TSG RAN Working Group 1#9 **TSGR1#9 (99) j19**
Dresden, Germany
November 30 – December 3, 1999-

Agenda:	**AH14**
Source:	**GBT**
Title:	**Review of Samsung's simulation papers**
Item for:	**Discussion and approval**

This contribution is a review of Samsung's simulation papers on CPCH performance. We had discussed the use of CA with channel monitoring and you had argued that in such a case use of CA improves the performance. Your argument was that there are errors on downlink broadcast channel and therefore CA will help. However, I have not yet seen any simulation results on that point yet.

The current simulation results that you have shown in this paper, are for the perfect CA case and do not properly reflect the degradation in CA performance in various cases such as:

1. A single CPCH case does not require the CA scheme. As a matter of fact we need some kind of monitoring scheme for this case.

2. At high CPCH rates, there will a couple of CPCH channels only. This could be 2,4 CPCH channels, your simulations is performed for 16 CPCH channels and 1 rate.

3. The case of multiple CPCH rates is also of interest. In this case, if the UE picks a rate and the CPCH is not available, then it will have to request CPCH again, when there are 7 different rates, the CA throughput delay performance will degrade significantly. This needs to be reflected in the simulation results.

4. Most importantly, with CA there is a significant amount of unnecessary requests. This will generate significant amount of unnecessary interference. This is the reason why Philips had suggested the transmission of status on data rates to reduce the total interference. At least this was my understanding. So how do you account for degradations caused by this unnecessary interference.

5. When the periodicity of the monitoring is reduced, then the performance of the monitoring case improves. I think with the free-status transmission [every few slots such as 5 ms], the performance will be off by a few percentage points from the perfect CA case that you have shown. I am not sure where the real CA performance lies in the curves, but I think with low periodicity such as 1.33, 2.66, 4 ms, the results will be very close to the perfect monitoring case.

Some preliminary remarks prior to the actual line-by-line review of this paper is due.

As we mentioned in our previous e-mails, we feel that this simulation is performed for the ideal Channel Assignment case. The following cases should be considered to reflect the realistic weaknesses of the method:

1. **Simulation of the single CPCH case operating at high rates such as 384 kbps. The CA scheme is not needed for the single CPCH case.**

2. **Simulation of the multiple rates (7 rates) CPCH to reflect the possible realistic deployment of multiple CPCH rates. This necessitates inclusion of another term in the delay formula for the CA case. This term should include the Back Off due to selection of a wrong rate. Note that we are required to have the UE capability of requesting a data rate. This point is completely ignored in these simulations.**

3. **Inclusion of negative impact of excessive interference by transmission of unnecessary AP-requests in the case of Channel Assignment. This will shift the curve to the left.**

4. Inclusion of collision term in the Delay formula for the Channel Assignment case and running the simulations for 1, 2 and 4 CPCH channels. In seems like the author has decided to neglect the collision term for the Channel Assignment case.

5. It is interesting to see the performance of the channel monitoring cases with periodicity of 1,2,3 slots (1.33, 2.66, 4 ms). These cases are realistic when free-indications are transmitted.

6. It is also interesting to include 1% error on the Downlink channels to see how that impacts the performance.

7. Another permutation is the performance with monitoring the channel Busy indications (simulated by GBT with real time monitoring) with the exponential Back-Off. When there are only 4 CPCH channels, then the periodicity is as low as 5.33 ms. So, the UEs will try the idle channels all the time. All the UEs should keep a busy indication table with some time-stamp. The channels should be declared busy after the CD phase only.

TSG-RAN Working Group 2 meeting #8
Cheju, Korea, Nov. 2 – 5, 1999

TSGR2#8(99)e13

Agenda item: X

Source: SAMSUNG.

Title: Performance Evaluation of CPCH.

Document for: Discussion.

