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Title	**Proposed Inputs to IEEE 802.18 on IMT-Advanced Requirements (Edited 8F/TEMP/574-E)**
Date Submitted	**2007-09-17**
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Abstract	For discussion and approval by IEEE 802.16 Working Group and forward to IEEE 802.18 TAG for consideration
Purpose	To help IEEE 802.16 Working Group to develop a contribution to IEEE 802.18 TAG on IMT-Advanced requirements.
Notice	
Release	
Patent Policy	

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS
22ND MEETING OF WORKING PARTY 8F
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30 May 2007
English only

SWG Radio Aspects

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

TABLE OF CONTENTS

2 Application of ~~multi-input multi-output~~MIMO technology in IMT-Advanced System

~~3 Input text to 22nd meeting of WP8F on general requirements~~

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 Minimum Requirements

[Editorial note: This should be a very limited set of parameters, to determine that proposals provide performance beyond IMT-2000 systems]

~~[~~Candidate radio interface technologies ~~do not have~~are not required to meet the requirements in all test environments, only those for which the technology is proposed to operate are required to be met or exceeded~~]~~.

The requirements are considered to be assessed separately and need to be evaluated according to the criteria defined in annex 7 of the Circular Letter.

4.1 Cell spectral efficiency

~~[~~Cell[1] spectral efficiency is defined as the aggregate throughput of all users divided by the spectrum block assignment size (inclusive of ~~only~~ PHY ~~/MAC~~and MAC layer overheads).~~]~~ The following requirements shall be met with a minimum of 2 transmit and 2 receive antennas in the base station and 1 transmit and 2 receive antennas in the mobile stations. Higher order antenna configurations may also be considered which results in higher cell spectral efficiencies. These targets assume that there are 10 active users per cell.

Test environment*	Downlink	Uplink
Stationary	~~[5]~~3 b/s/Hz/cell	~~[5]~~1.5 b/s/Hz/cell
Pedestrian	~~[3]~~3 b/s/Hz/cell	~~[3]~~1.5 b/s/Hz/cell
Vehicular	~~[2]~~2 b/s/Hz/cell	~~[2]~~1 b/s/Hz/cell
High Speed	~~[2]~~1 b/s/Hz/cell	~~[2]~~0.5 b/s/Hz/cell

* Assuming the Test Environments described in the IMT.EVAL working document, Doc. 8F/1170, Attachment 6.3.

4.2 Peak ~~data rate~~spectral efficiency

[Editors note: There is still discussion in SWG Radio Aspects as to how to include actual peak data rates within this document. This discussion will continue through the upcoming correspondence activity between WP 8F Meetings #22 and #23]

~~[~~The peak spectral efficiency is the highest theoretical ~~normalised~~ normalized (by bandwidth) data rate available to applications running over the radio interface and assignable to a single mobile station. The peak spectral efficiency can be determined from the combination of modulation constellation, coding rate, symbol rate, receiver structure amongst others that yields the maximum data rate ~~(~~including ~~layer 1~~PHY overhead~~)~~. The following requirements shall be met with a minimum of 2 transmit and 2 receive antennas in the base station and 1 transmit and 2 receive antennas in the mobile station. Higher order antenna configurations may also be considered which results in higher peak spectral efficiencies.

Mobility classes	Stationary (0 km/h)	Pedestrian (0-10 km/h)	vehicular (10-120 km/h)	High speed vehicular (120-350 km/h)

[1] A cell is equivalent to a ~~sector,~~sector; ~~-~~e.g., a 3-sector site has 3 cells.

Downlink Peak spectral efficiency	~~[10]~~8 b/s/Hz	~~[10]~~8 b/s/Hz	~~[5]~~4 b/s/Hz	~~[5]~~2 b/s/Hz
Uplink Peak spectral efficiency	~~[10]~~2.8 b/s/Hz	~~[10]~~2.8 b/s/Hz	~~[5]~~1.4 b/s/Hz	~~[5]~~0.7 b/s/Hz

Peak data rates can then be determined as in the following examples:

Downlink peak data rate for vehicular mobility in 20MHz is ~~[100]~~80 Mb/s

Downlink peak data rate for pedestrian mobility in 100MHz is ~~[1]~~800 ~~G~~Mb/s~~]~~
Note that downlink peak data rates in the excess of 1 Gb/s can be achieved through the use of higher order antenna configurations.

4.3 Cell edge user throughput

Cell edge user throughput to be greater than ~~[y]~~ 0.1 b/s/Hz and 0.06 b/s/Hz for downlink and uplink, respectively. ~~b/s~~
Cell edge user throughput is defined as ~~[~~5~~]~~% point of cdf of user throughput.

4.4 Latency

4.4.1 Control plane latency

Control plane (C-Plane) latency is typically measured as transition time from different connection modes, e.g. from idle to active state. A transition time (excluding downlink paging delay and wireline network ~~signalling~~signaling delay) of less than ~~[~~**100**~~]~~ **ms** ~~should~~shall be achievable from idle state to an active state in such a way that the user plane is established.

4.4.2 Transport delay (User/Data plane latency)

The t~~T~~ransport delay or User/Data Plane ~~(U-Plane)~~ delay is defined in terms of the one-way transit time between a packet being available at the IP layer in either the user terminal/base station or the availability of this packet at IP layer in the base station/user terminal. User/Data plane packet delay includes delay introduced by associated protocols and control ~~signalling~~signaling assuming the user terminal is in the active state, ~~. [A~~assuming all radio resources have been previously assigned.~~]~~
IMT-Advanced systems ~~should~~shall be able to achieve a ~~U-plane~~ transport delay of less than ~~[~~**10**~~]~~ **ms** in unloaded condition (i.e. single user with single data stream) for small IP packet, e.g. 0 byte payload + IP headers. The user/data plane latency shall be calculated when H-ARQ is operated at an initial transmission error probability of 0.3.

