Analysis of the IEEE 802.20 norm as the standard for developing new wireless technologies

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Abstract— This paper aims to compile existing information on the IEEE 802.20 standard and unify it in a document that will serve as support for parties interested in conducting research and / or projects related to wireless technologies.

Keyword- Mobile Broadband Wireless Access, IEEE 802.20, IEEE 802.16, OFDM, MAC.

I. INTRODUCTION

Progress in telecommunications has led to the development of new wireless applications. This has created the need for more research on this type of technology, deepening the study on the IEEE 802.20 standard, which is basically geared to the development of wireless broadband networks based on mobile IP services. Key features, significance, differences with other standards will be studied in this article so as to serve as a guide to those interested in the topic.

IEEE 802 is a study of standards developed by the IEEE that acts on computer networks. Specifically and according to its own definition on local and metropolitan area networks. It focuses on defining the behavior and performance of layers 1 and 2 of the OSI reference model (Open System Interconnection).

The standards that have been used as reference to the 802.20 have been IEEE 802.11 and IEEE 802.16. Each of these has had a number of improvements or protocols aimed at correcting flaws and technical details in the standards. In the following section important aspects of each are detailed.

II. IEEE 802.11 STANDARD

This standard specifies the air interface between a wireless client and a base station or between two wireless clients. As with many IEEE standards, 802.11 (also known as IEEE 802.11 legacy) has gone through many iterations and expansions over the years, initially it transmitted at 1Mpbs in a 900MHz channel, however now it supports 54Mbps in the 2400 and 5600MHz bands.

III. IEEE 802.16 STANDARD

This model specifies the technical characteristics of the Stationary (non-mobile) broadband metropolitan wireless access networks. IEEE 802.16 operates under WiMAX technology, (Worldwide Interoperability for Microwave Access), which is a data transmission standard that uses radio waves at frequencies from 2.3 to 3.5Ghz.

IV. IEEE 802.20 STANDARD

Also called MBWA (Mobile Broadband Wireless Access) is a standard that specifies the technical characteristics of the wireless broadband networks based on mobile IP services and aims to be a specification of the 4th generation mobile systems. The main objective of this standard is to develop a packet-switching wireless access protocol optimized to support service on the Internet Protocol (IP) to enable the development of affordable, interoperable mobile access wireless networks with a "permanently connected" characteristic. This system will provide bandwidths (symmetrical transfer rates between 1 and 4 Mbps in regulated frequency bands) below 3.5 GHz and at distances from the base station of about 15 km. Note that ie has been designed from the outset for intensive use on an IP structure and specially oriented to VoIP and IP [1] applications. The IEEE 802.20 standard focuses on true high-speed mobile broadband systems. The IEEE 802.20 interface aims at increasing real-time transmission data rates in metropolitan area wireless networks at a speed greater than DSL (Digital Subscriber Line). This will be achieved with base stations covering a radius of up to 15 km or more, and the plan is to deliver these transmission rates to mobile users, even when traveling at speeds of up to 250 kilometers per hour (155 miles per hour). This would make IEEE 802.20 a valid option for deployment even in high-speed trains. This project aims to globalize the spread of broadband mobile access wireless networks with efficient use of spectrum characteristics, at affordable cost to the general public, with high availability in addition to interoperability with other technologies.

IEEE 802.20 is specifically aimed at the PHY and MAC layers (layers 1 and 2 of the OSI reference model) with an AI (Air Interface) operating in bands below 3.5GHz, in which IP data transport, with transmission speeds close to 1Mbps are optimized, as shown in Fig. 1.The main points that IEEE 802.20 must meet are:

A. Broad market potential.

IEEE 802.20 should note that mobile broadband access based on IP enables access to everything on the Internet, strengthening in this regard the marketing aspect, and thanks to cooperation between 3GPP and 3GPP2 groups the market will be further strenghtend by the development of interface specifications between MBWA and 3G networks.