Introduction

There have been some proposals on CPCH operation scheme to enhance its performance, channel assignment [1] and monitoring scheme [2]. Briefly saying, the aim of channel assignment scheme is to avoid undesirable contention by using dynamic allocation of CPCH code channel, and the monitoring scheme tries to achieve this goal through UE's continuous monitoring CPCH status,

Your curves on the extent of the undesirable contentions show that in the case of perfect monitoring, there is no unnecessary requests whereas the perfect CA case demonstrates a rise in such unnecessary requests. This shows that the monitoring case will out-perform the CA case in more realistic deployment scenarios as mentioned above.

This contribution provides performance evaluation results showing that the channel assignment scheme is the most efficient at the point of throughput, delay, and number of needless AP transmission.

Even by your own simulation results, this conclusion is incorrect. The perfect monitoring case seems to perform better from the "needless AP transmission" metric point of view.

Brief operation scenario of each scheme

This section shows brief operation scenario of each scheme and their difference. The operation scenario in detail is described in Annex with flowchart format.

a) Selection Phase :

- Current & Channel Assignment scheme
  - UE determines a DCH/CPCH pair number by randomly selecting an AP(Access Preamble) signature *among DCH/CPCH pairs provided by UTRAN.*
- Monitoring scheme :
  - *UE continuously monitors occupancy status of CPCHs*.
  - *The status broadcast method could be such that either free***-indications or busy-indications are transmitted. The periodicity is also very important as mentioned in the introduction.**
  - UE determines a DCH/CPCH pair number by randomly selecting an AP signature *among unoccupied CPCHs.* Acquisition Phase :

- UE sends AP with the selected signature to UTRAN until receiving a response.
- What is the access slot distance between consecutive transmissions?

- UTRAN sends back ACK/NAK on AP-AICH according to resource occupancy status of the requested DCH/CPCH pair.

b) Contention Resolution Phase :

- Current & Monitoring scheme
  - UE randomly selects a signature for CD(Collision Detection) preamble and transmits it to UTRAN.
  - UTRAN selects a signature among received CP preambles, and sends back ACK regarding the selected signature on CD-AICH.
- Channel Assignment scheme
  - UE randomly selects a signature for CD preamble and transmits it to UTRAN.
  - UTRAN selects a signature among received CD preambles, and sends back an ACK on CD-AICH and *code channel used for CPCH transmission on CA-AICH* regarding the selected signature.

d) Transmission Phase :

- Current & Monitoring scheme
  - Upon receiving an ACK associated with CD preamble, the UE starts the transmission of burst data on CPCH *with the code channel that was predetermined by the selection of AP preamble signature.*
- Channel Assignment scheme
  - Upon receiving ACK associated with CD preamble, the UE starts transmission of burst data on CPCH *with the code channel assigned by UTRAN*.

Simulation Result

The simulation results of each scheme are shown in following figures at the point of throughput, average delay, and number of needless AP transmission. Among the cases shown in figure, the CPCH with perfect monitoring represents the case when the monitoring of CPCH occupancy status is perfect even though the air link is considerably unreliable.

Does this mean that for imperfect cases, you are including some kind of unreliable air link by introducing errors? Or by perfect monitoring you mean, the UE has knowledge of the channel occupancy or non-occupancy at all times?

Meanwhile, CPCH with monitoring (T_{period} = 10,20,40[ms]) represents the case that Node B periodically broadcasts CPCH occupancy status. The broadcasting of channel status information compensates the imperfection of monitoring mainly coming from unreliable characteristic of air link.

I don’t understand this last statement! ? Please explain?