4.4.3 QoS

~~*[Editor's note: include placeholder on QoS]*~~
IMT-Advanced systems shall support QoS classes, enabling an optimal matching of service, application and protocol requirements (including higher layer signaling) to radio access network resources and radio characteristics. This includes enabling new applications such as interactive gaming. IMT-Advanced systems shall provide support for preserving QoS during handover with other RITs when it is feasible.

4.5 Mobility

IMT-Advanced ~~should~~shall support ~~at least~~ the following mobility classes~~.~~:

- Stationary: 0 km/h
- Pedestrian: ~~up to~~0-10 ~~K~~km/h
- Vehicular~~:~~ ~~up to~~ 10-120 ~~K~~km/h
- High speed vehicular: ~~up to~~ 120-350 ~~K~~km/h

Vehicular speeds in excess of 350 km/h and up to 500 km/h may be considered depending on frequency band and deployment.
There is a need to define which mobility classes are supported by each test environment.

	Test environments*			
	Indoor	**Microcellular**	**Base coverage urban**	**High speed**
Mobility classes supported	Stationary~~, pedestrian~~	Stationary, pedestrian	Stationary, pedestrian, vehicular	High speed vehicular

* Assuming the Test Environments are as described in the IMT.EVAL working document, Doc. 8F/1170, Attachment 6.3.

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 spectrum efficiency. The table below summarizes the mobility performance.

Mobility	Performance
Stationary, pedestrian (0 – 10 km/h)	Optimized
Vehicular (10 – 120 km/h)	Graceful degradation as a function of vehicular speed~~Marginal degradation~~
High speed vehicular (120 ~~km/h to~~ - 350 km/h)	System should be able to maintain connection

4.6 Handover

4.6.1 Handover Support

IMT-Advanced systems shall provide handover methods to facilitate continuous service for a population of mobile terminals. The layer 2 or higher layers handover methods should enable mobile terminals to maintain seamless connectivity when moving between cells, between radio interface technologies, or between frequencies.

[Editor's note: Including support of at least one IMT-2000 family member to be included in chapters 5 and 6.]

4.6.2 Handover Interruption Time

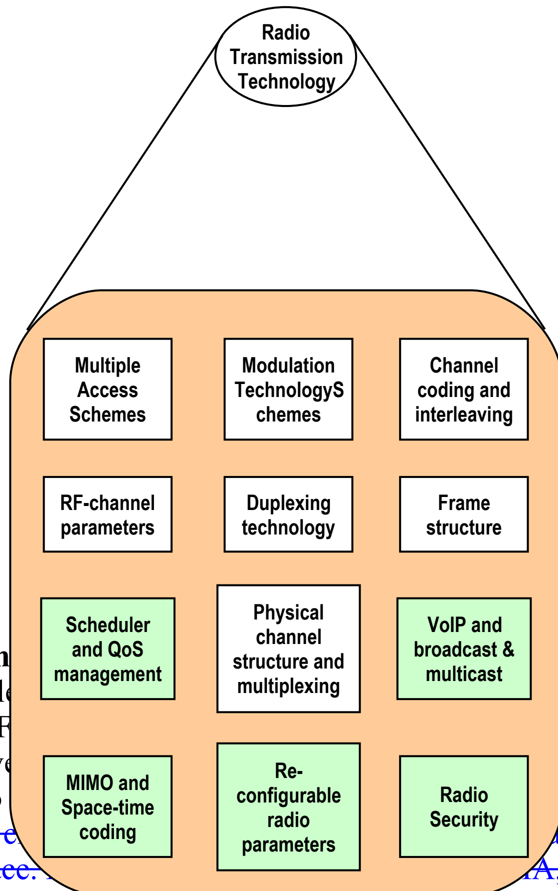
Handover performance requirements, and specifically the interruption times applicable to handovers for compatible IMT-2000 and IMT-Advanced systems, and intra- and inter-frequency handover should be defined.

The maximum intra-system MAC-service interruption times during handover are specified in the table below.

Handover Type	**Max. Interruption Time (ms)**
Intra-Frequency	~~[50]~~30
Inter-Frequency	~~[150]~~100
~~[Inter-system]~~	~~[z]~~

5 Technological items required to describe candidate air interface

~~*[Editor's note: target maxmium length for each item: 1/3 page]*~~
~~*[Included diagram below from 8F/1202 (Canada) as a placeholder, to be updated when sub-sections in 2.1 are concluded.]*~~



5.1 Multiple access m

~~[~~The choice of the multipl … e design of the radio interface. For instance, OF … rrier/Multi-carrier operation~~]~~. It can also have … atency and hence these requirements may need to … .

~~From 1259 (China): [The c … s major impact on the design of the radio interface. … A, also Single-carrier/Multi-carrier operation, as well as enhancement and combination of those technologies.~~

Some key factors that should be ~~considerd~~considered ~~here~~:

- New multiple ~~accsee~~access technologies should support compatibility and co-~~exsiting~~existence with legacy IMT systems
- Supporting flexible reuse and allocation of resource
- Supporting high-efficiency usage of spectrum ~~, (~~such ~~as:reducing~~as reducing and avoiding interfere, reducing overhead, etc.)]

~~From 1268 (Korea): [Multiple Access schemes for IMT-Advanced systems should support advanced features including followings:~~

~~Adequate for broadband transmission and packet switching~~

~~High granularity/flexibility for provision of wide class of services~~

~~The Orthogonal Frequency Division Multiple Access (OFDMA), Single Carrier Frequency Division Multiple Access (SC-FDMA) or hybrid types are the examples.~~

~~The Orthogonal Frequency Division Multiplexing - Time Division Multiple Access (OFDM-TDMA) can also be considered in the nomadic environments.]~~

From 1246 (Japan): [It is needed to be described what kind of multiple access methods is employed in the radio interface technology.]
From 1283 (IEEE): [IMT-Advanced systems should also allow for contention-based multiple access methods.]

