Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**A solution/scheme for coexistence with 802.11 in the LE bands**
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Re:	This is a contribution to IEEE 802.16a.
Abstract	Based on the scheme proposed in C802.16a-02/50 for coexistence with 802.11 in the LE bands, this contribution provides detailed explanation to the coexistence mechanism as well as suggested changes to 802.16a.
Purpose	Assist 802.16a to enable coexistence with 802.11.
Notice	
Release	
Patent Policy and Procedures	

A solution/scheme for coexistence with 802.11 in the LE bands

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Instruction

In contribution C802.16a-02/50, we proposed an optional frame structure in the LE bands to allow coexistence with 802.11. The mechanism is explained in detail as the following.

The license-exempt bands between 2-11 GHz allow deployment of both 802.16a BWA systems and 802.11 WLAN systems. When the two different systems partially overlap with each other and occupies the same band, a coexistence mechanism is needed to allow sharing of the channel between them. A simple and effective way to achieve this goal is to let the two systems to time-share the channel. In other words, the BWA system and the WLAN system control the channel alternatively. This naturally leads to the introduction of a silence part in each BWA frame, as shown in Figure 1. While the BWA transmissions can be carried out in the rest of each frame, this silence part prohibits any BWA transmission to allow the WLAN system to transmit. The BWA system should sense the existence of WLAN stations and issue a silence part in each frame with an appropriate duration. The control of the channel should be elegantly handed over from the BWA system to the WLAN system at the beginning of the silence part, and back to the BWA system at the end of the silence part. This is never a problem because 802.11 uses the CSMA/CA mechanism, which enables the WLAN system to take over the channel once the silence part begins. In addition, when the silence part is over and the BWA system resumes transmission, this mechanism makes the WLAN stations to sense the interference generated by the BWA transmissions, stop transmission and hand over the channel to the BWA system. Obviously, part of the BWA transmissions right after the silence part may collide with WLAN transmission and fail. However, this happens in only a brief period of time following the silence part. After this period of time, no WLAN transmission will continue, and the BWA transmissions no long suffers any interference from the WLAN system. In the optional frame structure shown in Figure 1, we introduced a risky transmission part after the silence part, in which the BWA transmissions may suffer interference from the WLAN system. We also name the period after the risky transmission part and the before the next silence part as safe transmission part. The names of the two parts are self-explaining. Each of the two parts has a DL subframe and a UL subframe. To ensure a strong interference to the WLAN system, the subframes in the risky transmission part should not contain any gap (except TTGs and RTGs). Obviously, DL and UL transmissions with high transmission requirements, such as the DL-MAP and UL-MAP, should be carried out in the safe transmission part. As a result, the optional frame structure starts with the safe transmission part, then the silence part, and ends with the risky transmission part. Moreover, ARQ should be applied to the risky transmission part so that retransmission can be arranged for failed transmissions.

The coexistence mechanism can be further improved if the BWA system and the WLAN system are synchronized in the sense that:

- the WLAN system is informed to shut down for the safe transmission part;
- the WLAN system is also informed in advance to start transmission when the silence part begins.

This can be achieved by the transmission of the so-called 802.11a compatible headers (optional) by the BWA BS and the SS's whenever the channel bandwidth is 20 MHz. This header is defined as an 802.11a frame containing an 802.11 CTS (Clear To Send) control message. The Duration/ID value in its MAC header shall be used to inform all reachable WLAN stations that the channel is reserved until the start of next silence part. We recommend that these optional headers be transmitted at the beginning of the DL subframes as well as some of the UL bursts in order to reach WLAN stations in the range of both the BWA DL and UL transmissions. This is illustrated in Figure 1, where the optional headers are denoted as NH's. In addition, these headers should be scheduled by the BWA BS, and be represented in the DL-MAP and UL-MAP as information elements with DIUC/UIUC=0. An 802.11a compatible header has duration of 32 μs. If only the DL subframes and some selected UL bursts are precluded with these headers, the overhead is not too much to accept.

The DL-MAP of the optional frame structure defines the usage of the DL subframes in both the safe and the risky transmission parts. The UL subframe in the safe transmission part and the silence part, which is between the two DL subframes, can be represented as transmission gaps with appropriate lengths. The UL-MAP defines the usage of the two UL subframes in a similar way. An example of the optional frame structure as well as its DL-MAP and UL-MAP is shown in Figure 2. The 802.11a compatible header, if located at the beginning of the safe transmission part, is actually the last DL transmission in the previous frame. As a result, it is represented as the last IE in the DL-MAP of the previous frame. This is also shown in Figure 2.

