무선 ATM 망에서 기지국 고장시 회복 기법

임 지 영†·정 태 명††

요 약

이동 호스트에서 기지국으로의 데이터 전송시 예상치 못한 기지국 전체 고장은 필연적으로 버퍼에 있는 데이터의 손실을 초래하고 적절한 손실 보상이 필요하다. 기지국의 고장시의 회복을 위한 기존의 기법들은 오버헤드가 많고 단순히 무선 링크 장애만을 고려하므로 기지국 전체 고장에는 적합하지 않다. 유무선망 전체의 신뢰성 있는 전송을 위한 End to End 전송 방식도 비효율적이고 이동 호스트가 보상할 데이터 량을 알기 위해 필요한 기지국 버퍼의 정확한 손실 정도를 알기 어렵다. 본 논문에서는 기존에 제안된 기법들의 문제점을 분석하고 무선 ATM망에서 기지국 고장시에 효율적으로 손실 보상을 하도록 하는 기법으로 CPS(CheckPoint Scheme)을 제안한다. CPS는 기지국이 버퍼의 출력 정보를 통보하여 고장시에 이동 호스트가 seamless한 전송을 할 수 있도록 한다. 기존의 기법들과 시뮬레이션 및 비교 분석을 통하여 CPS의 효율을 증명한다

Recovery Mechanism for Base Station Failure in Wireless ATM Networks

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ABSTRACT

During transmission in wireless networks a base station failure inevitably causes data loss of the base station buffer. Thus, it is required to compensate the loss for seamless communication. The existing schemes for a base station failure are not adequate because they all suffer from too much overhead and resolve only the link failure. The End to End scheme for reliable transmission of both wired and wireless networks is not efficient. In this paper we review the existing schemes and then propose CPS (CheckPoint Scheme) that enables the mobile host to compensate data loss efficiently in the case of base station failure. In CPS a base station deliveries an output information of data cells to a mobile host so, when a base station fails, the mobile host can retransmit just next data cells seamlessly. We also prove the efficiency of CPS by modeling and simulating WATM networks and analyze the simulation results.

키워드 : 무선망(Wireless ATM Networks), 기지국 고장(Base Station Failure), 이동 호스트(Mobile Host), 손실 보상(Seamless transmission), 기지국 버퍼(CheckPoint Scheme)

1. 서 론

During transmission from a MH (mobile host) to a BS (base station) a base station failure results in both broken beacon signal and loss of buffered data. For the adaptation of the situation, the affected MH requests a handoff to the new BS and receives channels from the new BS using a channel allocation scheme like the **Directed Retry**. The **Directed Retry** is a channel allocation scheme that the new BS in another cell allocates available channels to the MH in the case of not getting service as BS failure [1].

Just after receiving new channels as well as this, the MH desires to send data to the new BS seamlessly by compensating data lost at the failed BS. However, the traditional channel allocation schemes and the extended channel allocation schemes cannot provide seamless communication or require too much overheads to recover loss of data. One of the simplest schemes for the BS failure recovery is mirroring technique that prepares for the BS failure by backing up data of the BS into the neighboring BSs. When a BS fails the MH can continue to send the next data to one of the neighboring BS after a handoff [2]. But this scheme requires that too many BSs are involved in storing replicate data and always updating them even in normal state. In fact, some wireless networks maintain redundant BSs. But it is very expensive and useless in the case of the simultaneous failure.

