World WLAN Application Alliance

WAA-TS 015-2025

Technical Specification for WLAN Single-Device Performance and Experience in Home Scenarios (Based on IEEE 802.11be-2024)

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Foreword

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Contents

1 Overview

1.1 Scope

This document regulates the technical requirements for WLAN performance and experience in home scenarios proposed by WAA. The single device in home scenarios includes home gateways and wireless routers in home scenarios.

1.2 Applicability

This document is applicable to the design, development, production, and test of home gateways or wireless routers, and mainly applied to WAA technical requirements for WLAN performance and experience of home gateways or wireless routers. Devices on which the WAA performance and experience tests and certification are conducted should meet the regulatory requirements of relevant countries, including spectrum range, transmit power/transmit power control, interference avoidance/dynamic frequency selection, etc.

1.3 Word Usage

In this document, the word "shall" is used to indicate a mandatory requirement. The word "should" is used to indicate a recommendation. The word "may" is used to indicate that something is permitted. The word "can" is used to indicate that something is possible.

2 Normative References

The contents of the following documents, through normative references, constitute essential provisions of this document. For reference documents with a date, only the version corresponding to the date is applicable to this document. For undated reference documents, the latest version (including all amendments) is applicable to this document.

[1] IEEE Std 802.11-2024 IEEE Standard for Information Technology Telecommunications and Information Exchange between Systems Local and Metropolitan Area Networks Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

[2] IEEE Std 802.11be-2024 IEEE Standard for Information technology Telecommunications and information exchange between systems Local and metropolitan area networks Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 2 Enhancements for Extremely High Throughput (EHT).

[3] IEEE Std 802.11i-2024 IEEE Standard for Information technology Telecommunications and information exchange between systems Local and metropolitan area networks Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6 Medium Access Control (MAC) Security Enhancements.

[4] Wi-Fi Alliance WPA3™ Specification Version 3.5, https://www.wi-fi.org/system/files/WPA3%20Specification%20v3.5.pdf.

3 Terms and Definitions

3.1 Scenario

In this document, "scenario" is used generally to refer to systems and system running. Systems include endpoints, networks, wireless propagation environments, servers, users, etc. The system running includes the interaction conditions between subsystems and components in specific usage, including various factors that affect the network performance and service performance, such as the mobile phone and the wireless router within 3 meters, users participating in video conferences,etc.

3.2 Home Scenario

In this document, "home scenario" is used generally to refer to the service scenario consisting of network elements (such as network access devices, Internet services, endpoints) involved in users' activities such as learning, entertainment and social production using the network at home.

3.3 Scenario Model

In order to simulate the network environment used by users, a collection of usage environment elements and device requirements such as the proposed endpoints, networks, and wireless propagation environments are used to configure the test platform and create an integrated system for performance testing. Scenario models vary with requirements for basic network performance and service performance, to simulate the actual scenario where a tested device is used.

3.4 Basic Performance Requirements

During the process of using the network, network users have basic evaluation requirements for network performance, such as bandwidth, access endpoint connectivity, coverage, latency, and other indicators. Most indicators are requirements for devices, while some indicators are networking requirements, such as roaming capability. The basic performance requirements of the network can support the evaluation of service performance requirements.

3.5 Service Performance Requirements

Service performance requirements are derived on the application level and are used to evaluate the network performance of multiple services carried by one network. In the test, the service type, number of services, and proportion of each service on the network must be specified to simulate the actual usage environment with typical networking models and evaluate the network capabilities to support application experience. Performance requirements include human experience of interactive systems (including but not limited to frame freezing, voice delay, operation delay, etc.), as well as machine to machine interaction requirements (such as processing latency required for industrial robot control).

3.6 Test platform

Test platform consists of elements such as endpoints, networks, and the wireless propagation environment. It is an integrated system used to simulates the network environment used by users, which can modify environmental parameters, network parameters, and endpoint parameters to complete performance testing of devices, networks, and services.

3.7 Latency

Latency refers to the end-to-end (E2E) latency that needs to be guaranteed for different service networks.

3.8 Packet Loss Ratio

Packet loss ratio refers to the proportion of the number of packets that fail to be sent to the total number of packets.

3.9 Service concurrency

Service concurrency means users who actually access the network during the same time period are simultaneously using the network or services concurrently.

3.10 2.4 GHz

It generally refers to the available 2.4 GHz frequency band spectrum for wireless local area networks in a country where the device is used. Each country has different regulations on the spectrum that can be used. The devices must comply with the corresponding RF technical requirements and interference avoidance technical requirements of the country (for example, the 2.4 GHz frequency band range allowed for wireless local area networks in the People's Republic of China is 2400 MHz–2483.5 MHz).

3.11 5 GHz

It generally refers to the available 5 GHz frequency band spectrum for wireless local area networks in the country where the device is used. Each country has different regulations on the spectrum that can be used. The devices must comply with the corresponding RF technical requirements and interference avoidance technical requirements of the country (for example, the 5 GHz frequency band ranges allowed for wireless local area networks in the People's Republic of China are 5150 MHz–5350 MHz and 5725 MHz–5850 MHz).

3.12 Bandwidth

Different frequency bands of 20 MHz, 40 MHz, 80 MHz, and 160 MHz should comply with spectrum division requirements of the country.

3.13 Interference

Interference refers to the impact of unwanted energy generated by one or more types of transmission, radiation, induction, or a combination thereof on the reception of wireless communication systems. It can lead to performance deterioration, misunderstanding, or information loss. If such energy does not exist, the consequence can be avoided.

4 Acronyms and Abbreviations

The following acronyms and abbreviations apply to this document.

AC: Access Controller

AP: Access Point

CSMA/CA: Carrier Sense Multiple Access With Collision Avoidance

CCMP: Counter Mode with CBC-MAC protocol

FTTR: Fiber to the Room

IP: Internet Protocol

IPTV: Internet Protocol Television

KPI: Key Performance Indicator

KQI: Key Quality Indicator

LAN: Local Area Network

MAC: Media Access Control

MIMO: Multiple Input Multiple Output

MLO: Multi-Link Operation

MRU: Multi-Resource Unit

MTU: Maximum Transmission Unit

NSS: Number of Spatial Stream

OPEN-SYS: Open System

OWD: One-Way Delay

PHY: Physical Layer

RTT: Round Trip Time

SAE: Simultaneous Authentication of Equals

SSID: Service Set Identifier

STA: Station

TCP: Transmission Control Protocol

TID: Traffic Identifier

TKIP: Temporal Key Integrity Protocol

UDP: User Datagram Protocol

WEP: Wired Equivalent Privacy

WLAN: Wireless Local Area Network

WPA2: WLAN Protected Access2

WPA3: WLAN Protected Access3

5 Network Structure and Device Components in Home Scenarios

5.1 Network Structure in Home Scenarios

The network includes segments of home network, access network, metropolitan area network (MAN), backbone network, and operator interconnection, as shown in Figure 1. Each segment is defined as follows:

1. Home network segment: a segment from a user endpoint to the user-side interface of a user-side device in the access network, with added walls as shown in Figure 2;
2. Access network segment: a segment from the user-side interface of a user-side device in the access network to the network-side interface of a local device in the access network;
3. MAN segment: a segment from the network-side interface of the local device in the access network to the MAN egress;
4. Backbone network + server segment: a segment from the MAN egress to the server.

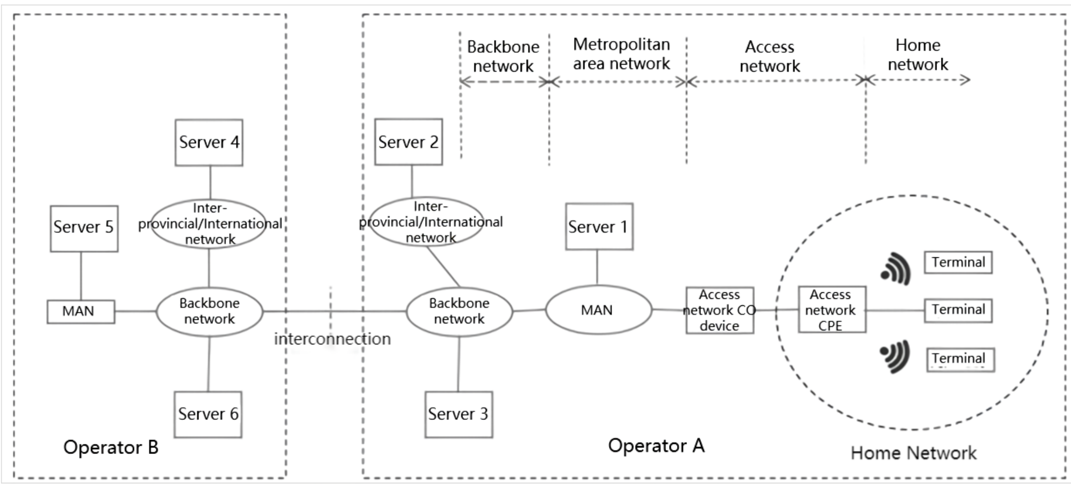

Figure 1 Diagram of home network structure

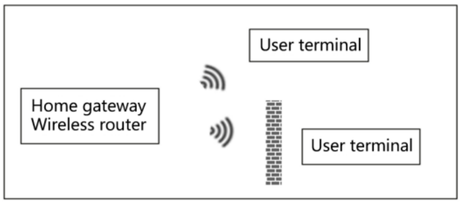

Figure 2 Diagram of home network single-device networking

5.2 Device Components

In home scenarios, network products mainly include home gateways, wireless routers, wireless router networking suite, and FTTR networking suite, etc. Based on the number of network devices in a home, the tested objects in home scenarios can be divided into single device products and networking device products.

1. single device products: home gateway or wireless router. This document only focuses on the single devices that support IEEE 802.11be technology.
2. Home networking device products: FTTR, wireless router networking, and home AC+AP.

6 Overview of Network Performance Requirements for Single-Device WLAN in Home Scenarios

6.1 Basic Performance Overview for Single-Device WLAN in Home Scenarios

For the single-device situation in home scenarios, bandwidth, latency, coverage, connectivity, security, and stability are the six network performance indicators that ensure the home WLAN service experience. See Figure 3.

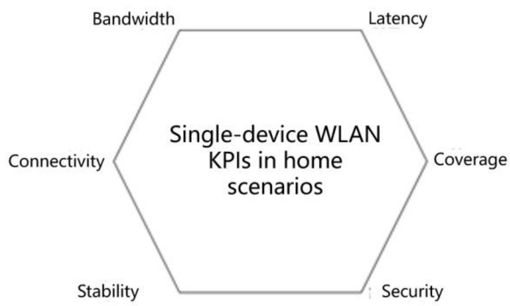

Figure 3 Performance indicators of single-device WLAN in home scenario

6.2 Overview of KPIs & KQIs for Services Carried by Single-Device WLAN in Home Scenarios

Services in home scenarios include voice, web browsing, upload/download, IPTV, mobile gaming, cloud gaming, Internet videos, e-Learning, VR videos, VR gaming, etc. For the above services, the network related KQI that affect users' perception of service experience are shown in Figure 4.

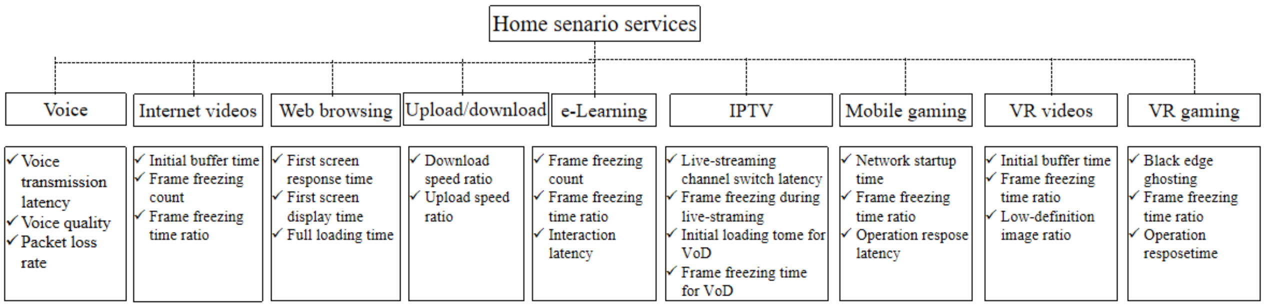

Figure 4　Service KQIs in home scenarios

Service KQIs in home scenarios refer to indicators that affect user experience and are perceptible to users, such as operation duration and frame freezing ratio, etc; From the perspective of network KPI, the network elements that affect the KQIs of a certain service mainly include the following indicators:

1. Minimum bandwidth required by the service;
2. Maximum latency and latency jitter that the service needs to satisfy;
3. Maximum packet loss ratio that the service needs to meet.

Service experience scenarios defined in this document are used to evaluate the bandwidth, latency, latency jitter, and packet loss ratio of each service application in a typical scenario mainly by constructing a comprehensive home scenario.

7 Basic Performance Requirements for Single-Device WLAN in Home Scenarios

7.1 Bandwidth

7.1.1 Bandwidth Parameters and Scenario Model

7.1.1.1 Bandwidth Parameters

The bandwidth parameters refer to the maximum performance parameters that a single user can obtain when using a WLAN network. In home scenarios, the bandwidth parameters directly affect the experience of bandwidth-hungry services, such as the speed test, data download, 8K video, and cloud gaming.

