Radiocommunication Study Groups

Institute of Electrical and Electronics Engineers

PROPOSED MODIFICATION TO ANNEX 10 TO DOCUMENT 5A/769-E

Source Information

IEEE 802 LAN/MAN Standards Committee (LMSC) respectfully submits this submission to ITU-R Working Party 5A (WP 5A). IEEE 802 is a committee of the IEEE Standards Association and Technical Activities, two of the Major Organizational Units of the Institute of Electrical and Electronics Engineers (IEEE). IEEE has about 400,000 members in over 160 countries. IEEE's core purpose is to foster technological innovation and excellence for the benefit of humanity. In submitting this document, IEEE 802 acknowledges and respects that other components of IEEE Organizational Units may have perspectives that differ from, or compete with, those of IEEE 802. Therefore, this submission should not be construed as representing the views of IEEE as a whole[1].

Introduction

This document proposes updates to the **Annex 10** to **Doc.5A/769** - Working document towards a preliminary draft revision of Recommendation ITU-R M.1801-2 - Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz. The proposed changes and embedded comments are indicated via the 'track changes' and highlighted in turquoise.

We applaud the efforts of the participants in WP 5A for undertaking this work and giving IEEE 802 the opportunity to contribute.

Discussion

Since the last revision of ITU-R M.1801-2 (2013), there have been a number of updates and comments to IEEE 802 standards that we would like to share with WP 5A for consideration.

Proposal

Incorporate the proposed updates below into ITU-R M.1801.

IEEE 802 proposes that the revision of Recommendation ITU-R M.1801-2 be completed during the September meeting of WP 5A and submitted to SG 5.

Contact: LYNCH Michael   **E-mail:**   freqmgr@ieee.org

Incl.: Annex 1

---

[1] This document solely represents the views of the IEEE 802 LAN/MAN Standards Committee and does not necessarily represent a position of either the IEEE, the IEEE Standards Association or IEEE Technical Activities.

Formatted: English (United Kingdom)

Radiocommunication Study Groups

Source: Document 5A/TEMP/303

**Annex 10 to
Document 5A/769-E
23 May 2023
English only**

Annex 10 to Working Party 5A Chairman's Report

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT REVISION OF RECOMMENDATION ITU-R M.1801-2*

Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service ~~operating below 6 GHz~~

(Questions ITU-R 212-4/5 and ITU-R 238-2/5)

(2007-2010-2013)

[Editor's note: text highlighted in yellow needs attention]

Summary of the revision

In this revision a new Annex has been added with a description of the IMT-2020 terrestrial radio interfaces and other consequential amendments throughout the draft revision, including updates of other annexes. The title of the Recommendation has been amended in accordance with the Radio Regulations (2020 Edition), which now identify certain frequency bands up to 71 GHz for the implementation of IMT. The organization of the draft revision has been updated in accordance with the mandatory Format of ITU-R Recommendations.

~~**1   Introduction**~~

~~This Recommendation recommends specific standards for broadband wireless access² in the mobile service. These specific standards are composed of common specifications developed by standards development organizations (SDOs). Using this Recommendation, manufacturers and operators should be able to determine the most suitable standards for their needs.~~

~~These standards support a wide range of applications in urban, suburban and rural areas for both generic broadband Internet data and real-time data, including applications such as voice and videoconferencing.~~

---

*   This Recommendation should be brought to the attention of ITU-T Study Groups 2 and 15.

~~² "Wireless access" and "BWA" are defined in Recommendation ITU-R F.1399, which also provides definitions of the terms "fixed", "mobile" and "nomadic" wireless access.~~

Formatted: English (United Kingdom)

2   Scope

This Recommendation provides~~identifies~~ specific radio interface standards for broadband wireless access[3] (BWA) systems in the mobile service ~~operating below 6 GHz~~. The standards included in this Recommendation are capable of supporting users at broadband data rates, taking into account the ITU-R definitions of "wireless access" and "broadband wireless access" found in Recommendation ITU-R F.1399[4].

This Recommendation is not intended to deal with the identification of suitable frequency bands for BWA systems, nor with any regulatory issues.

Keywords

Broadband wireless access standards.

3   Related ITU Recommendations

The existing Recommendations that are considered to be of importance in the development of this particular Recommendation are as follows:

Recommendation ITU-R F.1399   Vocabulary of terms for wireless access.

Recommendation ITU-R F.1763   Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz.

Recommendation ITU-R M.1678   Adaptive antennas for mobile systems.

4   Acronyms and abbreviations

AA   Adaptive antenna
ACK   Acknowledgement (channel)
AN   Access network
ARIB   Association of Radio Industries and Businesses
ARQ   Automatic repeat request
AT   Access terminal
ATIS   Alliance for Telecommunications Industry Solutions
ATM   Asynchronous transfer mode
BCCH   Broadcast control channel
BER   Bit-error ratio
BRAN   Broadband radio access network
BS   Base station
BSR   Base station router
BTC   Block turbo code

---

[3] "Wireless access" and "BWA" are defined in Recommendation ITU-R F.1399, which also provides definitions of the terms "fixed", "mobile" and "nomadic" wireless access.

[4] *Broadband wireless access* is defined as wireless access in which the connection(s) capabilities are higher than the *primary rate*, which is defined as the transmission bit rate of 1.544 Mbit/s (T1) or 2.048 Mbit/s (E1). *Wireless access* is defined as end-user radio connection(s) to core networks.

Formatted: English (United Kingdom)

BWA	Broadband wireless access
CC	Convolutional coding
CDMA	Code division multiple access
CDMA-MC	Code division multiple access – multi-carrier
CL	Connection layer
C-plane	Control plane
CQI	Channel quality indicator
CS-OFDMA	Code spread OFDMA
CTC	Convolutional turbo code
DECT	Digital enhanced cordless telecommunications
DFT	Discrete Fourier transform
DLC	Data link control
DS-CDMA	Direct-sequence code division multiple access
DSSS	Direct sequence spread spectrum
E-DCH	Enhanced dedicated channel
EGPRS	Enhanced general packet radio service
EPC	Evolved packet core
ETSI	European Telecommunication Standards Institute
EV-DO	Evolution data optimized
FC	Forward channel
FCC	Forward control channel
FDD	Frequency division duplex
FEC	Forward-error correction
FER	Frame error rate
FHSS	Frequency hopping spread spectrum
FSTD	Frequency switched transmit diversity
FT	Fixed termination
GERAN	GSM edge radio access network
GoS	Grade of service
GPRS	General packet radio service
GPS	Global positioning system
HC-SDMA	High capacity-spatial division multiple access
HiperLAN	High performance RLAN
HiperMAN	High performance metropolitan area network
HRPD	High rate packet data

Formatted: English (United Kingdom)

HSDPA	High speed downlink packet access
HS-DSCH	High speed downlink shared channel
HSUPA	High speed uplink packet access
ICIC	Inter-cell interference coordination
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task force
IP	Internet protocol
LAC	Link access control
LAN	Local area network
LDPC	Low density parity check
LLC	Logic link control
LTE	Long term evolution
MAC	Medium access control
MAN	Metropolitan area network
MCSB	Multi-carrier synchronous beamforming
MIMO	Multiple input multiple output
MS	Mobile station
NLoS	Non-line-of-sight
OFDM	Orthogonal frequency-division multiplexing
OFDMA	Orthogonal frequency-division multiple access
OSI	Open systems interconnection
PAPR	Peak-to-average power ratio
PDCP	Packet data convergence protocol
PHS	Personal handyphone system
PHY	Physical layer
PLP	Physical layer protocol
PMI	Preferred matrix index
PT	Portable termination
QAM	Quadrature amplitude modulation
QoS	Quality-of-service
RAC	Reverse access channel
RF	Radio frequency
RIT	Ratio Interface Technologies
RLAN	Radio local area network
RLC	Radio link control

Formatted: English (United Kingdom)

RLP	Radio link protocol
RTC	Reverse traffic channel
SC	Single carrier
SC-FDMA	Single carrier-frequency division multiple access
SCG	Subcarrier group
SDMA	Spatial division multiple access
SDO	Standards development organization
SFBC	Space frequency block coding
SISO	Single input single output
SL	Security/session/stream layer
SM	Spatial multiplexing
SNP	Signalling network protocol
TCC	Traffic code channels
TDD	Time-division duplex
TDMA	Time-division multiple access
TDMA-SC	TDMA-single carrier
TD-SCDMA	Time-division-synchronized CDMA
TTA	Telecommunications Technology Association
TTI	Transmission time interval
U-plane	User plane
WiBro	Wireless broadband
WirelessMAN	Wireless metropolitan area network
WTSC	Wireless Technologies and Systems Committee
WWINA	Wireless wideband Internet access
XGP	eXtended Global Platform

5 ~~Noting~~

~~Recommendation ITU-R F.1763 recommends radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz.~~

The ITU Radiocommunication Assembly,

Formatted: English (United Kingdom)

considering

a)   that the successful expansion of Internet connectivity over the past decades needs to continue and be accelerated[5];

b)   that standards facilitate interoperability and economies of scale, leading to the fulfilment of the United Nations' 2030 Agenda for Sustainable Development Goals (SDGs)[6],

noting

a)   that Recommendation ITU-R F.1763 recommends radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz.

recommends

that the radio interface standards in Annexes 1 to 8 10 should be used for BWA systems in the mobile service operating below 6 GHz.

NOTE 1 – Annex 9 10 provides a summary of the characteristics of the standards found in Annexes 1 to 8 9.

List of annexes

Annex 1

Broadband radio local area networks

Radio local area networks (RLANs) offer an extension to wired LANs utilizing radio as the connective media. They have applications in commercial enterprise environments where there may be considerable savings in both cost and time to install a network; in domestic residential environments where they provide low cost cheap and, flexible, connectivity to multiple computers and other devices used in the home; and in campus and public environments where the increasing use

---

[5] State of Broadband Report 2021: Geneva: International Telecommunication Union and United Nations Educational, Scientific and Cultural Organization, 2021. License: CC BY-NC-SA 3.0 IGO. *Available:* https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.23-2021-PDF-E.pdf

[6] https://sdgs.un.org/2030agenda.

Formatted: English (United Kingdom)

of portable computers, for both business and personal use, while travelling and due to the increase in flexible working practices, e.g., nomadic workers using laptop personal computers not just in the office and at home, but in hotels, conference centres, airports, trains, planes and automobiles. In summary, they are intended mainly for nomadic wireless access applications, with respect to the access point (i.e. when the user is in a moving vehicle, the access point is also in the vehicle).

Broadband radio local area network standards are included in Recommendation ITU-R M.1450, and can be grouped as follows:

– IEEE 802. 11 Wireless LAN
– ETSI BRAN HIPERLAN
– ARIB HiSWANa.

1 IEEE 802.11 Wireless LAN

The IEEE 802.11™ Wireless LAN Working Group has developed a standard for RLANs, IEEE Std 802.11-20122020, which is part of the IEEE 802 series of standards for local and metropolitan area networks. The medium access control (MAC) unit in IEEE Std 802.11 is designed to support physical layer units as they may be adopted dependent on the availability of spectrum. IEEE Std 802.11 operates in the 2 400-2 500 MHz band and in the bands comprising 3 650-3 700 MHz, 4.94-4.99 GHz, 5.03-5.091 GHz, 5.15-5.25 GHz, 5.25-5.35 GHz, 5.47-5.725 GHz and 5.725-5.850. IEEE Std 802.11 employs the frequency hopping spread spectrum (FHSS) technique, direct sequence spread spectrum (DSSS) technique, orthogonal frequency division multiplexing (OFDM) technique, Beamforming and multiple input and multiple output (MIMO) technique.

Approved amendments to the IEEE 802.11-2012 base standard include Prioritization of Management Frames (IEEE 802.11ae), and Robust Audio Video Streaming (IEEE 802.11aa).

The URL for the IEEE 802.11 Working Group is http://www.ieee802.org/11. IEEE Std 802.11-20122020 and some amendments are available at no cost through the Get IEEE 802™ program at http://standards.ieee.org/about/get, and future amendments will become available for no cost six months after publication. Approved amendments and some draft amendments are available for purchase at http://www.techstreet.com/ieeegate.html.

2 ETSI BRAN HIPERLAN

The HiperLAN 2 specifications were developed by ETSI TC (Technical Committee) BRAN (broadband radio access networks). HiperLAN 2 is a flexible RLAN standard, designed to provide high-speed access up to 54 Mbit/s at physical layer (PHY) to a variety of networks including Internet protocol (IP) based networks typically used for RLAN systems. Convergence layers are specified which provide interworking with Ethernet, IEEE 1394 and ATM. Basic applications include data, voice and video, with specific quality-of-service parameters taken into account. HiperLAN 2 systems can be deployed in offices, classrooms, homes, factories, hot spot areas such as exhibition halls and, more generally, where radio transmission is an efficient alternative or complements wired technology.

HiperLAN 2 is designed to operate in the bands 5.15-5.25 GHz, 5.25-5.35 GHz and 5.47-5.725 GHz. The core specifications are TS 101 475 (physical layer), TS 101 761 (data link control layer), and TS 101 493 (convergence layers). All ETSI standards are available in electronic form at: http://pda.etsi.org/pda/queryform.asp, by specifying the standard number in the search box.

ETSI TC BRAN has also developed conformance test specifications for the core HIPERLAN 2 standards, to assure the interoperability of devices and products produced by different vendors. The test specifications include both radio and protocol testing.

Formatted: English (United Kingdom)

ETSI TC BRAN has worked closely with IEEE-SA (Working Group 802.11) and with MMAC in Japan (Working Group High Speed Wireless Access Networks) to harmonize the systems developed by these three fora for the 5 GHz bands.

3 MMAC[7] HSWA[8]

MMAC HSWA has developed and ARIB[9] has approved and published a standard for broadband mobile access communication systems. It is called HiSWANa (ARIB STD-T70). The scope of the technical specifications is limited to the air interface, the service interfaces of the wireless subsystem, the convergence layer functions and supporting capabilities required to realize the services.

