DVB-H시스템에서 핸드오버를 위한 전력 효율적인 셀 탐색 기법

Power Efficient Cell Searching Scheme for Handover in DVB-H System

*박형근, **조재수
*Hyung-Kun Park, **Jae-Soo Cho

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 cell searching scheme to reduce power consumption by reducing the number of frequency scanning during the handover. Through the numerical evaluation, we analyzethe performance of handover schemes.

Key Words : DVB-H, Handover, Cell Search

Ⅰ. Introduction

DVB-H [1] is a new standard that enhances mobile features for DVB-T [2]. 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[1]. And also, time slicing support seamless handover by offering the possibility to use the same receiver to monitor neighboring cell during the off-time. Handover in DVB-H is rather different from handover in cellular telecommunications systems. This is mainly due to the unidirectional nature of DVB-H networks and the difference in the physical medium. 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 cell searching mechanism is required. In the instantaneous RSSI value based handover scheme, the receiver measures all of the possible signals and finds the signal with highest RSSI value[3]. If the number of possible signals increases, the power consumption increases.

In this paper, we propose a power efficient handover scheme. In the proposed handover scheme, the receiver dose not find the signal with highest RSSI value but compares with 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.

저자 소개
한국기술교육대학교 정보기술공학부 조교수 .공학박사
한국기술교육대학교 인터넷미디어공학부 조교수, 공학박사

2. Time slicing and Power saving

Time slicing is one of the main ideas of DVB-H. Off time between the bursts can be used for power saving by switching off the receiver front end in this time frame. A previous publication [4], which discussed time slicing and power saving, shows simplified formulas to calculate 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 Bs, burst bandwidth B_b and constant bandwidth C_b. Eq.(1)-(2) 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.

$$B_d = \frac{B_s}{B_b \times 0.96}, \quad O_t = \frac{B_s}{C_b \times 0.96} - B_d \tag{1}$$

$$P_s = \left(1 - \frac{(B_d + S_t + (3/4 \times D_j)) \times C_b \times 0.96}{B_s}\right) \times 100\% \tag{2}$$

3.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 [3], 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 and it requires lots of power consumption and reduce power saving effect of time slicing. If the receiver synchronized 'wrong signal', the receiver should measure the every possible signals again.

In the proposed cell searching scheme, the receiver measures signal strength of one signal and test the hypothesis. Testing is 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.

4. Performance of the Handover

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. Path loss can be written in dB scale

$$g_i[dB] = -10n\log_{10}(d_i) + \xi \tag{3}$$

where n is path loss exponent and ξ is a Gaussian random variable with mean of zero and standard deviation of [dB]. d_i is the distance from the i-th transmitter to the receiver.

In the maximum RSSI based handover, if the RSSI value 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. The probability that the signal with the highest RSSI is not the signal of the nearest cell is called missing probability $1-P_d$ where P_d is detection probability. The average time required for handover is shown in Eq. (4). The time required to measure the whole signal is $(N_f-1)\ F_t$, where N_f is the number of signals and F_t is frequency scanning time.

$$\begin{aligned} T_H &= \Pr(P_0 < P_{HO}) \cdot \sum_{k=0}^{\infty} (1-P_D)^k \left((N_f - 1)F_t + S_t + B_d\right) \\ &= \Pr(P_0 < P_{HO}) \cdot \frac{(N_f - 1)F_t + S_t + B_d}{1-(1-P_D)} \end{aligned} \tag{4}$$

where P_0 is the power from the nearest cell. The missing probability can be obtained in Eq. (5).

$$\begin{aligned} 1 - P_D &= \Pr[\mathrm{Max}\{P_i\} \neq P_0] = 1 - \prod_{i=1}^{N_f-1} \Pr(P_i < P_0) \\ &= 1 - \prod_{i=1}^{N_f-1} Q\left(\frac{-10n\log_{10}(d_i / d_0)}{2\sigma}\right) \end{aligned} \tag{5}$$

where Q(.) is a Q-function.

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

$$\Pr(P_0 > P_{HO}) = Q\left(\frac{P_{HO} - P_t + 10n\log_{10} d_0}{\sigma}\right) \tag{6}$$

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

In the proposed cell searching scheme, 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. 1. 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 representsfalse 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.

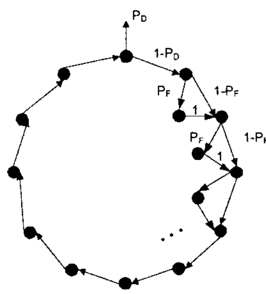

Fig. 1. frequency scanning state diagram

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, fromany 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. (7). If the false alarm happens, to simplify the analysis, we assume that the receiver measure again next signal after synchronization and burst time.

$$T_{tran} = P_F(S_t + B_d) + (1 - P_F)F_t \tag{7}$$

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 form the top to the final destination (correct) node is

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

$$= \Pr(P_0 < P_{HO})\left(i \cdot T_{tran} + S_t P_D + (1-P_D) \cdot \frac{(N_f - 1) S_t + F_t}{1-(1-P_D)} \right) \quad (8)$$

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

$$T_H = \Pr(P_0 < P_{HO})\left(\frac{N_f T_{tran}}{2} + S_t P_D + (1-P_D) \cdot \frac{(N_f - 1) T_{tran} + S_t}{1-(1-P_D)} \right) \quad (9)$$

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.(10), (11) respectively

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

$$P_D = \Pr(P_0 > P_{Th}) = Q\left(\frac{P_{th} - P_t + 10 n \log_{10} d_0}{\sigma} \right) \quad (11)$$

To find the power saving during handover, power saving formula in Eq.(2) should be modified as the Eq. (12).

$$P_s = \left(1 - \frac{(T_H + B_d + S_t + (3/4 \times D_j)) \times C_b \times 0.96}{B_s} \right) \times 100\% \quad (12)$$

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.(2).

Table 1. Parameters for numerical analysis

Parameter	meaning	Example value
Bs	Burst size (bits)	2Mbits
Bb	Burst bandwidth (bps)	12.5Mbps
Cb	Constant Bandwidth (bps)	500kbps
St	Synchronization time (sec)	250msec
Dj	Delta-t jitter (sec)	10msec
Ft	Frequency scanning time(sec)	20msec

Fig. 2 shows power saving performance of maximum RSSI and hypothesis testing based handover algorithm. In Fig. 2, we assume N_f=7 and hypothesis threshold is -105 dB. As shown in Fig 2, 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 %.

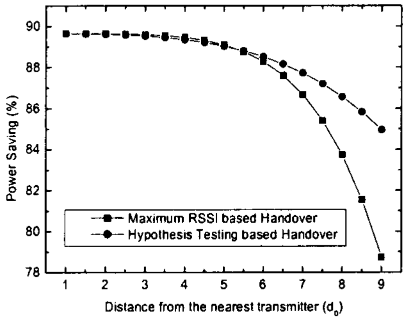

Fig. 2 Power saving according to the distance from the nearest transmitter

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 hypothesis testing based 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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