DVB-H 네트워크에서 HMT (handover map table)에 기반한 핸드오버 알고리즘

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HMT (Handover Map Table) based Handover Algorithm in DVB-H Networks

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요 약

이동 방송망에서 핸드오버는 단말의 이동성을 보장하는 매우 중요한 요소중의 하나이다. DVB-H (Digital Video Broadcasting for Handheld) 표준은 DVB-T(Digital Video Broadcasting - Terrestrial) 표준에 단말의 이동성을 향상시키기 위해 개발되었다. 본 논문에서는 DVB-H 네트워크에서 핸드오버 성능을 향상시키기 위하여 새로운 방식을 제안한다. 제안된 핸드오버 는 두 가지 형태의 단말을 대상으로 하는데 하나는 GPS수신기를 탑재한 단말이며 다른 하나는 GPS없이 동작하는 단말이다. 본 논문에서는 첫 번째 단말에서의 핸드오버 를 위해 논문[1]에서 제안된 CDT(Cell Description Table)을 개선하였으며 두 번째 단말의 경우 새롭게 제안된 HMT(Handover Map Table)에 기반하여 미리 정해진 핸드오버 영역을 추정하는 새로운 방법을 제안하였다. 제안된 핸드오버 방식에서는 RSSI(Received Signal Strength Indication)의 신호패턴을 이용하여 핸드오버 영역을 추정한다. 제안된 핸드오버 알고리즘을 이용하여 핸드오버 시 소요되는 시간 및 전력소모를 최소화 할 수 있으며 컴퓨터 시뮬레이션을 통해 이와 같은 핸드오버 알고리즘의 성능을 분석하였다.

ABSTRACT

In mobile broadcasting networks, handover is an important issue to support seamless mobility. DVB-H(Digital Video Broadcasting for Handheld) standard was developed to enhance mobile features for DVB-T(Digital Video Broadcasting -Terrestrial) standard. This paper proposes new approaches for improving handover performance in the DVB-H networks. The proposed handover schemes are targeted to two different DVB-H receivers: One is for the receivers equipped with GPS devices. The other is for ones without GPS support. The first handover approach modifies the cell description table (CDT) proposed in the literature [1]. The second proposes a novel estimation technique of predefined handover region based on a new handover map table (HMT). This new handover approach estimates a predefined handover region with the measured RSSI(Received Signal Strength Indication) signal patterns. Using proposed handover algorithm, we can reduce time and power consumption. Through the computer simulations, we evaluate the performance of handover algorithm.

키워드

DVB-H, Handover map table, GPS, Cell description table

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접수일자 2008. 02. 29

Ⅰ. Introduction

DVB-H is a standard built on DVB-T to enhance mobile features. In the mobile reception of services such as Mobile Phone TV, a seamless mobility is mandatory for enabling an uninterrupted service experience. Even though mobile reception of DVB-T transmissions has been shown possible, it leaves the special problems of handheld reception. DVB-H enables more robust reception and the use of the time-slicing technique. Time-slicing is a kind of time division multiplexing that was first introduced as a way to achieve power saving, later its use of for loss-free handover was discussed in[2]. It is an efficient solution to both of these problems, making DVB-H a viable technology for handheld reception of multimedia service broadcast.

Handover in DVB-H is rather different from handover in cellular telecom-communications systems. This is mainly due to the unidirectional nature of DVB-H networks and the difference in the physical medium. Unlike DVB-T, DVB-H transmits data streams using a burst mode called time slicing instead of a continuous mode. Depending on the transmission bit rate, the o® time in the transmission stream can vary. The DVB-H receiver can use the off time to synchronize and initialize soft handover when it moves from one cell to another.

Handover in DVB-H consists of three stages: the handover measurement process, the handover decision process and the handover execution process [2][3][6].An instantaneous RSSI(Received Signal Strength Indication) value based handover scheme was proposed in [2]. This is the earliest publicly available handover algorithm for DVB-H. The paper presented a soft handover algorithm for DVB-T/H networks. In the literature [3], they investigated and proposed many handover decision-making algorithms. Finally, they suggested a hybrid method without measurement of RSSI. But, the hybrid method has much difficulty in real implementation compared to the RSSI value based handover scheme[2].

