INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

L802.16-07/017

***** DRAFT *****

Document 8F/IEEE-3-E
15 March 2007
English only

Received:

TECHNOLOGY

Subject: Question ITU-R 229-1/8

***** DRAFT *****

Institute of Electrical and Electronics Engineers (IEEE)

DEVELOPMENT OF [IMT-TECH]

This contribution was developed by IEEE Project 802, the Local and Metropolitan Area Network Standards Committee ("IEEE 802"), an international standards development committee organized under the IEEE and the IEEE Standards Association ("IEEE-SA").

The content herein was prepared by a group of technical experts in IEEE 802 and industry and was approved for submission by the IEEE 802.16 Working Group on Wireless Metropolitan Area Networks, the IEEE 802.18 Radio Regulatory Technical Advisory Group, and the IEEE 802 Executive Committee, in accordance with the IEEE 802 policies and procedures, and represents the view of IEEE 802.

The IEEE 802.16 Working Group on Broadband Wireless Access has reviewed Attachment 6.2 to Doc. 8F/1170 and offers the material in Attachment 1 to assist in the development of [IMT.TECH].

Proposal

The amendments shown in Attachment 1 are proposed.

Attachments:

1. Proposed Amendments to IMT.TECH

Attachment 1

Proposed Amendments to IMT.TECH

Source: Attachment 6.2 to Doc. 8F/1170

DRAFT [REPORT ON] REQUIREMENTS RELATED TO TECHNICAL SYSTEM PERFORMANCE FOR IMT-ADVANCED RADIO INTERFACE(S) [IMT.TECH]

TABLE OF CONTENTS

Page

1 Introduction

[Editor's note:

Text will be imported from the common text which is discussed in WG-SERV.]

2 Scope and Purpose

IMT.TECH describes requirements related to technical system performance for IMT-Advanced candidate radio interfaces. These requirements are used in the development IMT.EVAL, and will be attached as Annex 4 to the Circular Letter to be sent announcing the process for IMT-Advanced candidacy.

IMT.TECH also provides the necessary background information about the individual requirements (technology enablers) and the justification for the items and values chosen. Provision of such background information is needed for wider reference and understanding.

IMT.TECH is based on the ongoing development activities from external research and technology organizations. The information in IMT.TECH will also feed in to the IMT.SERV document. IMT.TECH provides the radio interface requirements which will be used in the development of IMT.RADIO

3 Related Documents

Recommendation ITU-R M.[IMT.SERV]

Recommendation ITU-R M.1645

Recommendation ITU-R M.1768

Report ITU-R M.2038

Report ITU-R M.2072

Report ITU-R M.2074

Report ITU-R M.2078

Report ITU-R M.2079

Recommendation ITU-R M.1224

Recommendation ITU-R M.1225

[Recommendation ITU-T Q.1751

Recommendation ITU-T Q.1761

Recommendation ITU-T Q.1711

Recommendation ITU-T Q.1721

Recommendation ITU-T Q.1731

Recommendation ITU-T Q.1703]

[Editor's note: Document to be added]

4 General Requirements

[Editor's note: This section is for describing general requirements for cellular systems including IMT which are requested by market not only developed but also developing countries]

The following are the general system requirements and features that IMT-Advanced system shall support:

- Higher spectral efficiencies and peak data rates
- Lower latencies (air-link access latency, [Inter-FA HO, Intra-FA HO, inter-RAN HO] latencies) to enable new delay-sensitive applications.
- ~~[-~~Mobility Support ~~speed~~: Cellular systems including IMT-Advanced are required to support the environments described in following:
    - ~~-~~Stationary (Fixed applications) (i.e. can be used as a FWA systems)
    - ~~-~~Pedestrian (~~Walking speed of~~Pedestrian speeds up to ~~several~~10 ~~km/Hr~~km/h)
    - ~~-~~Typical Vehicular (~~Automobile~~ Vehicular speeds up to 120 ~~of one hundred and several tens~~ ~~km/Hr~~km/h)
    - - High Speed Vehicular (~~High speed train~~Vehicular speeds up to ~~500km~~-350 ~~/Hr~~km/h)
    - Optimized system performance for low mobility environments
    - ~~-~~Seamless application connectivity to other mobile networks~~/PSTN/ISDN~~ and other IP networks (global roaming capabilities).
- ~~Potential to s~~Support for larger cell sizes and improved cell-edge performance
- ~~Cheap~~ Low-cost and low-complexity terminals for worldwide use
- ~~-~~Mobile user interface
- ~~-~~Ubiquitous Access

~~etc.]~~

- Improved unicast and multicast broadcast services
- Provision for PAN/LAN/WAN Co-location / Coexistence

5 Technical Requirements

[Editor note: This chapter specifies the technical independent requirements that determine the performance of the IMT-Advanced systems.]

