

Handover in DVB-H

DVB-Seminar

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Abstract

Digital Video Broadcasting for Handhelds (DVB-H) is a standard for broadcasting IP data to portable devices.

In comparison to DVB-T, DVB-H is designed for mobile scenarios. Therefore besides reduction of energy consumption the mobility of the client is one of the main issues.

This paper explains how a handover in DVB-H works and provides an overview to recent solutions approaching the problem.

Keywords

Digital Video Broadcasting for Handhelds (DVB-H), Handover

Introduction

Multimedia Broadcast is getting more attention from both, broadcast and telecommunications operators [2, 14], as a 'one to many' broadcast system targeting PDAs, mobile phones, and laptop computers, is now being rolled out [2].

In Germany the DVB-T network has already a quickly growing audience and analogue stations are being shut off one by one.

However the DVB-T standard is not suitable for truly mobile devices, since the energy consumption is very high.

DVB-H is an extension to DVB-T providing additional features like a better service quality for mobile receivers, IP datacast services and most important handover schemes. Handover schemes ensure seamless reception of data streams from multiple sources in different locations.

How this paper is organised

This paper is meant as an introduction to the handover problematic in DVB-H networks.

At the beginning of this paper the general procedure of a handover is presented along with obstacles on the way to the perfect algorithm.

After presenting a more detailed look on the DVB-H handover, different approaches to the problem are presented to give an overview of recent studies in this field.

Finally a repeater aided approach is presented.

Handover in general

Shortly explained, handover means the switching of a mobile signal from one channel to another. This paper defines handover in DVB-H as a change of transport stream and frequency when the receiver moves from one DVB-H cell to another.

In a more old fashioned way it can be compared to a radio in a car. When the car moves from area-one, where the signal comes from antenna-one to area-two with antenna-two where stations have different frequencies and a different set of stations is available.

Now the driver notices that the reception of the radio station is not as clear as it used to be, maybe even two stations can be heard when signals overlap.

At this time he has to search for a new station or for the new frequency of his old station in case it is available in the new area. The handover in DVB-H takes similar steps and has similar problems.

Handover in DVB-H

Handover means the switching of a mobile signal from one channel or cell to another.

Generally speaking DVB-H is designed to provide IP data services like DVB-T, but in contrast to DVB-T the signal is intended to be received by mobile devices in such ways that the device always keeps at least one radio link to a base station [2, 4].

In DVB-H network cells will be smaller than DVB-T cells, due to technical reasons. As a side effect, the energy consumption of mobile devices is reduced.

Hence roaming will be a common scenario, in future DVB-H networks and handover becomes a critical issue.

Challenges in the Development of DVB-H Handovers

As mentioned above the handover can be compared to the situation of a driver in a car with an analogue radio.

With DVB-H the workload is taken from the user since he does not have to search for a new station any more.

In DVB-H during handover the received frequency (or transport stream) is changed without interruption of the ongoing service.

When moving from one cell to another, the device will try to synchronize with the new frequency of the target cell.

How this can be achieved will be explained in the following sections.

This paper only considers the soft handover process, so the word handover in this paper always means soft handover.

Generally we are speaking of passive handovers, in contrast to cellular networks, where both, the transmitting station and the mobile device are involved in an active handover.

In DVB-H however such communication is not desired because devices shall only receive data in the DVB-H network.

Handover in DVB-H networks can also be divided into active handover and passive handover [2].

In case a device is multifunctional it may send data over its cellular network could use an active handover.

In my point of view this is trying to fix an unfixable bug of the whole

DVB concept as it is as mentioned above a 'one to many' communication network.

DVB seems meant to be unidirectional like TV in the past 60 years. Communication in the other direction can only be achieved over other technologies like cellular networks.

Therefore I will concentrate on soft handovers in this paper as they seem just better fitting to the whole concept of purely receiving devices.

Handover in DVB-H consists of three stages, handover measurement, handover decision-making and handover execution [16].

Handover Measurement

During the handover measurement process all required measurement parameters such as Received Signal Strength Indicator (RSSI) or Signal to noise Ratio (SNR) to facilitate the handover process are gathered.

Handover Decision-making

In the decision-making stage the handover decision is made according to the predefined handover criteria and the obtained measurement parameters from both, the handover measurement stage and the handover decision-making stage.

Handover execution

The handover execution the signals of the targeted handover cell are synchronised after the targeted handover cell is chosen in the handover decision making stage. Subsequently the transmission continues without interruption.

