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| Abstract | The contribution proposes the frame structure to be included in the 802.16m System Description Document (SDD). The basic frame structure provides for the required legacy support while allowing for the introduction of advanced transmission technology in advanced BSs and MSs. In addition, a low-latency frame structure is introduced to provide lower-latency communications along with legacy support while still allowing for the introduction of advanced transmission technology in advanced BSs and MSs. |
| Purpose | To be discussed and adopted by TGm for use in the 802.16m SDD. |
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# 802.16m Frame Structure to Enable Legacy Support, Technology Evolution, and Reduced Latency

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## 1 Introduction

The contribution proposes the frame structure to be included in the 802.16m System Description Document (SDD). The basic frame structure provides for the required legacy support while allowing for the introduction of advanced transmission technology in advanced BSs and MSs. In addition, a low-latency frame structure is introduced to provide lower-latency communications along with legacy support while stille allowing for the introduction of advanced transmission technology in advanced BSs and MSs.

## 2 Basic 802.16m TDD Frame Structure

The basic objective of the proposed 802.16m frame structure is to achieve legacy support for the WirelessMAN-OFDMA Reference System (per 5.1 of [1]) while enabling the use of new physical layer and MAC layer features that are not themselves supported in the legacy systems. We focus here on WirelessMAN-OFDMA Reference System, per the legacy requirements of [1], though similar ideas may be applied in the FDD case.

Figure 1 outlines the proposal.

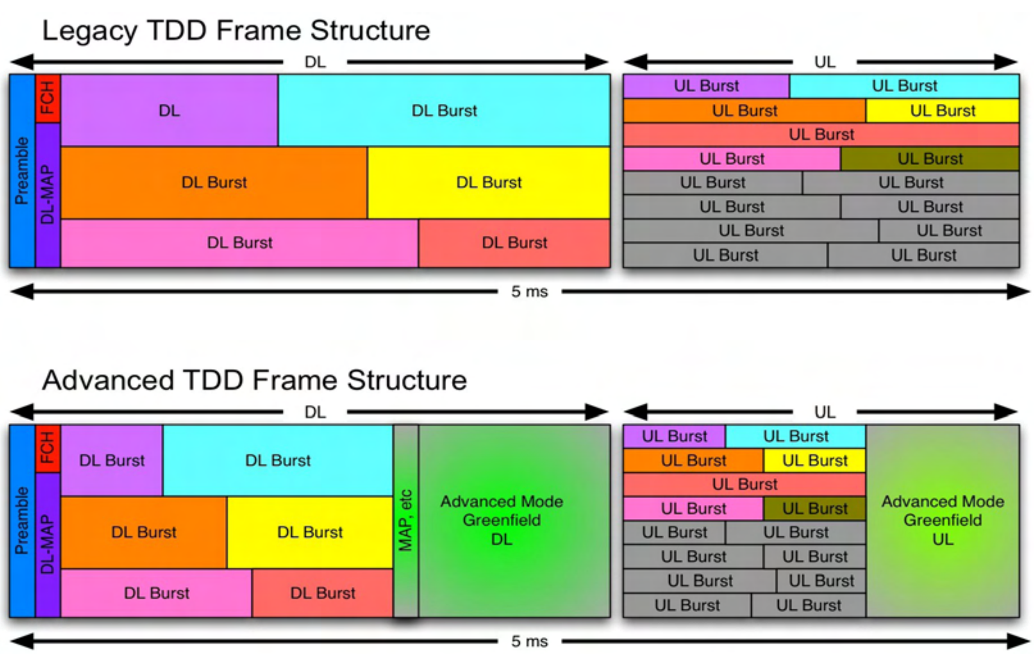


**Figure 1.Basic 802.16m TDD Frame Structure: High-level view**

Notice that the latter portions of the DL and UL subframes are allocated for the "Advanced Mode Greenfield." The "Advanced Mode Greenfield DL" portion of the DL subframe need not be understandable by a legacy MS, since each legacy MS can be addressed with DL bursts in the earlier (legacy) portion of the DL subframe. Likewise, the "Advanced Mode Greenfield UL" portion of the UL subframe may make use of transmission technology unavailable to a legacy MS, because a legacy MS will be assigned to the earlier portion of the UL subframe. In this way, the Advanced Mode BS can support both Advanced Mode MSs (in the Greenfield areas) and legacy MSs (in the earlier areas of the DL and UL subframes).

