(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 August 2010 (26.08.2010)

PCT

(10) International Publication Number
WO 2010/095984 A1

(51) International Patent Classification:
H04N 7/50 (2006.01) *H04N 7/173* (2006.01)

(21) International Application Number:
PCT/SE2009/050162

(22) International Filing Date:
17 February 2009 (17.02.2009)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)** [SE/SE]; S-164 83 Stockholm (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BRUHN, Stefan** [SE/SE]; Vassvägen 11 B, Sollentuna, 192 67 (SE). **SKILLERMARK, Per** [SE/SE]; Vitalisvägen 13, S-112 55 Stockholm (SE). **ALMGREN, Magnus** [SE/SE]; Viktoriavägen 1, S-191 43 Sollentuna (SE).

(74) Agent: **NORIN, Klas**; Ericsson AB, Patent Unit Service Layer and Multimedia, S-164 80 Stockholm (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR),

[Continued on next page]

(54) Title: SYSTEMS AND METHOD FOR ENABLING FAST CHANNEL SWITCHING

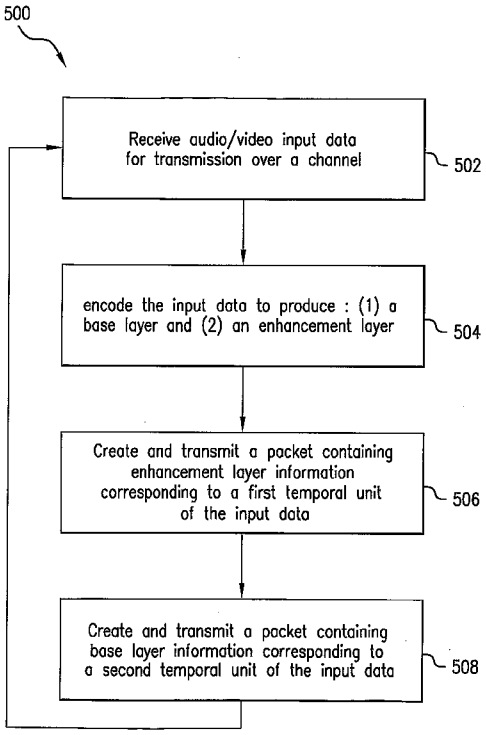

FIG.5

(57) Abstract: The invention provides a method for enabling fast channel switching. In some embodiments, this method includes: (1) using an encoder to encode input data to produce a base layer and one or more enhancement layers; (2) transmitting an enhancement layer packet comprising enhancement layer information corresponding to a first temporal unit of the input data; and (3) transmitting a base layer packet comprising base layer information corresponding to a second temporal unit of the input data and being decodable by a decoder to produce audio/video data having a first quality, characterized in that the enhancement layer information can be decoded in combination with the base layer information to produce audio/video data having a higher quality than the first quality, and the first temporal unit is larger than the second temporal unit.

WO 2010/095984 A1

OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

SYSTEMS AND METHOD FOR ENABLING FAST CHANNEL SWITCHING

TECHNICAL FIELD

[001] The present invention relates to the use of radio access networks to broadcast information (e.g., over a plurality of channels) to a group of potentially interested users. More specifically, an aspect of the present invention relates to systems and methods for enabling a user to switch channels quickly.

BACKGROUND

[002] It is possible to use radio access networks (RANs) (e.g., cellular networks) to broadcast information (e.g. audio and/or or video data - such as a TV program) to a group of potentially interested users. When broadcasting multiple channels of TV programs it is desirable, from the user's perspective, to be able to switch quickly between channels (i.e., it is desirable that channel switching time is low).

[003] Furthermore, because radio resources in a cellular network may be shared between broadcast traffic and other types of traffic (e.g. unicast data), it is important that the radio resources be used in an efficient and flexible manner depending on the current need. For example, there is no need to use radio resources to broadcast a TV channel that no one is watching. On the other hand, it is desirable that such a TV channel be quickly available to users whenever a user desires to tune into the TV channel.

[004] Accordingly, what is desired are systems and methods for enabling fast channel switching while efficiently utilizing radio resources.

SUMMARY

[005] In one aspect, the invention provides a method for enabling fast channel switching. In some embodiments, this method includes the following steps: (1) using an audio and/or video (audio/video) encoder to encode audio/video input data to produce an audio/video stream for transmission over a channel, the audio/video stream comprising a base layer of information and one or more enhancement layers of information; (2) creating and transmitting an enhancement layer packet comprising enhancement layer information, the enhancement layer information corresponding to a first temporal unit of the audio/video input data; and (3) creating and transmitting a base layer packet comprising base layer information, the base layer information corresponding to a second temporal unit of the audio/video input data and being decodable by a decoder without reference to any other layer of information to produce reconstructed audio/video data having a first quality, characterized in that the enhancement layer information can be decoded in combination with the base layer information to produce reconstructed audio/video data having a higher quality than the first quality, and the first temporal unit is larger than the second temporal unit.

[006] In some embodiments, the enhancement layer packet is transmitted using a first relative power level and the base layer packet is transmitted using a second relative power level, wherein second power level is greater than the first power level. Additionally, the enhancement layer packet may be transmitted using a first level of error protection efficiency and the base layer packet may be transmitted using a second level of error protection efficiency, wherein the second level of error protection

efficiency is less than the first level of error protection efficiency.

[007] In some embodiments, the enhancement layer information is encoded using a first level of source coding efficiency and the base layer information is encoded using a second level of source coding efficiency, wherein the second level of source coding efficiency is less than the first level of source coding efficiency.

[008] In some embodiments, the audio/video input data is arranged in blocks, each block representing a temporal unit of the audio/video input data, and the method may further comprise: creating and transmitting a plurality of base layer packets, each of the plurality of base layer packets consisting essentially of base layer information that corresponds to X blocks of the audio/video input data, where X is greater than or equal to one; and creating and transmitting a plurality of enhancement layer packets, each of the plurality of enhancement layer packets consisting essentially of enhancement layer information that corresponds to Y blocks of the audio/video input data, where Y is greater than X. In some embodiments, the step of transmitting the plurality of base layer packets comprises transmitting the plurality of base layer packets at a rate of Rb base layer packets per second, and the step of transmitting the plurality of enhancement layer packets comprises transmitting the plurality of enhancement layer packets at a rate of Re enhancement layer packets per second, wherein Rb > Re (e.g., Rb = YRe/X). In some embodiments, each base layer packet consists essentially of base layer information that corresponds to only a single block of the audio/video input data such that the base layer information consists of an intra-frame (I-frame), and

each the enhancement layer packet consists essentially of enhancement layer information that corresponds to multiple blocks of the audio/video input data such that the enhancement layer information comprises a plurality of forward predicted frames (P-frames) and/or bi-directional predicted frames (B-frames).

[009] In some embodiments, the step of transmitting the plurality of enhancement layer packets comprises transmitting an enhancement layer packet consisting essentially of enhancement layer information that corresponds to Y blocks of the audio/video input data, the step of transmitting the plurality of base layer packets comprises transmitting a base layer packet consisting essentially of base layer information that corresponds to not more than one of the Y blocks of the audio/video input data, and the step of transmitting the base layer packet comprises delaying the base layer packet for at least a certain amount of time and then transmitting the base layer packet. The step of delaying the base layer may consist of delaying the base layer packet such that the base layer packet is not transmitted substantially prior to the enhancement layer packet.

[0010] In some embodiments, the method also includes the step of adapting the transmission of enhancement layer packets based on information pertaining to user equipments tuned to the channel. For example, the information pertaining to user equipments tuned to the channel indicates that no user equipments are tuned into the channel, and the adapting step comprises: ceasing transmitting enhancement layer packets over the channel but continuing to transmit base layer packets over the channel until receiving information indicating that at least one

user equipment has tuned into the channel. In some embodiments, the method also includes the steps of: receiving information indicating that at least one user has tuned into the channel; and resuming the transmission of enhancement layer packets over the channel in response to receiving the information indicating that at least one user has tuned into the channel.

[0011] In some embodiments, the steps of transmitting the enhancement layer packet and base layer packet are performed such that a user equipment receiving the enhancement layer packet and the base layer packet will have the enhancement layer information available at the time that the user equipment is decoding the base layer information. Also, the size of the temporal unit the enhancement layer information corresponds to may be a function of whether the audio/video input data contains time-critical information.