5.2 Modulation sSchemes

[The choice of the modulation technology depends mainly on radio environment and the spectrum efficiency requirements.]
From 1259 (China): [The choice of the modulation technology depends mainly on radio environment and the spectrum efficiency requirements.
The process of varying certain parameters of a digital code signal (carrier) may be achieved, through digital signal processing, in accordance with a digital message signal, to allow transmission of the message signal through IF and RF channels, followed by its possible detection.
Modulation can be categorized as data modulation and spreading modulation. Data modulation explains how data can be mapped to the in-phase branch and quadrature-phase branch. Spreading modulation explains how in-phase branch data and quadrature-phase branch data are spread by channelization code and scrambled by scrambling code based on basic modulation scheme,such as QPSK, 16QAM, and 64QAM etc, several
Several factors need to be considered as belowfollows:

– For high moving environmentmobility scenarios, the modulation schemes which are more suited forto quickfast time-varyingiety channel need to be considered (for example: DAPSK)

– The -modulation schemes which have lower PAPR should have higher priority.
The modulation not only get higher spectrum efficiency, but have lower complexity.]
The following table summarizes modulation schemes that are typically used for the downlink and uplink in IMT-Advanced systems. The modulation and coding scheme shall be adapted to the radio channel conditions.

Modulation Scheme	Downlink	Uplink
	BPSK, QPSK, 16 QAM, 64 QAM	BPSK, QPSK, 16 QAM, 64 QAM

From 1268 (Korea): [In order to manage various radio channel environments and requested service traffic types of the users efficiently, various types of modulation schemes should be supported. Higher-order modulation such as 64QAM should be considered at both downlink and uplink in consideration of spectrum efficiency.]
From 1246 (Japan): [It is needed to be described what kind of modulation schemes are employed in the radio interface technology and also target CIR (or SIR) for each modulation scheme.]
From 1254 (New Zealand): [The modulation type is implicit in the determination of the area spectrum efficiency parameter which is input to the software model used to arrive at the spectrum estimation given in Report ITU-R M.2078.]

5.3 Error ~~c~~Control ~~c~~Coding ~~s~~Schemes

~~From 1259 (China),1292 (Finland) : [~~The choice of the error control coding affects qualit~~ies~~y of air link, throughput, terminal complexity, and coverage ~~and also~~ as well as delay performance.~~ of communications.]~~

~~From 1268 (Korea): [Advanced forward error correction coding scheme such as Turbo and LDPC should be considered for reliable communication. In conjunction with modulation scheme, AMC (adaptive modulation and coding) scheme should provide various MCS (modulation and coding scheme) levels. Furthermore, Hybrid ARQ should also be considered for both efficient use of spectrum and link reliability.]~~

~~From 1246 (Japan): [It is needed to be described what kind of error control coding schemes are employed in the radio interface technology.~~

~~If more than one schemes are employed, it is also needed to be described adaptation method for each scheme (e.g. error control coding A is adapted to B modulation scheme, etc.).]~~

The following table summarizes coding schemes (coding rates and repetition) that are typically used for the downlink and uplink in IMT-Advanced systems. The modulation and coding scheme shall be adapted to the radio channel conditions (i.e., link adaptation).

Coding Scheme	Coding Rate	Repetition
CTC (Convolutional Turbo Code)	1/5, 1/2 , 2/3, 3/4 , 5/6	x1, x2, x4, x6
BTC (Block Turbo Code)	1/5 , 1/3	x1, x2, x4, x6
CC (Convolutional Code)	1/2 , 2/3, 3/4 , 5/6	x1, x2, x4, x6
LDPC (Low Density Parity Check Codes)	1/2 , 2/3, 3/4 , 5/6	x1, x2, x4, x6

5.3.1 Error Control Mechanisms

The IMT-Advanced systems should take advantage of error control mechanisms such as automatic repeat request (ARQ) and Hybrid-ARQ (H-ARQ).

5.4 Physical, logical, and transport` channel structure and multiplexing

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different types of data transfer services provided by the MAC layer. Each logical channel type is defined by what type of information is transferred. In other words, the service access point between the MAC layer and the radio link control layer (RLC) provide the logical channels. Each logical channel represents one or more MAC function or processing on the data bearer path or control path. Logical channels are classified into two groups:

- Control channels for the transfer of control-plane information (i.e., control/signaling messages/information). There are two sub-types: common and dedicated.
- Traffic channels for the transfer of user/data-plane information (i.e., user data). There are two sub-types: unicast and multicast.

A transport channel is the service access point between the physical layer and the MAC layer. A transport channel is alternatively defined by how and with what characteristics data is transferred over the air-interface.

A physical channel is a manifestation of physical resources (time, frequency, code, and space) and corresponding physical layer processing that are used to transport data, control, or signaling to or from a single user or a multitude of users. Physical channels represent actual PHY processing on the data and control signal bearers.

The use of logical, transport, and physical channel structure and their corresponding mappings may differ in various radio access technologies.

