TSG-RAN Working Group 1 meeting #9
Dresden, Germany, Nov. 30 – Dec. 3, 1999

TSGR1#9(99)j73

Agenda item: AH14

Source: Samsung

Title: Performance Evaluation of CPCH. (Rev.2)

Document for: Discussion.

Introduction

There was a contribution [3] showing performance evaluation result on channel assignment scheme [1] and monitoring scheme [2]. However, there have been some concerns on the simulation condition of previous contribution. The purpose of this contribution is to provide revised evaluation result incorporating the raised concerns.

Additionally, this contribution shows the effects of downlink error, CPCH status broadcasting with its period 5.33[ms] and combining of channel assignment scheme with monitoring scheme. However, the evaluation result still shows that the channel assignment scheme is superior to other schemes.

Brief operation scenario of each scheme

Four schemes are compared at this contribution, current scheme, channel assignment scheme, monitoring scheme and channel assignment with monitoring. This section shows brief operation scenario of each scheme. The operation scenario in detail is described in Annex with flowchart format.

a) Selection Phase :

- Current scheme :
  - UE determines a DL-DPCCH/CPCH pair number by randomly selecting an AP(Access Preamble) signature *among DL-DPCCH/CPCH pairs provided by UTRAN.*
- Channel assignment scheme :
  - *UE randomly selects an AP(Access Preamble) signature among AP signature provided by UTRAN*
- Monitoring scheme :
  - *UE continuously monitors occupancy status of CPCHs*.
  - *If there is only one unoccupied CPCH*, UE determines a DL-DPCCH/CPCH pair number by randomly selecting an AP signature *among unoccupied CPCHs.*
- Channel Assignment with Monitoring scheme :
  - *UE continuously monitors occupancy status of CPCHs*
  - *If there is only one unoccupied CPCH, UE randomly selects an AP(Access Preamble) signature among AP signatures provided by UTRAN.*

b) Acquisition Phase :

- UE sends AP with the selected signature to UTRAN until receiving a response.
- UTRAN sends back ACK/NAK on AP-AICH according to resource occupancy status of the requested DCH/CPCH pair.

c) 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 & Channel Assignment with Monitoring 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:

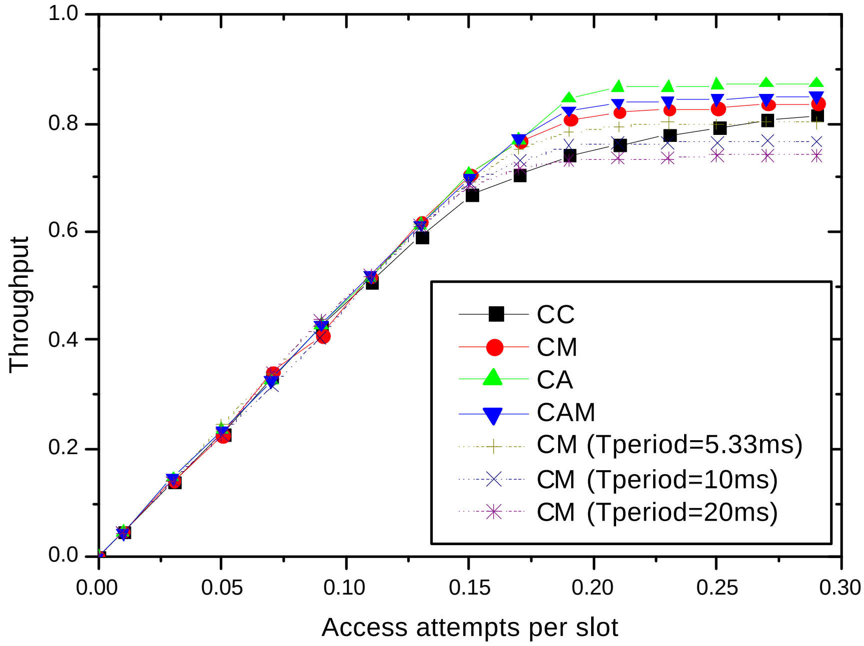
- Current & Monitoring scheme
  - Upon receiving an ACK associated with CD preamble, the UE starts the transmission of burst data on CPCH *with the code channel that was predetermined by the selection of AP preamble signature.*
- Channel Assignment & Channel Assignment with Monitoring scheme
  - Upon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

