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| Re: | IEEE 802.16m-07/047 ("Call for Contributions on Project 802.16m System Description Document (SDD)") |
| Abstract | The contribution proposes the frame structures to be included in the 802.16m System Description Document (SDD). The proposed frame structures provide for the required legacy support while 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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| Patent Policy |  |

# 802.16m Frame Structure

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## 1 Introduction

The contribution first discusses the key considerations for the 802.16m frame structure design criteria and proposes the general frame structure to be specified in the 802.16m System Description Document (SDD). The proposed frame structure provides for the required legacy support while allowing for the introduction of advanced transmission technology in Advanced Mode systems.

## 2 Key Considerations for 802.16m 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 the SRD [1]) while enabling the use of new physical layer and MAC layer features that are not themselves supported in the legacy systems.

The key considerations for 802.16m frame structure are:

1) Support for two deployment scenarios:

   1.a) Mixed deployment with both WirelessMAN-OFDMA Reference System and Advanced Mode MSs; i.e., with legacy support enabled. System performance should improve with the ratio of Advanced Mode MSs. According to the SRD, this occurs only in the case of TDD, since the WirelessMAN-OFDMA Reference System is TDD only. However, we can also consider legacy compatibility in the FDD case.

   1.b) Pure Advanced Mode deployment with legacy support disabled.

2) Support for two duplexing modes:

   2.a) TDD

   2.b) FDD/ (with support for HFDD MSs)

3) Frame structure in the time domain

   3.a) 5 ms frame duration for WirelessMAN-OFDMA Reference System support (TDD only).

   3.b) 5 ms frame duration divided into subframes for latency reduction. Backward compatibility can be satisfied by providing WirelessMAN-OFDMA Reference System support in one DL and one UL interval per frame; the others need support Advanced Mode only.

4) Channel Size (frame structure in the frequency domain)

   4.a) Advanced Mode uses the same channel size as WirelessMAN-OFDMA Reference System.

   4.b) Advanced Mode uses a larger channel size than WirelessMAN-OFDMA Reference System.

5) Granularity of the subframes

5.a) Time domain: at symbol boundary or at the symbol group boundary, where the symbol group consists of a predefined integer number of symbols.

5.b) Frequency domain: the granularity is one OFDMA subchannel.

6) Advanced Mode Frame Structure

The key question for this topic is: what elements of the legacy system should be reused and what new details should be developed? New features should be included only if they provide clear technical merits. The full details should be deferred to development of the 802.16m draft. The SDD should be limited to the basic design and key issues; e.g., preamble or no preamble, new preamble, or the same preamble as in the legacy system.

7) TDD Co-channel and Adjacent channel Coexistence

7.a) TDD coexistence with WirelessMAN-OFDMA Reference System

7.b) TDD coexistence with other RATs

8) Channel aggregation, also known as multi-channel operation or multi-carrier operation

8.a) adjacent channel aggregation

8.b) non-adjacent channel aggregation

9) Advanced Antenna Systems, e.g., MIMO, Beamforming.

The advanced antenna systems add another dimension to the frame structure; i.e., space. Thus we have a 3-dimensional frame structure including time, frequency, and space.

## 3 Proposed Criteria for 802.16m Frame Structure Design

As we have a long list of key considerations for the 802.16m frame structure design, as described in Section 2, it would be very helpful to list some basic design criteria. We propose:

1) meet the performance requirements as developed in the 802.16m SRD

2) support the legacy WirelessMAN-OFDMA Reference System per the 802.16m SRD

3) system performance that improves with the ratio of Advanced Mode MSs, per the 802.16m SRD

4) simple, practical, and efficient

5) flexible to accommodate all possible variants in a simple way

6) extendable

# 4 Suggested Text in 802.16m SDD for 802.16m Frame Structure

The following is proposed text to be included in the 802.16m SDD for the 802.16m frame structure:

# 802.16m Frame Structure

The 802.16m frame structure is designed to provide the required legacy system support while allowing for the introduction of advanced transmission technology in Advanced Mode BSs and MSs. In addition, the 802.16m frame structure provides support for lower latency, larger channel size, multi-channel operation, advanced antenna systems, and TDD coexistence for TDD systems.