In every wired and wireless networks including wireless ATM, ACK propagation and retransmission scheme, that is

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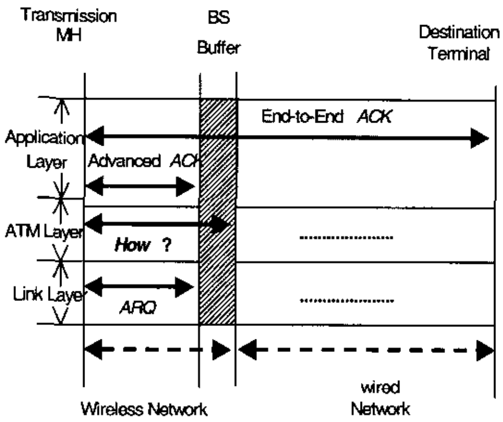
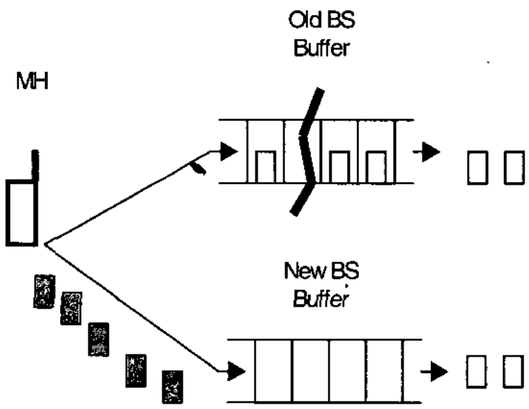
End to End scheme ,can be used as a method for reliable transmission as depicted in (Fig. 1) [3, 4].



(Figure 1) The scope of ACK Propagation3

As shown in (Fig. 1), the End to End scheme is for reliable transmission between the both terminals in the whole wired and wireless networks; thus, it is not efficient to apply the scheme to wireless networks failure such as a BS failure [3, 5, 6]. Because advanced ACK transmission for wireless network failure or ARQ offered in the wireless link layer uses ACK signal not for output data, but receiving data, a MH is unable to know how many data a BS sent to the destination terminal before failure [3, 7, 8]. Unless using any of the existing recovery mechanisms such as these, a MH must retransmit all the data of old BS buffer to the new BS as shown (Fig. 2).



(Figure 2) The data loss of BS Buffer

However, the retransmission of the all data makes unnecessary traffic and brings intolerable transmission delay and network congestion. Thus far, a few related schemes for wireless ATM networks are proposed. Li and Mitts proposed scheme which uses Mark cell for a seamless cell transmission at transition from the old BS to the new BS toward ATM switch [7, 9]. This scheme is not suitable for a BS failure because it deals with only a handoff in normal state. Vogel proposed a scheme for transmission guarantee by inserting Tag cells between data cells at each transmission [5]. In this scheme Tag cells play a role of acknowledgement for received data by looping back to the entity that has sent them. However, this method makes ATM switches suffer from too much overhead. Further, extra network traffic is generated because of the Tag cells between data cells. In ATM networks, AAL5 service often uses End to End scheme between a MH and a BS or both terminals, so called SSCOP [4, 8]. However, SSCOP is not suitable to apply to recover the general BS failure and has the same problems of the existing End to End schemes because it use ACK signal only for input data, but also is limited to special service category.

In this paper we propose CPS (CheckPoint Scheme) as seamless failure recovery scheme based on CheckPoint, that is analogous to the database transaction recovery scheme, as efficient means for a BS failure. CPS is to transmit data cells efficiently and seamlessly at a BS failure by making the BS giving not its input data information but its output data information, that is *CheckPoint* to the MH, which originally sent data prior to failure.

In section 2, we describe related issues to seamless data transmission. In section 3, the CPS is described. Then, we prove the efficiency of CPS by simulating and analyzing in section 4, and finally we draw conclusion and future directions in section 5.

2. Related Issues

In the wireless ATM networks, the mechanisms for seamless data transmission at network failure including a BS failure are considered as two folds - *forward handoff* implemented in the ATM layer at old BS failure and *End-to-End ACK* scheme or TCP scheme implemented in the transport layer. In this section we review details of those mechanisms.