The technical specifications describe the PHY and MAC/DLC layers, which are core network independent, and the core network-specific convergence layer. The typical data rate is from 6 to 36 Mbit/s. The OFDM technique and TDMA-TDD scheme are used. It is capable of supporting multimedia applications by providing mechanisms to handle the quality-of-service (QoS). Restricted user mobility is supported within the local service area. Currently, only Ethernet service is supported.

The HiSWANa system is operated in the 5 GHz bands (4.9-5.0 GHz and 5.15-5.25 GHz).

Annex 2

IMT-2000 terrestrial radio interfaces

The section titles are taken from § 5 of Recommendation ITU-R M.1457, additional updated information can be found there.

Contents

1 IMT-2000 CDMA Direct Spread[10]

The UTRAN radio-access scheme is direct-sequence CDMA (DS-CDMA) with information spread over approximately 5 MHz bandwidth using a chip rate of 3.84 Mchip/s. Higher order modulation

---

[7] Multimedia Mobile Access Communication Systems Promotion Council (now called "Multimedia Mobile Access Communication Systems Forum" or "MMAC Forum").

[8] High Speed Wireless Access Committee.

[9] Association of Radio Industries and Businesses.

[10] See § 5.1 of Recommendation ITU-R M.1457.

Formatted: English (United Kingdom)

(64-QAM in downlink and 16-QAM in uplink), multiple input multiple output antennas (MIMO), improved L2 support for high data rates and coding techniques (turbo codes) are used to provide high-speed packet access.

A 10 ms radio frame is divided into 15 slots (2 560 chip/slot at the chip rate of 3.84 Mchip/s). A physical channel is therefore defined as a code (or number of codes). For HS-DSCH (high-speed downlink packet access – HSDPA), E-DCH (high-speed uplink packet access – HSUPA) and associated signalling channels, 2 ms subframes consisting of 3 slots are defined. This technology achieves peak data rates approaching 42 Mbit/s for downlink and up to 11 Mbit/s for uplink. In the downlink, further enhancements of DC-HSDPA in combination with the MIMO feature support peak data rates reaching up to 84 Mbit/s. In the uplink, the dual cell feature is also applicable to two adjacent frequencies in the same band with enhanced uplink in order to support peak data rates reaching up to 23 Mbit/s. Large cell ranges (up to 180 km) can be achieved in good propagation conditions (e.g. desert, grassy and plain fields, coastal areas, etc.).

For efficient support of always-on connectivity whilst enabling battery saving in the UE and further increasing the air interface capacity, the specifications also include the continuous packet connectivity feature (CPC). The CS voice services are supported over HSPA.

The radio interface is defined to carry a wide range of services to efficiently support both circuit-switched services (e.g. PSTN- and ISDN-based networks) as well as packet-switched services (e.g. IP-based networks). A flexible radio protocol has been designed where several different services such as speech, data and multimedia can simultaneously be used by a user and multiplexed on a single carrier. The defined radio-bearer services provide support for both real-time and non-real-time services by employing transparent and/or non-transparent data transport. The QoS can be adjusted in terms such as delay, bit-error probability, and frame error ratio (FER).

The radio access network architecture also provides support for multimedia broadcast and multicast services, i.e. allowing for multimedia content distribution to groups of users over a point-to-multipoint bearer.

Evolved UTRA (E-UTRA) has been introduced for the evolution of the radio-access technology towards a high-data-rate, low-latency and packet-optimized radio-access technology.

The downlink transmission scheme is based on conventional OFDM to provide a high degree of robustness against channel frequency selectivity while still allowing for low-complexity receiver implementations also at very large bandwidths. The uplink transmission scheme is based on SC-FDMA (Single Carrier-FDMA), more specifically DFT-spread OFDM (DFTS-OFDM). It also supports multi-cluster assignment of DFTS-OFDM. The use of DFTS-OFDM transmission for the uplink is motivated by the lower Peak-to-Average Power Ratio (PAPR) of the transmitted signal compared to conventional OFDM.

E-UTRA supports bandwidths from approximately 1.4 MHz to 100 MHz, yielding peak data rates up to roughly 3 Gbit/s in the downlink and 1.5 Gbit/s in the uplink. Carrier aggregation, i.e. the simultaneous transmission of multiple component carriers in parallel to/from the same terminal, is used to support bandwidths larger than 20 MHz.

2 IMT-2000 CDMA Multi-Carrier[11]

The CDMA multi-carrier radio interface provides two options: cdma2000 operation where one or three RF carriers are utilized or cdma2000 high rate packet data (HRPD) where one to fifteen RF carriers are utilized.

---

[11] See § 5.2 of Recommendation ITU-R M.1457.

Formatted: English (United Kingdom)

The cdma2000 operation option supports one or three 1.2288 Mchips/s RF carriers. The radio interface is defined to carry a wide range of services to support both circuit-switched services (e.g. PSTN- and ISDN-based networks) as well as packet-switched services (e.g. IP-based networks). The radio protocol has been designed where several different services such as speech, data and multimedia can simultaneously be used in a flexible manner by a user and multiplexed on a single carrier. The defined radio-bearer services provide support for both real-time and non-real-time services by employing transparent and/or non-transparent data transport. The QoS can be adjusted in terms such as delay, bit-error probability and FER.

The radio-interface specification includes enhanced features for simultaneous high-speed packet data and other services such as speech on the single carrier. In particular, features for enhanced reverse link have been introduced, allowing for improved capacity and coverage, higher data rates than the current uplink maximum, and reduced delay and delay variance for the reverse link.

The radio access network architecture also provides support for multimedia broadcast and multicast services, i.e. allowing for multimedia content distribution to groups of users over a point-to-multipoint bearer.

For cdma2000 HRPD, the forward link, deployed on one to fifteen RF carriers, consists of the following time-multiplexed channels: the pilot channel, the forward MAC channel, the control channel and the forward traffic channel. The forward traffic channel carries user data packets. The control channel carries control messages, and it may also carry user traffic. Each channel is further decomposed into code-division-multiplexed quadrature Walsh channels.

The cdma2000 HRPD MAC channel consists of two sub-channels: the reverse power control (RPC) channel and the reverse activity (RA) channel. The RA channel transmits a reverse link activity bit (RAB) stream. Each MAC channel symbol is BPSK-modulated on one of (sixty-four) 64-ary Walsh codewords.

The cdma2000 HRPD forward traffic channel is a packet-based, variable-rate channel. The user data for an access terminal is transmitted at a data rate that varies from 38.4 kbit/s to 4.9 Mbit/s per 1.2288 Mchip/s carrier. The forward traffic channel and control channel data are encoded, scrambled and interleaved. The outputs of the channel interleaver are fed into a QPSK/8-PSK/16-QAM/64-QAM modulator. The modulated symbol sequences are repeated and punctured, as necessary. Then, the resulting sequences of modulation symbols are demultiplexed to form 16 pairs (in-phase and quadrature) of parallel streams. Each of the parallel streams are covered with a distinct 16-ary Walsh function at a chip rate to yield Walsh symbols at 76.8 ksymbol/s. The Walsh-coded symbols of all the streams are summed together to form a single in-phase stream and a single quadrature stream at a chip rate of 1.2288 Mchip/s. The resulting chips are time-division multiplexed with the preamble, pilot channel, and MAC channel chips to form the resultant sequence of chips for the quadrature spreading operation.

The cdma2000 HRPD forward traffic channel physical layer packets can be transmitted in 1 to 16 slots. When more than one slot is allocated, the transmitted slots use 4-slot interlacing. That is, the transmitted slots of a packet are separated by three intervening slots, and slots of other packets are transmitted in the slots between those transmit slots. If a positive acknowledgement is received on the reverse link ACK channel that the physical layer packet has been received on the forward traffic channel before all of the allocated slots have been transmitted, the remaining untransmitted slots are not transmitted and the next allocated slot is used for the first slot of the next physical layer packet transmission.

The cdma2000 HRPD reverse link, deployed on one to fifteen RF carriers, consists of the access channel and the reverse traffic channel. The access channel is used by the access terminal to initiate communication with the access network or to respond to an access terminal directed message.

Formatted: English (United Kingdom)

The access channel consists of a pilot channel and a data channel. The reverse traffic channel is used by the mobile station to transmit user-specific traffic or signalling information to the access network. The cdma2000 HRPD reverse link traffic channel comprises a pilot channel, a reverse rate indicator (RRI) channel, a data rate control (DRC) channel, an acknowledgement (ACK) channel, and a data channel. The user data for an access terminal is transmitted at a data rate that varies from 4.8 kbits/s to 1.8 Mbits/s per 1.2288 Mchips/s carrier. The RRI channel is used to indicate the data rate transmitted on the reverse traffic channel. The RRI channel is time-multiplexed with the pilot channel. The DRC channel is used by the mobile station to indicate to the access network the supportable forward traffic channel data rate and the best serving sector on the forward CDMA channel. The ACK channel is used by the access terminal to inform the access network whether or not the data packet transmitted on the forward traffic channel has been received successfully.

For the enhanced HRPD access, physical layer H-ARQ (hybrid automatic repeat request), shorter frame sizes, fast scheduling/rate-control, and adaptive modulation and coding are implemented to increase the peak data rate and system throughput of the reverse link.

2.1 Ultra mobile broadband system

The ultra-mobile broadband (UMB) system provides a unified design for full- and half-duplex FDD and TDD modes of operation with support for scalable bandwidths between 1.25 MHz and 20 MHz. The system is designed for robust mobile broadband access, and is optimized for high spectral efficiency and short latencies using advanced modulation, link adaptation, and multi-antenna transmission techniques. Fast handoff, fast power control, and inter-sector interference management are used. Adaptive coding and modulation with synchronous H-ARQ and turbo coding (LDPC optional) are used for achieving high spectral efficiencies. Sub-band scheduling provides enhanced performance on forward and the reverse link by exploiting multi-user diversity gains for latency-sensitive traffic.

The forward link is based on orthogonal frequency division multiple access (OFDMA) enhanced by multi-antenna transmission techniques including MIMO, closed loop beamforming, and space division multiple access (SDMA), with the maximum total spatial multiplexing order 4. Minimum forward link retransmission latency is approximately 5.5 ms and peak rate over 288 Mbit/s is achieved with 4th order MIMO in 20 MHz.

The reverse link is quasi-orthogonal. That is, it employs orthogonal transmission based on OFDMA, together with non-orthogonal user multiplexing with layered superposition or multiple receive antennas (SDMA). The reverse link also includes optional CDMA transmission for low-rate traffic. Interference management is obtained through fractional frequency reuse. An optimized throughput/fairness trade-off is obtained through distributed power control based on other-cell interference. The reverse link employs a CDMA control segment and OFDMA control segment. The system employs fast access with reduced overhead and fast requests. The reverse link employs a broadband reference signal for power control, handoff decisions, and sub-band scheduling. UMB MAC design allows for a power efficient reverse link transmission by power limited terminals through scheduling. The reverse link retransmission latency is approximately 7.3 ms and the peak data rate is over 75 Mbit/s in a 20 MHz bandwidth (with single codeword quasi-orthogonal coding).

UMB is designed to operate in partly or fully asynchronous deployments, however, air interface is optimized to take advantage of inter-cell synchronization. Low overhead pilot channels (beacons) are introduced to enable low-complexity neighbour search and facilitate same frequency handoff as well as inter-frequency handoff with minimum interruption.

UMB also features power efficient operation modes to improve terminal battery life. Specifically, selected interlace mode is optimized for low-rate latency sensitive applications such as VoIP while a

Formatted: English (United Kingdom)

semi-connected state is designed to provide efficient DTX/DRX with a low duty cycle latency tolerant traffic.

3   IMT-2000 CDMA TDD[12]

The universal terrestrial radio access (UTRA) time-division duplex (TDD) radio interface is defined where three options, called 1.28 Mchip/s TDD (TD-SCDMA), 3.84 Mchip/s TDD and 7.68 Mchip/s TDD can be distinguished.

The UTRA TDD radio interface has been developed with the strong objective of harmonization with the FDD component (see § 1) to achieve maximum commonality. This was achieved by harmonization of important parameters of the physical layer, and a common set of protocols in the higher layers are specified for both FDD and TDD, where 1.28 Mchip/s TDD has significant commonality with 3.84 Mchip/s TDD and 7.68 Mchip/s TDD. UTRA TDD with the three options accommodates the various needs of the different Regions in a flexible way and is specified in a common set of specifications.

The radio access scheme is direct-sequence code division multiple access. There are three chip-rate options: the 3.84 Mchip/s TDD option, with information spread over approximately 5 MHz bandwidth and a chip rate of 3.84 Mchip/s, the 7.68 Mchip/s TDD option with information spread over approximately 10 MHz bandwidth and a chip rate of 7.68 Mchip/s and the 1.28 Mchip/s TDD option, with information spread over approximately 1.6 MHz bandwidth and a chip rate of 1.28 Mchip/s. The radio interface is defined to carry a wide range of services to efficiently support both circuit-switched services (e.g. PSTN- and ISDN-based networks) as well as packet-switched services (e.g. IP-based networks). A flexible radio protocol has been designed where several different services such as speech, data and multimedia can simultaneously be used by a user and multiplexed on a single carrier. The defined radio bearer services provide support for both real-time and non-real-time services by employing transparent and/or non-transparent data transport. The QoS can be adjusted in terms such as delay, BER and FER.

The radio-interface specification includes enhanced features for high-speed downlink packet access (HSDPA) and improved L2 support for high data rates, allowing for downlink packet-data transmission with peak data rates of 2.8 Mbit/s, 10.2 Mbit/s and 20.4 Mbit/s for the 1.28 Mchip/s, 3.84 Mchip/s and 7.68 Mchip/s modes respectively, and for simultaneous high-speed packet data and other services such as speech on the single carrier. Features for enhanced uplink have been introduced, allowing for improved capacity and coverage, higher data rates, and reduced delay and delay variance for the uplink.