Simulation Result

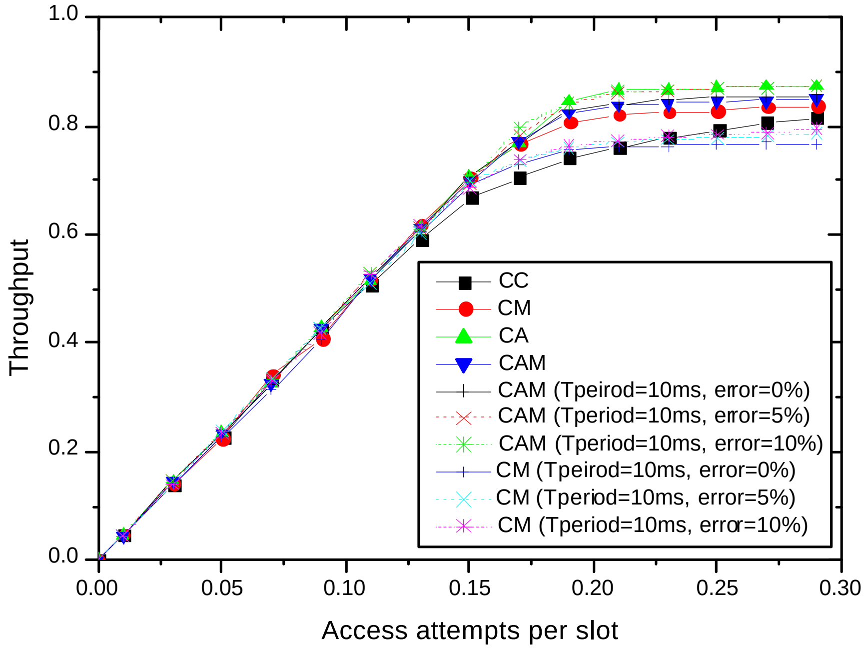
The simulation results of each scheme are shown in following figures at the point of throughput, average delay, and the ratio of needless AP transmission implying the amount of superfluous uplink interference. Two graphs are proved to each performance index so as to investigate the effect of downlink error and variation of downlink status broadcasting period. The T_{period} represent the broadcasting period of CPCH occupancy status. Following legends are used at figures for simplicity.

- CC : Current CPCH without monitoring
- CM : Channel Monitoring scheme
- CA : Channel Assignment scheme
- CAM : Channel Assignment with Ideal Monitoring scheme

Throughput



(a) According to variation of broadcasting period.



(b) According to variation of downlin error rate

Figure 1. Throughput

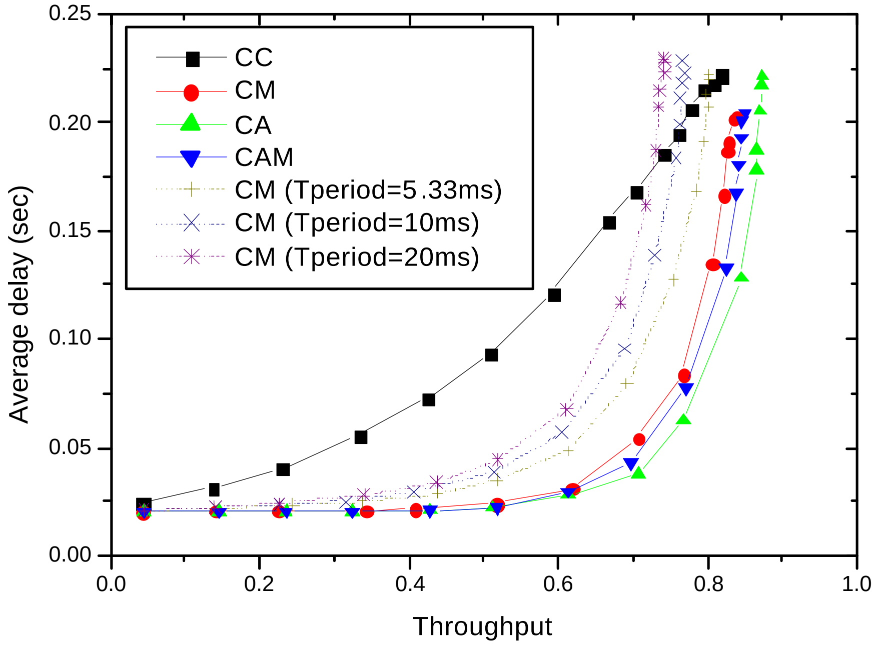
The figure 1 shows the throughput of each scheme, which represents the actual amount of transmitted data divided by channel capacity (for more detailed definition, refer annex).