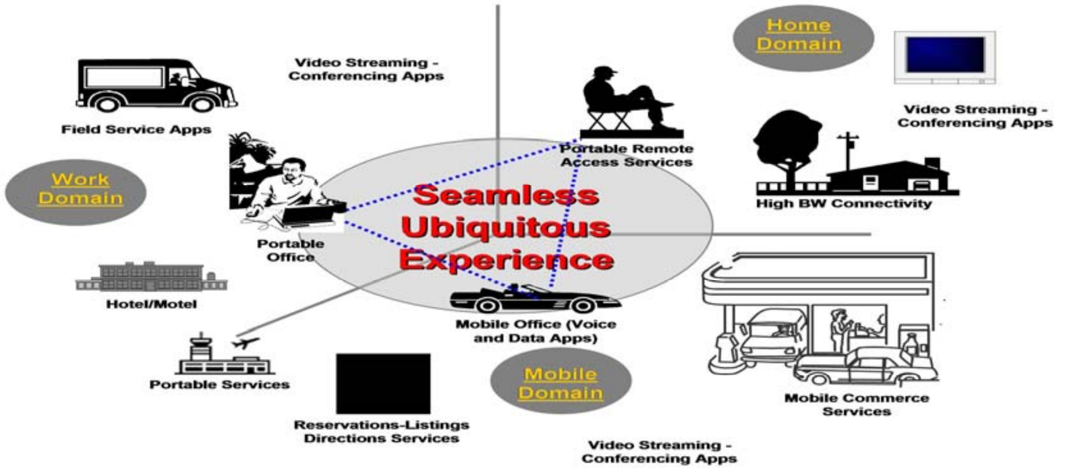

Fig. 1. Tests in various mobile internet scenarios without loss of connectivity [2]

B. Compatibility.

IEEE 802.20 conforms to IEEE 802.1D and IEEE 802.1F architecture and is proposed for applications in licensed spectrum. All problems related to compatibility, will be solved as the standard is developed.

C. Identity.

Currently IEEE 802.20 does not have a draft comprehensively covering vehicular mobility and this standard is intended to service public access networks via a WAN network (Wide Area Network), in addition to supporting service variety, not only supporting traffic engineering, but also real time QoS (quality of service).

D. Technical feasibility.

The plan for IEEE 802.20 is to use a frequency hopping solution, OFDM (Orthogonal Frequency Division Multiplexing), adaptive antenna, in addition to existing cellular architectures thus giving reliable support to the AI, for commercial deployment.

E. Financial viability.

IEEE 802.20 is intended to improve cost-benefit features to existing mobile wireless networks, since their design is based on network access through packages, delivering optimal spectral efficiency. This is due to the fact that some requirements are best handled through packet technologies that even enable cost reduction, since the number of required BS (Base Stations) decreases, thus lowering costs and eliminating frequency planning.

V. Basic Features

This standard has two operating modes: Wideband and 625k-MC (625kiloHertz-spaced multicarrier). Wideband operation mode was designed to operate in all FDD (Frequency Division Duplex) bandwidths and TDD (Time Division Duplex). The 625 k-MC mode works with a 625 kHz carrier bandwidth.

VI. Network Architecture (Wideband)

For Wideband, the MBWA consists mainly of Access Terminals (AT), Access to the Network (AN) and an air interface (AI). In OT, several Access Point (AP) services can be received and these in turn can optimize existing AI resources covering several sectors, as shown in Fig. 2.

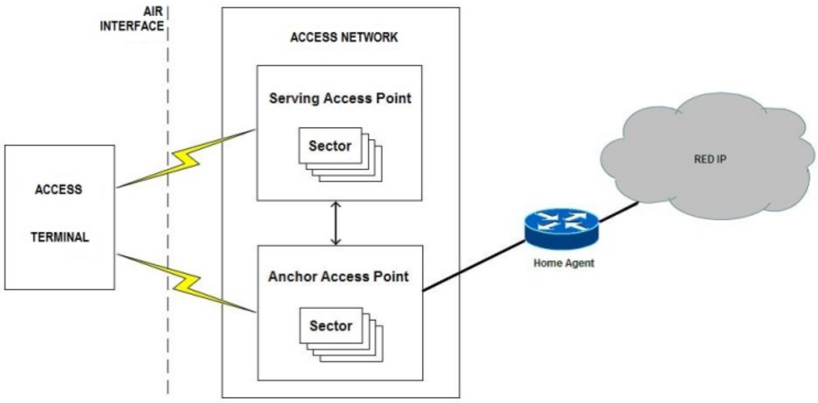

Fig. 2. IEEE 802.20 standard basic architecture. Reference is made here to how MBWA works [3]

VII. Reference Model

IEEE 802.20, uses a layered architecture compatible with other IEEE 802 standards, mainly consisting in implementing MAC and PHY layers, in which at least one AT can communicate with an AP via the AI towards external networks. Fig. 3 shows the layered model for each AI route. Each sublayer contains one or more functionality protocols.

