempts. The 120ms messages are suitable for operating in RA. In Figure 4-29, the RA saves more time in the large messages. Because of the heavy traffic the collisions happen easily. The MS must be back-off and wait. RA has a small size probe and can back-off less time. RA reduces the collision probability and delay time. Here we can observe the advantage of RA obviously.

Now the MS are operating in bad initial SIR condition. The PI is 3dB and initial SIR is -14dB in the case the success rate is also over 96%.

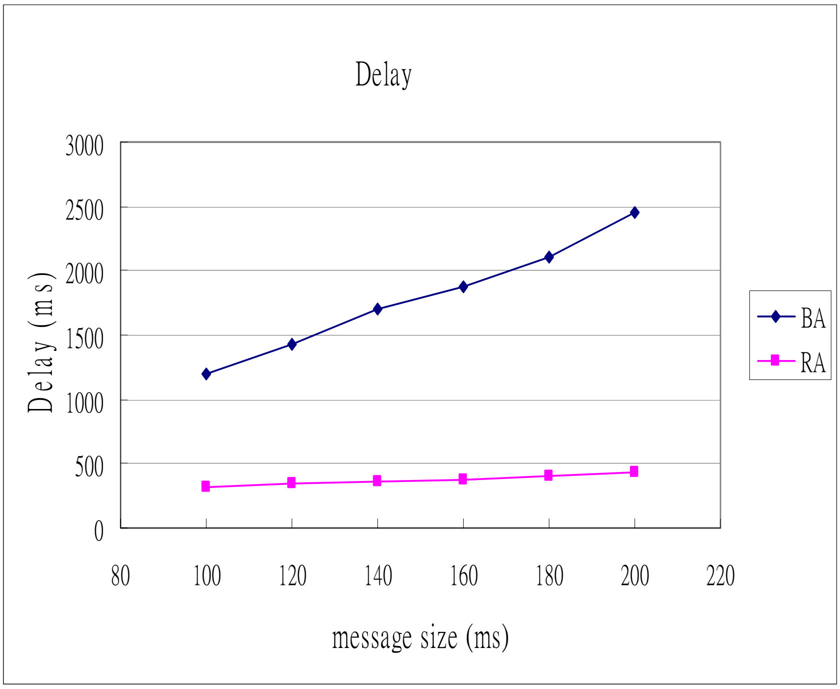

Figure 4-30 delay comparison in the initial SIR is -18dB, 0.2 attempts/sec

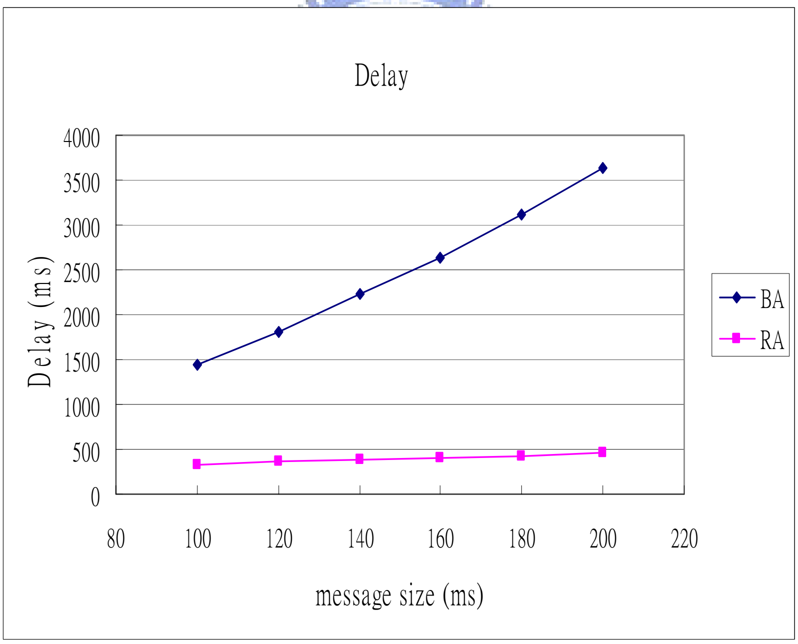

Figure 4-31 delay comparison in the initial SIR is -18dB, 4.6attempts/sec

In Figure 4-30 and Figure 4-31, RA is much better than BA when the initial SIR is bad and the traffic is heavy. In average the attempts will have more probes to complete the random access process. When the message size is 200ms the RA is faster than BA about 3 seconds. Because a long packet needs more time for acknowledgement and back-off. To sum up, the bad initial SIR, large messages and in heavy traffic, the RA is a better choice than BA

Chapter 5 Conclusions

This thesis expresses the performance of the access channel operating in reservation mode and basic mode. First, delay time will be larger than the MS operating in basic mode, when the data length is long or in high access traffic. Because we need to wait durations and send more messages or data but the reservation mode can reduce the collision probability of the long packet transmission but reservation mode is more efficient than basic