[0012] In another aspect, the present invention provides an apparatus for enabling fast channel switching. In some embodiments, the apparatus includes: (1) an audio/video encoder configured to encode audio/video input data to produce an audio/video stream for transmission over a channel, the audio/video stream comprising a base layer of information and one or more enhancement layers of information; and (2) a transmission system configured to (a) create and transmit an enhancement layer packet comprising enhancement layer information, the enhancement layer information corresponding to a first temporal unit of the audio/video input data; and (b) create and transmit a base layer packet comprising base layer information, the base layer information corresponding to a second temporal unit of the audio/video input data and being decodable by a

decoder without reference to any other layer of information to produce reconstructed audio/video data having a first quality, characterized in that the enhancement layer information can be decoded in combination with the base layer information to produce reconstructed audio/video data having a higher quality than the first quality, and the first temporal unit is larger than the second temporal unit.

[0013] The above and other aspects and embodiments are described below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The accompanying drawings, which are incorporated herein and form part of the specification, illustrate various embodiments of the present invention and, together with the description, further serve to explain the principles of the invention and to enable a person skilled in the pertinent art to make and use the invention. In the drawings, like reference numbers indicate identical or functionally similar elements.

[0015] FIG. 1 illustrates a communication system in which embodiments of the invention may be implemented.

[0016] FIG. 2 is a functional block diagram of an encoding and transmission system, according to some embodiments of the invention

[0017] FIG. 3 illustrates a transmission scheme according to an embodiment of the invention.

[0018] FIG. 4 illustrates a transmission scheme according to another embodiment of the invention.

[0019] FIG. 5 is a flow chart illustrating a process according to an embodiment of the invention.

[0020] FIG. 6 is a flow chart illustrating a process according to another embodiment of the invention.

[0021] FIG. 7 is a functional block diagram of an apparatus according to an embodiment of the invention.

[0022] FIG. 8 is a functional block diagram of a transmission system according to an embodiment of the invention.

DETAILED DESCRIPTION

[0023] Referring now to FIG. 1, FIG. 1 illustrates an exemplary communication system 100 in which aspects of the present invention may be used. The exemplary communication system 100, as shown in FIG. 1, is a cellular communication system 100 that includes a core network 106 in communication with a base station 104 or other network node. Base station 104, as shown in FIG. 1, may broadcast data to a set of one or more user devices 102 (a.k.a., user equipment (UE) 102). More specifically, base station 104 may broadcast different audio and/or video ("audio/video") data (e.g., TV programs or audio/video from live events) over different channels.

[0024] As described in the background section above, it is anticipated that a user of a UE 102 would like to have the ability to change channels quickly. For example, when a user of a UE 102 configures UE 102 to tune into a specific channel (for example, selects a "channel up" button or "channel down" button), the user of UE 102 would like to be able to receive the program transmitted over the channel without a significant delay. Typically, there is some delay due to the amount of time it takes for a decoder within UE 102 to decode the audio/video data that is being transmitted over the channel. Accordingly, it is desirable to limit the amount of such decode delay as much as

possible, but also at the same time making efficient use of the communication system 100, as system 100 may be resource limited. In other words, there is a trade off between coding efficiency, on the on hand, which generally requires long delay, and the desire of the user to get the channel data with minimum delay, on the other hand. For example, transmitting relatively small sized packets may lead to faster channel switching, but this may come at the expense of transmission efficiency because a higher transmission power may be needed to transmit the packet in order achieve a fixed performance requirement.

[0025] Referring now to FIG. 2, FIG. 2 is a functional block diagram of an encoding and transmission system 200 ("system 200"), according to some embodiments of the invention, for accomplishing the above goal. As shown in FIG. 2, system 200 utilizes an audio/video encoder 204 to produce an audio/video stream for transmission over a channel. More specifically, audio/video encoder 204 receives audio/video input data 202 and encodes such data 202 such that at least two layers of information are produced: (1) a base layer of information 206 (a.k.a., core layer 206 or base layer 206) and (2) at least one enhancement layer of information 208 (a.k.a., enhancement layer 208).

[0026] In some embodiments, base layer information 206 includes sufficient information to enable a decoder to decode the base layer information and produce an output having a relatively low quality, while the enhancement layer information 208 includes information that when decoded together with base layer information 206 produces an output with a relatively higher quality. In some

embodiments, the base layer can be decoded without any enhancement layer information, but not vice-versa.

[0027] An example scalable video codec that produces two or more layers is the MPEG-4 SVC codec. Accordingly, audio/video encoder 204 can be implemented using an MPEG-4 SVC codec. Additionally, information from non-scalable video codecs (e.g., H.264/AVC (and many others)) can be arranged in layers. Hence, it is contemplated that audio/video encoder 204 may be implemented using any of these non-scalable video codecs.

[0028] An MPEG encoder may encode the input video frames by arranging them in a plurality of group of pictures (GOPs) each containing I-frame, P-frames and B-frames. In embodiments where audio/video encoder 204 is implemented using an MPEG encoder, the total set of I-frames can be considered as the base layer information 206, and the P-frames and B-frames can make up enhancement layers. Each I-frame may be regarded as a temporally sub-sampled version of the set of frames in a GOP of the audio/video input data 202, while the other frame types (P-frame and B-fame) increase temporal resolution and thereby the video quality.

[0029] As shown in FIG. 2, a transmission system 210 receives base layer information 206 and enhancement layer information 208 and creates and broadcasts base layer packets 211 and enhancement layer packets 213. Each base layer packet 211 includes base layer information 206 that corresponds to a temporal unit of the audio/video input data 202. Similarly, each enhancement layer packet 213 includes enhancement layer information 208 that corresponds to a temporal unit of the audio/video input data 202. However, it is preferred that the enhancement layer packet 213 includes enhancement layer information 208 that

corresponds to a temporal unit of audio/video input data 202 that is longer than the temporal unit of audio/video input data 202 to which the base layer information 206 in a base layer packet 211 corresponds.

[0030] For example, in some embodiments, each base layer packet 211 includes base layer information 206 that corresponds to X temporal units of the audio/video input data 202, wherein each enhancement layer packet 213 includes enhancement layer information 208 that corresponds to M*X temporal units of the audio/video input data 202. In some embodiments, X is equal to 1 and M is equal to 5.

[0031] Thus, in some embodiments, base layer information 106 is transmitted in relatively short temporal units (short packets). As an example, such a short packet may comprise just a single I-frame. This allows a decoder in the UE 102 to decode the base layer information (i.e., sequence of I-frames, in this example) after only a short tune-in time that is given by the temporal distance between the I-frames, which may be in the order of a couple of seconds and which may correspond to the duration in time of a GOP. The enhancement layer information (P-frames and/or B- frames) are encoded in larger temporal units, which consequently require longer tune-in time in order to be able to decode them.

[0032] In some embodiments, audio/video encoder 204 generates one base layer and two enhancement layers, a first enhancement layer and a second enhancement layer. For example, it is possible to arrange audio/video encoder 204 such that the first enhancement layer includes only the P-frames and the second enhancement layer includes only the B-frames. It is also possible to arrange transmission system 210 such that the P-frames are transmitted in larger

temporal units than the I-frames and the B-frames are transmitted in larger temporal units than the P-frames.

[0033] The P-frames (i.e., first enhancement layer) can then be decoded after some intermediate tune-in time providing some intermediate quality enhancement. The ultimate quality level is achieved only after an even longer tune-in time which is required to receive and decode the long block of B-frames. The packets comprising enhancement information may contain frames from several GOPs.

[0034] One benefit of the invention arises from the fact that the enhancement layer(s) can be transmitted more efficiently, due to the channel coding gain enabled by the long data units that can be encoded jointly. As the channel error protection can be much more efficient, less transmission power and hence transmission resources are required. For the user, a significantly accelerated channel switching time can be achieved at a given similar transmission resource consumption. It is expected that the lower quality after the initial tune-in to merely the base layer information will be much more acceptable than relatively long tune-in time.

[0035] In some embodiments, it is desirable that the base layer and the enhancement layer (or layers) are synchronized. For example, it is desirable that the base layer and the enhancement layer be synchronized in the embodiment where the enhancement layer packets 213 contain enhancement layer information 208 that corresponds to a temporal unit of audio/video input data 202 that is longer than the temporal unit of audio/video input data 202 to which the base layer information 206 in a base layer packet 211 corresponds. That is, in the embodiment where each

enhancement layer packet 213 contains enhancement layer information 208 that corresponds to base layer information 206 in multiple base layer packets 211.