Time Slicing

The central issue beside mobility and roaming is the limited battery lifetime of DVB-H devices in contrast of unlimited broadcast. Time Slicing is a feature solving both issues.

Without time slicing seamless handover would not be possible for single antenna devices. Time slicing means that the data is sent in burst mode. The receiver receives a chunk of data and switches of the reception antenna for a certain amount of time to save battery

power. Then the device receives the next chunk of data. The user does not notice anything of this since the buffered data is played continuously.

While the antenna is in idle mode the receiving device will measure the received signal strength from different cells as explained above in Handover management.

As the receiver makes measurement only in off time the service will not be interrupted so enabling the soft handover in DVB-H while saving battery power.

Logical consequence is that the more measurement is taken, the more battery power is used during off time.

Ping Pong effect

Having presented the general procedure of handover in DVB-H I will now present the key problems.

Receivers cannot be expected to be moving around flat country all of the time.

In cities or mountainous regions shadows blocking the line of sight can significantly change the signal strength at the receiver side. This can cause unnecessary handovers between adjacent cells when a stronger signal is received from an adjacent cell even though the receiver's position is still in the original cell.

After a short while the original signal is stronger again causing the receiver to change the cell again. This is called Ping Pong effect [4].

Every handover increases the energy consumption and respectively reduces the battery lifetime.

Therefore unnecessary handovers should be minimised in the handover decision making stage.

Fake Signal

Along with other information a cell_id is transmitted by the transmitters.

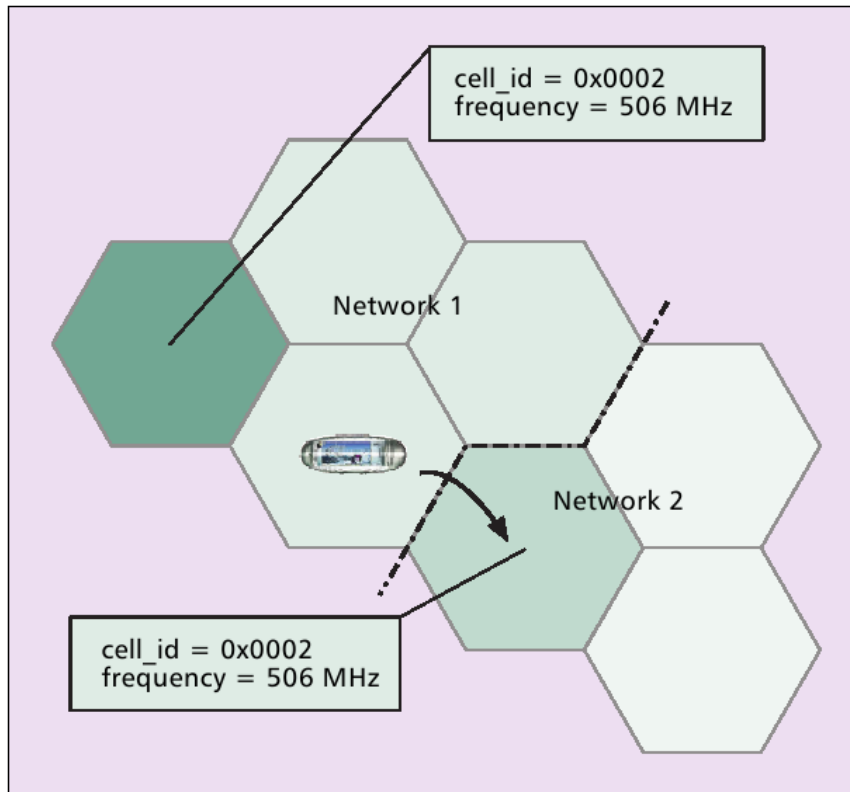


Figure 1: Tuning Failure or fake signals [1]

So in case of bad organisation and no communication between adjacent network service providers a situation like in figure 1 can occur, confusing the transmitter in the handover decision process. The concept of fake signals was introduced in [6]. The situation can simply be avoided by appropriate network design and cooperation between network service providers.

Handover Principles and Scenarios

This section gives an overview of recently deployed methods hence less efficient methods have been left out. A more extensive description of DVB-H handover, including the less efficient methods can be found in [5] and [1].