5.1 Technological items required to describe candidate air interface

[Editor's note: This section is for listing up technology enablers which need to be described in the candidate air interface proposal for IMT-Advanced and also the general explanation why those each technology enablers are important to be described.]

5.1.1 Radio transmission technologies functional blocks

5.1.1.1 Multiple access methods

[The choice of the multiple access technology has major impact on the design of the radio interface. For instance, OFDMA, CDMA and also Single-carrier/Multi-carrier operation]

5.1.1.2 Modulation scheme

[The choice of the modulation technology depends mainly on radio environment and the spectrum efficiency requirements.]

5.1.1.3 Duplex methods

[The choice of the duplexing technology mainly affects the choices of the RF-channel bandwidth and the frame length. Duplexing technology may be independent of the access technology since for example either frequency division duplex (FDD) , time division duplex (TDD) or half-duplex FDD may be used. It also affects band allocations, sharing studies, and cell size.]

IMT-Advanced systems shall support both TDD and FDD operational modes. The FDD mode shall support both full duplex and half duplex mobile station operation. Specifically, a half-duplex FDD mobile station is defined as a mobile station that is not required to transmit and receive simultaneously.

IMT-Advanced systems shall support both unpaired and paired frequency allocations, with fixed duplexing frequency separations when operating in full duplex FDD mode.

System performance in the desired bandwidths specified in Section 5.1.1.3 should be optimized for both TDD and FDD independently while retaining as much commonality as possible.

The UL/DL ratio should be configurable. In TDD mode, the DL/UL ratio should be adjustable. In FDD mode, the UL and DL channel bandwidths may be different and should be configurable (e.g. 10MHz downlink, 5MHz uplink). In the extreme, the IMT-Advanced system should be capable of supporting downlink-only configurations on a given carrier.

Asymmetrical operation should be supported in addition to symmetrical operation.

5.1.1.3 Operating Bandwidths

IMT-Advanced systems shall support scalable bandwidths from 5 to 20 MHz. Other bandwidths may be considered as necessary to meet additional deployment requirements.

5.1.1.4 Support of Advanced Antenna Techniques

IMT-Advanced systems shall support MIMO and beamforming operation.

Minimum antenna configuration requirements shall be:

- For the base station, a minimum of two transmit and two receive antennas shall be supported.
- For the MS, a minimum of one transmit and two received antennas shall be supported. This minimum is consistent with a 2x2 downlink configuration and a 1x2 uplink configuration.

5.1.1.4 Error control coding scheme

[The choice of the error control coding affects qualities of air link, throughput, terminal complexity and also delay performance of communications.]

5.1.1.5 Physical channel structure and multiplexing

[The physical channel is a specified portion of one or more radio frequency channels as defined in frequency, time spatial and code domain.]

5.1.1.6 Frame Structure

[The frame structure depends mainly on the multiple access technology (e.g. OFDMA, TDMA, CDMA) and the duplexing technology (e.g. FDD, TDD). Commonality should be maximised by maintaining the same frame structure whenever possible. That is, data fields identifying physical and logical channels, as well as the frame length should be maintained when possible.]

5.1.1.7 [FFT size, Chip rate etc.]

5.1.1.x xxxxxxxxxxxxxxxxxxxxxx

5.1.2 Other functional blocks

5.1.2.1 Source coder

[The choice of the source coder may generally be made independently of the access method.]

5.1.2.2 Interworking

[The interworking function (IWF) converts standard data services to the rates used internally by the radio transmission subsystem. The IWF feeds into the channel coder on the transmit side and is fed from the channel decoder on the receiver side. It also take some functionalities to deal with the applications such as voice, images, etc.]

5.1.2.3 Latency

[The latency is important factor especially if delay sensitive communication required.]

Latency should be further reduced as compared to IMT-2000 systems for all aspects of the system including the air link, state transition delay, access delay, and handover.

The following latency requirements shall be met by the system, under unloaded conditions.