[0036] In one embodiment, the desired synchronization is achieved by delaying the transmission of the first base layer packet 211. To illustrate this embodiment, we will assume that input data 202 consists of a sequence of data blocks 266 (in FIG. 2, three such data blocks are shown), where each data block represents a temporal unit of data. We will also assume that each base layer packet 211 contains a single I-frame that corresponds to a single block 266 of audio/video input data 202 and each enhancement layer packet 213 contains P-frames and/or B-frames that correspond to three blocks 266 of audio/video input data 202.

[0037] Because each enhancement layer packet 213 contains information pertaining to three blocks 266 of audio/video input data 202 and base layer packet 211 contains information pertaining to only a single block 266 of audio/video input data 202, the amount of time it takes to assemble the enhancement layer information 208 for an enhancement layer packet 213 may be greater than the amount of time it takes to assemble the base layer information 206 for a base layer packet 213. That is, the first base layer packet 211 may be ready to be transmitted well before the first enhancement layer packet 213 is ready to be transmitted.

[0038] Given this scenario, synchronization may be achieved by configuring the transmission system 210 to: (i) delay the transmission of the first base layer packet 211 until the time that the first enhancement layer packet 213 is ready to be transmitted, (ii) transmit the first base

layer packet 211 at about the same time as transmitting the first enhancement layer packet 213 (e.g., transmitting the base layer packet 211 just before or just after transmitting the enhancement layer packet 213), and (iii) ensure no base layer packet arrives before a corresponding enhancement layer packet (e.g., transmit no more than X base layer packets for each enhancement layer packet that is transmitted, where X is the ratio of the number of blocks of the audio/video input data 202 to which enhancement layer packets 213 pertain to the number of blocks of the audio/video input data 202 to which base layer packets 211 pertain -- in this scenario X equals three (3)). Thus, the first base layer packet 211 may be transmitted just after the first enhancement layer packet 213 is transmitted, even though the first base layer packet 211 could have been transmitted much sooner.

[0039] This above described feature is illustrated in FIG. 3. As shown in FIG. 3, transmission system 210: (1) transmits an enhancement layer packet 213a, which includes information corresponding to the first three blocks of audio/video input data 202 (i.e., blocks B1, B2 and B3); (2) then transmits three base layer packets 211a-211c, which include information corresponding to the first three blocks of audio/video input data 202, respectively; and (3) then transmits another enhancement layer packet 213b, which includes information corresponding to the next three blocks of audio/video input data 202. Although not shown, after transmitting enhancement layer packet 213b, transmission system 210 transmits three base layer packets that include information corresponding to the next three blocks of audio/video input data 202, respectively. This process continues. As illustrated in FIG. 3, three base layer

packets 211 are transmitted for each enhancement layer packet 213 that is transmitted.

[0040] It is also contemplated that the enhancement layer packets 213 and base layer packets 211 may be transmitted in parallel, as is shown in FIG. 4.

[0041] The advantage of delaying the transmission of base layer packets 211 is to ensure that a block 209 of enhancement layer information 208 that corresponds to a block 207 of base layer information 208 is available when block 207 of base layer information 208 is being decoded in the receiving unit.

[0042] Another advantage of a layered transmission in addition to enabling fast channel switching is that a layered transmission allows for balancing quality and resource consumption in a radio network. For example, one possible scenario is to configure the transmission system 210 such that the base layer information 206 can be received throughout an entire cell, while the enhancement layer(s) are available in only part of the cell. Similarly, popular channels can be transmitted with high quality over large parts of the cell (i.e., for popular channels base layer information 206 and enhancement layer information 208 are transmitted), while for less popular channels, the base layer information 206 has full cell coverage, but the enhancement layer information has limited cell coverage or no cell coverage. The coverage of the different layers may be regulated by, for example, adjusting the power assigned to the transmission of the different information layers.

[0043] In another embodiment, a feedback channel 280 is utilized. Feedback channel 280 is used to inform system 200 of the channels that the UEs 102 are currently receiving and possibly also an indication of the radio reception

quality. In this embodiment, the base layer information 206 for a channel is always transmitted, which allows for fast tune-in times and fast channel switching, but the enhancement layer information 208 for the channel is transmitted if, and only if, there is at least one UE 102 tuned to the channel. Accordingly, in this embodiment, when a UE 102 tunes in a certain channel, the UE 102 informs transmission system 210 via feedback channel 280. In response to receiving information indicating that UE 102 has tuned into the channel, transmission system 210 may then chose to enhance the quality of the channel by transmitting one or several of the enhancement layers. Hence, no resources are spent on transmitting the enhancement layers for channels that are not used. The coverage of the enhancements layers may also be adapted based on the radio quality experienced by the receiving user terminals.

[0044] Yet another advantage of some of the embodiments is that some embodiments (e.g., embodiments where enhancement layer packets 213 contain more information than base layer packets 211) allow for relatively long forward error correction (FEC) blocks for the enhancement layer(s) (e.g. 20 or more). The advantage of this is that the enhancement layer(s) can be error protected more efficiently, and consequently, could be transmitted with relatively lower power. Error protection efficiency is understood as the degree of robustness of the protection against transmission errors given a certain level of protection. At the same level of protection (e.g., ratio of added redundancy to source information) an error protection method is more efficient than another if it is able to correct/detect more transmission errors, when subjecting

the two methods with the same amount of transmission errors.

[0045] Alternatively, the coverage of the enhancement layer would be increased while maintaining the power budget for it. Also, some embodiments allow for longer source coding blocks of the enhancement layer, which in turn may lead to more efficient coding and less required bit rate for a given coding fidelity.

[0046] Referring now to FIG. 5, FIG. 5 is a flow chart illustrating a process 500 according to an embodiment of the invention. Process 500 may be performed by encoding and transmission system 200 (hereafter "system 200") and may begin in step 502. In step 502, system 200 receives audio/video input data 202 for transmission over a channel.

[0047] In step 504, system 200 uses audio/video encoder 204 to encode the audio/video input data 202 such that at least two layers of information are produced: (1) a base layer of information 206 and at least one enhancement layer of information 208.

[0048] In step 506, system 200 creates and transmits an enhancement layer packet 213 containing enhancement layer information 208 corresponding to a first temporal unit of the audio/video input data 202.

[0049] In step 508, system 200 creates and transmits a base layer packet 211 containing base layer information 206 corresponding to a second temporal unit of the audio/video input data 202, where the second temporal unit is less than the first temporal unit.

[0050] Additionally, the base layer information 206 included in a base layer packet 211 can be decoded by a decoder without reference to any enhancement layer information 208 or any other base layer information 206 to

produce reconstructed audio/video data having a first quality, and the enhancement layer information 208 included in an enhancement layer packet 213 can be decoded in combination with base layer information 206 to produce reconstructed audio/video data having a higher quality than the first quality.

[0051] As discussed, system 200 may ensure synchronization of the base and enhancement layers by, for example, delaying the transmission of base layer information 206 such that when UE 102 is decoding a block 207 of base layer information 206, UE 102 will have available to it enhancement layer information 208 that corresponds to the block of base layer information so that UE 102 can produce the higher quality audio/video output.

[0052] Referring now to FIG. 6, FIG. 6 is a flow chart illustrating a process 600 according to an embodiment of the invention. Process 600 may be performed by system 200 and is almost identical to process 500. The difference being is that system 200 (a) determines whether at least one UE 102 is tuned to the channel (step 602) and (b) transmits the enhancement layer(s) for the channel if, and only if, at least one UE 102 is tuned to the channel.

[0053] Referring now to FIG. 7, FIG. 7 is a functional block diagram of system 200 according to some embodiments of the invention. As shown, system 200 may comprise a data processing system 702 (e.g., one or more microprocessors), a data storage system 706 (e.g., one or more non-volatile storage devices) and computer software 708 stored on the storage system 706. Configuration parameters 710 may also be stored in storage system 706. System 200 also includes transmit/receive (Tx/Rx) circuitry 704 for transmitting data to and receiving data a network node (e.g., base

station 104), however, it is contemplated that system 200 (or components thereof) may be implemented as part of a base station or other network infrastructure elements like a media server.

[0054] Software 708 is configured such that when processor 702 executes software 708, system 200 performs steps described above (e.g., steps described above with reference to the flow chart shown in FIGs. 5 and 6). For example, software 708 may include: (1) computer instructions for encoding audio/video input data 202 to produce an audio/video stream for transmission over a channel (i.e., a base layer of information 206 and one or more enhancement layers of information 208); (2) computer instructions for creating and transmitting enhancement layer packets 213 comprising enhancement layer information 208; and computer instructions for creating and transmitting base layer packets 211 comprising base layer information 206.