The identification of a service and the use of service_id in DVB-H are rather different than of DVB-T although DVB-H was designed backward compatible to DVB-T. Main difference is the addition of time slicing and the resulting off periods as well as the signalling.

There are two kinds of signalling the receiver can use for handover. One is Transmission Parameter Signalling (TPS) signalling bits in the

physical layer. The other is DVB-H specific signalling within Program specific Information (PSI)/ Service Information (SI) [7, 8, 9].

PSI/ SI are the core signalling used for service discovery within all DVB services, hence the PSI/ SI used in DVB-H is different. A subset of PSI/ SI for IP Data Cast (IPDC) over DVB-H is defined in [10]. The PSI/SI data enables a DVB-H receiver to discover IPDC over DVB-H specific services in the transport stream and also provides essential information for enabling handover. Handover related information is mainly contained in the Network Information Table (NIT), Program Association Table (PAT), Program Map Table (PMT) [8] and IP/MAC Notification Table (INT) [7].

The DVB-H receiver does not need to support the Service Description Table (SDT) and Event Information Table (EIT), in [10] the SDT and EIT tables are considered mandatory for and IPDC over DVB-H network but optional for the receiver.

In DVB-T, a service is identified by a `service_id` within the SDT and the EIT. The EIT provides schedule information for the service advertised within the SDT. The PAT and PMT are used for associating services with elementary streams.

The identification of a service and the use of `service_id` in DVB-H are rather different to that of DVB-T. In DVB-H the services are first mapped to IP addresses within the Electronic Service Guide (ESG) [11]. Next the IP addresses are further mapped to `service_ids` within the INT, where it is possible to associate all the DVB-H services of an IP platform with only one `service_id`. The discrimination between the DVB-H services within one `service_id` is done within the PMT by means of a combination of `component_tag` and `service_id`.

Hence within DVB-H the `service_id` is just another parameter in mapping of IP addresses to elementary streams.

The handover in DVB-H as defined in [3] occurs when the terminal device receiving a transport stream switches to another transport stream and continues reception of the previously received IP streams.

According to this definition, DVB-H handover can occur only within MFN networks, between two different SFN areas that are part of the same network and between two different networks.

In other words, handover in DVB-H occurs each time the received transport stream and or frequency changes.