The addition of higher order modulation (16-QAM) for the enhanced uplink, allows for peak data rates up to 2.2 Mbit/s, 9.2 Mbit/s and 17.7 Mbit/s for the 1.28 Mchip/s, 3.84 Mchip/s and 7.68 Mchip/s modes, respectively. Support has been added for multi-frequency operation for the 1.28 Mchip/s UTRA TDD mode.

The radio access network architecture also provides support for multimedia broadcast and multicast services, i.e. allowing for multimedia content distribution to groups of users over a point-to-multipoint bearer.

Evolved-UTRA (E-UTRA) has been introduced for the evolution of the radio-access technology towards a high-data-rate, low-latency and packet-optimized radio-access technology.

The downlink transmission scheme is based on conventional OFDM to provide a high degree of robustness against channel frequency selectivity while still allowing for low-complexity receiver

---

[12] See § 5.3 of Recommendation ITU-R M.1457.

Formatted: English (United Kingdom)

implementations also at very large bandwidths. The uplink transmission scheme is based on SC-FDMA (Single Carrier-FDMA), more specifically DFT-spread OFDM (DFTS-OFDM). It also supports multi-cluster assignment of DFTS-OFDM. The use of DFTS-OFDM transmission for the uplink is motivated by the lower PAPR of the transmitted signal compared to conventional OFDM.

E-UTRA supports bandwidths from approximately 1.4 MHz to 100 MHz, yielding peak data rates up to roughly 3 Gbit/s in the downlink and 1.5 Gbit/s in the uplink. Carrier aggregation, i.e. the simultaneous transmission of multiple component carriers in parallel to/from the same terminal, is used to support bandwidths larger than 20 MHz.

4   IMT-2000 TDMA Single-Carrier[13]

This radio interface provides three bandwidth options for high-speed data, all using TDMA technology. The 200 kHz carrier bandwidth option (EDGE) utilizes 8-PSK or 32-QAM modulation with increased symbol rate with hybrid ARQ and achieves a channel transmission rate in dual-carrier mode of 1.625 Mbit/s or 3.25 Mbit/s while supporting high mobility. A 1.6 MHz bandwidth is provided for lower mobility environments which utilizes binary and quaternary offset QAM modulation with hybrid ARQ. This 1.6 MHz bandwidth option supports flexible slot allocation and achieves a channel transmission rate of 5.2 Mbit/s.

A rich broadcast or point-to-multipoint service known as multimedia broadcast/multicast service (MBMS) is provided. Point-to-multipoint services exist today which allow data from a single source entity to be transmitted to multiple endpoints. MBMS efficiently provides this capability for such broadcast/multicast services provided by the home environment and other value-added service providers (VASPs).

The MBMS is a unidirectional point-to-multipoint bearer service in which data is transmitted from a single-source entity to multiple recipients. It will also be capable of expanding to support other services with these bearer capabilities.

Multicast mode is interoperable with IETF IP multicast. This will allow the best use of IP service platforms to help maximize the availability of applications and content so that current and future services can be delivered in a more resource-efficient manner.

5   IMT-2000 FDMA/TDMA[14]

The IMT-2000 radio interface for FDMA/TDMA technology is called digital enhanced cordless telecommunications (DECT).

This radio interface specifies a TDMA radio interface with time-division duplex (TDD). The channel transmission rates for the specified modulation schemes are 1.152 Mbit/s, 2.304 Mbit/s, 3.456 Mbit/s, 4.608 Mbit/s and 6.912 Mbit/s. The standard supports symmetric and asymmetric connections, connection-oriented and connectionless data transport. Using multicarrier operation with, for example, three carriers, allows bit rates up to 20 Mbit/s. The network layer contains the protocols for call control, supplementary services, connection oriented message service, connectionless message service and mobility management, including security and confidentiality services.

The radio access frequency channels as well as a time structure are defined. The carrier spacing is 1.728 MHz. To access the medium in time, a regular TDMA structure with a frame length of 10 ms

---

[13] See § 5.4 of Recommendation ITU-R M.1457.

[14] See § 5.5 of Recommendation ITU-R M.1457.

Formatted: English (United Kingdom)

is used. Within this frame 24 full slots are created, each consisting of two half-slots. A double slot has a length of two full slots, and starts concurrently with a full slot.

The modulation method is either Gaussian frequency-shift keying (GFSK), with a bandwidth-bit period product of nominally 0.5, differential phase shift keying (DPSK) or phase amplitude modulation (QAM). Equipment is allowed to use 4-level and/or 8-level and/or 16-level and/or 64-level modulation in addition to 2-level modulation. This increases the bit rate of single radio equipment by a factor of 2 or 3 or 4 or 6. The 4-level modulation shall be $\pi/4$-DQPSK, the 8-level modulation $\pi/8$-D8-PSK, the 16-level modulation 16-QAM and the 64-level modulation 64-QAM.

The MAC layer offers three groups of services to the upper layers and to the management entity:

– broadcast message control (BMC);

– connectionless message control (CMC);

– multibearer control (MBC).

The BMC provides a set of continuous point-to-multipoint connectionless services. These are used to carry internal logical channels, and are also offered to the higher layers. These services operate in the direction FT to PT, and are available to all PTs within range.

The CMC provides connectionless point-to-point or point-to-multipoint services to the higher layers. These services may operate in both directions between one specific FT and one or more PTs.

Each instance of MBC provides one of a set of connection-oriented point-to-point services to the higher layers. An MBC service may use more than one bearer to provide a single service.

Four types of MAC bearer are defined:

– Simplex bearer: a simplex bearer is created by allocating one physical channel for transmissions in one direction.

– Duplex bearer: a duplex bearer is created by a pair of simplex bearers, operating in opposite directions on two physical channels.

– Double simplex bearer: a double simplex bearer is created by a pair of long simplex bearers operating in the same direction on two physical channels.

– Double duplex bearer: a double duplex bearer is composed by a pair of duplex bearers referring to the same MAC connection.

A bearer can exist in one of three operational states:

– Dummy bearer: where there are normally continuous transmissions (i.e. one transmission in every frame).

– Traffic bearer: where there are continuous point-to-point transmissions. A traffic bearer is a duplex bearer or a double simplex bearer or a double duplex bearer.

– Connectionless bearer: where there are discontinuous transmissions. A connectionless bearer is either a simplex or a duplex bearer.

The MAC layer defines a logical structure for the physical channels. The user bit rate depends on the selected slot-type, modulation scheme, level of protection, number of slots and number of carriers.

The mandatory instant dynamic channel selection messages and procedures provide effective coexistence of uncoordinated private and public systems on the common designated frequency band and avoid any need for traditional frequency planning. Each device has access to all channels (time/frequency combinations). When a connection is needed, the channel is selected that, at that instant and at that locality, is least interfered of all the common access channels. This avoids any need for traditional frequency planning, and greatly simplifies the installations. This procedure also

Formatted: English (United Kingdom)

provides higher and higher capacity by closer and closer base station installation, while maintaining a high radio link quality. Not needing to split the frequency resource between different services or users provides an efficient use of the spectrum.

The latest specifications provide an update to "New Generation DECT", where the main focus is the support of IP-based services. The quality of the speech service is further improved, by using wideband coding. The mandatory codec to provide interoperability over the air-interface is Recommendation ITU-T G.722. Further optional codecs can be negotiated. In addition to voice-over-IP, audio, video and other IP-based services can be provided by "New Generation DECT".

6   IMT-2000 OFDMA TDD WMAN[15]

The IMT-2000 OFDMA TDD WMAN radio interface is based on the IEEE standard designated as IEEE Std 802.16, which is developed and maintained by the IEEE 802.16 Working Group on Broadband Wireless Access. It is published by the IEEE Standards Association (IEEE-SA) of the Institute of Electrical and Electronics Engineers (IEEE). The radio interface technology specified in IEEE Standard 802.16 is flexible, for use in a wide variety of applications, operating frequencies, and regulatory environments. IEEE 802.16 includes multiple physical layer specifications, one of which is known as WirelessMAN-OFDMA. OFDMA TDD WMAN is a special case of WirelessMAN-OFDMA specifying a particular interoperable radio interface. OFDMA TDD WMAN as defined here operates in both TDD and FDD.

The OFDMA TDD WMAN radio interface comprises the two lowest network layers – the physical layer (PHY) and the data link control layer (DLC). The lower element of the DLC is the MAC; the higher element in the DLC is the logical link control layer (LLC). The PHY is based on OFDMA supporting flexible channelizations including 5 MHz, 7 MHz, 8.75 MHz and 10 MHz bands. The MAC is based on a connection-oriented protocol designed for use in a point-to-multipoint configuration. It is designed to carry a wide range of packet-switched (typically IP-based) services while permitting fine and instantaneous control of resource allocation to allow full carrier-class QoS differentiation.

The OFDMA TDD WMAN radio interface is designed to carry packet-based traffic, including IP. It is flexible enough to support a variety of higher-layer network architectures for fixed, nomadic, or fully mobile use, with handover support. It can readily support functionality suitable for generic data as well as time-critical voice and multimedia services, broadcast and multicast services and mandated regulatory services.

The radio interface standard specifies Layers 1 and 2; the specification of the higher network layers is not included. It offers the advantage of flexibility and openness at the interface between Layers 2 and 3 and it supports a variety of network infrastructures. The radio interface is compatible with the network architectures defined in Recommendation ITU-T Q.1701. In particular, a network architecture design to make optimum use of IEEE Standard 802.16 and the OFDMA TDD WMAN radio interface is described in the "WiMAX End to End Network Systems Architecture Stage 2-3", available from the WiMAX Forum[16].

---

[15] See § 5.6 of Recommendation ITU-R M.1457.

[16] https://wimaxforum.org/TechSpec~~http://www.wimaxforum.org/resources/technical specifications~~.

Formatted: English (United Kingdom)

Annex 3

IMT-Advanced terrestrial radio interfaces

1 LTE-Advanced[17]

The IMT-Advanced terrestrial radio interface specifications known as *LTE-Advanced* and based on LTE Release 10 and Beyond are developed by 3GPP.

LTE-Advanced is a Set of RITs (Radio Interface Technologies) consisting of one FDD RIT and one TDD RIT designed for operation in paired and unpaired spectrum, respectively. The TDD RIT is also known as TD-LTE Release 10 and Beyond or *TD-LTE-Advanced*. The two RITs have been jointly developed, providing a high degree of commonality while, at the same time, allowing for optimization of each RIT with respect to its specific spectrum/duplex arrangement.

The FDD and TDD RITs represent the evolution of the first releases of LTE FDD and TDD, respectively. The two RITs share many of the underlying structures to simplify implementation of dual-mode radio-access equipment. Transmission bandwidths up to 100 MHz are supported, yielding peak data rates up to roughly 3 Gbit/s in the downlink and 1.5 Gbit/s in the uplink.

The downlink transmission scheme is based on conventional OFDM to provide a high degree of robustness against channel frequency selectivity while still allowing for low-complexity receiver implementations also at very large bandwidths.

The uplink transmission scheme is based on DFT-spread OFDM (DFTS-OFDM). The use of DFTS-OFDM transmission for the uplink is motivated by the lower PAPR of the transmitted signal compared to conventional OFDM. This allows for more efficient usage of the power amplifier at the terminal, which translates into an increased coverage and/or reduced terminal power consumption. The uplink numerology is aligned with the downlink numerology.

Data channel coding is based on rate-1/3 Turbo coding and is complemented by Hybrid-ARQ with soft combining to handle decoding errors at the receiver side. Data modulation supports QPSK, 16-QAM, and 64-QAM for both the downlink and the uplink.

The FDD and TDD RITs support bandwidths from approximately 1.4 MHz to 100 MHz. Carrier aggregation, i.e. the simultaneous transmission of multiple component carriers in parallel to/from the same terminal, is used to support bandwidths larger than 20 MHz. Component carriers do not have to be contiguous in frequency and can even be located in different frequency bands in order to enable exploitation of fragmented spectrum allocations by means of spectrum aggregation.

Channel-dependent scheduling in both the time and frequency domains is supported for both downlink and uplink with the base-station scheduler being responsible for (dynamically) selecting the transmission resource as well as the data rate. The basic operation is dynamic scheduling, where the base-station scheduler takes a decision for each 1 ms Transmission Time Interval (TTI), but there is also a possibility for semi-persistent scheduling. Semi-persistent scheduling enables transmission resources and data rates to be semi-statically allocated to a given User Equipment (UE) for a longer time period than one TTI to reduce the control-signalling overhead.

Multi-antenna transmission schemes with dynamic scheduling are an integral part of both RITs. Multi-antenna precoding with dynamic rank adaptation supports both spatial multiplexing (single-user MIMO) and beam-forming. Spatial multiplexing with up to eight layers in the downlink and four layers in the uplink is supported. Multi-user MIMO, where multiple users are assigned the same time-

---

[17] See Annex 1 of Recommendation ITU-R M.2012.

C:\USERS\EDWARD\DOCUMENTS\STANDARDS\WI-FI\802.18\MEETING MATERIALS\PENDING FOR APPROVAL\PENDING\18-23-0083-00-0000-PROPOSED-MODIFICATIONS-TO-ITU-R-M-1801-2-FOR-SEP-2023-WP5A-MEETING.DOCXM:\BRSGD\TEXT2019\SG05\WP5A\700\769\769N10E.DOCX

Formatted: English (United Kingdom)

frequency resources, is also supported. Finally, transmit diversity based on Space-Frequency Block Coding (SFBC) or a combination of SFBC and Frequency Switched Transmit Diversity (FSTD) is supported.

Inter-cell interference coordination (ICIC), where neighbour cells exchange information aiding the scheduling in order to reduce interference, is supported for the RITs. ICIC can be used for homogeneous deployments with non-overlapping cells of similar transmission power, as well as for heterogeneous deployments where a higher-power cell overlays one or several lower-power nodes.

2   WirelessMAN-Advanced[18]

The *WirelessMAN-Advanced* radio interface specification is developed by IEEE. A complete end-to-end system based on *WirelessMAN-Advanced* is called WiMAX 2, as developed by the WiMAX Forum.