[0055] Referring now to FIG. 8, FIG. 8 illustrates a functional block diagram of transmission system 210 according to some embodiments. As illustrated in FIG. 8, transmission system 210 may include a packetizer 802 for creating base layer packets 211 and enhancement layer packets 213; a delay buffer 803 for delaying base layer packets 211; a transmitter for transmitting delayed base layer packets 211 and non-delayed enhancement layer packets 213; and a feedback module 806 for receiving feedback information via feedback channel 280 and for adapting transmitter 804 based on the feedback information such that, if no UEs 102 are tuned to a particular channel, then feedback module 806 causes transmitter 804 cease the

sending of enhancement layer packets 213 for the particular channel.

[0056] A complication with one or more of the above described embodiments may arise from the fact that the delay which is introduced in the sending side may be unacceptable for live content. For instance, when broadcasting a sporting event (e.g., a football game) it may be unattractive if events like goals can already be know by other users who listen to fm radio. Accordingly, in some embodiments, the system is configured such that aspects of the present invention are applied based on the content of the channel. For time-critical live programs the extra delay used for coding the enhancement layer could be smaller or completely be skipped. This compromises the efficiency of the error protection scheme and would need to be compensated by raising the transmission power level. In contrast, for non-time-critical programs like movies, shows, etc. extra delay in the sending side would be irrelevant and aspects invention could be applied as described above.

[0057] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments.

[0058] Additionally, while the processes described above and illustrated in the drawings are shown as a sequence of steps, this was done solely for the sake of illustration. Accordingly, it is contemplated that some steps may be added, some steps may be omitted, the order of the steps may be re-arranged, and some steps may be performed in

parallel.

What is claimed is:

1. A method for enabling fast channel switching, comprising:

encoding audio and/or video (audio/video) input data (202) using an audio/video encoder (204) to produce an audio/video stream for transmission over a channel, the audio/video stream comprising a base layer of information (206) and one or more enhancement layers of information (208);

creating and transmitting an enhancement layer packet (213) comprising enhancement layer information (208), the enhancement layer information (208) corresponding to a first temporal unit of the audio/video input data; and

creating and transmitting a base layer packet (211) comprising base layer information (206), the base layer information (206) corresponding to a second temporal unit of the audio/video input data and being decodable by a decoder (102) without reference to any other layer of information to produce reconstructed audio/video data having a first quality, characterized in that

the enhancement layer information (208) can be decoded in combination with the base layer information to produce reconstructed audio/video data having a higher quality than the first quality, and

the first temporal unit is larger than the second temporal unit.

2. The method of claim 1, wherein the enhancement layer packet is transmitted using a first relative power level and the base layer packet is transmitted using a

second relative power level, wherein second power level is greater than the first power level.

3. The method of any one of claims 1-2, wherein the enhancement layer packet is transmitted using a first level of error protection efficiency and the base layer packet is transmitted using a second level of error protection efficiency, wherein the second level of error protection efficiency is less than the first level of error protection efficiency.

4. The method of any one of claims 1-3, wherein the audio/video input data is arranged in blocks (266), each block (266) representing a temporal unit of the audio/video input data.

5. The method of claim 4, further comprising:

creating and transmitting a plurality of base layer packets, each of the plurality of base layer packets consisting essentially of base layer information that corresponds to X blocks of the audio/video input data, where X is greater than or equal to one; and

creating and transmitting a plurality of enhancement layer packets, each of the plurality of enhancement layer packets consisting essentially of enhancement layer information that corresponds to Y blocks of the audio/video input data, where Y is greater than X.

6. The method of claim 5, wherein

the step of transmitting the plurality of base layer packets comprises transmitting the plurality of base layer packets at a rate of Rb base layer packets per second, and

the step of transmitting the plurality of enhancement layer packets comprises transmitting the plurality of enhancement layer packets at a rate of Re enhancement layer packets per second, wherein

Rb > Re.

7. The method of claim 6, wherein Rb = YRe/X.

8. The method of any one of claims 5-7, wherein each base layer packet consists essentially of base layer information that corresponds to only a single block of the audio/video input data such that the base layer information consists of an intra-frame (I-frame).

9. The method of any one of claims 5-8, wherein each enhancement layer packet consists essentially of enhancement layer information that corresponds to multiple blocks of the audio/video input data such that the enhancement layer information comprises a plurality of forward predicted frames (P-frames) and/or bi-directional predicted frames (B-frames).

10. The method of any one of claims 1-9, wherein a block of audio/video data corresponds to a group of pictures (GOP).

11. The method of any one of claims 5-10, wherein

the step of transmitting the plurality of enhancement layer packets comprises transmitting an enhancement layer packet consisting essentially of enhancement layer information that corresponds to Y blocks of the audio/video input data,

the step of transmitting the plurality of base layer packets comprises transmitting a base layer packet consisting essentially of base layer information that corresponds to not more than one of the Y blocks of the audio/video input data, and

the step of transmitting the base layer packet comprises delaying the base layer packet for at least a certain amount of time and then transmitting the base layer packet.

12. The method of claim 11, wherein the step of delaying the base layer comprises delaying the base layer packet such that the base layer packet is not transmitted substantially prior to the enhancement layer packet.

13. The method of any one of claims 5-12, wherein

the step of transmitting the plurality of base layer packets further comprises transmitting a second base layer packet consisting essentially of base layer information that corresponds to not more than one of the Y blocks of the audio/video input data, and

the step of transmitting the second base layer packet comprises delaying the second base layer packet for at least a certain amount of time and then transmitting the second base layer packet.

14. The method of any one of claim 1-13, further comprising:

adapting the transmission of enhancement layer packets based on information pertaining to user equipments tuned to the channel.

15. The method of claim 14, wherein the information pertaining to user equipments tuned to the channel indicates that no user equipments are tuned into the channel, and the adapting step comprises:

ceasing transmitting enhancement layer packets over the channel but continuing to transmit base layer packets over the channel until receiving information indicating that at least one user equipment has tuned into the channel.

16. The method of claim 15, further comprising:

receiving information indicating that at least one user equipment has tuned into the channel; and

resuming the transmission of enhancement layer packets over the channel in response to receiving the information indicating that at least one user equipment has tuned into the channel.

17. The method of any one of claims 1-16, wherein the steps of transmitting the enhancement layer packet and base layer packet are performed such that a user equipment (102) receiving the enhancement layer packet and the base layer packet will have the enhancement layer information available at the time that the user equipment is decoding the base layer information.

18. The method of claim 17, wherein the size of the temporal unit the enhancement layer information corresponds to is a function of whether the audio/video input data contains time-critical information.

19. The method of any one of claims 1-18, wherein the enhancement layer information is encoded using a first level of source coding efficiency and the base layer information is encoded using a second level of source coding efficiency, wherein the second level of source coding efficiency is less than the first level of source coding efficiency.

20. An apparatus for enabling fast channel switching, comprising:

an audio and/or video (audio/video) encoder (204) configured to encode audio/video input data (202) to produce an audio/video stream for transmission over a channel, the audio/video stream comprising a base layer of information (206) and one or more enhancement layers of information (208); and

a transmission system (210) configured to (1) create and transmit an enhancement layer packet (213) comprising enhancement layer information, the enhancement layer information corresponding to a first temporal unit of the audio/video input data; and (2) create and transmit a base layer packet (211) comprising base layer information, the base layer information corresponding to a second temporal unit of the audio/video input data and being decodable by a decoder (102) without reference to any other layer of information to produce reconstructed audio/video data having a first quality, characterized in that

the enhancement layer information can be decoded in combination with the base layer information to produce reconstructed audio/video data having a higher quality than the first quality, and

the first temporal unit is larger than the second temporal unit.

21. The apparatus of claim 20, wherein the transmission system is configured to transmit enhancement layer packets using a first relative power level and transmit base layer packets using a second relative power level, wherein second power level is greater than the first power level.

22. The apparatus of any one of claims 20-21, wherein transmission system is configured to transmit the enhancement layer packet using a first level of error protection efficiency and transmit the base layer packet using a second level of error protection efficiency, wherein the second level of error protection efficiency is less than the first level of error protection efficiency.

23. The apparatus of any one of claims 20-22, wherein the audio/video input data is arranged in blocks (266), each block (266) representing a temporal unit of the audio/video input data.

24. The apparatus of claim 23, wherein the transmission system comprises:

a packetizer (802) configured to create a plurality of base layer packets, each of the plurality of base layer packets consisting essentially of base layer information that corresponds to X blocks of the audio/video input data, where X is greater than or equal to one, and create a plurality of enhancement layer packets, each of the plurality of enhancement layer packets consisting

essentially of enhancement layer information that corresponds to Y blocks of the audio/video input data, where Y is greater than X; and

a transmitter (804) for transmitting the plurality of base layer packets and the plurality of enhancement layer packets.