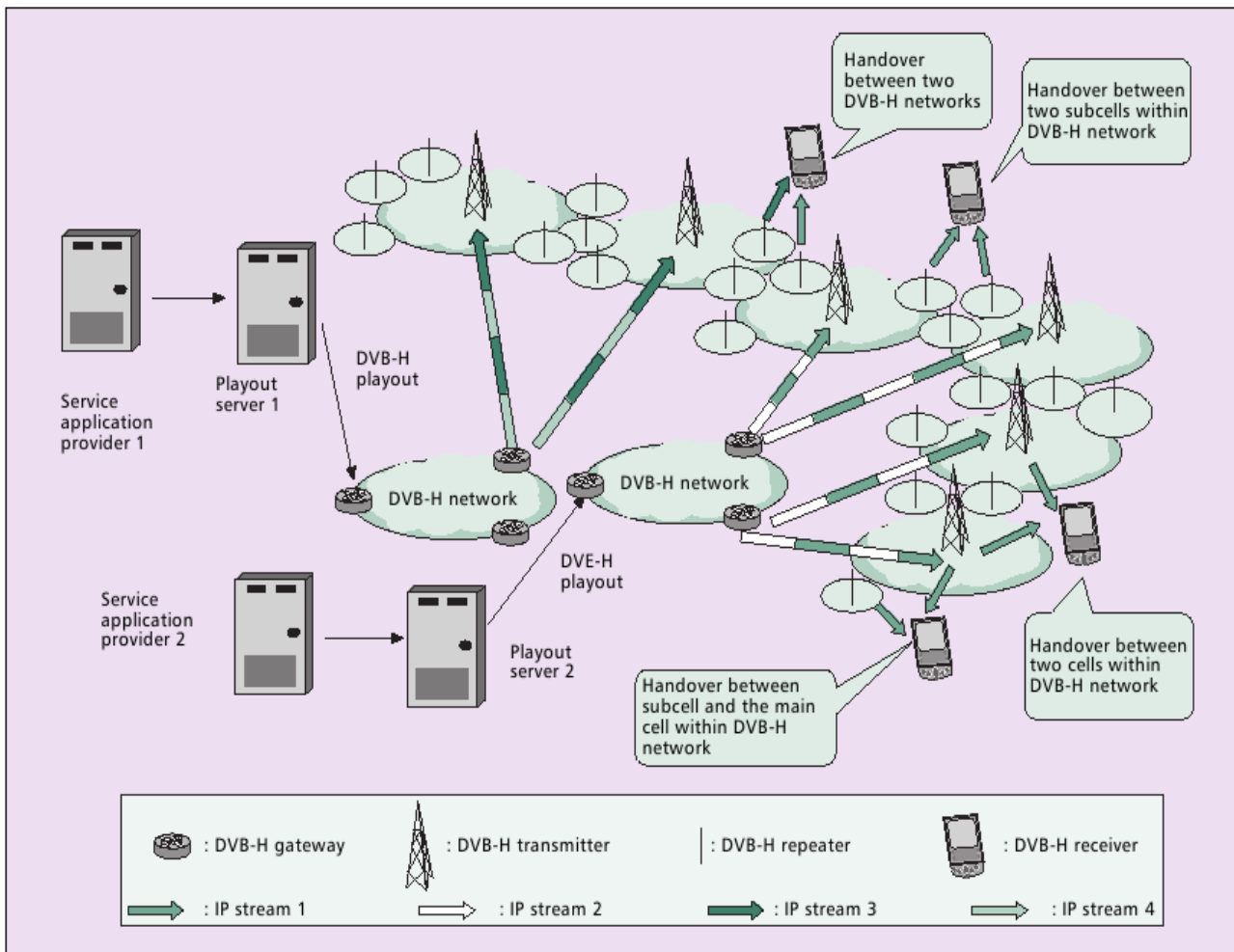


Figure 2: General handover situations in DVB-H networks [1]

The receiver is regularly monitoring adjacent cells that have the currently consumed IP streams available. This information is handled in the NIT and INT.

Geographical information about cells and sub cells are signalled within the NIT.

For the handover between two DVB-H networks for each network supported a new NIT is generated as NIT_other in addition to the current network.

Figure 2 shows the following handover schemes: Handover between two DVB-H networks, handover between two sub cells within a DVB-H network and handover between a sub cell and a main cell within a DVB-H network.

The handover in DVB-H is strictly distinguishable from the handover in cellular networks (e.g., UMTS). This is mainly because UMTS has a bidirectional connection.

In UMTS for example the terminal is communicating in the handover procedure with the network for an optimised and successful completion of the handover [12].

Although some convergence terminals have both DVB-H and telecommunication capabilities, it is not always possible and desired for a terminal to get in contact with the network to perform handover.

Handover without interaction is called passive handover. When an interaction channel such as an expensive UMTS return channel is used it is called active handover [13].

The following figures illustrate the two ideas just for the completeness.

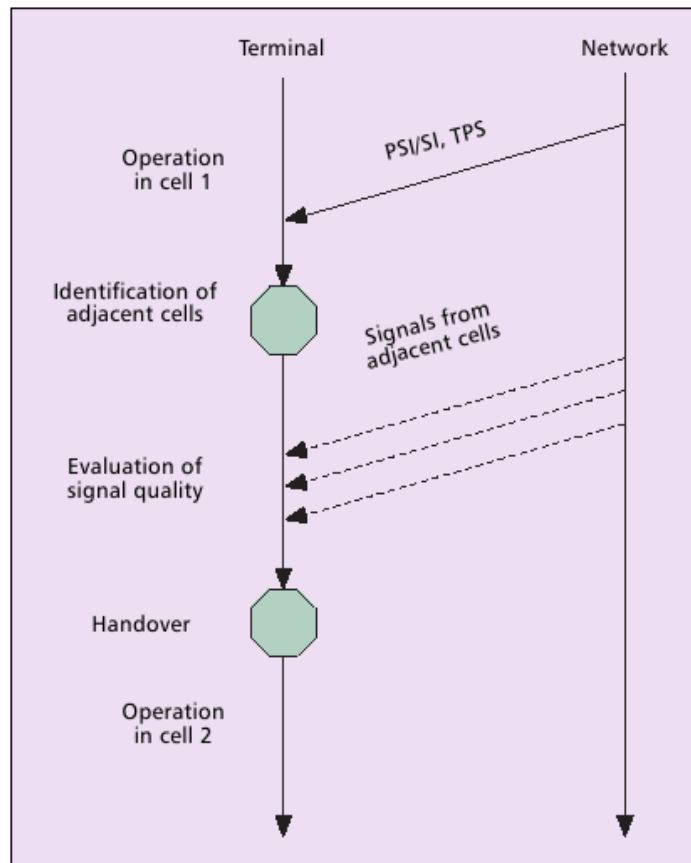


Figure 3: Passive Handover [1]

For DVB-T terminals with a single antenna (which is the normal case) seamless handovers are not possible. DVB-H terminals can make seamless handover because of the time slicing architecture.