## 4.1 802.16m TDD Frame Structure

### 4.1.1 802.16m Basic TDD Frame Structure

Figure 1 shows the proposed 802.16m Basic TDD frame structure, with the same frame duration and channel size as the WirelessMAN-OFDMA Reference System.

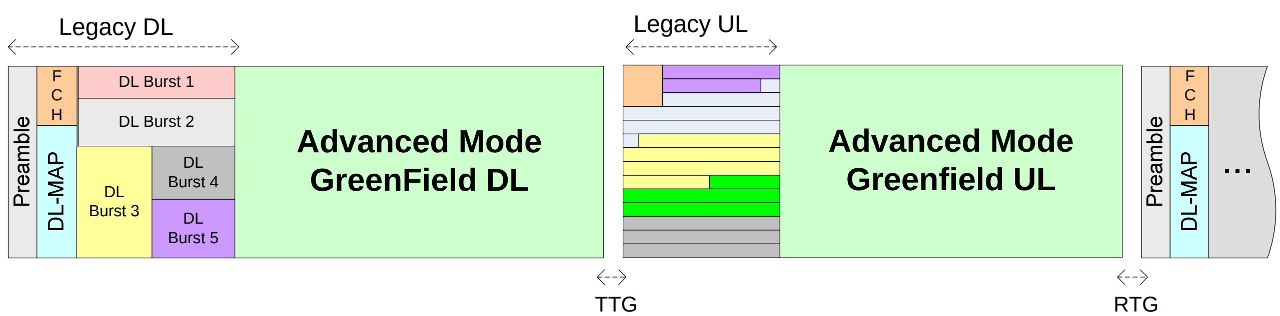


**Figure 1. Proposed 16m Basic TDD Frame structure**

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.”

### 4.1.2 802.16m Lower-Latency TDD 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 Figure 1, 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]).

Figure 1 illustrates the proposed 16m low-latency TDD frame structure, in which 5 ms frame has been divided into two 2.5 ms subframes [1]. 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.

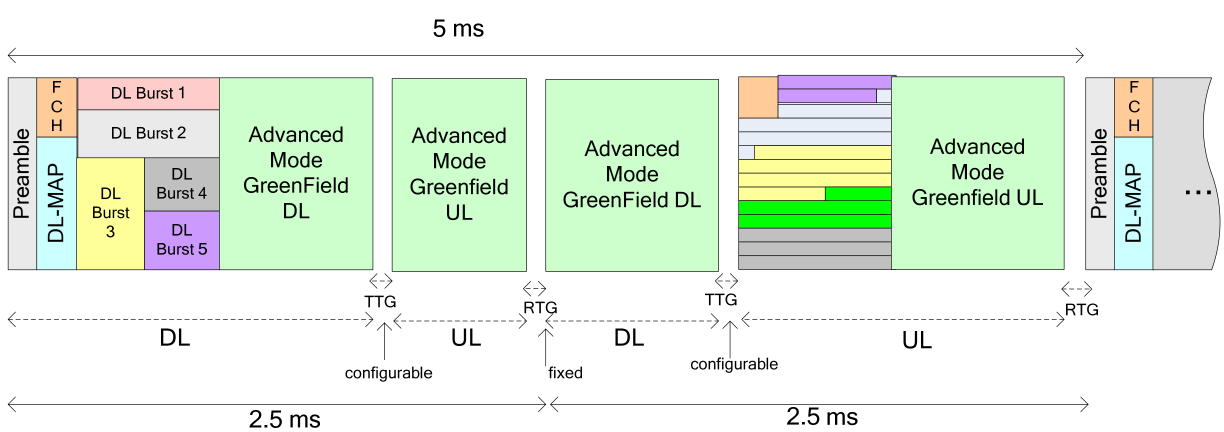


**Figure 2. 16m Low-Latency TDD Frame structure**

Compared to Figure 1, Figure 2 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.

### 4.1.3 Wider Bandwidth 802.16m TDD Frame Structure

The 802.16m systems may have a wider channel bandwidth than the Legacy system as specified in the 802.16m SRD [1]. With the Legacy support enabled, the 802.16m frame structure needs to support the cases where the 802.16m system has a wider channel bandwidth than the Legacy system [5][10][11].