In a word, with the addition of the silence part into the frame structure, we allow, for example, an organization to deploy 802.16a and 802.11 systems that share the same channel. The optional 802.11a compatible header used for 20MHz bandwidth systems helps to improve the coexistence performance. To ensure that this optional feature can be implemented, the license-exempt SS's must support the optional frame structure. In other words, a SS must be designed in such a way to allow logical overlap of the DL and UL. It does not require any additional development or cost. However, the implementation and use of this feature is optional for the BS.

Suggested changes

The above coexistence mechanism requires the following changes to 802.16a:

- add the optional frame structure to license-exempt bands,
- add a annex to explain the optional coexistence mechanism,
- define a DIUC/UIUC entry for the optional 802.11a compatible header.

The suggested annex is given in the following.

Annex: Recommended practice for coexistence with 802.11 in the license-exempt bands

The license-exempt bands between 2-11 GHz allow deployment of both 802.16a BWA systems and 802.11 WLAN systems. When the two different systems partially overlap with each other and occupies the same band, a coexistence mechanism is needed to allow sharing of the channel between them. A simple and effective way to achieve this goal is to let the two systems to time-share the channel. In other words, the BWA system and the WLAN system control the channel alternatively. This naturally leads to the introduction of a silence part in each BWA frame, as shown in Figure 1. While the BWA transmissions can be carried out in the rest of each frame, this silence part prohibits any BWA transmission to allow the WLAN system to transmit. The BWA system should sense the existence of WLAN stations and issue a silence part in each frame with an appropriate duration. The control of the channel should be elegantly handed over from the BWA system to the WLAN system at the beginning of the silence part, and back to the BWA system at the end of the silence part. This is never a problem because 802.11 uses the CSMA/CA mechanism, which enables the WLAN system to take over the channel once the silence part begins. In addition, when the silence part is over and the BWA system resumes transmission, this mechanism makes the WLAN stations to sense the interference generated by the BWA transmissions, stop transmission and hand over the channel to the BWA system. Obviously, part of the BWA transmissions right after the silence part may collide with WLAN transmission and fail. However, this happens in only a brief period of time following the silence part. After this period of time, no WLAN transmission will continue, and the BWA transmissions no long suffers any interference from the WLAN system. In the optional frame structure shown in Figure 1, a so-called risky transmission part is defined after the silence part, in which the BWA transmissions may suffer interference from the WLAN system. The period after the risky transmission part and the before the next silence part is defined as safe transmission part. The names of the two parts are self-explaining. Each of the two parts has a DL subframe and a UL subframe. To ensure a strong interference to the WLAN system, the subframes in the risky transmission part should not contain any gap (except TTGs and RTGs). Obviously, DL and UL transmissions with high transmission requirements, such as the DL-MAP and UL-MAP, should be carried out in the safe transmission part. As a result, the optional frame structure starts with the safe transmission part, then the silence part, and ends with the risky transmission part. Moreover, ARQ should be applied to the risky transmission part so that retransmission can be arranged for failed transmissions.

The coexistence mechanism can be further improved if the BWA system and the WLAN system are synchronized in the sense that:

- the WLAN system is informed to shut down for the safe transmission part;
- the WLAN system is also informed in advance to start transmission when the silence part begins.

This can be achieved by the transmission of the so-called 802.11a compatible headers (optional) by the BWA BS and the SS's whenever the channel bandwidth is 20 MHz. This header is defined as an 802.11a frame containing an 802.11 CTS (Clear To Send) control message. The Duration/ID value in its MAC header shall be used to inform all reachable WLAN that the channel is reserved until the start of next silence part. We recommend that these optional headers be transmitted at the beginning of the DL subframes as well as some of the UL bursts in order to reach WLAN stations in the range of both the BWA DL and UL transmissions. This is illustrated in Figure 1, where the optional headers are denoted as NH's. In addition, these headers should be scheduled by the BWA BS, and be represented in the DL-MAP and UL-MAP as information elements with DIUC/UIUC=0. Needless to say, these IEs should have appropriate durations so that the whole header can be transmitted.