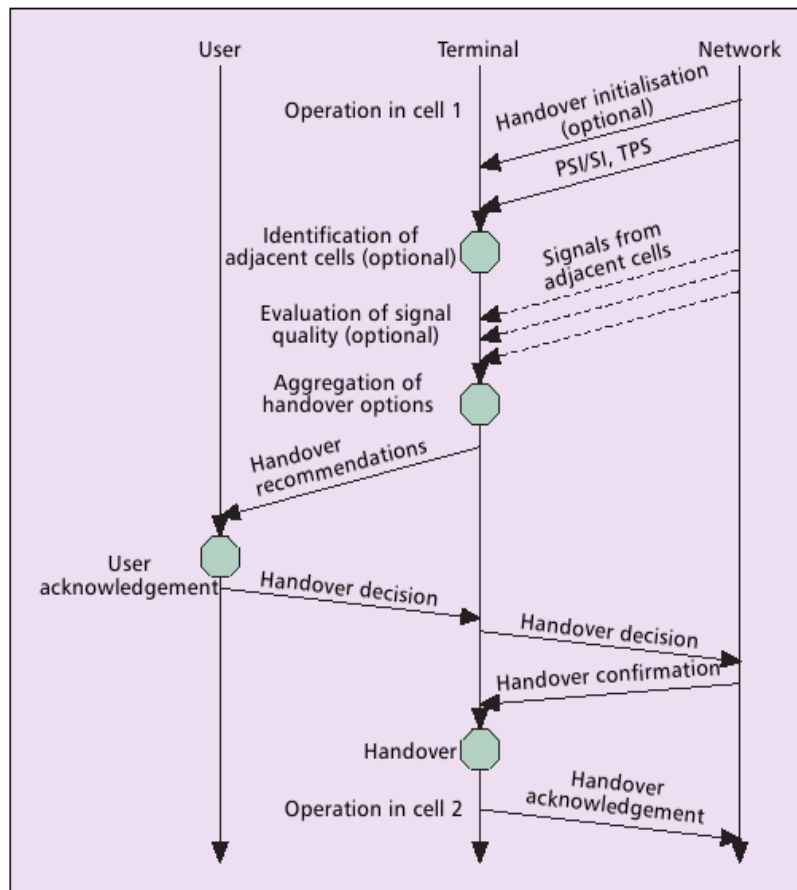


Figure 4: Active Handover [1]

The other main feature of DVB-H is the mandatory cell identifier [14]. Time slicing creates off times that can be used to monitor adjacent cells without interruption of transmission. Cell identifiers assist the handover decision process and reduce tuning failure probabilities.

Related Research

A lot of research on handover algorithms has been launched recently since it is quite a novel issue and a handover algorithm for DVB-H has not yet been finalised.

I am trying to give an overview of recent approaches in this section.

Received Signal Strength Indication

The first handover scheme proposed in literature was instantaneous Received Signal Strength Indication (RSSI) value based [6].

The scheme simply uses the off time to measure the signal strength of adjacent cells and switches to the cell with the strongest signal (RSSI value).

As discussed before the RSSI value does not always provide true

information about the best cell to choose.

The missing piece in this algorithm is a proactive prediction. In [5] Hamara presents an extension to the algorithm in his thesis where additionally the currently consumed services and bit error rate were used as criterion for handover.

The thesis gives an extensive analysis of the handover aspects within in comparison to standard solutions at that time.

Cumulative Distribution Functions

In order to avoid the Ping Pong effect and Fake Signals in [4] a handover scheme based on post processing the measured SNR value. The SNR is calculated from the RSSI and the noise characteristics and provides more accurate estimate of the received effective signal than only the RSSI. SNR values are used to calculate Cumulative Distribution Functions (CDFs). A CDF describes a statistical distribution. For each outcome of the received SNR the probability is calculated of receiving that outcome or a lower one. Therefore the value calculated does not incorporate only present values but also a history. Thereby it avoids Ping Pong effect and the Fake Signal confusion.