5.1.2.3.1 Data Latency

Requirements for air link data latency are specified in terms of the time for delivery of a MAC PDU, transmissible as a Layer 1 codeword (i.e. without fragmentation), from the MAC interface of a base station or mobile station entity to the MAC interface of the corresponding mobile station or base station entity, excluding any scheduling delay at the base station. A single Layer 1 re-transmission of the codeword is included in the definition. The latency does not include bandwidth requests. The corresponding maximum latency for delivery of the MAC PDU appears in Table 2.

Table 1. Maximum Data Latency

Link Direction	Max. Latency (ms)
Downlink (BS->MS)	10
Uplink (MS->BS)	10

5.1.2.3.2 State Transition Latency

Performance requirements for state transition delay define the transition from IDLE mode to ACTIVE mode.

IDLE to ACTIVE_STATE is defined as the time it takes for a device to go from an idle state (fully authenticated/registered and monitoring the control channel) to when it begins exchanging data with the network on a traffic channel or timeslot measured from the paging indication (i.e. not including the paging period).

Table 2. State Transition Latency

Metric	Max. Latency (ms)
IDLE_STATE to ACTIVE_STATE	100 ms

5.1.2.3.3 Handover Interruption Time

Handover performance requirements, and specifically the interruption times applicable to handovers for compatible IMT-2000 and IMT-Advanced systems, and intra- and inter-frequency handover should be defined.

The maximum MAC-service interruption times during handover are specified in Table 5.

Table 3. Maximum Handover Interruption.

Handover Type	Max. Interruption Time (ms)
Intra-Frequency	50
Inter-Frequency	150

5.1.2.4 QoS Management scheme

[The QoS is important factor especially the applications which are originally supported by circuit switched network in delay/jitter.]

IMT-Advanced systems shall support QoS classes, enabling an optimal matching of service, application and protocol requirements (including higher layer signaling) to RAN resources and radio characteristics. This includes enabling applications such as interactive gaming.

When feasible, support shall be provided for preserving QoS when switching between networks associated with other radio access technologies (RAT's).

5.1.2.5 Privacy and Authentication~~Security~~ Aspects

[The secure communication should be achieved at least the same level as the IMT-2000.]

IMT-Advanced systems shall include a privacy and authentication functions which provides the necessary means to achieve:

- protection of the integrity of the system (e.g. system access, stability and availability)
- protection and confidentiality of user-generated traffic and user-related data (e.g. location privacy, user identity)
- secure access to, secure provisioning and availability of services provided by the system

Example procedures that can be used to achieve the above-stated goals include user/device authentication, integrity protection of control and management messages, enhanced key management, and encryption of user generated and user-related data. The impact of these procedures on the performance of other system procedures, such as handover procedures, shall be minimized.

5.1.2.6 Capacity considerations/ Supported user density

[Requirements that specify how many users could be supported in different scenarios, e.g rural, urban and hotspot.]

5.1.2.7 Network Topology

[Proposed radio interface technology need to be considered for applying to Single-hop mode, Multi-hop mode, Mesh mode and Peer to peer mode.]

5.1.2.8 Mobility management and RRM

[Centrarized/Distributed RRM, Inter-RAT spectrum sharing/mobility management need to be considered.]

5.1.2.8.1 Reporting

IMT-Advanced systems shall enable advanced radio resource management by enabling the collection of reliable statistics over different timescales, including system (e.g. dropped call statistics), user (e.g. terminal capabilities, mobility statistics, battery life), flow, packet, etc.

5.1.2.8.2 Interference Management

IMT-Advanced systems shall support advanced interference mitigation schemes and enhanced flexible frequency re-use schemes.

5.1.2.8.3 Inter-RAT Mobility

IMT-Advanced systems shall support inter-RAT operations.

5.1.2.x xxxxxxxxxxxxxxxxxxxxxx

5.2 Required technology items for evaluation

5.2.1 Throughput and Capacity ~~Spectrum efficiency/ Coverage efficiency~~

[The supported information transmission rate under some constrains, e.g, bandwidth, area, time and system load.]

5.2.1.1 User throughput

The targets for average user-throughput and cell-edge user throughput of downlink/uplink for data only system for minimum antenna configuration are shown in Table 4. Both targets should be achieved as per minimum antenna configuration defined in section 5.1.1.4.

