DIGITAL TRANSPORT STREAM PROCESSING

The present invention relates to interfacing of application programs to physical devices, particularly but not exclusively in the context of receiver/decoders for digital television systems.

The advent of digital transmission systems has opened up the possibility of using such systems for other purposes. One of these is to provide interactivity with the end user. As used herein, the term "digital transmission system" includes any transmission system for transmitting or broadcasting for example primarily audiovisual or multimedia digital data. Whilst the present invention is particularly applicable to a broadcast digital television system, the invention may also be applicable to a fixed telecommunications network for multimedia internet applications, to a closed circuit television, and so on. As used herein, the term "digital television system" includes for example any satellite, terrestrial, cable and other system.

The present invention finds specific application in a broadcast digital television system in which received signals are passed through a receiver to a receiver/decoder and thence to a television set. The term "receiver/decoder" used herein may connote a receiver for receiving either encoded or non-encoded signals, for example, television and/or radio signals, which may be broadcast or transmitted by some other means. The term may also connote a decoder for decoding received signals. Embodiments of such receiver/decoders may include a decoder integral with the receiver for decoding the received signals, for example, in a "set-top box", such a decoder functioning in combination with a physically separate receiver, or such a decoder including additional functions, such as a web browser, a video recorder, or a television.

The receiver/decoder decodes a compressed MPEG-type signal into a television signal for the television set. It is controlled by a remote controller handset, through an interface in the receiver/decoder, also known as a set-top box or STB. The term MPEG refers to the data transmission standards developed by the International

Standards Organisation working group "Motion Pictures Expert Group" and in particular but not exclusively the MPEG-2 standard developed for digital television applications and set out in the documents ISO 13818-1, ISO 13818-2, ISO 13818-3 and ISO 13818-4. In the context of the present patent application, the term includes all variants, modifications or developments of MPEG formats applicable to the field of digital data transmission.

One way of providing the interactivity described above is to run an application on the receiver/decoder through which the television signal is received. It is desirable to enable a variety of applications to communicate with a variety of physical devices in a transparent manner. Our co-pending applications PCT/EP97/02115 and PCT/EP97/02116 describe systems in which one or more applications can be downloaded by a receiver/decoder and communicate with physical devices in the receiver/decoder such as parallel and serial interfaces and smartcard readers by means of a device driver for each device and an overall device manager. As used herein, the term "smartcard" includes, but not exclusively so, any chip-based card device, or object of similar function and performance, possessing, for example, microprocessor and/or memory storage. Included in this term are devices having alternative physical forms to a card, for example key-shaped devices such as are often used in TV decoder systems.

Pursuant to the present invention, it has been proposed to provide the capability for a set-top box to provide a digital output stream from a received data stream, for example to enable digital storage of received programmes and data, for example using a digital video recorder, or to facilitate data communication with other devices, for example over a TCP/IP network.

A problem with providing such a digital output stream is that the received data stream generally contains MPEG data at a very high bit rate, and it would be impractical to store the complete received data stream. In addition, the received data stream may contain much information which is not of interest to the viewer. A receiver/decoder contains apparatus for demultiplexing and if necessary descrambling a portion of the

received data stream to provide a single channel for analogue display which can be recorded via a conventional analogue video recorder. However, the conventional apparatus lacks flexibility and cannot provide a data stream suited for digital storage.

Aspects of the invention propose novel techniques for providing a digital data stream suited to storage on a digital video recorder. Although the invention offers most advantages in processing an MPEG data stream containing a number of television programmes and other data received by a receiver/decoder (for cable or more preferably satellite) to produce an output stream suitable for transmission to a digital video recorder, it has been appreciated by the inventors that the invention can be applied to processing of other data streams, and can provide real–time editing of digital video.

In a first aspect, the invention provides apparatus for processing a digital data stream comprising:

means for receiving a digital data stream comprising a plurality of packets of information;

means for storing a list of specified packets to be selected from the received digital data stream, said list including priority information indicating a priority assigned to each packet;

means for extracting packets specified in said list from the received data stream; and

processing means for processing the extracted packets to produce an output data stream, and for reducing selectively the number of extracted packets in the output data stream by including extracted packets with higher priority in the output data stream in preference to extracted packets with lower priority.