~~[The physical channel is a specified portion of one or more radio frequency channels as defined in frequency, time spatial and code domain.]~~
~~From 1259 (China): [The physical channel is a specified portion of one or more radio frequency channels as defined in frequency, time spatial and code domain. The PHY channel can be distinguished by orthogonality of any one of factors such as frequency, time ,spatial and code domain, some elements for the design of PHY channel structure should be considered as below:~~

– ~~Frequeny spectrum efficency.~~

– ~~Reliability and capability of coverage.]~~
~~From 1268 (Korea): [Physical channels should be constructed in order to support both high granularity and high flexibility. The physical channel structure must be adequate for wide range of packets from very small packets to very large packets for high multi-media.]~~
~~From 1246 (Japan): [It is needed to be described the physical channel structure and multiplexing method employed in the radio interface technology.]~~

5.5 Frame Structure

~~From 1259 (China): [~~The frame structure depends mainly on the multiple access technology (e.g. OFDMA, TDMA, or CDMA) and the duplexing ~~technology~~method (e.g. FDD or ~~,~~ TDD). Commonality should be ~~maximised~~maximized by maintaining the same frame structure wherever ~~whenever~~ possible. ~~That is, data fields identifying physical and logical channels, as well as the frame length should be maintained when possible.~~ The design of the frame structure should consider shorter TTI (transmission time interval) and shorter RTT (round trip time) to allow reduced air link latency, faster feedback, and shorter handoff interruption time. Typical radio frame lengths include but are not limited to 1, 2, 5, and 10 ms.
In addition, ~~F~~for design of frame structure, ~~some elements should be considered below~~the following considerations should be made:

1. Spectrum coexistence: Two coexistence scenarios should be considered ~~intra-~~

   Scenario I: IMT-Advanced system co-exists with a co-located legacy IMT system deployed ~~i~~on adjacent carriers ~~(partly re-farming legacy IMT spectrum)~~.

   Scenario II: IMT-Advanced systems co-exists with ~~with~~ each other

2. Maximum ~~C~~commonality between FDD and TDD duplex modes is ~~desire~~desirable~~d~~. However, some differences due to FDD/TDD inherent features ~~is~~ should be allowed.
3. The frame structure should be ideally the same for the downlink and uplink transmissions.
4. ~~IMT-ADVANCED system which used different multiple access mode adopting same or similar frame structure are desired.~~
5. ~~Legacy system frame structure should be considered, so as to achive the flexible co-exisiting and co-operating among multi-RATs~~.

~~The application of new technology (such as multi-antenna) should be considered.]~~
~~From 1268 (Korea): [In order to maximise commonality, compatibility and inter-operability, frame structure should be designed in consideration of following items:~~

~~Sealable with respect to bandwidth assignment~~

~~Sealable with respect to performance and complexity for accommodating cost-effective user equipments~~

Common and/or scalable frame structure which is adequate for various radio environments and cell types.

To support channel reciprocity in TDD, some portion of frequency resources in a frame structure should be identically allocated to both DL and UL.

To support SDMA, some portion of frequency resources in a frame structure should be identically allocated to a group of users.

To take advantage of benefit from multi-hop relay architectures, frame structure should be designed to support transparent and non-transparent relay operation modesstations.]

5.5.1 Physical Resource Blocks (Sub-Channelization and Permutation)

Description of downlink and uplink physical resource blocks, pilot structure, sub-channelization and permutation schemes should be provided. It should be further described how transport channels (data and control bearers) are mapped to the actual physical resources.

5.6 Spectrum Capabilities

5.6.1 Duplex Methods (Paired and unpaired operation)

IMT-Advanced systems shall support both Time Division Duplex (TDD) and Frequency Division Duplex (FDD) operational modes. The FDD mode shall support both full-duplex and half-duplex MS operation. Specifically, a half-duplex FDD (H-FDD) mobile station (MS) is defined as an MS that is not required to transmit and receive simultaneously. A base station (BS) supporting FDD mode shall be able to simultaneously support half duplex and full duplex terminals operating on the same RF carrier. The MS supporting FDD mode shall use either H-FDD or FDD.

The IMT-Advanced systems shall support both unpaired and paired frequency allocations, with fixed duplexing frequency separations when operating in FDD mode. System performance in the desired bandwidths 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 the extreme, the IMT-Advanced system should be capable of supporting downlink-only configurations on a given carrier.

In FDD mode, the UL and DL channel bandwidths may be different and should be configurable (e.g. 10MHz downlink, 5MHz uplink).

[The proponents should indicate if their proposal supports paired and/or unpaired operation, and in which test environment, and in which frequency bands.]

[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.]

From 1259 (China): [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.

(1) TDD and FDD system have the ability of optimizing performance respectively.

(2) The FDD mode shall support both full duplex and half duplex mobile station operation. The

UL/DL ratio should be configurable, which be capable of supporting downlink-only configurations on a given carrier.

In TDD mode, the DL/UL ratio should be adjustable which be capable of supporting downlink-only configurations on a given carrier.]

From 1268 (Korea): [Time Division Duplex (TDD) and Frequency Division Duplex (FDD) with Full Duplex and Half Duplex must be considered depending on the system environment and cell type. Hybrid Division Duplex (HDD) can be considered as an efficient combination.]

From 1246 (Japan): [It is needed to be described what kind of duplex methods is employed in the radio interface technology.]

From 1254 (New Zealand): [In addition to duplexing technology choice, RF channel bandwidth is also dependent on the area spectrum efficiency and the application data rate.]

From 1283 (IEEE): [IMT-Advanced systems shall support TDD and/or 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.]

5.6.2 Flexible Spectrum Use

From 1292 (Finland): [Proponents should describe the potential flexible spectrum use (FSU) mechanisms that they are proposing to enable FSU within the same Rradio Accessinterface Ttechnology between operators. This might allow going even beyond 100MHz determined in the minimum capabilities.]

5.6.3 Spectrum Sharing

From 1292 (Finland): [Sharing frequency band capabilities: to what degree is the proposal able to deal with spectrum sharing among IMT-systems as well as with all other systems.]

It is envisioned that the IMT-Advanced systems will be deployed in the same or overlapping geographical areas with other wireless networks based on different radio interface technologies. They may or may not have the same network topology. Moreover, it is anticipated that IMT-Advanced system can be deployed in the same (on a co-channel and no co-channel basis) or adjacent RF bands as non legacy IMT networks. For instance, these non-IMT-Advanced networks may operate in the adjacent licensed frequency bands such as CDMA2000, 3GPP (e.g., GSM, UMTS, HSDPA/HSUPA, LTE), in unlicensed bands such asIEEE 802.11x or IEEE 802.15.1 networks, or in the same frequency band on an adjacent carrier such as TD-SCDMA. The IMT-Advanced systems shall provide a method whereby coexistence with these networks as well as other IMT-Advanced networks can be achieved from the perspective of being both an interferer and being a victim depending on the coexistence

5.6.4 Channel bBandwidth sScalability

[Editor's note: WG spectrum may expect input on requirements in this area from IMT.TECH.]

