Title of the Invention: Additional data streams for wireless systems

Abstract Title: Inserting additional data into wirelessly-transmitted data streams

A method of transmitting additional data into a wirelessly-transmitted data stream is disclosed wherein the data is additional to first data transmitted within a physical frame structure. The additional data is transmitted on one or more radio frequency channels within additional physical slots 2a,2b of the physical frame structure that are not used for the transmission of the first data. At least a first set of the plurality of data streams is mapped onto a first plurality of logical frames, and signaling information is generated for a given logical frame 27 for indicating one or more locations relating to one or more of the data streams for the given logical frame 27. The given logical frame is transmitted in at least parts of two or more of the additional physical slots 2a,2b, each of the two or more additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel. The described method and apparatus enable the distribution of the given logical frame content between the two or more additional slots, thereby avoiding the necessity to squeeze the additional data into the limited capacity of a single additional physical slot. The method is particularly applicable to a digital video broadcast (DVB) system, especially for mobile/handheld receivers, and in which the additional physical slots 2a,2b are parts of Future Extension Frames (FEFs). The method is also applicable to a unicast transmission system. A method of receiving the additional data, and apparatuses for the transmission and receipt thereof are also disclosed.

FIG. 2

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 2007.
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**FIG. 13**
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**FIG. 14**
FIG. 15

Start

Search for P1 symbol

Does the P1 belong to an NGH signal?

Yes

Is this an NGH only channel?

No

Set CURRENT_FREQUENCY = PNC_RF_FREQ

Yes

PNC_RF_FREQ = CURRENT_FREQUENCY?

No

Decode L1-Pre

Wait for L1-Config

Start

Decode L1-Config

Decode L1-Dyn

Select Logic NGH Channel

(Logic) NGH channel found
FIG. 16
Additional Data Streams for Wireless Systems

Field of the Invention

The present invention relates generally to wireless systems, and more specifically, but not exclusively, to a method and apparatus relating to transmission and reception of additional data streams in digital video broadcast systems.

Background of the Invention

A wireless system, such as a digital video broadcasting (DVB) system or a unicast transmission system, may transmit data in the form of a sequence of frames arranged in a frame structure. A digital video broadcasting system may, for example, operate according to a DVB-T2 (Terrestrial 2\textsuperscript{nd} Generation) standard, or for example, to the following families of standards: ATSC (Advanced Televisions Systems Committee), ISDB (Integrated Services Digital Broadcasting), or DMB (Digital multimedia Broadcasting). Each frame typically comprises a preamble section and a data section, the preamble section and the data section being time-multiplexed. The data section may carry data that is arranged in the form of a number of data streams that may be referred to as physical layer pipes (PLP). A physical layer pipe may carry, for example, a service such as a video channel provided to a user. Reception of data from the frames, and reception of the data streams, may be assisted by signalling, which may typically be carried in the preamble of the frame. The signalling may be referred to as physical layer signalling, or Layer 1 (L1) signalling. The signalling may indicate a modulation or coding scheme to be used for decoding data, and it may for example indicate sections of a data field to be decoded, or the location of a data stream within the data section.

Digital Video Broadcast frame structures may provide physical slots within the DVB physical frame structure, which are reserved in a standard for future use, for example Future Extension Frame (FEF) slots. For example, Future Extension Frame slots may be provided in addition to the parts of the
frame structure which are for transmission of signals intended for reception by conventional fixed Digital Video Broadcast receivers.

Digital video broadcasting systems may provide for the transmission of signals specifically intended for reception by hand held devices, as such as Next Generation Handheld receivers. Such signals may be, for example, of lower bandwidth and have more robust modulation and coding than signals intended for reception by fixed receivers.

There have been proposals to use the additional physical slots, such as the FEF slots, for the transmission of signals intended for reception by handheld receivers. Typically, a frame for the transmission of a signal intended for reception by a handheld receiver would be transmitted within the additional physical slot, including signalling information for the frame, which would be typically transmitted as a preamble in each FEF slot.

However, such a scheme may suffer from limited capacity, due to short physical slot duration and high signalling overhead. Furthermore, such a scheme may be limited in terms of achievable statistical multiplexing gain, due to the limited capacity that may be achieved.

It is an object of the invention to mitigate the problems with the prior art systems.

Summary of the Invention

In accordance with a first aspect of the present invention, there is provided a method of transmitting additional data comprising a plurality of data streams in a wireless system, said data being additional to first data transmitted within a physical frame structure, and said additional data being transmitted on one or more radio frequency channels within additional physical slots of the physical frame structure that are not used for the transmission of said first data, the method comprising:

mapping at least a first set of said plurality of data streams onto a first plurality of logical frames;
generating signalling information for a given logical frame of said first plurality of logical frames for indicating one or more locations relating to one or more of said plurality of data streams for said given logical frame; and

transmitting said given logical frame in at least parts of two or more of said additional physical slots, each of said two or more said additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel.

This has an advantage that the length of a logical frame may be independent of the length of an additional physical slot, so that the logical frame may be arranged to have a longer duration and thus a lower proportion of signalling information to data capacity than would be the case if the length of the logical frame were limited by the length of an additional Physical slot. Furthermore, the logical frames may be arranged to have a constant length, that is to say duration, even though the length of additional physical slots in a sequence of additional physical slots may vary between slots, so that the length of the logical frames may be set to an optimum value in terms of a trade off between signalling overhead and acquisition time for a receiver requesting access to the additional data.

In an embodiment of the invention, said signalling information is included in one and not in another of said two or more said additional physical slots.

This has an advantage of reducing the proportion of signalling information in respect to transmitted additional data. It is conventional to transmit a logical frame within a physical slot, and to transmit signalling information for indicating one or more locations relating to one or more data streams for a given logical frame within the given logical frame.

In an embodiment of the invention, each of said two or more said additional physical slots are within the transmission sequence of the same radio frequency channel. This has an advantage that a receiver need not retune to receive the given logical frame within the two or more additional physical slots.
In an embodiment of the invention, said two or more said additional physical slots do not overlap in time. This has an advantage that a single tuner may be used to receive the given logical frame within the two or more additional physical slots.

In an embodiment of the invention, the method comprises mapping said first plurality of logical frames to a first sequence of said additional physical slots within one or more radio frequency channels to form a first logical channel for transmitting at least said first set of data streams.

This has an advantage that the first logical channel may be formed as a single channel having a large data capacity, resulting from the data capacity of the sequence of additional physical slots, rather than multiple channels each with a smaller data capacity, so that services may be multiplexed onto the single channel with a resulting gain in terms of statistical multiplexing.

In an embodiment of the invention, at least a guard interval is provided between each said additional physical slot and a preceding said additional physical slot of the first sequence of said additional physical slots.

The provision of the guard interval has an advantage of allowing re-tuning of a tuner between the reception of each of the additional physical slots, so that a single tuner may be used to receive the first sequence of additional physical slots.