This aspect of the present invention extends to a method of processing a digital data stream comprising:

receiving a digital data stream comprising a plurality of packets of information;

storing a list of specified packets to be selected from the received digital data stream, said list including priority information indicating a priority assigned to each

packet;

extracting packets specified in said list from the received data stream;

processing the extracted packets to produce an output data stream; and

reducing selectively the number of extracted packets in the output data stream by including extracted packets with higher priority in the output data stream in preference to extracted packets with lower priority.

Thus, with this aspect of the invention, specified packets can be extracted directly from the received data stream (which may also be termed the original transport stream) and selected portions, for example corresponding to one or more programmes of interest, extracted and compiled into the output data stream (which may also be termed a partial transport stream).

It will be appreciated that the apparatus offers considerable flexibility as it may be employed simply to copy an original transport stream containing data for several channels unchanged, or to select an individual packet of data.

As the list contains priority information indicating priority assigned to each packet, less important information, for example associated with a programme of lesser interest can be discarded, leading to a deterioration in quality of that programme, whilst another programme is more reliably recorded.

In one embodiment, the processing means is adapted to reduce selectively the number of extracted packets in the output data stream in the event of the number of extracted packets to be included becoming too great for the data handling capacity of the output stream. Packets may be excluded for a number of reasons, for example, packets may be excluded in the event that the number of packets is too great for the data handling capacity of a storage medium to which the packets are being output, or the data handling capacity of a device or output port receiving the output data stream.

The processing means may be adapted to selectively reinsert excluded extracted packets into the output data stream, for example, if the data handling capacity of the

output data stream increases.

A packet typically comprises a plurality of sections. The means for processing extracted sections can preferably perform one of a number of operations to encapsulate or package received MPEG sections in a suitable format. In a simple embodiment, processing the extracted sections may simply comprise stripping MPEG header information or other data from the sections, for example by deleting portions of the segments, preferably at the beginning or the end, to extract the "raw" data for onward transmission. In such a case, addition of communication protocol specific headers and the like must be performed at the sending end, by sending, for example, ready–prepared TCP/IP packets.

Preferably, the means for processing the extracted sections includes means for adding at least one of a header and a footer, and preferably both, to a received section to provide a data stream conforming to a communication protocol other than the communication protocol of the received data stream. The section processing means may include means for adding a frame check sequence to the data. Inclusion of such features may reduce the amount of processing required at the transmitter, as well as reducing the amount of data that must be transmitted. In addition, the communication protocol can be changed at the receiver/decoder.

In each case, the received digital data stream is preferably an MPEG data stream (by which is meant any variant, modification or development of the basic MPEG format, preferably an MPEG–2 data stream) comprising a series of packets having respective packet identifiers (also termed PIDs).

Particularly (but not exclusively), the list preferably comprises a list of packet identifiers to be selected from the received data stream.

Particularly (but not exclusively), if the list comprises a list of sections, each section may be identified according to a numeric value in a specified field in the section. The section is preferably specified by defining a field of a first predetermined number of

bits at an offset of a second predetermined number of bits from an identified point, preferably the start, in the section.

The apparatus may include means for logging the identifiers of sections received. The logging means may comprise means for defining a bitmap, each bit in the bitmap corresponding to a section received or expected to be received, and means for altering the state of the bit corresponding to a received section to signify reception of that section.

The apparatus preferably includes means for storing at least one further list of packet identifiers and applying one or more specified processing operations, for example descrambling, to packets specified in the or each further list prior to inclusion in the output data stream. This allows, for example, a scrambled programme to be descrambled and stored in descrambled form.

The apparatus preferably also includes means for inserting further data, for example packets, into the output data stream. The apparatus is preferably arranged to receive the further data from an application. This enables other information, for example information identifying the programmes included in the output data stream, to be stored, or enables other data generated by an application receiving the original transport stream to be stored.