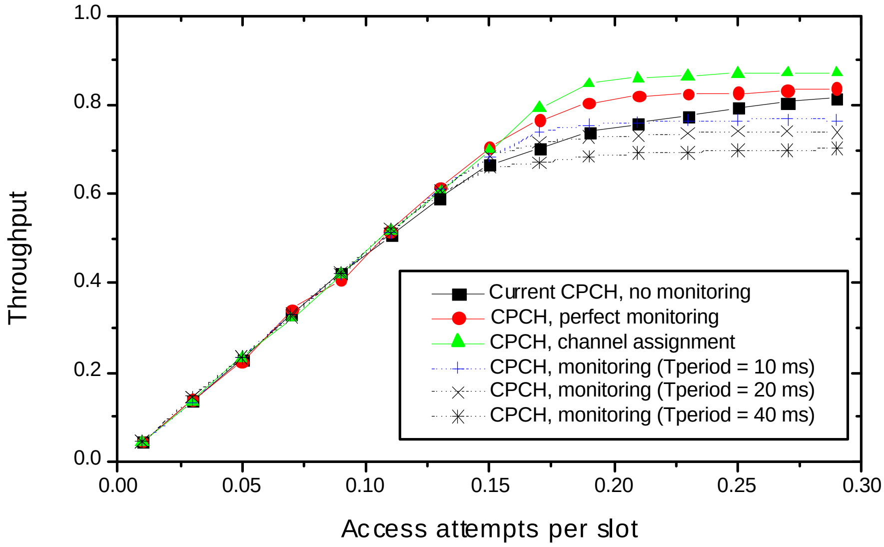


Figure 1. Throughput

The throughput represents the actual amount of transmitted data divided by channel capacity (for more detailed definition, refer annex). At lightly loaded situation, there is no difference among all schemes. However, at heavily loaded situation, the channel assignment scheme shows the best throughput. The major reason of this result is that the CPCH code channel is assigned and managed by Node B based on centralised manner, whereas CPCH code channel in monitoring scheme is managed by each UE based on distributed manner. Moreover, the monitoring scheme with periodic status broadcasting shows poor performance than that of perfect monitoring scheme since the broadcasting information from Node B can't represent current situation. Your last point here shows that if we simply had less CPCH channels or only sent out the free-indications in short periods, then the information would be more current and much better performance will result for the monitoring case approaching the "ideal CA" case.

I am not sure why the CA case is doing better than the perfect channel monitoring case. In the "ideal CA" case, the transmission of needless AP might be giving rise to an exponential back-off which should be long since it indicates that all CPCH channels are busy. In the case of perfect monitoring, the UE passes the first phase [since it has perfect knowledge on channel occupancy], but some of the UEs collide in the second phase (collision resolution). So as soon as the number of CPCh channels is decreased from 16 to 8, 4, 2, 1 the "ideal CA" case will start doing worse than the "perfect monitoring case".

It would be helpful if the horizontal access was changed to "offered load" rather than access attempts per slot.

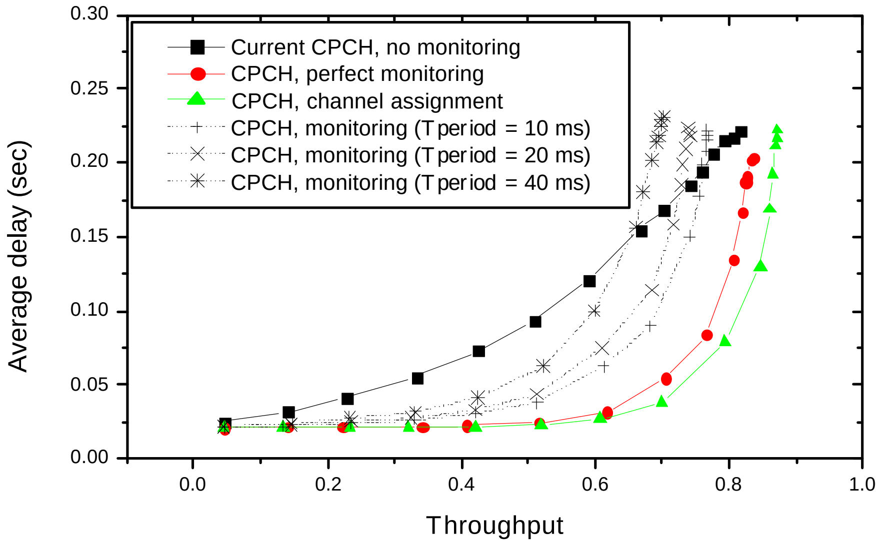


Figure 2. Average Delay

The Average delay represents the total waiting time from starting of first access attempt to beginning of successful transmission on CPCH (for more detailed definition, refer annex). In this result as shown in figure 2, the channel assignment scheme also shows the lowest average delay. Even in lightly loaded situation, current scheme and monitoring scheme with broadcasting information shows longer delay than that of channel assignment scheme due to needless contention and backoff duration induced by imperfect channel status monitoring.

