

기준 의사 결정에 의한 모바일 트래킹을 이용한 향상된 핸드오버

강일고*, 신성윤*, 이종찬*, 표성배**, 이양원*

An Improved Handover Method Using Mobile Tracking by Fuzzy Multi-Criteria Decision Making

Kang Il Ko*, Shin Seong Yoon*, Lee Jong Chan*, Pyo Seong Bae**, Rhee Yang Won*

요약

서비스를 요구하는 다수의 사용자를 수용하려면 마이크로- 와 피코-셀과 같은 작은 셀로 크기를 더욱 줄이는 것이 일반적으로 수용되고 있다. 이런 환경에서는 빈번한 핸드오버가 발생하게 되고 이로 인해 허용 가능한 핸드오버 처리 지연 시간을 감소시켜 결국 패킷 손실과 핸드오버 실패를 초래하게 된다는 것이다. 또한 패킷 손실을 보상하기 위한 재전송이 필요하게 되어 시스템의 성능을 저하시킨다. 본 논문에서는 차세대이동통신시스템을 위한 새로운 핸드오버 기법을 제시한다. 이동 단말기의 현재 위치와 이동 방향을 기반으로 핸드오버 셀을 예측함으로써, 핸드오버 설정 절차가 핸드오버 요청 전에 선행된다. 시뮬레이션은 핸드오버 실패율과 패킷 손실율에 초점을 두었다. 시뮬레이션 결과를 통하여 제시된 방안이 기존의 방법보다 향상된 성능을 보임을 입증한다.

Abstract

It is widely accepted that the coverage with high user densities can only be achieved with small cell such as micro- and pico-cell. The smaller cell size causes frequent handovers between cells and a decrease in the permissible handover processing delay. This may result in the handover failure, in addition to the loss of some packets during the handover. In these cases, re-transmission is needed in order to compensate errors, which triggers a rapid degradation of throughput. In this paper, we propose a new handover scheme in the next generation mobile communication systems, in which the handover setup process is done in advance before a handover request by predicting the handover cell based on mobile terminal's current position and moving direction. Simulation is focused on the handover failure rate and packet loss rate. The simulation results show that our proposed method provides a better performance than the conventional method.

▶ Keyword : 핸드오버(Handover), 모바일 트래킹(Mobile Tracking), 다기준 의사결정(Multi-Criteria Decision Making), 핸드오버 설정 절차(Handover Setup Process).

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* 군산대학교 컴퓨터정보과학과, **인덕대학 소프트웨어개발과

I. 서론

Next generation wireless communication systems are considered to support various types of high-speed multimedia traffic with packet switching at the same time. To do that, more upgraded quality of service and system capacity are needed. Due to the limitations of the radio spectrum, the next generation wireless networks will adopt micro/pico-cellular architectures for various advantages including higher data throughput, greater frequency reuse, and location information with finer granularity. In this environment, because of small coverage area of micro/pico-cells, the handoff rate grows rapidly and fast handoff support is essential [1]. The handover algorithm for the current 3G system is based on the received signal strength. As a mobile terminal(MT) moves further away, towards the edge of a cell the received signal strength decreases. The MT continuously measures this signal strength and that of the neighboring cells at the allotted broadcast channels. The MT passes this information to the BS. If the signal strength in the current cell is lower than a certain threshold, it finds out which neighboring cell has the highest signal strength and request it to setup a session for the MT. However, in small cell areas, handovers occur more frequently and the permissible handover processing delay is smaller than in large cell areas. These would incur situations where the network cannot complete the handover before the deadline [2], which is when a MT cannot continue communications via the old (i.e., before the handover) base station (BS) because of radio signal degradation (i.e., handover failure).