The bandwidth parameters of a WLAN interface is mainly used to measure the maximum throughput of the WLAN interface. The device working models is defined as follows.

7.1.1.2 Bandwidth Scenario Model 1: Single User on a Single Frequency Band Without Interference

When there is no interference, a single user connects to a single frequency band (2.4 GHz/5 GHz) of a AP at close range and obtains the maximum throughput of the single frequency band.

As shown in Figure 5, the TCP service carrying capacity of a home gateway or router working under ideal air interface conditions is mainly measured. To test the carrying capacity of the maximum TCP service, the air interface conditions have the following constraints:

1. There are no other co-channel interference sources in the environment, including WLAN interference sources (such as other gateway or router devices) and non-WLAN interference sources (such as Bluetooth, cordless phones, and microwave ovens);
2. There are no other obstacles between the STA (such as mobile phone, laptop, or wireless network card) and the home gateway or router, and the line-of-sight (LOS) distance is 1 m;
3. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has the same number of receive/transmit antennas and protocol mode as the home gateway or router;
4. The number of connected users is 1;
5. The packet length of the TCP service flow defined in the scenario depends on the MTU value of the network path between the server and the client, with a default MTU value of 1500 bytes.

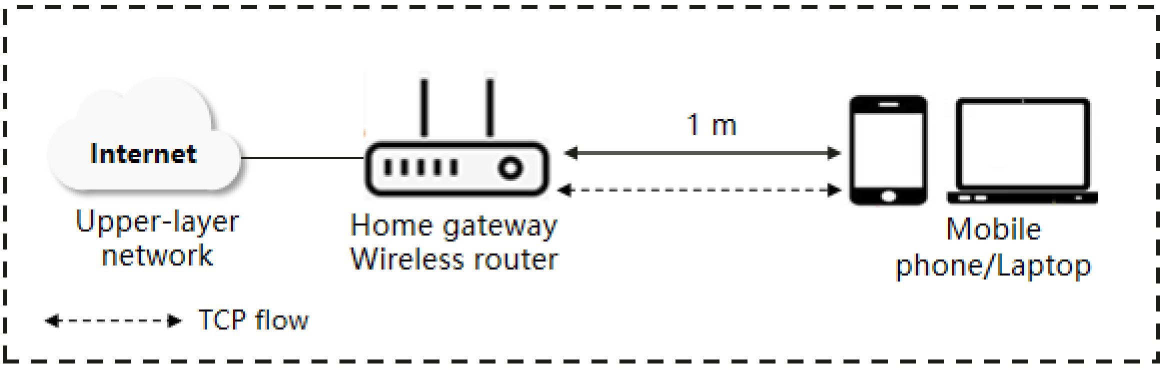

Figure 5 Single-device maximum performance scenario

7.1.1.3 Bandwidth Scenario Model 2: Multiple Concurrent Users on Multiple Frequency Bands Without Interference

When multiple users connect to the home gateway or router concurrently, the maximum throughput of multi-frequency band concurrency is obtained. As shown in Figure 6, the home gateway or router supports 2.4 GHz/5 GHz or even 6 GHz frequency band concurrency. The TCP service carrying capacity under multiple frequency band concurrency is mainly measured. To test the carrying capacity of the maximum TCP service in the multi-frequency band concurrent scenario, the air interface conditions have the following constraints:

1. There are no other co-channel interference sources in the environment, including WLAN interference sources (such as other gateway or router devices) and non-WLAN interference sources (such as Bluetooth, cordless phones, and microwave ovens);
2. There are no other obstacles between the STA (such as mobile phone, laptop, or wireless network card) and the home gateway or router, and the LOS distance is 1 m;
3. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has the same number of receive/transmit antennas and protocol mode as the home gateway or router;
4. The number of connected users is the same as the number of frequency bands supported by the home gateway or router. For example, if a dual-band gateway is used, the number of connected users is 2;
5. The packet length of the TCP service flow defined in the scenario depends on the MTU value of the network path between the server and the client, with a default MTU value of 1500 bytes.

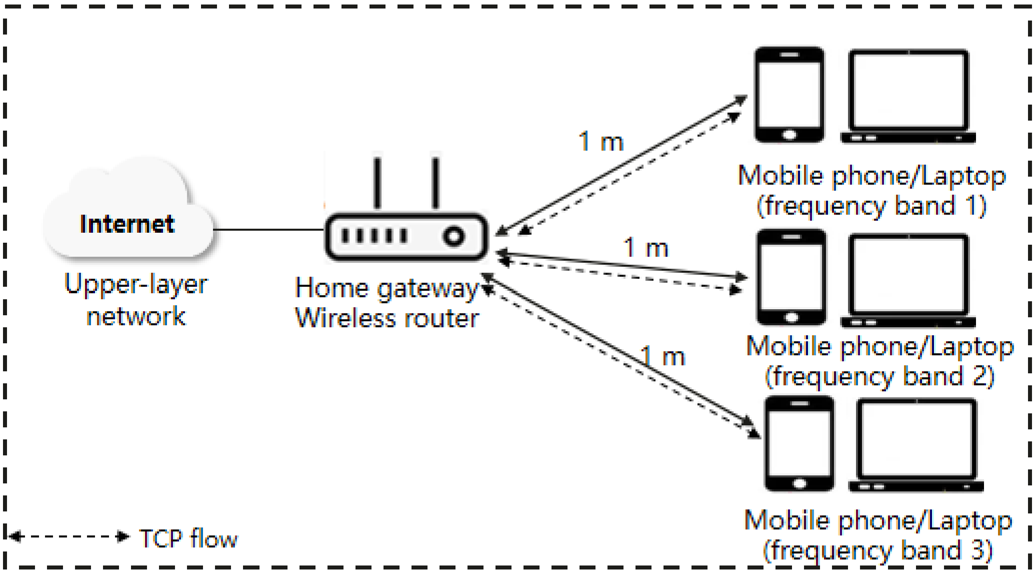

Figure 1 Different STA access concurrent scenario of a single device on multiple frequency bands

7.1.1.4 Bandwidth Scenario Model 3: Single-device throughput in time-varying interference scenarios

When under time-varying interference, a single user connects to a home gateway or router at close range, the maximum throughput of the 5 GHz frequency band is obtained. See Figure 7:

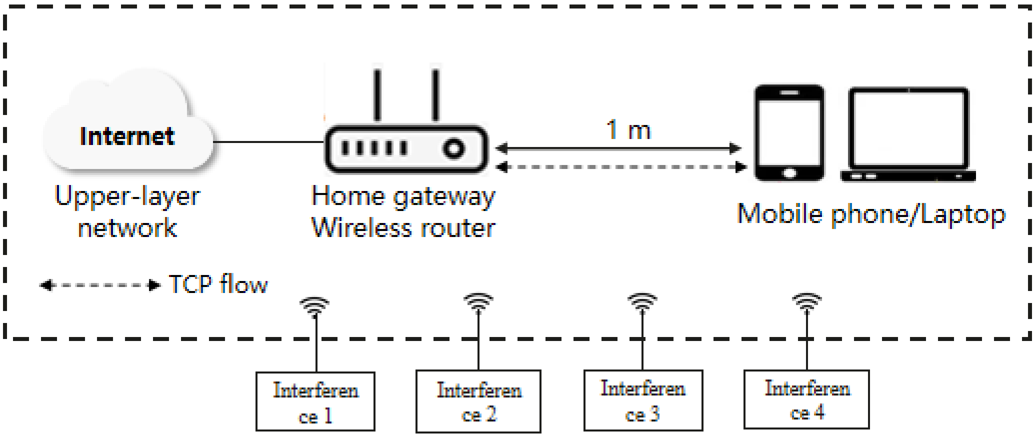

Figure 2 5 GHz throughput scenario under time-varying interference

For devices that support a maximum bandwidth of 160 MHz, the interference model is as follows:

1. There are four WLAN interference sources in the environment. No other interference exist except WLAN interference.The interference cycle varies, and one interference variation cycle is 30 seconds. The types and variation patterns of interference within one cycle are shown in Table 1;
2. The channel of the device under test is set to Channel 36. For devices that support a bandwidth of 160 MHz, interference 3 and interference 4 are frequency overlapping interference, with interference occurring on the secondary 80 MHz of the 160 MHz bandwidth.
3. The interference traffic models are defined as follows:
    a) Interference type 1: 200 Mbps TCP services; simulating neighboring AP for downloading services.
    b) Interference type 2: 30 Mbps UDP services; simulating neighboring AP for playing 4K video services.
    c) Interference type 3: burst services, 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5; simulating neighboring AP for gaming service.
    d) Interference type 4: 5 Mbps TCP services; simulating neighboring AP for browsing web pages and watching short video service.

Table 1 The variation pattern of time varying interference

Interference Type	**Interference Source 1**	**Interference Source 2**	**Interference Source 3**	**Interference Source 4**
Frequency band	Same frequency band and same channel	Same frequency band and different channels	Secondary 80 MHz frequency overlapping (adjacent-channel)	Secondary 80 MHz frequency overlapping (adjacent-channel)
Channel	36	48	52	52

Interference Type	Interference Source 1	Interference Source 2	Interference Source 3	Interference Source 4
Protocol	Consistent with the protocol of the gateway or router under test			
Bandwidth	160 MHz	160 MHz	80 MHz	80 MHz
Interference strength	-65 dBm to -70 dBm	-65 dBm to -70 dBm	-65 dBm to -70 dBm	-65 dBm to -70 dBm
Time	**Interference 1**	**Interference 2**	**Interference 3**	**Interference 4**
0-10s	200 Mbps TCP services	30 Mbps UDP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.	5 Mbps TCP services
10-20s	30 Mbps UDP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.	200 Mbps TCP services	5 Mbps TCP services
20-30s	5 Mbps TCP services	30 Mbps UDP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.	200 Mbps TCP services

For home gateways or routers that support MLO technology, when in the presence of time-varying interference on both 2.4 GHz and 5 GHz frequency bands, a single user connects to the home gateway or router at close range, the maximum throughput of MLO connection is obtained. See Figure8:

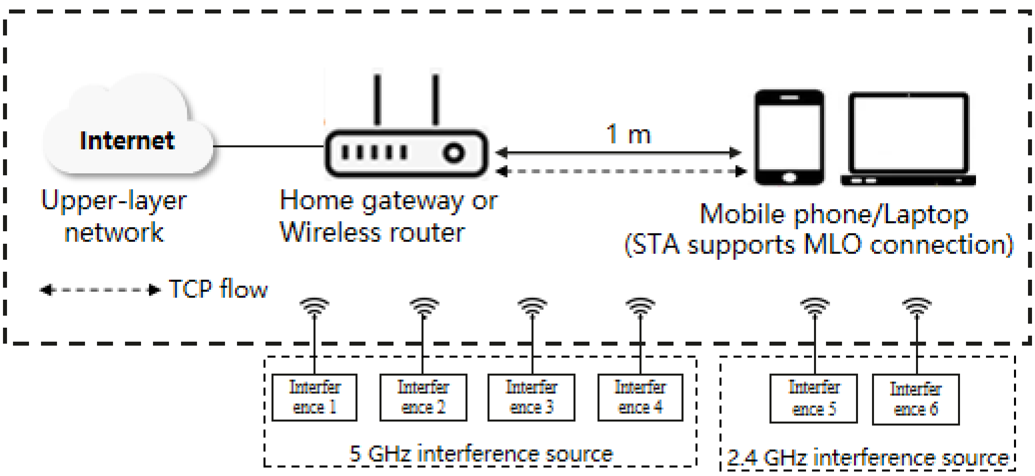

Figure 8 MLO connection throughput scenario under time-varying interference

The interference model in the MLO access scenario is as follows:

1. There are 8 WLAN interference sources in the environment, with 4 interference sources each at 2.4 GHz/5 GHz. There is no other interference except WLAN interference. The interference cycle varies, and one interference variation cycle is 30 seconds. The types and variation patterns of interference within one cycle are shown in Table 2.
2. If the channel of the device under test is set to channel 36 and the bandwidth is set to 160 MHz, interference 1 and 2 are co-channel interference, while interference 3 and interference 4 are frequency overlapping interference, with interference occurring on the secondary 80 MHz of the 160 MHz bandwidth; if the 2.4 GHz channel is set to channel 1 and the bandwidth is set to 20 MHz, interference 5 is co-channel interference, interference sources 6/7 are frequency overlapping interference, and interference 8 is adjacent channel interference.
3. The interference traffic models are defined as follows:
   a) Interference type 1: 2.4 GHz 40 Mbps TCP services, 5 GHz 200 Mbps TCP services; simulating neighboring AP for downloading service.
   b) Interference type 2: 2.4 GHz 6 Mbps UDP services, 5 GHz 30 Mbps UDP services; simulating neighboring AP for playing 4K video service.
   c) Interference type 3: burst services, 5 bursts per second for 2.4 GHz/5 GHz, 10 packets in each burst, 256-byte packet length, TID 5; simulating neighboring AP for gaming service.
   d) Interference type 4: 2.4 GHz 1 Mbps TCP services, 5 GHz 5 Mbps TCP services; simulating neighboring AP for browsing web pages and watching short video service.