Table 4. Data only system

Metric	Throughput	
	DL Data	UL Data
Average User Throughput	TBD	TBD
Cell Edge User Throughput	TBD	TBD

5.2.1.2 Sector Capacity

Sector Throughput is defined as the total unidirectional sustained throughput (downlink/uplink), excluding MAC & PHY layer overheads, across all users scheduled on the same RF channel. Sector throughput requirements must be supported for realistic distributions of users of a fully loaded cell surrounded by other fully loaded cells using the same RF channel (i.e. an interference limited environment with full frequency reuse).

Table 5. Sector Throughput (bps/Hz/sector)

Speed (km/h)	DL	UL
TBD	TBD	TBD

Table 6. Voice-over-IP Capacity

Capacity (Active Users/MHz/sector)
>60 (FDD)

5.2.1.3 Mobility

IMT-Advanced shall be optimized for low speeds such as mobility classes from stationary to pedestrian and provide high performance for higher mobility classes. The performance shall be degraded gracefully at the highest mobility. In addition, IMT-Advanced shall be able to maintain the connection up to highest supported speed and to support the required spectral efficiency.

Table 7 summarizes the mobility performance.

Table 7. IMT-Advanced mobility support

Mobility	Performance
Low (0 –15 km/h)	Optimized
High (15– 120 km/h)	Marginal degradation
Highest (120 km/h to 350 km/h)	System should be able to maintain connection

5.2.2 Technology complexity

The IMT-Advanced systems PHY/MAC should enable a variety of hardware platforms with differing performance and complexity requirements.

IMT-Advanced shall minimize complexity of the architecture and protocols and avoid excessive system complexity.

5.2.3 Quality

5.2.4 Flexibility of radio interface

5.2.5 Implication on network interface

5.2.6 Cell Coverage

[Requirements that specify the area could be covered by a cell of the IMT-Advanced system.]

~~A cell radius over 50km should be supported by proper configuration of the system parameters~~

Support for larger cell sizes should not compromise the performance of smaller cells. Specifically, IMT-Advanced systems shall support the following deployment scenarios in terms of maximum cell range:

Table 8. IMT-Advanced Deployment Scenarios

Cell Range	Performance target
Up to 5 km	Performance targets defined in section 5.2.1 should be met
5-30 km	Graceful degradation in system/edge spectral efficiency
30-100 km	System should be functional (thermal noise limited scenario)

5.2.7 Power efficiency

[The maximum transmission power allowed for achieving the performance requirements]

5.2.8 Spectrum compatibility

[Requirements that specify how the technology utilize spectrum and minimize interference to the adjacent spectrum. ~~MiMo~~ MIMO or Beam-Forming is a candidate technology for this requirement.]

5.2.9 Voice-over-IP

Table 9. VoIP Capacity

Capacity (Active Users/MHz/sector)
> 60 (FDD)

VoIP capacity assumes a 12.2 kbps codec with a 40% activity factor such that the percentage of users in outage is less than 3% where outage is defined such 97% of the VoIP packets are delivered successfully to the users within the delay bound of 80 msec.

5.2.10 Enhanced Location Based Services (LBS)

IMT-Advanced systems shall provide support for high resolution location determination.

5.2.11 Enhanced Multicast Broadcast Service (E-MBS)

IMT-Advanced systems shall provide support for an Enhanced Multicast Broadcast Service (E-MBS), providing enhanced multicast and broadcast spectral efficiency (Section 5.2.11.2). E-MBS delivery shall be supported via a dedicated carrier.

IMT-Advanced systems shall support optimized switching between broadcast and unicast services, including the case when broadcast and unicast services are deployed on different frequencies.

5.2.11.1 MBS Channel Reselection Delay and Interruption Times

E-MBS functionality defined as part of IMT-Advanced systems shall support the following requirements for maximum MBS channel change interruption times when applied to broadcast streaming media.

Table 10. MBS channel reselection maximum interruption times.

MBS Channel Reselection Mode	Max. Interruption Time (s)
Intra-frequency	1.0
Inter-frequency	1.5

Note that requirements of Table 10 apply to the interruption time between terminating delivery of MAC PDU's from a first MBS service to the MAC layer of the mobile station, and the time of commencement of delivery of MAC PDU's from a second MBS service to the mobile station MAC layer.

5.2.11.2 Minimum performance requirements for E-MBS

Minimum performance requirements for E-MBS, expressed in terms of spectral efficiency over the coverage area of the service, appear in Table 11.