A major problem arises in providing real-time services due to frequent handoffs resulting from mobility [3]. When a MT moves from one BS to another, packets arrived in the previous one are either dropped or forwarded to the

new one without QoS support. The most common way to make this handoff adjustment period faster is to send all packets to the potential future BS in addition to the current BS [4-5]. When the current BS knows the position of the MT, it does not need to send packets to all of its neighboring BSs. Instead, it can specify the BSs that are in the direction of the movement and only send to them. This eliminates the packet loss in handoff and time interval between packets is reduced. This is important for satisfying quality of service for real time data. We propose a new method that makes it possible to avoid a handover failure by performing the handover setup process in advance before a handover request in order to shorten the handover delay, in which the handover cell is selected based on the direction information from a block information database and the current position information from Position Estimator (PE) using Fuzzy Multi-Criteria Decision Making (FMCDM). To enhance estimation accuracy, we propose a scheme based on FMCDM which considers multiple parameters: the signal strength, the distance between the BS and MTs, the moving direction, and the previous location. For predicting the MT's movement to the handover cell, we also propose the use of a block information database composed of block objects for mapping into the positional information provided by PE.

II. Defining Location

The process of making a block object, which is the constituent of the block information database and comprise of handover cell information and so on, is described in this section. The position of a MT within a cell can be defined by dividing each cell into tracks and blocks, and relating these to the signal level received by it at that point. It is done automatically in two phases of track definition and block definition. Then the block information database is constructed with these results. The system scheme estimates in stepwise the optimal block at which the MT locates with the help of the block information database and the position information for PE.

Three classified tracks are used to predict the mobility

of the MT as shown in Fig 1. Each cell consists of track_1 as a serving cell area, track_2 as a handover cell selection area, and track_3 as a handover area, where the handover area is defined to be the area where the received signal strength from the BS is between the handover threshold and the acceptable received signal strength. Within this area, a handover is performed to the BS with the highest signal strength.

The track_1 does not need pre-established sessions since the handover probability of the MT is very low. In track_2, the number of pre-established sessions is dynamically changed according to the MT's moving direction and neighboring cells. The track_3 needs handover. Track_2 is divided into n blocks by the location information, and block objects are created for each block. The MT's position information from PE is valid only in track_2, and is ignored in other tracks.

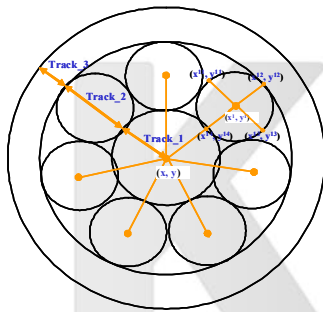


그림 1. 셀을 트랙으로 분할하고 벡터를 이용한 블록의 식별
Fig 1. Dividing a cell into tracks and identifying the block using the vector

The collection of block information is called the block object as shown in Fig 2. The block object contains the following information: BlockId, BlockLocationInfo indicating the information on the block's location within a cell comprised of one center point and four of area point; HandoverCellId indicating the adjacent cells to which a MT may hand over in this block; NextBlockId indicating another block within track_2 which may be traveled by a MT; VerificationRate indicating verification rate for the selected handover cells.

```

class BlockObject
{
private:
    int BlockId;
    int BlockLocationInfo[4];
    int HandoverCellId[i];
    int NextBlockId[j];
    int VerificationRate;
public:
    :
}

class MobileObject
{
private:
    int Mtid;
    int BlockId;
    int HandoverCellId[i];
    int NextBlockId[j];
    int MovementPath [n];
    int VerificationRate;
public:
    :
}
    
```

그림 2. MT와 블록을 위한 객체 정보
Fig 2. Object information for a MT and a block

Each MT updates periodically his mobile object which represents his current state for handover as shown in Fig 2. The Mobileobject contains the following information: Mtid, BlockId, HandoverCellId, NextBlockId, MovementPath, VerificationRate. BlockId is ID of the block in which a MT is located, HandoverCellId is IDs of the cells which a MT may hand over, and MovementPath is the moving course of a MT.

III. Mobile Tracking based on FMCDM

3.1 Membership Function

The membership function with a trapezoidal shape is used for determining the membership degree of the MT because it provides a more versatile degree between the upper limit and the lower one than the membership function with a step-like shape. Let us define the membership functions for the pilot signal strengths from neighboring base stations. The membership function of PSS_i , $\mu_R(PSS_i)$, is given by Fig 3. PSS_i is the signal strength received from the base station i, s_1 is the lower limit, and s_2 is the upper limit.