Table 2 The variation pattern of time varying interference within the MLO connection cycle

Interference Type	**Interference Source 1**	**Interference Source 2**	**Interference Source 3**	**Interference Source 4**	**Interference Source 5**	**Interference Source 6**	**Interference Source 7**	**Interference Source 8**
Frequency band	Same frequency band and same channel	Same frequency band and different channels	Secondary 40 MHz frequency overlapping	Secondary 40 MHz frequency overlapping	Co-channel interference	Frequency overlapping 15 MHz interference	Frequency overlapping 10 MHz	Adjacent channel interference
Channel	36	48	44	44	1	2	3	6
Protocol	Consistent with the protocol of the gateway or router under test							
Bandwidth	160 MHz	160 MHz	80 MHz	80 MHz	20 MHz	20 MHz	20 MHz	20 MHz

Interference Type	**Interference Source 1**	**Interference Source 2**	**Interference Source 3**	**Interference Source 4**	**Interference Source 5**	**Interference Source 6**	**Interference Source 7**	**Interference Source 8**
Interference strength	-65 dBm to -70 dBm				-60 dBm to -65 dBm			
Time	Interference type							
0-10s	200 Mbps TCP services	30 Mbps UDP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.	5 Mbps TCP services	40 Mbps TCP services	6 Mbps UDP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.	1 Mbps TCP services
10-20s	30Mbps UDP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.	200 Mbps TCP services	5 Mbps TCP services	6 Mbps UDP services	1 Mbps TCP services	40 Mbps TCP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.
20-30s	5 Mbps TCP services	30 Mbps UDP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.	200 Mbps TCP services	1 Mbps TCP services	Burst traffic: 5 bursts per second, 10 packets in each burst, 256-byte packet length, TID 5, UDP services.	6 Mbps UDP services	40 Mbps TCP services

4. There are no other obstacles between the STA (such as mobile phone, laptop, or wireless network card) and the home gateway or router, and the LOS distance is 1 m;
5. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has 2 receive/transmit antennas, and its protocol mode is the same as that of the home gateway or router;
6. The packet length of the TCP service flow defined in the scenario depends on the MTU value of the network path between the server and the client, with a default MTU value of 1500 bytes.

7.1.1.5 Bandwidth Scenario Model 3: Concurrent Throughput in MLO Mode

When there is no interference, a STA and AP that support IEEE 802.11be can connect through MLO technology. At this time, the STA and AP can transmit data in parallel through multiple frequency bands, as shown in Figure 9. The AP and STA perform concurrent throughput test through MLO. In this scenario, the maximum throughput of a home gateway or home router when connecting to an endpoint that supports MLO can be tested when MLO is enabled.

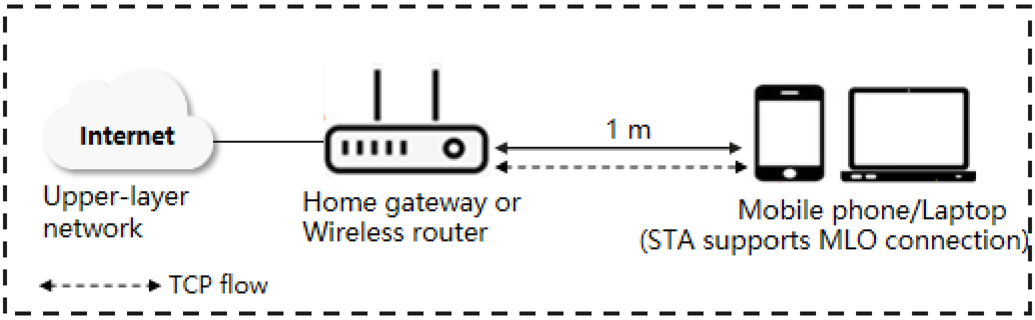

Figure 9 Concurrent throughput scenario in MLO mode

In the scenario of MLO with multi-frequency concurrency, according to the capabilities of AP and STA, it can be divided into multi-frequency band aggregation transmission and reception such as 2.4 GHz + 5 GHz, 5 GHz + 5 GHz, 5 GHz + 6 GHz, and even 2.4 GHz + 5 GHz + 6 GHz. Based on the domestic WLAN wireless spectrum range, this article focuses on two-link aggregation scenarios: 2.4 GHz + 5 GHz and 5 GHz + 5 GHz. To test the carrying capacity of the maximum TCP service in the MLO concurrent scenario, the air interface conditions have the following constraints:

1. There are no other co-channel interference sources in the environment, including WLAN interference sources (such as other gateway or router devices) and non-WLAN interference sources (such as Bluetooth, cordless phones, and microwave ovens);
2. There are no other obstacles between the STA (such as mobile phone, laptop, or wireless network card) and the home gateway or router, and the LOS distance is 1 m;
3. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has 2 receive/transmit antennas, and its protocol mode is the same as that of the home gateway or router;
4. The number of connected users is 1;

5. The packet length of the TCP service flow defined in the scenario depends on the MTU value of the network path between the server and the client, with a default MTU value of 1500 bytes.

7.1.1.6 Bandwidth Scenario Model 5: Single-User Throughput in a 20 MHz/40 MHz Channel Interference Scenario

In IEEE 802.11be protocol, the MRU preamble puncturing technology is defined. When WLAN APs are affected by interference signals of 20 MHz or 40 MHz from surrounding neighbors, the impact of interference can be reduced through preamble puncturing. Thus, the AP under test can obtain the maximum wireless spectrum resources, and the interference source will not cause interference to the AP under test. Figure 10 is a schematic diagram of throughput test under 20 MHz/40 MHz interference scenarios.

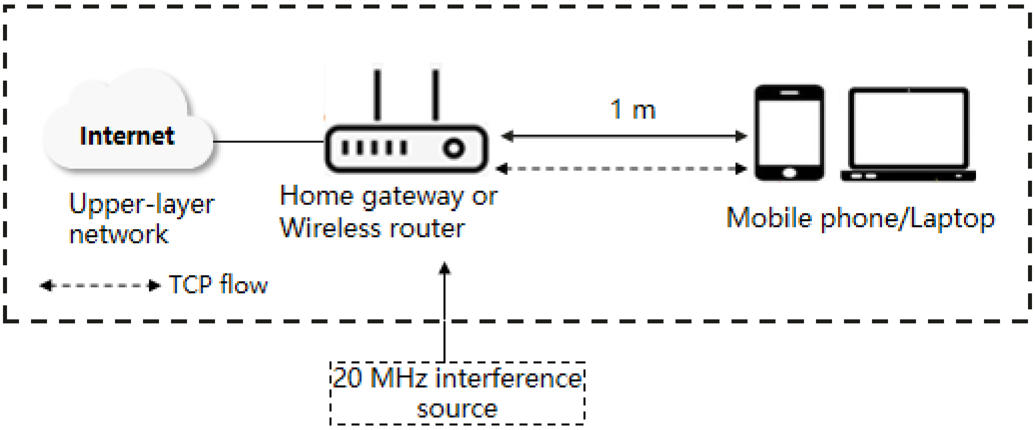

Figure 3 MRU Preamble Puncturing throughput scenario

In this scenario, the constraints on interference and air interface are as follows:

1. There are no other interference sources in the environment except for the designated 20 MHz or 40 MHz interference sources, including WLAN interference sources (such as other gateway or router devices) and non-WLAN interference sources (such as Bluetooth, cordless phones, and microwave ovens);
2. Interference model: The interfering AP operates in a 20 MHz/40 MHz bandwidth, while the AP under test operates in a 160 MHz bandwidth. The signal strength of the interference source from the device under test is -60±2dBm. The interference traffic consists of continuous 100 Mbps/200 Mbps downlink UDP flow (with a data traffic byte length of 1500 bytes).
3. There are no other obstacles between the STA (such as mobile phone, laptop, or wireless network card) and the home gateway or router, and the LOS distance is 1 m;
4. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has 2 receive/transmit antennas, and its protocol mode is the same as that of the home gateway or router;
5. The number of connected users is 1;
6. The packet length of the TCP service flow defined in the scenario depends on the MTU value of the network path between the server and the client, with a default MTU value of 1500 bytes.

7.1.2 Bandwidth Requirements

Table 3 lists the bandwidth requirements under the scenario model of a single user on a single frequency band without interference (see 7.1.1.2).

Table 3 Performance requirements for maximum throughput of a single user

WLAN Configuration for the Gateway under Test	WLAN Configuration for the Endpoint	Protocol Mode	Bandwidth (MHz)	Downlink Throughput Requirement (Mbps)
2.4 GHz (Nss = 2)	2.4 GHz (Nss = 2)	IEEE 802.11be	20	≥ 220
2.4 GHz (Nss = 2)	2.4 GHz (Nss = 2)	IEEE 802.11be	40	≥ 440
5 GHz (Nss = 2)	5 GHz (Nss = 2)	IEEE 802.11be	160	≥ 1800

Table 4 lists the bandwidth requirements under the concurrent scenario model of multiple users on multiple frequency bands without interference (see 7.1.1.3): when multiple frequency bands coexist, the performance of each frequency band should not be lower than 80% of the performance requirements defined in the scenario model of a single user on a single frequency band without interference.

Table 4 Throughput performance requirements for multi-frequency concurrency

Frequency Band 1	Frequency Band 2	Frequency Band 3	Protocol Mode	Downlink Throughput Requirement (Mbps)
2.4 GHz (Nss = 2) 20 MHz bandwidth	5 GHz (Nss = 2) 160 MHz bandwidth	/	IEEE 802.11be 802.11be	≥ 1950
2.4 GHz (Nss = 2) 40 MHz bandwidth	5 GHz (Nss = 2) 160 MHz bandwidth	/	IEEE 802.11be 802.11be	≥ 2150
2.4 GHz (Nss=2) 20 MHz bandwidth	5.1 GHz (Nss=2) 160 MHz bandwidth	5.8 GHz (Nss = 2) 80 MHz bandwidth	IEEE 802.11be 802.11be 802.11be	≥ 2800

Table 5 lists the bandwidth requirements for the scenario model of a single user under time-varying interference (see 7.1.1.4).

Table 5 Throughput requirements in a time-varying interference scenario

WLAN Configuration for the Gateway under Test	WLAN Configuration for the Endpoint	Protocol Mode	Bandwidth (MHz)	Downlink Throughput Requirement (Mbps)
5 GHz (Nss = 2)	5 GHz (Nss = 2)	IEEE 802.11be	160	≥ 960
2.4 Hz (Nss = 2) + 5 GHz (Nss = 2)	2.4 GHz (Nss = 2) + 5 GHz (Nss = 2)	IEEE 802.11be	20 + 160	≥ 1080

Table 6 lists the bandwidth requirements for the concurrent scenario model of a single user on dual-frequency bands without interference under MLO mode (see 7.1.1.5).

Table 6 Performance requirements for concurrent throughput under MLO mode

WLAN Configuration for the Gateway under Test	WLAN Configuration for the Endpoint	Protocol Mode	Bandwidth (MHz)	Downlink Throughput Requirement (Mbps)
2.4 GHz (Nss = 2) 5 GHz (Nss = 2)	2.4 GHz (Nss = 2) 5 GHz (Nss = 2)	IEEE 802.11be	20 + 160	≥ 1950
2.4 GHz (Nss = 2) 5 GHz (Nss = 2)	2.4 GHz (Nss = 2) 5 GHz (Nss = 2)	IEEE 802.11be	40 + 160	≥ 2150
5 GHz (Nss = 2) 5 GHz (Nss = 2)	5 GHz (Nss = 2) 5 GHz (Nss = 2)	IEEE 802.11be	80 + 160	≥ 2700

Table 7 lists the bandwidth requirements for the scenario model of single-user MRU Preamble Puncturing in 20 MHz/40 MHz neighboring interference scenarios (see 7.1.1.6).

Table 7 Performance requirements for MRU throughput of a single user in 20/40 MHz neighboring interference scenarios

WLAN Configuration for the Gateway under Test	WLAN Configuration for the Endpoint	Protocol Mode	Interfering Channel/Bandwidth (MHz)	Channel/Bandwidth (MHz)	Interfering user Receiving Traffic Requirements (Mbps)	Downlink Throughput Requirement (Mbps)
5 GHz (Nss = 2)	5 GHz (Nss = 2)	IEEE 802.11be	44/20	36/160	90	1550
5 GHz (Nss = 2)	5 GHz (Nss = 2)	IEEE 802.11be	44/40	36/160	180	1350

7.2 Directivity

7.2.1 Directivity Parameters and Scenario Model

The directivity parameters refer to the differences in performance obtained by a single user using a WLAN network from different directions of a gateway or router. In home scenarios, due to factors such as the antenna polarization direction, directional pattern, and spatial MIMO channel differences of a gateway or a router, the performance indicators in different directions are different.

For single device scenarios, the directivity parameters of a WLAN interface are usually measured as the difference between the minimum performance and average performance in the 360° directions of a gateway or a router.