mode in time delay aspect. The reservation characteristic can improve the success rate and delay performance. As for access channel interference to traffic channel ratio, the power control algorithm will make them better than basic mode or IS95 without the common power control channel. If there is no power control algorithm, PI 3 dB is a good value to set. Finally this thesis presents the benefit of the reservation mode especially in bad initial SIR heavy traffic and long messages. And analysis of RA performance and we can decide the channel capacity.

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Appendix A: Simulation Platform

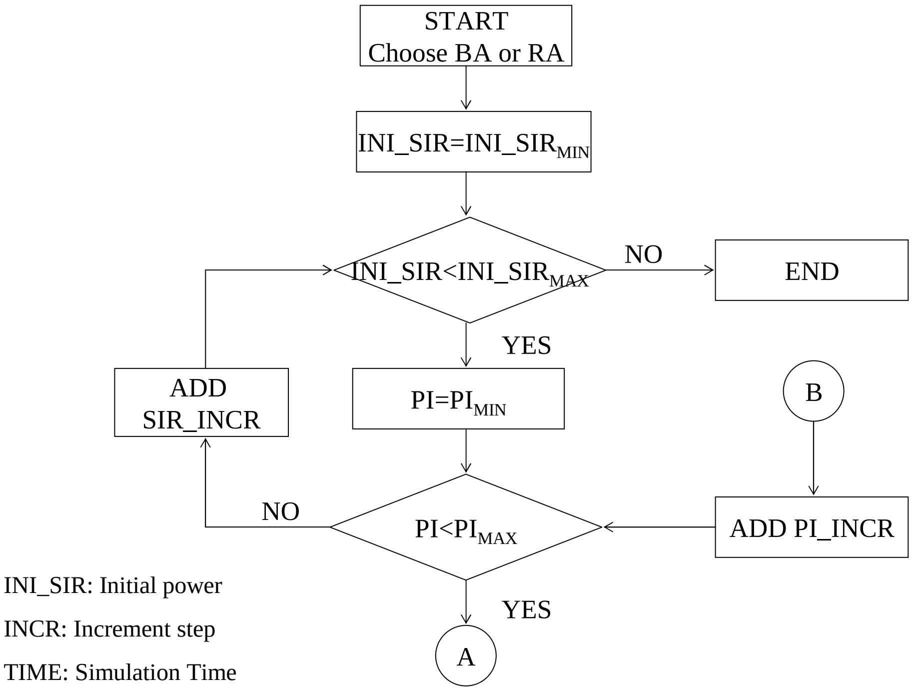

Figure A-1 initial condition setup

Here are four parameters about the simulation condition: initial signal to interference ratio (SIR), power increment value (PI), arrival rate (ARR), simulation time. In Figure A-1, we first choose the BA or RA platform. After choosing the platform system will give the MSs the ini_SIR and PI value. In Figure A-2, according to the arrival rate to decide how many mobiles will be in the queue and assign the same SIR value, power increment (PI) value, and different arrival time offset for all mobiles in this queue. We give the initial condition and start the timer to execute the random access process. If a mobile access successfully by the BS the timer adds one slot or assigned slot by using BA or RA and goes back to the queue to random access the mobiles which are not access successfully. When the timer expires, we remove all MSs in the queue and add arrival rate according to the arrival rate and increment step (ARR_INCR).

