DVB-H시스템을 위한 전력 효율적인 핸드오버 알고리즘

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Power Efficient Handover Algorithm for DVB-H System

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요 약

DVB-H (Digital Video Broadcasting for Handheld)시스템은 DVB-T (DVB-Terrestrial)를 향상시킨 휴대용 방송시스템이다. 이동 단말을 통해 방송 서비스를 수신하기 위해서는 끊김 없는 이동성을 보장하고 전력효율을 높이는 것이 무엇보다 중요한 요구사항이다. 끊김 없는 핸드오버 위해서는 단말은 이웃 셀 들을 주기적이고 지속적으로 탐색해야 하나 이는 전력소모를 증가시킨다. 따라서 전력소모를 줄이면서도 이동성을 보장할 수 있는 핸드오버 알고리즘이 필요하다. 본 논문에서는 핸드오버 동안 탐색해야 할 주파수의 수를 최대한 줄임으로써 소모전력을 줄일 수 있는 전력효율적인 핸드오버 기법을 제안하고 수학적 분석을 통해 제안된 핸드오버의 성능을 분석하였다.

ABSTRACT

DVB-H (Digital Video Broadcasting for Handheld) is a new standard, currently being developed, which defines mobile enhancements for the DVB-T (DVB-Terrestrial) standard. For the reception of service via mobile handheld devices, seamless mobility and power saving are essential requirements of DVB-H. For seamless handover, the receiver should monitor neighboring cells and it increases the power consumption. And so, power efficient handover scheme to support both mobility and power saving is required. In this paper, we propose power efficient handover scheme to reduce power consumption by reducing the number of frequency scanning during the handover. Through the numerical evaluation, we analyze the performance of handover schemes.

키워드

DVB-H, handover, power saving,

Ⅰ. INTRODUCTION

DVB-H [1] is a new standard that enhances mobile features for DVB-T [2]. The DVB-H system is largely compatible to the DVB-T standard, which means that the modulator and RF circuits can be reused with only slight addition. The main innovations of DVB-H are the battery power saving technology, time slicing, and the additional Forward Error Correction (FEC) providing improved transmission error correction also for difficult propagation channels to handheld terminals [3]. Time slicing is one of the main enhancements in DVB-H. Time slicing enables a receiver to switch power off when no data are being received and the system can get the power saving[4]. And also, time slicing support seamless handover by offering the possibility to use the same receiver to monitor neighboring cell during

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the off-time.

Handover in DVB-H is rather different from handover in cellular 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 indstead of a continuous mode. Time slicing is the characteristic that make seamless soft handover in DVB-H.

When a receiver goes into another cell, the receiver starts to measure RSSI (Received Signal Strength Indication) value between bursts. RSSI measurement requires power consumption and it can reduce power saving effect of time slicing. And so, power efficient handover scheme is required. An instantaneous RSSI value based handover scheme was proposed [5]. In that handover scheme, the receiver measures all of the possible signals and findsthe signal with highest RSSI value. If the number of possible signals increases, the power consumption due to handover increases. To reduce RSSI measurement, we propose power efficient handover scheme. In the proposed handover scheme, the receiver dose not find the signal with highest RSSI value but compareswith threshold and if the RSSI value is over that threshold the receiver synchronize with that signal. In that scheme, the receiver doesn't have to measure all of the possible signals and reduces power consumption.

Ⅱ. Time slicing and power saving

Time slicing is one of the main ideas of DVB-H. By transmitting low data rate services in bursts with a much higher data rate, the so called “off time” between the bursts can be used for power saving by switching off the receiver front end in this time frame. The off time also enables soft handover. The receiver can measure the RSSI values of the signals in the adjacent cells during off-time which is the time interval between the bursts and ultimately executes handover.

A previous publication [6], which discussed time slicing and power saving, shows simplified formulas to calculate the length of a burst, length of the off-time, O_t, and achieved power saving. Power saving depends on burst duration, B_d, burst synchronization time ,S_t, constant bandwidth ,C_b, and delta jitter, D_j. Burst bandwidth and off time depends on burst size B_s, burst bandwidth Bb and constant bandwidth C_b. The parameters are illustrated in Fig. 1. Eq.(1)-(3) show the formulas for calculating burst duration, off time and achieved power saving. Correction factor 0.96 compensates for the overhead caused by transport packet and section headers.