I have a couple of points on this figure.

1. If T=100 ms, then at 3T = 300 ms, the current CPCH scheme might outdo the other schemes including the perfect monitoring and "ideal CA case". It is important to note that the operating point could be 10T in random access schemes.

2. Based on my understanding of the dynamics of the collision and access attempts, the curves for "perfect monitoring" and the "ideal CA" cases should be overlapping for these particular scenarios. A couple parameters can change the whole situation: a) change the Collision Back-off from 50 ms to 10 ms. This will improve the perfect monitoring situation at some points in the curve. b) Change the number of CPCH channels to 1,2,4 and 8. This will change the situation again making the "perfect monitoring" better than "ideal CA case".

3. As far as the imperfect monitoring cases, the periodicity has to change to 1.33 ms, 2.66 ms, 4 and 5.33 ms to make the imperfect monitoring parameters more realistic. It is absolutely not fair to compare an "ideal CA" case which does not consider the negative impact of "excessive interference" at high loading condition, which does not operate at multiple CPCH rates, which does not operate in single CPCH case with "exaggerated imperfect monitoring condition".

4. At D=150 ms, I read the following: Imperfect monitoring (10 ms), yields 78% throughput, the perfect monitoring is giving 85%, and the "ideal CA" case is giving 86%. If the realistic conditions are simulated, the whole situation changes dramatically.

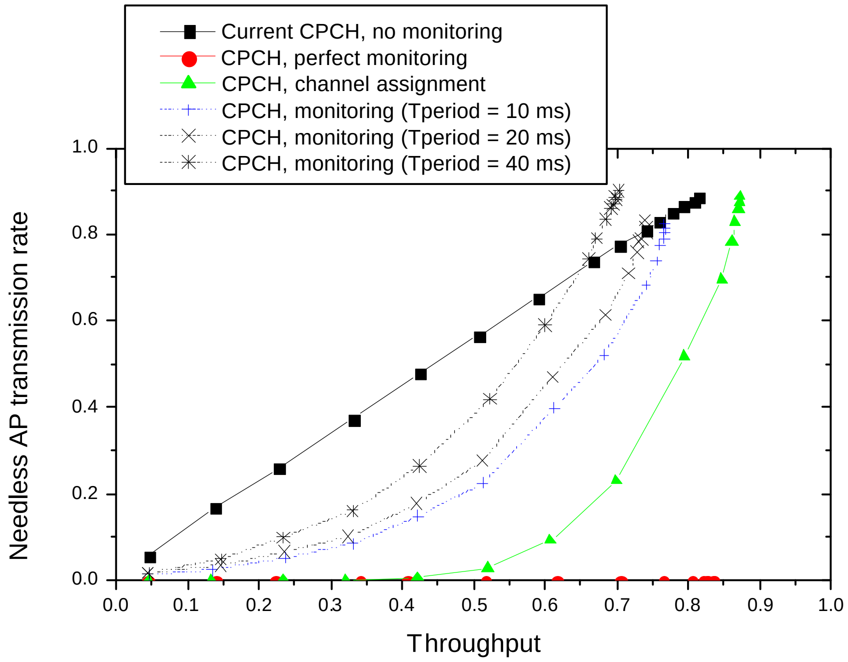


Figure 3. Needless AP transmission

The Needless AP transmission rate represents the number of AP transmission against occupied CPCH over the total number of AP transmission (for more detailed definition, refer annex). If the monitoring is perfect then it is possible to avoid needless AP transmission. However, since it is an ideal case, we have to compare channel assignment scheme with monitoring scheme including channel status broadcasting. From this index, we can compare the amount of interference generated during CPCH operation. The fact that there is no needless AP transmission represents that the operation on CPCH is fulfilled with minimal uplink interference.