This frame structure allows great latitude to add new technical innovations in the Greenfield area. In addition, the Advanced Mode Greenfield areas can be dynamically adjusted according to the traffic loads of the system.

Note that this proposal supports the five "backward compatibility requirements" in subclause 5.1 of the System Requirements Document (SRD) [1]. In particular, the second requirement says:

• *An IEEE 802.16m BS shall support a mix of IEEE 802.16m and legacy MSs when both are operating on the same RF carrier. The system performance with such a mix should improve with the fraction of IEEE 802.16m MSs attached to the BS.*

Note that, as the allocation to legacy MSs on the system is reduced, the relative portion of the subframes allocated to the Greenfield technology may be increased dynamically through map allocations. Therefore, this SRD requirement will be met as long as the performance of the Greenfield transmission technology is superior to that of the legacy technology.

Note also that, in the limit as the allocation to legacy MSs falls to zero, the system can be configured to support only Greenfield advanced mode MSs. This will satisfy the requirement in 5.1 of [1] that "IEEE 802.16m shall provide the ability to disable legacy support."

## 2.1 Basic 802.16m TDD Frame Structure: Additional Details

Figure 2 presents a detailed view of the proposed Basic 802.16m TDD Frame Structure.

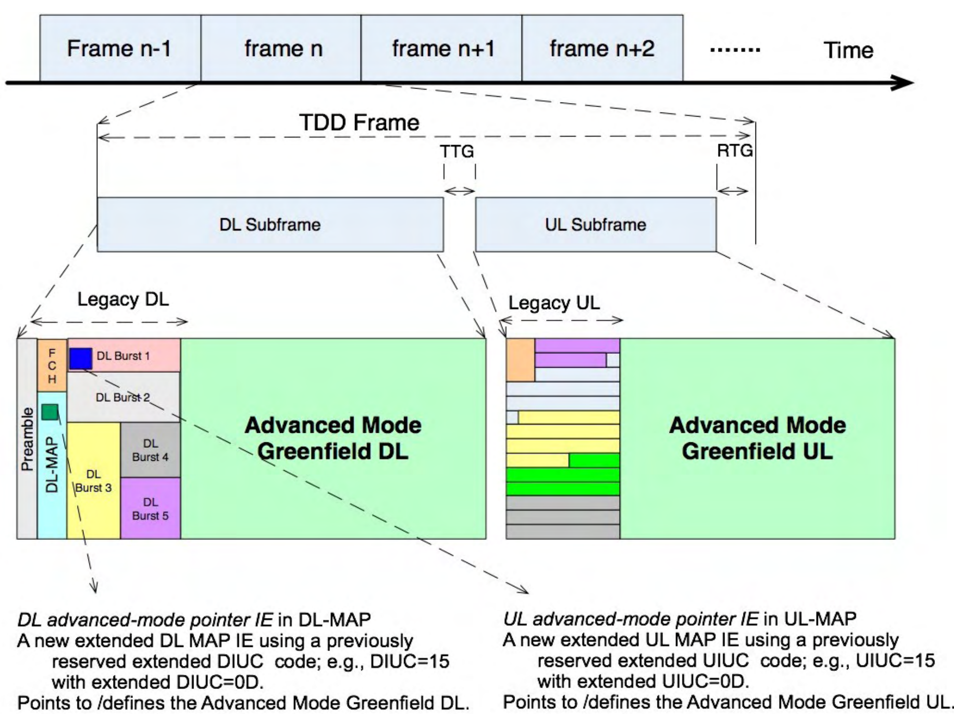


**Figure 2.Basic 802.16m TDD Frame Structure: Detailed view**

The basic idea is to accommodate legacy systems and the newly developed 802.16m communications technologies within the TDD frame in a time-division manner. A frame starts with the preamble, first DL PUSC zone with FCH, and DL-MAP, all in accordance with the legacy WirelessMAN-OFDMA Reference System. A new DL MAP IE, designated the *DL advanced-mode pointer IE*, is defined and used in the DL-MAP to point to and specify the Greenfield DL portion of the DL subframe. The new *DL advanced-mode pointer IE* uses a heretofore-reserved extended DIUC code; e.g., DIUC=15 with extended DIUC=0D. Since it is currently a reserved code, the legacy MS shall skip it. Similarly, a new *UL advanced-mode pointer IE* is defined and used to point to and specify the Greenfield UL portion of the subframe. The new *UL advanced-mode pointer IE* uses a heretofore-reserved extended UIUC code; e.g., UIUC=15 with extended UIUC=0D.