At lightly loaded situation, the difference is negligible. However, at heavily loaded situation, the channel assignment (CA) scheme shows higher throughput than that of others. This result mainly comes from the fact that in CA scheme the CPCH code channel is assigned by Node B, whereas in channel monitoring (CM) scheme each UE randomly selects CPCH code channel. UE's channel selection fulfilled at selection phase by selecting AP signature, but NodeB's channel selection fulfilled at contention resolution phase by assigning code channel. Since the time gab between channel selection epoch and channel using epoch of CA scheme is smaller than that of CM scheme, the CA scheme shows better performance even than perfect channel monitoring scheme.

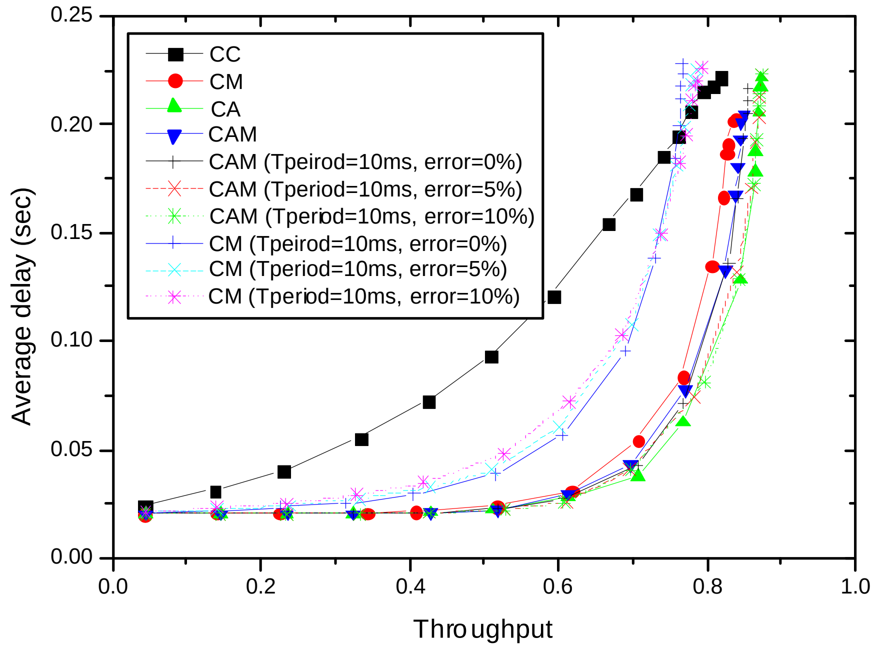
It seems interesting to note that the CA scheme shows better performance than that of channel assignment with perfect monitoring (CAM) scheme. In CAM scheme, UE fulfils backoff at selection phase if all CPCH is busy. However, if a CPCH will be released at the beginning of contention resolution phase, then this backoff becomes needless. It is the reason of this phenomenon.

The effect of varying period of CPCH status broadcasting is depicted at figure 1-(a). Even though the period is decreased until 5.33[ms], the gab with the curve of CA scheme doesn't become negligible. The effect of downlink error rate is also plotted at figure 1-(b). The change of curve induce by downlink error rate variation is also negligible.