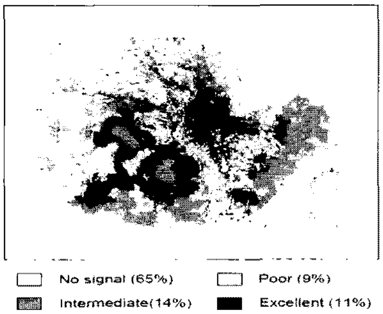
The signaling of cell coverage area information [4] can be used to improve handover performance for DVB-H receivers equipped with a GPS receiver. The method for signaling cell coverage areas by means of bitmap data was proposed in the literature [1]. This paper proposed a new feature for DVB-H, a new method for signaling cell coverage area, thus improving performance for loss-free handovers. But, the proposed method is targeted at DVB-H handhelds that have GPS receivers. Even though the method can increase the handover performance, that can not be used without GPS receivers. Furthermore, we should consider the power consumption of GPS receiver. Therefore, this paper proposes two different handover approaches: One scheme is for the receivers equipped with GPS devices. The other is targeted to those that don't have GPS receivers. As with the DVB standard method, the proposed solutions aim at improving handover performance in DVB-H receivers. A new addition - Handover Map Table (HMT) - is proposed for the set of PSI/SI tables in DVB-H, similarly for the CDT(cell description table) in the paper [1]. The principle for the proposed approaches is given. Moreover, the advantages and disadvantages of the proposed methods are discussed with some simulation results. Finally, conclusions are drawn.

Ⅱ. Location based handover using GPS

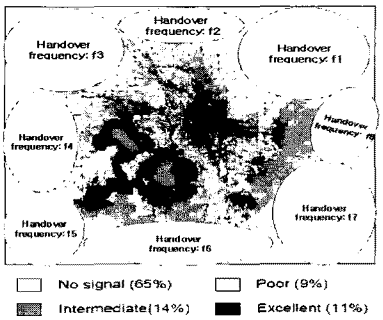
When the DVB-H receiver notices that the currently received signal is fading and a handover must be performed, there are three things to consider [6]: How to determine signals carrying wanted services, how to limit the number of tested frequencies, and how to verify that the tuned signal really is suitable. The naïve method is to go through every possible frequency, trying to tune and if a tuning lock is achieved, checking PAT to find out if the signal is carrying the same transport stream as the current signal. Another simple, but more flexible, method is to go through the signals as previously, but checking the PAT for the service-ids of the currently received services. However, these methods are highly inefficient, consuming a great amount of time on known-bad signals.

The set of tested signals can be reduced to nearby cells by examining the geographical dimensions of cells retrieved from terrestrial delivery descriptors in NIT, and only testing the cells that have adjacent locations to the current one. Further reduction can be achieved if the receiver is equipped with a GPS device, in which case only cells overlapping the current receiver position can be tested.

Signaling of four different signal levels, as illustrated in Fig. 1(a), can be provided in the CDT(Cell Description Table) proposed in the literature [1]. Fig. 1(a) shows a simulation data which was evaluated in the literature [1] for one DVB-H cell coverage area from the Helsinki. It was based on estimates of the signal propagation affected by the different terrain shapes and obstacles. The rectangle enclosing the cell coverage area is in accordance with the DVB specifications and has dimensions of 25 km x 15 km. The simulated signal levels vary from 'no signal' to 'excellent'. Different shades of grey were used to indicate four different signal levels.



(a)



(b)

Fig.1 (a) Simultation of four signal levels within a DVB-T/H cell coverage area[1], (b) A concept of predefined handover regions and handover frequencies in the modified CDT.
그림 1. (a) DVB-T/H 셀영역 내의 신호레벨 시뮬레이션 (b) 미리설정된 핸드오버영역 및 핸드오버주파수의 개념

As Fig. 1(a) illustrates, the majority (65 %) of the cell coverage area has no signal, resulting in gratuitous signal strength measurement, which increase power consumption. The signal level can be detected with a CDT receiver without measuring the signal strength. Therefore, the DVB-H receivers equipped with a GPS receiver can determine the handover moment based on the CDT. However, the DVB-H receiver can not directly determine the handover frequency, because the current CDT table doesn't have the handover frequency information in the handover candidate regions (for example, no signal or poor signal regions in the Fig. 1(a)).

Even though the previous handover scheme [1] based on CDT can determine the handover decision moment without measuring the instantaneous RSSI value, and can reduce the testing signal frequencies aided by the GPS device, there are still three things to consider: How to determine signals carrying wanted services, how to limit the number of tested frequencies, and how to verify that the tuned signal really is suitable. Furthermore, in the current method, there are no means for indicating handover frequencies within the different areas of the cell coverage area.

As illustrated in Fig. 1(b), if we include some predefined handover regions and the relevant handover frequencies of the specific handover regions in the current CDT, especially the handover map information, we don't have to consider the three questions any more: How to determine signals carrying wanted services and how to limit the number of tested frequencies, and how to verify that the tuned signal really is suitable. We can determine an exact handover frequency based on the modified CDT, directly when the DVB-H receiver moves into the predefined handover regions with the help of a GPS receiver.