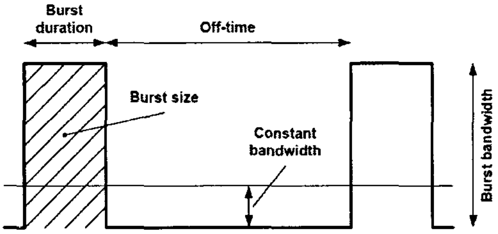

Fig. 1. Time slicing method and parameters
그림 1. 시간 slicing 기법과 관련 파라미터들

$$B_d = \frac{B_s}{B_b \times 0.96} \tag{1}$$

$$O_t = \frac{B_s}{C_b \times 0.96} - B_d \tag{2}$$

$$P_s = \left(1 - \frac{(B_d + S_t + (3/4 \times D_j)) \times C_b \times 0.96}{B_s}\right) \times 100\% \tag{3}$$

Ⅲ. Power efficient cell searching for handover

The receiver measures power strength of current signal periodically. If the power strength goes under the threshold value, the receiver tries to find a new signal. In the maximum RSSI based handover [4], when the handover is initiated, the receiver scans the RSSI values of the every possible signal during the off-time and synchronizes to the signal with strongest power so called highest RSSI value. If the receiver synchronized 'wrong signal', the receiver should measure the every possible signals again. In this paper, we assume that all the cells have the same channel conditions and the 'nearest cell' means the target cell into which the receiver should handover.

Maximum RSSI based handover should measure every possible signal when the handover is initiated and it requires lots of power consumption and reduce power saving effect of time slicing. In the proposed handover, the receiver measures signal strength of one signal and test the hypothesis. Testingis done by comparing the RSSI value with threshold. If the RSSI value is over the threshold, the receiver accepts the hypotheses and synchronizes to that signal or test next hypothesis. In this handover scheme, we can reduce the time to RSSI measurement by reducing the number of measured signals. The threshold of hypothesis testing affects on the handover performance. If the threshold is high, the missing probability may be high. Missing probability is the probability that the RSSI value of the desired signal is under the threshold and the receiver misses the desired signal. If the threshold is low, the false alarm probability may be high. False alarm probability is the probability that the RSSI value of the other signals except desired signal is over the threshold and the receiver synchronize to unwanted signal.

Ⅳ. Performance of the handover

A. Channel modeling

As a generally accepted radio propagation model for DVB system, log-normal distribution of shadowing with its mean path loss of l-th power is adopted. The long-term path loss model used in this paper is given by

$$g_i = d_i^{-n} \cdot 10^{\xi/10} \tag{4}$$

Where n is path loss exponent, typically 3 or 4 and is a Gaussian random variable with mean of zero and standard deviation of [dB]. In the broadcasting system, is typically 8.5dB. d_i is the distance from the i-th transmitter to the receiver. Path loss can be written in dB scale

$$g_i[dB] = -10n\log_{10}(d_i) + \xi \tag{5}$$

If the location of the receiver is fixed, the path loss in dB scale is a Gaussian random variable with mean of $10n\log_{10}(d)$ and standard deviation of [dB]

B. Performance of power saving

In the maximum RSSI based handover, if the RSSI vaue of the current signal is under the handover threshold P_{HO}, the receiver start to measure the RSSI values of all possible signals and find the signal with maximum RSSI value, and ultimately executes handover. To find the highest RSSI, the receiver should scan the whole frequencies of adjacent cells. Even if the receiver finds the cell containing the signal with highest RSSI, the cell may not be the nearest one from the receiver. The probability that the signal with the highest RSSI is not the signal of the nearest cell is called missing probability $1\text{-}P_d$ where P_d is detection probability. The average time required for handover is shown in Eq. (6). If the signal with highest RSSI is not the signal of nearest cell, after synchronization time and burst duration, the receiver should measure again the whole possible signal. The time required to measure the whole signal is $(N_f\text{-}1)\ F_t$, where N_f is the number of signals and F_t is frequency scanning time.