Average Delay



(a) According to variation of broadcasting period



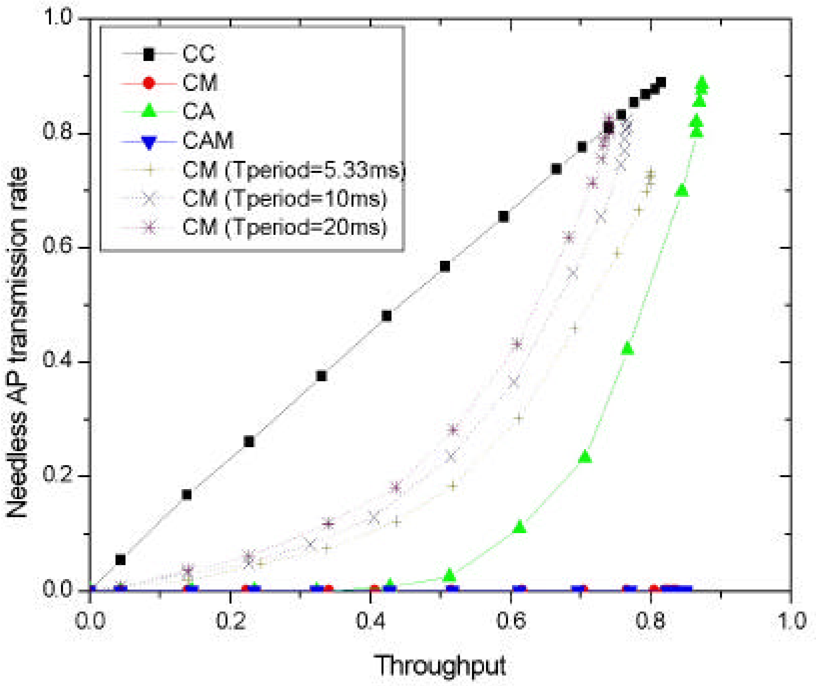
(b) According to variation of downlink error rate

Figure 2. Average Delay

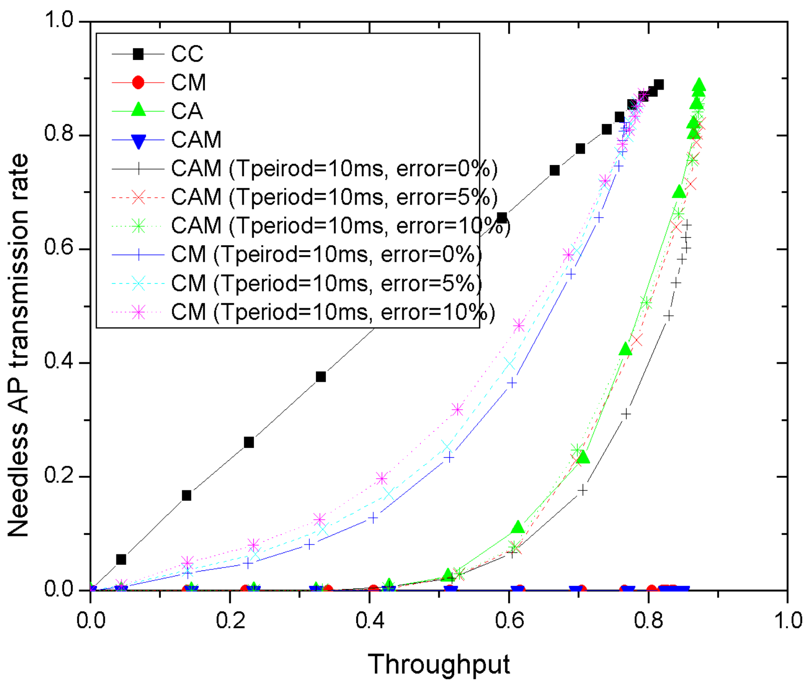
The figure 2 shows the Average delay of each scheme, which represents the total waiting time from starting of first access attempt to beginning of successful transmission on CPCH (for more detailed definition, refer annex). In this result the CA scheme also has lower average delay than that of others even at lightly loaded situation.