This is an interesting curve, showing where the advantage of monitoring condition is coming from. I am surprised to see the imperfect monitoring case located to the left of the CA case. How could having some information on the channel occupancy [10 ms, 20 ms, etc] be worse than no knowledge on the channel occupancy [ideal CA case]? So, I do not trust this curve and think the “ideal CA” case should be doing much worse or the imperfect monitoring cases should stay to the right of the “ideal CA” curve.

Please see more comments on the annex.

Reference

[1] TSGR1#7(99)B13 Enhanced CPCH with Channel Assignment, Samsung and Philips

[2] TSGR1#6(99)B38 Status information for CPCH, Philips

Appendix

A1. Assumptions

<u>Source Traffic</u>

- Message transmission time has exponential distribution with mean 100[ms] excluding 10[ms] power control time.

- Message is generated by Poisson distribution.
- This assumption is not in line with the realistic packet models. This will change the throughput delay curves drastically. GBT's simulations are employing the "packet train model". The reason that this is important is that the delay performance will be sensitive to different considerations that small tweaking on the protocol and the relationship between the curve shifts based on the traffic model. Please refer to GBT simulation paper F11.

UE and System Operation

- AP(Access Preamble) can be transmitted without contention and the time from AP transmission to receiving of response from Node B is fixed valued, 5.4[ms].
- Why isn't there any contention?
- CRP(Contention Resolution Preamble) can be transmitted without contention and the time from CRP transmission to receiving of response from Node B is fixed value, 5.4[ms]
- Why isn't there any contention?
- UE always receives AP-AICH and CD-AICH without error (It implies ideal downlink).
- The selection of CPCH is fulfilled with fairness.
- Nap_retrans_max = 10
- There is no mention of any errors on the broadcast channel?

CPCH

- 16 signature (N_{SIG}), 16 CPCH(N_C)
- This is an important assumption, which impacts the results significantly. We should change this value to 8,4,2,1 and see the impact.
- Fixed transmission rate.
- This assumption is not good when the true packet models are employed. The throughput delay curves change when the "packet train" models is deployed.

Back off

- Backoff 1: Exponential distribution with 50[ms] mean value. (used at all channel busy case)
- Backoff 2 : Exponential distribution with 50[ms] mean value. (used at selected channel busy case)
- This value could be less [ex: 20 ms] Since only one channel is busy not all.
- Backoff 3 : Not used at this simulation. (used at AI_AICH, CD_AICH error case)
- Backoff 4 : Exponential distribution with 50[ms] mean value. (used at collision case)
- This value could be less as well [10 ms, 20 ms]
- Backoff 5 : Exponential distribution with 50[ms] mean value. (used at all channel busy case in channel assignment scheme)
- Backoff 6: Exponential distribution with 5o(?) ms value. (used when the selected data rate is not avaiable in channel assignment scheme)

Monitoring

- Broadcasting period of CPCH channel occupancy status (Tperiod) = 10[ms], 20[ms], 40[ms]
- Please add the 1.33, 2.66, 4 and 5.33 ms to see the more realistic results for the monitoring case. Also I remind you that you are challenging an existing "agreement" here. So at the very least the comparison should be fair.

- UE immediately starts access procedure on CPCH without waiting next broadcasting.
- Does the UE opt for the first available channel or sits through the whole broadcast period?