The allocations in the Greenfield portions of the subframes can be specified by the DL/UL-MAPs, which can be designed and encoded in more efficient way than the current legacy DL/UL MAPs. Futhermore, new channel descriptors can be designed and transmitted in the Greenfield portion of the DL subframe.

## 3 Low-Latency 802.16m Frame Structure

The IEEE 802.16m System Requirements includes latency requirements (per 6.2 of [1]). Although it may in principle be possible to meet those requirements by means of the frame structure of Clause 2 above, issues such as HARQ retransmission may reduce the effective latency. Here we propose a low-latency 802.16m Frame Structure that provides legacy support for the WirelessMAN-OFDMA Reference System (per 5.1 of [1]).

The basic idea is described in Figure 3.

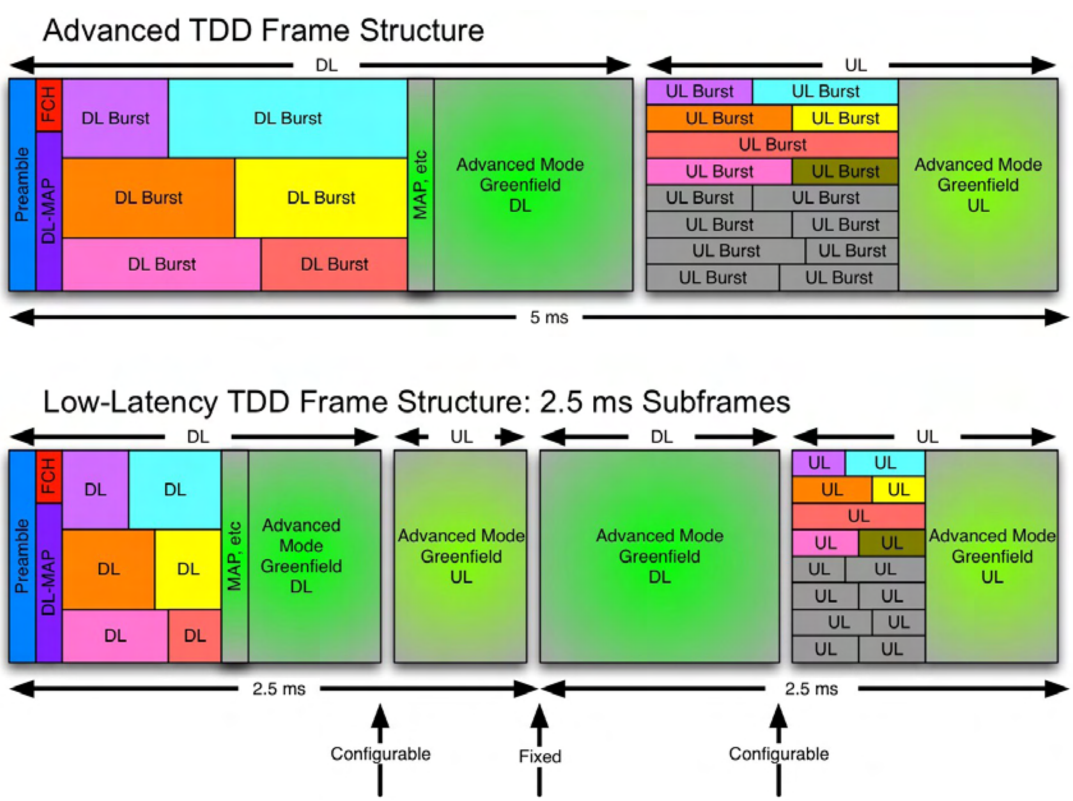


**Figure 3.Low-Latency 802.16m TDD Frame Structure**

Note that the 5 ms frame has been divided into two 2.5 ms subframes. Each includes a DL subsubframe and then a UL subsubframe. The DL subsubframe of the first subframe is similar to the DL subframe of Figure 1, including the Greenfield portion. The UL subsubframe of the second subframe is similar to the UL subframe of Figure 1, including the Greenfield portion. In between, we have inserted a UL subsubframe and then a DL subsubframe. These are entirely based on Greenfield transmission technologies.