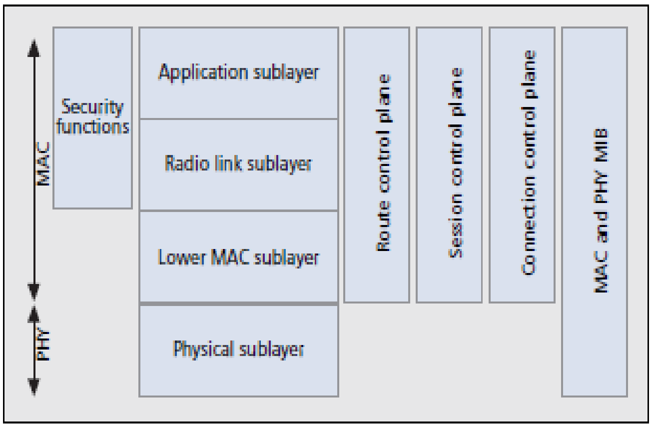

Fig. 3. Architecture of the component layers of IEEE 802.20 [4]

The Wideband mode, is defined as a multi-path standard and each route is defined as unique in the network regardless of the operation but with identical support protocols, and only one route may "be in use" to the forward link (FL) and the reverse link (RL), however many routes can be configured if so required.

The physical layer provides channel structure, working frequency, output power, modulation and specific coding for forward and reverse of wireless links. In Wideband mode, the physical layer includes support for implementing FDD and TDD. FDD mode provides this support to improve compatibility with previous versions, including other technologies. Whereas the TDD mode provides flexible resource allocation [5], MC 625 k mode allows access to wireless broadband that uses multiple radio frequencies (RF) with 625 kHz carrier deployed in the 5 MHz channel. MC 625 k mode adds multiple TDD RF carriers to further increase the maximum available data rates per user. The 625k-MC mode is an improvement of iBurst, HCSDMA specifications and the radio interface standard (ATIS.0700004.2005), compatible with commercially deployed systems based on HC-SDMA specifications. Mode 625 k - MC, is designed around multiple antennas with spatial processing and SDMA, which allows for IP traffic transmission, the PHY and MAC layers are designed to obtain maximum benefit from spatial processing technologies, increased spectral efficiency and wider coverage even if the available spectrum is as small as 625 kHz (Fig. 4).

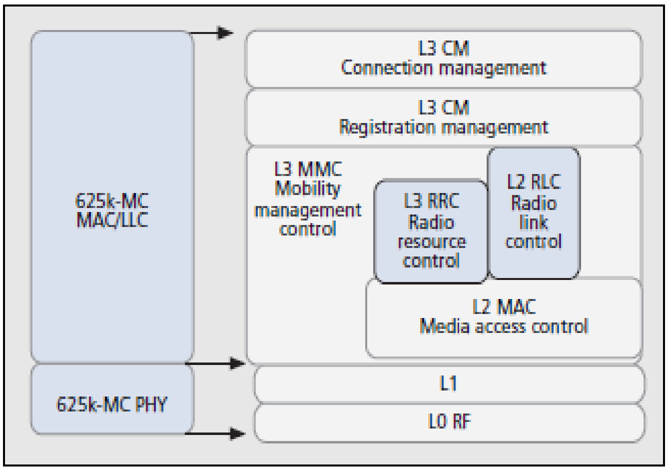

Fig. 4. The architecture established for the 625 k-MC layer protocol. The composition of the 625 k-MC coating [6] is detailed here

The IEEE 802.20 AI should allow operation of high-speed services based on IP supporting applications that conform to existing protocols and standards, such as video, uploading and downloading files of unlimited size, audio and video streaming, VoIP, etc. In addition to continuous, uninterrupted service similar to that offered by cable and DSL systems.

As for mobility, IEEE 802.20 AI supports vehicle speeds ranging from 35km/h to 250 km/h. According to these speeds, spectral efficiencies within the allowable range must be considered, however, as vehicle speed increases, the spectral efficiency will be gradually reduced, as shown in Table I.

TABLE I. Spectral efficiency values according to vehicle speed [7]

Parameter	**Spectral efficiency requirements**			
	RL		**FL**	
	3Km/h	120Km/h	3Km/h	120Km/h
Spectral efficiency (bps/ Hz/sector)	2.0	1.5	1.0	0.75

The IEEE 802.20 AI must also withstand user peak transmission speeds exceeding those shown in Table II.