A. 2 Definition of performance indices

<u>Throughput</u>

The *throughput* representing the actual amount of transmitted data divided by channel capacity is defined as following :

$$Throughput = \frac{\sum_{N_{succ}} T_p}{T_e \cdot N_c}$$

Where,

T_P : packet transmission time (except 10[ms] CPCH preamble transmission time)

N_{SUCC} : number of packets transmitted successfully during simulation time

T_e : simulation time

N_C : number of CPCH channel

We need to introduce an excessive interference factor into this equation so that the negative impact of excessive "needless AP transmission" is captured in the capacity. I realise that it is captured in the "Delay performance". This excessive interference will simply increase the overall level of the interference and impact the overall capacity in a negative manner. This is extremely important in the CDMA systems. Even if this turns out to be equivalent to a 64 kbps channel, it means that in the "realistic CA " throughput will be hit by 2-3%:

Throughput of a single CPCH channel = .86 x 64 = 55 kbps

Excessive interference per CPCH channel = 64 kbps/16 = 4 kbps

So the throughput per single CPCH channel = 51 kbps = .79 x 64 kbps

This is only an example and might be unrealistic. But I think a point is made that the interference generated at high loading conditions can not be ignored in the case of CA method.

<u>Delay</u>

<u>I think it would be useful if you provided your formulas for the "perfect monitoring case" as well.</u>

The *Average Delay* representing the total waiting time from starting of first access attempt to beginning of successful transmission on CPCH is defined as following:

1) Current Scheme

$$Delay = \sum_{M2}(T_{ap} + D_{BO2}) + \sum_{M4}(T_{ap} + T_{cp} + D_{BO4}) + T_{ap} + T_{cp} + T_{pr} \quad \text{, if packet is transmitted successfully}$$

$$(M2 + M4 + 1 = M)$$

2) Monitoring Scheme

$$Delay = \sum_{M1} D_{BO1} + \sum_{M2}(T_{ap} + D_{BO2}) + \sum_{M4}(T_{ap} + T_{cp} + D_{BO4}) + T_{ap} + T_{cp} + T_{pr} \quad \text{if packet is transmitted successfully}$$

$$(M1 + M2 + M4 + 1 = M)$$

The Backoff values should be adjusted to reflect the severity of the situation. This is true for all cases.

3) Channel Assignment Scheme

$$Delay = \sum_{M1}(T_{ap} + D_{BO1}) + \sum_{M5}(T_{ap} + T_{cp} + D_{BO5}) + T_{ap} + T_{cp} + T_{pr} \quad \text{, if packet is transmitted successfully}$$

$$(M1 + M5 + 1 = M)$$

BO4 and BO 6 should be added to this formula to introduce some "reality" into the channel assignment case. You might have assumed there is no collision in the case of Channel Assignment case, but this assumption is not true [if made]. While at Nc =16, the collision for CA might be less severe, when various data rates are added the whole picture changes.

Where,

T_{ap} : The time from PA transmission to receiving corresponding response.

T_{cp} : The time from CD-PA transmission to receiving corresponding response.

T_{pr} : The CPCH preamble transmission time (10[ms] fixed value).

M*n* : Total number of type *n* Backoff.

D_{BOn} : The delay induced by type n Backoff.

M : Total number of PA/CD-PA transmission for successful transmission. ($M \le N\text{ap\_retrans\_max}$)

$$\textbf{Average Delay} = \frac{\sum_{i=1}^{N_{access}} D_i}{N_{access}}$$

Where,

D_i = The Delay of i_{th} access attempt.

N_{access} : The total number of access attempt during simulation time.

<u>Needless AP transmission rate (Qap)</u>

The *Needless AP transmission rate (Qap)* represents the ratio of the AP transmission against occupied CPCH over the total AP transmission is defined as following :

$$Qap = \frac{Nap\_nak}{Naccess}$$

Where,

N_{access} : The total number of access attempt in simulation time.

N_{ap_nak} : The total number of packets received NAK after AP transmission in simulation time

More comments on the last flow chart.

A3. Detailed flow chart of each scheme

Figure A1. Flow chart of current scheme.