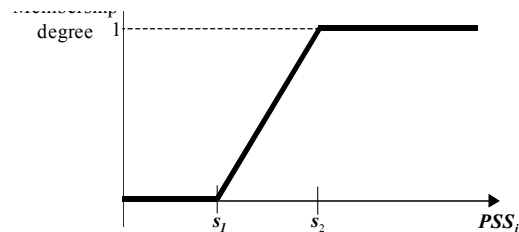


그림 3. PSS의 멤버십 함수
Fig 3. The membership function of the PSS

Now we define the membership function of the distance. The membership function of the distance, $\mu_R(D_i)$, is given by Fig 4, where D_i is the distance between the base station i and the MT, d_1 is the upper limit, and d_2 is the lower limit.

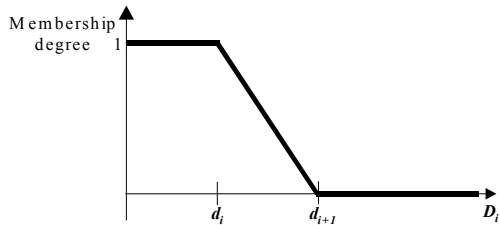


그림 4. 거리의 멤버십 함수
Fig 4. The membership function of the distance

The membership function of the previous location of the MT, $\mu_R(L_i)$, is given by Fig 5. Where L_i is the vector information of its current location, E_1, \dots, E_4 is the vector information of the previous location, and g_i is the physical difference between them.

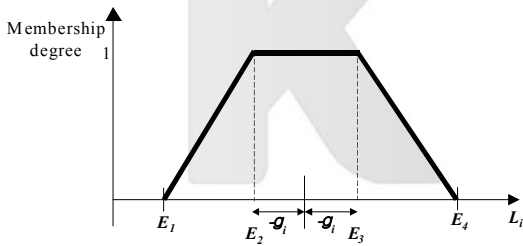


그림 5. 위치의 멤버십 함수
Fig 5. The membership function of the location

The membership function of the moving direction, $\mu_R(C_i)$, is given by Fig 6. C_i is the vector information of the moving direction, PSS_1, \dots, PSS_4 is the pilot signal strength and α_i the physical difference between the previous location and the current one.

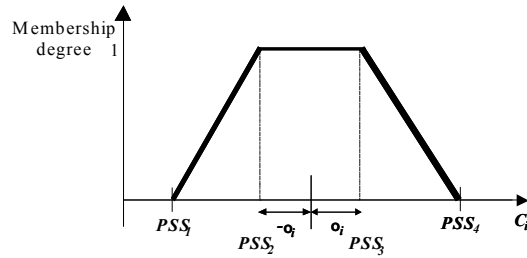


그림 6. 방향의 멤버십 함수
Fig 6. The membership function of the direction

3.2 Location Estimation

Most of the FMCDM approaches face the decision problem in two consecutive steps: aggregating all the judgments with respect to all the criteria and per decision alternative and ranking the alternatives according to the aggregated criterion. Also our approach uses this two-steps decomposition [6]. Let J_i ($i \in \{1, 2, \dots, n\}$) be a finite number of alternatives to be evaluated against a set of criteria K_j ($j=1, 2, \dots, m$). Subjective assessments are to be given to determine (a) the degree to which each alternative satisfies each criterion, represented as a fuzzy matrix referred to as the decision matrix, and (b) how important each criterion is for the problem evaluated, represented as a fuzzy vector referred to as the weighting vector. From our study, each decision problem involves n alternatives and m linguistic attributes corresponding to m criteria. Thus, decision data can be organized in a $m \times n$ matrix. The decision matrix for alternatives is given by Eq. (1).

$$\mu = \begin{bmatrix} \mu_R(PSS_{11}) & \mu_R(D_{12}) & \mu_R(L_{13}) & \mu_R(C_{14}) \\ \mu_R(PSS_{21}) & \mu_R(D_{22}) & \mu_R(L_{23}) & \mu_R(C_{24}) \\ \mu_R(PSS_{31}) & \mu_R(D_{32}) & \mu_R(L_{33}) & \mu_R(C_{34}) \\ \dots & \dots & \dots & \dots \\ \mu_R(PSS_{n1}) & \mu_R(D_{n2}) & \mu_R(L_{n3}) & \mu_R(C_{n4}) \end{bmatrix} \dots \dots \dots (1)$$