The apparatus is most preferably implemented as a device in a receiver/decoder, for example for a digital satellite system as described in our co-pending applications PCT/EP97/02106 – 02117. In such an implementation, the device can operate under the control of an application, via a device manager, providing a convenient and flexible arrangement for controlling the composition of the output data stream. The device is preferably arranged to communicate with a digital video recorder using a high-speed digital interface, such as the IEEE 1394 interface, using a suitable device driver, such as the one described in our European patent application no. 97401793.1, but can be used with any suitable digital interface.

The apparatus may be arranged to provide a virtual TCP/IP connection to a computer, by receiving broadcast MPEG packets and encapsulating the packets to provide a TCP/IP data stream to the computer. In such a case, communication may be via a serial or parallel port, preferably an enhanced or bi-directional parallel port.

In a third aspect, the invention provides a device for operating under the control of an application to process a received digital data stream to produce an output stream therefrom, the device comprising:

means for receiving a digital data stream comprising a plurality of packets of information;

means for receiving from an application information for compiling a list of specified packets to be selected from the received digital data stream, said list including priority information indicating a priority assigned to each packet;

means for extracting packets specified in said list from the received data stream; and

processing means for processing the extracted packets to produce an output data stream, and for reducing selectively the number of extracted packets in the output data stream by including extracted packets with higher priority in the output data stream in preference to extracted packets with lower priority.

The device preferably operates in one of two modes, an idle mode in which no output stream is being produced and a running mode in which data is passing through the device. Although production of the output stream could be stopped simply by specifying no packets for inclusion, provision of an idle mode may allow a more efficient use of system resources. The device preferably also includes means for receiving commands from an application for starting and stopping output stream generation (for switching between modes).

Preferably, in said idle mode, the device is arranged to receive information for compiling said list in the form of an initial list of all packet identifiers to be copied to the output stream. This allows the initial list to be set efficiently. Thereafter, in running mode, the device is preferably arranged to receive a list of packet identifiers

to be added to or deleted from the current list. In this way, to update the list, it is not necessary to handle increasingly long lists and to keep track of all previous packet identifiers; this is particularly advantageous as running mode processing may be more time–critical than idle mode processing.

In a similar manner to the initial storing of lists of packet identifiers to be copied in idle mode, and the adding and deleting of entries in running mode, the device is preferably arranged to maintain a further list of packet identifiers to be descrambled, preferably by descrambling means of the receiver/decoder used to descramble programmes for display. In addition, the device may be arranged to receive information for use in descrambling from an application, preferably as part of a procedure for setting the initial list of packet identifiers to be descrambled.

The device preferably further includes means for storing a list of MPEG sections to be inserted by an application. Preferably, the device is arranged to receive parameters from an application for controlling repetition of the section in the output stream and the device is arranged to repeat the section based on the parameters. This allows production of complicated data streams with relatively little input from an application. For example, an application can send a simple command to insert a section identifying the programmes included in the output stream, and this can automatically be inserted at regular intervals into the output stream by the device.

The device preferably includes means for returning to an application information concerning the currently selected packet identifiers included in the output stream.

Functions of the device may be implemented in hardware, for example in a dedicated integrated circuit; this may provide enhanced speed of operation. Preferably, however, at least some of the device driver is implemented in software, preferably run by processing means which runs the application; this allows greater flexibility, requires less components, and allows the device driver to be updated more readily.

In a fourth aspect, the invention provides a data processing system comprising:

run–time engine means for running at least one application;

means for receiving a broadcast digital data stream;

a device, preferably as defined above, for processing the received digital data stream under the control of the or each application; and

means for supplying the data stream output by the device to an output interface.

Preferred features of the first and second aspects may be applied to the third and fourth aspects.