Fig. 1(b) illustrates an example of the predefined handover regions and the predetermined relevant handover frequencies of the handover regions. The other cells in the DVB-H networks also have their own predetermined handover regions and their own predetermined handover frequencies. The handover information(predetermined handover regions and frequencies) for each cell are predefined and signaled to the receivers. Then, when the receiver is on the move in the handover regions, eliminating the needless searching for a handover frequency, this modified CDT-based handover scheme can choose directly a predetermined handover frequency without consuming a great of time and power.

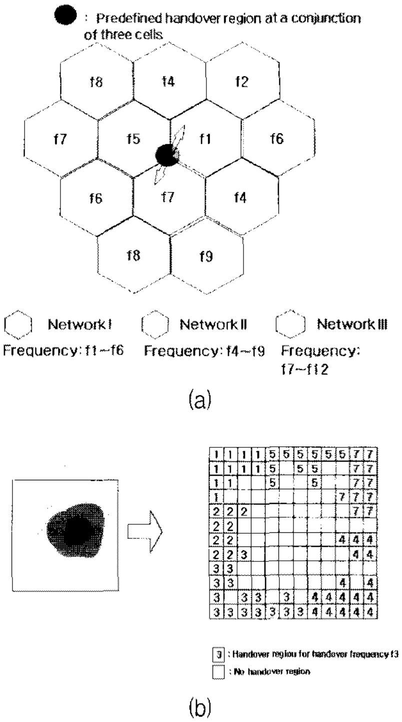


Fig. 2 (a) Handover decision at a conjunction of three cells in different networks, (b) The bitmap mapping principle for the handover region and the relevant handover frequencies.
그림 2. (a) 셀경계에서의 핸드오버결정 (b) 핸드오버영역과 주파수에 대한 핸드오보 비트맵 메핑

Fig. 2 illustrates an example of the handover decision and measurement when the receiver is located at the conjunction of three cells in three different networks. The receiver is moving away from a cell f1 in network I to a cell f7 in network III across the conjunction of three cells. And, let's assume that the cell f5 of network II does not provide the current receiving service of f1 and the cell f7 of network III provides the same DVB-H service of network I. If the decision was made only on the basis of signal strength and even the current CDT, it would be obvious that the receiver would lock and synchronize to the cell f5 frequency in network II, since it may have agood signal strength and is a neighbor cell. And, even according to the current CDT, it would favor the selection cell f5 of network II because the current CDT only describes the actual signal strength level without handover information for the handover candidate regions.

If the current CDT of the cell f1 includes handover frequency f7 at the conjunction of three cells, the handover frequency will be directly f7 instead of f5. And, if the current CDT of cell f7 includes handover frequency information f1 at the same position, when the receiver is moving away from the cell f7 of network III to the cell f1 of network I, then, the handover frequency will be directly determined into f1 instead of f5.

When a handover is done to follow IP services using INT, the simple method for IP services would require the reception of NIT and INT on every signal. This would be unacceptably slow, consuming up to 40 seconds on bad signals. Even though we know the exact handover frequency without searching for a good handover candidate frequency, it will usually consume up to 8 seconds. Therefore, in case of the DVB-H receiver equipped with a GPS receiver, the current CDT will be very useful to find a good handover frequency comparing to the conventional handover method based on the instantaneous RSSI value. And, if the current CDT additionally includes the handover information, namely the handover map information (handover region and the relevant handover frequency), the handover performance will be more increased. Fig. 2(b) illustrates a modified CDT which includes handover bitmap information instead of signal level. The handover bitmap information is related to the HMT (Handover Map Table) which will be described in next section.

In case of the DVB-H receiver not equipped with a GPS receiver, how can we utilize the good benefits of the modified CDT information in the handover situation? We will propose a novel approach in order to estimate the predefined handover region based on simple RSSI signal patterns in the next section. For this purpose, we will propose a new HMT (Handover Map Table).

Ⅲ. HMT based handover scheme

In the previous section, the proposed method can not be used without GPS device because the receiver cannot know the current receiver's location. If there is a proper location estimation technique, especially if we have a good method to estimate the predetermined handover region without GPS, the proposed handover scheme can still be used.