$$\begin{aligned} T_H &= \Pr(P_0 < P_{HO}) \cdot \sum_{k=0}^{\infty} (1-P_D)^k \left((N_f - 1)F_t + S_t + B_d\right) \\ &= \Pr(P_0 < P_{HO}) \cdot \frac{(N_f - 1)F_t + S_t + B_d}{1-(1-P_D)} \end{aligned} \tag{6}$$

where P_0 is the power from the nearest cell. The missing probability can be obtained by

$$\begin{aligned} 1 - P_D &= \Pr[\mathrm{Max}\{P_i\} \neq P_0] = 1 - \prod_{i=1}^{N_f - 1} \Pr(P_i < P_0) \\ &= 1 - \prod_{i=1}^{N_f - 1} Q\left(\frac{-10n\log_{10}(d_i / d_0)}{2\sigma}\right) \end{aligned} \tag{7}$$

where

$$Q(a) = \int_a^{\infty} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx \tag{8}$$

As shown in channel model, the RSSI value in dB scale has Gaussian distribution with the mean of $10n\log_{10}(d)$ and the standard deviation of [dB], and the missing probability can be obtained as a form of Q-function in Eq.(7).

The receiver starts RSSI measurements when the RSSI value of current cell goes down under P_{HO} and the probability that the current RSSI value is under P_{HO} can be calculated as follows

$$\Pr(P_0 > P_{HO}) = Q\left(\frac{P_{HO} - P_t + 10n\log_{10} d_0}{\sigma}\right) \quad (9)$$

where Pt is the transmitted power in dB scale at the transmitter of current cell.

In the proposed handover, the total handover time is the time to find the correct signal hypothesis. Note that if the signal search has proceeded through all possibilities without accepting the correct hypothesis, the process will repeat. Hence, a signal power measurement can be described by a circular diagram, as shown in Fig. 2. Each node means the all possible signals to be measured and the labels on branched between nodes indicate the probability of the particular transition. The state on the inner dotted circle represents false alarm states reached as a consequence of the acceptance of an incorrect hypothesis. Note that the signal where the measuring begun, can be any one of N_f nodes on the outer circle.

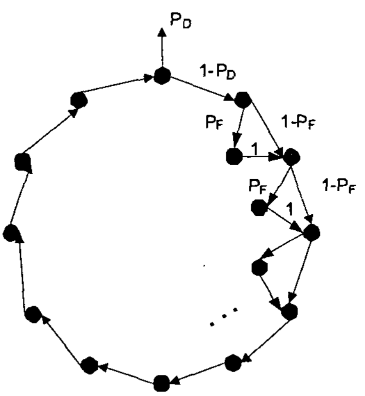

Fig. 2. frequency scanning state diagram
그림 2. 주파수 탐색의 상태도

The frequency scanning time is a random variable equal to the sum of the transition times of all the branches on the path taken in the state diagram, from any one of the equally likely initial states to the final correct detection state at the top of the diagram. The time required to state transition top can be calculated as the Eq. (10). If the false alarm happens, to simplify the analysis, we assume that the receiver measure again next signal after synchronization and burst time.

$$T_{tran} = P_F(S_t + B_d) + (1 - P_F)F_t \quad (10)$$

This applies to all cases except the branches coming from the node at the top of the circle (which connects also to the final node). Then the average time from an initial node that is i-th branches counterclockwise from the top to the final destination (correct) node is

$$\begin{aligned} T_i &= \Pr(P_0 < P_{HO})\left(i \cdot T_{tran} + S_t P_D + \sum_{k=1}^{\infty}(1 - P_D)^k\left((N_f - 1)S_t + F_t\right)\right) \\ &= \Pr(P_0 < P_{HO})\left(i \cdot T_{tran} + S_t P_D + (1 - P_D)\cdot\frac{(N_f - 1)S_t + F_t}{1 - (1 - P_D)}\right) \end{aligned} \quad (11)$$

Now, since all nodes are a priori equally likely, the total time averaged over all Nf-1 starting nodes is

$$T_H = \Pr(P_0 < P_{HO})\left(\frac{N_f T_{tran}}{2} + S_t P_D + (1 - P_D)\cdot\frac{(N_f - 1)T_{tran} + S_t}{1 - (1 - P_D)}\right) \quad (12)$$

