Seamless Soft Handover In DVB-H Networks

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Abstract: **DVB-H (Digital Video Broadcasting for Handhelds) is a standard specified by the DVB Organization specifically for the broadcast of TV-like content and data to handheld devices, such as mobile phones, which have unique requirements in terms of power consumption, screen-size and mobility. Seamless handover in such a unidirectional network is especially challenging. In this paper we describe the handover issues of DVB-H networks and propose a novel seamless soft handover mechanism based on measuring CDF (Cumulative Distribution Function) of the signal to noise ratio (SNR) in the DVB-H terminal receiver front-end . Details of the algorithm is given and simulation is done to prove the benefits of such soft handover scheme.**

1. INTRODUCTION

DVB is the European standard for Digital Video Broadcasting. There are mainly three standards depending on the transmission medium. They are DVB-S (for satellite), DVB-C (for cable) and DVB-T (for terrestrial). DVB-H is a standard extension for DVB-T [1]. It is designed to meet the requirements for "TV on mobile" and targeting IP based services.

Handover is the switching of a mobile signal from one channel or cell to another. Soft handover means that the radio links are added and removed in a way that the terminal always keeps at least one radio link to the transmission station. The handover in this paper is defined as follows:

When a user moves from one DVB-H cell to another, the DVB-H terminal has to be synchronized to another signal without service interruption.

Because DVB-H is a unidirectional network and must support high quality video display on mobile terminal consuming battery power, the handover issues in DVB-H are much more different from those of cellular network which is a bi-directional network and supports mainly voice and data. Much of the research has been done for handover issues in cellular networks, but still few papers can be seen about handover issues in DVB-H networks. In this paper, we first describe the characteristics of DVB-H which makes it possible to do seamless soft handover. Then we propose and analyse a novel seamless soft handover algorithm and do some simulations using OPNET [6] and Matlab. At the end we give the future research tasks in the DVB-H handover area and conclude the paper.

2. DVB-H CHARACTERISTICS

2.1 Overview

The DVB-H transmission system is based on the DVB-T standard and backwards fully compatible [2]. Besides that, DVB-H has additional features to support handheld mobile reception. They are: power saving for battery; single antenna reception; impulse noise tolerance; support for seamless handover. But what characteristics of DVB-H make it possible to do that? The most important of its characteristics is time-slicing.

2.2 Time-slicing

Time-slicing is the mechanism DVB-H uses to transmit data in bursts with significantly higher instantaneous bit rate compared to the bit rate required if the data are in continuous transmission as in DVB-H. Time-slicing enables a receiver to stay active only a fraction of the time, while receiving bursts of a requested service, thus saves battery power. It is said that 90% power saving for the front-end can easily be achieved [7]. The high bit rate signals will be buffered in the Time slice memory. Time-slicing also supports the receiver to monitor neighbouring cells during the off-times (between bursts), thus makes seamless service handover possible. Being different from normal DVB-T soft handover, the soft handover in DVB-H requires only one front end instead of two in a single terminal, which is resulting from the existence of time-slicing. The time-slicing method is illustrated in figure 1.

Depending on the transmission bit rate, the off-time in the transmission stream can vary. Thus DVB-H receiver can use this off-time to synchronize and initialise service handover to another cell which is impossible without the use of time-slicing.

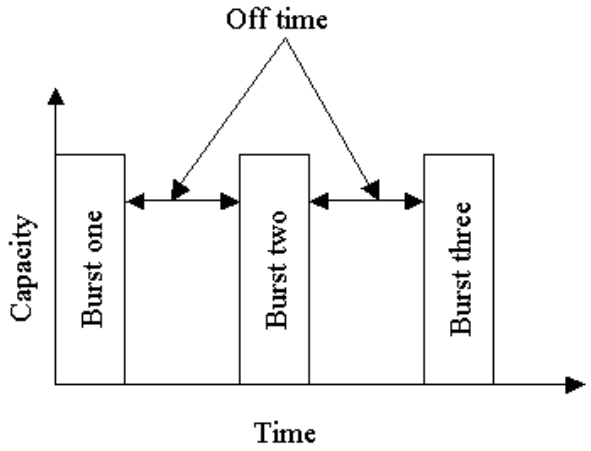

Figure 1 – Time-slicing structure

2.3 DVB-H Signalling

TPS (Transmission Parameter Signalling) is the DVB-H signalling method in physical layer to support service discovery and quicker signal handover on mobile receivers. The modulation scheme in DVB-H is OFDM. Each OFDM symbol is constituted by a set of carriers. The TPS carriers convey information on channel coding, modulation and cell identification. TPS can be used for synchronization and cell identification in handover.