Table 1 shows an example of HMT (handover map table) which is consist of handover bitmap value, handover frequency and the RSSI patterns in each predefined handover region. Fig. 3 illustrates an example of the predefined handover regions at cell borders. We assume that the maximum radius of the cell is 20 km and a maximum transmitter power is assumed 800 watt. The RSSI value can be modelled as followings [7]:

$$RSSI = P_t - [10n\log_{10}(d) + L_0 + \xi]\,\text{dB} \quad (1)$$

$$L_0 = 20\log_{10}(\frac{4\pi}{\lambda}) \quad (2)$$

where P_t means a transmitted power and ξ is the lognormal fading effect with Gaussian distribution, the standard deviation 8.3 dB, and d is the distance between transmitting and receiving antennas in meters. The value of n intrinsically embeds the effects of all propagation mechanisms: attenuation, diffraction, reflection, etc. L_0 is the attenuation at 1m in free space and λ is the wavelength in meters.

Table 1 An example of HMT,
표 1. HMT의 예

Bitmap Value	Handover frequency	RSSI Pattern (dB) = [f0 f1 f2 f3 f4 f5 f6 f7]
0	No	No
1	f1	[a1 b1 c1 d1 e1 f1 g1]
2	f2	[a2 b2 c2 d2 e2 f2 g2]
3	f3	[a3 b3 c3 d3 e3 f3 g3]
4	f4	[a4 b4 c4 d4 e4 f4 g4]
5	f5	[a5 b5 c5 d5 e5 f5 g5]
6	f6	[a6 b6 c6 d6 e6 f6 g6]
7	f7	[a7 b7 c7 d7 e7 f7 g7]

Using the RSSI model equation (1), Fig. 4 (a) shows the RSSI patterns at the predefined handover regions. The RSSI values are the averages of 100 instantaneous ones. In the handover region 1, the RSSI signal values of the f1 and the f2 frequencies are larger than those of other frequencies. Even though the real instantaneous RSSI values are much fluctuated due to various environmental effects, the RSSI pattern values represent the reference RSSI values in each region and can be considered distinctive features in order to estimate a specific handover region. Even though we use the simulated signal values in this paper, the real measured RSSI values should be utilized in real applications. The HMT tables will be designed in the same way for all the different cells with the real measured data in each predefined handover region.

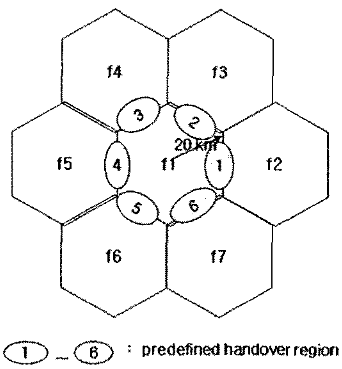


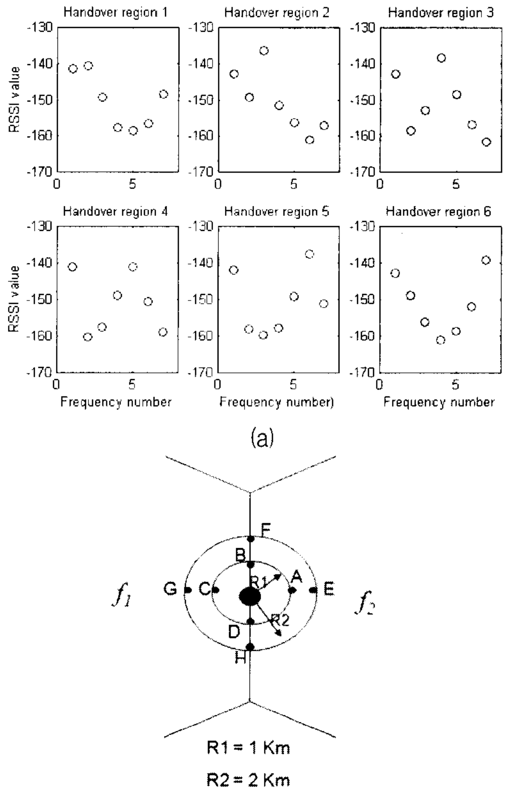
Fig. 3 Predefined handover regions at cell borders.
그림 3. 셀 경계에서의 미리 설정된 핸드오버영역

If a DVB-H receiver doesn't have a GPS device, we need to estimate which handover region the receiver is moving into after the handover decision making. We will propose a proper estimation technique based on the RSSI signal pattern and the HMT. We will use a simple RMSE (Root Mean Square Error) criterion to determine an exact handover region, k*, as followings:

$$[\textit{Handover region } k^*] = \arg Min_k\, RMSE_k \quad (3)$$

$$RMSE_k = \sqrt{(RSSI_{r1} - RSSI_1)^2 + \cdots + (RSSI_{r7} - RSSI_7)^2} \quad (4)$$

where $RSSI_{r1}, \cdots, RSSI_{r7}$ means the reference RSSI values stored in the HMT, and $RSSI_1, \cdots, RSSI_7$ denotes the instantaneous RSSI values at a test position.