False alarm probability, P_F, is the probability that the RSSI value of the other signals except desired signal is over the threshold, and missing probability ($1-P_D$) is the probability that the RSSI value of the desired signal is under the threshold and the P_F and P_D can be calculated by Eq.(13), (14) respectively

$$\begin{aligned} P_F &= \frac{1}{N_f}\sum_{i=1}^{N_f - 1}\Pr(P_i > P_{Th}) \\ &= \frac{1}{N}\sum_{i=1}^{N_f - 1} Q\left(\frac{P_{th} - P_t + 10n\log_{10} d_i}{\sigma}\right) \end{aligned} \quad (13)$$

$$P_D = \Pr(P_0 > P_{Th}) = Q\left(\frac{P_{th} - P_t + 10n\log_{10} d_0}{\sigma}\right) \quad (14)$$

To find the power saving during handover, power saving formula in Eq.(3) should be modified as the Eq. (15).

$$P_s = \left(1 - \frac{(T_H + B_d + S_t + (3/4 \times D_j)) \times C_b \times 0.96}{B_s}\right) \times 100\% \quad (15)$$

C. The results of numerical evaluation

To evaluate the power saving, we assumed parameters in Table 1 and we assumed the transmitted power at transmitter is 800W, the cell coverage is 10 Km, path loss exponent is 3.3 and standard deviation of shadow fading is 8.5dB. With the parameters in table 1, we can get the 89.82% power saving due to time slicing using Eq. 3.

Table 1. Parameters for numerical analysis
표 1. 수학적 분석을 위한 관련 파라미터

Parameter	meaning	value
B_s	Burst size (bits)	2Mbits
B_b	Burst bandwidth (bps)	12.5Mbps
C_b	Constant Bandwidth (bps)	500kbps
S_t	Synchronization time (sec)	250msec
D_j	Delta-t jitter (sec)	10msec
F_t	Frequency scanning time(sec)	20msec

Fig. 3 shows power saving according to hypothesis testing threshold, P_{Th}. Near P_{Th}=-100dB, Power saving has highest value. High and low hypothesis testing threshold increase the missing and false alarm probability, respectively and the power saving decrease, and to determine the proper threshold value is important.

Fig. 4 shows power saving performance of maximum RSSI and proposed handover algorithm. In Fig. 4, we assume N_f=7 and hypothesis threshold is -105dB. As shown in Fig 4, if the receiver is near the transmitter, power saving is almost same because handover event is rarely initiated. The power saving of the proposed handover scheme comes higher than that of maximum RSSI based scheme as the distance from the transmitter increase. At the cell edge, difference of power saving is almost 16 %.

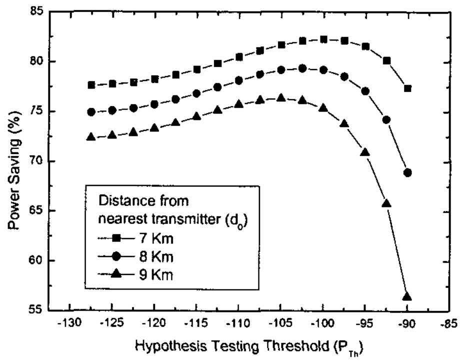

Fig. 3 Power saving vs. hypothesis threshold
그림 3. Hypothesis 문턱값에 따른 전력절감

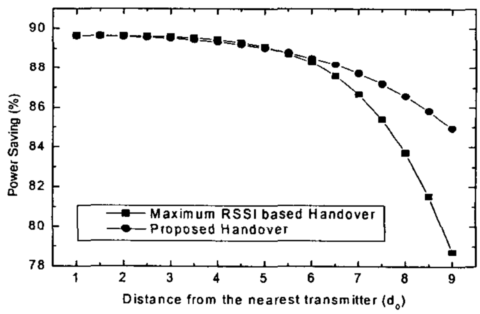

Fig. 4 Power saving according to the distance from the nearest transmitter
그림 4. 송신기로 부터의 거리에 따른 전력절감

V. Conclusion

In the DVB-H system, both seamless mobility and power saving are essential requirements. To support seamless handover, the receiver should monitor neighboring cell during the off-time and this cell monitoring increases power consumption and reduce the power saving effect in DVB-H system. In this paper, we propose the power efficient handover scheme. The proposed handover scheme tests signals one by one with threshold. This scheme doesn't have to scan the whole possible frequencies and reduces the number of frequencies to be scanned and the power consumption. Through the numerical analysis, we show that there is optimum threshold for hypothesis testing and the proposed handover scheme is more power efficient than the maximum RSSI based handover scheme.

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