Design on Different Recording Ways in Android Set-top Box

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Abstract
         The design and implementation on different recording ways in Android Set-top Box (STB) are described. When consumers are watching a TV program, there are three alternative recording ways which are continuous recording, timer recording and time-shifting recording being designed for us to record the program, and the three kinds of recording ways are diacritical by the different trigger modes. When consumers want to record a TV program playing in the future, the way of scheduled recording is designed, and the implementation of scheduled recording depends on the Time and Date Table (TDT) and Electronic Program Guide (EPG) information. The test results show that the recording scheme can satisfy the individual needs of consumers for recording TV programs in some different ways, and it is effective to enrich the interface function between TV and consumers.

Keywords: android set-top Box, TV program, recording way, scheduled recording

1. Introduction
         The digital TV Set-top Box (STB) is a TV network terminal device which converts digital signal to analog signal [1]. Nowadays, there are more and more people watching TV using Personal Video Recorder (PVR) STB. But at present, digital TV STBs are mostly based on Linux platform. There are many shortcomings in this platform such as the number of applications is not rich enough and the portability among different platforms is not easy enough. While Android system is open, cross-platform, and easy to be developed [2], PVR function in digital TV STB based on Android platform is developed in this paper.
         Consumers can record and play back broadcast programs with this kind of STB for that programs can be saved in a local hard disk or other storage medium applied by the STB [3]. Consumers are not only satisfied with that they can record TV programs but also they want to record TV programs in their own way. Aim at different consumers' needs, different recording ways in Android STB are designed in this paper. They are continuous recording, timer recording, time-shifting recording and scheduled recording.

2. PVR System Overview
         There is only one tuner in traditional digital TV STB with PVR function. Thus only the program which is in the same TS stream with the playing one can be recorded. The hardware architecture of traditional PVR STB is shown in Figure 1.
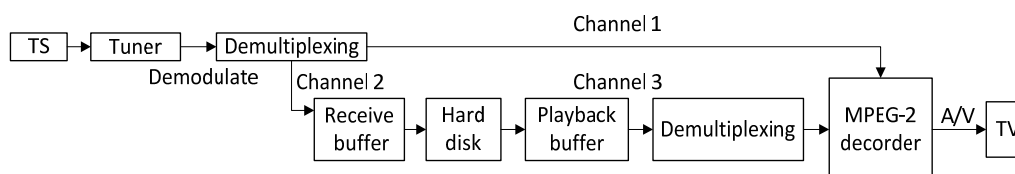

Figure 1. The Hardware Architecture of Traditional PVR STB

The source decoder chip Hi3716C is particularly powerful. Firstly, The ARM's advanced Cortex A9 architecture processor is adopted on Hi3716C chip and the high processing capacity of this chip can meet the needs of the business in the future. Secondly, 3-way TS inputs can be supported on it. The last but not the least, there are 2-way Ethernet interfaces, 2-way USB interfaces, 1-way SATA/eSATA interface and 1-way PCIe interface on Hi3716C. So the connection scheme can be very flexible provided by these interfaces.

For the excellent characteristics of chip Hi3716C, the digital TV STB developed in this paper is equipped with this kind of chip [4]. Two tuners are used in the hardware architecture design of this system. So it is possible for consumers to record one program and watch another which is in any TS stream.

The hardware architecture of advanced PVR STB is shown in Figure 2.
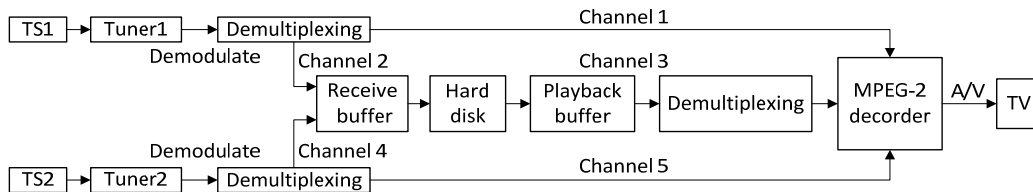