The functionality has been proved in simulation but further studies are necessary to investigate the limits of this algorithm.

Cell Description Table

A table called Cell Description Table (CDT) was proposed in [15] for the PSI/SI. Bitmap data is used in a method for signalling cell coverage areas to improve handover performance. 256 different signal levels within the cell coverage area can be signalled to the receiver to inform it of the cell coverage. Thereby the receiver can make better decisions about handover. Of course the Ping Pong effect and the Fake Signals can be prevented. At the receiver side more memory will be consumed to support the process.

Additionally the receiver must have GPS support which is not only additional cost to the customer but also additional battery consumption.

Hybrid Handover Algorithm

In [16] Yang et al. proposed a hybrid handover decision making algorithm. The key idea is to reduce the frequency of handover

measurement in the handover decision making stage by designing a soft handover algorithm with prediction of the handover moment.

The proposed handover decision-making algorithms are Context-Aware Handover Decision-making, Location-Aided Handover Decision-making, UMTS Aided Handover Decision-making, Repeater-Aided Handover Decision-making and Hidden Markov Model Based Decision-making. As a conclusion a hybrid handover decision-making algorithm is proposed that can utilize the advantages of the different handover decision-making algorithms while eliminating their limitations.

Practical tests need to be run to prove the functionality of the central management module used to control the choice of the modules in different scenarios.

Fast Scattered Pilot Synchronisation

In [17] a correlation based Fast Scattered Pilot synchronisation for DVB-H receivers is presented to substitute the conventional TPS-based OFDM frame synchronisation for finding the position of Scattered Pilots within an OFDM symbol in the handover execution stage. It exploits the temporally repetitive structure of the scattered pilots and Schwoerer and Vesma showed using mathematical analysis that the synchronisation time (until channel estimation) could be cut by 84 percent using the new technique. In further studies a reduction of power consumption by 89 percent was shown which are promising results. Further studies and practical tests are necessary to prove the functionality of the approach.

Phase Shifting

May wants to synchronise the signals of adjacent cells in IP Datacast over DVB-H networks in order to ensure loss-free handovers in [18] because the IP network delay and jitter may be different for different cells.

During handover synchronisation techniques must be used in order to ensure a handover without loss of packets caused by a time sliced burst overlap when the next time slice burst arrives.

There are three different types of synchronisation where the first one is no synchronisation which causes a considerable packet loss.

In the second approach, an in-phase synchronisation, all streams in

different cells must be perfectly synchronised. The third one is called Phase Shifting, where a time shift between adjacent cells is ensured to leave enough time for neighbouring time slices to avoid possible packet loss. Analysis and simulation showed that phase shifting synchronisation techniques can achieve much better performance with respect to the packet loss probability compared with no synchronisation and in-phase synchronisation techniques.

DVB Project Reports

In DVB Project technical reports [3, 9] simple handover algorithms are presented which are based on the DVB-T handover algorithm. Basic idea is to use the terrestrial delivery system descriptor, the frequency list descriptor, the original network id and the transport stream id together as a pair along with the service list descriptor to decide which frequency and transport stream the receiver should switch to.

Several methods to reduce the risk of tuning failures or Fake Signals are also presented.

In [9] each cell is a separate network with individual Service Information. Thereby there will be only one frequency per network.

In the second method the cell identifier is used so the terminal can know which cell it has entered. The terminal can determine and check the cell id of a signal from its TPS bits to see if it is in its cell id list of interest after checking the frequency thus reducing the tuning failure.

The third method uses location information from GPS receivers to aid the handover to reduce the Ping Pong effect.

The fourth method uses two front-ends including a second demultiplexer. In this case the tuning of different frequencies can be done in parallel and the target cell frequency can be validated in advance so that the risk of tuning failure can be completely eliminated.

Repeater Aided Soft Handovers

In this section I am taking a more detailed look at a promising approach by Xiaodong Yang et al. combining digital repeaters in the handover process providing the terminal device more information [2].

Digital repeaters

Repeaters provide an efficient solution to increase the coverage of the broadcasting networks [2].

The problem is easily explained. A provider puts up a few high power transmitters to get a broad coverage over an area. This works fine on the flat land.

However, as soon as a few mountains and tunnels come into the scenery network coverage is not so easily done.