3. SEAMLESS SOFT HANDOVER

DVB-H is a unidirectional network. It receives transport stream from transmitter passively and could not send information to the base station as in cellular networks. This makes it impossible nowadays to do handover without existence of the off burst time. Jani Väre proposed a simple handover scheme based on measuring the RSSI (Received Signal Strength Indication) of the signals in the adjacent cells and executing handover to the cell containing the signal with the strongest RSSI [3]. It is obvious that handover will take place frequently if the receiver moves along the cell border or perform a "snake like" backward-forward movement. Frequent handover leads to more power consumption and low quality service which is not good to DVB-H receiver. Dohler's paper present an interesting idea which described a simple power drop model based on distant dependent time-gradient for handover in cellular networks [4]. But his model is based on the base station side of the bi-directional cellular networks .Our proposed seamless soft handover is based on the post processing of SNR (Signal to Noise Ratio) instead of RSSI, thus avoid frequent handover. SNR is calculated from the RSSI and the noise characteristics, thus is more accurate for estimating the received effective signal.

Suppose that all the service and network information are already stored in the memory of the receiver at the beginning, we focus on the handover measurement and decision. Our algorithm is illustrated in figure 2 below.

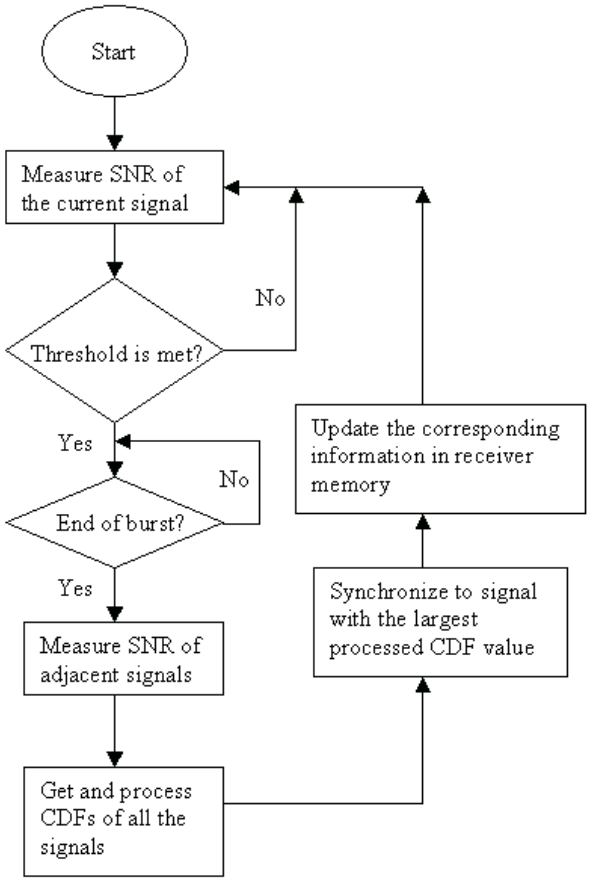

Figure 2 – Seamless Soft handover algorithm

In figure 2 above, when the receiver get all the SNR values of the adjacent signals, it will calculate the CDFs (Cumulative Distribution Functions) of all the SNR values. A Cumulative Distribution Function describes a statistical distribution. It has the value, at each possible outcome, of the probability of receiving that outcome or a lower one. The computation of CDF is shown in equation (1).

$$F(x) = P(X \le x) = \int_{-\infty}^{x} f(x)dt \qquad (1)$$

In the equation above, *f(x)* is the probability density function for random variable *X*, *F(x)* is the probability of observing any outcome less than or equal to *x*.

Because CDF is a probability value, its value does not depend only on the current SNR. Instead it depends on the SNR history of the signal. In this case, we can not only

eliminate the frequent handover phenomenon caused by instantaneous RSSI value based handover, but also avoid the "fake signals" [3] caused by frequency confusion. Our simulation proves that the CDF based handover decision is seamless and more reliable.

4. SIMULATION AND ANALYSIS

We use simulations to further illustrate and test our seamless soft handover algorithm in DVB-H. Our simulation is done in OPNET and the results is analysed using Matlab.

We first build a simple DVB-H model in OPNET. The model scenario is shown in figure3.

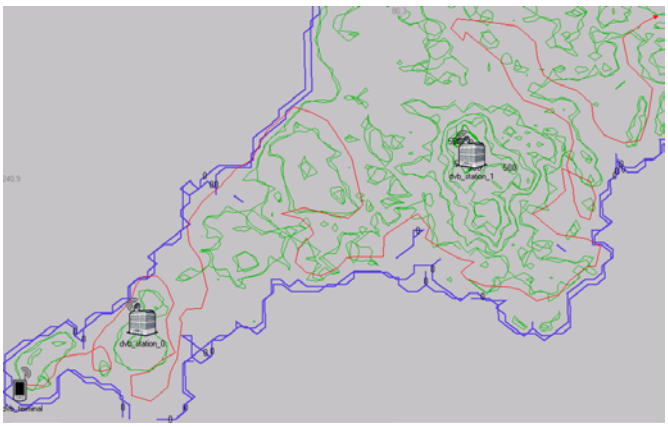

Figure 3 –Soft Handover Scenario

We choose the southwest of Britain as the terrain model background. The southwest of Britain contains various geographical features: plains, open spaces, hilly and mountainous rural areas, rivers, seas,etc. These complex terrain features make the simulation more realistic. We use Longley-Rice propagation model to compute the signal path loss [5].