Figure 2. The Hardware Architecture of Advanced PVR STB

When consumers watch TV programs in real-time, the working process is as follows: Firstly, TS stream outputted from the front-end is being sent into the demultiplexer module after being demodulated. Secondly, the PES stream which is consisted of audio, video and other information of the program is extracted in the demultiplexer module. Thirdly, the PES stream is sent to MPEG-2 decoder [5] through channel 1. At last, after the PES stream is decoded in the decoder, the analog audio signal and video signal are outputted to the TV display by DAC (Digital-to-Analogue Conversion) [6].

when the current playing program or a program which is in the same frequency point with the current playing program is being recorded, it is through channel 3 that the TS stream of this program is sent to the hard disk by corresponding control to the demultiplexer. In this situation, the audio signal and video signal are outputted to the TV display still through channel 1. At the same time, channel 2, channel 4 and channel 5 are disconnected.

When the program consumers are watching is not in the same TS stream with the program they want to record, the former is sent to MPGE-2 decoder through channel 1 and can be played on TV display, and the latter is sent to hard disk through channel 4. At the same time, channel 2, channel 3 and channel 5 are disconnected.

3. Software Implementation

Java language is selected in Android system. In order to improve the efficiency of developing applications, it is necessary to call C functions in Android project.

The data access mechanism between JAVA language and C language is shown in Figure 3. Through this access mechanism, the underlying C functions can be called by the Android application through JAVA API to implement PVR function. The access mechanism not only satisfies the requirements but also is very efficient. By accessing like this, the development efficiency and portability of Android applications can be greatly improved [7].
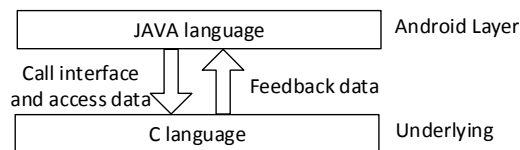

Figure 3. Data Access Mechanism

3.1 Design Process in Android Layer

Aim at the current playing TV program, three kinds of recording modes are designed in the Android layer to achieve personalized recording way.

When consumers record current playing TV program by the operation of pressing the record button without setting the record time, it is the way of continuous recording. When the consumers press the stop button or the storage medium is full, the recording process is stopped.The specific implementation process of continuous recording is shown in Figure 4.

When consumers record current playing TV program by the operation of pressing the record button and setting the record time, it is the way of timer recording. The recording process can be stopped when three conditions have been met: the consumers press the stop button; the storage medium is full; and the time has reached the deadline.The specific implementation process of timer recording is shown in Figure 5.
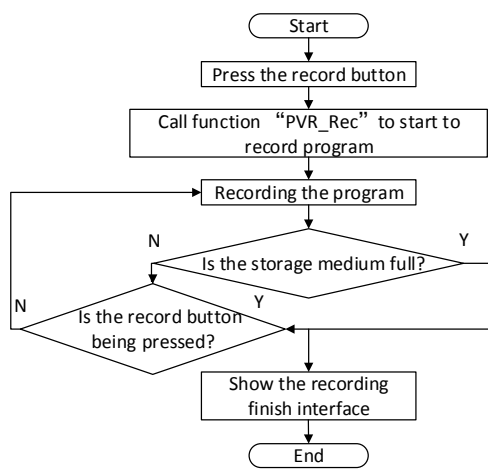
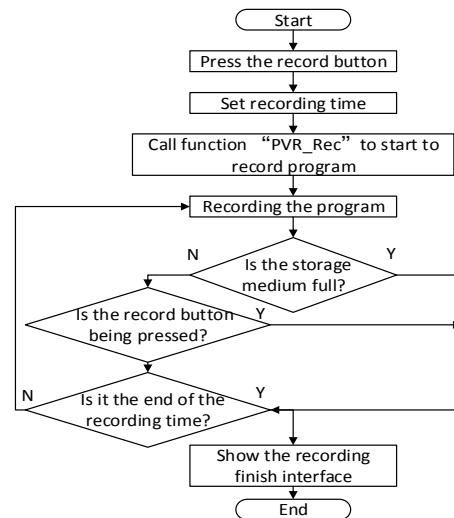Figure 4. The flow chat of continuous recording   Figure 5. The flow chat of timer recording