~~From 1292 (Finland): [Minimum and maximum operating bandwidths of the system should be specified together with possible intermediate steps.]~~
~~From 1268 (Korea): [The IMT-Advanced systems should support bandwidths up to TBD MHz with flexible and scalable air interface parameters. Also, aggregation of multiple bands may be supported.~~
~~The IMT-Advanced system air interface should support system implementation in TDD or FDD licensed spectrum below [TBD] GHz and allocated to the mobile service. The system's frequency plan should include both paired and unpaired channel plans with multiple bandwidths to allow co-deployment with existing cellular systems. It is desirable that channel bandwidths are consistent with frequency plans and frequency allocations for other wide-area systems. The IMT-Advanced system air interface should be readily extensible to wider channels as they become available in the future.]~~
~~From 1283 (IEEE): [~~IMT-Advanced systems shall initially support scalable bandwidths from 5 to 20 MHz. The IMT-Advanced air interface should be readily extensible to larger channel bandwidths ~~as~~, as they become available, through aggregation of smaller contiguous or non-contiguous bands (i.e., virtual wideband channel).

The IMT-Advanced systems air interface shall support system implementation in TDD or FDD licensed spectrum allocated to the mobile service. The system's frequency plan shall include both paired and unpaired channel plans with multiple bandwidths to allow co-deployment with existing cellular systems.~~]~~ The IMT-Advanced systems should be able to aggregate multiple channels in more than one frequency band within the scope of a single MAC protocol instance.

5.6.5 Supported RF Bands

~~From 1292 (Finland): [~~The supported frequency bands should be described.~~]~~

5.7 Support of Advanced/Multiple Antenna CapabilitiesSchemes

[The IMT--Advanced system standard should include MAC/ and PHY features to support multi-antenna capabilities at both the base station and at the mobile terminal, including closed-loop and open-loop single-user and multi-user MIMO operation for both UL and DL, and both UL and DL beamforming, SDMA, and precoding.].

From 1246 (Japan): [Antenna technologies such as Multiple-input multiple-output antenna, adaptive array antenna, etc. affect spectrum efficiency and also complexity of the terminal. It is needed to be described what kind of antenna technology is employed and effectiveness of the technology.]

From 1259 (China): [The choice of multi-antenna scheme can greatly improve system performance. Spatial division multiplexing (SDM), transmit diversity (TxD), beamforming (BF), spatial division multi-access (SDMA) and the combinations of those technologies need tomay be considered.]

From 1283 (IEEE): [IMT-Advanced systems shall support MIMO and beamforming including features to support multi-antenna capabilities at both the base station and at the mobile terminal, including MIMO operation for both UL and DL, both UL and DL beamforming, SDMA, and precoding. .

Minimum antenna configuration requirements shall be:

> For the base station, a minimum of two transmit and two receive antennas shall be supported.
>
> For the MSmobile terminal, 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.]

Other antenna configurations may also be considered.

5.8 Link Adaptation and Power Control

From 1283 (IEEE): [IMT-Advanced systems shall support automatic selection of optimized user data rates that are consistent with the RF environment constraints and application requirements. The IMT-Advanced shall provide for graceful reduction or increase of user data rates, on the downlink and uplink, as a mechanism to maintain an appropriate frame error rate performance. Link adaptation (e.g., adaptive modulation and coding) shall be used by the IMT-Advanced systems for increasing spectrum efficiency, data rate, and cell coverage reliability.
Both base station and mobile terminal should employ transmit power control mechanisms and exchange control and monitoring information required to achieve optimal performance while keeping the environmental noise floor as low as possible and helping the MS preserve its battery power. The number of transmit Power levels as well as the associated control messaging should be optimized for cost effectiveness and performance.]

5.9 RF channel parametersRequirements

From 1246 (Japan): [RF channel parameters include parameters such as operating bandwidth, allocation, channel spacing (FDD), guard time (TDD) and FFTand size (OFDMA) parameters or chip rate (CDMA) that are the key of characterizingcharacteristics of radio interface technologies.]

5.9.1 Out of Band Emissions

The spectrum mask(s) and provisions to limit out of band emissions in the base station and mobile terminal should be described.

5.10 [Scheduling algorithm-]

~~From 1246 (Japan): [Scheduling algorithm affects the delay performance and total cell bit rate.It is needed to be described what kind of scheduling algorithm(s) is employed in the radio interface technology and also how that algorithm maintain the delay of each user and total cell bit rate.]~~

A baseline scheduling algorithm such as proportional fair (PF) must be defined for the mandatory traffic mixes; e.g., full-buffer data and VoIP, for consistent evaluaiton of the proposals.

5.11 Radio Interface Architecture and Protocol Stack and Packet Framing

[Editor's note: Text needed to describe this item.]

The IMT-Advanced system proposals shall include description of the radio interface architecture, protocol stack, and packet framing; i.e., how upper-layer packets are encapsulated and what headers and trailers are added at each layer of the protocol stack.

5.12 Positioning (Support of Location Based Service)

(Not required for evaluation).

From 1292 (Finland): [IMT-Advanced system proposal Proponents should describe how the proposed technology supports positioning, and what is the achieved positioning accuracy in different environments.Positioning needs to be supported in such a way that it guarantees user privacy.]; i.e., MAC and PHY support for accurate and fast location determination.

5.13 Support of Multicast and Broadcast Service

(Not required for evaluation)

From 1292 (Finland) [The proponents should describe the supported broadcasting solutions.]