In order to investigate the characteristics of monitoring scheme, the effect of varying broadcasting period (T_{period}) from 0 to 20[ms] is also plotted at figure 2-(a). Even the broadcasting period is reduced to 5.33[ms], the gab between CA scheme and CM scheme doesn't become negligible. The CM scheme with T_{period} =5.33[ms] has lower saturation point (around throughput 0.7) and has higher average delay than CA scheme. If we consider that the system is usually operated at the range where the reasonable average delay is ensured, it should be noted that the CA scheme provides reasonable average delay at wider range than other schemes do. The effect of the error on CPCH status broadcasting is also depicted at figure 2-(b).

Needless AP transmission ratio



(a) Accroding to variation of broadcasting period



(b) According to variation of downlink error rate

Figure 3. Needless AP transmission

Figure 3 shows the Needless AP transmission rate of each scheme, which represents the number of AP transmission to occupied CPCH over the total number of AP transmission (for more detailed definition, refer annex). This figures shows which scheme is most efficient from the perspective of uplink interference since the less the needless AP transmission rate, the less uplink interference is induced.

If the monitoring is perfect, then the needless AP transmission, transmitting AP preamble to occupied CPCH, is not occurred. However, the perfect monitoring is an ideal case since it requires error free and realtime broadcasting of CPCH status. Therefore, the CA scheme should be compared with CM scheme including periodic broadcasting.

In addition, there is one more considerable factor, the effect of persistency value. UTRAN varies the persistency value of CPCH according to the amount of offered load so as to maintain reasonable uplink interference level. Therefore, the figure 3 has meaning at the range where the reasonable uplink interference level is ensured. For the case of CA scheme, the reasonable range is where the throughput is 0 to 0.5.

Conclusion

Through the evaluation result, it is proven that the channel assignment scheme is superior to other schemes from the perspective of throughput, average delay and uplink interference. The effect of downlink error on CPCH status broadcasting and the effect of variation of CPCH status broadcasting period are ‘t sufficient to change trend of evaluation result.

Reference

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

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

[3] TSGR2#8(99)E13 Performance evaluation of CPCH, Samsung

Appendix

A1. Assumptions

System

- All physical channels are treated as error free physical channel except CPCH status broadcasting channel.

Source Traffic

- Message transmission time has exponential distribution with mean 100[ms] excluding 10[ms] power control time.
- Message is generated with Poisson distribution.[1]

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].[2]
- The selection of CPCH code channel is fulfilled with fairness.
- Nap_retrans_max = 10

[1] The basic assumption on source traffic is that the CPCH will be used to transmit short burst user traffic not whole WWW traffic since soft handover mechanism is not supported on CPCH.

[2] Since contention on AP transmission brings same effect on both CA and CM scheme, the error free AP transmission is assumed.

CPCH

- 16 signature (N_{SIG}), 16 CPCH(N_C)[3]
- Single transmission rate.[4]

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)
- 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)
- Backoff 5 : Exponential distribution with 50[ms] mean value. (used at all channel busy case in channel assignment scheme)

Monitoring

- Broadcasting period of CPCH channel occupancy status (T_{period}) = 5.33[ms], 10[ms] and 20[ms]
- UE immediately starts access procedure on CPCH without waiting next broadcasting.

A. 2 Definition of performance indices

Throughput

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

Delay

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

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

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

[3] There is a close relationship between CPCH channel number and the performance gain achieved by channel assignment scheme. If channel number is increased, then the better output can be achieved by channel assignment scheme. If the channel number is 1, then the CA scheme and CM scheme bring nearly same result. Therefore, it is reasonable to apply channel assignment scheme only when the number of CPCH is not 1.

[4] Multiple rate case is not considered in this simulation since it still has much open issue on UE's rate decision rule. However, the effect of multiple rate on throughput, delay seems similar to the effect of variation of CPCH channel number.

2) Monitoring Scheme

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

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

3) Channel Assignment Scheme

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

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

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. ($M \leq N\text{ap\_retrans\_max}$)

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

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

A3. Detailed flow chart of each scheme

Figure A1. Flow chart of current scheme.