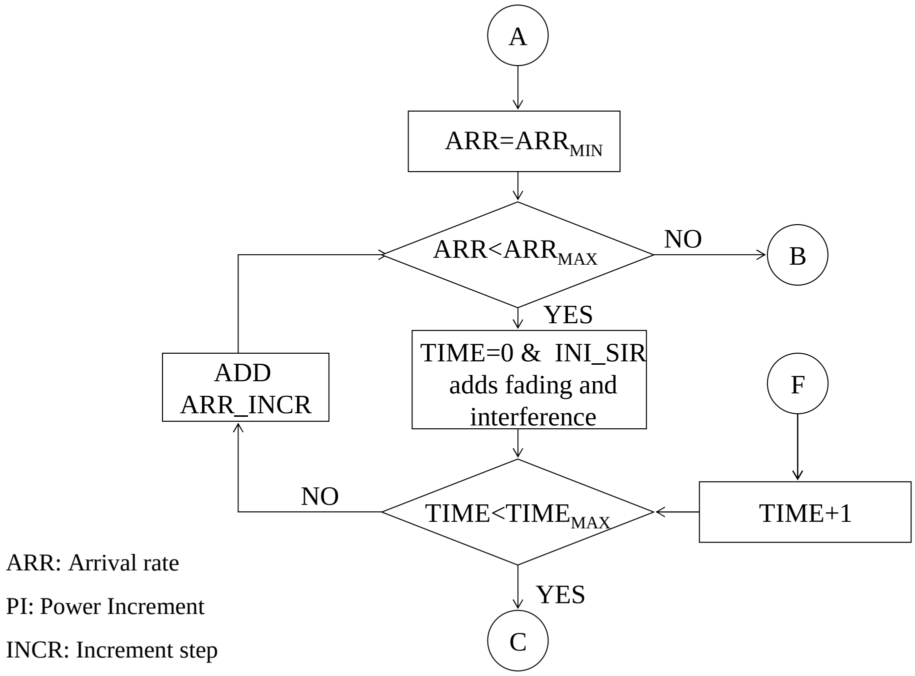

Figure A-2 Initial condition setup

When this condition simulation finishes, the next loop will change the arrival rate. This new arrival rate is sum of the previous arrival rate and the arrival rate increment step. This cycle will repeat with changing the arrival rate until the new arrival rate lager than the arrival maximum rate we define. When this condition happens, we will go back to change the power increment step. The new power increment step is the sum of the old power increment step and PI increment (PI_INCR). Here we increase the PI and run the cycle again from the minimum arrival rate to maximum arrival rate.

It means we have the same ini_SIR but different PI to run the random access. When the PI value gets to the maximum value, the cycle will go back to set the initial SIR. The new initial SIR is sum of the old initial SIR and SIR_INCR. When we have new ini_SIR, do the total above process.

A.1: Random access process details in Reservation Mode (RA) and Basic Mode (BA)

In the random access process (Figure 3-43), if the signal to interference (SIR) of the mobiles is higher than the SIR of the BS predefined, the BS will check whether the mobile collision or not. If the SIR of the mobile is smaller than the threshold, the access process fails and this mobile needs to reschedule. When the mobiles collide, the access process fails and the mobile needs to reschedule. Neither collisions nor the SIR of the MS is lower than the threshold, the mobile access successfully by the BS.

In BA (Figure 3-5A-4) the others mobiles which don't get the acknowledgement will go back to the queue and retransmit the probes by using power ramping method and back-off strategy. Here we say that all fail MSs will be rescheduled. Oppositely, the mobile which is accepted by the BS will record its SIR, delay time, and the total number of the success mobiles adds one, and we calculate the performance parameters of the access channel. Finally remove the successful mobile from the queue.