From 1283 (IEEE): [IMT-Advanced systems shall provide support for an Enhanced Multicast Broadcast Service (E-MBS), providing enhanced multicast and broadcast spectrum efficiency efficiency(Section 5.2.10.2). E-MBS delivery shallmay 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.]

5.14 QoS Support and Management

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

From 1259 (China): [The QoS is important factor especially the applications which are originally supported by circuit switched network in delay/jitter.

IMT-ADVANCED system should support QoSclasses, enabling an optimal matching of service, application and protocol requirements (including higher layer signaling) to RAN resources and radio characteristics.

This includes:

- enabling the QoS keep at least same level when the services converted from CS domain in legacy system to PS domain ,for example ,VoIP in IMT-ADVANCED system should have same QoS compare with voice in CS network;
- enabling new applications such as interactive gaming.

Access level QoS management, including Radio access side QoS management and QoS management of UE's traffic, should be supported.]

From 1268 (Korea): [IMT-Advanced systems should support the configuration (e.g., by the system operator) of a flexible set of variety of traffic classes with different latency and packet error rates performance, in order to meet the end-user QoS requirements for the various applications,

Specifically, it is important for IMT-Advanced systems to

Have the ability to negotiate the traffic class associated with each packet flow.

~~Permit the set of traffic classes to be defined by the system operator in terms of QoS attributes (along with the range of allowed values) that include the following:~~

1. ~~Data rate (ranging from the lowest supported data rate to maximum data rate supported by the MAC/PHY),~~
2. ~~Latency (delivery delay),~~
3. ~~Packet error rate (after all corrections provided by the MAC/PHY layers), and~~

~~Delay variation (jitter).]~~

~~From 1246 (Japan): [It is needed to be described QoS control can be achieved in which level (e.g. session level/ connection level/ can be carried during communication, etc.).]~~

~~From 1254 (New Zealand): [The quality of service used in the tele-traffic models can have a noticeable impact on the spectrum requirement. The values chosen must reflect the performance to be expected. For example, requirements for blocking probability for Circuit-switched Service Categories and mean packet delay for packet-switched Service Categories are key QoS Service Category attributes given in Report ITU-R M.2078.]~~

~~From 1283 (IEEE): [~~IMT-Advanced systems shall support a flexible set of QoS classes and their respective configuration (e.g., by the system operator), enabling an optimal matching of service, application and protocol requirements (including higher layer signaling) to RAN resources and radio characteristics. This includes enabling a variety of applications including Mobile Internet Access, Voice over IP, IPTV, and interactive gaming. The QoS classes should be defined by a common set of parameters to address all classes of service and QoS parameters for all services. Specifically, it is important for IMT-Advanced systems to

Have the ability to negotiate the QoS class associated with each service flow.[2]

Permit the set of QoS classes to be defined by the system operator in terms of QoS attributes (along with the range of allowed values[3]) that include, but not limited to, the following:

- Data rate (ranging from the lowest supported data rate to maximum data rate supported by the MAC/PHY),
- Latency (delivery delay) ~~(ranging from 10 ms to 10 seconds),~~
- Packet error rate (after all corrections provided by the MAC/PHY layers) ~~(ranging from 10E-8 to 10E-1)~~, and
- Delay variation (jitter) ~~(ranging from 0 to 10 seconds).~~

~~Support (but not require) PHY/MAC implementations that satisfy the QoS characteristics that are specified by the following QoS classes:~~

~~{ADD TRAFFIC LIST HERE}~~

~~As is the case for all wireless networks, the specified QoS characteristics for certain QoS classes or services need only be satisfied in deployments and RF link conditions that are appropriate to permit the desired characteristics to be feasible. However, the MAC/PHY structure IMT-Advanced systems should support the capabilities to negotiate and deliver all of the QoS characteristics specified for the indicated QoS classes.~~

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2 *There can be multiple service flows associated with a single user, and multiple users associated with a single mobile terminal, e.g., in the case where a mobile terminal is a device providing service for multiple end devices.*

3 *No specific granularity for these parameters is implied by this requirement.*

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

Other QoS factors include:

Providing MAC and PHY capabilities to conform to an end-to-end QoS architecture e.g., as negotiated by upper layer protocols such as MPLS, DiffServ, IntServ, and RSVP.

Supporting IPv4 and IPv6 enabled QoS resolutions with efficient radio resource management (allocation, maintenance, and release) to satisfy user QoS and policy requirements.

Providing the MAC and PHY layer capabilities to satisfy link-level QoS requirements by resolving system resource demand conflicts between all mobile terminals while still satisfying the negotiated QoS commitments for each individual terminal. A given user may be using several applications with differing QoS requirements at the same time (e.g., web browsing while also participating in a video conferencing activity with separate audio and video streams of information).

Providing MAC and PHY layer capabilities to distinguish between various service flows from the same mobile terminal or user and provide differentiated QoS delivery to satisfy the QoS requirement for each service flow.

Providing admission control, as well as the ability to map traffic to an admitted flow, and to negotiate the QoS parameters (e.g.; priority, direction, SDU size, mean data rate, latency, jitter) that define various service flows within a user's IP traffic.

Providing the ability to create static service flows provisioned by the network at the time of network entry as specified by authorization policy.

Providing the ability to create, modify and delete QoS service flows dynamically at any point during the MS's authorized attachment to the RAN as initiated by either the BS or the MS.]