A, B, C, D, E, F, G, H : Test points

(b)

Fig. 4 (a) RSSI signal patterns for the predefined handover regions, (b) Test points.
그림 4. (a) 핸드오버 영역에서의 RSSI 신호 패턴 (b) 테스트포인드

Fig. 4 (b) illustrates various test positions at the handover region 1. The test positions of A, B, C and D are within a radius of 1 km at the reference point of the handover region 1. And the test positions of E, F, G, H are within a radius of 2 km. After 5, 10 and 15-times signal scanning and testing, we can determine the final handover region using the RMSE criterion in equation (3) and (4). At each test point, we tested 100 times and evaluated the success rate of the exact handover region. The simulation results are shown in Fig. 5 and Fig. 6. As illustrated in the simulation results, the proposed scheme for handover region estimation based on the RSSI reference signal pattern can be very effective when the DVB-H receiver doesn't have a GPS device.

Ⅳ. Conclusions and discussion

This paper addressed an improved CDT in the definition and signaling for better handover performance. The improved CDT includes the exact handover frequencies in the predefined handover regions for the whole cell coverage area, such as handover map information table. Therefore, the DVB-H receiver equipped with a GPS device can switch off an exact handover frequency when the receiver is moving into the handover region without time and power consuming. And, this paper also proposed a novel approach to estimate a specific handover region. The proposed estimation of specific handover region is based on the HMT and RSSI signal pattern on each handover region. The HMT includes the handover bitmap value, the handover frequency and the RSSI reference patterns in each predefined handover region. We used a simple RMSE criterion in order to determine the exact handover region. The simulation results illustrate good success rate up to 95% if we estimate the handover region by

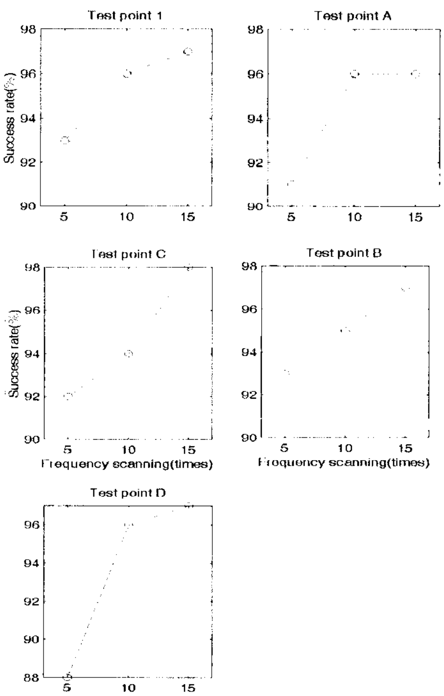


Fig. 5 Handover region estimation within a radius of 1 km.
그림 5. 반경이 1km이내에서 핸드오버 영역추정

testing more than 10-time scanning. If we assume that the signal strength can be measured in 20ms without the need to synchronize, the total frequency scanning time will be 1.4 sec approximately for measuring the RSSI values of the 7-frequency. The required time for handover region estimation is usually less than one off-burst time in the DVB-H time-slicing mode. According to [2], the typical off burst time is about 3 seconds. Therefore, we can deduce that the proposed handover region estimation will consume very little power in the handover process. But, we need to elaborate good HMT tables for each cell in every network.

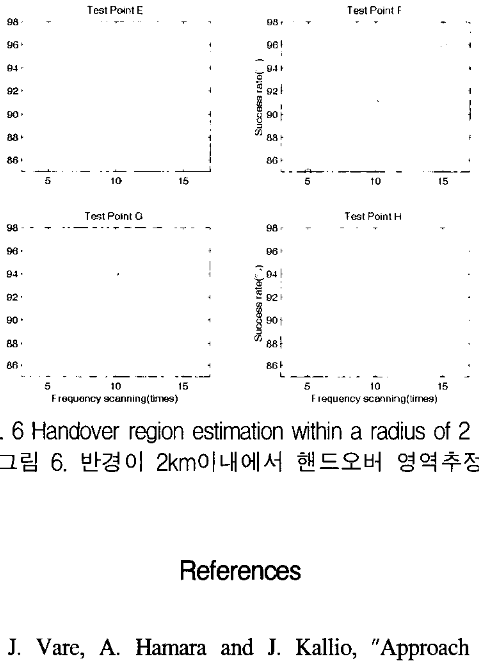


Fig. 6 Handover region estimation within a radius of 2 km.
그림 6. 반경이 2km이내에서 핸드오버 영역추정

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