When consumers record current playing TV program by the operation of pressing the pause button or the back button, it is the way of time-shifting recording. There are two ways of time-shifting recording. Consumers can choose each one of them as they like. The first one is only the pause button has been pressed the time-shifting recording begins. When the consumer presses the play button or the playback receive is full, the time-shifting recording ends. The specific implementation process is shown in Figure 6(a).
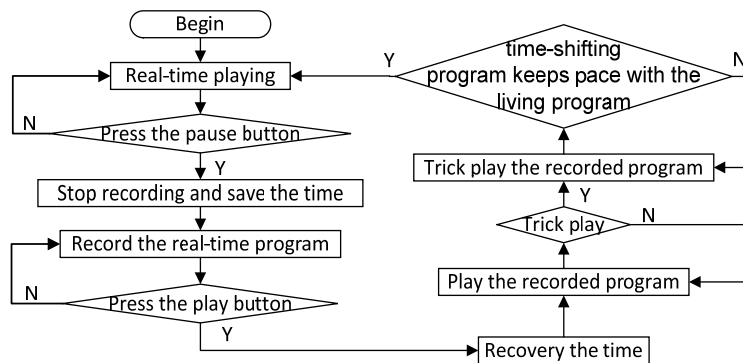
Figure 6(a). The First Way of Time-shifting Recording

Figure 6(a) shows that we can't press the back button anywhere we want. In Figure 6(a), trick play includes some operations such as pausing, jumping forwards or backwards, and playing at different speeds.

The second way is that the time-shifting recording is kept on going. We can press the back button anywhere we want to watch the program played just now and we can press the fast forward button to watch the program until the time-shifting program keeps pace with the living program. The specific implementation process is shown in Figure 6(b). The shortcoming of this way is that the times of writing and reading hard disk is more than the first way.
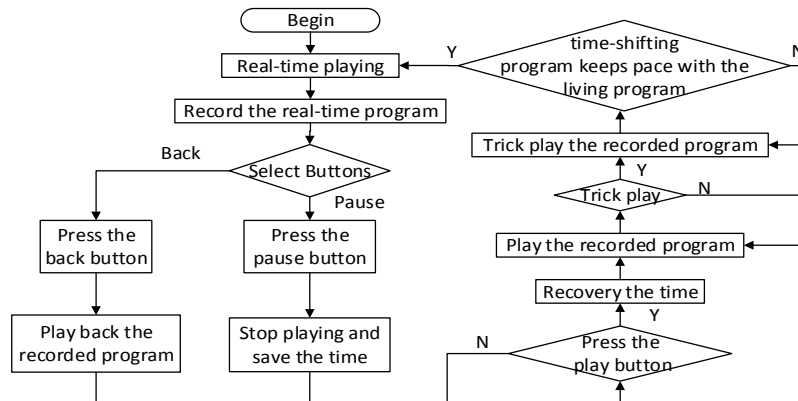

Figure 6(b). The Second Way of Time-shifting Recording

The function of "PVR_Rec" wil be introduced in subsection 3.2. The design of these three recording ways makes it easy for consumers to record real-time programs as they please.

Electronic Program Guide (EPG) technology is a new technology in the field of STB. The basic function of EPG can be implemented by the use of Network Information Table (NIT), Service Description Table (SDT), Event Information Table (EIT), and Time and Date Table (TDT) in Service Information (SI) [8]. All information over a period of time of a television program can be showed in a format of "channel - time - program" to consumers by EPG menu.

Consumers not only want to record programs which are living, they also want to record programs which are going to be played in the future. Aim at TV programs in the future, the method of implementing PVR function perfectly combined with EPG technology [9] is presented so as to solve the problem that consumers miss recording some programs just for forgetting. This recording way is called scheduled recording.

The associated events for each of the programs are stored in the event list of the program. The data structure of the events for a single channel is as follows:

```
typedef struct _EPG_INFO _T
{
        short  service_id;
        short  event_id;
      char  event_name;
        short  event_name_lenth;
        TIME  start_time;
        int  duration;
} EPG;
typedef struct   nnnTIME
{
      int year;
      int month;
      int day;
      int hour;
      int minute;
int second;
};
```

As shown above, the corresponding EPG information of each scheduled program are mainly consisted of the name of the program, the length of the name, the start time and duration of the program. Of course, the corresponding service id and event id of the channel are also included [10].