The weighting vector for evaluation criteria can be given by using linguistic terminology with fuzzy set theory [7]. It is a finite set of ordered symbols to represent the weights of the criteria using the following linear ordering: very high \geq high \geq medium

\geq low \geq very low. Weighting vector W is represented as Eq. (2).

$$W = (w_i^{PSS}, w_i^D, w_i^L, w_i^C) \dots\dots\dots (2)$$

The fuzzification procedure leads to a performance matrix $\mu \in [0,1]^{n \times m}$ where each element μ_{nm} expresses how much the n -th alternative satisfies the m -th criterion. Therefore, each row of the performance matrix is a fuzzy set μ_m expressing the satisfaction of the m -th criterion in the universe of the available alternatives [6-7]. By multiplying the weighting vector by the decision matrix, the performance matrix is given by Eq. (3).

$$\mu = \begin{bmatrix} \mu_R(PSS_1) \times w_1^{PSS} & \mu_R(D_{12}) \times w_1^D & \mu_R(L_{13}) \times w_1^L & \mu_R(C_{14}) \times w_1^C \\ \mu_R(PSS_2) \times w_2^{PSS} & \mu_R(D_{22}) \times w_2^D & \mu_R(L_{23}) \times w_2^L & \mu_R(C_{24}) \times w_2^C \\ \mu_R(PSS_3) \times w_3^{PSS} & \mu_R(D_{32}) \times w_3^D & \mu_R(L_{33}) \times w_3^L & \mu_R(C_{34}) \times w_3^C \\ \dots & \dots & \dots & \dots \\ \mu_R(PSS_n) \times w_n^{PSS} & \mu_R(D_{n2}) \times w_n^D & \mu_R(L_{n3}) \times w_n^L & \mu_R(C_{n4}) \times w_n^C \end{bmatrix} \dots\dots (3)$$

Given the decision matrix and the weighting vector, the decision making objective for the general FMCDM problem is to rank all alternatives by giving each of them an overall preference rating with respect to all criteria [7]. GMV (Generalized Mean Value) is used for ranking the alternatives according to the aggregated criterion. The GMV for alternatives is represented as Eq. (4).

$$m(\mu_n) = \frac{(C_i + D_i)^2 - (A_i + B_i)^2 + A_i \cdot B_i - C_i \cdot D_i}{3 \cdot [(C_i + D_i) - (A_i + B_i)]} \dots\dots (4)$$

where $A_i = \mu_R(PSS_{n1}) \times w_1^{PSS}$,
 $B_i = \mu_R(D_{n2}) \times w_2^D$, and $C_i = \mu_R(L_{n3}) \times w_3^L$,
 $D_i = \mu_R(C_{n4}) \times w_4^C$, respectively.

IV. Direction Based Handover Method

In this section a new handover method, which is based on the direction information from a block information database described in Section 2 and the current position information from PS, is presented. The basic principle of

the prediction based handover is list as follow:

1. The position of each active MT is detected by active BS based on the use of the position information provided by PE for predicting the MT's position within a cell.
2. Handover system knows and determines the target cell for handover based on the selection of handover cells from a handover cell selection algorithm.
3. Handover system will inform each MT the information about the BS in the selected handover cells.
4. MT will search the neighboring BSs based on the handover cell information.
5. MT will be synchronized with the target BS based on the execution of the handover pre-processing procedure before handover.