Instead of setting up more high power transmitters it is more cost and energy efficient to set up low power repeaters at dead spots like valleys or tunnels.

In the repeater aided handover approach the active repeaters are located in the border area of the cell. The area covered by the repeater is defined as on sub cell.

In comparison to a passive repeater which only amplifies and relays an incoming signal, an intelligent repeater can demodulate and incoming transport stream, add handover scheme information and sub cell id information.

In this approach it is assumed that terminals have multi input, multi output antennas (MIMO). That means that they can receive and decode information from different transmitters at the same time.

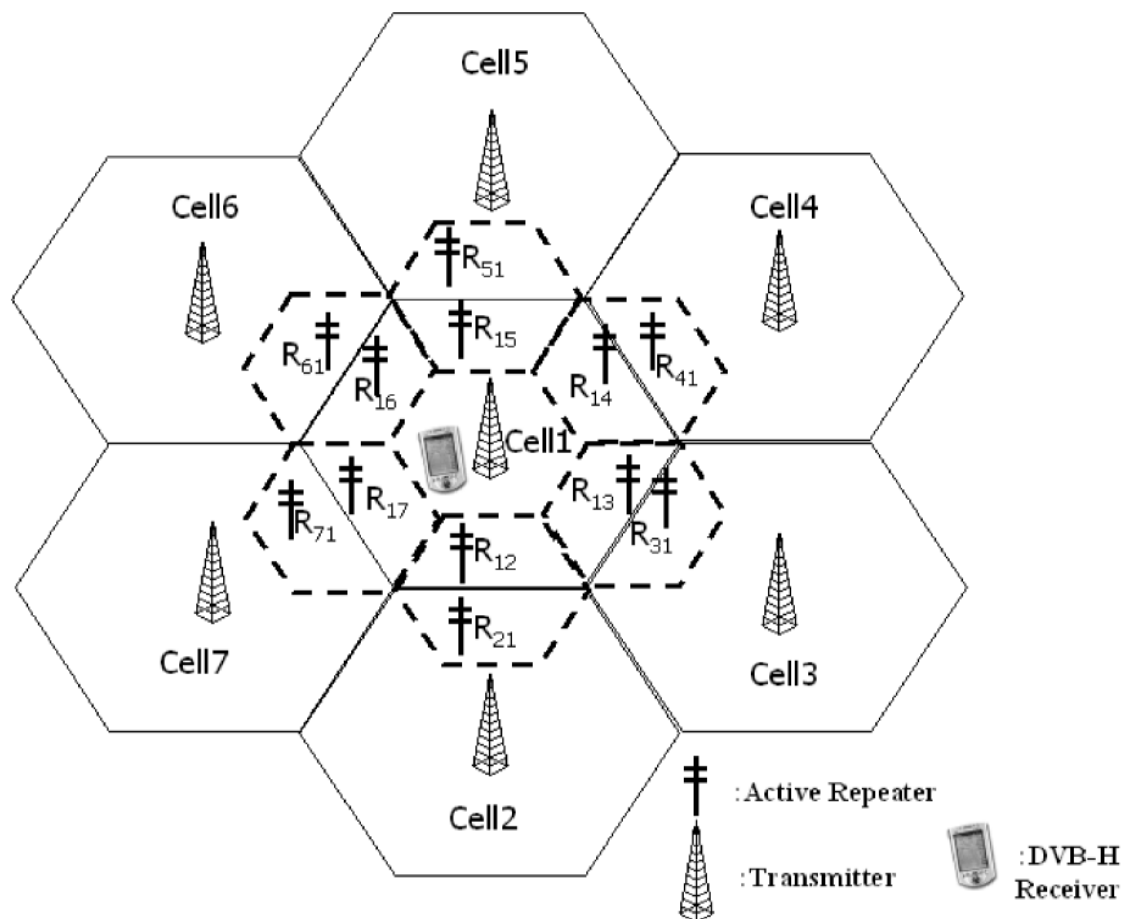


Figure 5: Repeater Aided Handover algorithm cellular structure

When a terminal device enters a repeater covered sub cell, it receives unique repeater identification information letting it know, which sub cell it has entered. By using this information in the handover decision making stage the Ping Pong effect shall be reduced because the handovers are better coordinated by the terminal device.

With the MIMO antennas the terminals are able to increase the signal quality by receiving data from multiple antennas, thus improving the Quality of Service.