Generally, in home scenarios, a single device is only responsible for the coverage of each room in the horizontal direction. The directivity indicator is used to measure different performance available to a STA by accessing a gateway or a router from different directions on the horizontal plane. See Figure 11:

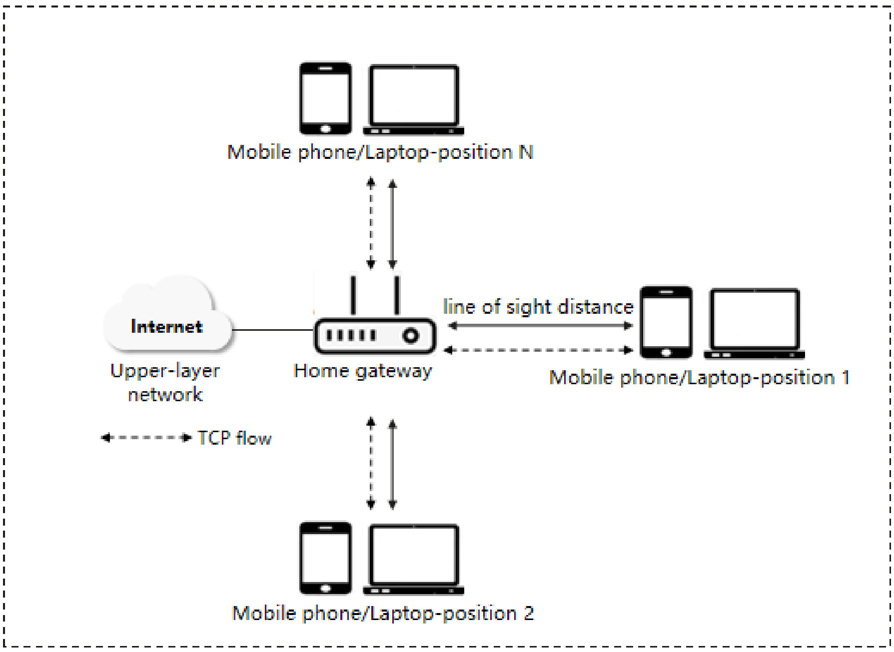

Figure 4 Directivity scenario model

7.2.2 Directivity Requirements

Based on the definition of directivity indicator scenario, the directivity indicator requirement for a gateway or wireless router accessed by a single user is defined as follows:

The minimum downlink performance in different direction shall not be lower than 50% of the average downlink performance in multiple directions.

Note: For uplink and downlink performance scenarios in different directions, see definitions in the bandwidth indicator scenarios.

7.3 Latency

7.3.1 Latency Parameters and Scenario Model

7.3.1.1 Latency Parameters

The latency parameters refer to the time required for data transmission from one end of a network (or a link) to the other end. It includes sending latency, propagation latency, queuing latency, and processing latency. In home scenarios, the WLAN latency parameters are mainly used when users have high requirements for WLAN network latency in using services with strong real-time requirements, such as gaming, online real-time streaming media, video conferencing.

In traditional latency measurement, there are mainly two types of latency indicators: Round-Trip Time (RTT) and One-Way Delay (OWD). Different latency indicators are applied to different scenarios. For TCP service interaction latency, RTT is generally used for evaluation, while for UDP service scenarios, OWD is generally used for evaluation.

In order to accurately measure the latency on a WLAN interface, it is recommended to use OWD for pure WLAN links. This part of latency excludes the processing latency of the protocol stack and therefore can more accurately measure the impact of WLAN link layers on latency.

In addition, for common service scenarios with uplink and downlink interaction, it is recommended to use RTT as a measure to reflect the service speed perceived by users.

To accurately evaluate the latency on a WLAN interface of a home gateway or router, this document defines the start and end points for latency measurement as follows:

1. Two-way latency: round-trip time from the service server for the UNI interface of a home gateway or wireless router to the WLAN endpoint;
2. Downlink one-way latency: one-way time from the service server for the UNI interface of a home gateway or wireless router to the WLAN endpoint;
3. Uplink one-way latency: one-way time from the WLAN endpoint to the service server for the UNI interface of a home gateway or wireless router.

Based on different service types, packet sizes, and air interface concurrency conditions, the latency indicator is defined as the following scenario.

7.3.1.2 Latency Scenario Model 1: a Single User on a Single Frequency Band Without Interference

Figure 12 shows the one-way latency for a single user that performs services with different traffic throughput and packet sizes in an ideal environment.

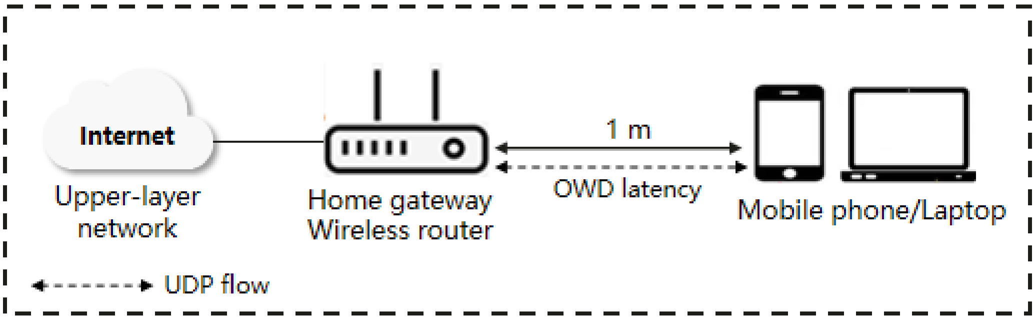

Figure 5 WLAN link latency of a single device and a single user with different traffic throughput and packet sizes

In this scenario, to evaluate the absolute latency indicator of a home gateway or router WLAN link, the following scenario setting requirements need to be met:

1. The latency indicator for actual usage of service traffic includes the accumulated latency of the server segment + backbone network segment + MAN segment + access network segment + home network segment. For home WLAN scenarios, the latency indicator refers to the latency from the LAN side of the home gateway or router to the STA side. (The indicator test is conducted by shielding the uplink interface on the home gateway or wireless router and using the Ethernet port on the user side.)
2. There are no other co-channel interference sources in the environment, including WLAN interference sources (such as other gateway or router devices) and non-WLAN interference sources (such as Bluetooth, cordless phones, and microwave ovens);
3. There are no other obstacles between the STA (such as mobile phone, laptop, or wireless network card) and the home gateway or router, and the LOS distance is 1 m;
4. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has the same number of receive/transmit antennas and protocol mode as the home gateway or router;
5. The UDP traffic model for measuring latency includes:
    a) Evenly distributed traffic of large-sized packets: Payload length of 1472 bytes, high load scenario;
    b) Evenly distributed traffic of mid-sized packets: Payload length of 512 bytes, high load scenario;
    c) Evenly distributed traffic of small-sized packets: Payload length of 88 bytes, high load scenario.

7.3.1.3 Latency Scenario Model 2: Multiple Users Without Interference

Figure 13 shows the scenario of multi-user concurrent latency in an ideal environment.

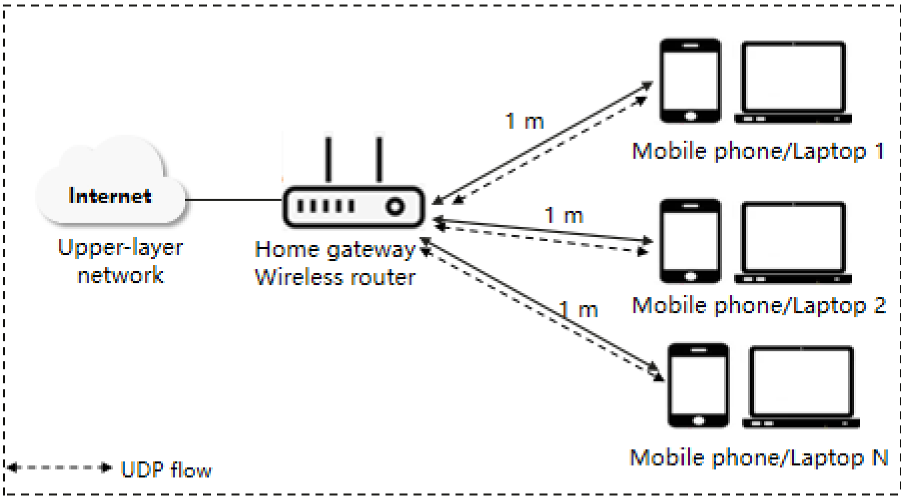

Figure 13 Concurrent latency of a single device and multiple users

In this scenario, considering the medium control layer (MAC) scheduling mechanism CSMA/CA of WLAN, as the number of users increases, the latency indicator will deteriorate sharply. This scenario needs to meet the following settings:

1. Based on the survey and statistics of the user scale in the current home scenario, the average concurrent number of users in the current home scenario is 13. It is recommended that the number of users for the multi-user concurrent latency indicator scenario is 16.
2. The latency indicator for actual usage of service traffic includes the accumulated latency of the server segment + backbone network segment + MAN segment + access network segment + home network segment. For home WLAN scenarios, the latency indicator refers to the latency from the LAN side of the home gateway or router to the STA side. (The indicator test is conducted by shielding the uplink interface on the home gateway or wireless router and using the Ethernet port on the user side.)
3. There are no other co-channel interference sources in the environment, including WLAN interference sources (such as other gateway or router devices) and non-WLAN interference sources (such as Bluetooth, cordless phones, and microwave ovens);
4. Service traffic model for latency measurement: aligning the measurement standards for 2.4 GHz and 5 GHz latency, and defining the service model for each user by using the proportion of negotiated rate uniformly;

   5 GHz WLAN: Payload length of 1472 bytes, with 16 concurrent users, service traffic of each user: negotiated rate *0.6*0.4/16

   2.4 GHz WLAN: Payload length of 1472 bytes, with 16 concurrent users, service traffic of each user: negotiated rate *0.6*0.4/16.

7.3.1.4 Latency Scenario Model 3: Multiple Users in Interference Scenarios

Figure 14 shows the latency scenario for multiple concurrent users in interference scenarios.

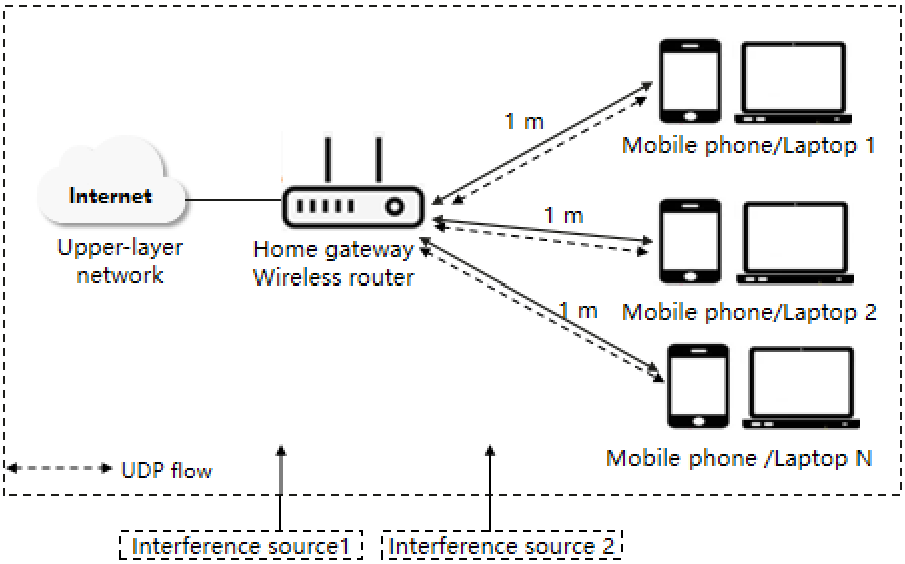

Figure 14 Concurrent latency of a single device and multiple users in interference scenarios

In interference scenarios, due to the WLAN air interface being occupied by other interfering signals, there is packet loss and retransmission during data transmission, and retransmission will increase the service latency. In this scenario, the following settings need to be met:

1. Based on the survey and statistics of the user scale in the current home scenario, the average concurrent number of users in the current home scenario is 13. It is recommended that the number of users for the multi-user concurrent latency scenario is 16.

2. The latency indicator for actual usage of service traffic includes the accumulated latency of the server segment + backbone network segment + MAN segment + access network segment + home network segment. For home WLAN scenarios, the latency indicator refers to the latency from the LAN side of the home gateway or router to the STA side.

3. Definition of an interference source:

   5 GHz frequency band: Two-way 20 Mbps downlink and 2 Mbps uplink co-channel interference for TCP service flows, with interference signal strength ranging from -65 dBm to -70 dBm

   2.4 GHz frequency band: Two-way 5 Mbps downlink and 1 Mbps uplink co-channel interference for TCP service flows, with interference signal strength ranging from -65 dBm to -70 dBm

4. Service traffic model for latency measurement: aligning the measurement standards for 2.4 GHz and 5 GHz latency, and defining the service model for each user by using the proportion of negotiated rate uniformly.

   5 GHz WLAN: Payload length of 1472 bytes, with 16 concurrent users, service traffic of each user: negotiated rate *0.6*0.4/16;

   2.4 GHz WLAN: Payload length of 1472 bytes, with 16 concurrent users, service traffic of each user: negotiated rate *0.6*0.4/16.