Compared to Figure 1, Figure 3 provides for a shorter cycle time between the DL and UL. This allows for a more rapid exchange of data and therefore a lower latency.

As in Figure 1, the “Advanced Mode Greenfield” portion of the subframes need not be understandable by a legacy MS. Therefore, the entire center Greenfield portion of the 5 ms frame will appear to the MS just like the center Greenfield portion of the Basic 802.16m TDD Frame Structure of Figure 1. As a result, the legacy support using the Low-Latency 802.16m TDD Frame Structure will be identical to that of the Basic 802.16m TDD Frame Structure. (However, see Section 3.1 regarding coexistence of the Low-Latency 802.16m TDD Frame Structure with the legacy frame structure and the Basic 802.16m TDD Frame Structure.)

Note that this proposal supports the five “backward compatibility requirements” in subclause 5.1 of the System Requirements Document (SRD) [1]. In particular, the second requirement says:

• *An IEEE 802.16m BS shall support a mix of IEEE 802.16m and legacy MSs when both are operating on the same RF carrier. The system performance with such a mix should improve with the fraction of IEEE 802.16m MSs attached to the BS.*

Note that, as the allocation to legacy MSs on the system is reduced, the relative portion of the subframes allocated to the Greenfield technology may be increased dynamically through map allocations. Therefore, this SRD requirement will be met as long as the performance of the Greenfield transmission technology is superior to that of the legacy technology.

Note also that, in the limit as the allocation to legacy MSs falls to zero, the system can be configured to support only Greenfield advanced mode MSs. This will satisfy the requirement in 5.1 of [1] that “IEEE 802.16m shall provide the ability to disable legacy support.”

## 3.1 Coexistence with Basic 802.16m Frame Structure and Legacy Frame Structure

As mentioned earlier, the legacy support using the Low-Latency 802.16m TDD Frame Structure will, in principle, be identical to that of the Basic 802.16m TDD Frame Structure. However, TDD systems are generally synchronized to avoid simultaneous BS and MS transmissions in adjacent cells or adjacent bands. The use of the 2.5 ms subframe could result in MS transmission during a period when the BS of the legacy system (or the Basic 802.16m TDD Frame Structure system) is transmitting, or vice versa. The resulting interference could be difficult to manage.

However, coexistence can be enabled through synchronization, as shown in Figure 4. Note that the time at which the subframes transition from DL to UL is configurable, as noted in Figure 3. Those transition times establish the amount of the 5 ms frame that can be used by a synchronized Basic 802.16m TDD Frame Structure system. If the two transitions move toward the center of the 5 ms frame, the synchronized Basic 802.16m TDD Frame Structure system is provided with more transmission opportunities and therefore better efficiency. On the other hand, this reduces the amount of the frame available for the center Greenfield areas; this would reduce the amount of the frame available for low-latency communications. The optimal configuration could be selected by the operator to balance the two requirements. With time, the requirements for legacy support may decrease; in this case, the operator could easily reconfigure the systems.