In my point of view the question is whether the MIMO antennas require more battery power than conventional antennas should not be neglected.

With addition of repeaters the main transmitter power can be reduced although additional repeaters will add costs to the network equipment.

Whether the overall costs will be reduced has to be shown in the future. The improved costs on the terminal side have to be considered as well.

Simulation Results

A simple mathematical calculation was deployed by the developers that showed that the repeater aided handover scheme could save at least 25% of battery power compared with that of a handover scheme without active repeaters.

A simulation model has been deployed to show the theoretical performance of the approach.

Simulation results showed that the receiver-received quality of service is increased with the increase of the repeater covered area.

The cost-issues of the handover algorithm have been analysed as well although the developers admit that it is difficult to calculate total costs caused by an introduction of the algorithm and compare it to a system without the repeater aided approach.

In order to make a final statement about the approach practical analysis has to be done.

Finally it should be mentioned that the approach offers new options for service providers to improve localized services.

Since the standardisation of the handover algorithm in the DVB-H standard has not yet been finalised this approach could be a competitive candidate for the selection of handover algorithms incorporated to it.

Conclusion

The field of studies for handover algorithms for DVB-H networks is large and continuously growing. Most of the solutions focus on reduction of energy consumption during handovers. This can be achieved by reducing useless handovers as described with the Ping Pong effect or handovers caused by Fake Signals.

Straightforward ideas incorporating GPS information or MIMO antennas seem to be promising solutions.

However the more additional data is downloaded the more energy is consumed.

In the repeater aided approach the Quality of Service is as well mentioned which seems useful to me.

The important aspect hereby is not only the question about what is technically possible but what is useful.

Since GPS receivers have a not neglect able energy consumption themselves, the benefit of reduced energy costs during handovers has to be analysed with caution. Furthermore additional costs will be pushed to the consumer since the devices have to be equipped

with a GPS receiver.

However the use of location information can be useful in some cases. To elaborate on that I want to explain the different use scenarios from my point of view DVB-H receivers can be used in cars and trains, where it is usually possible to operate devices on an external energy source. In such a scenario the user does not care about energy consumption but appreciates a good Quality of Service.

On the other hand network service providers know the main traffic ways like highways and tracks for long distance trains. This information along with geographical information used during network design can improve the reception and handovers significantly.

It is not necessary to regard non highways or regional trains because the amount of handovers on short trips is lower. Furthermore passengers usually do not spend more than one or two hours on those routes.

The same can be said about public transportation in cities as mostly a big city can be traversed in an hour with busses and trams.

The next user group is using the terminal device in some location without moving at all, so handovers will not happen at all, therefore they do not have to be mentioned here further except that those people would appreciate the longest operation time on batteries.

Another question is whether DVB-H will be received mostly on special mobile TVs or if it will be an additional feature to cell phones notebooks or digital cameras. Practically every device with a display and a battery would be capable for the addition of a DVB-H module. The conclusion I get from all this is that there is not one perfect solution.

For instance the use of saved data of past handovers can be useful, especially if a certain route is travelled frequently.

The approach incorporating active repeaters seems also useful to me. But we have to keep in mind that as long as the device does not know where the user is going the best prediction is useless.

The final handover algorithm shall leave options for developers to choose the algorithms or modules and combine them in a useful way for the terminal device.

A question bothering me throughout my analysis is the general use of the DVB-H system in general. The first DVB standards were ratified in the mid ninties, more than 13 years ago. Regarding the concept of DVB as a broadcast system with additional information it seems to me not much more than an extension to Videotext as we

know it for decades. Of course the handover (in DVB-H) is a truly useful feature which users will appreciate a lot.

But this is it already. There is no interaction or proper selection in the service possible. We have a broadcasting network here. In these days of video on demand services and UMTS, DVB-H will have quite big competitors.

The big boom of pod casts shows that recipients care today much more which service they like to consume and traditional broadcasting television seems already antiquated.

Users want to watch their show whenever they want, not when they are transmitted.

My intention is not to decry the concept of DVB (-H), it can do great work supporting huge events where many people intent to receive the same information at the same time.

But when I want to watch my favourite show and I can download it with an UMTS connection from public websites (like dailymotion.com, you tube ... the list is long). Then I am not forced into boundaries of states, languages and time.

My short digression shall underline the importance to point out the advantages of the technology, especially to the user. Furthermore I want to accentuate that a technology shall not only be developed because development was started once.

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