From 1292 (Finland): [Most of the quality parameters which are dealt with in other Report are minimum requirements which must be met and are not to be treated in the evaluation process. RTTs will be evaluated on the impact of transmission processing delay on the end-to-end delay, expected average bit error ratio (BER) under the stated test conditions, on their maximum supportable bit rate under specified conditions and their overall ability to minimise circuit disruption during handover. In addition, they will be evaluated on their ability to sustain quality under certain extreme conditions such as system overload, hardware failures, interference, etc.[Recommendation 1225]]

5.15 Security Aspects

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

From 1268 (Korea): [Network security in IMT-Advanced systems are needed to protect the service providers from theft of service, the user's privacy and mitigate against denial of service attacks. IMT-Advanced systems will need to provide provisions for authentication of both base station and mobile terminal, for privacy, and for data integrity. The IMT-Advanced system link layer security should be part of an end-to-end security mechanism that includes higher layers. Encryption across the air interface to protect user data traffic and signaling messages, from unauthorized disclosure should be supported. The IMT-Advanced systems should provide protection from unauthorized disclosure of the device permanent identity to passive attackers. Security aspects include:

Both the network and mobile terminal having to perform mutual entity authentication and session key agreement protocol. After authentication of the mobile terminal the network may perform authorization before providing service.
Providing a method that will enable message integrity across the air interface to protect user data traffic and signaling messages from unauthorized modification.
Making it possible to operate the MAC and PHY with any of the following combinations of privacy and integrity:

encryption and message integrity;

encryption and no message integrity;

message integrity and no encryption;
no message integrity and no encryption.]
From 1246 (Japan): [It is needed to be described the security methods are employed in the radio interface technology.]
From 1283 (IEEE): [Network security in IMT Advanced systems are needed to protect the service provider from theft of service, to protect the user's privacy, and to mitigate denial of service attacks. IMT Advanced systems will need provisions for authentication of both base station and mobile terminal, for privacy, and for data integrity. The IMT Advanced link layer security shall be part of an end-to-end security mechanism that includes higher layers such as TLS, SSL, IPSec, etc. Protection of user data traffic and signaling messages across the air interface shall be supported. In addition, the IMT Advanced systems shall provide protection from unauthorized disclosure of the device permanent identity to passive attackers.
The Internet Protocol (IP)-based technologies of the IMT-Advanced architecture should enable secure communications with an identity on every packet, or, at a minimum, an identity within the Domain Name Service (DNS) with which to identify the communicating parties with the Host Identity Tag in the DNS resource record. IMT-Advanced systems shall enable independent identification of equipment and user for authentication purposes. The identity of the equipment may be obtained from a certificate, smart card, SIM, USIM, UIM, password, etc. The identity of the user may be obtained from a smart card or an authenticated identity source and translated to a packet identity that is included the network packets (e.g., IPSEC ESP field).
The provision of emergency services shall be supported.
Security aspects include:

Supporting network and mobile terminal mutual entity authentication and session key agreement protocols. After authentication of the mobile terminal the network may perform authorization before providing service.

Allowing for flexible mobile terminal and/or user credentials for authentication to be specified by the Authentication Server.

Providing a method to enable data confidentiality on the air interface for user and control plane traffic.

Providing a method that will enable message integrity and origin authentication across the air interface to protect user data traffic and signaling messages from unauthorized modification.

Implementing Layer 2 mobility to support crossing network boundaries without losing the connection or the security association.

Providing a method to ensure messages are fresh to protect against replay attacks.

Making it possible to operate the MAC and PHY with any of the following combinations of privacy and integrity:

- Encryption and message integrity.
- Encryption and no message integrity.
- Message integrity and no encryption.
- No message integrity and no encryption.

Providing protection of both user and control plane data over non-secure backhaul links.

Providing a method to signal the network that the physical security of the cryptographic module has been compromised.]

IMT-Advanced systems shall include a security function 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

The impact of security procedures on the performance of other system procedures, such as handover procedures, shall be minimized. The security function should be self-contained and capable of maintaining security without relying on specific behaviors on the part of algorithms/protocols at any other functions or layers outside the security function. Such dependencies, if and when necessary, shall be explicitly specified.

5.15.1 Privacy and Authentication Aspects

From 1283 (IEEE): [IMT-Advanced systems shall include privacy and authentication functions which provide the necessary means to achieve:

Protection for the integrity of the system (e.g. system access, stability and availability).

System access via certificate, smart card, SIM, USIM, UIM, password, etc.

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.

Secure Operations, Administration, Maintenance and Provisioning (OAM&P) of system components.

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/integrity protection 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.]

5.16 Network tTopology and Reference Model

The IMT-Advanced systems shall employ simple and scalable network architecture to allow more efficiency, lower deployment cost, and lower end-to-end latency. The proponents should describe various usage models and deployment scenarios based on their proposed technology.

The IMT-Advanced systems should efficiently provide very high data rates and service continuity in smaller cells including indoor pico cells, femto cells, and hot-spots. The small cells may be deployed as an overlay to larger outdoor cells. The operation in small cells should not cause significant interference to the outdoor cells or other wireless devices, or alternatively suffer from interference caused by other wireless devices.
[Proposed radio interface technology need to be considered for applying to Single-hop mode, Multi-hop mode, Mesh mode and Peer to peer mode.]
From 1292 (Finland): [Proposal should describe how the proposed system scales to different types of operators and deployment cases.]

From 1292 (Finland): [This item is of utmost importance for IMT operators. IMT systems will have to be flexible in terms of deployment, service provision, resource planning and spectrum use.]
From 1259 (China): [Proposed radio interface technology need to be considered for applying to Single-hop mode, Multi-hop mode, Mesh mode and Peer to peer mode.
the design for IMT-ADVANCED systemradio interface technology should be considered:

– simplifying the network structure, supporting network complanation;

– supporting multi-RATs cooperation;

– supporting co-exsiting with legacy system;

– supporting Relay system;

– supporting multi-hop.]

From 1268 (Korea): [Relay stations may be used in IMT-Advanced systems to extend coverage and to increase capacity of the system, reducing operators' initial investment. The relay stations are auto-configurable and deliver packets to/from mobile station/relay station/base station. Depending on the situation, mobile stations may communicate with base station via multi-hop relay nodes or vice versa.]