In an embodiment of the invention, the method comprises:

- mapping at least a second set of said plurality of data streams onto a second plurality of logical frames; and

- mapping said second plurality of logical frames to a second sequence of said additional physical slots within one or more radio frequency channels to form a second logical channel for transmitting at least said second set of data streams.

In an embodiment of the invention, said second sequence of said additional physical slots does not include any of said first sequence of said additional physical slots.
This has an advantage that a second logical channel can be provided, and may make use of further additional physical slots beyond those that may be received using a single tuner.

In an embodiment of the invention, said first logical channel conveys configuration signalling to enable acquisition of a service provided by the second logical channel.

This has an advantage that the first logical channel may be used as primary channel, so that a receiver requiring access to services carried on the second, or further, logical channel may first receive the first logical channel, which will provide configuration signalling to enable acquisition of a service provided by the second logical channel or further logical channels. As a result, it may only be necessary to convey configuration signalling on the first logical channel, reducing signalling overhead and increasing data capacity of the second and further channels.

In an embodiment of the invention, said configuration signalling indicates a configuration of one or more of said plurality of data streams.

In an embodiment of the invention, said configuration signalling is carried at least by each logical frame that is mapped to the first logical channel.

This has an advantage of reducing the delay in accessing a data stream by use of the configuration signalling.

In an embodiment of the invention, said configuration signalling is carried by at least a first logical frame that is mapped to a superframe of the second logical channel and not by another logical frame that is mapped to the second logical channel.

This has an advantage of reducing the signalling overhead of the second logical channel.

In an embodiment of the invention, the method comprises including information relating to the first sequence of said additional physical slots in said configuration signalling.
In an embodiment of the invention, the method comprises including information relating to the second sequence of said additional physical slots in said configuration signalling.

In an embodiment of the invention, each of said first plurality of logical frames carries dynamic signalling information relating to at least an address within the respective logical frame of at least one of said first set of data streams and does not carry dynamic signalling information relating to the second set of data streams.

This has an advantage that signalling overhead is reduced, since dynamic signalling information need not be included in a logical channel that relates to another logical channel.

In an embodiment of the invention, each of said second plurality of logical frames carries dynamic signalling information relating to at least an address within the respective logical frame of at least one of said second set of data streams and does not carry dynamic signalling information relating to the first set of data streams.

In an embodiment of the invention, the method comprises: determining said first sequence of said additional physical slots by selecting a sequence of said additional physical slots that has a shorter interval between said additional physical slots in preference to a sequence of said additional physical slots that has a longer interval between said additional physical slots.

This has an advantage that the first logical channel may be selected to have a higher capacity and also a shorter signal acquisition time.

In an embodiment of the invention, the method comprises: determining said first sequence of said additional physical slots by a process comprising selecting a sequence of said additional physical slots on a single radio frequency channel.

This has an advantage that the first sequence of physical slots may be received without re-tuning a receiver.

In an embodiment of the invention, the method comprises:
determining said first sequence of said additional physical slots by a process comprising selecting a sequence of said additional physical slots that has a higher robustness in preference to a sequence of said additional physical slots that has a lower robustness.

This has an advantage that the robustness of the first logical channel may be maximised; this may be advantageous in particular if the first logical is to be used as a primary channel for acquisition by a receiver.

In an embodiment of the invention, the method comprises:

determining said first sequence of said additional physical slots by a process comprising selecting a sequence of said additional physical slots that has a lower overhead in preference to a sequence of said additional physical slots that has a higher overhead.

In an embodiment of the invention, the method comprises:

determining said second sequence of said additional physical slots by a process comprising selecting from said additional physical slots that are not selected for the first sequence of said additional physical slots.

In an embodiment of the invention, the method comprises:

determining said first and second sequences of said additional physical slots by a process comprising selecting respective said additional physical slots for said first and second sequences that would enable a lower difference in capacity between said first and second logical channels in preference to respective said additional physical slots that would enable a higher difference in capacity between said first and second logical channels.

In an embodiment of the invention, the method comprises:

determining said first and second sequences of said additional physical slots by a process comprising selecting respective said additional physical slots for said first and second sequences that would enable a higher frequency diversity in preference to respective said additional physical slots that would enable a lower frequency diversity.

In an embodiment of the invention, the method further comprises:
at a repeater, selecting a plurality of said additional physical slots for retransmission of data received within said plurality of said additional physical slots in preference to other received data.

In an embodiment of the invention, said plurality of additional physical slots relate to at least one logical channel.

This has an advantage that the efficiency of a repeater may be improved, since only data received within the additional physical slots may need to be retransmitted, as the additional data may be intended for reception by handheld devices. The handheld devices may require a stronger signal than is required for reception of the first data transmitted within the physical frame structure which may be intended for reception by fixed receivers that may have rooftop antennas. Furthermore, only a single tuner may be required at the repeater for each logical channel.

In an embodiment of the invention, the method comprises:

transmitting said additional data in a plurality of logical channels each comprising a sequence of said additional physical slots,

wherein the number of logical channels constituting the plurality of logical channels is determined in dependence on a maximum number of said additional physical slots that are transmitted simultaneously.

In an embodiment of the invention, the method comprises:

setting a timing offset of said additional physical slots on a first radio frequency channel with respect to said additional physical slots on a second radio frequency channel such that overlap in time of said additional physical slots is reduced.

This has an advantage of distributing the additional physical slots more evenly in time, so that the capacity of each logical channel may be increased, while the number of logical channels required to make use of available additional slots may be reduced.

In an embodiment of the invention, each of said first plurality of logical frames has the same number of Orthogonal Frequency Division Multiplexing Symbols for a given superframe.
In an embodiment of the invention, third signalling information is transmitted within each said additional physical slot, said third signalling information comprising signalling information indicating the start of the respective said additional physical slot and indicating physical layer parameters to be used in receiving a transmission in the respective said additional physical slot. This may, for example, be signalling information carried by the P1 symbol, which may be required for each additional physical slot.

In an embodiment of the invention, said third signalling information comprises signalling information indicating the next additional physical slot of the next logical frame for the first logical channel.

In an embodiment of the invention, said one or more locations relating to one or more of said plurality of data steams comprises a start address of a data stream.

In an embodiment of the invention, the wireless system is a digital video broadcast system.

In an embodiment of the invention, the wireless system is a unicast transmission system.

In an embodiment of the invention, said plurality of data streams are physical layer pipes.

In an embodiment of the invention, said additional physical slots are at least parts of Future Extension Frames.

In accordance with a second aspect of the present invention, there is provided apparatus for transmitting additional data comprising a plurality of data streams in a wireless system, said data being additional to first data transmitted within a physical frame structure, and said additional data being transmitted on one or more radio frequency channels within additional physical slots of the physical frame structure that are not used for the transmission of said first data, said apparatus being arranged to:

map at least a first set of said plurality of data streams onto a first plurality of logical frames;
generate signalling information for a given logical frame of said first plurality of logical frames for indicating one or more locations relating to one or more of said plurality of data streams for said given logical frame; and

transmit said given logical frame in at least parts of two or more of said additional physical slots, each of said two or more said additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel.