7.3.1.5 Latency Scenario Model 4: Multi-User Latency in Interference Scenario under MLO Mode

MLO technology is a key technical feature in the IEEE 802.11be, which allows devices to simultaneously connect to multiple wireless networks at the same time to achieve higher bandwidth and more reliable connections. MLO technology allows devices to simultaneously transmit data streams on multiple frequency bands (such as 2.4 GHz, 5 GHz, and 6 GHz). By dividing data into smaller blocks and transmitting them simultaneously on different frequency bands, MLO can significantly improve the throughput and stability of wireless networks. When interference or signal attenuation occurs in one of the frequency bands, the device can automatically switch to other frequency bands to maintain stable connection and data transmission. MLO also supports simultaneous transmission of data streams on multiple channels within a single frequency band, thereby enhancing the anti-interference ability of WLAN signals. This technology makes WLAN signals more resistant to interference from specific frequencies, improving the reliability and stability of data transmission.

Figure 15 shows the definition of the MLO multi-user concurrent latency scenario model in interference scenarios.

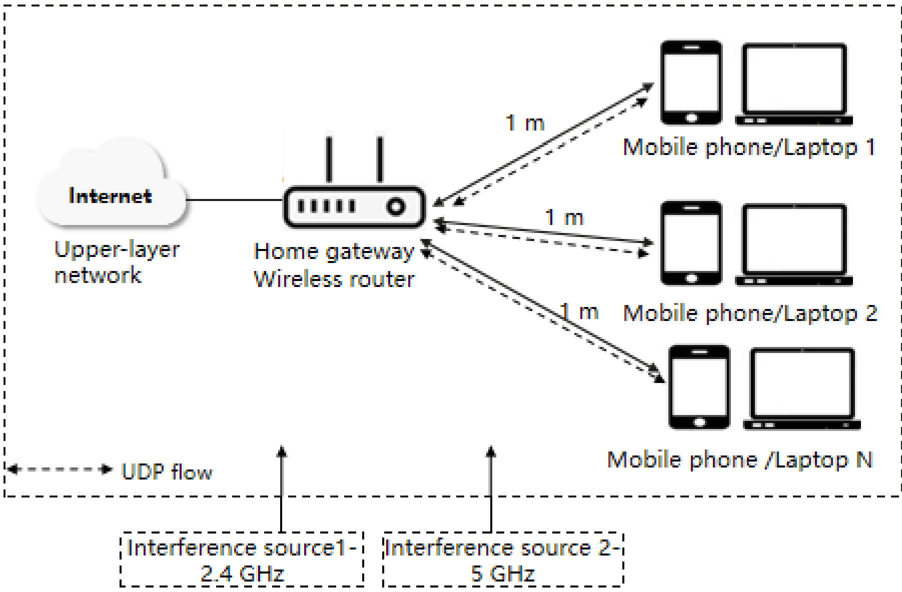

Figure 15 Concurrent latency of multiple users in interference scenario under MLO mode

Due to the WLAN air interface being occupied by other interfering signals, there is a certain degree of packet loss and retransmission during data transmission, and retransmission will increase service latency. In the MLO enabled mode, the following sub interference scenarios are defined:

1. Sub scenario 1: The AP under test operates in 2.4 GHz 20 MHz and 5 GHz 160 MHz MLO concurrent mode, with interference sources on the 5 GHz channel and no interference on the 2.4 GHz channel.
2. Sub scenario 2: The AP under test operates in 2.4 GHz 20 MHz and 5 GHz 160 MHz MLO concurrent mode, with interference sources on the 2.4 GHz channel and no interference on the 5 GHz channel.
3. Sub scenario 3: The AP under test operates in 2.4 GHz 20 MHz and 5 GHz 160 MHz MLO concurrent mode, with interference on both 2.4 GHz and 5 GHz channels.

The interference source is determined as follows:

5 GHz frequency band: Two-way 20 Mbps downlink and 2 Mbps uplink co-channel interference for TCP service flows, with interference signal strength ranging from -65 dBm to -70 dBm;

2.4 GHz frequency band: Two-way 5 Mbps downlink and 1 Mbps uplink co-channel interference for TCP service flows, with interference signal strength ranging from -65 dBm to -70 dBm.

In addition, this scenario needs to meet the following settings:

1. Based on the survey and statistics of the user scale in the current home scenario, the average concurrent number of users in the current home scenario is 13. It is recommended that the number of users for the multi-user concurrent latency indicator scenario is 16.
2. There are no other obstacles between the STA (such as mobile phone, laptop, or wireless network card) and the home gateway or router, and the LOS distance is 1 m;
3. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has 2 receive/transmit antennas, and its protocol mode is the same as that of the home gateway or router. The MLO mode is enabled.
4. The latency indicator for actual usage of service traffic includes the accumulated latency of the server segment + backbone network segment + MAN segment + access network segment + home network segment. For home WLAN scenarios, the latency indicator refers to the latency from the LAN side of the home gateway or router to the STA side.
5. Service traffic model for latency measurement: for home gateways or wireless routers that support IEEE 802.11be, MLO functionality needs to be enabled, and STAs also need to support MLO. In order to align the measurement standards for 2.4 GHz and 5 GHz latency, the proportion of negotiated rate should be uniformly used to define the service model for each user: Payload length of 1472 bytes, with 16 concurrent users, service traffic of each user: negotiated rate (2.4 GHz + 5 GHz) *0.6*0.4/16.

7.3.2 Latency Requirements

Table 8 to Table 9 list the latency requirements for the latency scenario model of a single user with different byte lengths and service traffic throughput (see 7.3.1.2).

Table 8 Latency requirements for 2.4 GHz 20 MHz transmission of a single user on a single frequency band without interference

Traffic Service Model	Traffic (Mbps)	Payload Length (Byte)	Protocol Mode	Average Downlink Latency (ms)
Evenly distributed traffic of large-sized packets	150	1472	802.11be 2*2	≤6
Evenly distributed traffic of mid-sized packets	120	512		≤6
Evenly distributed traffic of small-	40	88		≤6

sized packets				

Table 8 Latency requirements for 5 GHz 160 MHz transmission of a single user on a single frequency band without interference

Traffic Service Model	Traffic (Mbps)	Payload Length (Byte)	Protocol Mode	Average Downlink Latency (ms)
Evenly distributed traffic of large-sized packets	1400	1472	802.11be 2*2	≤4
Evenly distributed traffic of mid-sized packets	800	512		≤4
Evenly distributed traffic of small-sized packets	100	88		≤4

Table 10 lists the latency indicator requirements for the latency scenario model of multi-user concurrency with fixed service traffic under no interference conditions (see 7.3.1.3).

Table 10 Concurrent latency requirements for multiple users without interference

Traffic Service Model	Traffic (Mbps)	Payload Length (Byte)	Protocol Mode	Downlink Average Latency per User (ms)	Downlink TP99 Latency per User (ms)
Evenly distributed traffic of large-sized packets	Negotiated rate *0.6*0.4/16	1472	2.4 GHz IEEE 802.11be 2*2 20 MHz	≤35	≤70
Evenly distributed traffic of large-sized packets	Negotiated rate *0.6*0.4/16	1472	5 GHz IEEE 802.11be 2*2 160 MHz	≤25	≤50

Table 11 lists the latency indicator requirements for the latency scenario model of multi-user concurrency with fixed service traffic under neighboring interference conditions (see 7.3.1.4).

Table 11 Multi-user concurrent latency requirements in interference scenarios

Traffic Service Model	Traffic (Mbps)	Payload Length (Byte)	Protocol Mode	Downlink Average Latency per User (ms)	Downlink TP99 Latency per User (ms)
Evenly distributed traffic of large-sized packets	Negotiated rate *0.6*0.4/16	1472	2.4 GHz IEEE 802.11be 2*2 20 MHz	≤30	≤60
Evenly distributed traffic of large-sized packets	Negotiated rate *0.6*0.4/16	1472	5 GHz IEEE 802.11be 2*2 160 MHz	≤30	≤60

Table 12 lists the latency indicator requirements for the latency scenario model of multi-user concurrency in MLO mode with fixed service traffic under neighboring interference conditions (see 7.3.1.5).

Table 12 Multi-user concurrent latency requirements under MLO mode in interference scenarios

Traffic Service Model	Traffic (Mbps)	Byte Length (Byte)	Protocol Mode	Interference Model	Downlink Average Latency per User (ms)	Downlink TP99 Latency per User (ms)
Evenly distributed traffic of large-sized packets	2.4 GHz Negotiated rate *0.6*0.4/16 + 5 GHz Negotiated rate *0.6*0.4/16	1500	2.4 GHz IEEE 802.11be 2*2 20 MHz 5 GHz IEEE 802.11be 2*2 160 MHz	2.4 GHz OFF 5 GHz ON	≤30	≤60
Evenly distributed traffic of large-sized packets	2.4 GHz Negotiated rate *0.6*0.4/16 + 5 GHz Negotiated rate *0.6*0.4/16	1500	2.4 GHz IEEE 802.11be 2*2 20 MHz 5 GHz IEEE 802.11be 2*2 160 MHz	2.4 GHz ON 5 GHz OFF	≤25	≤50
Evenly distributed traffic of large-sized packets	2.4 GHz Negotiated rate *0.6*0.4/16 + 5 GHz Negotiated rate *0.6*0.4/16	1500	2.4 GHz IEEE 802.11be 2*2 20 MHz 5 GHz IEEE 802.11be 2*2 160 MHz	2.4 GHz ON 5 GHz ON	≤35	≤70

7.4 Coverage

7.4.1 Coverage Parameters and Scenario Model

7.4.1.1 Coverage Parameters

The coverage parameters are the core parameters of WLAN devices in home scenarios. In home scenarios, wireless signals attenuate as the distance from the device increases or when signals are blocked by walls, and the effective bandwidth obtained by the user decreases accordingly.

7.4.1.2 Scenario Model 1 for Coverage Evaluation: the LOS Coverage for a Single User Without Interference

Figure 16 shows the scenario of TCP service performance of a single user with a LOS distance of 10 m, corresponding to the scenario where the user uses the service in the living room.

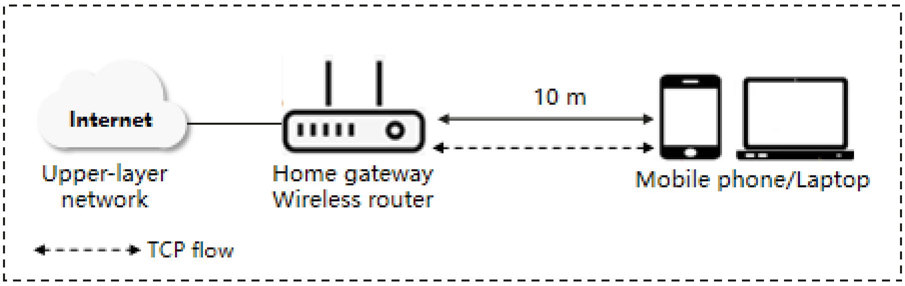

Figure 16 TCP service performance scenario of a single device with a line-of-sight (LOS) distance of 10 m

In this scenario, the service performance of the home gateway or router over long distances in wireless LOS channel is evaluated according to the following constraints:

1. There are no other co-channel interference sources in the environment, including WLAN interference sources (such as other gateway or router devices) and non-WLAN interference sources (such as Bluetooth, cordless phones, and microwave ovens);
2. There are no other obstacles between the STA (such as mobile phone, laptop, or wireless network card) and the home gateway or router, and the LOS distance is 10 m;
3. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has the same number of receive/transmit antennas and protocol mode as the home gateway or router.

7.4.1.3 Scenario Model 2 for Coverage Evaluation: the Wall-Penetrating Coverage for a Single User Without Interference

Figure 17 shows the wall-penetrating scenario of a single device and a single user, corresponding to the scenario where the user uses the service in the room or study.

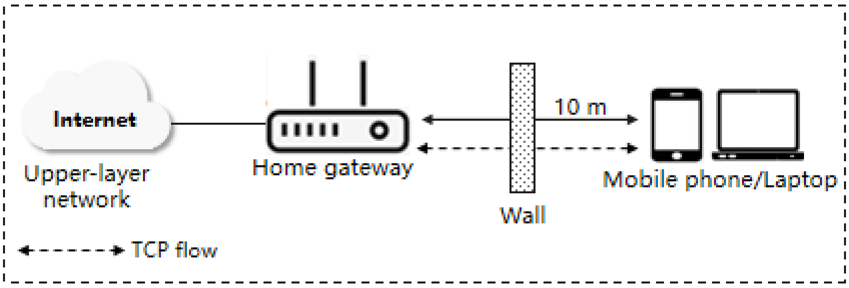

Figure 17 TCP service performance scenario of a single device with wall penetration

The wall penetration scenario is shown in Figure 17. To evaluate the wall-penetrating capability of a home gateway or router, the constraints on the scenario are as follows:

1. There are two typical test cases for the spatial distance between the STA (such as a mobile phone, laptop, or wireless network card) and the home gateway or router:
   a) LOS distance of10 m;
   b) 10-m LOS distance + one brick wall (240-mm thick).
2. With reference to the description in Appendix A, on the 5 GHz frequency band, the attenuation value caused by a wall with a thickness of 240 mm is about 25 dB, the attenuation value caused by a wall with a thickness of 120 mm is about 20 dB; on the 2.4 GHz frequency band, the attenuation value caused by a wall with a thickness of 240 mm is about 15 dB, and the attenuation value caused by a wall with a thickness of 120 mm is about 10 dB;
3. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has the same number of receive/transmit antennas and protocol mode as the home gateway or router;
4. There are no other co-channel interference sources in the environment, including WLAN interference sources (such as other gateway or router devices) and non-WLAN interference sources (such as Bluetooth, cordless phones, and microwave ovens).