2.1 *Forward Handoff*

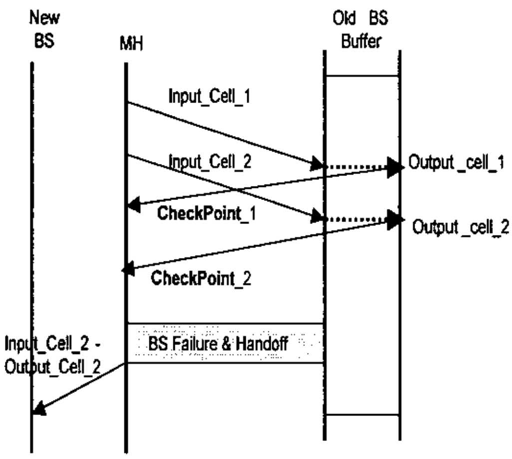
At the *forward handoff* a BS transmits the data cells in its buffer to the ATM switch [7, 10]. At the end of transmitting a block of data cells, the old BS sends last cell with *Up_ready*, a Mark cell for seamless transmission of cells. The switch can maintain seamless transmission at a handoff by receiving cells from a new BS just only after receiving the *Up_ready* cell. However, this scheme cannot be directly used to a BS failure which loses all the data cells because the forwarding handoff is a mechanism applied only to wireless link failure at a BS.

2.2 TCP in Wireless Network

Because of the differences of transmission method and transmission efficiency, it is general tendency that a method for guaranteed network transmission is not an End-to-End scheme between terminals, but is to divide the whole networks into wireless network from MHs to a BS, and wired network from a BS to fixed network [3, 6, 11]. The schemes are based on the *Indirect-TCP(I−TCP)* protocol which separates End to End TCP connection into two connections and adds another function to a BS[11], the Fast *Retransmission* scheme which retransmits data immediately after a handoff for seamless transmission [6], and the *Snoop* protocol which a BS caches and retransmits data [3]. Among the these protocols, *Fast Retransmission* has a disadvantage to cause network congestion from many retransmission data because of the End-to-End ACK scheme. In addition, the *Indirect-TCP (I-TCP)* and Snoop are also problematic in terms of the data loss from the BS because they depend on the information of received data from the BS.

3. CPS(CheckPoint Scheme)

The basic unit of CheckPoint is output cell block (OCB) of the BS and the end of each OCB is informed to the MH shown in (Fig. 3).



(Figure 3) CheckPoint Scheme

In normal state, the MH is able to know the size of data cells stored in the BS buffer by receiving CheckPoint. Therefore, when the MH suffers from data loss due to the BS failure, it can transmit just next cell to the last OCB that the BS sent before failure. Because CPS acts only in ATM layer where a handoff is required, it minimizes unnecessary overheads generated in the handoff procedure. For CPS to work correctly, we assume two. One is that the MH has a mechanism to find the BS failure and its time of failure occurrence, other is that the wired network has its own recovery mechanism so that the transmission between the BS and the destination is reliable.

3.1 Procedure in Normal State

In this procedure, the BS informs to the MH its transmission of each OCB and is as shown in Algorithm 1.

- MH's Actions

The MH initializes pointer p to indicate sequential number of data cells stored in its buffer. When receiving the CheckPoint from the BS while transmitting data cells, the MH deletes the data cells in the buffer associated with the CheckPoint and write the time that it receives the CheckPoint.

```
Before Transmission
For Base Station  CheckPoint  k;
For  Mobile Host p=1;
During Transmission
For Mobile Host
Do{Send Data_Cell to Base Station ;
    it(Recieve(c))}
      Delete Data_Cell from Buffer;
    ./* p<=Data_Cell<=c */
      p=c+1;
      t_m_1=t_m;
      t_m=current_CheckPoint_Time ;
      }}while(!=End)
For Base Station { c=p-1;
  n=0;
  Do{ n++ ;
        if(n==k||End){c=c+n;
          CP_Cell=c;
          Send CP_Cell to Mobile Host ; }
  }while(!=End)
```

(Algorithm 1) Procedure in the Normal State

- BS's Action

The BS determines k, the size of OCB. If the number of data cells is k or the transmission ends, the BS puts the sum of OCBs in CheckPont (CP) cell and transmits it to the MH.