25. The apparatus of claim 24, wherein the transmitter is configured to transmit the plurality of base layer packets at a rate of Rb base layer packets per second, and transmit the plurality of enhancement layer packets at a rate of Re enhancement layer packets per second, wherein Rb > Re.

26. The apparatus of claim 25, wherein Rb = YRe/X.

27. The apparatus of any one of claims 24-26, wherein each base layer packet consists essentially of base layer information that corresponds to only a single block of the audio/video input data such that the base layer information consists of an intra-frame (I-frame).

28. The apparatus of any one of claims 24-27, wherein each enhancement layer packet consists essentially of enhancement layer information that corresponds to multiple blocks of the audio/video input data such that the enhancement layer information comprises a plurality of forward predicted frames (P-frames) and/or bi-directional predicted frames (B-frames).

29. The apparatus of any one of claims 24-28, wherein the transmission system further comprises a delay buffer (803) for delaying the plurality of base layer packets.

30. The apparatus of claim 29, wherein the transmission system is configured to use the delay buffer (803) to delay the plurality of base layer packets such that an enhancement layer packet that contains enhancement layer information that can be used together with base layer information contained in a particular base layer packet to produce the reconstructed audio/video data having the higher quality is transmitted prior to, shortly after or simultaneously with the particular base layer packet.

31. The apparatus of any one of claim 20-30, wherein the transmission system is configured to transmit the enhancement layer packet only if there is at least one user equipment (102) that is tuned to the channel.

32. The apparatus of any one of claims 20-31, wherein the transmission system is configured to transmit the enhancement layer packet and base layer packet such that a user equipment (102) receiving the enhancement layer packet and the base layer packet will have the enhancement layer information available at the time that the user equipment is decoding the base layer information.

33. The apparatus of claim 32, wherein the size of the temporal unit the enhancement layer information corresponds to is a function of whether the audio/video input data contains time-critical information.

34. The apparatus of any one of claims 20-33, wherein a block of audio/video data corresponds to a GOP.

35. The apparatus of any one of claims 20-33, wherein the audio/video encoder is configured to encode the enhancement layer information using a first level of source coding efficiency and is configured to encode the base layer information using a second level of source coding efficiency, wherein the second level of source coding efficiency is less than the first level of source coding efficiency.

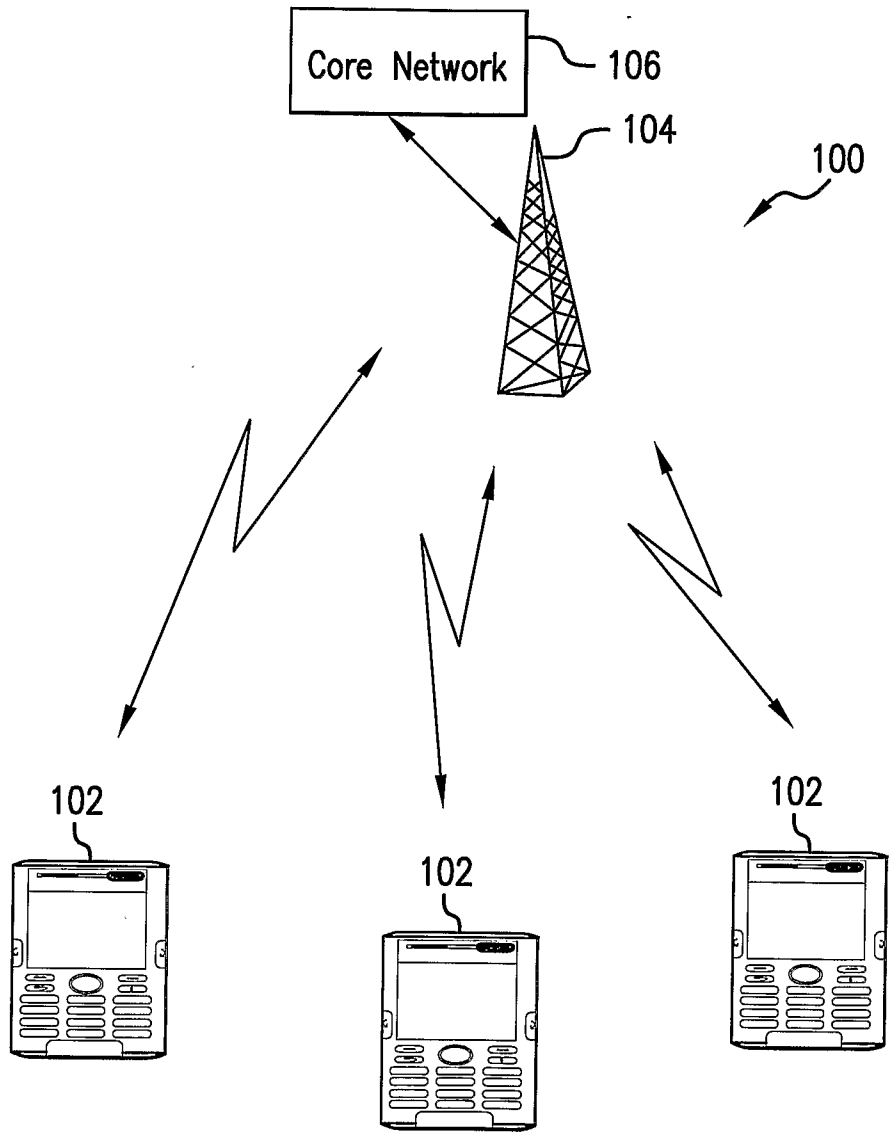

FIG. 1

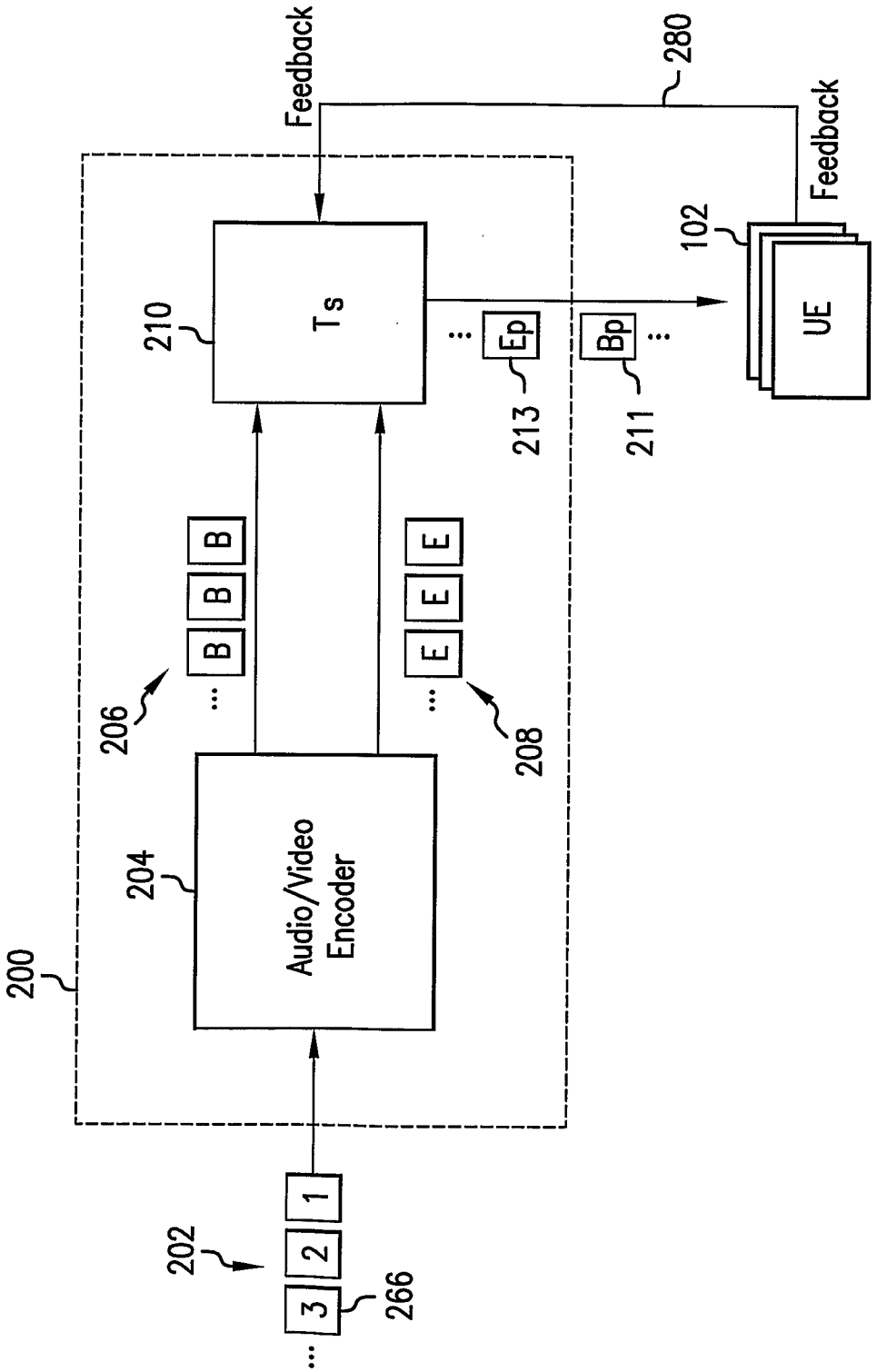
Feedback
280
Feedback
102
UE
210
Ts
Ep
213
Bp
211
B B B
206
E E E
208
Audio/Video Encoder
204
200
1 2 3
202
266