WirelessMAN-Advanced uses OFDMA as the multiple-access scheme in downlink (DL) and uplink (UL). It further supports both TDD and FDD duplex schemes including H-FDD operation of the mobile stations (MSs) in the FDD networks. The frame structure attributes and baseband processing are common for both duplex schemes. *WirelessMAN-Advanced* supports channel bandwidths up to 160 MHz with carrier aggregation.

WirelessMAN-Advanced utilizes the convolutional turbo code (CTC) with code rate of 1/3. The CTC scheme is extended to support additional FEC block sizes. Furthermore, the FEC block sizes can be regularly increased with predetermined block size resolutions.

Modulation constellations of QPSK, 16-QAM, and 64-QAM are supported. The mapping of bits to the constellation point depends on the constellation-rearrangement (CoRe) version used for HARQ retransmission and further depends on the MIMO scheme. The QAM symbols are mapped into the input of the MIMO encoder. The sizes include the addition of CRC (per burst and per FEC block), if applicable. Other sizes require padding to the next burst size. The code rate and modulation depend on the burst size and the resource allocation.

Incremental redundancy HARQ (HARQ-IR) is used in *WirelessMAN-Advanced* by determining the starting position of the bit selection for HARQ retransmissions. Chase combining HARQ (HARQ-CC) is also supported and considered as a special case of HARQ-IR.

Channel Quality Indicator (CQI) feedback provides information about channel conditions as seen by the MS. This information is used by the BS for link adaptation, resource allocation, power control, etc. The channel quality measurement includes both narrowband and wideband measurements. The CQI feedback overhead can be reduced through differential feedback or other compression techniques. Examples of CQI include effective carrier-to-interference plus noise ratio (CINR), band selection, etc.

MIMO feedback provides wideband and/or narrowband spatial characteristics of the channel that are required for MIMO operation. The MIMO mode, preferred matrix index (PMI), rank adaptation information, channel covariance matrix elements, and best sub-band index are examples of MIMO feedback information.

Power control mechanism is supported for DL and UL. Using DL power control, user-specific information with dedicated pilot is received by the terminal with the controlled power level. The DL advanced MAPs can be power-controlled based on the terminal UL channel quality feedback.

---

[18] See Annex 2 of Recommendation ITU-R M.2012.

Formatted: English (United Kingdom)

The UL power control is supported to compensate the path loss, shadowing, fast fading and implementation loss as well as to mitigate inter-cell and intra-cell interference. The BS can transmit necessary information through control channel or message to terminals to support UL power control. The parameters of power control algorithm are optimized on a system-wide basis by the BS and broadcasted periodically.

WirelessMAN-Advanced supports several advanced multi-antenna techniques including single and multi-user MIMO (spatial multiplexing and beamforming) as well as a number of transmit diversity schemes. In single-user MIMO (SU-MIMO) scheme only one user can be scheduled over one (time, frequency, space) resource unit. In multi-user MIMO (MU-MIMO), on the other hand, multiple users can be scheduled in one resource unit.

The minimum antenna configuration in the DL and UL is 2×2 and 1×2, respectively. For open-loop spatial multiplexing and closed-loop SU-MIMO, the number of streams is constrained to the minimum number of transmit or receive antennas. The MU-MIMO can support up to two streams with two transmit antennas and up to four streams for four transmit antennas and up to eight streams for eight transmit antennas.

Annex 4

IMT-2020 terrestrial radio interfaces

IMT-2020 is a system with global development activity and the IMT-2020 terrestrial radio interface specifications identified in Recommendation ITU-R M.2150 have been developed by the ITU in collaboration with the GCS Proponents and the Transposing Organizations.

Sections 1-4 of this annex describe the terrestrial radio interfaces for IMT-2020 covered in Recommendation ITU-R M.2150:

1   "3GPP 5G-SRIT"

2   "3GPP 5G-RIT"

3   "5Gi"

4   "DECT 5G-SRIT"

1   3GPP 5G − SRIT[19] radio interface technology

The IMT-2020 specifications, known as 5G, have been developed by 3GPP and consist of long-term evolution (LTE) and new radio (NR) Releases 15 and beyond. In 3GPP terminology, the term Evolved-UMTS Terrestrial Radio Access (E-UTRA) is also used to signify the LTE radio interface.

5G SRIT is a set of radio interface technologies (RITs) consisting of E-UTRA/LTE as one component RIT and NR as the other component RIT. Both components are designed for operation in IMT spectrum.

5G fulfils all technical performance requirements in all five selected test environments: Indoor Hotspot – enhanced Mobile Broadband (eMBB), Dense Urban – eMBB, Rural – eMBB, Urban Macro

---

[19] See Annex 1 of Recommendation ITU-R M.2150.

Formatted: English (United Kingdom)

– Ultra Reliable Low Latency Communication (URLLC) and Urban Macro – massive Machine Type Communication (mMTC).

Also, 5G fulfils the service and the spectrum requirements. Both component RITs, NR and E-UTRA/LTE, utilize the frequency bands below 6 GHz identified for International Mobile Telecommunication (IMT) in the ITU Radio Regulations. In addition, the NR component RIT can also utilize the frequency bands above 6 GHz, i.e. above 24.25 GHz, identified for IMT in the ITU Radio Regulations.

The complete set of standards for the terrestrial radio interface of IMT-2020 identified as 5G includes not only the key characteristics of IMT-2020 but also the additional capabilities of 5G both of which are continuing to be enhanced.

The 3GPP 5G System (5GS) also includes specifications for its non-radio aspects, such as the core network elements (the EPC Network and 5GC Network), security, codecs, network management, etc. These non-radio specifications are not included in the so-called "Global Core Specifications (GCS)" of IMT-2020.

2   3GPP 5G – RIT[20] radio interface technology

The IMT-2020 specifications known as 5G RIT have been developed by 3GPP and encompass NR Releases 15 and beyond.

New Radio (NR) is designed for operation in IMT spectrum and fulfils all technical performance requirements in all five selected test environments: Indoor Hotspot – enhanced Mobile Broadband (eMBB), Dense Urban – eMBB, Rural – eMBB, Urban Macro – Ultra Reliable Low Latency Communication (URLLC) and Urban Macro – massive Machine Type Communication (mMTC).

Also, NR fulfils the service and the spectrum requirements. NR utilizes the frequency bands below 6 GHz identified for International Mobile Telecommunication (IMT) in the ITU Radio Regulations. In addition, NR can also utilize the frequency bands above 6 GHz, i.e. above 24.25 GHz, identified for IMT in the ITU Radio Regulations.

The complete set of standards for the terrestrial radio interface of IMT-2020 identified as 3GPP 5G – RIT. NR − includes not only the key characteristics of IMT-2020 but also the additional capabilities of NR both of which are continuing to be enhanced.

The 3GPP 5G System (5GS) also includes specifications for its non-radio aspects, such as the core network elements (the Enhanced Packet Core (EPC) Network and 5G Core (5GC) Network), security, codecs, network management, etc. These non-radio specifications are not included in the so-called "Global Core Specifications (GCS)" of IMT-2020.

3   5Gi[21] radio interface technology

TSDSI RIT (5Gi) is a versatile radio interface that fulfils all the technical performance requirements of IMT-2020 across all the different test environments. This RIT focuses on connecting the next generation of devices and providing services across various sectors. This RIT focuses on:

1   Enhanced spectral efficiency and broadband access.

2   Low latency communication.

3   Support millions of IOT devices.

---

[20] See Annex 2 of Recommendation ITU-R M.2150.

[21] See Annex 3 of Recommendation ITU-R M.2150.

Formatted: English (United Kingdom)

4   Power efficiency.

5   High speed connectivity.

6   Large Coverage (in particular for Rural areas).

7   Support multiple frequency bands including mmWave spectrum.

While, the current specifications provide a robust RIT, the specification also provides a framework on which future enhancements can be supported, providing a future-proof technology.

4   IMT-2020 DECT 5G-SRIT technology

[To be completed]

Annex 54

Harmonized IEEE and ETSI radio interface standards, for broadband wireless access (BWA) systems including mobile and nomadic applications in the mobile service

1   Overview of the radio interface

The IEEE Std 802.16-2009 and ETSI HiperMAN standards define harmonized radio interfaces for the OFDM and OFDMA physical layers (PHY) and MAC/data link control (DLC) layer, however the ETSI BRAN HiperMAN targets only the nomadic applications, while the IEEE Std 802.16-2009 standard also targets full vehicular applications.

The use of frequency bands below 6 GHz provides for an access system to be built in accordance with this standardized radio interface to support a range of applications, including full mobility, enterprise applications and residential applications in urban, suburban and rural areas. The interface is optimized for dynamic mobile radio channels and provides support for optimized handover methods and comprehensive set of power saving modes. The specification could easily support both generic Internet-type data and real-time data, including applications such as voice and videoconferencing.

This type of system is referred to as a wireless metropolitan area network (WirelessMAN in IEEE and HiperMAN in ETSI BRAN). The word "metropolitan" refers not only to the application but to the scale. The architecture for this type of system is primarily point-to-multipoint, with a base station serving subscribers in a cell that can range up to a few kilometres. Users can access various kinds of terminals, e.g. handheld phones, smart phone, PDA, handheld PC and notebooks in a mobile environment. The radio interface supports a variety of channel widths, such as 1.25, 3.5, 5, 7, 8.75, 10, 14, 15, 17.5 and 20 MHz for operating frequencies below 6 GHz. The use of orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA) improves bandwidth efficiency due to combined time/frequency scheduling and flexibility when managing different user devices with a variety of antenna types and form factors. It brings a reduction in interference for user devices with omnidirectional antennas and improved NLoS capabilities that are essential when supporting mobile subscribers. Sub-channelization defines sub-channels that can be allocated to different subscribers depending on the channel conditions and their data requirements. This gives the service providers more flexibility in managing the bandwidth and transmit power, and leads to a more efficient use of resources, including spectrum resources.

The radio interface supports a variety of channel widths and operating frequencies, providing a peak spectral efficiency of up to 3.5 bit/s/Hz in a single receive and transmit antenna (SISO) configuration.

Formatted: English (United Kingdom)

The radio interface includes PHY as well as MAC/DLC. The MAC/DLC is based on demand-assigned multiple access in which transmissions are scheduled according to priority and availability. This design is driven by the need to support carrier-class access to public networks, through supporting various convergence sub-layers, such as Internet protocol (IP) and Ethernet, with full QoS.

The harmonized MAC/DLC supports the OFDM (orthogonal frequency-division multiplexing) and OFDMA (orthogonal frequency-division multiple access) PHY modes.

Figure 1 illustrates pictorially the harmonized interoperability specifications of the IEEE WirelessMAN and the ETSI HiperMAN standards, which include specifications for the OFDM and OFDMA physical layers as well as the entire MAC layer, including security.

FIGURE 1

BWA standards harmonized for interoperability for frequencies below 6 GHz
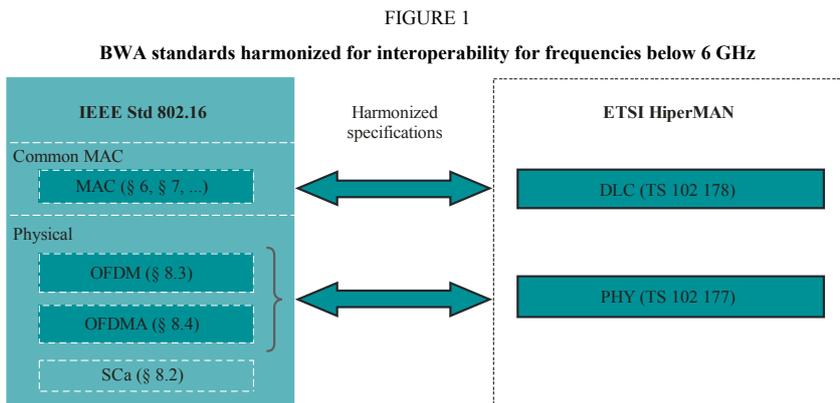
M.1801-01

The WiMAX Forum™, IEEE 802.16 and ETSI HiperMAN define profiles for the recommended interoperability parameters. IEEE 802.16 profiles are included in the main standards document, while HiperMAN profiles are included in a separate document. TTA (Telecommunications Technology Association) defines the standard for WiBro service which is based on WiMAX Forum profile 1A[22]. Although not explicitly included in Annex 2, the content of this standard, TTAK.KO-06.0082/R2, including channelization of 8.75 MHz, is identical to one of the options in § 6 of Annex 2.

2   Detailed specification of the radio interface

2.1   IEEE 802.16

IEEE Standard for local and metropolitan area networks Part 16: Air Interface for Broadband Wireless Access Systems.

IEEE Std 802.16 is an air interface standard for broadband wireless access (BWA). It supports fixed, nomadic and mobile systems, and it enables combined fixed and mobile operation in licensed frequency bands below 6 GHz. The current IEEE Std 802.16-2009 is designed as a high-throughput packet data radio network capable of supporting several classes of IP applications and services based

---

[22] http://www.wimaxforum.org/resources/technical-specifications.

Formatted: English (United Kingdom)

on different usage, mobility, and business models. To allow such diversity, the IEEE 802.16 air interface is designed with a high degree of flexibility and an extensive set of options.

The mobile broadband wireless technology, based on the IEEE-802.16 standard enables flexible network deployment and service offerings. Some relevant key standard features are described below:

Throughput, spectral efficiency and coverage

Advanced multiple antenna techniques work with OFDMA signalling to maximize system capacity and coverage. OFDM signalling converts a frequency selective fading wideband channel into multiple flat fading narrow-band subcarriers and therefore smart antenna operations can be performed on vector flat subcarriers. Major multiple antenna technique features are listed here:

–   2nd, 3rd and 4th, order MIMO and spatial multiplexing (SM) in uplink and downlink;

–   adaptive MIMO switching between spatial multiplexing/space time block coding to maximize spectral efficiency with no reduction in coverage area;

–   UL (uplink) collaborative spatial multiplexing for single transmit antenna devices;

–   advanced beamforming and null steering.

QPSK, 16-QAM and 64-QAM modulation orders are supported both in uplink and downlink. Advanced coding schemes including convolution encoding, CTC, BTC and LDPC along with chase combining and incremental redundancy hybrid ARQ and adaptive modulation and coding mechanism enables the technology to support a high performance robust air link.