The way of scheduled recording is convenient and accurate for the following reasons. First of all, we don't need to set a long list of date and time like in traditional Video Cassette Recorder (VCR). What's more, if the playing time of the scheduled program is changed in the front-end, the recording time can be changed automatically in accordance with the new program list.

According to the TV program list generated by EPG, consumers can press the record button at the program that they want to record. When it is time to record, the scheduled program will be recorded into hard disk automatically. To implement scheduled recording function, a background timing clock that can update Time and Date Table mechanism is created firstly. And a background monitor task that can check the scheduled program in real-time is set secondly. At last, some management functions are created to implement the functions of increasing, deleting, modifying and checking programs. The specific implementation process of scheduled recording is shown in Figure 7.
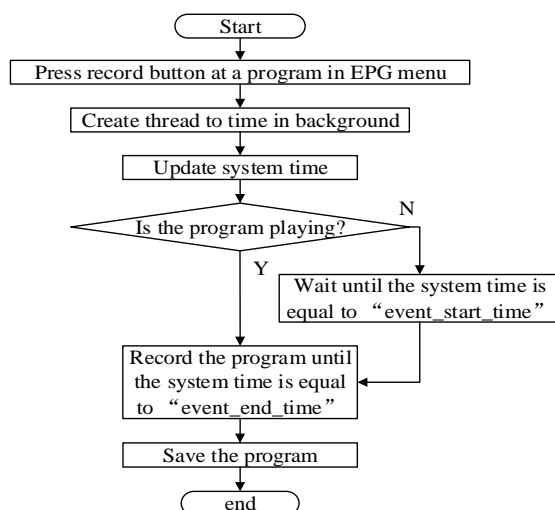

Figure 7. Scheduled Recording

In Figure 7, "event_start_time" stands for the start time of the recording program and "event_end_time" stands for the end time of the recording program. Due to the background clock is being detected continuously, it begins to record a program when it is the start time and it stops recording when it is the end time.

When consumers select a program they want to record in the EPG menu, relevant recording information including channel number, the start time and end time of the program and the name of the program will be written to the configuration file. Scheduled recording programs will be sorted by time. When consumers select a program they want to record in the EPG menu again, the relevant recording information of this program will be inserted into the correct location of the configuration file automatically.

The contents of the configuration file are checked continuously. When the current time is equal to the recording time, the program will be recorded automatically [11]. It is easy for consumers to check and manage recorded programs by using the configuration file.

3.2. Design Process in Underlying

In digital STB, recording function is defined as that when the consumer presses the record button of the remote control, the data outputted from the demultiplexer are sent to receive buffer firstly, and if the receive buffer is full, the data are sent to hard disk automatically.

In order to record a program, the basic information like audio PID, video PID, the name of the program, the start time of the program and the duration of the program must be written to hard disk.

In this scheme, a function called "PVR_Rec" is designed to implement recording function. The format of this function is PVR_Rect (char * path, PROG_INFO * pProgInfo, int DemuxID, long MaxSize, int * pRecChn). Here, parameters "* path" stands for storage path. Program can be recorded in the SATA hard disk of the STB or an external USB device. According to consumers' custom, we set the priority of USB mobile hard disk is higher than SATA hard disk.

The parameter "* pProgInfo" stands for the basic information of a recording program. The data structure of the basic information of a recording program is as follows:

```
typedef struct PMT_COMPACT_PROG_S
{
  int     ProgID;            /* program ID */
  int     PmtPid;            /*the PID of PMT*/
  int     PcrPid;            /*the PID of PCR*/
  int     VideoType;       /*the type of video */
  short   VNum;   /* the number of video stream */
  short   VPid;    /*the first video stream PID*/
  int     AudioType;       /* the type of audio*/
  short   ANum;   /* the number of audio stream */
  short   APid;    /*he first audio stream PID*/
} PROG_INFO;
```

The parameter "DemuxID" stands for the ID of DEMUX applied for. There are five DEMUXs on the Hi3716C chip. Here, DEMUX0 is adopted for direct playing. DEMUX1 and DEMUX2 are adopted for recording. DEMUX3 is adopted for time-shift playing. DEMUX4 is adopted for playback.

The parameter "maxSize" stands for the maximum length of the recorded program. It is available only when the recording way is set as timer recording.

The parameter "* pRecChn" stands for recording channel. The channel should be applied before recording and be finished after recording in time.