In the MAC layer, the system is provided with some QoS end to end characteristics such as DiffServ and RSVP (Resource Reservation Protocol). This layer also take into account critical parameters such as power saving and Handoff. The 802.20 MAC layer, must be able to control more than 100 active sessions (time during which a user receives or transmits data with minimum delay, this delay should be less than 25ms), simultaneously for each sector [9].

Some applications will be given priority in order to comply with QoS between AP and AT for both IPv4 and IPv6. QoS specifications include transmission speed, latency and MAC/PHY layer packet error rate. For this it is necessary that the MBWA frequency plan include BW multiple channels, thereby allowing co-deployment with existing systems.

TABLE III. Peak velocity values for each user set by IEEE 802.20 [8]

Parameter	**Bandwidth**			
	1.25MHz		**5MHz**	
	FL	**RL**	**FL**	**RL**
User peak transmission speed	4.5Mbps	2.25Mbps	18Mbps	9Mbps

VIII. PHY PHYSICAL LAYER

For the physical layer, combinations such as OFDMA (Orthogonal Frequency-Division Multiple Access), CDMA (Code Division Multiple Access) will be used, all deployed in flexible BW ranging from 5MHz to 20MHz, and also using multiple MIMO inputs and outputs supporting peak transmission speeds above 260Mpbs with a 20MHz BW [10]. In PHY, resource planning refers to the allocation of subcarriers and of spectral efficiency to maximize system capacity while managing QoS requirements, such as latency and throughput. System resources are allocated in hop ports, where a hop port is a statistical resource set on a physical subcarrier. In this case, an AP assigns a group of Hopping ports to each AT using frequency hops over time. In MIMO (Multiple-input Multiple-output), peak transmission rates over 260Mbps at 20 MHz of bandwidth are supported. 802.20 supports FDD and TDD operation modes and can work with 512, 1024 or 2048 subcarriers. Air interface supports QPSK modulation (Quadrature Phase Shift Keying), 8PSK, 16QAM (16 - Quadrature Amplitude Modulation) and 64QAM and enables the system to work with HARQ (Hybrid automatic repeat request).

In MIMO, higher spectral efficiency is given by spatial multiplexing. There, the AP creates multiple signals using a group of physical antennas, where each signal is referred to as an effective antenna. Each signal uses different antennas for transmission, thus ensuring that all power amplifiers in the AP are used equitably.

A. Frame structure.

Transmission of links in MBWA is divided into OFDM symbol units. FL and RL transmissions are divided into hyper-frame units of and these in turn are divided into PHY frame units, its structure is designed to minimize data transmission latency maintaining acceptable processing durations for encoding and decoding in AT and AP, as well as planning in AP.

1) Structure of the hyper-frame: Hyper-frames for FL are formed by a preamble, which are followed by PHY frames. The hyper frame preamble is made up eight OFDM symbols, of which the top 5 are used to carry two Primary Broadcast Channels (pBCH0 and pBCH1) which carry the configuration information used by the AT to demodulate PHY frames. Whereas the last three hyper-frame preamble OFDM symbols are known as TDM pilots as shown in Fig. 5.

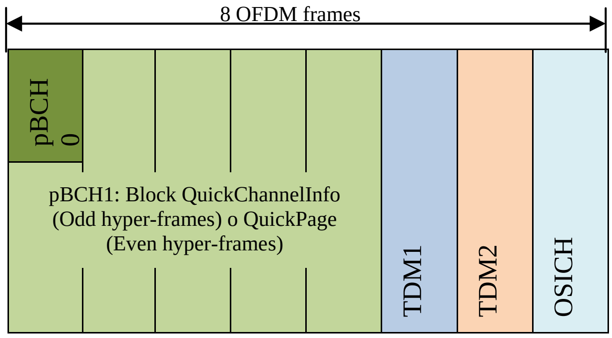

Fig. 5. Structure of the hype- frame preamble. This figure shows how the 8 OFDM symbols are distributed for MBWA[11]

The hierarchical structure of pilot is used to reduce the acquisition complexity. A scramble using 2 bits of information is performed on pilot TDM1, 8-bits (two of TDM1) on pilot TDM2 and 12-bits on the third pilot. Pilot TDM1 is periodic, facilitating acquisition and frequency synchronization. On the other hand a hyper-frame in RL has no preamble. The main features of pBCH0 and pBCH1 are shown below in Table III.