3.2 Procedure at the BS failure

At the BS failure, the MH determines the data cells to retransmit and retransmits them. It is proceeded as described in Algorithm 2.

```
For Mobile Host{
  T=BS_Fail_Time ;
  if(t_m==T){
     Retransmit Data_Cell[*p] to New Base Station ;}
  else(t_m<T){p=p + k(T-t_m)/(t_m-t_m-1) ;
     Retransmit Data_Cell[*p] to New Base Station ;}}
For New Base Station{
  Do as well as Old Base Stationdo before Failure }
```

(Algorithm 2) Procedure at the BS Failure

- MH's Actions

The MH determines the number of the data cells to retransmit based on the value of T, the time of the BS failure. Let's say that t_m is the time that the MH receives a CheckPoint. If $t_m = T$, the first cell to retransmit is what p refers to. If $t_m < T$, it is determined as the Equ.(3-1).

$$p = p + k(T - t_m)/(t_m - t_{m-1}) \cdots\cdots \text{Equ.} \quad (3\text{-}1)$$

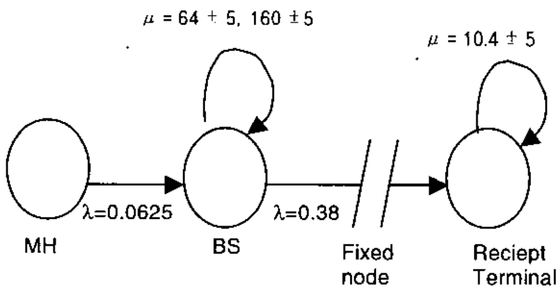
- The new BS's Action

The new BS performs its action as the normal BS does at the handoff.

4. Simulation

4.1. Simulation Model

The simulation model for wireless ATM networks is described in (Fig. 4).



(Figure 4) Wireless ATM Network Model

As shown in (Fig. 4), the data cells are transmitted from the MH, stored in the BS buffer for a short period of service time and transmitted to wired network. The data inter-arrival time and service time are distributed in Poisson and Uniform Distribution respectively. The parameters used in the model are followings.

- Inter-arrival time of between input data cells to the BS is distributed in Poisson and λ is 0.0625, which is the value according to the reasonable data traffic between a MH and a BS, 25Mbps in wireless ATM networks [12].
- μ, the mean service time in a BS buffer, are varied as $64\mu s \pm 5$ and $160\mu s \pm 5$. The service time values are set up according to an assumption that when the input cells arrive at the BS buffer at intervals of $16\mu s \pm 5$ they stays at the BS buffer for four times and twenty times of interval time each.
- Inter-arrival time of between input data cells to the fixed node is distributed in Poisson and λ is 0.38 which is the value according to the reasonable data traffic between the fixed nodes, 155Mbps in fixed ATM networks.
- μ, the mean service time in a fixed node buffer, is $10.4 \mu s \pm 5$. The service time value is set up according to an assumption that when the input cells arrive at the BS buffer at intervals of $2.6\mu s$ they stays at the BS buffer for four times of interval time.
- The numbers of nodes in the fixed network are varied as 10 ± 5.

4.2 Simulation Procedure

The parameters used in simulation procedure are followings.