Support for mobility

The standard supports BS and MS initiated optimized hard handover for bandwidth-efficient handover with reduced delay achieving a handover delay less than 50 ms. The standard also supports fast base station switch (FBSS) and Marco diversity handover (MDHO) as options to further reduce the handover delay.

A variety of power saving modes is supported, including multiple power saving class types sleep mode and idle mode.

Service offering and classes of services

A set of QoS options such as UGS (unsolicited grant service), real-time variable rate, non-real-time variable rate, best effort and extended real-time variable rate with silence suppression (primarily for VoIP) to enable support for guaranteed service levels including committed and peak information rates, minimum reserved rate, maximum sustained rate, maximum latency tolerance, jitter tolerance, traffic priority for varied types of Internet and real time applications such as VoIP.

Variable UL and DL subframe allocation supports inherently asymmetric UL/DL data traffic.

Multiple OFDMA adjacent and diversified subcarrier allocation modes enable the technology to trade off mobility with capacity within the network and from user to user. OFDMA with adjacent subcarrier permutation makes it possible to allocate a subset of subcarriers to mobile users based on relative signal strength.

Sub-channelization and MAP-based signalling schemes provide a mechanism for optimal scheduling of space, frequency and time resources for simultaneous control and data allocations (multicast, broadcast and unicast) over the air interface on a frame-by-frame basis.

Scalability

The IEEE-802.16 standard is designed to scale in different channel bandwidths from 1.25 to 28 MHz to comply with varied worldwide requirements.

Formatted: English (United Kingdom)

Scalable physical layer based on the concept of scalable OFDMA enables the technology to optimize the performance in a multipath fading mobile environment, characterized with delay spread and Doppler shift, with minimal overhead over a wide range of channel bandwidth sizes. Scalability is achieved by adjusting the FFT size to the channel bandwidth while fixing the subcarrier frequency spacing.

Reuse planning

IEEE 802.16 OFDMA PHY supports various subcarrier allocation modes and frame structures such as partially used sub-channelization (PUSC), fully used sub-channelization (FUSC) and advance modulation and coding (AMC). These options enable service providers to flexibly perform wireless network reuse planning for spectrally efficient re-use factor 1, interference robust re-use factor 3 or optimal fractional reuse deployment scenarios.

In the case of reuse factor 1, although system capacity can typically increase, users at the cell edge may suffer from low connection quality due to heavy interference. Since in OFDMA, users operate on sub-channels, which only occupy a small fraction of the channel bandwidth, the cell edge interference problem can be easily addressed by reconfiguration of the sub-channel usage and reuse factor within frames (and therefore the notion of fractional reuse) without resorting to traditional frequency planning. In this configuration, the full load frequency re-use factor 1 is maintained for centre users[23] with better link connection to maximize spectral efficiency while fractional frequency reuse is achieved for edge users[24] to improve edge-user connection quality and throughput.

The sub-channel reuse planning can be adaptively optimized across sectors or cells based on network load, distribution of various user types (stationary and mobile) and interference conditions on a per-frame basis. All the cells/sectors can operate on the same RF frequency channel and no conventional frequency planning is required.

Security sublayer

IEEE 802.16 supports privacy and key management – PKMv1 RSA, HMAC, AES-CCM and PKMv2 – EAP, CMAC, AES-CTR, MBS security.

Standard

The IEEE standard is available in electronic form at the following address:

> http://standards.ieee.org/getieee802/download/802.16-2009.pdf.

2.2 ETSI standards

The specifications contained in this section include the following standards for BWA, the last available versions being:

– ETSI TS 102 177 V1.5.1: Broadband Radio Access Networks (BRAN); HiperMAN; physical (PHY) layer.

– ETSI TS 102 178 V1.5.1: Broadband Radio Access Networks (BRAN); HiperMAN; Data Link Control (DLC) layer.

– ETSI TS 102 210 v1.2.1: Broadband Radio Access Networks (BRAN); HiperMAN; System Profiles.

---

[23] Users who are located towards the middle of a sector, far from the adjacent sectors.

[24] Users who are located towards the edges of a sector, close to adjacent sectors.

Formatted: English (United Kingdom)

Abstract: The HiperMAN standard addresses interoperability for BWA systems below 11 GHz frequencies, to provide high cell sizes in non-line-of-sight (NLoS) operation. The standard provides for FDD and TDD support, high spectral efficiency and data rates, adaptive modulation, high cell radius, support for advanced antenna systems, high security encryption algorithms. Its existing profiles are targeting the 1.75 MHz, 3.5 MHz and 7 MHz channel spacing, suitable for the 3.5 GHz band.

The main characteristics of HiperMAN standards, which are fully harmonized with IEEE 802.16, are:

–   all the PHY improvements related to OFDM and OFDMA modes, including MIMO for the OFDMA mode;

–   flexible channelization, including the 3.5 MHz, the 7 MHz and 10 MHz raster (up to 28 MHz);

–   scalable OFDMA, including FFT sizes of 512, 1 024 and 2 048 points, to be used in function of the channel width, such that the subcarrier spacing remains constant;

–   uplink and downlink OFDMA (sub-channelization) for both OFDM and OFDMA modes;

–   adaptive antenna support for both OFDM and OFDMA modes.

Standards: All   the   ETSI   standards   are   available   in   electronic   form   at: http://pda.etsi.org/pda/queryform.asp, by specifying in the search box the standard number.

Annex 65

ATIS WTSC radio interface standards for BWA systems in the mobile service

1   ATIS WTSC wireless wideband internet access and other standards

The Wireless Technologies and Systems Committee (WTSC) of the Alliance of Telecommunications Industry Solutions (ATIS), an American National Standards Institute (ANSI)-accredited standards development organization, has developed an American National Standard that adheres to its adopted requirements for wireless wideband internet access (WWINA) systems. The WWINA air interface standard enables wireless portability and nomadic roaming subscriber services that complement the DSL and cable modem markets. This system is optimized for high-speed packet data services that operate on a separate, data-optimized channel. The WWINA requirements specify a non-line-of-sight wireless internet air interface for full-screen, full-performance multimedia devices.

This air interface provides for portable access terminal (AT) devices with improved performance when compared to other systems that are targeted for high-mobility user devices. More specifically, the WWINA air interface optimizes the following performance attributes:

–   system data speeds;

–   system coverage/range;

–   network capacity;

–   minimum network complexity;

–   grade-of-service and quality-of-service management.

Formatted: English (United Kingdom)

2 ATIS-0700004.2005 high capacity-spatial division multiple access (HC-SDMA)

2.1 Overview of the radio interface

The HC-SDMA standard specifies the radio interface for a wide-area mobile broadband system. HC-SDMA uses TDD and adaptive antenna (AA) technologies, along with multi-antenna spatial processing algorithms to produce a spectrally efficient mobile communications system that can provide a mobile broadband service deployed in as little as a single (unpaired) 5 MHz band of spectrum licensed for mobile services. HC-SDMA systems are designed to operate in licensed spectrum below 3 GHz, which is the best suited for mobile applications offering full mobility and wide area coverage. Because it is based on TDD technology and does not require symmetrical paired bands separated by an appropriate band gap or duplexer spacing, systems based on the HC-SDMA standard can easily be re-banded for operation in different frequency bands. The HC-SDMA technology achieves a channel transmission rate of 20 Mbit/s in a 5 MHz licensed band. With its frequency reuse factor of $N = 1/2$, in a deployment using 10 MHz of licensed spectrum the 40 Mbit/s transmission rate is fully available in every cell in an HC-SDMA network, which is a spectral efficiency of 4 bit/s/Hz/cell.

2.2 Detailed specifications of the radio interface

The HC-SDMA air interface has a TDD/TDMA structure whose physical and logical characteristics have been chosen for the efficient transport of end-user IP data and to extract maximum benefit from adaptive antenna processing. The physical aspects of the protocol are arranged to provide spatial training data, and correlated uplink and downlink interference environments, for logical channels amenable to directive transmission and reception such as traffic channels. Conversely, channels not amenable to directive processing, such as paging and broadcast channels have smaller payloads and receive a greater degree of error protection to balance their links with those of the directively processed channels. Adaptive modulation and channel coding, along with uplink and downlink power control, are incorporated to provide reliable transmission across a wide range of link conditions. Modulation, coding and power control are complemented by a fast ARQ to provide a reliable link. Fast, low-overhead make-before-break inter-cell handover is also supported. Authentication, authorization, and privacy for the radio access link is provided by mutual authentication of the terminals and access network, and by encryption.

The HC-SDMA air interface has three layers designated as L1, L2, and L3.

Table 1 describes the air interface functionality embodied in each layer. Each layer's feature is briefly described below; more detailed overviews of key aspects are described in subsequent sections of this annex.

TABLE 1

Air interface layers

Layer	Defined properties
L1	Frame and burst structures, modulation and channel coding, timing advance
L2	Reliable transmission, logical to physical channel mapping, bulk encryption
L3	Session management, resource management, mobility management, fragmentation, power control, link adaptation, authentication

Table 2 summarizes the key elements of the HC-SDMA air interface.

Formatted: English (United Kingdom)

TABLE 2

Summary of the basic elements of the HC-SDMA air interface

Quantity	Value
Duplex method	TDD
Multiple access method	FDMA/TDMA/SDMA
Access scheme	Collision sense/avoidance, centrally scheduled
Carrier spacing	625 kHz
Frame period	5 ms
User data rate asymmetry	3:1 down:up asymmetry at peak rates

TABLE 2 (*end*)

Quantity	Value
Uplink time-slots	3
Downlink time-slots	3
Range	> 15 km
Symbol rate	500 kbaud/s
Pulse shaping	Root raised cosine
Excess channel bandwidth	25%
Modulation and coding	– Independent frame-by-frame selection of uplink and downlink constellation + coding – 8 uplink constellation + coding classes – 9 downlink constellation + coding classes – Constant modulus and rectangular constellations
Power control	Frame-by-frame uplink and downlink open and closed loop
Fast ARQ	Yes
Carrier and time-slot aggregation	Yes
QoS	DiffServ (differentiated services) policy specification, supporting rate limiting, priority, partitioning, etc.
Security	Mutual AT and BSR authentication, encryption for privacy
Handover	AT directed, make-before-break
Resource allocation	Dynamic, bandwidth on demand

All the standards referenced in this annex are available in electronic form at: https://www.atis.org/docstore/default.aspx.

Formatted: English (United Kingdom)

Annex 7~~6~~

"eXtended Global Platform: XGP" for broadband wireless access (BWA) systems in the mobile service

1 Overview of the radio interface

XGP Forum, formerly known as PHS MoU Group, which is a standards development organization, has developed "eXtended Global Platform: XGP" as one of the BWA systems. "eXtended Global Platform" also known as "Next-generation PHS", achieves high efficiency of spectral utilization mainly because of using micro-cells whose radii are much shorter than the typical mobile phone cells, as well as original PHS system.

XGP is the mobile BWA system which utilizes OFDMA, SC-FDMA/TDMA-TDD, and some more advanced features described below:

– Realization of always-connected environment at IP level

  The always-connected session at IP level that enables users to start up high-speed transmission immediately is essential, taking into account the convenience of always-connected environment provided in cable modem circumstance, etc.

– High transmission data rate

  It is also important to keep throughput to some extent for practical use even in case that serious concentration of traffic occurs.

– High transmission data rate for uplink

  Considering future demand of bidirectional broadband communication such as a videoconference, an uplink transmission data rate over 10 Mbit/s is considered to become still more important in the near future.

– High efficiency in spectral utilization

  Highly efficient spectral utilization is necessary in order to avoid interruption of service applications by the shortage of frequency, due to the serious traffic congestion concentrated at a business district or downtown area.

In addition, it has the ability of highly efficient spectral utilization by adopting the latest technologies such as adaptive array antenna technology, space division multiple access technology and autonomous decentralized control technology. These three technologies also contribute to make cell designing plans unnecessary, and as a result, the cell radius down to less than 100 m is realized.

Mobile wireless systems generally require a relatively high level of accuracy in their installation position in order to avoid interference with other cells. In the case of macro-cell networks, an offset of the base station from the intended building/position to an adjoining substitute building/position due to unsuccessful negotiations with the building owner, only causes inter-cell interferences which still lies within the range of a marginal error.

However, in the case of micro-cell networks, as such offset cannot be ignored as a marginal error; readjustments of the surrounding cell designs are needed in some cases.

This issue is already solved with XGP system, as it has an interference resistant structure and does not require strict accuracy for the positioning of the base stations, promising less trouble for the construction of micro-cell networks.

Formatted: English (United Kingdom)

XGP is a system among BWA systems, which possesses a differentiating feature by flexibly utilizing micro-cell networks as well as macro-cells in order to resolve heavy traffic congestions in densely-populated areas.

The autonomous decentralized control method of XGP demonstrates advantage in the construction of micro-cell networks. It is also possible to form a network without being bothered with the interference problems that occur when the pico cell and the femto cell are similarly introduced with the same method. Moreover, as strict cell design is unnecessary for the macro-cell network construction, a simple network operation is possible, and regardless of the micro-cell or the macro-cell, it allows simple method operations for the installation of additional base stations to the network.

From the version 2 of XGP specifications, in addition to XGP original mode, Global Mode that referred to 3GPP specification (LTE TDD) has been added in order to attain the scale of merits provided by LTE. Therefore, XGP became substantially compatible with LTE TDD and can be regarded as a part of LTE community sharing a common eco-system.

The version 2 of XGP specifications also accommodates some specific requirements complying with regional or local regulations.

Similar approach as XGP specification, XGP Forum also introduces a new specification named sXGP (shared XGP) using 1.9 GHz private dedicated band which can also be used for BWA purpose, referring to 3GPP specification (LTE TDD).