Figure 4 show an 802.16m frame structure that supports the wider bandwidth for the 802.16m than for the Legacy system, while the support for the Legacy system is enabled. In Figure 4, the Legacy frame is in the middle of the larger channel, which provides the advantages of having the same center frequency settings for both 802.16m and the Legacy system, broad guardband on either side of legacy devices, and applicable to any combinations of the 802.16m channel and the Legacy system channel.

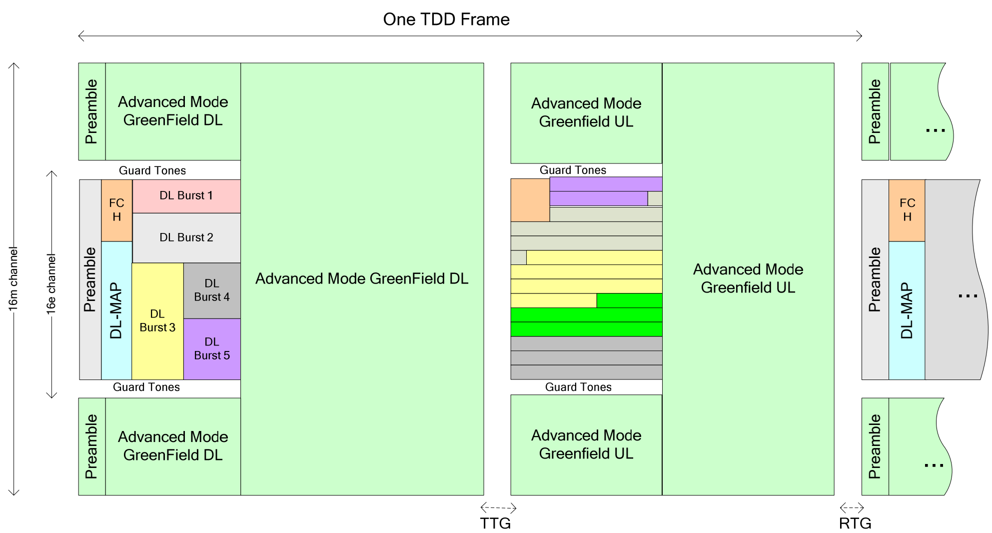


**Figure 3. Wider Bandwidth 802.16m TDD Frame Structure with Legacy Frame in the Middle**

When the 802.16m channel is twice as large as the Legacy system channel, Figure 3 represents alternative 802.16m TDD frame structure that supports two Legacy system channels in an 802.16 channel. This gives the advantage of providing higher system capacity for the Legacy systems that may be needed at the initial deployment of 802.16m systems.

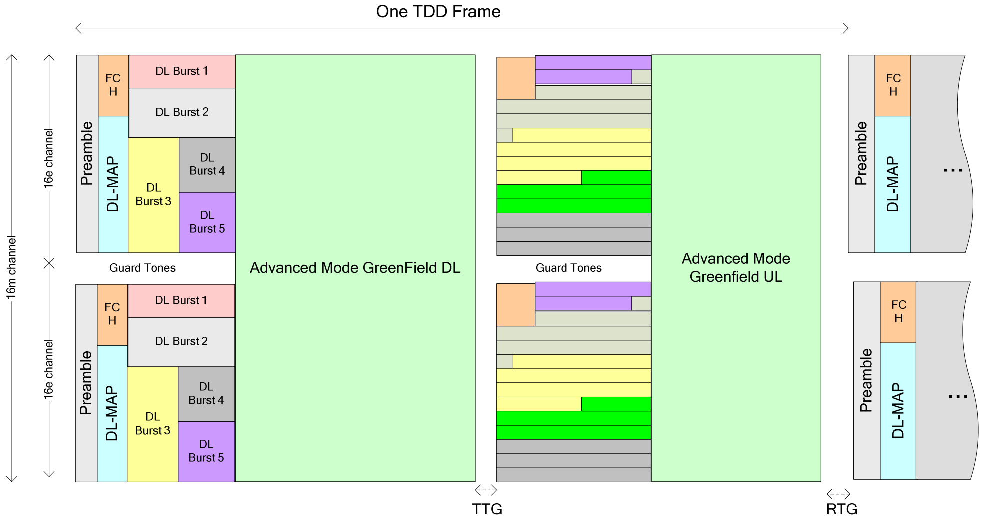


**Figure 4. 802.16m TDD Frame Structure with Twice the Legacy System Bandwidth**

### 4.1.4 802.16m TDD Frame Structure with Support for Coexistences

Figure 5 and Figure 6 shows two alternative 802.16m TDD frame structures with support for coexistence [7].