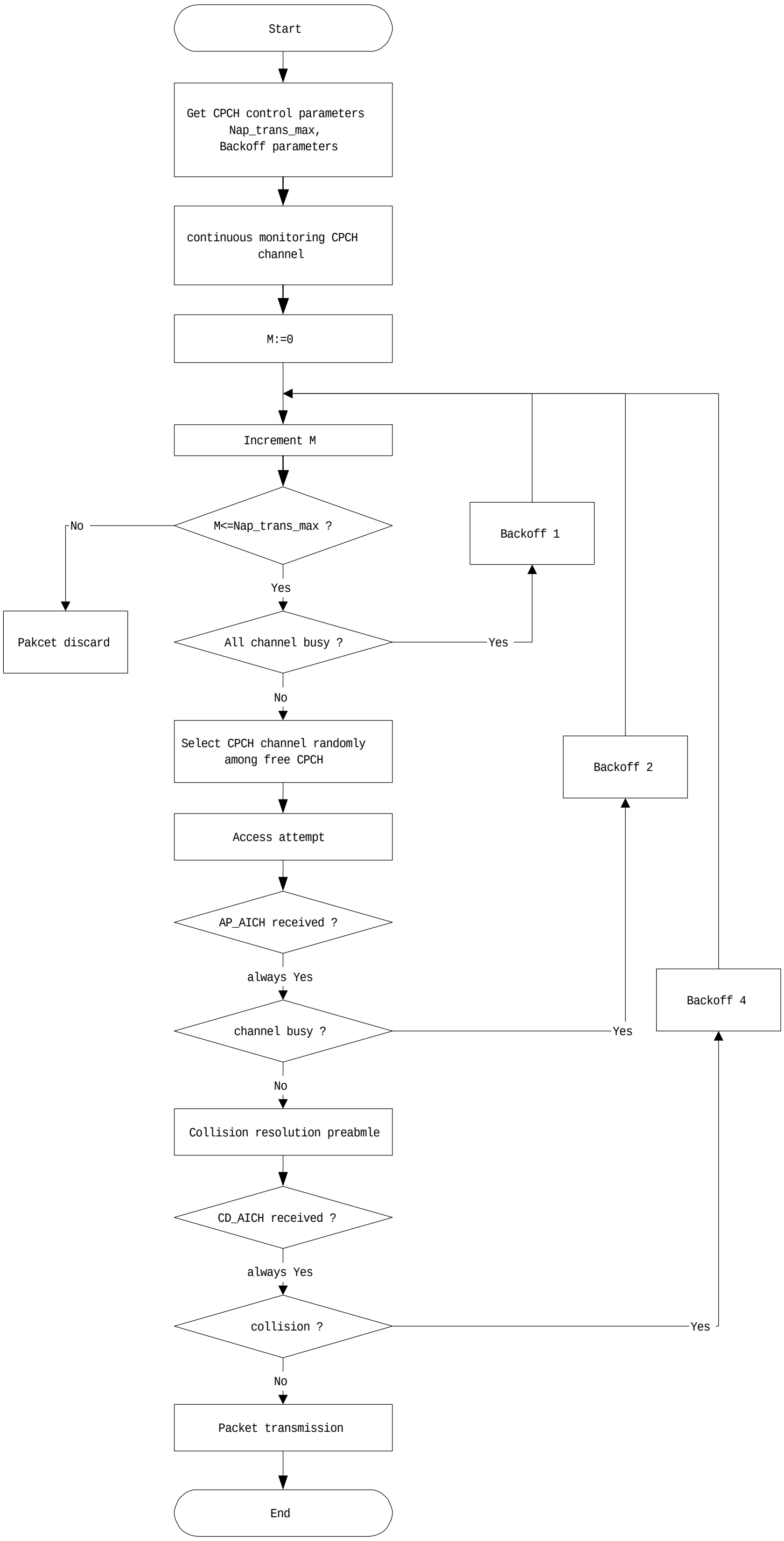


Figure A2. Flow chart of monitoring scheme

Figure A3. Flow chart of channel assignment scheme.