In accordance with a third aspect of the present invention, there is provided a method of receiving additional data comprising a plurality of data streams in a wireless system, said data being additional to first data transmitted within a physical frame structure, and said additional data being transmitted on one or more radio frequency channels within additional physical slots of the physical frame structure that are not used for the transmission of said first data, and at least a first set of said plurality of data streams being mapped onto a first plurality of logical frames, the method comprising:

receiving a given logical frame in at least parts of two or more of said additional physical slots, each of said two or more said additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel; and

receiving signalling information for said given logical frame of said first plurality of logical frames for indicating one or more locations relating to one or more of said plurality of data streams for said given logical frame.

In accordance with a fourth aspect of the present invention, there is provided apparatus for receiving additional data comprising a plurality of data streams in a wireless system, said data being additional to first data transmitted within a physical frame structure, and said additional data being transmitted on one or more radio frequency channels within additional physical slots of the physical frame structure that are not used for the transmission of said first data, and at least a first set of said plurality of data streams being mapped onto a first plurality of logical frames, the apparatus being arranged to:
receive a given logical frame in at least parts of two or more of said additional physical slots, each of said two or more said additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel; and

receive signalling information for said given logical frame of said first plurality of logical frames for indicating one or more locations relating to one or more of said plurality of data streams for said given logical frame.

Further features and advantages of the invention will be apparent from the following description of preferred embodiments of the invention, which are given by way of example only.

**Brief Description of the Drawings**

Figure 1 is a schematic diagram showing physical slots according to an embodiment of the invention;

Figure 2 is a schematic diagram showing mapping of a logical frame to physical slots in an embodiment of the invention;

Figure 3 is a schematic diagram showing logical channels according to an embodiment of the invention;

Figure 4 is a schematic diagram showing mapping of signalling information to logical channels according to an embodiment of the invention;

Figure 5 is a schematic diagram showing mapping of a primary and secondary logical channel to physical slots in an embodiment of the invention;

Figure 6 is a schematic diagram showing FEF slots on a three RF channels in an embodiment of the invention;

Figure 7 is a schematic diagram showing an arrangement of three logical channels according to an embodiment of the invention;

Figure 8 is a schematic diagram illustrating shifting of physical slots according to an embodiment of the invention;

Figure 9 is a schematic diagram showing an arrangement of two logical channels according to an embodiment of the invention;
Figure 10 is a schematic diagram showing NGH frames in an embodiment of the invention;

Figure 11 is a schematic diagram illustrating the alignment of NGH superframe configuration and T2 superframe configuration in an embodiment of the invention;

Figure 12 is a table showing the L1-Pre signalling field in an embodiment of the invention;

Figure 13 is a table showing the L1-config signalling field in an embodiment of the invention;

Figure 14 is a table showing the L1-dynamic and Inband signalling fields in an embodiment of the invention;

Figure 15 is a flow diagram illustrating a receiver in an embodiment of the invention;

Figure 16 is a schematic diagram illustrating a network and transmitter architecture in an embodiment of the invention;

Figure 17 is a schematic diagram illustrating a repeater in an embodiment of the invention; and

Figure 18 is a schematic diagram illustrating a repeater in an embodiment of the invention.

Detailed Description of the Invention

By way of example, embodiments of the invention will now be described in the context of a Digital Video Broadcasting Next Generation Handheld (DVB-NGH) system, in which additional data for reception by DVB-NGH receivers is transmitted within Future Extension Frame (FEF) slots in the 2nd generation terrestrial DVB-T2 system.

However, it will be understood that this is by way of example only and that other embodiments may involve other wireless broadcast systems or unicast systems; embodiments are not limited to the use for transmission of digital video signals.
As illustrated in Figure 1, existing Digital Video Broadcast frame structures may provide for Future Extension Frame slots 2a, 2b, 2c within a transmission sequence 1 of a radio frequency channel. The Future Extension Frames slots occupy physical slots within the DVB physical frame structure, that may be reserved in a standard for future use. The Future Extension Frame slots may be provided in addition to the parts of the frame structure which are for transmission of signals intended for reception by conventional Digital Video Broadcast receivers, as shown in Figure 1 as T2-frames.

There have been proposals to use the FEF slots for the transmission of signals intended for reception by Next Generation Handheld receivers. An example of such a scheme is illustrated as “Option 1” 3 in Figure 1. It can be seen that the NGH signals on a logical NGH channel 3 are transmitted as a series of logical NGH frames, each logical frame 6a, 6b, 6c, being transmitted within a separate FEF slot 2a, 2b, 2c. As shown, the logical NGH frame 6a may occupy a NGH slot 4 that may be smaller, but no larger, than the FEF slot 2a. Each NGH frame has associated signalling information; this would be typically transmitted as a preamble 7a, 7b, 7c in each FEF slot. However, such a scheme may suffer from limited capacity, due to high signalling overhead.

In a first embodiment of the invention, as illustrated by Figure 1 as “Option 2” 5 and by Figure 2, a logical NGH frame 27 is transmitted in at least parts of two or more FEF slots 2a, 2b, so that the length of a logical NGH frame 27 may be greater than the length of a FEF slot, 2a, 2b. The logical frame, in this case the logical NGH frame 27, may be arranged to have a lower proportion of signalling information to data capacity than would be the case if the length of the logical frame were limited by the length of an additional physical slot, in this case a FEF slot 2a, 2b. The two or more FEF slots may be within a transmission sequence for different radio frequency channels and the logical frames may be arranged to have a constant length, even though the length of additional physical slots in a sequence of additional physical slots may vary between the radio frequency channels, for example. The length of the logical NGH frames may be
set to an optimum value in terms of a trade off between signalling overhead and acquisition time for a receiver requesting access to the additional data.

The signals intended for reception by Next Generation Handheld receivers typically comprise several data streams, that may be physical layer pipes, and a first set of these data streams may be mapped onto a series of logical frames, that may be NGH frames, that are typically part of a superframe. As illustrated in Figure 1, in an embodiment of the invention, a given logical frame 27 may be transmitted in at least parts of two or more FEF slots, also referred to as FEF parts. In the case of NGH frame j of Figure 1, it can be seen that this frame is transmitted in parts of three FEF slots, which may be referred to as additional physical slots 12a, 12b, 12c. The length of a logical frame may accordingly be independent of the length of an additional physical slot, so that the logical frame may be arranged to have a lower proportion of signalling information to data capacity than would be the case if the length of the logical frame were limited by the length of an additional Physical slot.

As illustrated by Figure 2, a given logical frame 27, typically comprises signalling information and data, the signalling information typically comprising sections “P1” 20a, 20b and “L1-pre” 22a, 22b, “L1-config” 24, “L1-dynamic” 25. The data sections 23, 26, 28 comprise physical layer pipes. The physical layer pipes may overlap in time and be multiplexed in frequency, for example.