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.

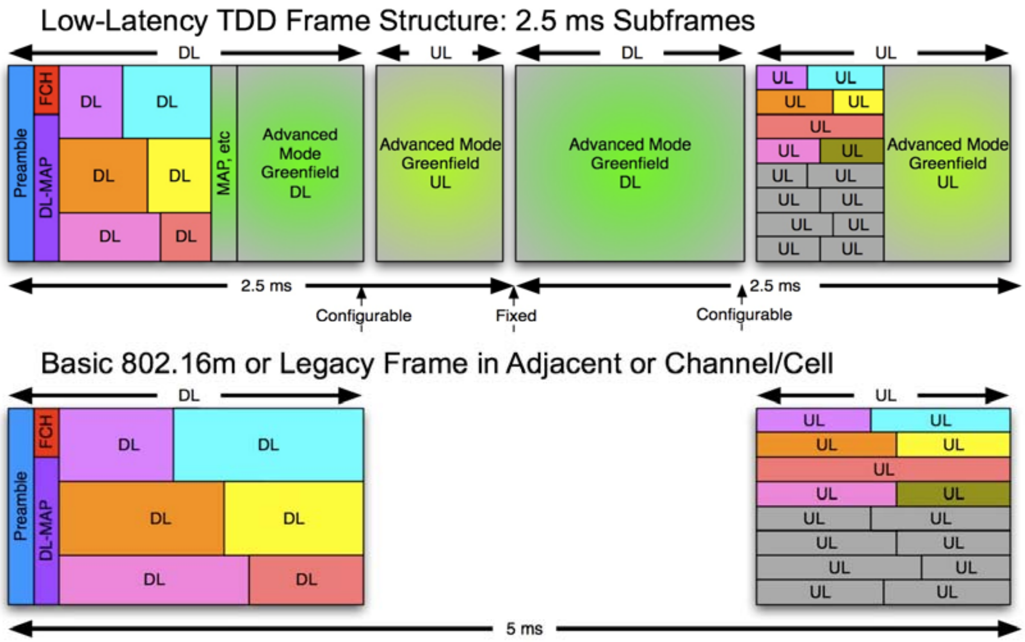


**Figure 5. Coexistence with Basic 802.16m Frame Structure and Legacy Frame Structure**

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.