4.1 Selection of a Handover Cell and Resource Reservation

The basic principle of the handover cell selection is list as follow:

1. Position information creation and the measurement of the received signal strengths from the active cell and surrounding cells, the PE determines MT's position based FMCDM. First candidate cell set is obtained from the measurement of the downlink channel quality of the active cell and the surrounding cells.
2. Block selection, system selects the corresponding block object by comparing the computed position by PE with the BlockLocationInfo of each block object. Handover cell set is obtained from the selected block object.
3. The first effectiveness inspection, the first effectiveness inspection between the first candidate cell set and the handover cell set is done. The exception handling is done if there is no correspondence between the two.
4. Handover cell selection, if an effectiveness inspection for the selected block is completed, handover cells are determined from HandoverCellIdinformation of the block object.
5. The registration of the handover cell information,

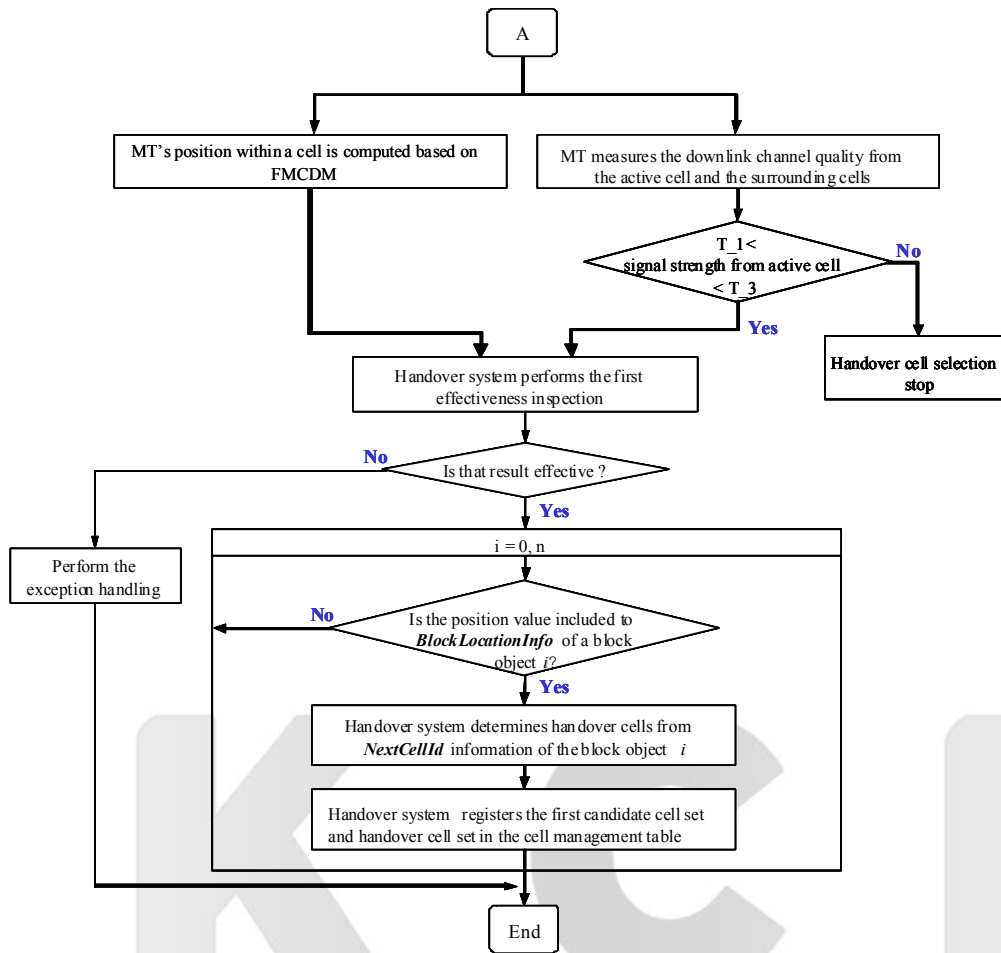


그림 7. 핸드오버 선택 알고리즘의 플로우차트
 Fig 7. Flowchart of a handover cell selection algorithm

the handover cell information is registered to a cell management table.

Fig 7 shows a handover cell selection procedure. Each MT's position information from PE is valid only in track₂. Therefore, the handover cell selection process is terminated if a MT is located another tracks. The first effectiveness inspection between the first candidate cell set and the handover cell set is done, and if there is no correspondence between the two, the exception handling is performed. If one more cells are same, Handover system selects an optimum handover cell

based on the resource availability.

4.2 Handover pre-processing

Using information on the MT's handover cells determined from the above handover cell selection algorithm, two level handover process, radio level and network level, is performed as shown in Fig 8.