The L1 config section typically carries information that is valid for each frame of the super-frame, and is typically the same for each logical frame of the super-frame. The L1-dynamic information typically varies from logical frame to logical frame, and relates to decoding the physical layer pipe within the logical frame. Typically, it may include a start address of the physical layer pipe, for example.

In an embodiment of the invention, a sequence of additional physical slots are bundled together to form a logical channel for transmitting a set of data streams, and a series of NGH logical frames is mapped to the sequence of additional physical slots, for example FEF slots. The sequence may fall within one within one or more radio frequency channels. If the sequence is chosen to
fall on a single radio frequency channel, then a tuner need not re-tune between additional physical slots in order to receive the sequence, which may simplify implementation of the receiver. If the sequence 30a ... 30h is chosen to fall on several radio frequency channels, as illustrated by Figure 3 as RF1, RF2, RF3 and RF4, then a logical channel with a larger capacity may be formed, and also the logical channel may benefit from frequency diversity. A single channel may be formed having a large data capacity resulting from the data capacity of the sequence of additional physical slots, rather than multiple channels each with a smaller data capacity, so that services may be multiplexed onto the single channel with a resulting gain in terms of statistical multiplexing.

As shown in Figure 3, a guard interval is provided between each additional physical slot and each preceding additional physical slot of the sequence 30a ... 30 h, to allowing re-tuning of a tuner between the reception of each of the additional physical slots, so that a single tuner may be used to receive the sequence.

As also shown by figure 3, a second logical channel can be formed by mapping a second set of data streams onto a second series of logical frames and mapping the second sequence of logical frames to a second sequence of additional physical slots, for example FEF slots 32a...32h. As shown in Figure 3, the second sequence of additional physical slots 32a...32h may not include any of the first sequence of said additional physical slots 30a...30h, so that the second logical channel may make use of further additional physical slots beyond those that may be received using a single tuner. Further logical channels may be provided by further sequences of additional physical slots.

In cases where more than one logical channel is provided, one of the logical channels may be designated as a primary logical channel, which may be referred to as a Primary NGH Channel (PNC) and the others as secondary logical channels, which may be referred to as Secondary NGH Channels (SNC). The primary logical channel may be formed from physical slots that are selected for greater robustness, greater capacity, shorter intervals between physical slots, and/or lower overhead, and the primary logical channel may be used for first
acquisition of a signal by a receiver. The primary logical channel may convey configuration signalling to enable acquisition of a service provided by a secondary logical channel, so that a receiver requiring access to services carried on a secondary logical channel may first receive the primary logical channel, which will provide configuration signalling to enable acquisition of a service provided by a secondary logical channel or further logical channels. As a result, it may only be necessary to convey configuration signalling in every frame of the first logical channel, and not in every frame of a secondary logical channel, reducing signalling overhead and increasing data capacity of the second and further channels.

The configuration signalling may indicate a configuration of one or more of said plurality of data streams, and may be carried by each logical frame that is mapped to the primary logical channel, to reduce the delay in accessing a data stream. The configuration signalling may also be carried by the first logical frame in a superframe of a secondary logical channel, but not necessarily by other logical frames in the secondary logical channel, to reduce the signalling overhead.

In an embodiment of the invention, the configuration information may include information relating to the sequences of additional physical slots forming the primary and secondary logical channels.

By contrast, dynamic signalling information may be included in each logical frame of the primary and secondary logical channels, but the dynamic signalling may only carry information relating to the respective logical channel, reducing signalling overhead.

The arrangement of configuration information (for example L1-config) and dynamic signalling information (for example L1-Dyn) within primary and secondary channels is illustrated by Figure 4. It can be seen that the L1-dyn signalling is carried by each of the PNC and SNC logical channels, whereas the L1-config signalling is carried primarily by the PNC logical channel, and the dashed lines indicate that the L1-config signalling is carried by only a subset of
the frames of the SNC logical channels. Figure 4 also illustrates that the PNC and SNC logical each channels include FEF slots on a number of RF channels.

Figure 5 illustrates how a sequence of data frames 52 forming a primary logical channel and a sequence of data frames 54 forming a secondary logical channel may be mapped to within FEF slots on a three RF channels 56, 57, 58. Typically, each logical frame for a given superframe has the same number of Orthogonal Frequency Division Multiplexing Symbols.

Digital video broadcast systems may include repeaters or gap fillers to provide coverage in regions where propagation from a main transmitter antenna is poor. In an embodiment of the invention, physical slots forming at least one logical channel are selected for retransmission at a repeater or gap filler in preference to the other received data, such as DVB signals intended for reception by fixed receivers. This may improve the efficiency of the repeater, since only data received within the additional physical slots may need to be retransmitted, as the additional data may be intended for reception by handheld devices. The handheld devices may require a stronger signal than is required for reception of the first data transmitted within the physical frame structure which may be intended for reception by fixed receivers that may have rooftop antennas. Furthermore, only a single tuner may be required at the repeater for each logical channel.

The number of logical transmitted may depend on the maximum number of additional physical slots, e.g. FEF slots, that are transmitted simultaneously. This is illustrated by Figure 6 and Figure 7. In Figure 6, it can be seen that sequences of FEF slots may be available on three RF channels 60, 62, 64 and it can be seen from the lower time line 66 that there may be between 0 and a maximum of three FEF slots transmitted simultaneously in this example. In figure 7 it can be seen that three logical channels 70, 72, 74 may be formed from these FEF slots, in the frequency hopping manner illustrated.

As illustrated by Figure 8, timing offsets of the FEF slots on a set of RF channels 80, 82, 84, 86 may be arranged to reduce the overlap between FEF slots, so that the FEF slots are distributed more evenly in time, so that the
capacity of each logical channel may be increased, while the number of logical channels required to make use of available additional slots may be reduced. As shown in Figure 8, the maximum number of FEF slots transmitted simultaneously may be reduced to two by appropriate timing offsetting between the four RF channels shown, so that two logical channels 90, 92 may be formed as shown in Figure 9, as primary 94 and secondary 96 logical channels.

In an embodiment of the invention, third signalling information 14a, 14b, 14c, 14d, 14e is transmitted within each additional physical slot, which may be a FEF slot as illustrated in Figure 1, indicating the start of the slot and indicating physical layer parameters to be used in receiving a transmission in the respective said additional physical slot. This may, for example, be P1 and/or L1-Pre signalling information, which may be required for each additional physical slot, and may indicate the start of the next additional physical slot for a logical channel. L1 post signalling information 16a, 16b, 16c, such as L1-dyn and L1-config, may not be transmitted within each additional physical slot. Data 18a, 18b, 18c, 18d, 18e, 18f, such as payload data may be transmitted within each additional physical slot.

Embodiments of the invention will now be described in more detail.