2   Detailed specification of the radio interface

The XGP radio interface has two dimensions for multiple access methods such as OFDMA, SC-FDMA (controlled along frequency axis), and TDMA (controlled along time axis). OFDMA is an FDMA technique that divides a communications channel into a small number of equally spaced frequency bands, each of which carries a portion of the radio signal in parallel. These subcarriers are then transmitted simultaneously at different frequencies to the receiver. OFDMA have developed into a popular scheme for wideband digital communication.

Duplex method is TDD. TDD is not needed for paired spectrum channels, and allows to devote resources to uplink and downlink asymmetrically, freeing capacity for up/downlink data-intensive applications.

The operation channel bandwidths supported by XGP are 1.25 MHz, 2.5 MHz, 5 MHz, 10 MHz, 20 MHz, 22.5 MHz, 25 MHz, 30 MHz and its modulation scheme supports BPSK, QPSK, 16-QAM, 64-QAM and 256-QAM. The subcarrier frequency spacing is 15 kHz and 37.5 kHz. The time-frame has 4, 8, 10, 16, 20 slots of 2.5 ms, 5 ms, 10 ms. Each slot can be used separately, or continuously by a single user, and moreover continuously in an asymmetric frame structure.

The frame structure image of XGP is shown in Fig. 2.

Formatted: English (United Kingdom)

FIGURE 2

The frame structure image of XGP
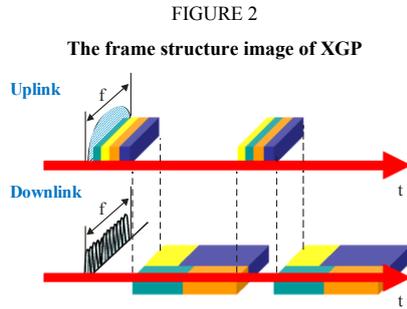
M.1801-02

XGP achieves efficient spectral utilization by some functions, such as adaptive array antenna, SDMA and MIMO.

Adaptive array antenna is a technique to make adaptive beam forming from a BS/MS to an MS/BS by combining signals of respective antennas. The adaptive array antenna uses multiple antennas and combines their signals (1) to adaptively form a beam to desired directions in order to avoid harmful interference from interferers and (2) to send the most suitable radio waves/signals to a specific terminal by using the formed beam. In XGP system that employs OFDMA SC-FDMA/TDMA-TDD schemes, this antenna technology is well-suited and can be effectively applied to both transmitter and receiver. It has a potential to increase XGP's spectrum efficiency and to make it possible to cover a wider area with lower cost.

XGP Global Mode, which refers to TDD part of 3GPP technical specifications, specifies the air interface including the physical layer, MAC, RLC and PDCP layers and RRC layer related specifications. Due to the reference of the latest 3GPP release, XGP can now be compatible with 5G, which has been developed by 3GPP.

The key specifications of the radio interface are shown in Table 3.

TABLE 3

The key specifications of XGP

Multiple access method	OFDMA, SC-FDMA/TDMA
Duplex method	TDD
Operation channel bandwidth	1.25 MHz, 2.5 MHz, 5 MHz, 10 MHz, 20 MHz, 22.5 MHz, 25 MHz, 30 MHz
Subcarrier frequency spacing	15 kHz, 37.5 kHz
Frame duration	2.5 ms, 5 ms, 10 ms
Number of slots	4, 8, 10, 16, 20 slots
Modulation scheme	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM
Technologies of efficient spectral utilization	Adaptive array antenna, SDMA, MIMO
Peak channel transmission rate/20 MHz (in case of SISO, UL:DL=1:3) *higher peak rate can be achieved by changing the combination of conditions such as UL/DL configuration, modulation scheme and the number of MIMO	Uplink: 15 Mbit/s Downlink: 55 Mbit/s

Formatted: English (United Kingdom)

Characteristics	XGP	XGP compatible with NR	sXGP
Multiple access method	OFDMA, SC-FDMA/TDMA	OFDMA, SC-FDMA/TDMA	SC-FDMA/TDMA
Duplex method	TDD	TDD	TDD
Frequency band	2.5 GHz (mainly)	2.5 GHz (mainly)	1.9 GHz (mainly)
Operation channel bandwidth	1.4 MHz, 2.5 MHz, 5 MHz, 10 MHz, 20 MHz	10 MHz, 20 MHz, 30 MHz, 40 MHz, 50 MHz	1.4 MHz, 5 MHz
Frame duration	2.5 ms, 5 ms, 10 ms	10 ms, Sub-frame length 1 ms	10 ms, Sub-frame length 1 ms
Modulation scheme	BPSK, QPSK, 16-QAM, 32-QAM, 64-QAM, 256-QAM	BPSK, π, 2shift-BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM
Support for Beam-forming and MIMO	Yes	Yes	Yes
Peak channel transmission rate *depending on the combination of conditions such as UL/DL configuration, modulation scheme and the number of MIMO	Uplink: up to 300 Mbit/s in 20 MHz Downlink: up to 600 Mbit/s in 20 MHz *referring to 3GPP Standard	Uplink: depending on slot configuration and no. of aggregated component carriers (up to 16), 256QAM, 8-layers: from 17.9 to 64.6 Gbit/s Downlink: similarly, from 37 to 140.2 Gbit/s. *referring to 3GPP Standard	Uplink: up to 75 Mbit/s in 5 MHz Downlink: up to 150 Mbit/s in 5 MHz *referring to 3GPP Standard

Standards

The "eXtended Global Platform" specifications of XGP Forum are available in an electronic form at its website:

"A-GN4.00-02-TS: eXtended Global Platform SpecificationsXGP Forum standards"
https://www.xgpforum.com/new_XGP/en/002/technical_specification.html.

The Association of Radio Industries and Businesses (ARIB) has also standardized "eXtended Global Platform" for Japanese domestic use.

The ARIB standards of "eXtended Global Platform" is are also available at the ARIB website.

"ARIB STD-T95: Broadband Mobile Wireless Access System (XGP)OFDMA/TDMA TDD Broadband Access System ARIB STANDARD"

"ARIB STD-T118: OFDMA/TDMA TDD for digital cordless telephone (sXGP)"

https://www.arib.or.jp/english/std_tr/telecommunications/st_ej.html.

The standards "ARIB STD-T95" includes Japanese regulation specifications as well as the system original specifications.

Annex ~~7~~8

IEEE 802.20: Standard air interface for mobile broadband wireless access supporting vehicular mobility

IEEE 802.20 is designed to provide IP-based broadband wireless (Internet) access in a mobile environment. The standard includes a wideband mode and a 625k-multicarrier mode. Time division duplexing is supported by both the 625k-MC mode and the wideband mode; frequency division duplexing is supported by the wideband mode.

1 System aspects

The 802.20 standard specifies requirements to ensure compatibility between a compliant access terminal (AT) and a compliant access node (AN) or base station (BS), conforming to properly selected modes of the standard.

The intent of the 802.20 standard is to permit either a fixed hierarchical backhaul structure (traditional to the cellular environment) or a more dynamic and non-hierarchical backhaul structure. The architecture of the 802.20 specification is intended to provide a backward compatibility framework for future service additions and expansion of system capabilities without loss of backward compatibility and support for legacy technology.

The wideband mode is based on OFDMA techniques and is designed to operate for frequency division duplex (FDD) and time division duplex (TDD) bandwidths from 5 MHz to 20 MHz. For systems having more than 20 MHz available, the wideband mode defines a suitable multicarrier mode that can accommodate larger bandwidths.

The 625k-MC mode is a TDD air interface that was developed to extract maximum benefit from adaptive, multiple-antenna signal processing. The 625k-MC mode enables wireless broadband access using multiple radio frequency (RF) carriers with 625 kHz carrier spacing that typically are deployed in channel block sizes of 5 MHz and up. The 625k-MC mode supports aggregation of multiple TDDD RF carriers to further increase the peak data rates available on a per user basis.

1.1 Wideband mode – physical layer features

The 802.20 wideband mode provides physical layer support based on OFDMA for both forward and reverse links. Supporting both FDD and TDD deployments, the PHY utilizes a similar baseband waveform for both, thereby reducing the number of technologies to be implemented by vendors. The specification provides modulation signal sets up to 64-QAM with synchronous HARQ, for both forward and reverse links, to improve throughputs in dynamic environments. To handle different environments, several different supported coding schemes include convolutional codes, turbo codes, and an optional LDPC scheme featuring performance comparable or better than turbo codes at all HARQ terminations.

Although the RL physical layer is based on OFDMA, a portion of the signalling from AT to AN takes place over a CDMA control segment embedded in certain subcarriers of the OFDM waveform. This unique feature enables robust and continuous signalling from AT to AN and can make use of soft handoff techniques, and other techniques developed for CDMA cellular transmission. The result is improved robustness of RL signalling, and continuity of the signalling channel even during transitions such as access and handoffs. Since the CDMA segment is "hopped" over the entire broadband channel, the AN can easily make broadband measurements needed for improved interference and resource management.

Formatted: English (United Kingdom)

1.2 Wideband mode – multi-antenna techniques

From a system point of view, the 802.20 technology specifies several multi-antenna techniques for use with the FL. Both SISO and MIMO users can be supported simultaneously, thus optimizing the user experience to the best experience possible given channel conditions. For users close to the AP, MIMO enables very high data rate transmissions. Beamforming increases user data rates by focusing the transmit power in the direction of the user, thus enabling higher receive SINR at the AT. SDMA further increases sector capacity by allowing simultaneous transmissions to spatially separated users using the same sets of subcarriers. Thus, beamforming in combination with MIMO and SDMA provides improved user data rates in both high and lower SINR regions.

1.3 625k – MC mode – air interface features

IEEE 802.20's 625k-MC Draft Specification is an enhancement to the baseline specifications as given by High Capacity-Spatial Division Multiple Access (HC-SDMA) Radio Interface Standard (ATIS.0700004.2005) and is fully backward compatible to the commercially deployed systems based on HC-SDMA specifications.

The 625k-MC mode, which is uniquely designed around multiple antennas with spatial processing and spatial division multiple access (SDMA), enables the transfer of IP traffic, including broadband IP data, over a layered reference model as shown in Fig. 2. The physical (PHY) and data link layers (MAC and LLC) are optimally tailored to derive maximum benefit from spatial processing technologies: Adaptive antenna processing and SDMA: Enhanced spectral efficiency and capacity, and wider coverage while enabling the economic operation even when the available spectrum is as small as 625 kHz. Secondly, the physical and data link layers support higher data rates and throughputs by enabling multiple 625 kHz carrier aggregation – hence the name "625k-MC mode".

https://sbwsweb.ieee.org/ecustomercme_enu/start.swe?SWECmd=GotoView&SWEView=Catalog+View+(e Sales)_Standards_IEEE&mem_type=Customer&SWEHo=sbwsweb.ieee.org&SWETS=1192713657.

Annex 98

Air interface of SCDMA broadband wireless access system standard

1 Overview of the radio interface

The standard radio interface defines TDD/code-spread OFDMA (CS-OFDMA) based physical layer and media access control (MAC)/data link control (DLC) layer. Packet data based, mobile broadband system built according to the standard radio interface supports a full range of applications, including best effort data, real-time multimedia data, simultaneous data and voice.

The radio interface is optimized for highly efficient voice, full mobility for voice and data, and high spectrum efficiency for single frequency deployment. Multiple antenna based techniques such as beam-forming, nulling and transmit diversity have been incorporated into the radio interface to provide better coverage, mobility performance and interference mitigation to support deployment with a frequency reuse factor of $N = 1$.

The radio interface supports a channel bandwidth of a multiple of 1 MHz up to 5 MHz. Sub-channelization and code spread, specially defined inside each 1 MHz bandwidth, provides frequency diversity and interference observation capability for radio resource assignment with bandwidth granularity of 8 kbit/s. The channelization also allows coordinated dynamic channel allocations among cells to efficiently avoid mutual interference. A system using 5 MHz bandwidth

Formatted: English (United Kingdom)

can support 120 concurrent users. Sub-channel and power assignments for multiple users are thus conducted based on both link propagation conditions and link interference levels.

The standard radio interface supports modulations of QPSK, 8-PSK, 16-QAM and 64-QAM for both uplink and downlink, giving rise to peak spectral efficiency of 3 bit/s/Hz for single transmit and single receive antenna configuration. The system employs TDD to separate uplink and downlink transmission. The ratio between uplink and downlink data throughput can be flexibly adjusted by changing the switching point of uplink and downlink.

The MAC/DLC performs user access control, session management and ARQ error recovery. It also conducts bandwidth assignments, channel allocation and packet scheduling for multiple users communications according to user bandwidth requests, user priorities, user QoS/GoS requirements and channel conditions.

2 General aspects of the radio interface

2.2 Key features of the standard radio interface

The standard radio interface provides an optimized framework to integrate PHY/MAC/DLC techniques such as advanced multiple antenna, adaptive loading factor and modulation, dynamic channel allocation, make-before-break handoff and QoS/GoS control. The mobile broadband system based on the standard radio interface offers deployment flexibility to meet various requirements on coverage, capacity and service.

2.1 CS-OFDMA and frame structure

The standard radio interface employs CS-OFDMA as a key technique for both signal transmission and multiple accessing. CS-OFDMA is based on the OFDMA technique. Like OFDMA, each user is allocated a dedicated set of time-frequency grids for communication such that no multiple access interference and multipath interference incur. However, unlike conventional OFDMA where each coded symbol is directly mapped to an allocated time-frequency grid, a vector of CS-OFDMA signal is generated by pre-coding a vector of coded symbols. The resulting CS-OFDMA signal vector is then mapped onto multiple time-frequency grids which are spread out in time and frequency. In this way, signals are transmitted with intrinsic frequency and time diversity. The CS-OFDMA and multiple accessing are best illustrated by the following frame structure.