7.4.2 Coverage Requirements

Table 13 lists the performance requirements based on the coverage distance, wall penetration scenario, and coverage direction in home scenarios.

Table 9 Coverage performance requirements

WLAN Configuration for the Gateway under Test	**Bandwidth (MHz)**	**Protocol Mode**	**10-m LOS Distance**	**10 m + One Brick Wall**
			Downlink performance (Mbps)	**Downlink performance (Mbps)**
2.4 GHz (Nss = 2)	20	IEEE 802.11be	≥150	≥100
5 GHz (Nss = 2)	160	IEEE 802.11be	≥1000	≥400

MLO: 2.4 GHz(Nss = 2) 5 GHz (Nss = 2)	20+160	IEEE 802.11be	≥1150	≥500

7.5 Connection

7.5.1 Connection Parameters and Scenario Model

7.5.1.1 Connection Parameters

Service concurrency is a characteristic in home scenarios and connectivity reflects the degree of integration between the network and the physical world. Its indicators are the number of connected users and the number of concurrent.

1. Number of connected users: the maximum number of users that can be associated.
2. Number of concurrent users: the number of users that are carrying services simultaneously.

The duty cycle of the home WLAN is calculated by formula (1):

$$\text{Duty Cycle} = \frac{\sum_{1}^{n} T_{nrate}}{N_{SS} * (N_{CBPS} * R) * (1/(T_S + T_{GI}))} \quad \text{………………(1)}$$

In the formula,

N_{SS}: number of spatial streams;

N_{CBPS}: total number of encoded bits in each OFDM symbol;

R: bit rate;

T_{GI}: GI length;

T_S: symbol (IFFT) length;

T_{nrate}: the actual rate of the endpoint.

As the number of concurrent users increases, the air interface occupancy ratio increases. As a result, the contention and conflicts intensify and service experience deteriorates.

In home scenarios, the measurement scenario of connection capability is defined based on the maximum number of connected users and the number of users with concurrent services.

7.5.1.2 Connection Scenario Model 1: Multi-User Concurrent Access

The maximum user access scenario is defined as the state where the STAs can connect to the home gateway or router concurrently and maintain low service traffic without packet loss. At this time, the maximum number of connected users is the maximum number of users connected to the home gateway or router. In this scenario, the number of connected users gradually increases, and the concurrent service packet loss ratio of the connected users remains at a low level, indicating that the STAs are in a stable access state. The key constraints and measurement conditions in this scenario are as follows:

1. When the STAs are stably connected, for a 100-pps stream, the packet loss ratio of each user shall not exceed 0.1%;
2. During the STA access process or concurrent service process, there needs to be random contention. This contention requires a complete simulation of the actual scenario of multiple concurrent mobile phone access or concurrent service, that is, the STA has independent WLAN physical layer (PHY) and Media Access Control (MAC) layer.

7.5.1.3 Connection Scenario Model 2: Multi-User Service Concurrency

The maximum number of connected users only indicates the number of users supported on the home gateway or router with stable connection status. However, in actual home scenarios, each STA carries services with different of traffic throughput. Based on formula (1), when the service traffic of an actual endpoint increases, the air interface usage also increases, exacerbating contention conflicts and making service experience deteriorate. In this case, the maximum concurrent throughput of multiple users is used to measure the service scheduling capability of the home gateway or router in multi-user concurrent service.

As shown in Figure 18, N STAs concurrently connect to a home gateway or a router. By measuring the maximum number of users that the system can support while meeting certain performance requirements through unrestricted TCP service flow, we can evaluate the concurrent performance of home gateways or routers and the fairness of multi-user concurrent scheduling. The key constraints and measurement conditions in this scenario are as follows:

1. Each STA has independent physical layer (PHY) and Media Access Control (MAC) layer, the spatial streams of the STA is 2*2, and the protocol modes are the same;
2. The air interface conditions between each STA and the gateway are basically the same. It is initially defined that the STA is 1 m away from the home gateway or router;
3. The packet length of TCP service flow depends on the MTU value of the network path between the server and the client, with a default MTU value of 1500 bytes.

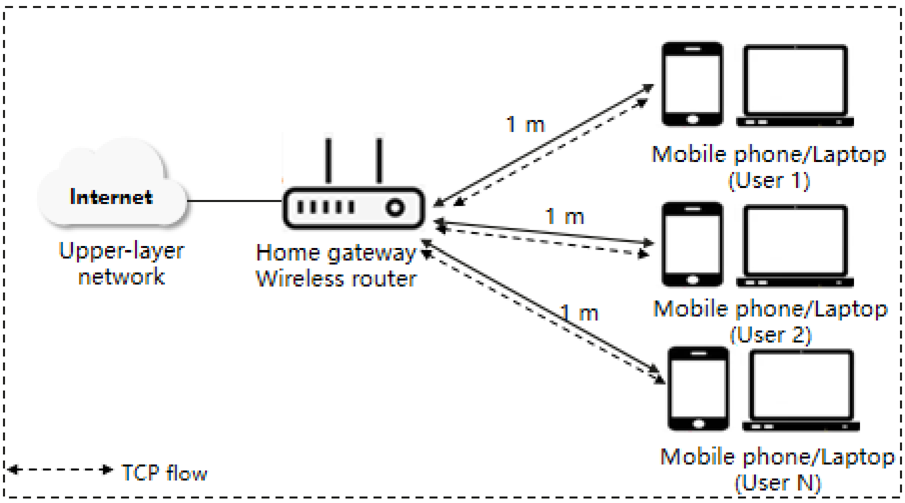

Figure 18 Multi-user concurrent throughput scenario

7.5.2 Connection Requirements

In connection scenario model 1 (multi-user concurrent access), performance requirements: a single frequency band shall support at least 32 users in a stable state; support for 64 users is recommended.

In connection scenario model 2 (multi-user concurrent services), performance requirements: Table 14 lists the throughput requirements for multi-user concurrent throughput scenarios.

Table 14 Connection performance requirements

WLAN Configuration for the Gateway under Test	Bandwidth (MHz)	Protocol Mode	16 Concurrent Users		32 Concurrent Users	
			Total Throughput (Mbps)	Minimum Throughput (Mbps)	Total Throughput (Mbps)	Minimum Throughput (Mbps)
2.4 GHz (Nss = 2)	20	IEEE 802.11be	140/2		90/0.5	
5 GHz (Nss = 2)	160	IEEE 802.11be	950/4		700/2	
MLO: 2.4 GHz(Nss = 2) 5 GHz (Nss = 2)	20 + 160	IEEE 802.11be	1090/4		790/2	

7.6 Stability

7.6.1 Stability Parameters and Scenario Model

In home scenarios, the stability of WLAN interfaces is mainly reflected by the stability of signals, connections, and traffic handling capability. There are many factors that affect WLAN stability, including fluctuations in wireless channel, changes in environmental interference, and the robustness of product hardware and software systems.

The stability test scenario mainly considers the superposition of the above scenario factors and time dimensions, in order to test the capability of a home gateway or router to provide long-term stable performance in a complex scenario.

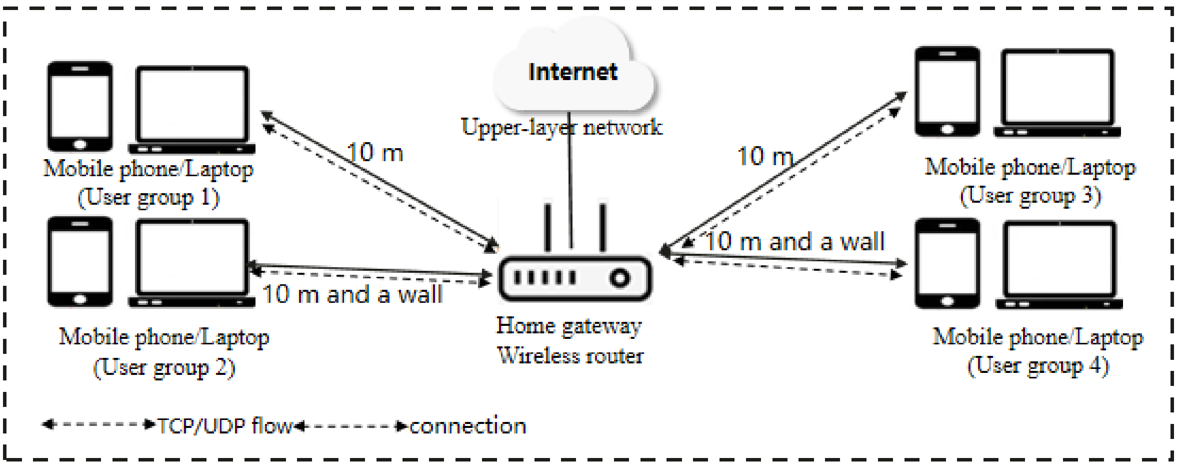

Figure 19 Long-term stability scenario

As shown in Figure 19, in home scenarios, some users disconnect and reconnect repeatedly, and other users transmit data traffic. Users are distributed at different distances from the home gateway or router. In this service scenario, the connection success ratio and service performance fluctuation of each STA are evaluated. The specific testing conditions and constraints are as follows:

1. Eight accompanying 2.4 GHz STAs are associated with the gateway or router under test according to the distance defined in Table 15 and carry out the corresponding operations:

Table 15 2.4 GHz STA distribution and behavior in Stability Test

2.4 GHz STA Location	Number of Repeatedly Associated Users	Number of Continuous TCP Service Users	Number of Continuous UDP Service users
10 m LOS distance	2	1	1
10 m ＋ one wall	2	1	1

2. Eight accompanying 5 GHz STAs are associated with the gateway or router under test according to the distance defined in Table 16 and carry out the corresponding operations:

Table 16 5 GHz STA distribution and behavior in Stability Test

5 GHz user Location	Number of Repeatedly Associated Users	Number of Continuous TCP Service Users	Number of Continuous UDP Service Users
10 m LOS distance	2	1	1
10 m ＋ one wall	2	1	1

3. Six accompanying MLO STAs are associated with the gateway or router under test according to the distance defined in Table 17 and carry out the corresponding operations:

Table 17 MLO STA distribution and behavior in Stability Test

MLO STA Location	Number of Repeatedly Associated Users	Number of Continuous TCP Service Users	Number of Continuous UDP Service Users
10 m LOS distance	1	1	1
10 m ＋ one wall	1	1	1

4. Running duration: 12 hours.
5. STA definition: Each STA has independent physical layer (PHY) and Media Access Control (MAC) layer, the spatial streams of the STA is 2*2, and the protocol version is the same as that of the gateway or router under test.

7.6.2 Stability Indicator Requirements

The requirements for the 12 hour performance stability of a home gateway or router under pressure test in home scenarios are as follows:

1. The connection success ratio of all STAs that repeatedly disconnect and reconnect shall not be less than 90%;
2. The average service traffic of all STAs with concurrent TCP services within 1 minute shall not be less than 60% of their packet transmission ratio;
3. The average latency per minute of all STAs with concurrent UDP services within 12 hours shall not exceed 20 ms.

7.7 Security

7.7.1 Security Scenario Definition

The endpoint devices in WLAN networks may face attacks from the Internet or LAN. As more and more smart devices involving sensitive user information and privacy, such as smart screens, smart speakers, and printers, are connected to the Internet, as home hub devices, we classify the home gateway or router devices related to security mechanisms as follows:

1. Access Security

Wireless-side security mainly includes the security of user access and authentication, as well as the security of user data transmission. User access and authentication security mainly rely on various user access methods and multiple user identity authentication and authorization methods to provide security guarantee. User data security mainly uses various encryption methods to ensure the secure transmission of user data.

The current home WLAN network supports the following types of user access identity authentication and data encryption:

a) OPEN-SYS authentication
b) WEP authentication/encryption
c) WPA2 authentication/encryption (TKIP/CCMP encryption)
d) WPA3-SAE authentication

The latest access authentication specification WPA3-SAE replaces the PSK authentication method of WPA2 Personal Edition, which can effectively resist offline dictionary attacks and increase the difficulty in brute force cracking. SAE can provide forward secrecy, so even if attackers know the password on the network, they cannot decrypt the obtained traffic, thus greatly improving the security of networks running WPA3-Personal. For details about WPA2 and WPA3, see normative document [3] and [4].

WLAN networks not only have certain authentication and encryption security measures at the access level, but also have the ability to control access behavior through upper layer software at the application level, mainly including:

a) Directly rejecting the AP from going online by adding the MAC addresses to the blacklist
b) Performing authentication by configuring the whitelist and based on the MAC addresses
c) Performing authentication by using 802.1x, portal, etc.

d) Allowing manually confirmed APs to go online

2. System Security

The system security of WLAN mainly manifests in the protection against various attacks, and system security requires the simultaneous use of multiple protection measures to achieve protection against attacks. Common protection measures include: blacklist/whitelist-based user filtering, DoS detection, Rouge AP detection, defense against MAC/IP spoofing, prohibition of BSSID broadcasting, MAC/SN-based AP filtering, use of advanced encryption algorithms, etc.