In prior art systems, due to the high capacity requirements of conventional T2 DVB services intended primarily for reception by fixed receivers, including High Definition (HD) and three dimensional (3D) services, the amount of bandwidth per RF channel used for NGH is typically quite low (FEF_length < 20% in most cases). The number of NGH services per T2 RF channel may be very low (3-5 TV and radio programs), limiting the gain achievable by Statistical Multiplexing. Additionally, the padding overhead that is introduced at the end of each frame may become more significant the shorter the frame is. In order not to affect the zapping time (time to receive a new service) of T2 services, short FEFs may be used (FEF_INTERVAL ≤ 2). In this case, the NGH L1 overhead may become quite significant (>10%). When the number of PLPs is increased, the main overhead may be caused by L1-Post signalling information (L1-Config and L1-Dyn).
An Embodiment of the invention addresses these problems by bundling FEF frames to provide one or more logical NGH channels. An Embodiment of the invention introduces a new frame format, as illustrated by as “Option 2” 5 in Figure 1. A P1 symbol indicates the start of the NGH slot, as may be required by T2 specs (i.e. T2 receivers would be disturbed otherwise).

“Option 1” 3 in figure 1 represents the situation in the prior art, in which a NGH frame is transmitted within a FEF slot. In this case, a DVB-T2 frame is encapsulated within the FEF.

In an embodiment of the invention, a NGH frame is not equivalent to a FEF and is not equivalent to a DVB-T2 frame. In this arrangement, an NGH frame is not aligned with the FEF part, also referred to as a FEF slot, and the NGH signal does not have to use the full FEF; the portion used by NGH is referred to in Figure 1 as the NGH slot. FEFs are then bundled (time-domain bundling) to form the NGH frames as shown in Figure 1. Typically, all NGH frames may have the same number of OFDM symbols, and all frames may have the same capacity. Typically, L1-Pre is transmitted immediately after the P1 symbol. P2 symbols (which may have special pilot patterns) may be used to carry the L1-Pre. Typically only one P2 symbol may be enough for this. As in T2, L1-Pre may carry minimum information about the frame format, resulting in a small overhead. With L1-Pre, the NGH receiver knows the start/end of the NGH physical slot, as well as when the next NGH logical frame is scheduled and its duration. This may simplify the detection of L1-Config and L1-Dyn (L1-Pre contains a pointer to the next L1-Config and L1-Dyn). Typically, L1-Config and L1-Dyn are transmitted starting at any OFDM symbol of the frame, but may not be present in some frames.

As illustrated by Figure 2, FEFs from different T2 RF channels can be bundled (frequency domain bundling) increasing the capacity of the logical NGH channel. However, in case of overlapping FEFs, only the signal from one of them may be recovered if a single tuner is used for reception. Multiple logical NGH channels may be provided, in which each data service is transmitted by a single logical NGH channel, so that only one tuner is required
to recover the service. In the case of multiple logical NGH channels, instead of
signalling all the services as proposed with TFS, which may cause excessive
overhead, one logical NGH channel may be selected as primary (PNC) and the
rest as secondary (SNC). In an embodiment of the invention, L1-Pre contains
information about in which RF will appear the next L1 signalling (i.e. L1-
Config) carried by the primary NGH channel. L1-Config is mapped onto to the
primary channel and at the beginning of each superframe in each secondary
channel. L1-Dyn may be mapped to all logical channels but may contain only
the signalling for the services carried by such logical NGH channel. The
primary NGH channel may then be responsible for providing the fast zapping
and acquisition, and may be considered the entry point to any service
transmitted in any of the secondary NGH channels. If only one tuner is required
at the receiver side, the bandwidth assigned to one logical NGH channel is
typically not higher than that of a T2 RF channel.

In embodiment of the invention, the FEFs may be bundled, and this may
be signalled in various scenarios as follows.

Firstly, a single T2 RF channel may be used, and any T2 superframe
structure may be used.

Alternatively, multiple T2 RF channels may be used. In this case, there
may be several options as follows: the same T2 superframes structures may be
provided in all T2 RF channels and a single Logical NGH channel may be
provided; or there may be the same T2 superframes structures in all T2 RF
channels and multiple Logical NGH channels. In each of the above cases, the
T2 frame length and FEF interval may be flexible and may be adapted to
provide an optimum configuration of the NGH channel.

As a further alternative, different T2 superframes structures may be
provided among T2 RF channels and multiple logical NGH channels; this may
be termed a generic scenario. In this case, the only degree of freedom may be a
time shift in the T2 superframes from each channel.

In case of an NGH only channel, the NGH slots can be chosen freely,
also introducing FEF parts within the NGH signal.
Figure 2 illustrates the case of a single T2 RF channel. In this case, FEF bundling operates only in the time domain. No constraints may be required on the T2 signal.

In the case of multiple T2 RF channels, with the same T2 superframes structures in all T2 RFs and single logical NGH channel, the case may represent the simplest scenario for FEF bundling over multiple T2 RF channels. In order to bundle all T2 RF channels in a single logical NGH channel, the following condition may be met:

\[ N_{RF} \cdot (T_{SLOT} + T_{SW}) \leq (T_{FFE} + FEF\_INTERVAL \times T_F) \]

where \( T_{SW} \) is the time required by the receiver to tune to a new frequency. The maximum logical NGH channel capacity (bit rate) may be achieved when both sides of the expression are equal.

In the case of multiple T2 RF channels, with the same T2 superframes structures in all T2 RFs and multiple logical NGH channels, when previous condition is not met, it may be inferred that during some intervals two NGH slots are simultaneously allocated to T2 RF channels or not enough time is available to switch between frequencies. In order to require only one tuner at the receiver, embodiments of the invention may employ multiple logical NGH channels. In the case of multiple logical channels, the previous condition may be updated to:

\[ N_{RF} \cdot (T_{FFE} + T_{SW}) \leq N_{LNC} \cdot (T_{FFE} + FEF\_INTERVAL \times T_F) \]

where \( N_{LNC} \) is the number of logical NGH channels \((1 \leq N_{LNC} \leq N_{RF})\).

Figure 5 illustrates the case of multiple T2 RF channels, with the same T2 superframes structures in all T2 RFs and multiple Logical NGH channels.

Figure 6 illustrates the case of Multiple T2 RF channels, with different T2 superframes structures among T2 RFs and multiple logical NGH channels.
In this more general case, NGH percentage bandwidth (BW %) may be different across T2 RF channels, with different superframe structures (i.e. T2 frame length, FEF interval and FEF length) and non-synchronized T2 RFs. In this case, as illustrated by Figure 6, the number of multiple logical NGH channels $N_{LNC}$ may be computed as the maximum number of overlapping FEFs, for example $N_{LNC} = 3$ in Figure 6.