FIG.2

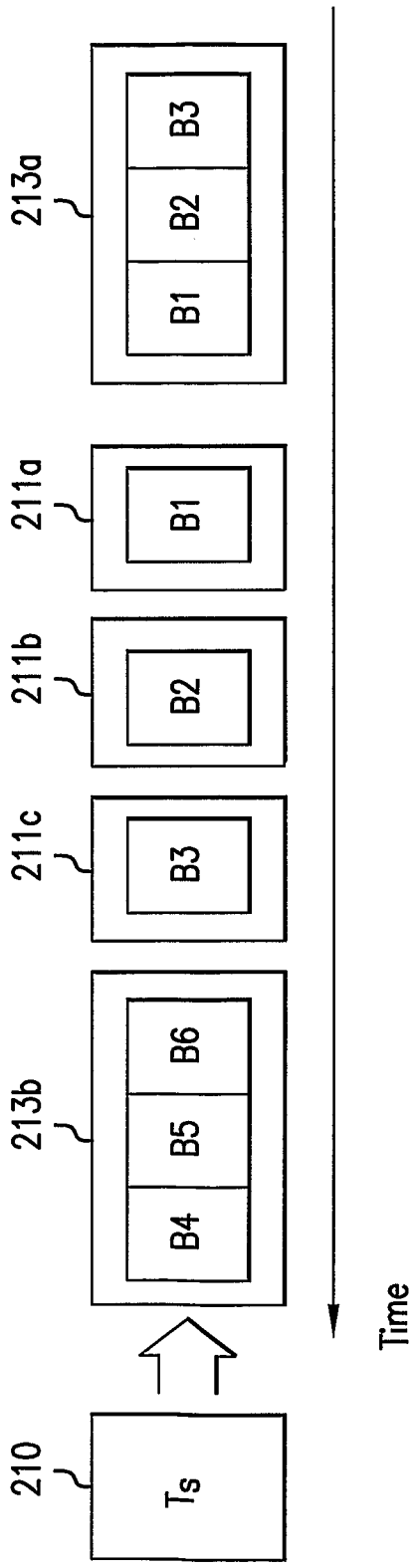

FIG.3

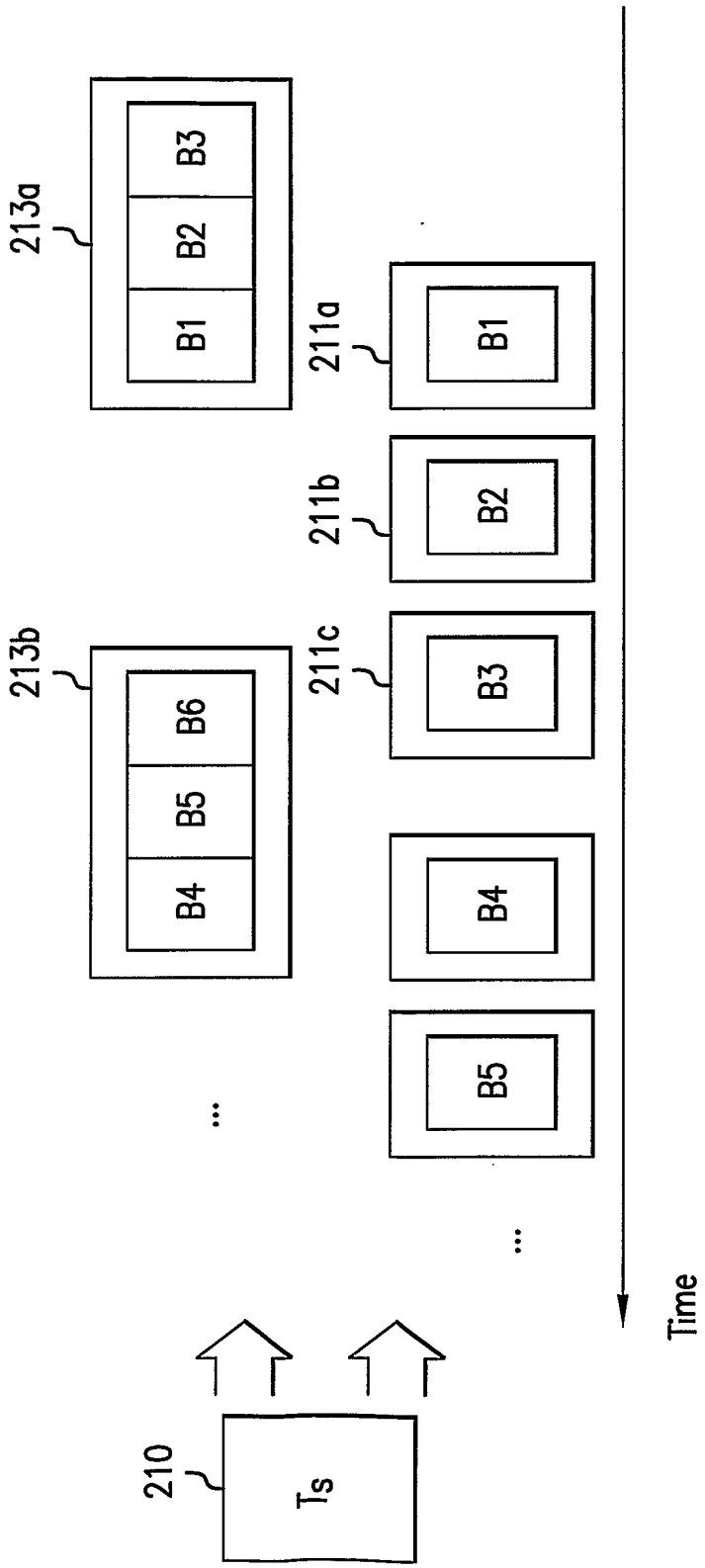
213a
B1
B2
B3
213b
B4
B5
B6
211a
B1
211b
B2
211c
B3
B4
B5
...
...
Time
210
Ts