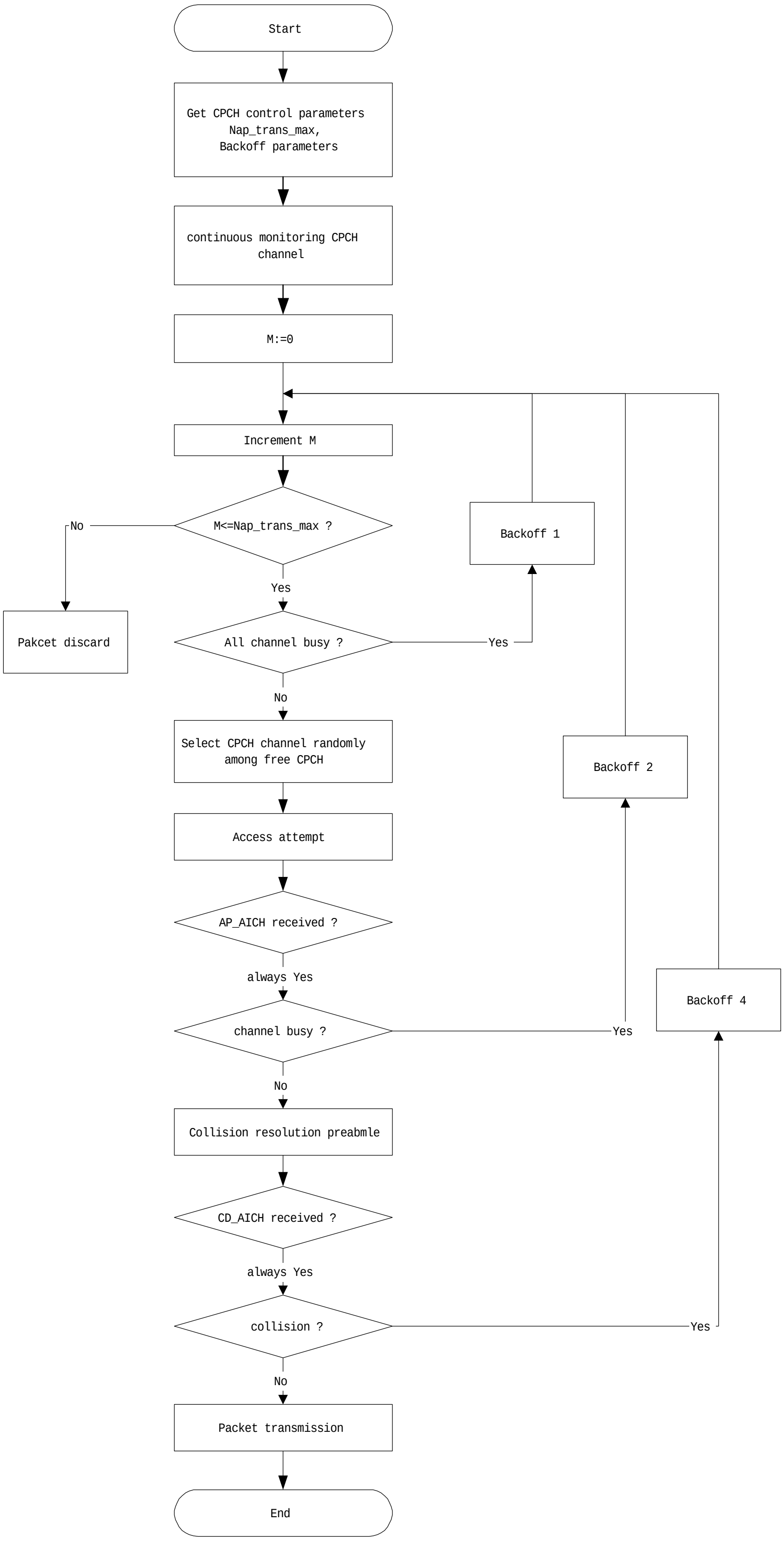


Figure A2. Flow chart of monitoring scheme

Figure A3. Flow chart of channel assignment scheme.