Figure 7 illustrates the case of multiple T2 RF channels, with different T2 superframes structures among T2 RF channels and multiple logical NGH channels. Typically, the first logical NGH channel to be allocated is the PNC 72. A main function of the PNC may be to enable fast zapping time, therefore, the PNC may be the logical channel with the largest capacity. This may also help to compensate the additional overhead of the PNC. In the example of Figure 7, the FEFs are assigned to the PNC in a way that the frequency diversity gain is maximized (PNC may use all RF frequencies). In other embodiments, other criteria may be used, e.g. increased robustness for the PNC (e.g. only a lower frequency allocated to PNC), a single RF for the PNC to avoid switching between channels, a lower difference in frequency between consecutive FEFs, etc. In an embodiment of the invention, after the PNC has been allocated, remaining FEFs are allocated to the SNC(s). Multiple combinations may be possible as long as the minimum switching time between RF carriers is guaranteed. In the example of Figure 7, FEFs are connected in order to average the bit rate between logical NGH channels and also to increase frequency diversity thanks to frequency hopping, but other criteria could be introduced, in a similarly manner as for the PNC.

In the previous example, the FEFs on different RF channels occur mostly simultaneously (i.e. $N_{LNC} \rightarrow N_{RF}$). In an embodiment of the invention, the T2 superframes may be shifted to reduce the number of logical NGH channels, increasing the capacity of each logical NGH channel. Increasing the capacity of each NGH carrier may increase the potential gain of statistical multiplexing.

Since the superframe format from each RF is known, the period of the multiple
logical NGH channel set may be computed. This period $T_b$ is useful since optimisation algorithms may work with that span.

Figure 8 illustrates an algorithm to bundle the FEFs as an embodiment of the invention. A suboptimal algorithm may be employed to obtain the shift to be applied to each RF as follows. A guard time is inserted before each FEF, this time accounting for the tuning time (time required for the tuner to start decoding after switching the RF frequency). This time is represented by the black boxes in Figure 8. The RF channels may be sorted according to the FEF length from the largest FEF to the shortest FEF (in case of equal FEF length, the RF with the largest FEF_INTERVAL is placed first). For a given FEF (e.g. the first in the superframe), each $i^{th}$ RF may be shifted so that the FEF is transmitted after the said FEF of the $i^th$-1 RF. The number of simultaneous FEFs $N_{LNC}(t)$ is obtained. At a first point in the algorithm, for the highest value of $N_{LNC}(t)$, referred as $n_{LNC}$, the overlapping FEFs $N_{OV}$ are obtained. The $N_{OV}$ overlapping FEFs are sorted from longer FEFs to shorter FEFs. The longest $N_{OV}$-1 FEFs are then evaluated for shifting. The shifting will be carried out if the $\max(N_{LNC}(t))$ is decreased. If $n_{cr}$ is reduced, the next step is to go to said first point in the algorithm, if not, then the end of the algorithm may be reached.

In an embodiment of the invention, the FEFs may be mapped to the resulting logical NGH channels as illustrated in Figure 9. It can be seen that, as previously discussed, FEFs are mapped to a PNC and SNC(s). Due to the shifts applied, several adjacent FEFs may be mapped to the same PNC / SNC. This may be beneficial in terms of power consumption since the FEF may be transmitted/received for each PNC/SNC as bursts. In an embodiment of the invention, the FEFs are assigned to the logical NGH channels such that the differences in bit rate between the logical NGH channels are minimized while maximizing the number of explored RF frequencies is maximized (i.e. higher frequency diversity). The final FEF mapping may be signalled in the L1-Config transmitted in the PNC.

Figure 10 illustrates how the NGH frames may be defined. In this example, NGH frames are defined in terms of the number of OFDM symbols in
each NGH frame, which is constant for all the NGH frames in one NGH superframe. The NGH frame capacity may be kept constant from NGH frame to NGH frame, however, due to the bursty nature of the transmission, there may be variations on the instantaneous throughput. However, different logical NGH channels may have different number of OFDM symbols per frame. For the PNC, L1-Config and L1-Dyn are typically transmitted at the beginning of each NGH frame, whereas for the SNCs typically only L1-Dyn is transmitted at the beginning of each NGH frame, except for the first frame of the superframe where L1-Config may also be transmitted.

Figure 11 illustrates how the NGH superframes and T2 superframes may be aligned. A change in NUM_T2_FRAMES, NUM_DATA_SYMBOLS, FEF_LENGTH, or FEF_INTERVAL creates a new superframe structure (denoted as SFS in Figure 11). Since FEF-bundling operates on top of the multiple T2 RF channels, any change to any of the forming T2 RF channels may cause the NGH configuration to reconfigure too. Each reconfiguration may need to be signalled and propagated to all the receivers. To allow this fast reconfiguration option, L1-Pre may allow signalling L1-Config and L1-Dyn in any logical NGH channel (PVC and SVC). This option may be used during SFS reconfiguration avoiding possible micro-cuts in case the receivers had to switch to PVC and then came back to the SVC. However, these changes do not happen frequently, and are usually scheduled during late hours to minimize the impact. Therefore, the extra signalling required (and impact) may be negligible. Apart from this possible limitation, NGH superframe may be defined freely.

Figure 12 illustrates an example of signalling in L1-pre in an embodiment of the invention. Note that typically in existing T2 signalling, the signalling fields that determine the frame structure (and the FEF length) are typically as follows: NUM_T2_FRAMES [8 bits] (L1Pre); NUM_DATA_SYMBOLS [12bits] (L1Pre); FEF_LENGTH [22 bits] (L1Post); FEF_INTERVAL [8 bits](L1Post).

As illustrated in Figure 12 as an embodiment of the invention for NGH, the T2/NGH frame structure may be signalled in a single field (i.e. L1Pre); this
can be done transmitting the FEF_INTERVAL and the (NGH) NUM_DATA_SYMBOLS in the L1Pre. For example: NGH_SLOT_INTERVAL [30 bits] indicates the number of T periods between two consecutive NGH slots. The longest interval may be obtained when FEF_INTERVAL = 256 and the longest frame length is used (250ms), this gives an interval of 64 seconds. The NGH_SLOT may be limited to 250ms. The number of OFDM symbols per NGH frame may also be also explicitly signalled (NUM_SYMBOLS_NGH_FRAME). L1_Pre may indicate the position of the next L1 Config and L1 Dyn (start of next NGH frame); information may only be necessary during the initial scanning or zapping. L1-Pre may also be used to indicate the RF in the L1-Config of the Primary Logical NGH Channel is mapped next (PNC_RF_FREQUENCY). This may indicate to a receiver in an initial scan or zapping where to find the L1_Config needed to start decoding the desired service (mapped to any PNC/SNC).

Figure 13 illustrates an example of signalling in L1-config in an embodiment of the invention. In this example, the number of associated RF channels as well as the number of logical NGH channels (NUM_LNC) is indicated. The T2_frame / NGH slot structure is signalled for every T2 RF. NGH SLOT OFFSET indicates the shift between the first FEF in each T2 superframe. This loop provides the information to know the T2 superframe structures of all associated T2 RF channels. A second loop signals how the FEFs are mapped to the logical NGH channels (only one cycle is signalled, and the number of cycles per superframe is an integer number). Each PLP is then assigned to one logical NGH channel. In this example, since NGH frames are not aligned with the FEFs, the FIRST_FRAME_IDX refers then to the first NGH frame, not to the first NGH slot. In the case that FEF bundling is not used, L1-Config remains close to prior art signalling, so that there may be little or no overhead.