The data processing system is preferably implemented in a receiver/decoder (for example a set–top box) which includes means for receiving the broadcast digital data stream from a satellite receiver or cable, the interface being arranged for connection to a digital video recorder (which term is meant to include any suitably configured digital storage device capable of storing data for a television program, regardless of the physical medium in which the data is actually stored) or digital display device or computer for display or storage of at least a portion of the received data. The device is preferably arranged to cooperate with a device driver for outputting the output data stream to a high–speed (100Kbit/s upwards, preferably at least 1Mbit/s, 10Mbit/s or higher) digital interface.

The interface preferably conforms to the IEEE 1394 standard or a variant or modification thereof.

Where the system is implemented in a receiver/decoder arranged for connection to a digital video recorder, the receiver/decoder preferably includes an application arranged to control the device to select portions (packets or sections) of the received data stream comprising two or more television programmes for outputting to the digital video recorder and preferably including means for adding information to the output data stream identifying the programmes. In this way, a user may select two or more programmes for recording, for viewing at a later time; this would conventionally require two or more analogue video recorders and two or more receiver/decoders. The

application may include means for controlling the video recorder, for example as described in our European patent application no. 97401793.1, the disclosure of which is herein incorporated by reference.

This feature may be provided independently, in a fifth aspect, in which the invention provides an application for a receiver/decoder having means for receiving a broadcast digital data stream, an interface for connection to a digital storage medium, and a device for processing the received digital data stream to produce an output data stream for supply to the digital storage medium, the application comprising means for controlling said device to select portions of the received digital data stream corresponding to two or more broadcast programmes and for outputting the portions to the digital storage medium for storage in a form enabling the programmes to be played back subsequently, the application being adapted to reduce selectively the number of portions in the output data stream by including portions of the received digital data stream with higher priority in the output to the digital storage medium in preference to portions with lower priority.

The application is preferably run in an interpreted language and the device driver is preferably compiled.

Embodiments incorporating preferred features of the present invention will now be described, purely by way of example, with reference to the accompanying drawings, in which:–

Figure 1 is a schematic diagram of interfaces of the receiver/decoder;

Figure 2 is a functional block diagram of the receiver/decoder;

Figure 3 shows certain components of the virtual machine and run time engine in more detail;

Figure 4 shows a schematic overview of the functions provided by a first device

embodying the invention;

Figure 5 is a schematic diagram for explaining the insertion of repeated sections into the output data stream;

Figure 6 is a schematic overview of the functions provided by a second device embodying the invention;

Figure 7 is a schematic diagram of a datagram produced by the embodiment of Fig. 6;

Figure 8 illustrates a list of PIDs which should be copied directly from an input data stream to an output data stream; and

Figure 9 illustrates a list of PIDs which should be descrambled before being copied from the input data stream to the output data stream.

RECEIVER/DECODER BASICS

To assist in understanding of the device, the preferred platform on which the device operates, our digital satellite receiver/decoder will first be described briefly.

Referring to Fig. 1, a receiver/decoder 2020 or set–top box for use in a digital interactive television system in which the device driver of the embodiment is intended to be installed is schematically depicted. Details of a suitable digital interactive television system may be found in our co–pending applications PCT/EP97/02106 – 02117 to which reference should be made, and the disclosures of which are herein incorporated by reference. For ease of reference, parts described in more detail in the aforementioned specifications are generally designated by the reference numerals used in those specifications.

As described in more detail in the aforementioned specifications, referring to Figure

1, the receiver/decoder 2020 includes several interfaces; specifically, a tuner 4028 for the MPEG signal flow, a serial interface 4030, a parallel interface 4032, and two card readers 4036, one for a smartcard forming part of the system and one for bank cards (used for making payments, home banking, etc) or another smartcard. The receiver/decoder also includes an interface 4034 to a modemmed back channel 4002 to the television signal producer, so that the user can indicate preferences, etc back to the television signal (programme) producer. The receiver also comprises a Run-Time-Engine 4008, a Device Manager 4068 and a plurality of Devices 4062 for running one or more applications 4056.

For the purposes of this specification, an application is a piece of computer code for controlling high level functions of preferably the receiver/decoder 2020. For example, when the end user positions the focus of a remote controller on a button object seen on the screen of the television set 2022 and presses a validation key, the instruction sequence associated with the button is run.

