Switched Digital Video Using Convergence Transmission of Broadcasting and Communication on Cable TV Network

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***Abstract*— The cable TV network is considered as an optimal network for convergence of broadcasting and communication because it is possible to provide two-way services. Recently, the cable broadcasting network is in shortage of available frequency resources due to high quality broadcasting services, increased demand for VoD, and increased bandwidth of high-speed Internet services. This paper presents a new method for switched digital video (SDV) technology to obtain additional transmission resources in cable broadcasting networks. In the proposed SDV method, communication and broadcasting service share the same frequency band, it is possible to improve the frequency usage efficiency by providing switching of broadcasting channels without complex system construction.**

Keywords — switched digital video; convergence transmission; Cable TV Network; Data over Cable Service Interface Specifications

I. INTRODUCTION

In general, a broadcast signal always occupies a service channel regardless of a viewer's viewing situation. In terms of transmission, it is a very inefficient. Switched Digital Video (SDV) is a technology for saving transmission resources by transmitting only channels that viewers actually watch without transmitting all channels [1-2].

Figure 1 shows an example of frequency use in the current cable broadcasting network. Channel arrangements may be slightly different for each cable broadcaster, but in most cases they are similar to those in Figure 1. As shown in Figure 1, in the cable broadcasting network, the 5 ~ 42 MHz band is used for upstream transmission, and up to 54 ~ 864 or 1,002 MHz is used for downstream transmission. Downstream can be classified into analog broadcasting, digital broadcasting, and transmission of communication data, and each is transmitted using channels of 6 MHz.

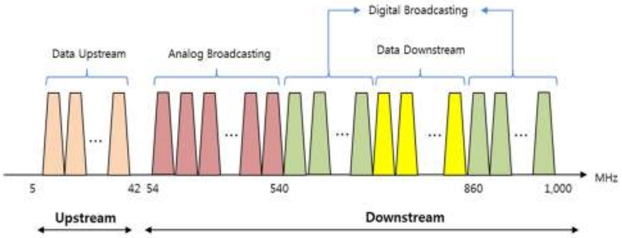

Fig. 1.Frequency Usage Example of Cable TV Network

In particular, in cable broadcasting networks, broadcasting services transmit all channels to subscribers regardless of whether or not a viewer selects a channel, but in general, the channels mainly viewed by viewers are often limited to the upper few channels, so the viewing rate is low. Transmission bandwidth is wasted by the channel. Figure 2 shows the total channels transmitted to each viewer and the channels that viewers are currently watching by time by performing a sample survey of 3,000 households. In the existing broadcast transmission method, all 170 channels are transmitted to viewers. It can be seen that the sample viewers only watched a maximum of 67 channels and an average of 56 channels, including watching the same channel, and about 100 channels were unnecessarily wasted [3].

Above results show that when SVD is applied to all channels, quite a lot of additional channel resource can be obtained. However, although the use of SDV saves transmission channel resources, it is difficult to apply to actual broadcasting system due to the complexity of implementation. So it is mainly applied to some low viewership channels.

In this paper, we propose an implementation method that can apply SDV to all channels by solving the complexity of the existing SDV system.

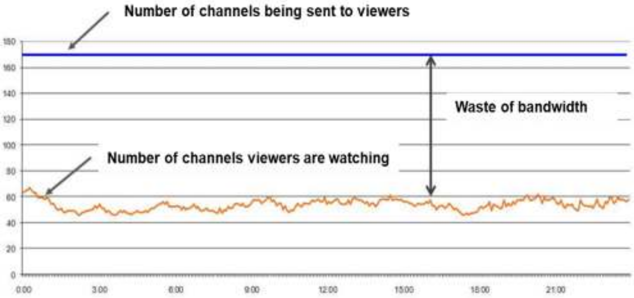

Fig. 2. Measure the number of viewing channels

II. SWITCHED DIGITAL VIDEO

The basic concept of SDV is to secure an available transmission band by transmitting only the channels that subscribers watch during the corresponding time period and stopping the transmission of channels that are not viewed.

For SDV application, it is necessary to determine the distribution of the number of TV channels watched during peak hours for a given number of viewers, and a channel preference model to express this must be presented.