- The radio level handover process is performed for the conversion of radio link modem reconfiguration, synchronization setting and so forth—from previous access point to new access point.
- The network level handover process is performed

for packet buffering and re-routing, for the purpose of supporting the radio level handover.

releases all the resource allocated for the MT, reports the result to the handover system.

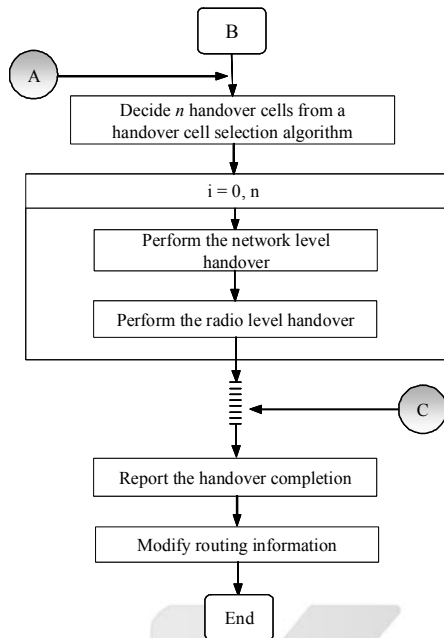


그림 8 핸드오버 전처리 절차의 플로차트
Fig 8. The flowchart of a handover pre-processing procedure

4.3 Handover Decision

For a handover decision, a MT will search the neighboring BSs using the information on the handover cells selected from the above handover cell selection algorithm. Three types of handover can be provided, namely forward handover, backward handover and reconfiguration as shown in Fig 9. A forward handover is done if the handover cell set is identical with the set of the second candidate cells, and backward handover with MAHO procedure is done if the handover cell set does not correspond with the second candidate cell set, and reconfiguration is done if the position traveled by the MT is another block within track₂. The MT reports his handover completion to a handover system through the target cell, and the handover system requests the release of the connections related with the MT. An old cell

5. Simulation Results

The simulation model composed of a single cell, which will keep contact with its six neighboring cells. Each cell contains a BS, which is responsible for the session setup and tear-down of new applications and to serve handover applications. The moving path and the MT velocity are affected by the road topology. The moving pattern is described by the changes in moving direction and velocity. In our study we assume that the low speed MTs, the pedestrian, occupy 60% of the total population in the cell and the high-speed MTs, the vehicles, 40%. Vehicles move forward, leftward/rightward and U-Turn. The moving velocity is assumed to have the uniform distribution. The walking speed of the pedestrian is 3~5 Km/hr, the speed of the private car and the taxi 30~100 Km/hr, and the bus 10~70 Km/hr. The speed is assumed to be constant during walking or driving.

Fig 10 shows the handover failure rate versus the session arrival rate. The solid curve represents the prediction based handover method applied and the dashed curve represents a previous handover method. The major cause of the handover failure is because of the prediction error caused by PE. It can be seen that the prediction error does very largely with increase in the PE error. The proposed method performs the handover setup process in advance before a handover request by predicting the handover cell based on each MT's current position so that the handover failure can be reduced.