Figure 14 illustrates an example of signalling in L1-dyn and Inband Signalling in an embodiment of the invention. Note that RF_ID field is replaced by SLOT_ID. SLOT_ID may allow the receiver to know in which
position of the FEF_bundling sequence is, and therefore, knowing the SLOT(s) that will be used by each logical NGH channel in the future. In the case of SVC with the different components are mapped into different PLPs, the whole set of PLPs should be mapped to the same logical NGH channel so that only one tuner may be required.

Figure 15 is a flow chart showing the operation of a receiver in an embodiment of the invention, showing steps at the receiver to discover the logical NGH channels and their structure. This process may be carried during initial scanning, zapping when the structure of the target logical NGH channel is unknown or during changes in the superframe structure.

Figure 16 illustrates a network and transmitter architecture as an embodiment of the invention. In this embodiment, at least two new elements are introduced: the FEF bundler and FEF distributor. The FEF bundler may be in charge of creating the logical NGH channels and assign the FEFs to them. It may assign the physical slots to the logical channels. Its input may be the superframe configuration in a set of T2 RF channels transmitted in at least one T2 network where FEF parts are available for NGH transmission. The FEF bundler may be connected to at least one NGH network, but it could be connected to multiple NGH networks since the bandwidth allocation may be done by the FEF agent. Once the logical channels are defined, the FEF bundler may inform the NGH gateway of the number of logical channels, the bit rate of each, the frame duration in each, which physical slots are assigned to each logical channel and the timing of each, etc.

As illustrated in Figure 16 in an embodiment of the invention, the FEF distributor typically receives all NGH slots, and then may pad the rest of the FEF part with null cells, and may create the T2-MI packets addressing each NGH slot to the right T2 modulator. The input to the FEF distributor, in this example, is the IQ samples corresponding to every physical slot, and the NGH logical channel configuration defined by the FEF bundler. The output of the FEF distributor may be a T2-MI packet containing the input IQ samples and adding the signalling required to address the modulator that should transmit the
modulated physical slot, and the padding cells in case the FEF is not fully used. The T2-MI packet may then be transmitted into the T2 distribution network. In this example, NGH BB modulators generate a BB NGH signal and NGH modulators generate a RF NGH signal transmitted in NGH-only RF channels. This allows reusing a part of the T2 modulator in charge of upconverting the FEF IQ cells to the corresponding frequency. This may help decreasing the cost of the NGH network, in particular when the NGH signal is transmitted in the FEF part.

Figure 17 and Figure 18 illustrate embodiments of repeaters in an embodiment of the invention. Amplifying the T2 signal may be a waste of power in situations where it is primarily the NGH coverage that need to be improved (e.g. in indoors, tunnels, public transport, etc.), since for conventional fixed receivers, the T2 signal may typically be received from roof-top antennas with much better reception conditions. In an embodiment of the invention, a potentially much more efficient scheme is provided where the signal that is repeated is only the NGH signal. This may be achieved if the repeaters operate on a logical NGH channel basis. Since NGH slots of a logical channel may occur more frequently than FEF parts of a single T2 signal, the repeater may operate more continuously (less gaps between bursts). The number of tuners required by each repeater may be reduced since $1 \leq N_{LNC} \leq N_{RF}$ (i.e. one tuner per logical NGH channel). As illustrated by Figure 17, an additional module (logical NGH channel selector) may be in charge of retrieving the L1 signalling related to each logical NGH channel that needs to be repeated. The L1 signalling is then used to switch between the FEFs forming the logical NGH channel. An independent amplify and forward RF chain may be required for each logical NGH channel that is repeated. As illustrated by Figure 18, in case of a more advanced repeater, the NGH signal may be decoded before forwarding it to the receivers (a so-called Decode-Amplify-Forward scheme). However, since decoding the signal may introduce a greater delay, the restored NGH signal may be transmitted in a different frequency to avoid interference to the original RF channel. For the same reasons previously explained in relation to the temporal
overlapping of the logical NGH channel, each NGH channel should be transposed to a different frequency.

As has been described, FEF bundling may tie together FEFs both in time and frequency domains, and this may have benefits including the following. In case of a single RF, FEF bundling may help to reduce the L1 overhead since FEF length and NGH frame duration independent, and may provide a gain in terms of time diversity. In case of multiple RF, FEF bundling may also help to reduce the L1 overhead since FEF length and NGH frame duration may be independent since L1 Config may only be transmitted in the PNC (SNC only on the first frame of the superframe). FEF bundling may reduce the zapping time and FEF bundling may simplify the mapping of the services since a single large capacity NGH channel is seen, so that more services may be multiplexed increasing the statistical multiplexing gain. If FEF bundling works over multiple RF carriers, frequency hopping may bring additional frequency diversity, with gains up to 4dB or more in case of indoor or low mobility scenarios. FEF bundling may not impose any constraint to the T2 signal (e.g. minimum FEF length/NGH bandwidth), nor degrade the T2 receiver’s performance (e.g. zapping time). Since no synchronization is required between the T2 RF signals, FEF bundling may be used even when the T2 RFs are operated by different broadcasters and the T2 RF could be transmitted from different sites.

The above embodiments are to be understood as illustrative examples of the invention. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.
Claims

1. A method of transmitting additional data comprising a plurality of data streams in a wireless system, said data being additional to first data transmitted within a physical frame structure, and said additional data being transmitted on one or more radio frequency channels within additional physical slots of the physical frame structure that are not used for the transmission of said first data,

   the method comprising:
   mapping at least a first set of said plurality of data streams onto a first plurality of logical frames;
   generating signalling information for a given logical frame of said first plurality of logical frames for indicating one or more locations relating to one or more of said plurality of data streams for said given logical frame; and
   transmitting said given logical frame in at least parts of two or more of said additional physical slots, each of said two or more said additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel.

2. A method according to claim 1, wherein said signalling information is included in one and not in another of said two or more said additional physical slots.

3. A method according to claim 1 or claim 2, wherein each of said two or more said additional physical slots are within the transmission sequence of the same radio frequency channel.

4. A method according to any preceding claim, wherein said two or more said additional physical slots do not overlap in time.
5. A method according to any preceding claim, the method comprising mapping said first plurality of logical frames to a first sequence of said additional physical slots within one or more radio frequency channels to form a first logical channel for transmitting at least said first set of data streams.

6. A method according to claim 5, wherein at least a guard interval is provided between each said additional physical slot and a preceding said additional physical slot of the first sequence of said additional physical slots.

7. A method according to claim 5 or claim 6, the method comprising:
   mapping at least a second set of said plurality of data streams onto a second plurality of logical frames; and
   mapping said second plurality of logical frames to a second sequence of said additional physical slots within one or more radio frequency channels to form a second logical channel for transmitting at least said second set of data streams.

8. A method according to claim 7, wherein said second sequence of said additional physical slots does not include any of said first sequence of said additional physical slots.