- The propagation time of a cell from the MH to the BS : $T1_i$
- The propagation time of a cell between the fixed nodes : $T2_i$
- The number of input cells to the BS : C1
- The number of output cells from the BS : C2
- The number of cells for CheckPoint unit : C3
- The number of output cells from the BS during CheckPoint cell propagates : C4
- The number of output cells from the BS during ACK propagates : C5
- The service time in the BS buffer : $D1_i$
- The service time in the BS buffer : $D2_i$
- The number of the nodes in the fixed networks : N

4.2.1 The measurement of Overhead traffic

Whenever the number of cells, C3 is output from the BS, CheckPoint cells propagate to the MH. The overhead traffic, OHCP, originated from CheckPoint cells is as the following Equ.(4-1).

$$OHCP = C2 / C3 \cdots\cdots \text{Equ.} \quad (4\text{-}1)$$

4.2.2 The measurement of overlay cell

When CheckPoint cell propagates for $T1_i/2$, the output cells of C4 come from the BS and when ACK propagates for $(T1_i/2 + T2_i*N)$, the output cells of C5 come from the BS. In CPS the distance between the MH and the BS is always 1 hop but in End-to-End scheme it is more than 1 hop. Comparing C4 and C5 because $T1_i/2$ is very short time, C4 is nearly 0, we conclude that $C4 < C5$.

4.2.3 The measurement of the data cells to retransmit

There are three methods according to transmission scheme.

- When the MH retransmits the whole data cells sent before : C1
- Using CPS : C1-C2
- Using End to End scheme : (C1-C2) + C5

4.2.4 The measurement of retansmission time

The retransmission time of data cell is measured as following Equations. In the Equ.(4-2) and (4-3), Cr is the data cells to retransmit.

- T_{MB}, the sum of the transmission time from the MH to the BS and the service time in the BS :

$$T_{MB} = \sum_{i=1}^{Cr} (T1_i + D1_i) \cdots\cdots \text{Equ.} \qquad (4\text{-}2)$$

- T_{BF}, the sum of the transmission time from the BS to the recipient terminal and the service times in the fixed nodes:

$$T_{BF} = \sum_{i=1}^{N} \sum_{i=1}^{Cr} (T2_i + D2_i) \cdots\cdots \text{Equ.} \qquad (4\text{-}3)$$

The whole retransmission time is the sum of Equ. (4-2) and Equ. (4-3).

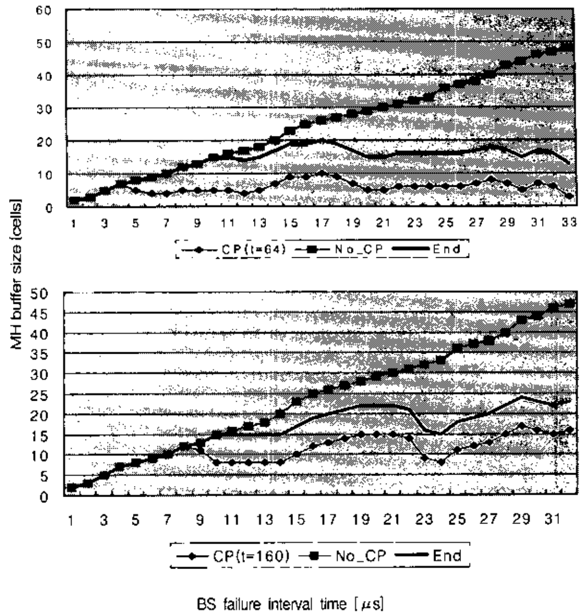
4.3 Simulation Results

Simulation results come from using the three schemes as followings when the BS fails.

- The first scheme(No_CP) : the MH retransmits all the data cells sent before.
- The second scheme(End) : the MH retransmits data using End to End scheme.
- The third scheme(CP) : the MH retransmits data using CPS.

In the graphs, (t = 64) and (t = 160) are the service times in the BS buffer and mean 64μs±5 and 160μs±5.

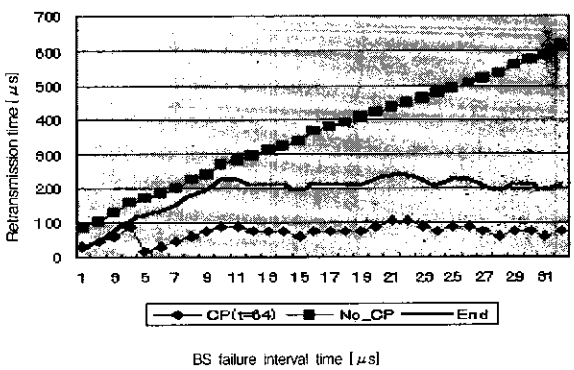
(Fig. 5) presents the buffer size needed to transmit the data cells when BS fails.