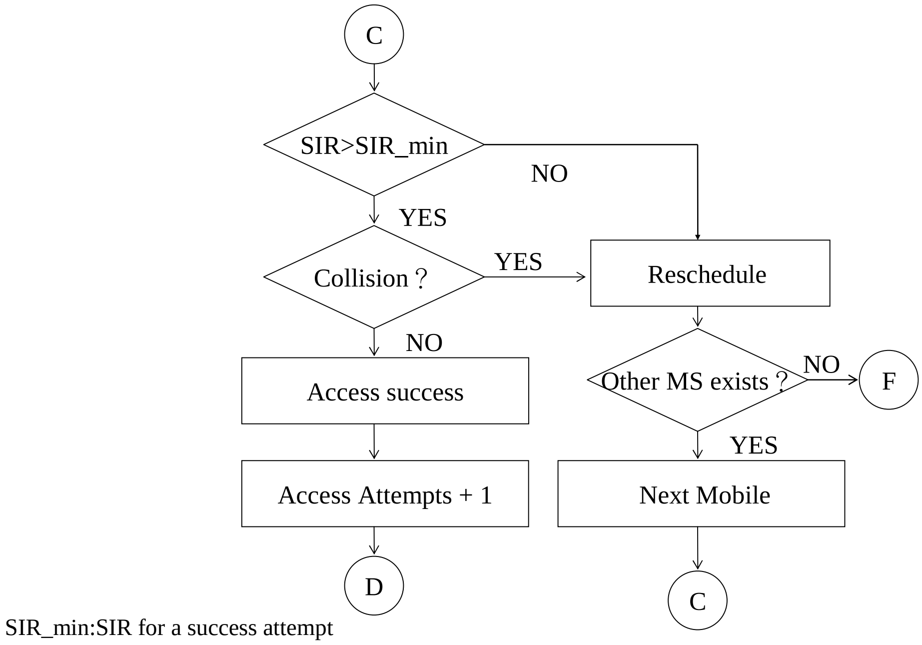

Figure A-3 Random access flow

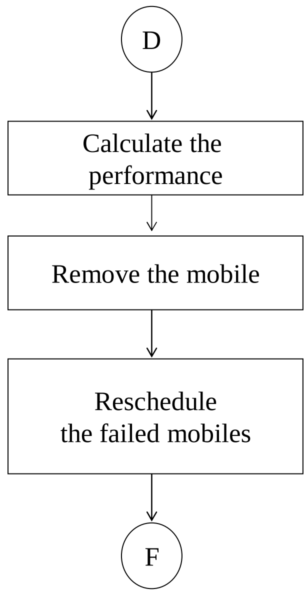

Figure A-4 BA MODE

In RA (Figure A-5) when MS is successfully accepted by BS, the BS will send the channel assignment messages to the successful MS and MS can upload its messages during the reserve time which the BS will tell other users in this cell. The BS will broadcast the inhibit bit to tell all the other MSs. Thus the other MSs cannot send their probe until the BS turns off the inhibit bit. The MS which accesses successfully will record its performance parameters and then remove it from the access queue. During the reserved time, the queue still adds the new MSs according to the arrival rate. But new arrival MSs and the fail MSs only permit to transmit their probes when the inhibit bit is off.

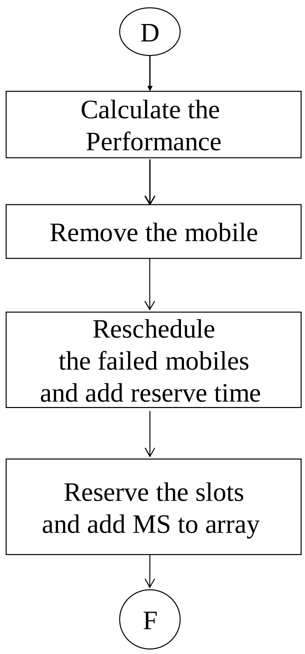

Figure A-5 RA MODE