According to previous studies, the preference of TV channels is expressed as a Zipf-like distribution [4,5]. The cumulative probability distribution function for the Zipf-like distribution is given as (1).

$$q(n) = \frac{n^{-\beta}}{\sum_{i=1}^{N} n^{-\beta}} \quad (1)$$

where, i denotes the i-th in the preferred channel order, and N denotes the total number of channels. In the zipf-like distribution, the preference of the i-th preferred channel is proportional to $i^{-\beta}$.

Figure 3 compares the actual measured channel preference distribution and the Zipf-like distribution according to the value. The channel preference distribution measured in Figure 3 corresponds to the field experiment result when 118 channels are serviced during the peak time. The measured channel preference distribution was approximated when the Zipf parameter β was about 1.7. In this case, 50% of the total requests correspond to the most preferred channel, and more than 90% of the preferences are distributed to the top 12 channels. And from this measurement result, it can be seen that the number of channels actually viewed during peak times is only about 50% of the total number of channels. This means that when channel switching is applied, an additional transmission bandwidth of at least 50% can be obtained.

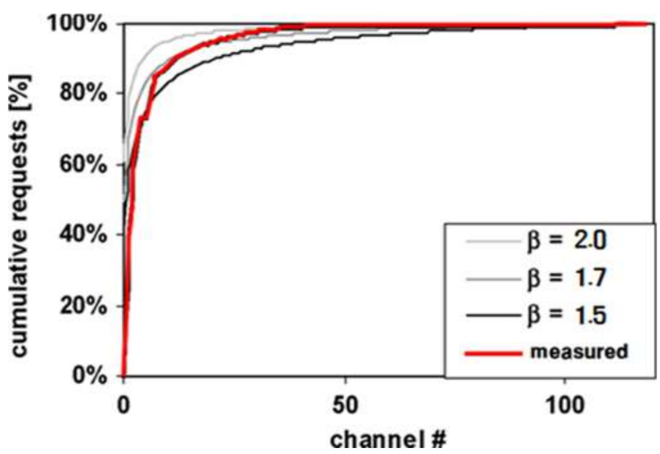

Fig. 3. Cumulative Distribution of Channel Requests

Figure 4 shows the existing SDV technology. Figure 4-a) shows conceptually that broadcast data is transmitted to all channels before channel switching. In digital cable TV broadcasting, there are multiple virtual channels within a physical 6MHz channel. A channel where viewers watch a program means this virtual channel. Figure 4-b) indicates only the virtual channel currently being viewed. Figure 4- c) shows an example of SDV which re-multiplexes only the virtual channels actually watched in Figure 4-b) to fill from the front physical channel and uses the remaining physical channel as a DOCSIS (Data over Cable Service Interface Specifications) channel for data communication.

However, whenever there is a change in the channel in real time, channel reconfiguration (e.g. re-multiplexing for each channel) and related system and service information have to be changed, which makes the implementation very complicated. For this reason, SDV is only applied to some non-preferred channels in an actual broadcasting system.

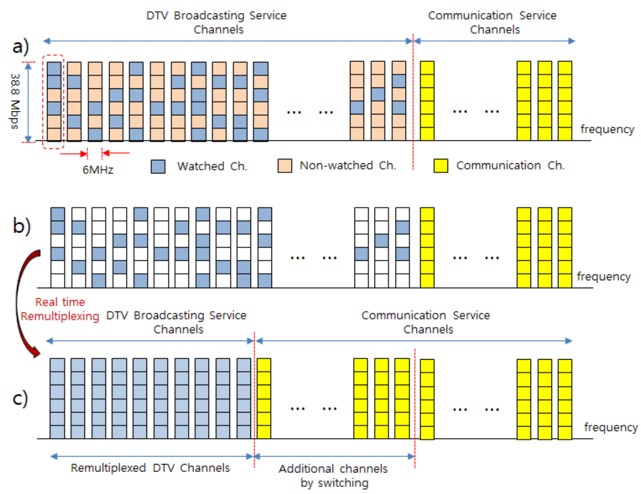

Fig.4. Existing Technology of Switched Digital Video

III. Proposed a New Method

Figure 5 is a newly proposed SDV method, which is similar to the broadcasting channel switching shown in Figure 1 above, but features that the communication data is mixed with the broadcasting data in the remaining idle bands for each channel. Unlike in the example of Figure 1, there is no need to remultiplex the broadcast channels transmitted after switching the broadcast channels. In addition, since there is no change of the physical channel, update of the system and service signaling information is not required. The reason why broadcast and communication service share the same physical channel is that the DOCSIS 3.0 specification defines data transmission by bonding channels, and communication data and broadcast data are transmitted through MPEG-2 TS packet and can be distinguished by packet identifier (PID).