TABLE IIIII. Main features of pBCH0 and pBCH1

pBCH0	**pBCH1**
	It carries paging information
It is encoded on 16 hyper frames, occupying 1/4 OFDM symbol in each preamble	It is coded on a single hyper frame
It includes information such as the number of guardband carriers	Contains settings information required by the AT to demodulate channels transmitted in a PHY frame

2) Frame structure for FDD: The FL hyper frame consists of a preamble followed PHY FL frames (24 frames). The preamble carries acquisition sequences and header parameters that allow the AT to receive FL control channels and access system. Since for RL there is no preamble, it is replaced by a PHY RL frame that has the same duration as the FL hyper-frame preamble, to thus ensure that they are aligned in time. FL and RL support HARQ, thus providing better performance, especially in wireless networks. This system supports extended length assignments. For FL the frame provides HARQ retransmission latency of approximately 11ms and 1.8ms processing time, while for RL a latency of HARQ retransmission of 11ms with 1.8ms processing time is provided for AT and 2.7ms for AP.

3) Frame structure for TDD: This system supports partitioning TDD M:N, where M:N is the relationship between the FL transmission duration and the RL transmission duration. The guard time for the transition from FL to RL is 78. 12µs and for RL to FL, 16. 28µs. Both FL and RL support HARQ. A structure similar to the one used in FDD but applying TDD is used to provide AP and AT the processing time related with HARQ, alternating M frames of 8 OFDM symbols of the AN and N frames of 8 OFDM symbols of the AP depending on the M:N relationship used.

4) Transmission Process: The processes of encoding and modulation are performed prior to transmission. The packages are divided into sub-packages of equal size and are encoded separately, allowing the decoders to work in parallel, speeding up the decoding. After the encoding process, the data arrive at the interlaver channel, which has a design based on the PBRI which operates in length N sequences and eliminates repetitive symbols through a bit-reversal interaver. The AI supports four types of modulation, QPSK, 8PSK, 16QAM and 64QAM and this allows a wide range of spectral efficiencies. This system supports 15 packet formats both for FL RL.

B. Operation and control mechanisms.

1) Allocation of resources: Planning refers to the allocation of subcarriers and spectral efficiency to ATs over time and is centered in the AP both for FL, and RL. Central planning is used to ensure orthogonal resources allocations to various ATs in the system. The Scheduler is also responsible to ensure that the ATs can have uneven link qualities, since they can withstand diverse spectral efficiencies instantly.

2) Hopping Modes: IEEE 802.20 supports two hopping modes, the SRH (Symbol Rate Hopping) and BH (block hopping). FL supports both SRH, and BH. On the other hand RL only supports BH. In SRH, subcarriers which are assigned to a particular user, are scattered on the frequency band and the hopping exchange which locates the assigned hop ports in frequencies changes every two OFDM symbols. For BH (for FL), users are randomly assigned 16 contiguous carriers distributed through the frequency band. The allocation between hopping ports and frequency is constant throughout the PHY frame. For RL the performance is similar. SRH maximizes channel and interference diversity, while BH provides support for interference cancellation.

3) *Reverse link Quasi-Orthogonal:* In this scheme, quasi-orthogonal multiplexing is used, where same sector multiple ATs are assigned the same bandwidth resources, reducing the orthogonal access limitation. Thus it is a design that retains the benefits of an orthogonal design when the number of antennas is small, offering scaling capability improved with the number of antennas. This scheme achieves diversity of intra-sector interference through random hopping.

4) Fractional Frequency Reuse (FFR): This scheme has a reduced overhead bandwidth compared to common frequency reuse schemes. Unlike traditional reuse schemes in which the same frequency is used in one of 3, 7, 12, sectors, FRR allows ATs with different channel conditions to have a reuse factor at different frequencies.

5) Sub-Band Planning: When multiple ATs are located in selective frequency channels, the system capacity can be increased if each AT is located in a selected sub-band based on the frequency response of current channel. The size of this sub-band should provide great power diversity, enough to prevent performance degradation in high mobility ATs. On this basis, a sub-band of approximately 1.25 MHz in size is used.