Table 11. MBS minimum spectral efficiency vs. inter-site distance

Inter-Site Distance (km)	Min. Spectral Efficiency (bps/Hz)
0.5	4
1.5	2

The following notes apply to Table 11:

1. The performance requirements apply to a wide-area multi-cell multicast broadcast single frequency network (MBSFN).
2. The specified spectral efficiencies neglect overhead due to ancillary functions (such as synchronization and common control channel) and apply to both mixed unicast-broadcast and dedicated MBS carriers, where the performance is scalable with carrier frequency bandwidth.

5.2.x xxxxxxxxxxxxxxxxxxxxxx

6 Conclusions

This Report provides useful information on technology issue which is required for evaluate the air interface(s) for IMT-Advanced.

7 Terminology, abbreviations

Appendices

The following 2 appendices illustrate technology enablers which can be used for IMT-Advanced Radio Interface(s)

Appendix 1

Overview of major new technologies

1 Spectrum and deployment

[Editor note: Technologies that can improving spectrum efficiency, flexibility and sharing possibility could be included in this section.]

2 Radio Access Interface and Network

[Editor note: New radio access technologies, such as soft-defined radio, short range radio and new multiple access method etc, could be include in this section. The innovations of network deployment, e.g. wireless relay enhanced cellular, can also be included in this section]

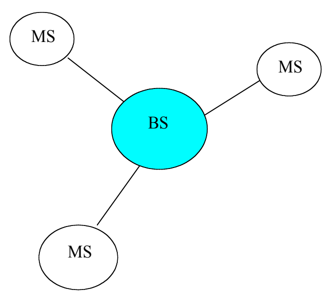
2.1 Network topology

2.1.1 Single-hop mode

The information is transmitted between radio access point (e.g. base-station) and mobile stations (e.g. user terminals) directly in a single hop. An example of network topology in this case is shown in Figure 2.1.1.1).

FIGURE 2.1.1.1

Working mode of radio access network – Single Hop Mode



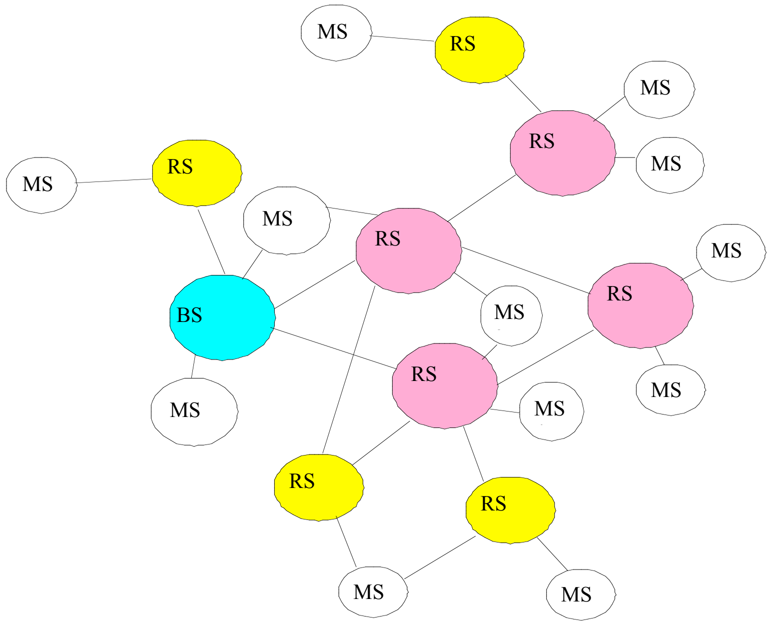
2.1.2 Multi-hop mode

The direct communications between BSs and the data transportation through multihop across BSs should be considered.

The information is transmitted between radio access point to mobile stations in more than one hop. The intermediate points between access point and destination are relay nodes that regenerate and re-transmit radio signals. The topology of multi-hop mode is shown in Figure 2.1.2.1.

FIGURE 2.1.2.1

Working mode of radio access network – Multi Hop Mode

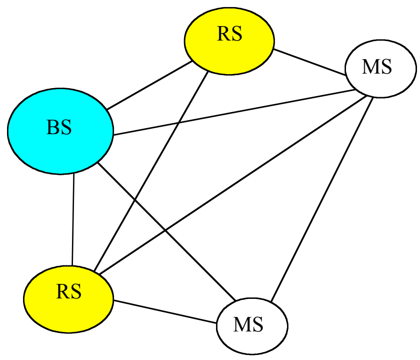


2.1.3 Mesh mode

This mode is similar to multi-hop mode. However, in this mode, relay nodes are supposed to have connections between each of them, if physically possible. Routing algorithms between relay nodes are necessary in this mode. An example of network topology in this case is shown in Figure 2.1.3.1.