Based on the above atomic security capabilities, WLAN security in home scenarios is classified into the following three scenarios:

Scenario 1: Brute force cracking

Generally, users access the home WLAN in PSK mode. This mode is vulnerable to brute force cracking, also known as an exhaustive attack, which is a password analysis method by trying all possible password combinations until the correct password is found. For example, a password that contains 4 digits and consists entirely of numbers may have a maximum of 10,000 combinations. Therefore, the correct password can be found after a maximum of 10,000 attempts. Theoretically, this method can decrypt any password without all-round security protection. The only problem is how to shorten the trial and error time. Some people use computers to increase efficiency, and others use dictionaries to narrow down the range of password combinations. Home gateways or routers should support defense against brute force PSK cracking. By detecting frequent PSK authentication attempts, home gateways or routers can interrupt the attack process by reducing the number of authentication attempts and attack efficiency, so as to prevent passwords from being cracked.

Scenario 2: Unauthorized access from neighbors

Currently, WLAN user passwords are often shared by third-party software, leading to unauthorized access and decreasing the network speed. Users need to frequently check online users and blacklist unknown users. Home gateways or routers should be able to prevent unknown devices from accessing the home network. By accurately identifying attacks to crack and steal WLAN passwords, a router can automatically prevent malicious devices from accessing the home WLAN network.

Scenario 3: Protocol packet attack

A malicious user sends a large number of protocol packets to attack the system,causing the system to be unable to process service requests from normal users, i.e. refusing to provide services to normal users. To protect the system, the number of protocol packets that can be received by the system should be limited within the prescribed range. If the number of protocol packets exceeds the prescribed range, the packets are dropped as invalid packets; the user who initiate DoS attacks is added to the blacklist to deny protocol packets from the user.

Scenario 4: Man-in-the-middle attack

An unauthorized user uses a network tool to intercept communication packets between a wireless client and a home gateway or router, and inserts itself into the normal communication between the wireless client and the AP. Once successfully inserted, the unauthorized user first sends a Deauthentication packet to force the client to disconnect, and then copies the MAC address of the authorized AP and forges the consistent SSID to deceive the wireless client. At the same time, the attacker's computer will establish a normal connection with the AP. In this way, all data from the wireless client first passes through the attacker's access point and then flows to the authorized AP. A home gateway or router should be able to defend against man-in-the-middle attacks.

7.7.2 Security Requirements

A home gateway or router should support defense against brute force cracking, unauthorized user access, protocol packet attacks, man-in-the-middle attacks.

8 Single-Device WLAN Experience Scenario Definitions and Experience Requirements in Home Scenarios

8.1 Classification of Home Comprehensive Scenarios

Based on the typical deployment of home gateways and routers in home scenarios, the maximum coverage area of a single device is generally less than 120 m^2. Larger house coverage requires mesh devices. In single-device home scenarios, the home layouts can be categorized into small-sized residences with an area of less than 90 m^2 and mid-sized residences with an area of less than 120 m^2. In addition, since multiple protocol hybrid access remains in home scenarios, it is necessary to increase the experience requirements for hybrid access scenarios.

8.2 Service Model and Performance Requirements for Typical Small-Sized Residence Scenarios

8.2.1 Home Scenario Definition for Typical Small-Sized Residences

A typical small-sized residence scenario is defined as a three-person household scenario with an area of less than 90 m^2. In this scenario, the case with the highest concurrency of user service is selected as the test and evaluation scenario. The basic scenario diagram is shown in Figure 20.

Figure 20 Schematic diagram of the concurrent WLAN service for a three-person household

In this scenario, the home gateway or router is placed on the TV bench in the living room. The location and services of each STA are as follows:

1. **TV or STB**: 1 m away from the home gateway, running 4K OTT video service.
2. **Mobile phone**: 3-4 m away from the home gateway, running online gaming, short video, or speed test applications. The mobile phone is subject to slight shaking or blocking by people.
3. **Laptop**: 5-6 m away from the home gateway with a brick wall (240 mm thick) in between, running the online video conferencing service.
4. **Tablet**: 7-8 m away from the home gateway with signals slanting through at most one wall, running the e-Learning and more services.

For the scenario of a three-person household, there are differences in the location and service types of major internet devices such as TVs, mobile phones, and laptops. The vast majority of ordinary user scenarios can be covered through scenario combinations.

The above STAs should meet the following requirements:

1. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) has the same number of receive/transmit antennas and protocol mode as the home gateway or router;
2. The background interference in the scenario is modeled: the duty cycle of 2.4 GHz interference is about 20%, and the duty cycle of 5 GHz interference is about 10%. The specific definition of interference sources refers to the interference model defined in latency Scenario Model 3 (7.3.1.4).

8.2.2 Performance Requirements for Typical Small-Sized Residence Scenarios

In a typical scenario of 90 m^2 residence, the KPI experience requirements for concurrent service are defined as follows (E2E):

1. Requirements for FTP download services: The download rate fluctuation within 5 minutes is no greater than 10%. The average download rate is no lower than 100 Mbps.
2. Table 18 lists the experience requirements for other services.

Table 10 Service experience requirements in typical small-sized residence scenarios

Service Type	Average Latency (ms)	Percentage of Latency Longer Than 100 ms	Packet loss ratio	Count of Frame Freezing within 5 Minutes (Optional)
Mobile gaming	≤ 60	≤ 1%	≤ 10^{-3}	NA
Video live streaming	≤ 50	≤ 1%	≤ 10^{-3}	0
Video conferencing	≤ 50	≤ 1%	≤ 10^{-3}	0
4K OTT video	≤ 50	≤ 1%	≤ 10^{-3}	0

8.3 Service Model and Performance Requirements for Typical Mid-Sized Residence Scenarios

8.3.1 Definition of Typical Mid-Sized Residence Scenarios

A typical mid-sized residence scenario is defined as a five-person household scenario with an area of less than 120 m^2; In this scenario, the case with the highest concurrency of user service is selected as the test and evaluation scenario. The basic scenario diagram is shown in Figure 21.

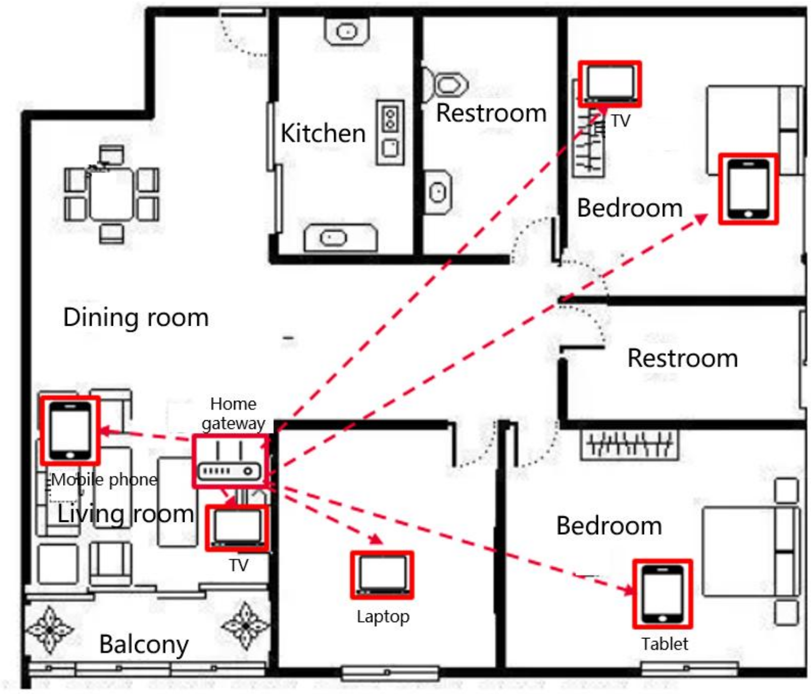

Figure 21 Schematic diagram of the concurrent WLAN service for a five-person household

In this scenario, the home gateway or router is placed on the TV bench in the living room. The location and services of each STA are as follows:

TV or STB in the living room: 1 m away from the home gateway, running 4K OTT video service.

TV or STB in the master bedroom: 10 m away from the home gateway (with signals slanting through at least two walls), running 4K OTT video service.

Mobile phone in the master bedroom: 10 m away from the home gateway (with signals slanting through at least two walls), running the online gaming service or short video service.

Laptop in the study: 3-4 m away from the home gateway with a brick wall (240 mm thick) in between, running the video conferencing service.

Tablet: 7–8 m away from the home gateway with two walls in between (one is 240 mm thick and the other 120 mm thick), running e-Learning and more services.

Mobile phone in the living room: 3-4 m away from the home gateway, running online gaming service, short video service, and speed test service. The mobile phone is subject to slight shaking or blocking by people.

For the scenario of a three-person household, there are differences in the location and service types of major internet devices such as TVs, mobile phones, and laptops. The vast majority of ordinary user scenarios can be covered through scenario combinations.

The above STAs should meet the following conditions:

1. The WLAN interface specification of the STA (such as mobile phone, laptop, or wireless network card) should have the same number of receive/transmit antennas and protocol mode as the home gateway or router.
2. Background interference in the scenario is defined: the duty cycle of 2.4 GHz background interference is 20%, and the duty cycle of 5 GHz interference is 10%. The specific definition of interference sources refers to the interference model defined in latency Scenario Model 3 (7.3.1.4).

8.3.2 Performance Requirements for Typical Mid-Sized Residence Scenarios

In a typical scenario of 120 m^2 residence, the KPI experience requirements for concurrent service are as follows:

1. Requirements for FTP download services: The download rate fluctuation within 5 minutes is no greater than 10%. The average download rate is no lower than 100 Mbps.
2. Table 19 lists the experience requirements for other services.

Table 19 Service experience requirements in typical mid-sized residence scenarios

Service Type	Average Latency (ms)	Percentage of Latency Longer Than 100 ms	Packet loss ratio	Count of Frame Freezing within 5 Minutes (Optional)
Mobile gaming	≤60	≤1%	$\leq 10^{-3}$	NA
Video live streaming	≤50	≤1%	$\leq 10^{-3}$	0
Video conferencing	≤50	≤1%	$\leq 10^{-3}$	0
4K OTT video	≤50	≤1%	$\leq 10^{-3}$	0

8.4 Concurrent Scenario Experience of Multi-Protocol Hybrid Access Service

8.4.1 Definition of Multi-Protocol Hybrid Access Home Scenario

A typical multi-protocol hybrid access home scenario is defined as a five-person household scenario with a medium-sized residence of 120 m^2; in this scenario, the case with the highest concurrency of user service is selected as the test and evaluation scenario. See Figure 22:

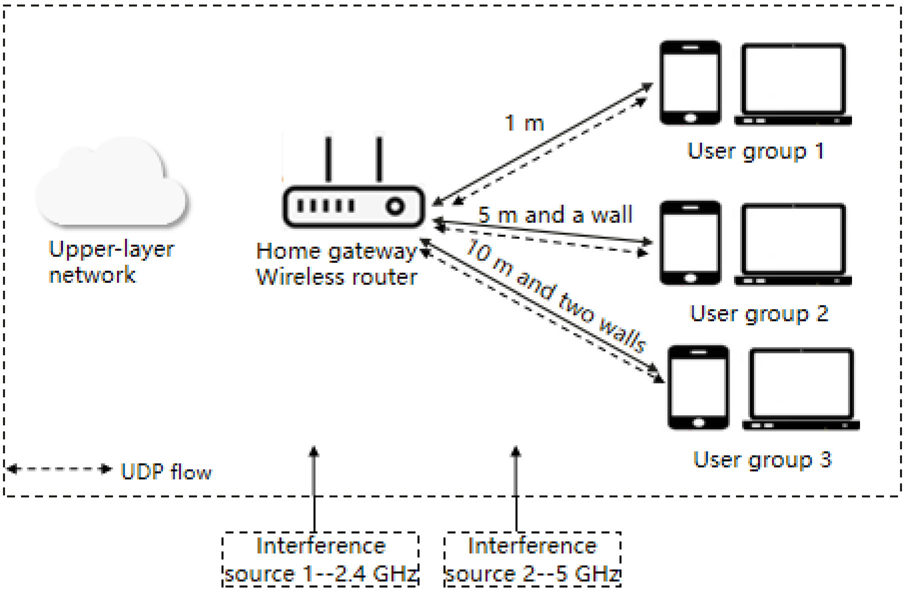

Figure 22 Concurrent scenario experience of multi-protocol hybrid access service

In this scenario, the home gateway or router is placed on the TV bench in the living room. The number, location distribution and service requirements of STAs are as follows:

1. The number of users is 16, divided into 3 groups according to deployment location; user group 1 includes 6 endpoints, namely STA 1/5/6/9/13/14, which are deployed in close proximity to the router (The signal strength of the tested AP in the 5 GHz frequency band is -30 dBm±2 dBm); user group 2 includes 6 endpoints, namely STA 3/7/10/11/12/15, which are deployed at a distance of 5 m from the router and separated by a wall (the signal strength of the tested AP in the 5 GHz frequency band is -55 dBm±2 dBm); user group 3 includes 4 endpoints, namely STA 2/4/8/16, and the STAs of this group are deployed at a distance of 10 m from the router and separated by two walls (the signal strength of the tested AP in the 5 GHz frequency band is -65 dBm±2 dBm);
2. 16 users include five types of service endpoints: IoT, mobile gaming, 4K videos, cloud gaming, and download. Among them, STA 1 to STA 4 support up to IEEE 802.11n protocol with a bandwidth of 20 MHz, simulating 3 IoT devices and 1 camera device respectively. STA 5 to STA 8 support up to IEEE 802.11ac protocol with a bandwidth of 80 MHz, simulating a mobile game, a 4K video, a cloud gaming/VR, and a download service respectively; STA 9 to STA 12 support up to IEEE 802.11ax protocol, simulating a mobile game (160 MHz bandwidth), a 4K video (80 MHz bandwidth), a cloud gaming/VR (160 MHz bandwidth), and a download service (80 MHz bandwidth) respectively; STA 13 to STA 16 support up to IEEE 802.11be protocol with a bandwidth of 160 MHz, simulating a mobile gaming, a 4K video, a cloud gaming/VR, and a download service respectively, and MLO function is enabled;
3. service model
    a) STA 1 to STA 3 simulate IoT service, using data packets with a payload of 512 bytes, generating 5 packets per second; STA 4 simulates IPC service using data packets with a payload of 1472 bytes, with a traffic rate of 2 Mbps;

b) STA 5/12/15 simulate 4K ultra-high definition video service, using AC_VI priority, with a packet payload of 1472 bytes and service traffic rate of 15 Mbps;

c) STA 6/10/16 simulate mobile gaming service, using AC_VI priority and adopting hybrid service packets (payload of 88 bytes, 10 packets per second; payload of 512 bytes, 3 packets per second; payload of 1472 bytes, 2 packets per second);

d) STA 7/9/14 simulate download service, using AC_BE priority, with a packet payload of 1472 bytes and each with a service traffic rate of 40Mbps;

e) STA 8/11/13 simulate cloud gaming service, using AC_VI priority and adopting hybrid service packets (payload of 88 bytes, 160 packets per second; payload of 512 bytes, 50 packets per second; payload of 1472 bytes, 850 packets per second);

4. Interference source: the duty cycle of 2.4 GHz interference is 20%, and the duty cycle of 5 GHz interference is 10%. The specific definition of interference sources refers to the interference model defined in latency Scenario Model 3 (7.3.1.4).