FIGURE 3

Frame structure for symmetric uplink and downlink
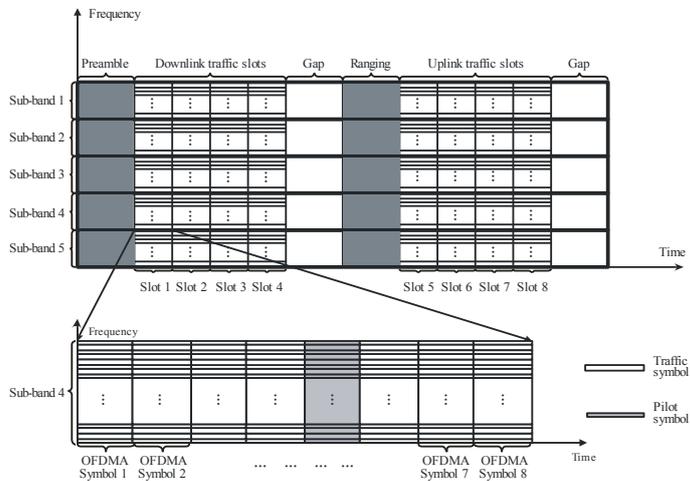
M.1801-03

In Fig. 3, the 5 MHz band is divided into five sub-bands with each sub-band occupying 1 MHz. Each sub-band consists of 128 sub-carriers which are partitioned into 16 sub-channels; each sub-channel includes eight distributed sub-carriers. The CS-OFDMA TDD frame has a length of 10 ms, consisting of one preamble slot, one ranging slot, eight traffic slots and two guard slots. The ratio of uplink traffic slots to downlink slots can be configured. Each slot includes 8/10 consecutive OFDMA symbols. The basic CS-OFDMA signal parameters are listed in Table 4.

TABLE 4

Basic CS-OFDMA signal parameters

Parameters	Values
FFT size	1 024
Sub-carrier spacing	7.8125 kHz
CS-OFDMA symbol duration	137.5 μs
Cyclic prefix duration	9.5 μs
BS occupied bandwidth	5 MHz
Number of guard sub-carriers	32

All sub-carriers inside a sub-band and a slot form a resource block which contains 128 sub-carriers by eight OFDMA symbols. The code spreading is performed on eight selected sub-carriers in each resource block with the eight sub-carriers uniformly distributed across the 1 MHz sub-band. A CS-OFDMA signal vector of size 8-by-1 is generated by left-multiplying a L-by-1 coded symbol vector by a pre-coding matrix of size 8-by-L. The resulting eight signals are then mapped onto the eight

Formatted: English (United Kingdom)

sub-carriers. L is a loading factor of code spreading which is an integer variable equal to or less than 8. The scheme is illustrated in Fig. 4.

FIGURE 4

Code spreading with pre-coding matrix and its mapping onto sub-carriers
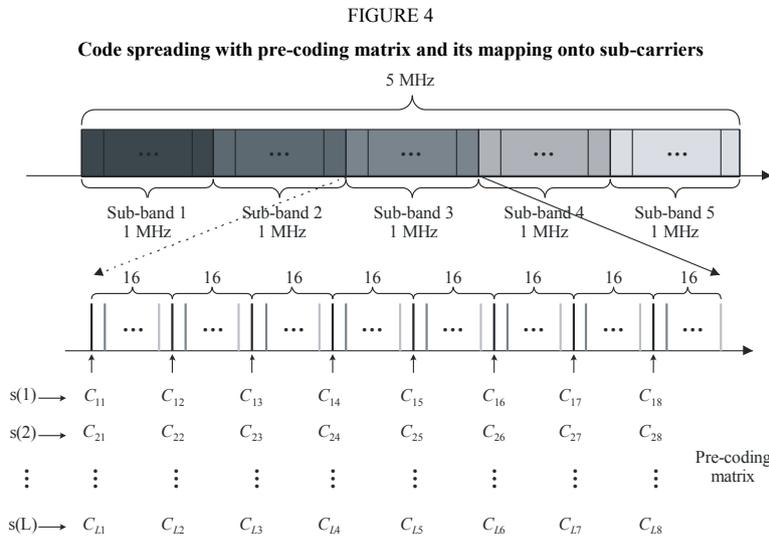
M.1801-04

2.2.1 Multiple antenna technique

The TDD/CS-OFDMA frame structure is amenable to apply multiple antenna techniques. With uplink and downlink beam-forming, the link quality and coverage is significantly improved while reducing inter-cell interference. The optimized spatial nulling technique enables the system to work under strong interference. Multiple beam-forming based signal transmit enhances the robustness of downlink link communication.

2.2.2 TDD

The TDD/CS-OFDMA frame structure supports flexible uplink and downlink throughput ratios 1:7, 2:6, 3:5, 4:4, 5:3, 6:2 and 7:1. TDD makes many un-paired spectrum usable for broadband access service. The standard radio interface is immune to BS-to-BS interference due to long distance, at the same time supports BS-to-terminal coverage larger than 80 km.

2.2.3 Adaptive loading factor and modulation

The radio interface supports the following modulation scheme for both uplink and downlink: QPSK, 8-PSK, 16-QAM and 64-QAM. The FEC employs shortened Reed-Solomon (31, 29) with fixed code rate 96/106. The channel-dependent rate control is conducted by jointly adjusting modulation order and code-spreading loading factor according to the path loss, channel condition, bandwidth request and user Grade of Service (GoS) to achieve optimum system-wise spectral efficiency.

2.2.4 Dynamic channel allocation

The radio interface has incorporated intelligent interference detection and avoidance mechanism. The BS assigns channels for each terminal based on the real time uplink and downlink interference

Formatted: English (United Kingdom)

distribution observed by all terminals. In this way, each terminal can always communicate in the sub-channels with the least interference level. The technique, combined with the adaptive nulling technique, makes it feasible to deployment with frequency reuse factor equal to one.

2.2.5   QoS/GoS

The radio interface provides a QoS/GoS control mechanism to meet quality requirements of various classes of service. The mechanism is realized through QoS aware link adaptation, packet scheduling and GoS based bandwidth management. Eight QoS levels and eight GoS grades are defined in the radio interface.

2.2.6   Mobility

The TDD/CS-OFDMA frame structure offers dynamic pilot assignment based on the terminal mobility characteristics. More pilots are assigned for sub-channels allocated for fast moving terminals in order to track fast varying channel. The radio interface supports make-before-break handoff by allowing the terminal to communicate with anchor BS and target BS simultaneously as a way of testing connection reliability before eventually switching to the target BS.

REFERENCES

Technical Requirements for Air Interface of SCDMA Broadband Wireless Access System (YD/T 1956-2009)
http://www.ccsa.org.cn/standardDetail?title=1800MHz%20SCDMA%E5%AE%BD%E5%B8%A6%E6%97%A0%E7%BA%BF%E6%8E%A5%E5%85%A5%E7%B3%BB%E7%BB%9F%20%E7%A9%BA%E4%B8%AD%E6%8E%A5%E5%8F%A3%E6%8A%80%E6%9C%AF%E8%A6%81%E6%B1%82&standardNum=YD%2FT%201956-2009%282017%29.

Annex 10~~9~~

Key characteristics of standards

Table 5 provides a summary of key technical characteristics of each standard.

TABLE 5

Key technical ~~parameters~~ characteristics

[Editor's Note: The last column has been proposed for deletion]

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[(1)] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IEEE 802.16 WirelessMAN/ ETSI HiperMAN (Annex ~~4~~5)	Flexible from 1.25 MHz up to 28 MHz. Typical bandwidths are: 3.5, 5, 7, 8.75, 10 and 20 MHz	Up: – QPSK-1/2, 3/4 – 16-QAM-1/2, 3/4 – 64-QAM-1/2, 2/3, 3/4, 5/6 Down: – QPSK-1/2, 3/4 – 16-QAM-1/2, 3/4 – 64-QAM-1/2, 2/3, 3/4, 5/6	CC/CTC Other options: BTC/ LDPC	Up to 17.5 Mbit/s with SISO Up to 35 Mbit/s with (2 × 2) MIMO Up to 70 Mbit/s with (4 × 4) MIMO	Yes	Yes	TDD/ FDD/ HFDD	OFDMA TDMA	5 ms Other options: 2, 2.5, 4, 8, 10, 12.5 and 20 ms	Mobile
ATIS-0700004.2005 high capacity-spatial division multiple access (HC-SDMA) (Annex ~~5~~6)	0.625 MHz	Up: – BPSK, QPSK, 8-PSK, 12-QAM, 16-QAM 3/4 Down: – BPSK, QPSK, 8-PSK, 12-QAM, 16-QAM, 24-QAM 8/9	Convolu-tional and block code	Up: 2.866 Mbit/s × 8 sub-channels × 4 spatial channels = 91.7 Mbit/s Down: 2.5 Mbit/s × 8 sub-channels × 4 spatial channels = 80 Mbit/s	Yes	Yes	TDD	TDMA/F DMA/ SDMA	5 ms	Mobile

Formatted: English (United Kingdom)

TABLE 5 (*continued*)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate(1) – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
eXtended Global Platform: XGP (Annex 67)	1.25 MHz 2.5 MHz 5 MHz 10 MHz 20 MHz	Up and down: BPSK QPSK 16-QAM 64-QAM 256-QAM	Convolu-tional code Turbo code (option)	Up: 15 Mbit/s Down: 55 Mbit/s (in case of 20 MHz, SISO, UL:DL=1:3)	Yes (option)	Yes (option)	TDD	OFDMA SC-FDMA TDMA	2.5 ms, 5 ms, 10 ms	Mobile
IEEE 802.11-2012 2020 Subclause 16 17 (Formerly 802.11b) (Annex 1)	22 MHz	Up and down: DQPSK CCK BPSK PBCC – 1/2 QPSK PBCC – 1/2	Uncoded/ CC	2.511 Mbit/s in 22 MHz	No	No	TDD	CSMA/ CA	Variable frame duration	Nomadic
IEEE 802.11-202012 Subclause 17 18 (Formerly 802.11a, 802.11j and 802.11y) (Annex 1)	5 MHz 10 MHz 20 MHz	Up and down: 64-QAM OFDM 2/3, 3/4 16-QAM OFDM – 1/2, 3/4 QPSK OFDM – 1/2, 3/4 BPSK OFDM – 1/2, 3/4	CC	13.554 Mbit/s in 20 MHz	No	No	TDD	CSMA/CA	Variable frame duration	Nomadic

Formatted: English (United Kingdom)

TABLE 5 (*continued*)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate(1) – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IEEE 802.11-20~~20~~16 Subclause 17 ~~18~~ (Formerly 802.11g) (Annex 1)	20 MHz	Up and down: 64-QAM OFDM 2/3, 3/4 16-QAM OFDM – 1/2, 3/4 QPSK OFDM – 1/2, 3/4 BPSK OFDM – 1/2, 3/4 8-PSK PBCC – 2/3 64-QAM DSSS-OFDM – 2/3, 3/4 16-QAM DSSS-OFDM – 1/2, 3/4 QPSK DSSS-OFDM – 1/2, 3/4 BPSK DSSS-OFDM – 1/2, 3/4	CC	~~13.5~~ 54 Mbit/s in 20 MHz	No	No	TDD	CSMA/CA	Variable frame duration	Nomadic
IEEE 802.11-20~~20~~12 Subclause 18 ~~19~~ ~~As amended~~ (Formerly 802.11n) (Annex 1)	20 MHz 40 MHz	Up and down : 64-QAM OFDM – 2/3, 3/4, 5/6 16-QAM OFDM – 1/2, 3/4 QPSK OFDM – 1/2, 3/4 BPSK OFDM – 1/2	CC and LDPC	~~75~~ 600 Mbit/s in 40 MHz	Yes	Yes	TDD	CSMA/CA	Variable frame duration	Nomadic

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[(1)] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IEEE Std 802.11-2020 (Clause 21, commonly known as 802.11ac)	20 MHz 40 MHz 80 MHz 160 MHz 80+80 MHz	Up and down: BPSK OFDM-1/2 QPSK OFDM-1/2 QPSK OFDM-3/4 16-QAM OFDM-1/2 16-QAM OFDM-3/4 64-QAM OFDM-2/3 64-QAM OFDM-3/4 64-QAM OFDM-5/6 256-QAM OFDM-3/4 256-QAM OFDM-5/6	CC and LDPC	6 933.3 Mbit/s in 160 MHz	Yes	Yes	TDD	CSMA/CA	Variable frame duration	Nomadic
IEEE Std 802.11-2020 (Clause 23, commonly known as 802.11ah)	1 MHz 2 MHz 4 MHz 8 MHz 16 MHz	Up and down: BPSK OFDM-1/2 with 2x repetition BPSK OFDM-1/2 QPSK OFDM-1/2 QPSK OFDM-3/4 16-QAM OFDM-1/2 16-QAM OFDM-3/4 64-QAM OFDM-2/3 64-QAM OFDM-3/4 64-QAM OFDM-5/6 256-QAM OFDM-3/4 256-QAM OFDM-5/6	CC and LDPC	346.7 Mbit/s in 16 MHz	Yes	Yes	TDD	CSMA/CA	Variable frame duration	Nomadic

Formatted: English (United Kingdom)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate(1) – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IEEE Std 802.11ax-2021	20 MHz 40 MHz 80 MHz 160 MHz 80+80 MHz	Up and down: BPSK OFDM-1/2 BPSK OFDM-3/4 QPSK OFDM-1/2 QPSK OFDM-3/4 16-QAM OFDM-1/2 16-QAM OFDM-3/4 64-QAM OFDM-1/2 64-QAM OFDM-2/3 64-QAM OFDM-3/4 64-QAM OFDM-5/6 256-QAM OFDM-3/4 256-QAM OFDM-5/6 1024-QAM OFDM-3/4 1024-QAM OFDM-5/6	CC and LDPC	9 607.8 Mbit/s in 160 MHz	Yes	Yes	TDD	CSMA/CA, Trigger-based access and OFDMA	Variable frame duration	Nomadic
ETSI BRAN HiperLAN 2 (Annex 1)	20 MHz	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM both upstream and downstream	CC	6, 9, 12, 18, 27, 36 and 54 Mbit/s in 20 MHz channel (only 20 MHz channels supported)	No	No	TDD	TDMA	2 ms	Nomadic