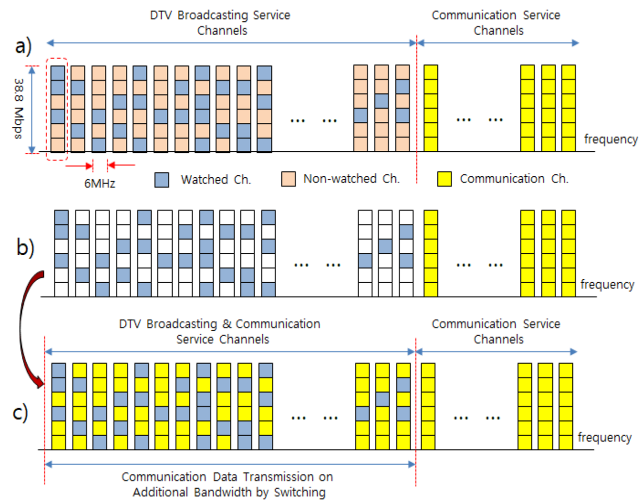

Fig. 5. Proposed Technology of Switched Digital Video

Using the characteristics of DOCSIS 3.0, the structure of the transmitter is shown in Figure 6 for switching the broadcasting channels and transmitting the broadcasting and communication data in the same physical channel.

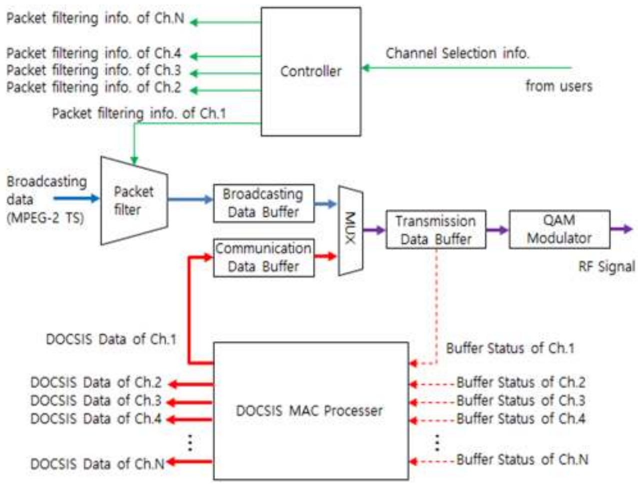

Fig. 6. Transmission Structure of Switched Digital Video

It can be implemented only by generating control information according to the channel selection information of the viewer, filtering MPEG-2 TS packets, and multiplexing with DOCSIS data. Figure 7 shows the structure of broadcasting channel switching for one physical channel. Practically, the device is applied to all physical channels used for communication service, so that broadcast data and communication data are mixed and transmitted.