The DL-MAP of the optional frame structure defines the usage of the DL subframes in both the safe and the risky transmission parts. The UL subframe in the safe transmission part and the silence part, which is between the two DL subframes, can be represented as transmission gaps with appropriate lengths. The UL-MAP defines the usage of the two UL subframes in a similar way. An example of the optional frame structure as well as its DL-MAP and UL-MAP is shown in Figure 2. The 802.11a compatible header, if located at the beginning of the safe transmission part, is actually the last DL transmission in the previous frame. As a result, it is represented as the last IE in the DL-MAP of the previous frame. This is also shown in Figure 2.

In a word, with the addition of the silence part into the frame structure, we allow, for example, an organization to deploy 802.16a and 802.11 systems that share the same channel. The optional 802.11a compatible header used for 20MHz bandwidth systems helps to improve the coexistence performance. To ensure that this optional feature can be implemented, the license-exempt SS's must support the optional frame structure. In other words, a SS must be designed in such a way to allow logical overlap of the DL and UL. It does not require any additional development or cost. However, the implementation and use of this feature is optional for the BS.

Figures

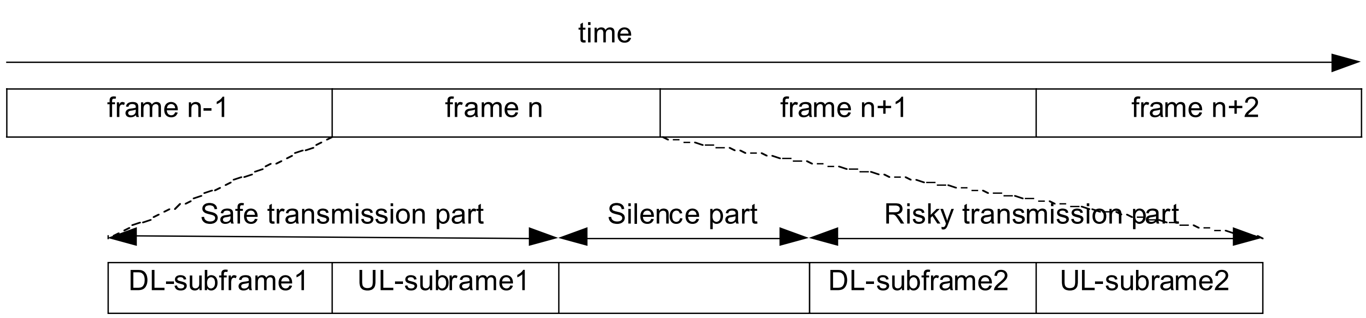

Figure 1—Optional frame structure in the LE bands

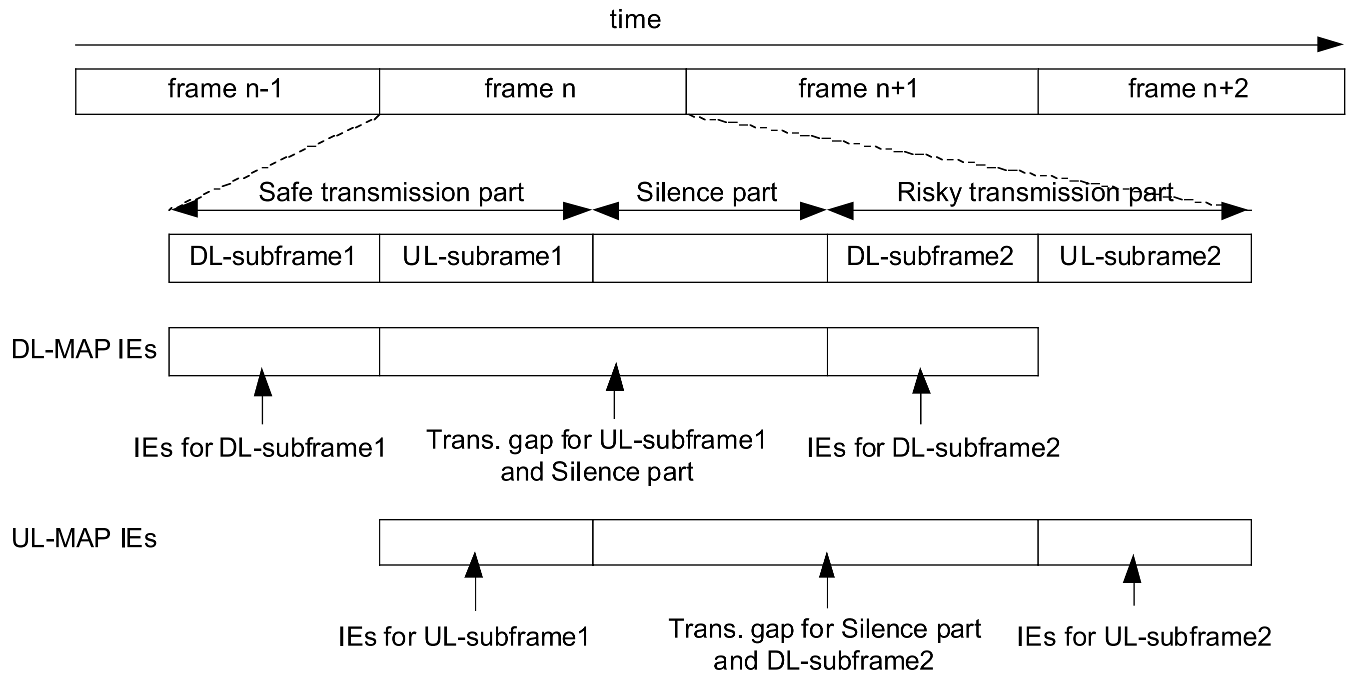

Figure 2—DL-MAP and UL-MAP for the optional frame structure in the LE bands

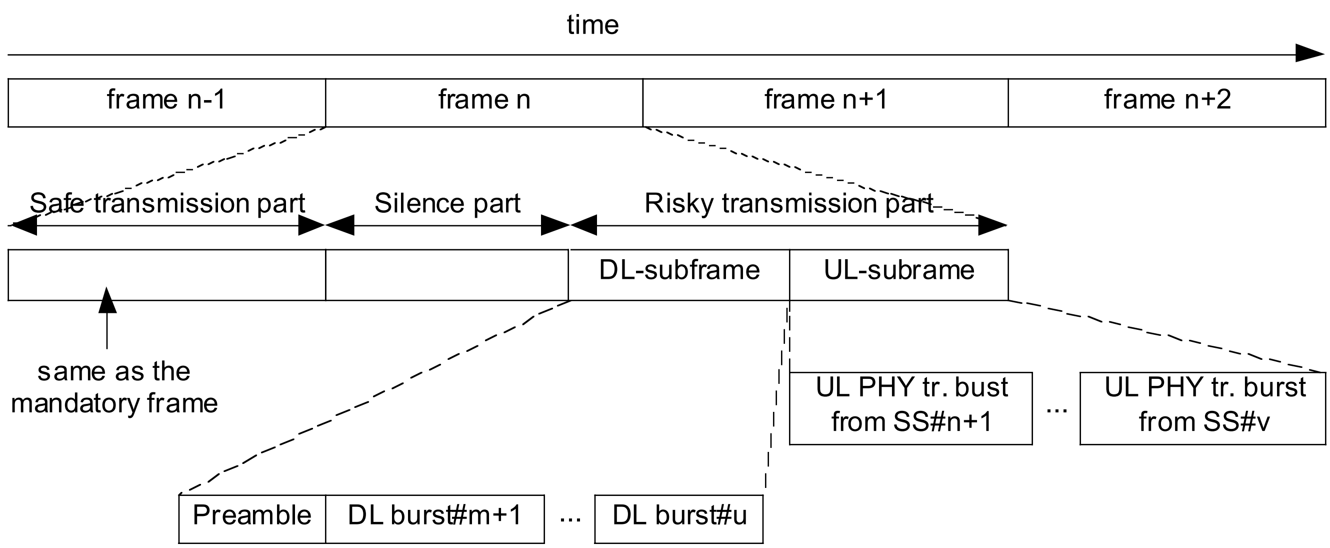

Figure 3—An example of optional OFDM frame structure with TDD in the LE bands

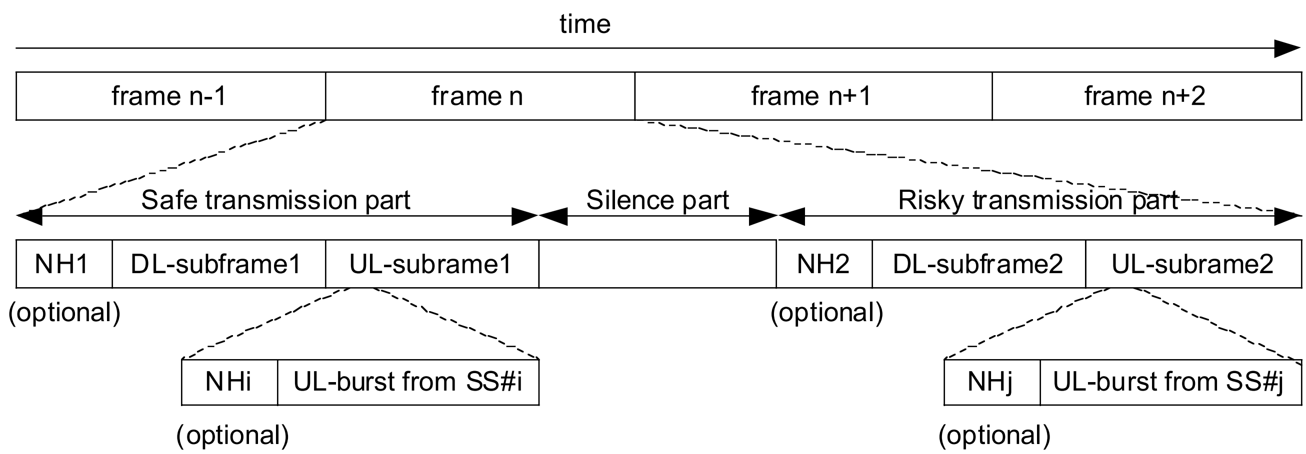

Figure 4—Optional frame structure in the LE bands

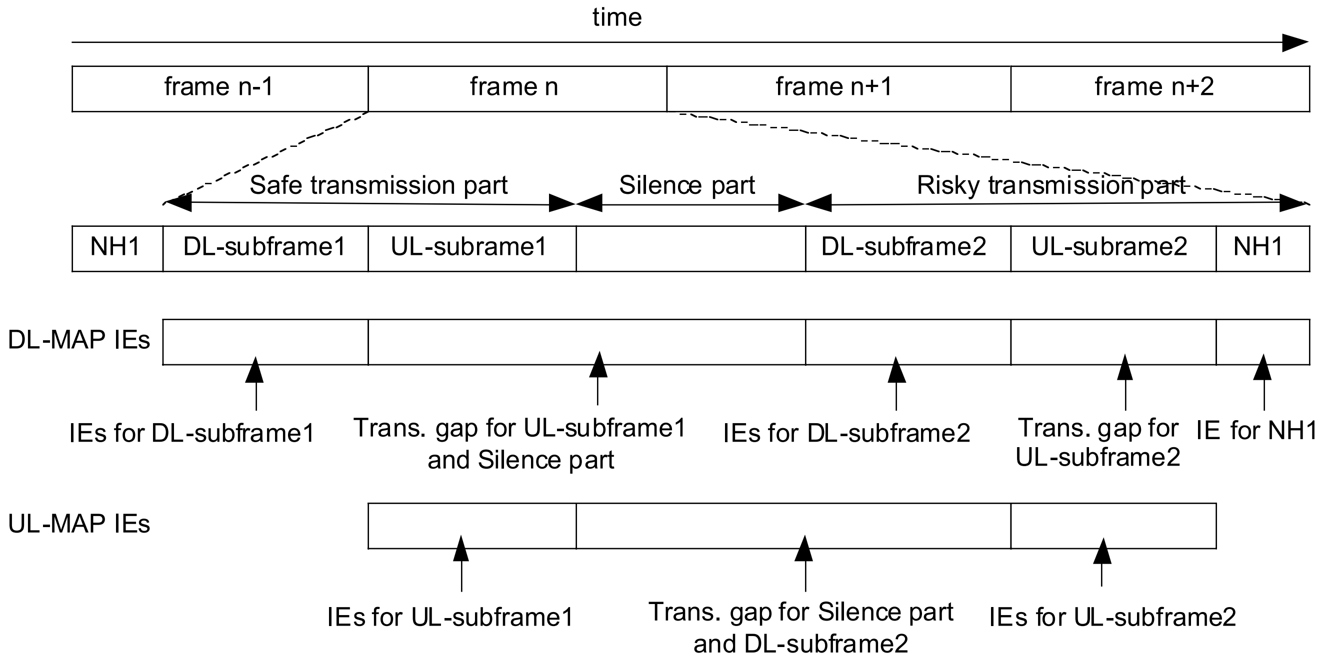

Figure 5—An example of the optional frame structure and its MAPs