(Figure 5) MH Buffer usage for three schemes

As can be seen from (Fig. 5), using the first scheme (NO_CP) the MH buffer size grows quickly as time goes. Using the second scheme, the MH buffer size grows steadily as the same as the first scheme in the early stage and it keeps uniformly after that time though a bit of wave. That the MH buffer size grows in the early stage is because that the MH continues to transmit data cells while the first ACK signal propagates from the recipient to the MH. Because it takes longer to propagate ACK signal than to propagate CheckPoint cell in second scheme, the MH buffer size is bigger than using CPS. In CPS the MH retransmits only the data lost in the BS buffer, therefore buffer size grows a little only in early stage after that time, it is smallest among the three schemes.

(Fig. 6) presents the comparison of three retransmission times.

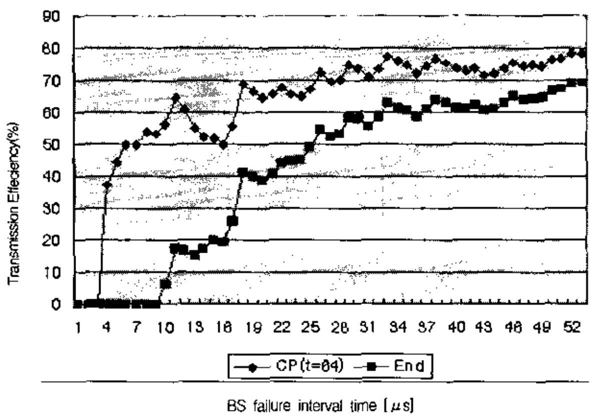


(Figure 6) Retransmission Time for three schemes

(Fig. 6) is the times to retransmit data of the buffer shown in the (Fig. 5). Therefore it shows a similar graph like (Fig. 5). From the above results using CPS we get the transmission efficiency like the Equ. (4-4).

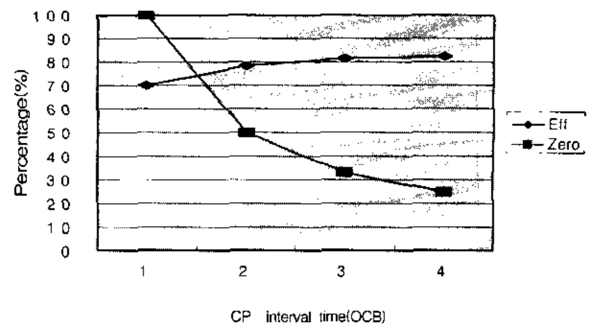
$$\text{Transmission Efficiency} = \left[1 - \frac{(l-c)+c/k}{l}\right] \times 100 \quad \cdots \text{ Equ. (4-4)}$$

In the Equ. (4-4), l is the whole size of data to retransmit and c is the size of the output data from the BS. The k presents the number for the unit of CheckPoint cells and c/k is the value for overhead of CheckPoint scheme. The overhead c/k implies that how many CheckPoints take place while the BS transmits the number, c of data cells to the receipent. (Fig. 7) shows the comparison of the transmission efficiency of CheckPoint and End to End scheme based on the Equ. (4-4). As shown in (Fig. 7) the transmission efficiency of CPS rises rapidly just after the beginning of transmission for the most part. In the middle phase it grows slowly and keeps high position after that phase. Considering that the BS failure takes place more often after the beginning of transmission than at the beginning, we know that the efficiency of CPS is very high. In End to End scheme, its efficiency grows too, as time goes by. But comparing CPS, its efficiency is lower than the efficiency of CPS. As can be seen from the results above, we know that the first scheme that the MH retransmits the whole data sent before, is not related to the service time but sensitive to the failure interval time. End to End scheme is sensitive to the failure interval time only in the beginning transmission time and it is less sensitive to the failure interval time as time goes by. CPS is the least sensitive to the failure interval time among three schemes.