In the scenario shown in figure 3, for simplicity reasons we place two DVB-H transmission stations (dvb_station_0 and dvb_station_1) in two different mountainous areas with the higher altitude. The DVB-H receiver moves along the red curve from the southwest tip of the area towards northeast. As the receiver moves, it measures the SNR from the two different transmission stations. Because the receiver's movement is irregular which is very common in reality, the SNR values obtained from the two transmission stations will fluctuate.

After 15 hours simulation time, we get the SNR statistics from both transmission stations which are shown in figure 4.

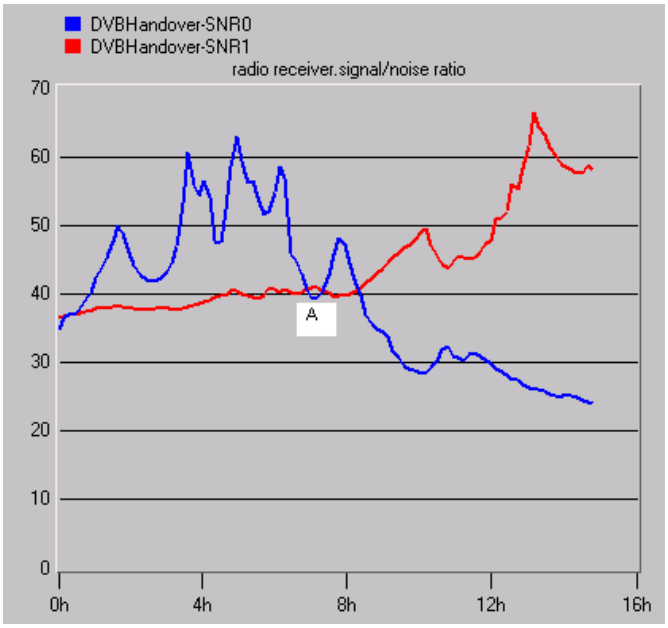

Figure 4 –SNR From Transmission Station

In figure 4, the blue line stands for the SNR that the receiver measured from dvb_station_0. While the red line stands for the SNR that the receiver measured from dvb_station_1. We can see that the red line is above the blue line around point A which is shown in figure 4 as well. If the handover is based on the instantaneous value of SNR, then the handover to dvb_station_1 will happen around point A. But soon it will have to handover back to dvb_station_0 again according to the SNR graph. This will cause frequent handover. In order to avoid such unnecessary frequent handover, we use post-processed CDFs of the two SNR curves to make a handover decision.

We imported the simulation result data from OPNET to Matlab to compute the CDF of the two SNR curves using uniform distribution. Because the discrete points of the CDF curve are not very suitable for making a decision, we use Savitzky-Golay method to smooth the obtained CDF curves. The final diagram is shown in figure 5.

In figure 5, the red line is the smoothed CDF for dvb_station_0, while the black line stands for the smoothed CDF for dvb_station_1. The red line and the black line cross at point B in the graph. Suppose that the system is already qualified with above threshold SNR value, we can see that the moment corresponding to point B should be the time to carry out handover from dvb_station_0 to dvb_station_1. Because such handover happens in the off burst time, it is seamless. And because it is not depending on instantaneous SNR value, the "fake signals" will not have any influence.

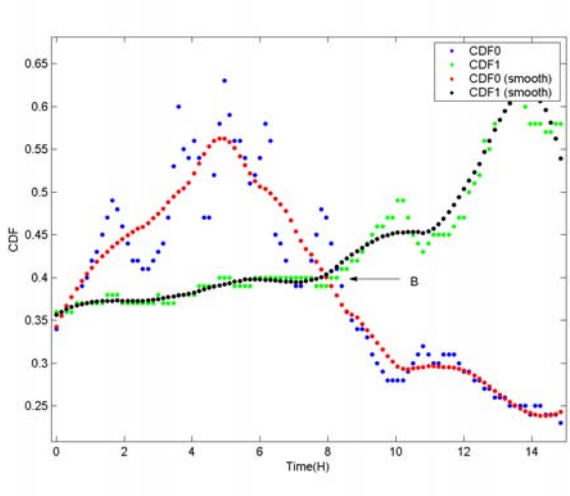

Figure 5 –CDF From Measured SNR Value

5. CONCLUSION

In this paper, we proposed a seamless soft handover scheme in DVB-H networks. This algorithm is based on the post processing of the CDFs obtained from SNR value in the receiver front-end. It can effectively eliminate frequent handover and avoid "fake signals" caused by RSSI based handover. We proved the algorithm theoretically and did simulation to further illustrate its benefits. Because DVB-H is still in the developing and experimenting stage, no realistic field test data have been obtained at the moment. Being one of the participants of the EU project INSTINCT, we are going to build a DVB-H test bed. Further experiments and simulations need to be done to test our algorithm.

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