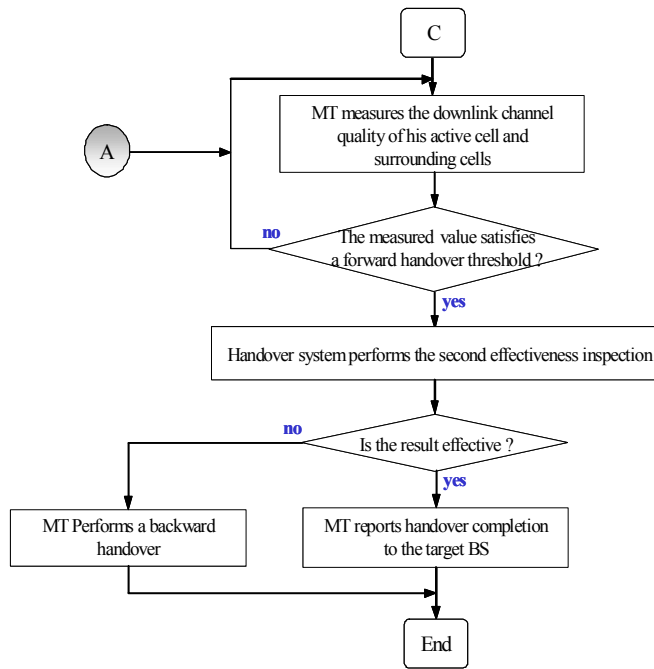


그림 9. 핸드오버 결정 방법의 플로우차트
Fig 9. Flowchart of a handover decision method

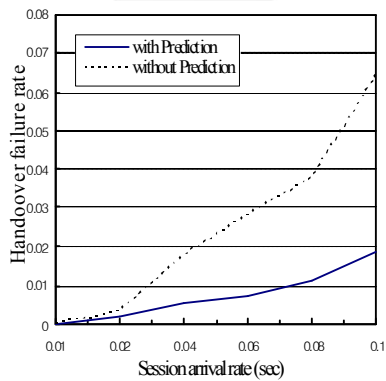


그림 10. 핸드오버 실패율의 비교
Fig 10. The comparison of handover failure rate

Fig 11 shows the effect of the proposed method on packet loss rate. It is observed that the proposed method provides a noticeable improvement over the conventional scheme, because the MT has already established synchronization to the BS in target cell and switches its Tx to target BS while

stop communicating with the original BS at the same time after the cell search procedure so that there will be data lost for uplink of 2~4 frames due to the uplink synchronization and there's no data lost for downlink.

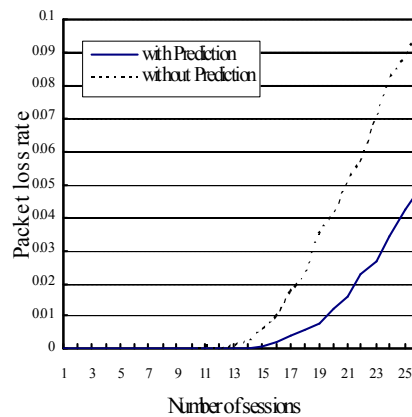


그림 11. 패킷 손실율의 비교
Fig 11. The comparison of packet loss rate

V. Conclusion

This paper main goal is to address the problem of handover failure for MTs as they move from one position to another at high speeds in small cell environment. This is achieved through mobility information such as the current position and the moving direction that is presented with a set of attributes that describes the user mobility. In this scheme, the handover connection setup process is established prior to the handover request. The handover cell is predicted by the MT's position and direction and a database that includes the MT's position information. We have focused in improving the overall system performance. The proposed scheme shows a great improvement of the handover failure probability and packet loss rate. It is because our handover method is more adaptive than previous handover methods. The determination of the optimal direction should be studied consecutively. Also further researches are required on their implementation and applications to the handover.

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저자 소개



강 일 고

2002년 8월 전북대학교
컴퓨터공학과 공학석사
2003년~현재 군산대학교
컴퓨터공학과 박사과정
<관심분야> 멀티미디어, 비디오
프로세싱, 영상처리



신 성 운

2003년 2월 군산대학교
컴퓨터공학과 이학박사
2006년~현재 군산대학교
컴퓨터정보공학과 전임강사
<관심분야> 비디오 인덱싱, 비디오
요약, 멀티미디어



이 종 찬

2000년 2월 숭실대학교
컴퓨터학부 공학박사
2000년~2004 ETRI 선임연구원
2005년~현재 군산대학교
컴퓨터정보과학과 조교수

<관심분야> 차세대이동통신망,
이동멀티미디어, WPAN



표 성 배

2004년 2월 숭실대학교
컴퓨터학부 공학박사
1992년~현재 인덕대학
소프트웨어개발과 교수

<관심분야> 멀티미디어, 비디오
색인화, 비디오 요약



이 양 원

1994년 8월 숭실대학교
전자계산학과 공학박사
1986년~현재 군산대학교
컴퓨터정보과학과 교수

<관심분야> 모바일 프로그래밍,
텔레매틱스, 가상현실