(Figure 7) Transmission Efficiency for two schemes

(Fig. 8) shows CheckPoint Efficiency according to CheckPoint interval time variation.

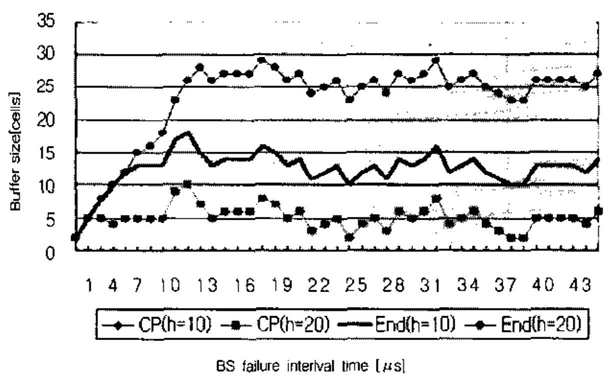


(Fig. 8) Efficiency for CheckPoint Interval

CheckPoint interval time is the same as the k(OCB) in the Equ.(3-1) and Equ.(4 - 4). The Zero in (Fig. 8) depicts the probability of ($T-t_m=0$) in the Equ.(3-1) and the Eff in (Fig. 8) depicts CheckPoi

nt Efficiency. As shown in (Fig. 8) the more CheckPoint interval time increase the more efficiency increase. However the probability of ($T-t_m=0$) decrease, so it is difficult MH to retransmit next cell to the new BS correctly. Eq.(3-1) assists to solve this problem and it is required to research for selection of proper CheckPoint interval time.

(Fig. 9) is the comparison of the buffer size between CPS and End to End scheme supposing the number of hops as 10±3 and 20±3. In this scheme ,(h = 10) and (h = 20) present the number of hops 10±3 and 20±3 each.



(Figure 9) MH Buffer usage for two cases of hops

As can be seen from (Fig. 9), in End to End scheme ACK propagation time is in proportion to the number of hops, the number of data cells to retransmit is dependent on the number of hops. But in CPS the number of hops to propagate CheckPoint cell is always 1, therefore the number of data cells to retransmit is always constant not being related to the number of hops. From this result we know that CPS is more efficient in the long distance than in the short distance.

<Table 1> shows the comparison between CPS and End to End scheme.

〈Table 1〉 Characteristics for CPS and End to End scheme.

	End to End scheme	CPS
The layer to perform scheme	Above ATM layer	ATM layer
The time to need to generate data cell	Long	Short
The overlap data cells to retransmit	Many	Few
The sensitive parameter	Hop counts	The BS service time
The distance property	Short distance	Both of short and long

5. Conclusion

BS failure inevitably causes loss of data due to disconnection of transmission. Thus, it is necessary the MH to retransmit data for seamless communication. In this paper we proposed CPS (CheckPoint scheme) for seamless transmission at BS failure. CheckPoint scheme supports the MH to transmit data cells more efficiently and seamlessly at BS failure by making the MH receive the information of output cell block from the BS before its failure. The overhead for exchanging the information is negligible and the gain is prominent as the simulation shows. From the results of simulation and comparison, we know that CPS minimizes retransmission time to improve the transmission efficiency and reduces the size of the MH buffer needed to retransmit data cells at data loss. We also know from the simulation results that CPS is not sensitive to BS failure interval time and hop counts. Because CPS is only for wireless networks and acts only in the ATM layer, it reduces unnecessary overheads and transmits quickly the information of output cell block as compared with other schemes. In the future we will study the way to reduce overlap cells expected at transmission delay and to select proper ChekPoint interval time.

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