FIG.4

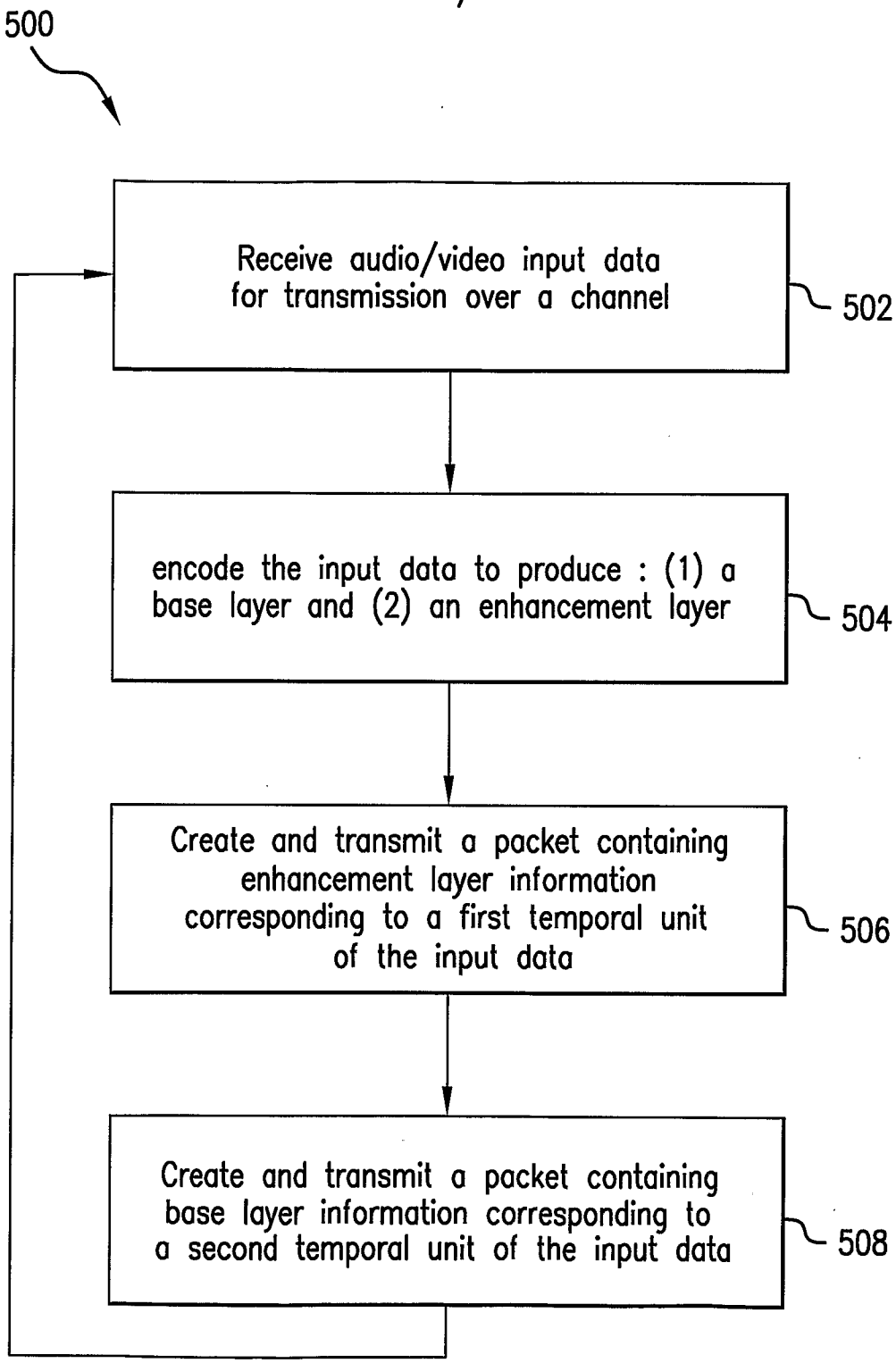
500
Receive audio/video input data for transmission over a channel
502
encode the input data to produce : (1) a base layer and (2) an enhancement layer
504
Create and transmit a packet containing enhancement layer information corresponding to a first temporal unit of the input data
506
Create and transmit a packet containing base layer information corresponding to a second temporal unit of the input data
508

FIG.5

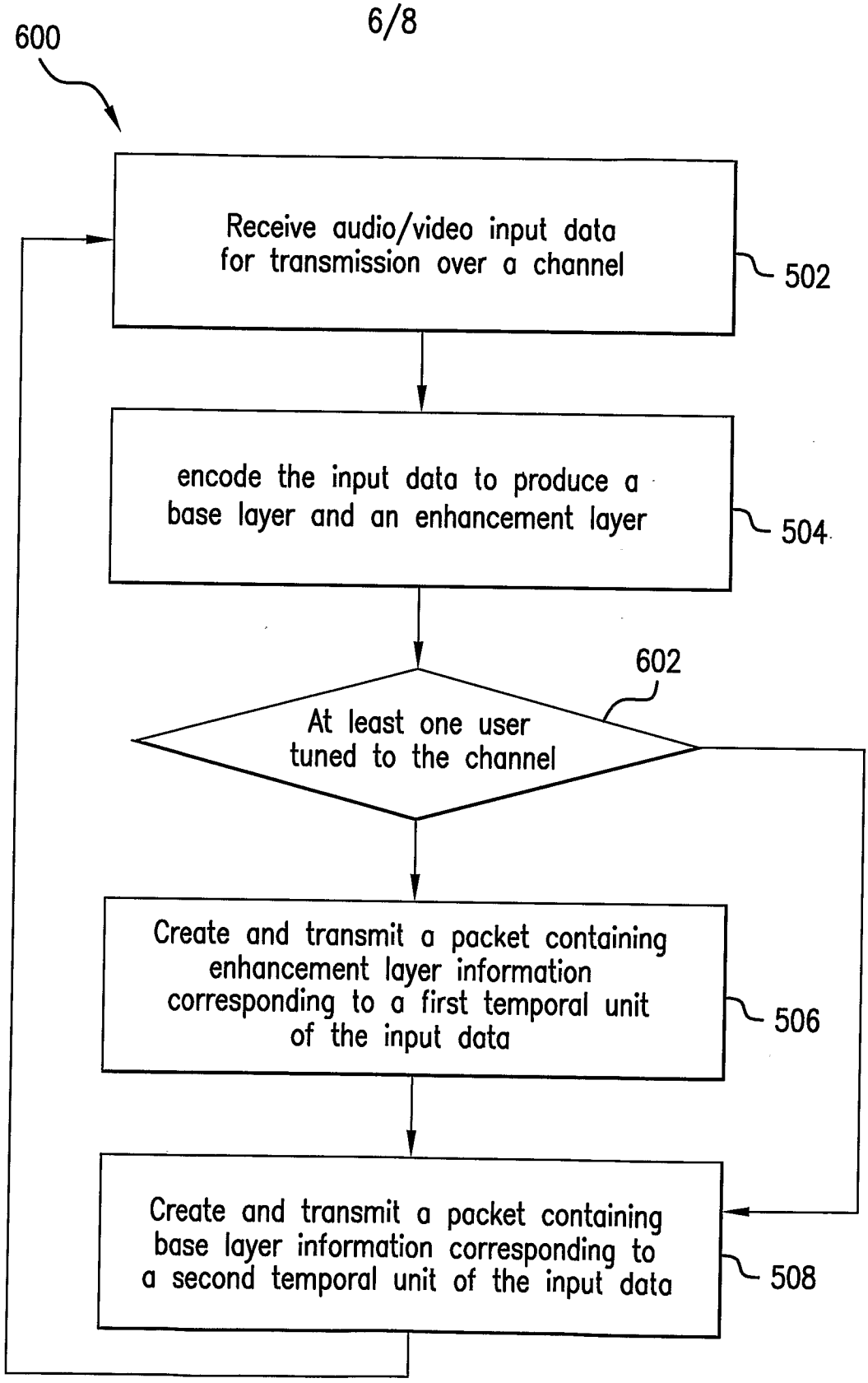
600
Receive audio/video input data for transmission over a channel
502
encode the input data to produce a base layer and an enhancement layer
504
602
At least one user tuned to the channel
Create and transmit a packet containing enhancement layer information corresponding to a first temporal unit of the input data
506
Create and transmit a packet containing base layer information corresponding to a second temporal unit of the input data
508