This flow chart should include the collision case as well. There might be a condition where a collision has occurred and a channel is assigned. This will hit the throughput depending on the severity of the condition. As an example, if the loading is high and there are three arrivals, then the probability of undetected collision will be 3/256 (very simplistic case) which is roughly 1.2%. In cases where the number of Nc = 2,4 then the collision probability will be 3/(16 x 4) = 4.8%, 3/(16x 2) = 9.6%. So these numbers will change your results at high loading conditions dramatically. These are first order approximations and the simulation might show more severe conditions.

Title : Further results of CPCH performance 1

Author : Samsung

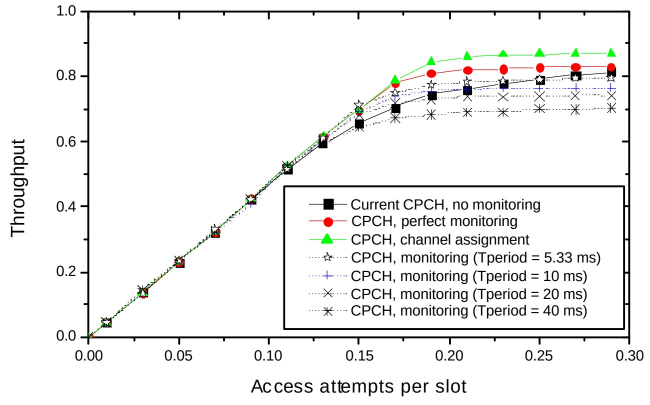
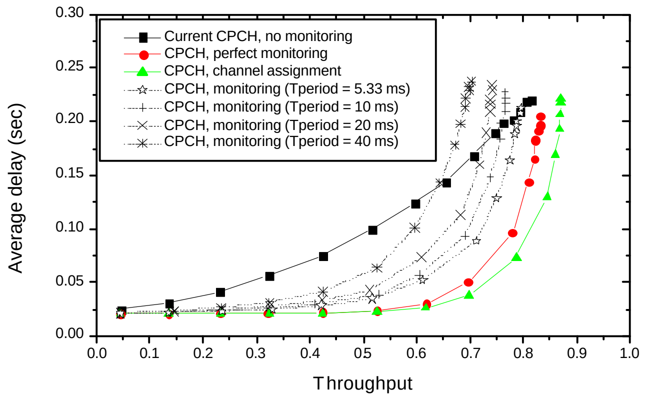
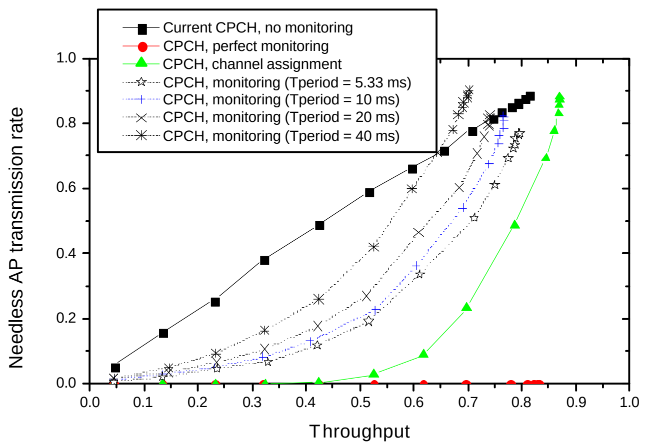
Date : 1999/11/20

1. Addition

- Tperiod = 5.33ms (4 access slots)

  We added the performacne of UE’s channel selection with the availability information of each channel, when the broadcasting period is 5.33ms.

2. Results

Throughput	
Average Delay	
Needless AP transmission rate	

Review of Further results from Samsung simulations:

1. The results show that the 5.33 ms period performs best and is near optimum as compared to perfect monitoring.
2. Furthermore, it is interesting to note the behaviour of the “current CPCH” which seems to begetting better than all other cases.
3. The CA case is still “suspect” and under question as it does not reflect the realistic assumptions.

Conclusion

The results shown here are not for realistic CA method and are not conclusive. They are also not performed with a packet train model assumption and therefore do not have comparative value.