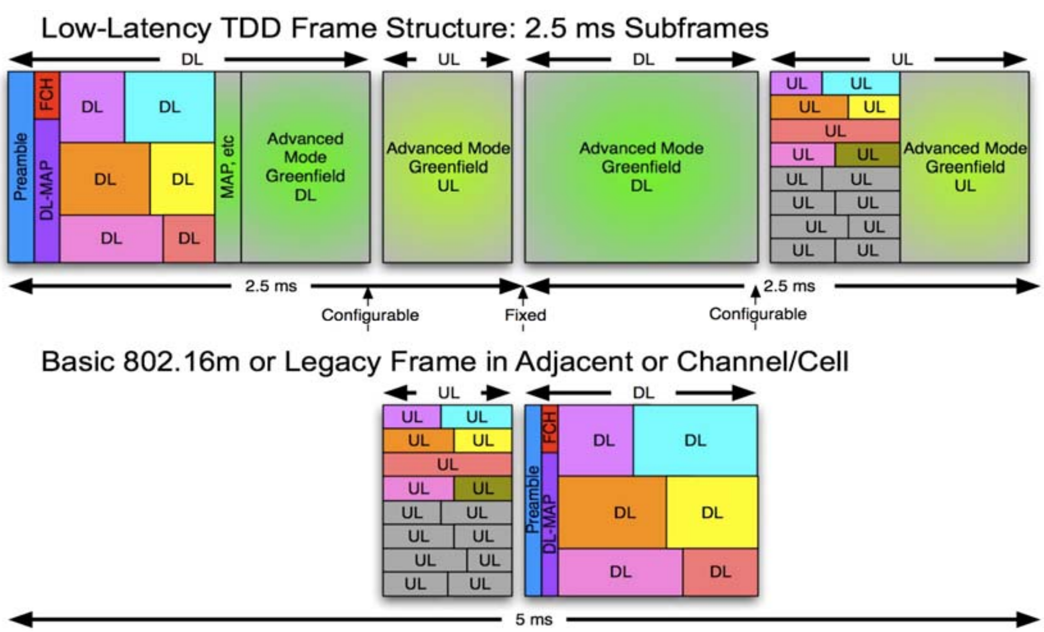


**Figure 6. Alternative Coexistence Scenario with Basic 802.16m Frame Structure and Legacy Frame Structure**

## 4.2 802.16m FDD Frame Structure

Per subclause 5.6 of the SRD [1], "IEEE 802.16m shall support both Time Division Duplex (TDD) and Frequency Division Duplex (FDD) operational modes. The FDD mode shall support both full-duplex and half-duplex MS operation.  Specifically, a half-duplex FDD (H-FDD) MS is defined as an FDD MS that is not required to transmit and receive simultaneously."

### 4.2.1 802.16m Basic FDD Frame Structure

Figure 7 shows the proposed 802.16m basic FDD frame structure.

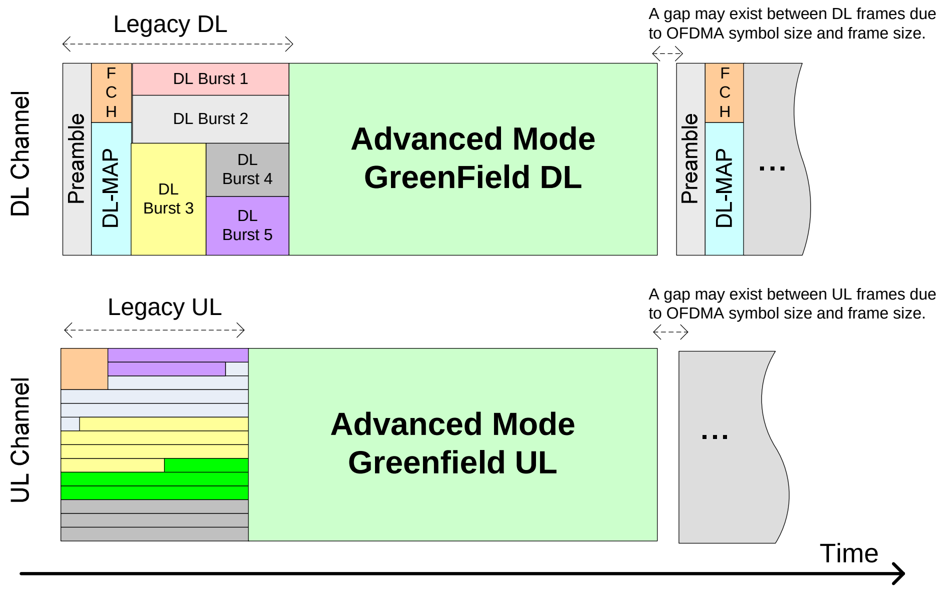


**Figure 7. Proposed 16m Basic FDD/HFDD Frame structure**

In Figure 7, the Legacy DL and Legacy UL refers to possible FDD deployments based on the legacy IEEE Std 802.16, even though the WirelessMAN-OFDMA Reference System is defined for TDD only. The basic idea of supporting the legacy FDD systems is to share the channels between the Advanced Mode devices and the Legacy devices in a time-division manner, so that the complexity of having different transmission technologies in the same symbol can be avoided.

More details will be added based on 802.16 Rev2 FDD development.

## 5 Conclusion and Recommendation

The 802.16m System Description Document (SDD) should include a section on the frame structure, as described in Section 4 in this document.

## 6 References

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