The program can be named based on EPG information, just like the format "channel-name-time". By designing like this, programs recorded are convenient for consumers to check and edit in the Recorded List Interface.

4. Test Methods and Results

According to the test specifications of digital TV STB with PVR function, some equipments included one reference board Hi3716C, one SATA interface hard disk (160GB), one USB mobile hard disk (80GB), a TV display with HDMI (High-Definition Multimedia Interface) [12], and a 2-way splitter are used to test the recording function.

The connection method is as follows: the TS stream of the Broadcast & TV front-end is connected to the input of the splitter and the two outputs of the splitter are connected to the two tuners of Hi3716C. The SATA hard disk is set in the STB. Whether the USB hard disk is connected to the STB depends on the test method. The HDMI of Hi3716C is connected to the HDMI input of the TV display to send audio signal and video signal.

Table 1. Test Methods and Results for Continuous Recording

Hard disk connected	Operations	Results
SATA interface hard disk	Press the stop button	Stop recording and the programs are stored in the SATA interface hard disk
SATA interface hard disk and USB mobile hard disk	Press the stop button before the USB mobile hard disk is full	Stop recording and the programs are stored in the USB mobile hard disk
SATA interface hard disk and USB mobile hard disk	Press the stop button after the USB mobile hard disk is full	Stop recording and the programs are stored in the USB mobile hard disk firstly, the rest of the programs are stored in the SATA interface hard disk

The test methods include the way of connecting hard disk and different operations. The test items include continuous recording, timer recording, time-shifting recording and scheduled recording. Firstly, when a TV program is living, press the record button without setting the record time. In this condition, it is continuous recording. The test methods and results are shown in Table 1.

Secondly, when a TV program is living, press the record button and set the record time. In this condition, it is timer recording. The test methods and results are shown in Table 2.

Table 2. Test Methods and Results for Timer Recording

Hard disk connected	Operations	Results
SATA interface hard disk	Press the stop button before it is the deadline time set	Stop recording right now and the programs are stored in the SATA interface hard disk
SATA interface hard disk and USB mobile hard disk	Do nothing until it is the deadline time set	The programs between the period of time set are stored in the USB mobile hard disk

Thirdly, when a TV program is living, press the pause button or the back button. In this condition, it is time-shifting recording. There are two diffenrent ways for time-shifting recording. Test each of them and the test methods and results are shown in Table 3.

Table 3. Test Methods and Results for Time-shifting Recording

Recording way	Operations	Results
The first way of time-shifting recording	Press the pause button and the play button	The time-shifting recording begins if the pause button is pressed and the time-shifting recording stops if the play button is pressed. The recorded programs are deleted automatically after playing
The second way of time-shifting recording	Press the back button and fast forward button	The program can play back for a period of time if the back button is pressed and the program can play forward until the time-shifting program keeps pace with the living program if the fast forward button is pressed

At last, when a TV program is going to be played in the future, it is scheduled recording when consumers want to record the program. The operations and results are shown in Table 4.

Table 4. Test Methods and Results for Scheduled Recording

Operations	Results
Press the record button at a program which is living in the EPG window	Recording begins right now and ends at the end of the program
Press the record button at a program which is going to be played in the future in the EPG window	Recording begins at the beginning of the program and ends at the end of the program
Press the record button at a program which has been scheduled recorded in the EPG window	The recording task can be cancelled
Delete a recorded program in the Recorded List Interface	The program can be deleted
Rename a recorded program in the Recorded List Interface	The program can be renamed

Table 1 to Table 4 show that by the design scheme presented in this paper, the current playing TV programs can be recorded in three alternative ways and the program in the future can be recorded based on EPG information. When there is USB hard disk connected, the programs are recorded in it. Diffenrent consumers can record TV programs in their own way with this kind of STB. What's more, the TS files stored in the hard disk can be played on PC fluently.

5. Conclusion

The design scheme of recording TV programs in Android STB presented in this paper can implement four recording ways including continuous recording, timer recording, time-shifting recording and scheduled recording by calling JAVA language and C language flexibly. The implementation of PVR function enriches the technology of STB and brings new experiences to the consumers. With the deeper development of storage technology and digital technology in the future, PVR function will be more popular.

Acknowledgements

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