FIGURE 2.1.3.1

Working mode of radio access network – Mesh Mode

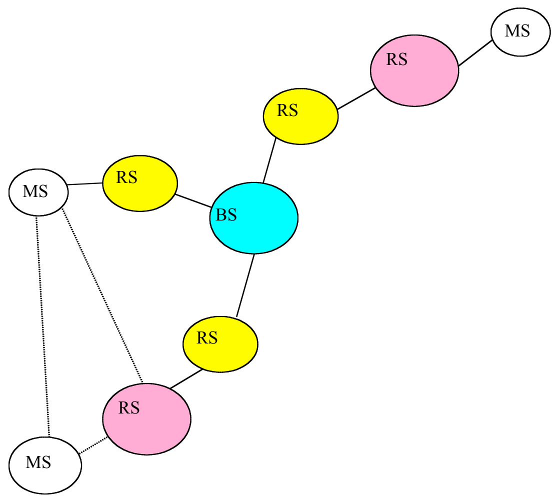


2.1.4 Peer-to-peer mode

In this mode, mobile stations are connected directly or through relay nodes, but no radio access point are explicit in their connections. An example of network topology in this case is shown in Figure 2.1.4.1.

FIGURE 2.1.4.1

Working mode of radio access network – Peer-to-Peer Mode



2.2 Duplexing

2.2.1 FDD

Conventional frequency division duplex (FDD) operation allocates equal-size paired spectrum for uplink and downlink. It is expected that the future IMT-Advanced systems would require higher data rate and throughput mainly in downlink to support ultra high-speed asymmetric services, e.g. large-size file downloading (similar to broadband internet access) and high-quality video broadcasting (similar to digital TV). These asymmetric services encourage an asymmetric spectrum allocation for IMT-Advanced deployment.

2.2.2 TDD

Conventional time division duplex (TDD) operation can support asymmetric transmission very well. Flexibility is available with respect to the degree of traffic asymmetry, depending on the co-channel and adjacent channel interference conditions. The spectrum efficiency of the arrangement is less dependent on the actual network traffic asymmetry since TDD can vary the degree of asymmetry within a specified range.

2.2.3 Half duplex FDD

TBD

2.3 Multiple-Access technologies

2.3.1 Single-carrier transmission

TBD

2.3.1 Multi-carrier transmission

2.3.1.1 OFDMA

2.3.1.2 Multi-carrier CDMA

2.4 Multiple-Antenna technologies

2.4.1 MIMO (MTMR)

2.4.1.1 Single-User MIMO

2.4.1.2 Multi-User MIMO

2.4.2 Beam forming (Smart Antenna)

2.5 Channel Coding

2.5.1 Turbo codes

Double binary tail-biting turbo codes can be regarded as one choice of improved turbo codes.

For the component encoder of the improved turbo codes, the Double Binary Circular Recursive Systematic Convolutional codes shall substitute the original Binary Recursive Systematic Convolutional Codes, which leads to the improvement of the link performance. Compared to the original binary turbo codes, the double binary turbo codes can eliminate the error floor, decrease the performance gap between the optimal algorithm and the approximate algorithm, and enhance the performance of high code rate.

Since the tail bits of UTRA Turbo coding reduce the throughput, tail-biting trellis termination can be considered to improve the transmission efficiency, and then the tail bits can be removed.

To obtain variable code rate and extend the application fields, the combination of rate matching and the improved turbo codes should be considered as a complement of turbo coding.

The improved turbo codes should have the capability of supporting iterative redundancy HARQ (IR_HARQ).

2.5.2 Low density parity check codes (LDPC)

LDPC coding can be considered an alternative channel coding scheme in that it has such benefits as low complexity, large decoder throughput, low latency, and high coding performance.

A special type of LDPC codes, namely structured-LDPC codes, can achieve very efficient hardware architecture and routing. The code rate of LDPC codes is flexible by using different base matrices or by shortening or puncturing base matrices. The code size can be flexible by modifying one base matrix. As a typical choice, with single uniform base matrix and single uniform hardware structure, any code rate and any code size can be supported.

The LDPC codes should have the capability of supporting IR_HARQ.

For irregular LDPC codes, the protection abilities vary differently from the nodes' degrees, and the differential protection ability of different degrees should be considered (e. g. HARQ).