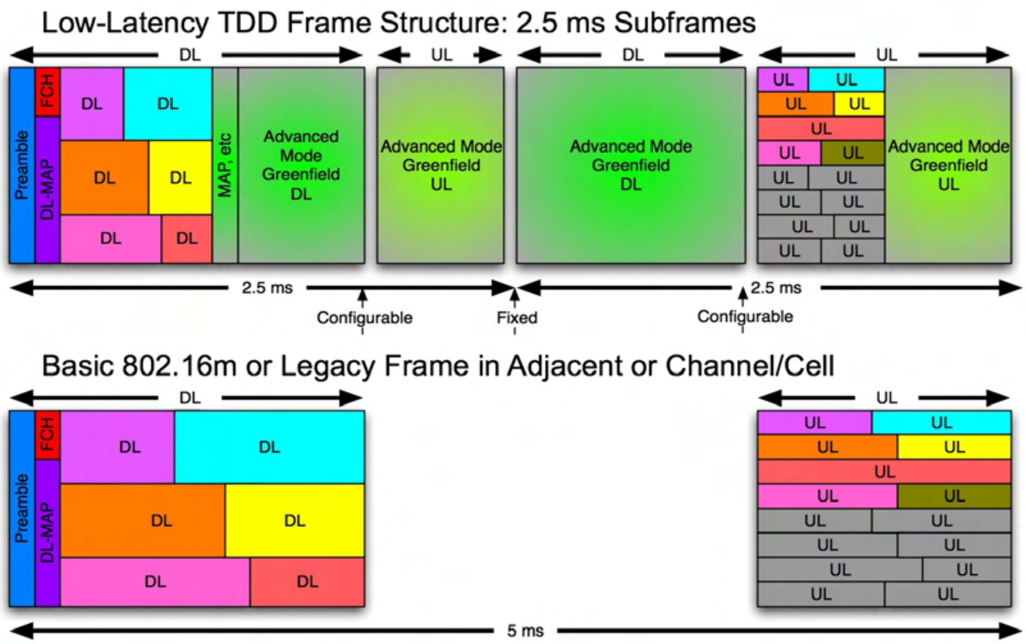


**Figure 4.Coexistence with Basic 802.16m Frame Structure and Legacy Frame Structure**

Note that coexistence is also possible by aligning the legacy subframes in the alternative fashion shown in Figure 5. This could prove advantageous in some cases.

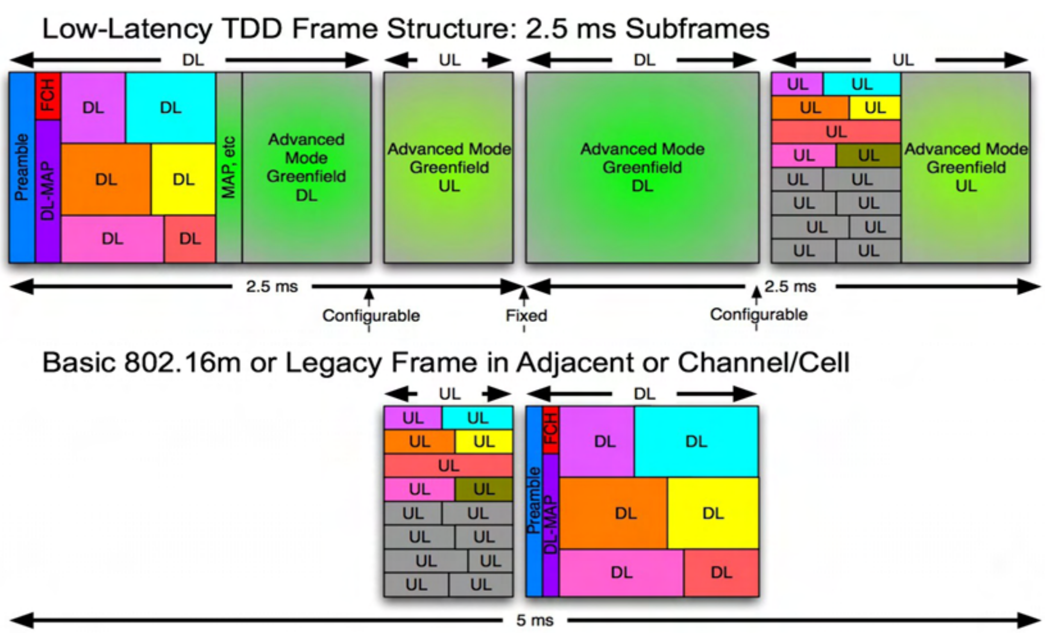


**Figure 5.Alternative Coexistence Scenario with Basic 802.16m Frame Structure and Legacy Frame Structure**

# 4 Conclusion and Recommendation

Legacy support is a critical issue for 802.16m, and the frame structure is the key to legacy support.

The 802.16m System Description Document (SDD) should include a section on the frame structure. It should specify the Basic 802.16m TDD Frame Structure of Section 2 as well as the Low-Latency 802.16m TDD Frame Structure of Section 3 as alternatives.

# 5 References

[1] IEEE 802.16m-07/002r4 ("IEEE 802.16m System Requirements")