FIG.6

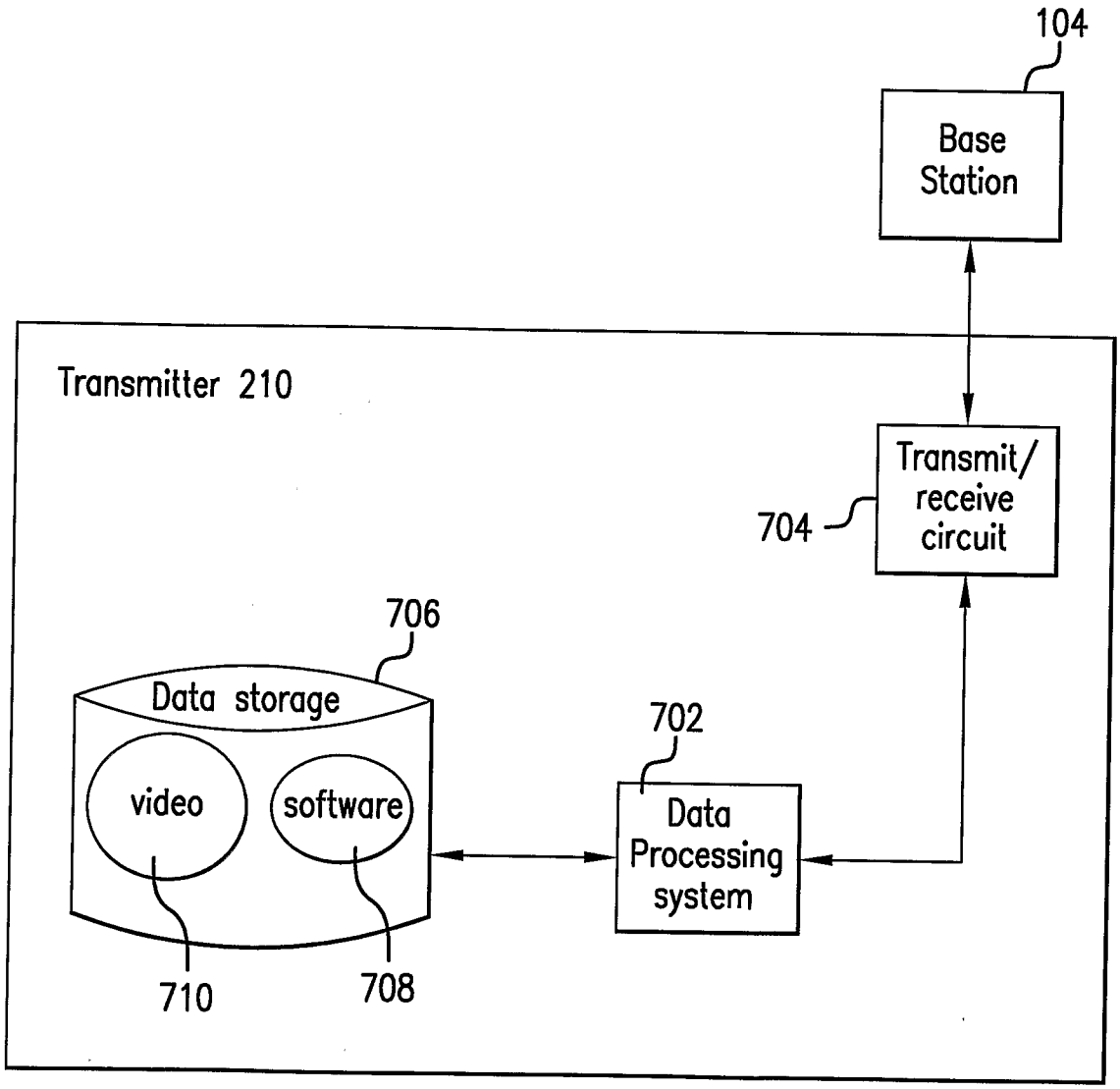
104
Base Station
Transmitter 210
Transmit/ receive circuit
704
706
Data storage
video
software
710
708
702
Data Processing system

FIG.7

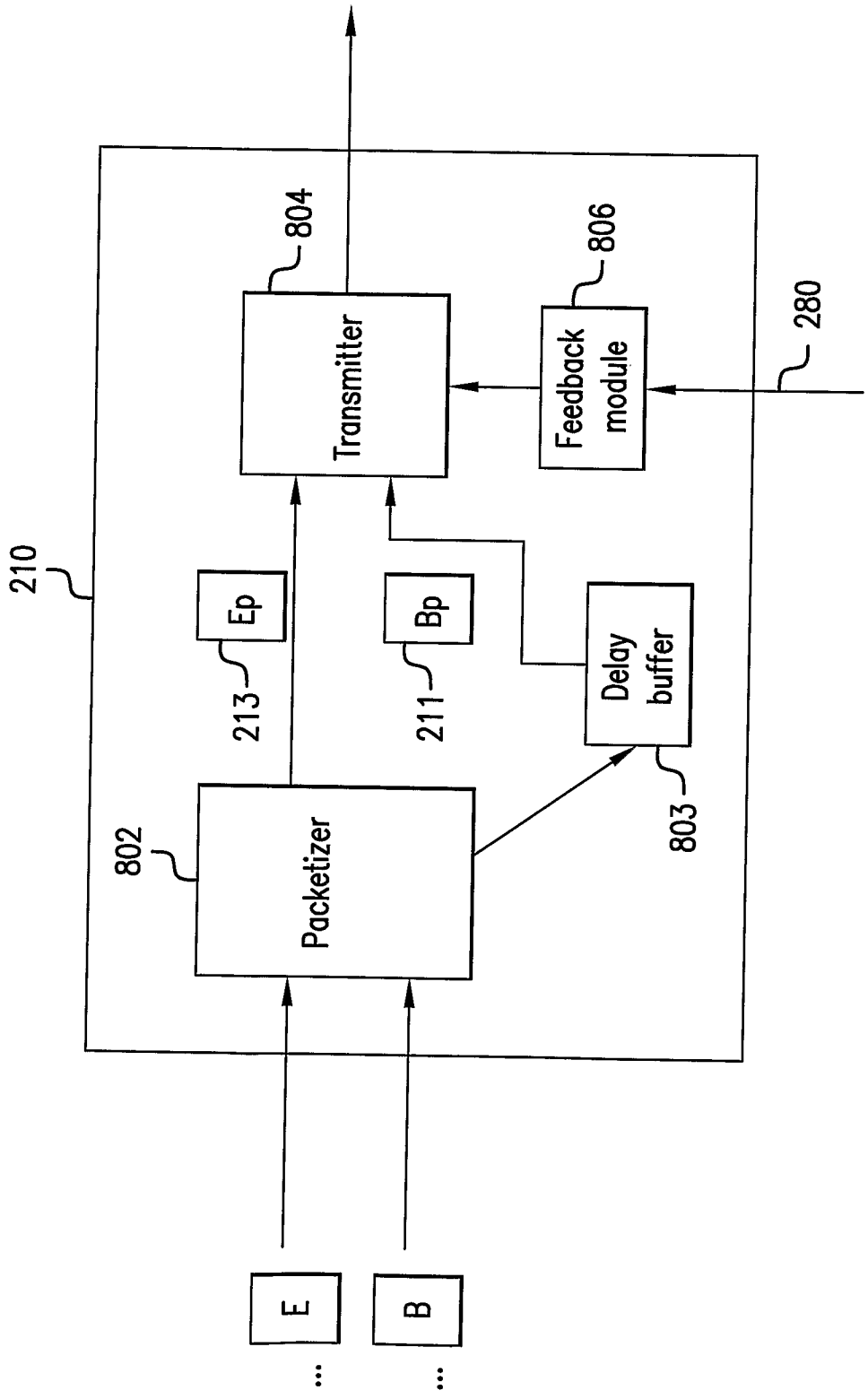
210
804
Transmitter
806
Feedback module
280
Ep
213
Bp
211
Delay buffer
802
Packetizer
803
E
B

FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/050162

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1715693 A2 (SAMSUNG ELECTRONICS CO., LTD.), 25 October 2006 (25.10.2006), abstract --	1-35
A	EP 1331822 A2 (MICROSOFT CORPORATION), 30 July 2003 (30.07.2003), abstract --	1-35
A	US 20070230564 A1 (CHEN ET AL), 4 October 2007 (04.10.2007), abstract --	1-35
A	US 20030138043 A1 (HANNUKSELA), 24 July 2003 (24.07.2003), abstract --	1-35

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 October 2009	23-10-2009
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Magnus Wallin Leijel / JA A Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/050162

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1458196 A2 (MICROSOFT CORPORATION), 15 Sept 2004 (15.09.2004), abstract ---	1-35
A	JP 2009010649 A (..), 15 January 2009 (15.01.2009), figure 9 --- --------	1-35

International patent classification (IPC)

H04N 7/50 (2006.01)
H04N 7/173 (2006.01)

Download your patent documents at www.prv.se
The cited patent documents can be downloaded:

- From "Cited documents" found under our online services at www.prv.se (English version)
- From "Anförda dokument" found under "e-tjänster" at www.prv.se (Swedish version)

Use the application number as username. The password is **KCBWSBICPA.**

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

EP	1715693	A2	25/10/2006	AU	2006201490	A,B	22/05/2008
				BR	PI0602466	A	26/12/2006
				CA	2543947	A	19/10/2006
				JP	2006304307	A	02/11/2006
				WO	2006112642	A	26/10/2006
EP	1331822	A2	30/07/2003	US	6996173	B	07/02/2006
				US	20030142744	A	31/07/2003
				US	20060067401	A	30/03/2006
				US	20060067402	A	30/03/2006
US	20070230564	A1	04/10/2007	NONE			
US	20030138043	A1	24/07/2003	NONE			
EP	1458196	A2	15/09/2004	CN	1531349	A	22/09/2004
				CN	100479524	C	15/04/2009
				JP	2004274773	A	30/09/2004
				KR	20040081315	A	21/09/2004
				US	7283589	B	16/10/2007
				US	20040179617	A	16/09/2004
JP	2009010649	A	15/01/2009	NONE			