9. A method according to claim 7 or claim 8, wherein said first logical channel conveys configuration signalling to enable acquisition of a service provided by the second logical channel.

10. A method according to claim 9, wherein said configuration signalling indicates a configuration of one or more of said plurality of data streams.
11. A method according to claim 9 or claim 10, wherein said configuration signalling is carried at least by each logical frame that is mapped to the first logical channel.

12. A method according to any of claims 9 to 11, wherein said configuration signalling is carried by at least a first logical frame that is mapped to a superframe of the second logical channel and not by another logical frame that is mapped to the second logical channel.

13. A method according to any of claims 9 to 12, the method comprising including information relating to the first sequence of said additional physical slots in said configuration signalling.

14. A method according to any of claims 9 to 13, the method comprising including information relating to the second sequence of said additional physical slots in said configuration signalling.

15. A method according to any of any of claims 7 to 14, wherein each of said first plurality of logical frames carries dynamic signalling information relating to at least an address within the respective logical frame of at least one of said first set of data streams and does not carry dynamic signalling information relating to the second set of data streams.

16. A method according to any of any of claims 7 to 15, wherein each of said second plurality of logical frames carries dynamic signalling information relating to at least an address within the respective logical frame of at least one of said second set of data streams and does not carry dynamic signalling information relating to the first set of data streams.

17. A method according to any of claims 5 to 16, the method comprising:
determining said first sequence of said additional physical slots by selecting a sequence of said additional physical slots that has a shorter interval between said additional physical slots in preference to a sequence of said additional physical slots that has a longer interval between said additional physical slots.

18. A method according to any of claims 5 to 17, the method comprising:

determining said first sequence of said additional physical slots by a process comprising selecting a sequence of said additional physical slots on a single radio frequency channel.

19. A method according to any of claims 5 to 18, the method comprising:

determining said first sequence of said additional physical slots by a process comprising selecting a sequence of said additional physical slots that has a higher robustness in preference to a sequence of said additional physical slots that has a lower robustness.

20. A method according to any of claims 5 to 19, the method comprising:

determining said first sequence of said additional physical slots by a process comprising selecting a sequence of said additional physical slots that has a lower overhead in preference to a sequence of said additional physical slots that has a higher overhead.

21. A method according to any of claims 15 to 18, the method comprising:

determining said second sequence of said additional physical slots by a process comprising selecting from said additional physical slots that are not selected for the first sequence of said additional physical slots.
22. A method according to claim 21, the method comprising:

determining said first and second sequences of said additional physical slots by a process comprising selecting respective said additional physical slots for said first and second sequences that would enable a lower difference in capacity between said first and second logical channels in preference to respective said additional physical slots that would enable a higher difference in capacity between said first and second logical channels.

23. A method according to claim 21 or claim 22, the method comprising:

determining said first and second sequences of said additional physical slots by a process comprising selecting respective said additional physical slots for said first and second sequences that would enable a higher frequency diversity in preference to respective said additional physical slots that would enable a lower frequency diversity.

24. A method according to any of claims 5 to 23, the method further comprising:

at a repeater, selecting a plurality of said additional physical slots for re-transmission of data received within said plurality of said additional physical slots in preference to other received data.

25. A method according to claim 24, wherein said plurality of additional physical slots relate to at least one logical channel.

26. A method according to any preceding claim, the method comprising:

transmitting said additional data in a plurality of logical channels each comprising a sequence of said additional physical slots,
wherein the number of logical channels constituting the plurality of logical channels is determined in dependence on a maximum number of said additional physical slots that are transmitted simultaneously.

27. A method according to any preceding claim, the method comprising:
   setting a timing offset of said additional physical slots on a first radio frequency channel with respect to said additional physical slots on a second radio frequency channel such that overlap in time of said additional physical slots is reduced.

28. A method according to any preceding claim, wherein each of said first plurality of logical frames has the same number of Orthogonal Frequency Division Multiplexing Symbols for a given superframe.

29. A method according to any preceding claim, wherein third signalling information is transmitted within each said additional physical slot, said third signalling information comprising signalling information indicating the start of the respective said additional physical slot and indicating physical layer parameters to be used in receiving a transmission in the respective said additional physical slot.

30. A method according to claim 29 and claim 5, wherein said third signalling information comprises signalling information indicating the start of the next additional physical slot for the first logical channel.

31. A method according to any preceding claim, wherein said one or more locations relating to one or more of said plurality of data streams comprises a start address of a data stream.
32. A method according to any preceding claim, wherein the wireless system is a digital video broadcast system.

33. A method according to any of claims 1 to 31, wherein the wireless system is a unicast transmission system.

34. A method according to any preceding claim, wherein said plurality of data streams are physical layer pipes.

35. A method according to any preceding claim, wherein said additional physical slots are at least parts of Future Extension Frames.

36. Apparatus for transmitting additional data comprising a plurality of data streams in a wireless system, said data being additional to first data transmitted within a physical frame structure, and said additional data being transmitted on one or more radio frequency channels within additional physical slots of the physical frame structure that are not used for the transmission of said first data,

    said apparatus being arranged to:

    map at least a first set of said plurality of data streams onto a first plurality of logical frames;

    generate signalling information for a given logical frame of said first plurality of logical frames for indicating one or more locations relating to one or more of said plurality of data streams for said given logical frame; and

    transmit said given logical frame in at least parts of two or more of said additional physical slots, each of said two or more said additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel.

37. A method of receiving additional data comprising a plurality of data streams in a wireless system, said data being additional to first data
transmitted within a physical frame structure, and said additional data being transmitted on one or more radio frequency channels within additional physical slots of the physical frame structure that are not used for the transmission of said first data, and at least a first set of said plurality of data streams being mapped onto a first plurality of logical frames, the method comprising:

receiving a given logical frame in at least parts of two or more of said additional physical slots, each of said two or more said additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel; and

receiving signalling information for said given logical frame of said first plurality of logical frames for indicating one or more locations relating to one or more of said plurality of data streams for said given logical frame.

38. A method according to claim 37, wherein said signalling information is included in one and not in another of said two or more said additional physical slots.

39. Apparatus for receiving additional data comprising a plurality of data streams in a wireless system, said data being additional to first data transmitted within a physical frame structure, and said additional data being transmitted on one or more radio frequency channels within additional physical slots of the physical frame structure that are not used for the transmission of said first data, and at least a first set of said plurality of data streams being mapped onto a first plurality of logical frames, the apparatus being arranged to:

receive a given logical frame in at least parts of two or more of said additional physical slots, each of said two or more said additional physical slots being a time slot within a transmission sequence of a respective radio frequency channel; and

receive signalling information for said given logical frame of said first plurality of logical frames for indicating one or more locations relating to one or more of said plurality of data streams for said given logical frame.
Application No: GB1100901.6
Claims searched: 1,36,37,39
Examiner: Mr Jeremy Cowen
Date of search: 19 May 2011

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

<table>
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<tr>
<th>Category</th>
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- H04H; H04L
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- WPI,EPODOC,INSPEC

International Classification:

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