The LDPC coded modulation possibly shall be exploited to improve the link performance.

2.6 Mobility management and RRM

2.6.1 Centralized RRM

2.6.2 Distributed RRM

2.6.3 Inter-RAT spectrum sharing

2.6.4 Inter-RAT mobility management

3 Mobile user interface

[Editor note: This section include new technologies that can improve user experience when using mobile communication service.]

3.1 Mobile user terminal design

3.2 New innovative network to humane interfaces

3.3 Human-free interface

3.4 RF micro-electro-mechanical systems (MEMS)

3.5 Reconfigurable networks

Appendix 2

The application of multi-input-multi-output technology in IMT-Advanced system

In the IMT-Advanced system, MIMO technology mainly is introduced in the region the capacity already has approached the limit, or hot spot area.

1 The multi-antenna system application scenario

Better performance can be achieved in the following scenarios by using MIMO technology.

Scenario A (suburban macro): The wireless downlink channel, the base station position is high, the wireless signal scattering spots around the mobile terminations are rich. Then, looking from the terminal antenna, the wireless channel relevance of the base station with many transmit antenna is high, but looking from the base station antenna, the wireless channel relevance of the terminal with many receiving antenna is weak, namely low transmit diversity, high receive diversity scenario.

Scenario B (urban macro): The uplink wireless channel of scenario A, high transmit diversity, low receive diversity scenario.

Scenario C (urban micro): The wireless channel relevance of transmit, receiving antenna in uplink, downlink channel is medium, namely the medium transmit diversity, the medium receive diversity scenario.

Scenario D (line of sight-LOS): Because of the existence of the LOS component signal, the relevance between transmit and receive antennas is very strong, namely the low transmit diversity, the low receive diversity scenario.

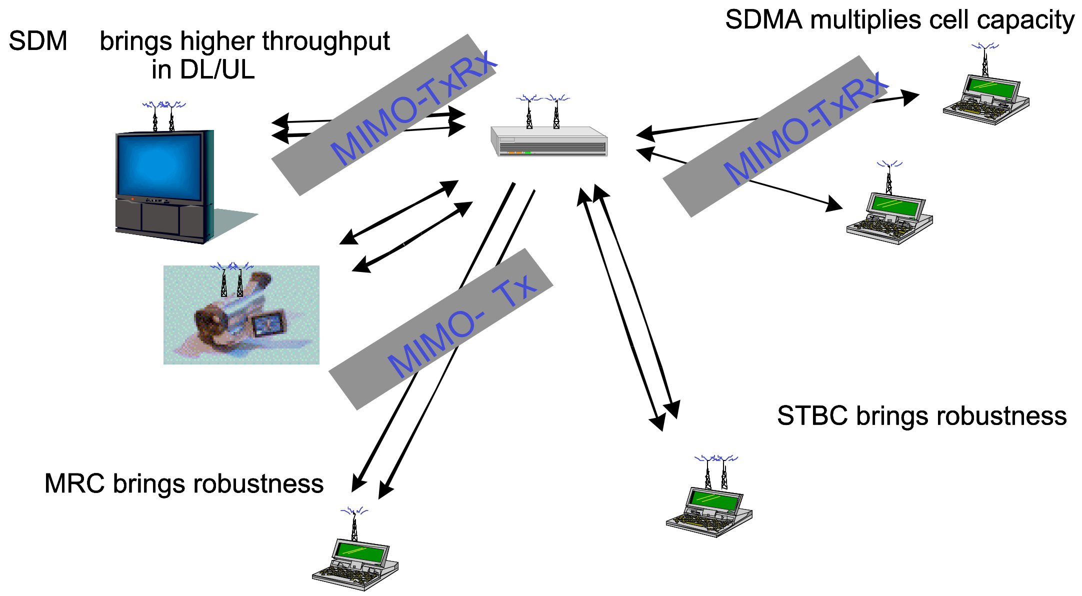
Performance lost may be suffered in the following scenario: low SNR area and high mobile scenario.

Because MIMO technical may need channel information feedback between receiving and transmitting, based on present feedback mechanism, when UE makes the high speed migration (e.g. velocity >50km/h), The feedback speed is unable to support the variation rate of measure information; These measure information including the scope and phase information in closed loop diversity pattern, as well as feedback link quality information.