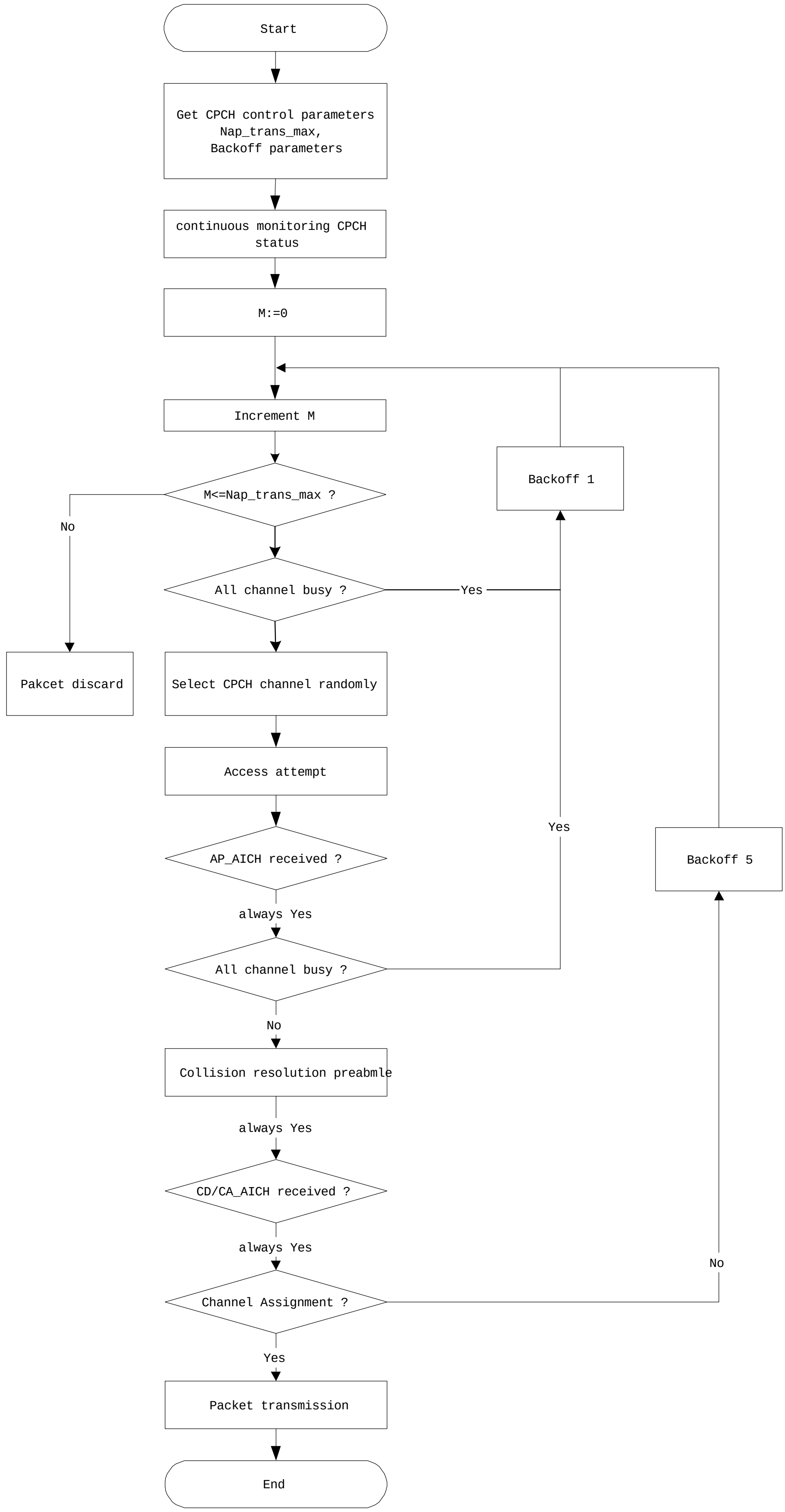


Figure A4. Flow chart of channel assignment with monitoring scheme