TABLE 5 (*continued*)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[1] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
ARIB HiSWANa (Annex 1)	4 × 20 MHz (5.15-5.25 GHz) 4 × 20 MHz (4.9-5.0 GHz)	– BPSK 1/2 – BPSK 3/4 – QPSK 1/2 – QPSK 3/4 – 16-QAM 9/16 – 16-QAM 3/4 – 64-QAM 3/4	Convolu-tional	6-54 Mbit/s in 20 MHz	No	No	TDD	TDMA	2 ms	Nomadic
IMT-2000 CDMA Direct Spread (Annex 2)	5 MHz (E-UTRAN) Flexible 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz; carrier aggregation up to 100 MHz	Up: QPSK, 16-QAM Down: 16-QAM, QPSK, 64-QAM (E-UTRAN) QPSK, 16-QAM, 64-QAM. Fully variable code rate with Hybrid ARQ with incremental redundancy.	Convolu-tional turbo (E-UTRAN) Turbo code for data; convolu-tional and block codes for some control channels	Up: 11.5 Mbit/s Down: 42 Mbit/s (E-UTRAN) Up: 300 Mbit/s/20 MHz[3] Down: 600 Mbit/s/20 MHz[3] Up: 1.5 Gbit/s in aggregated 100 MHz[4] Down: 3 Gbit/s in aggregated 100 MHz[4]	Yes	Yes	FDD HD-FDD	CDMA (E-UTRAN) OFDM in DL SC-FDMA in UL	2 ms and 10 ms (E-UTRAN) 10 ms Sub-frame length 1 ms	Mobile

Formatted: English (United Kingdom)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[(1)] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IMT-2000 CDMA Multi-Carrier (Annex 2)	1.25 MHz and 3.75 MHz (cdma2000) 1.25-20 MHz (cdma2000 HRPD) 1.25-20 MHz, 153.6 kHz granularity (UMB)	Up: BPSK, QPSK, 8-PSK Down: QPSK, 8-PSK, 16-QAM, (cdma2000) QPSK, 8-PSK, 16-QAM, 64-QAM (cdma2000 HRPD) QPSK, 8-PSK, 16-QAM, 64-QAM (UMB)	Convolu-tional/turbo (cdma2000 and cdma2000 HRPD) Convolu-tional/turbo/ LDPC (optional) (UMB)	Up: 1.8 Mbit/s per 1.25 MHz channel Down 3.1 Mbit/s Per 1.25 MHz (cdma2000) Up: 4.3 Mbit/s per 1.25 MHz channel Down: 18.7 Mbit/s per 1.25 MHz channel (cdma2000 HRPD) Up: 75 Mbit/s for 20 MHz Down: 228 Mbit/s for 20 MHz (UMB)	No (cdma2000) Yes (cdma2000 HRPD, UMB)	No (cdma2000) Yes (cdma2000 HRPD, UMB)	FDD (cdma 2000 and cdma 2000 HRPD) FDD/ TDD (UMB)	CDMA (cdma2000) CDMA, OFDM and OFDMA (cdma2000 HRPD) CDMA and OFDMA (UMB)	Down: 1.25, 1.67 2.5, 5, 10, 20, 40, 80 ms Up: 6.66, 10, 20, 26.67, 40, 80 ms (cdma2000) Down: 1.67, 3.33, 6,66,13.33,26.67 Up: 1.67, 6.66, 13.33, 20, 26.67 (cdma2000 HRPD) Down: 0.911 ms Up: 0.911 ms (UMB)	Mobile

Formatted: English (United Kingdom)

TABLE 5 (*continued*)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[(1)] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IMT-2000 CDMA TDD (Annex 2)	1.28 Mchip/s TDD option: Less than 1.6 MHz 3.84 Mchip/s TDD option: Less than 5 MHz 7.68 Mchip/s TDD option: Less than 10 MHz (E-UTRAN) Flexible 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz; carrier aggregation up to 100 MHz	1.28 Mchip/s TDD option: Up: 8-PSK, QPSK, 16-QAM, Down: 8-PSK, 16-QAM, QPSK 3.84 Mchip/sTDD option: Up: 16-QAM, QPSK Down: 16-QAM, QPSK 7.68 Mchip/s TDD option: Up: 16-QAM, QPSK Down: 16-QAM, QPSK (E-UTRAN) QPSK, 16-QAM, 64-QAM. Fully variable code rate with Hybrid ARQ with incremental redundancy.	Convolutional turbo (E-UTRAN) Turbo code for data; convolutional and block codes for some control channels	1.28 Mchip/s TDD option: Up: 2.2 Mbit/s / 1.6 MHz[(2)] Down: 2.8 Mbit/s / 1.6 MHz[(2)] 3.84 Mchip/s TDD option: Up: 9.2 Mbit/s Down: 10.2 Mbit/s 7.68 Mchip/s TDD option: Up: 17.7 Mbit/s / 10 MHz Down: 20.4 Mbit/s / 10 MHz (E-UTRAN) Up: 300 Mbit/s / 20 MHz[(3)] Down: 600 Mbit/s / 20 MHz[(3)] Up: 1.5 Gbit/s in aggregated 100 MHz[(4)] Down: 3 Gbit/s in aggregated 100 MHz[(4)]	Yes	No (E-UTRAN) Yes	TDD	TDMA/ CDMA (E-UTRAN) OFDM in DL. SC-FDMA in UL	1.28 Mchip/s TDD option: 10 ms Sub-frame length: 5 ms 3.84 Mchip/s TDD option: 10 ms 7.68 Mchip/s TDD option: 10 ms (E-UTRAN) 10 ms Sub-frame length: 1 ms	Mobile

TABLE 5 (*continued*)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[(1)] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IMT-2000 TDMA Single-Carrier (Annex 2)	2 × 200 kHz 2 × Dual 200 kHz 2 × 1.6 MHz	Up: – GMSK – 8-PSK – QPSK, – 16-QAM, – 32-QAM – B-OQAM – Q-OQAM 0.329 – 1/1 Down: – GMSK – 8-PSK – QPSK, – 16-QAM, – 32-QAM – B-OQAM – Q-OQAM 0.329 – 1/1	Punctured convolutional code Turbo code	Up: 16.25 Mbit/s 20.312 Mbit/s 40.625 Mbit/s Down: 16.25 Mbit/s 20.312 Mbit/s 40.625 Mbit/s	Not explicit but not precluded	Not explicit but not precluded	FDD	TDMA	4.6 ms 4.615 ms	Mobile
IMT-2000 FDMA/TDMA (Annex 2)	1.728 MHz	Up and down: GFSK π/2-DBPSK π/4-DQPSK π/8-D8-PSK 16-QAM, 64-QAM	Depends on service: CRC, BCH, Reed-Solomon, Turbo	20 Mbit/s	Partial	Partial	TDD	TDMA	10 ms	Mobile

Formatted: English (United Kingdom)

TABLE 5 (*continued*)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate(1) – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IMT-2000 OFDMA TDD WMAN (Annex 2)	5 MHz, 7 MHz, 8.75 MHz, 10 MHz	Up: – QPSK-1/2, 3/4 – 16-QAM-1/2, 3/4 – 64-QAM-1/2, 2/3, 3/4, 5/6 Down: – QPSK-1/2, 3/4 – 16-QAM-1/2, 3/4 – 64-QAM-1/2, 2/3, 3/4, 5/6	CC/CTC Other options: BTC/ LDPC	Up to 17.5 Mbit/s with SISO Up to 35 Mbit/s with (2 × 2) MIMO Up to 70 Mbit/s with (4 × 4) MIMO	Yes	Yes	TDD FDD	OFDMA	5 ms	Mobile
LTE-Advanced (Annex 3)	Flexible 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz; carrier aggregation up to 100 MHz	QPSK, 16-QAM, 64-QAM. Fully variable code rate with Hybrid ARQ with incremental redundancy.	Turbo code for data; convolutional and block codes for some control channels	Up: 300 Mbit/s in 20 MHz(3) Down: 600 Mbit/s in 20 MHz(3) Up: 1.5 Gbit/s in aggregated 100 MHz(4) Down: 3 Gbit/s in aggregated 100 MHz(4)	Yes	Yes	FDD TDD HD-FDD	OFDM in DL, SC-FDMA in UL	10 ms Sub-frame length 1 ms	Mobile
IMT-2020 3GPP 5G-SRIT (Annex 4) E-UTRA/LTE component	200 kHz (NB-IoT) Flexible: 1.4, 3, 5, 10, 15 and 20 MHz (E-UTRA/LTE) Carrier aggregation supported for bandwidths greater than 20 MHz (up to max aggregated bandwidth of 640 MHz)	Up & down: QPSK 16QAM 64QAM 256QAM Up only(NB-IoT): Pi/2-BPSK Pi/4-QPSK Down: 1024QAM	Rate 1/3 turbo coding, complemented by HARQ Rate 1/3 tail-biting convolutional coding)	N/A for 5 MHz For 20 MHz carrier: 24 Gbit/s (256 QAM) – DL, 8 layers 30.1 Gbit/s (1024 QAM) – DL, 8 layers 12.9 Gbit/s (256 QAM) – UL 4 layers	Yes	Yes	TDD FDD Half-duplex FDD	OFDM on the DL DFTS-OFDM on the UL	10 ms Sub-frame length: 1 ms	Mobile

Formatted: English (United Kingdom)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[(1)] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IMT-2020 3GPP 5G-SRIT (Annex 4) .NR component	For 450-7 125 MHz: Flexible: 5,10,15,20, 25,30,40, 50, 60, 70, 80, 90 and 100 MHz based on various numerologies (with up to 16 carriers aggregation capability) For between 24.25-52.6 GHz: 200 and 400 MHz (with up to 16 carriers aggregation capability)	For DL: QPSK 16QAM 64QAM 256QAM For UL: Pi/2 BPSK (when precoding enabled) QPSK 16QAM 64QAM 256QAM	LDPC for data Polar for L1/L2 control	N/A to 5 MHz only. DL: depending on slot configuration and no. of aggregated component carriers (up to 16), 256QAM, 8-layers: from 37 to 140.2 Gbit/s. UL: similarly, from 17.9 to 64.6 Gbit/s.	Yes	Yes	TDD FDD SDL SUL	Convention al OFDM with cyclic prefix on both DL and UL (on UL, DFT precoding capability exists)	10 ms Sub-frame length: 1 ms	Mobile
IMT-2020 3GPP 5G-RIT (Annex 4)	For 450-7125 MHz: 5, 10, 15, 20, 25, 40, 50, 60, 80, 100 MHz (with up to 16 carriers aggregation capability) For between 24.25-52.6 GHz 50, 100, 200 and 400 MHz (with up to 16 carriers aggregation capability)	For DL: QPSK 16QAM 64QAM 256QAM For UL: Pi/2 BPSK (when precoding enabled) QPSK 16QAM 64QAM 256QAM	LDPC for data Polar for L1/L2 control (Repetition for 1-bit, simplex for 2-bit and Reed-Muller for 3-11 bits also available)	N/A to 5 MHz only. DL: depending on slot configuration and no. of aggregated component carriers (up to 16), 256QAM, 8-layers: from 37 to 140.2 Gbit/s. UL: similarly, from 17.9 to 64.6 Gbit/s.	Yes	Yes	TDD FDD SDL SUL	CP-OFDM for both DL and UL DFT-spread OFDM for UL TDMA, CDMA & SDMA also enabled	10 ms Sub-frame length: 1 ms 15, 30, 60, 120 & 240 kHz SCS	Mobile
IMT-2020 5Gi (Annex 4)										
IMT-2020 DECT 5G-SRIT (Annex 4)										

Commented [E1]: IEEE 802: As IEEE 802 commented previously on M.1801, we believe that M.1801 has never been about frequencies and inclusion of frequency ranges for different technologies is out of scope of this recommendation. Although we understand that the reason for inclusion of frequency ranges for IMT-2020 3GPP 5G-SRIT and RIT could be to describe the conditional nature of supported channel bandwidth sizes, we still think that this will implicitly specify frequency ranges. IEEE 802 proposes to remove the reference to frequency ranges highlighted in turquoise. As an alternative, two sets of supported channel bandwidth sizes may be listed and be stated that "the option of channel bandwidths depends on operational frequency".

Formatted: Font: 9 pt

Formatted: Font: 9 pt, Highlight

Formatted: Font: 9 pt

Formatted: Font: 9 pt, Highlight

Formatted: Font: 9 pt

Formatted: Font: 9 pt

Formatted: English (United Kingdom)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[1] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
IEEE 802.20 (Annex 78)	Flexible from 625 kHz, up to 20 MHz	Wideband mode: Up: QPSK, 8-PSK, 16-QAM, 64-QAM Down: QPSK, 8-PSK, 16-QAM, 64-QAM 625 kHz mode: π/2 BPSK, QPSK, 8-PSK, 12-QAM, 16-QAM, 24-QAM, 32-QAM, 64-QAM	Convolu-tional, Turbo, LDPC Code, parity check code, extended Hamming code	Peak rates of 288 Mbit/s DL and 75 Mbit/s UL in 20 MHz	Yes: SDMA, and beam-forming support on forward and reverse links	Yes: Single codeword and multi-codeword MIMO support	TDD FDD HFDD	OFDMA TDMA/ FDMA/ SDMA	Wideband mode: 0.911 ms 625 kHz mode: 5 ms	Mobile

TABLE 5 (*end*)

Standard	Nominal RF channel bandwidth	Modulation/ coding rate[1] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel (except as noted)	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/ mobile)
YD/T 1956-2009 Air interface of SCDMA broadband wireless access system standard (Annex 98)	Multiple of 1 MHz up to 5 MHz	QPSK, 8-PSK, 16-QAM, 64-QAM	Reed-Solomon	15 Mbit/s in 5 MHz	Yes	Yes	TDD	CS-OFDMA	10 ms	Mobile

[1] Including all applicable modes, or at least the maximum and the minimum.

[2] In 5 MHz three 1.28 Mchip/s TDD carriers can be deployed.

[3] E-UTRAN supports scalable bandwidth operation up to 20 MHz in both the uplink and downlink.

[4] E-UTRAN supports bandwidth carrier aggregation up to 100 MHz.

_____

Formatted: English (United Kingdom)