An interactive application proposes menus and executes commands at the request of the end user and provides data related to the purpose of the application. Applications may be either resident applications, that is, stored in the ROM (or FLASH or other non-volatile memory) of the receiver/decoder 2020, or broadcast and downloaded into the RAM or FLASH memory of the receiver/decoder 2020.

Some examples of applications, described in more detail in the aforementioned applications are:-

- An Initiating Application which is an adaptable collection of modules enabling the receiver/decoder 2020 to be immediately operative in the MPEG-2 environment.
- A Startup Application which allows any application, either downloaded or resident, to run on the receiver/decoder 2020.
- A Program Guide which is an interactive application which gives full information about programming.
- A Pay Per View application which is an interactive service available on each

PPV channel of the digital TV bouquet to enable the end user to buy the current event.

- A PC Download application enabling an end user to download computer software using the PC download application.
- A Magazine Browser application comprising a cyclic video broadcast of images with end user navigation via on-screen buttons.
- A Teleshopping application enabling offers of goods for sale to be transmitted to the receiver/decoder 2020 and displayed on the television 2022 and enabling the user to select a particular item to buy.

Applications are stored in memory locations in the receiver/decoder 2020 and represented as resource files. The resource files comprise graphic object description unit files, variables block unit files, instruction sequence files, application files and data files, as described in more detail in the above mentioned specifications.

In the MPEG data stream, each module comprises a group of MPEG tables. Each MPEG table may be formatted as a number of sections. In the MPEG data stream, each section has a "size" of up to 4 kbytes. For data transfer via the serial and parallel port, for example, modules similarly are split into tables and sections, the size of the section varying with the transport medium.

Modules are transported in the MPEG data stream in the form of data packets of typically 188 bytes within respective types of data stream, for example, video data streams, audio data streams and teletext data streams. Each packet is preceded by a Packet Identifier (PID) of 13 bits, one PID for every packet transported in the MPEG data stream. A programme map table (PMT table) contains a list of the different data streams and defines the contents of each data stream according to the respective PID. A PID may alert a device to the presence of applications in the data stream, the PID being identified using the PMT table.

The decoder contains memory divided into a RAM volume, a FLASH volume and a ROM volume, but this physical organization is distinct from the logical organization.

The memory may further be divided into memory volumes associated with the various interfaces. From one point of view, the memory can be regarded as part of the hardware; from another point of view, the memory can be regarded as supporting or containing the whole of the system shown apart from the hardware.

The system can be regarded as centred on a run time engine 4008 forming part of a virtual machine 4007. This is coupled to applications on one side (the "high level" side), and, on the other side (the "low level" side), via various intermediate logical units discussed below, to the receiver/decoder hardware 4061. The receiver/decoder hardware can be regarded as including the various ports or interfaces as discussed above (the interface 2030 for the handset 2026, the MPEG stream interface 4028, the serial interface 4030, the parallel interface 4032, the interfaces to the card readers 4036, and the interface 4034 to the modemmed back channel 4002).

With reference to Figure 2, various applications 4056 are coupled to the unit 4007; some of the more commonly used applications may be more or less permanently resident in the system, as indicated at 4057, while others will be downloaded into the system, eg from the MPEG data stream or from other ports as required.

The unit 4007 includes, in addition to the run time engine 4008, some resident library functions 4006 which include a toolbox 4058. The library contains miscellaneous functions in C language used by the engine 4008. These include data manipulation such as compression, expansion or comparison of data structures, line drawing, etc. The library 4006 also includes information about firmware 4060 in the receiver/decoder 2020, such as hardware and software version numbers and available RAM space, and a function used when downloading a new device 4062. Functions can be downloaded into the library, being stored in Flash or RAM memory.

The run time engine 4008 is coupled to a device manager 4068 which is coupled to a set of devices 4062 which are coupled to device drivers 4060 which are in turn coupled to the ports or interfaces. In broad terms, a device driver can be regarded as defining a logical interface, so that two different device drivers may be coupled to