6) Scalable bandwidth: In this system, support is provided through MultiCarrierOn mode in which the entire bandwith is divided into multiple carriers, each made up of 512 subcarriers. A 20 MHz display, covering 2048 subcarriers, would carry 4 carriers and each carrier with guard subcarriers in the limits, called Quasi-guard subcarriers.

7) Power control: A 150 Hz power control frequency or higher, is sufficient for the channel general conditions. Implying that an AT may be receiving one bit of power control every six PHY frames.

IX. MAC MEDIUM ACCESS CONTROL LAYER

The MAC layer is subdivided into 6 layers, convergence sublayer, safety sublayer, lower MAC sublayer, session control sublayer, security control sublayer, and the lower MAC control sublayer.

1) Session control sublayer: Since it contains non-carrier Protocols, it serves to negotiate sessions between AT and AN, in addition, it provides management, negotiation and configuration protocols and state maintenance services. It does not have Playload, not being a carrier layer. The session management protocols are handled in this sublayer, which provides the means to control all activation and deactivation processes of the address management protocol. The address management protocol, is where the initial UATI is assigned, in addition to the session setup protocol, where the means for Token setup Session negotiation used in the session are provided, the capabilities discovery protocol, which provides the means where the AN discovers the AT capabilities and the RAT Protocol, which allows the AN and the AT to send messages to other radio access technologies.

2) Convergence sublayer: Provides transport and protocols that are used to carry messages and data between the AT and the AN, it is considered extensible, since new transport can be defined for other types of packets. This sublayer, handles the signaling transport, which provides the means for carrying messages between a protocol/transport from a given point to the same protocol / transport at another point. Packet transport transmits data from upper layers and packets that can be used for transport between the AT and the AN. The packets consolidation Protocol, which delivers the multiplexing of different transports for an AT

3) Security Control sublayer: Provides key exchange and also the procedures that both the AN and the AT should follow to exchange authentication and encryption keys through 4-way key exchange. This is due to the key exchange protocol.

4) Security sublayer: The Cryptosonyc is generated in this sublayer , which is used in authentication and encryption procedures. Encryption protocols are handled by default in this sublayer, which allows transfer of packets between authentication and security protocols. The generic encryption protocol, which provides the procedures that both the AN and the AT should follow to encrypt sublayer of convergence packets and decrypt them from the authentication protocol. The authentication protocol, which supports authentication of packets. The Security Protocol, where a cryptosonyc is generated based on the information obtained in lower MAC sublayer.

5) Lower MAC Control sublayer: There the air link status is monitored. Also it provides functions related to the connection, such as handling the initial network acquisition, manages the opening and closing of connections, among others. This sublayer does not encapsulate data. Air link management protocols are handled, in which the administration states that the AN and AT continue to the connection and also provides protocol activation and deactivation in the MAC control sublayer. The State of initialization protocol that provides the procedures and messages that an AT needs to acquire a server network. The idle state protocol, delivers procedures that an AT and an AN use when the AT acquires a network and a connection that is not open. In addition to the connected state protocol, the active set protocol and the overead Protocol.

6) Lower MAC sublayer: Here are rules for packet formulation of lower MAC sublayer, for transmissions on the physical channels, it also contains the rule specifications for control and processing of the physical layer signaling channels on the RL and FL links. This sublayer contains the channel control protocols, which provide the procedures followed by the AN to transmit through the AT for the reception of control channels. The access channel MAC protocol, which enables the delivery procedures followed by the AT to transmit through the AN to receive the access probe. The shared MAC signaling protocol, which allows having the procedures by which the AN transmits and through the AT receives the physical layer channels. The forward traffic channel MAC protocol, the reverse traffic channel MAC protocol and the reverse control channel MAC protocol [12].

A. MAC Features.

1) QoS: Provides the configuration of QoS policies, differentiation of requirement priorities and also the segmenting users into different types of access.

2) Paging: Is the process by which an AN initiates connection to an AT that is in idle mode.

3) Security: IEEE 802.20 it uses encryption and authentication procedures and to reduce overhead, cryptosyn is used based on parameters such as System Time, which is a common parameter for both the transmitter and receiver and it also uses Connection CONUT which ensures that the cryptosyn is not reused when an AT moves between different sectors, the Identifier Channel and PilotPN.

4) Handoff: For IEEE 802.20, handoff is used to refer to the change in the RL sector or an AT RL. For the 625KHz-MC mode the MAC layer is the L2 layer and handles the mapping of data messages and control over physical resources and also provides message delivery modes with acknowledgment (AM) and unacknowledged (UM). L2 also provides encryption to ensure confidentiality of user data and control [13].