8.4.2 Performance requirements for multi-protocol hybrid access home scenarios

A typical multi-protocol hybrid access home scenario is defined as a five-person household scenario with a medium-sized residence of 120 m^2. In this scenario, the case with the highest concurrency of user service is selected as the test and evaluation scenario. The KPI experience requirements for concurrent service are as follows:

Table 20 Concurrent scenario experience of multi-protocol hybrid access service

Protocol	Service Scenarios	Average Latency	TP99 Latency	Packet loss ratio
IEEE 802.11be	4K videos	≤ 8ms	≤ 40ms	≤ 0.05%
	Download	≤ 12ms	≤ 50ms	≤ 0.05%
	Cloud gaming	≤ 8ms	≤ 40ms	≤ 0.05%
	Mobile gaming	≤ 8ms	≤ 40ms	≤ 0.05%
IEEE 802.11ax	4K videos	≤ 10ms	≤ 50ms	≤ 0.05%
	Download	≤ 15ms	≤ 60ms	≤ 0.05%
	Cloud gaming	≤ 10ms	≤ 50ms	≤ 0.05%
	Mobile gaming	≤ 10ms	≤ 50ms	≤ 0.05%
IEEE 802.11ac	4K videos	≤ 20ms	≤ 80ms	≤ 0.05%
	Download	≤ 30ms	≤ 100ms	≤ 0.05%
	Cloud gaming	≤ 20ms	≤ 80ms	≤ 0.05%
	Mobile gaming	≤ 20ms	≤ 80ms	≤ 0.05%
IEEE 802.11n	IoT (non-IPC)	≤ 30ms	≤ 100ms	≤ 0.05%
	IoT (IPC)	≤ 30ms	≤ 100ms	≤ 0.05%

Appendix A (Normative): Requirements for Test and Certification Scope

Table A.1 describes the scope of test and certification based on this requirement.

Table A.1 Requirements for test and certification scope

Primary Indicators	Secondary Indicators	Endpoint Configuration	11be Devices
7.1 Bandwidth	A single user on a single frequency band without interference	2.4 G 20 MHz	Mandatory
		2.4 G 40 MHz	Mandatory
		5 G 160 MHz	Mandatory
	Multi-user concurrent on multiple frequency bands without interference	2.4 G 20 MHz + 5 G 160 MHz	Optional
		2.4 G 40 MHz + 5 G 160 MHz	Mandatory
		5 GH 80 MHz + 5 GL 160 MHz	Optional
	Single-user throughput in time-varying interference scenarios	5 G 160 MHz	Mandatory
		MLO 2.4 G 20 MHz + 5 G 160 MHz	Mandatory
	Concurrent throughput in MLO mode	MLO 2.4 G 20 MHz + 5 G 160 MHz	Optional
		MLO 2.4 G 40 MHz + 5 G 160 MHz	Mandatory
		MLO 5 GH 80 MHz + 5 GL 160 MHz	Optional
	Single-user throughput in 20 MHz/40 MHz channel interference scenario	5 G 160 MHz + interference bandwidth 20 MHz	Mandatory
		5 G 160 MHz + interference bandwidth 40 MHz	Mandatory
7.3 Latency	A single user on a single frequency band without interference	2.4 G 20 MHz 88 bytes	Mandatory
		2.4 G 20 MHz 512 bytes	Mandatory
		2.4 G 20 MHz 1518 bytes	Mandatory
		5 G 160 MHz 88 bytes	Mandatory
		5 G 160 MHz 512 bytes	Mandatory
		5 G 160 MHz 1518 bytes	Mandatory
	Multiple users without interference	2.4 G 20 MHz average latency	Mandatory
		2.4 G 20 MHz TP99 latency	Mandatory
		5 G 160 MHz average latency	Mandatory
		5 G 160 MHz TP99 latency	Mandatory
		2.4 G 20 MHz average latency	Mandatory

	Multiple users in interference scenarios	2.4 G 20 MHz TP99 latency	Mandatory
		5 G 160 MHz average latency	Mandatory
		5 G 160 MHz TP99 latency	Mandatory
	Multi-user latency under MLO mode in interference scenarios	2.4 G OFF + 5 G ON: MLO average latency	Mandatory
		2.4 G OFF + 5 G ON: MLO TP99 average latency	Mandatory
		2.4 G ON + 5 G OFF: MLO average latency	Mandatory
		2.4 G ON + 5 G OFF: MLO TP99 average latency	Mandatory
		2.4 G ON + 5 G ON: MLO average latency	Mandatory
		2.4 G ON + 5 G ON: MLO TP99 average latency	Mandatory
7.4 Coverage	Coverage for a single user in certain LOS distance without interference	10 m LOS distance - 2.4 G channel 6 20 MHz	Mandatory
		10 m LOS distance - 5 G channel 36 160 MHz	Mandatory
		10 m LOS distance - MLO 2.4 G 20 MHz + 5 G 160 MHz	Mandatory
	Wall-penetrating coverage for a single user without interference	10 m + wall - 2.4 G channel 6 20 MHz	Mandatory
		10 m + wall - 5 G channel 36 160 MHz	Mandatory
		10 m + wall - MLO 2.4 G 20 MHz + 5 G 160 MHz	Mandatory
7.5 Connection	Multi-user concurrent access	2.4 G 20 MHz	Mandatory
		5 G 160 MHz	Mandatory
	Multi-user service concurrency	16 users - 2.4 G 20 MHz maximum throughput	Mandatory
		32 users - 2.4 G 20 MHz maximum throughput	Mandatory
		16 users - 5 G 160 MHz maximum throughput	Mandatory
		32 users - 5 G 160 MHz - maximum throughput	Mandatory
		16 users - MLO 2.4 G 20 MHz + 5 G 160 MHz - maximum throughput	Mandatory
		32 users - MLO 2.4 G 20 MHz + 5 G 160 MHz - maximum throughput	Mandatory
7.6 Stability	The long-term stability for multiple users	16 users - success ratio of access user	Mandatory
		16 users - throughput performance fluctuations of TCP service user	Mandatory
		16 users - latency fluctuations of UDP service user	Mandatory
8.2 Service model and performance requirements in typical small-sized residence scenarios	Typical small-sized residence scenarios	STA 1 (air interface 3 m) + 4K high definition videos	Mandatory
		STA 2 (air interface 10 m + a wall) + 4K high definition videos	Mandatory
		STA 3 (air interface 10 m + a wall) + online mobile gaming	Mandatory
		STA 4 (air interface 3 m) + FTP download	Mandatory
8.3 Service model and	Typical mid-sized residence scenarios	STA 1 (air interface 3 m)(5 G frequency band)+ 4K high definition videos	Mandatory

performance requirements in typical mid-sized residence scenarios		STA 2 (air interface 10 m + a wall) (5 G frequency band)+4K high definition videos	Mandatory
		STA 3 (air interface 10 m + a wall)(5 G frequency band)+ FTP download	Mandatory
		STA 4 (air interface 3 m) (5 G frequency band) + video conferencing	Mandatory
		STA 5 (air interface 10 m + a wall) (2 G frequency band) + online mobile gaming	Mandatory
		STA 6 (air interface 10 m + a wall) (2 G frequency band) + video live streaming	Mandatory
8.4 Concurrent scenario experience of multi-protocol hybrid access service	Multi-protocol hybrid access home scenarios	IEEE 802.11be 4K videos - average latency	Mandatory
		IEEE 802.11be 4K videos - TP99 latency	Mandatory
		IEEE 802.11be 4K videos - packet loss ratio	Mandatory
		IEEE 802.11be download - average latency	Mandatory
		IEEE 802.11be download - TP99 latency	Mandatory
		IEEE 802.11be download - packet loss ratio	Mandatory
		IEEE 802.11be cloud gaming - average latency	Mandatory
		IEEE 802.11be cloud gaming - TP99 latency	Mandatory
		IEEE 802.11be cloud gaming - packet loss ratio	Mandatory
		IEEE 802.11be mobile gaming - average latency	Mandatory
		IEEE 802.11be mobile gaming - TP99 latency	Mandatory
		IEEE 802.11be mobile gaming - packet loss ratio	Mandatory
		IEEE 802.11ax 4K videos - average latency	Mandatory
		IEEE 802.11ax 4K videos - TP99 latency	Mandatory
		IEEE 802.11ax 4K videos - packet loss ratio	Mandatory
		IEEE 802.11ax download - average latency	Mandatory
		IEEE 802.11ax download - TP99 latency	Mandatory
		IEEE 802.11ax download - packet loss ratio	Mandatory
		IEEE 802.11ax cloud gaming - average latency	Mandatory
		IEEE 802.11ax cloud gaming - TP99 latency	Mandatory
		IEEE 802.11ax cloud gaming - packet loss ratio	Mandatory
		IEEE 802.11ax mobile gaming - average latency	Mandatory
		IEEE 802.11ax mobile gaming - TP99 latency	Mandatory
		IEEE 802.11ax mobile gaming - packet loss ratio	Mandatory
		IEEE 802.11ac 4K videos - average latency	Mandatory
		IEEE 802.11ac 4K videos - TP99 latency	Mandatory
		IEEE 802.11ac 4K videos - packet loss ratio	Mandatory
		IEEE 802.11ac download - average latency	Mandatory
		IEEE 802.11ac download - TP99 latency	Mandatory
		IEEE 802.11ac download - packet loss ratio	Mandatory
		IEEE 802.11ac cloud gaming - average latency	Mandatory

		IEEE 802.11ac cloud gaming - TP99 latency	Mandatory
		IEEE 802.11ac cloud gaming - packet loss ratio	Mandatory
		IEEE 802.11ac mobile gaming - average latency	Mandatory
		IEEE 802.11ac mobile gaming - TP99 latency	Mandatory
		IEEE 802.11ac mobile gaming - packet loss ratio	Mandatory
		IEEE 802.11n IOT - average latency	Mandatory
		IEEE 802.11n IOT - TP99 latency	Mandatory
		IEEE 802.11n IOT - packet loss ratio	Mandatory
		IEEE 802.11n IOT - average latency	Mandatory
		IEEE 802.11n IOT - TP99 latency	Mandatory
		IEEE 802.11n IOT - packet loss ratio	Mandatory
		IEEE 802.11n IOT - average latency	Mandatory
		IEEE 802.11n IOT - TP99 latency	Mandatory
		IEEE 802.11n IOT - packet loss ratio	Mandatory
		IEEE 802.11n IOT (IPC) - average latency	Mandatory
		IEEE 802.11n IOT (IPC) - TP99 latency	Mandatory
		IEEE 802.11n IOT (IPC) - packet loss ratio	Mandatory

Appendix B (Informative): Reference Values of Signal Attenuation Caused by Common Obstacles

Table B.1 lists the reference values of common obstacles.

Table B.1 Reference values of signal attenuation caused by common obstacles

Common Obstacle	Thickness (mm)	2.4 GHz Signal Attenuation (dB)	5 GHz Signal Attenuation (dB)
Common brick wall	120	10	20
Thick brick wall	240	15	25
Concrete	240	25	30
Asbestos	8	3	4
Foam materials	8	3	4
Hollow wood	20	2	3
Common wood door	40	3	4
Solid wood door	40	10	15
Common glass	8	4	7
Thick glass	12	8	10
Armored glass	30	25	35
Load-bearing column	500	25	30
Roller shutter door	10	15	20
Steel plate	80	30	35
Elevator	80	30	35