In addition, the micro honeycomb environment with rich multi-diameter condition can maximize the MIMO antenna gain, therefore the multi-antenna technology more suits for the micro honeycomb scenario such as the crowded city, the city, the room and so on. One kind of intelligent MIMO system based on the using boundary and user demand is shown in Figure 1.

FIGURE 1

The application of smart MIMO in different scenarios

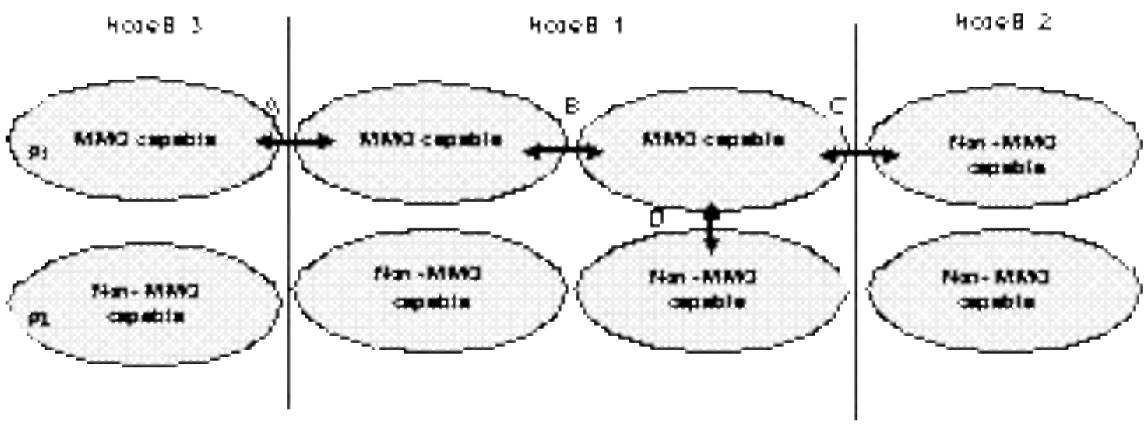


2 MIMO's impact on mobility

After introducing MIMO, the wireless environment of cell has improved, and the carry frequency quality of UE has obtained quite large gain, and the number of hand-over in mobility management has decreased. Because every pair of antennas have been configured a dedicated pilot channel, not a common pilot channel as in SISO. The condition of hand-over synthetically considers multi-pilot channel quality according to some algorithm.

Considering the following network configuration, there are MIMO cells and non-MIMO cells in the neighbour NodeB and in different frequency within a NodeB. Because of the mobility of UE and payload, that may lead to the following scenario.

FIGURE 2



- UEs work at the F1 frequency in NodeB3, and move towards NodeB1 (Figure 2 A)
  - If the current UE is MIMO UE, when UE moves from NodeB3 towards NodeB1, system should touch off the soft hand-over. For service channel, network can select a best cell according to channel quality, make it as service cell.
  - If the current UE is MIMO UE, but works at the frequency F2 in NodeB3, when moving towards Node B, there are two different strategies: one is to make soft hand-over in same frequency, and the other is to make hard hand-over in different frequency, that makes the UE hand off the frequency which supports MIMO. The former can make use of the benefit which is leaded by soft hand-over, and the disadvantage is the UE still works on the non-MIMO cell. The latter avoids the disadvantage, but that leads the complexity of hand-over increases.
  - If the current UE is MIMO UE, whether working at F1 or F2, soft hand-over should be the optimum choice.
- When the above example occurs in one NodeB, the strategy should be the same as the different NodeB. The only difference is the hand-over is the softer hand-over.
- If MIMO UE moves into a non-MIMO cell(C), the network side can balance between to hold the MIMO service and to ensure UE interference to system at the same frequency is minimum. That is to say, network can configure higher threshold which is used to touch off moving towards non-MIMO, that ensures the largest delay of MIMO service. We can also use the same threshold as the normal hand-over, to ensure MIMO UEs can not produce too large payload to network.
- At different frequency in one NodeB, we also solve the payload balance through blind hand-over in one NodeB (D). The blind hand-over in one NodeB can be touched by the change of channel type. This can place the MIMO UEs and non-MIMO UEs in MIMO cells and non-MIMO cells as possible to ensure the performance of MIMO UE.

Appendix 3

List of Acronyms and Abbreviations

Terms	Descriptions
FDD	Frequency Division Duplex
TDD	Time Division Duplex
DL	Downlink
UL	Uplink
MAC	Media Access Control
PDU	Protocol Data Unit
RAT	Radio Access Technology