X. COMPARISON BETWEEN IEEE 802.16 E AND IEEE 802.20

The IEEE 802.20 and IEEE 802.16Ee standards originate from the IEEE 802.16 study group since it is determined that there are different proposals within the same group, and the separation of these working groups is suggested. Thus the IEEE 802. 16E continues with its studies, to provide mobility to systems that work with IEEE 802.16 (WiMax) with maximum speeds of 120 Km/h. On the other hand the IEEE 802.20 work group focuses on broadband wireless systems that allow high velocity, with vehicular speeds of up to 250 Km/h. Below in Table IV, there is a brief comparison between both standards.

TABLE IVV. Comparison between IEEE 802.16 and IEEE 802.20, here features and differences of each standard

	IEEE 802.16E	IEEE 802.20
Standard type	IEEE 802.16E Amendment. Extension of the PHY and MAC layers of 802.16[a]	New standard. New PHY and MAC layers Optimized for transport of data packets and adaptive antennas
Compatibility and coexistence with other technologies	Optimized for compatibility with 802.16 fixed stations	Optimized for full mobility and coexistence with other wireless technologies
Frequency Bands	Bands under 2-6GHz license	Licensed bands below 3.5GHz (500MHz-3.5GHz)
Bandwidth (BW)	Typical channel bandwidth greater than 5 MHz (10MHz)	Typical channel bandwidth less than 5 MHz (FDD: 1.5MHz, TDD: 5MHz) up to 20MHz
Architecture	Packet-oriented	Packet-oriented
Mobility	Local and Regional roaming support	Packet-oriented
Coverage	Cells from 2 to 5km (2.5Km approx.)	Cells of 2.5 km up to 15 km approximately
Data Rate	Data rate up to 30Mbps and speeds up to 120 Km/h	Data rates up to 260 Mbps with MIMO on 20MHz bandwidth, data rate up to 1Mbps for speeds of 250 km/h

Although IEEE 802.20 and IEEE 802.16e were created with different approaches, the market they face is very similar, both offer wireless access systems for mobile broadband with packet access, but 802.20 offers larger systems in terms of mobility capability. The main advantage of IEEE 802.16e over IEEE 802.20 is that having been approved before 802.20 it carries a distinct time advantage market compared to IEEE 802.20.

Since IEEE 802. 16e is an extension of IEEE 802.16, IEEE 802. 16e works with some of the same physical layers.

The main advantage of IEEE 802.20 compared to IEEE 802. 16e is that as regards processing, IEEE 802.20 has processing units working in parallel, allowing the reduction of transmission time, however, by increasing the processing speed the complexity and costs could increase. IEEE 802.20 supports a larger number of working mechanisms such as MIMO, SDMA, which help to improve the system's efficiency.

XI. Technologies Related to IEEE 802.20

Currently we cannot say that there are technologies based on IEEE 802.20, as some of these were marketed prior to the adoption and publication of this standard. However, some of these technologies are closely related with IEEE 802.20.

A. iBurst.

Also known as HC-SDMA, it provides wide area wireless broadband connectivity for fixed, portable and mobile equipment.

B. Flash-OFDM.

Provides delivery of advanced Internet services in a mobile environment. It is based on OFDM technology, which allows it to target user requirements for broadband and voice packet data applications.

This standard specifies requirements to ensure compatibility between an access terminal and a base station, appropriately adapting this standard's selected modes, which is designed for use in a variety of frequency and regulatory environment licensed bands. And due to fractional frequency reuse, planning of sub-band and scalable bandwidth support could allow to improving system capacity.

XII. CONCLUSIONS

IEEE 802.20 is introduced as a system designed to provide the user access to all types of information at high transmission rates while he is in motion. Among this standard's advantages is the interoperability with other wireless access systems and it covers a wider area in application with respect to other standards such as 802.16e.

IEEE 802.20 is a standard that saves power by using the Idle state protocol and two modes of operation, it also supports a Fast Handoff and separates sector servers RL and FL, allowing the performance of a separate handoff for each. By supporting a larger number of working mechanisms, it improves the system's efficiency. With the implementation of this standard even suppliers stand to benefit, since they could improve the services offered.

XIII. ACKNOWLEDGMENT

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