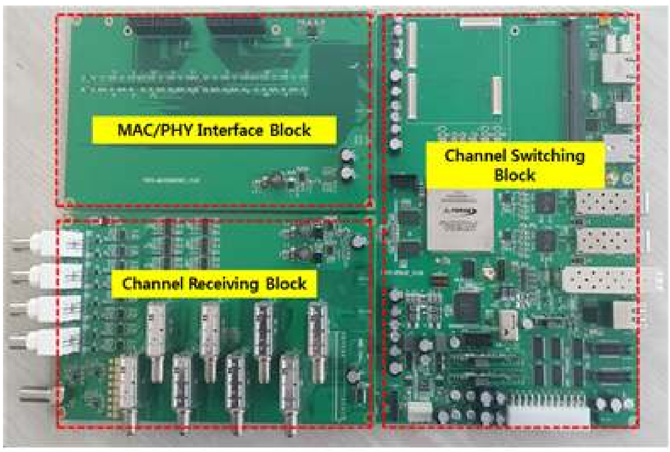

Fig. 7. Implementation of Switched Digital Video

The device in Figure 7 is located at the cell node of the cable TV network and consists of a broadcast channel receiving block, a channel switching block, and a MAC/PHY interface block. The broadcast channel receiving block demodulates QAM modulated RF signals for all TV channels transmitted through the cable TV network and delivers the demodulated signals to the channel switching block. The channel switching block collects channel selection information of viewers in real time and broadcasts the selected channels based on the information. The channel switching block collects channel selection information of viewers and passes only broadcast data of selected channels based on the channel selection information, and filters broadcast data of unselected channels. The MAC/PHY interface block transmits the selected broadcast data to the DOCSIS MAC processing block, receives data of channels mixed with broadcast and communication data, and delivers the data to the QAM modulator of the corresponding channel.

Figure 8 shows the real-time experimental environment for the implemented channel switching device. This experiment verified the switching of about 130 service channels in a commercial cable broadcasting network. In the experiment, viewers' channel selection information is generated through computer emulation. It is confirmed that channel switching is performed according to channel selection information and data traffic is filled to the remaining broadcast channel band after switching.

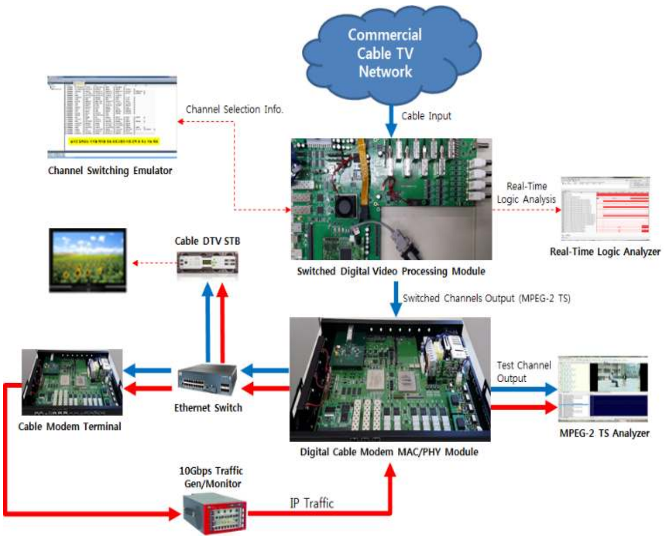

Fig. 8. Experiment Environment of Switched Digital Video

Figure 9 shows the transmission data traffic of each physical channel in the actual experiment. In the data traffic analysis graph of Figure 8, the red bar represents broadcast data traffic and the blue bar represents communication data traffic. In particular, it can be seen that the communication data occupies the remaining band after switching the broadcast channel.

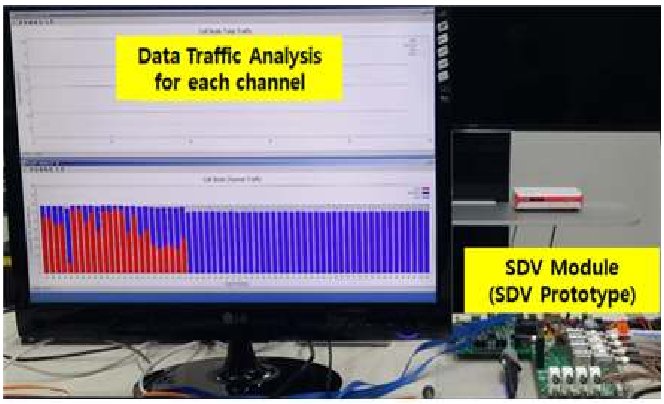

Fig. 9. Real-time Traffic Analysis of Switched Digital Video

IV. CONCLUSIONS

The proposed SDV method is relatively simple compared to the conventional complex broadcast channel switching implementation. In addition, in the existing implementation method, it was possible to apply only to some channels due to the complexity, but the proposed method can be applied to all channels to obtain higher frequency usage efficiency.

In recent years, the cable broadcasting network has emerged as a new service, higher quality of broadcast channels, and improved transmission speeds for high-speed Internet services. The proposed SDV method can maximize the frequency use efficiency, which can save the frequency resource and expand the new service through the saved frequency resource.

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