5.16.1 Support of Multi-hop Relays

Relay stations may be used in IMT-Advanced systems to extend coverage and to increase capacity of the system, reducing operators' initial investment. The relay stations should be auto-configurable and deliver packets to or from mobile station, relay station, or base station. Depending on the network architecture, mobile stations may communicate with base station via multi-hop relay nodes or vice versa.

5.17 Mobility management and Radio Resource ManagementRRM

IMT-Advanced systems shall enable the advanced radio resource management (RRM) for efficient utilization of radio resources. This may be achieved by appropriate measurement/reporting, interference management ,and flexible resource allocation mechanisms. [CentrarizedCentralized or /Ddistributed RRM, iInter-RAT spectrum sharing/mobility management need tomay also be considered.]

5.17.1 Mobility mManagement

From 1268 (Korea): [The term "mobility management" in the IMT-Advanced systems indicates the use of "seamless mobility" technology techniques that ensures global mobilityroaming of the mobile terminal onacross the integrated systems composed of Wi-FiLAN/Mobile WiMAX/cellular/satellite and broadcasting cells. Vertical handover should be adopted as the mobility management method in the IMT-advanced systems, especially between cellular (New Mobile Wireless Access) and nomadic (New Nomadic/Local Area Wireless Access).

The mobility management enables universal access across different systems by supporting the following technologies:

- Global roaming using location management~~.~~
- Efficient ~~target~~network discovery using 'periodic searching', '~~neighbour~~neighbor system information broadcasting' and location server, etc.
- Optimal target system selection to minimize the operator's CAPEX & OPEX as well as ~~user~~mobile terminal's charging burden.
- Fast target system acquisition in order to guarantee seamless connection continuity by providing exact guidance to terminal on how to make initial synch, what is initial transmit power level, target system information and radio resource configuration, etc.
- Handover decision to minimize ping-pong effect and terminal power consumption, etc.
- Vertical handover, especially between cellular (New Mobile Wireless Access) and nomadic (New Nomadic/Local Area Wireless Access).~~]~~

5.17.2 Radio Resource Management

~~From 1268 (Korea): [The r~~Radio resource management is used to ensure ~~the~~ efficient utilization of the radio resources ~~on~~in the integrated systems composed of heterogeneous systems by supporting the following technologies:

- Improved end-to-end QoS provisioning during inter-system handover enabling optimal matching of service requirements to radio resources.
- Enhanced mobility control, especially to support best target system selection reflecting the service requirements and radio environments, etc.
- Efficient load sharing and policy management across different systems.
- Dynamic and flexible radio resources management mechanism ~~(e.g. Policy-Based RRM)~~ to accommodate all the relevant aspects including service type, radio environments, QoS level and charging rate, terminal speed, power consumption, charging rate, etc.

In addition, all the relevant elementary technologies including initial system selection, resource allocation, radio admission control, dynamic resource allocation and inter-cell interference control.~~]~~

~~From 1254 (New Zealand): [The RATG concept was used to facilitate spectrum estimation considering the evolutionary development of IMT-2000 ad IMT-Advanced. Thus, both mature systems (pre-IMT and IMT-2000) and futuristic systems (IMT-Advanced) would both be considered. The traffic is distributed among the RATGs according to tables 24a – 24c in Report ITU-R M.2078 reflecting three timeframes, years 2010, 2015, and 2020.~~

~~In each Service Category there are up to six Service Environments (SE). Each Service Environment has values specified for the market parameters, including mobility. The market study gives four mobility classes ranging from stationary to super-high. These are mapped into three mobility classes suitable for input to the spectrum estimation methodology by the use of splitting factors (J-factors). This process is described in section 7.1.3 of Report ITU-R M.2078.~~]

5.17.3 Inter-RAT Mobility [/Interworking] and Handover

~~[IMT-Advanced systems shall support inter-RAT operations.]~~

~~From 1268 (Korea): [The interworking functions among heterogeneous systems should be supported to provide seamless connectivity which includes mobility management,~~

~~interoperability, constant connection and application scalability.(For definition of seamless connectivity, refer to PDNR IMT.SERV).]~~
~~From 1246 (Japan): [It is needed to be described the functional block for interworking (such as network architecture model or network reference model) for each application.]~~

IMT-Advanced systems shall support interworking functionality to allow efficient handover to other radio access technologies. Those of interest include:

IEEE 802.11
3GPP GSM/EDGE, UTRA (FDD and TDD) and E-UTRA (FDD and TDD)

3GPP2 CDMA2000

5.17.4 Intra-RAT Mobility and Handover

IMT-Advanced systems shall support intra-RAT handover within and between all cell types in an IMT-Advanced system.

IMT-Advanced systems shall provide service continuity during handover for both inter-RAT and intra-RAT handover. IMT-Advanced systems should support IEEE 802.21 Media Independent Handover (MIH) Services.

5.17.~~4~~5 Reporting, Measurements, and Provisioning Support

~~From 1283 (IEEE): [~~IMT-Advanced systems shall enable advanced radio resource management by enabling the collection of reliable statistics over different timescales, including:

System statistics (e.g. ~~dropped call statistics~~BS loading condition, channel occupancy).

User information and statistics (e.g. terminal capabilities, mobility statistics, battery life)~~.~~

Flow statistics.

Packet statistics.

~~Etc.~~

These resource management elements enable the network operator to effectively control, monitor, and tune the performance of the air interface. The air interface shall support measurements in the physical layer of both the base station and the mobile terminal.
~~The IMT-Advanced systems shall provide a mechanism to enable the provisioning and collection of metrics, so that the network operator can effectively control, monitor, and tune the performance of the air-interface.~~
For example, the air interface shall support measurements in the physical layer of both the base station and the mobile terminal. These physical layer measurements ~~should~~may include: signal strength, signal quality (C/I), error rates, access delays, session interruption, effective throughput, neighboring cells' signals and provide any other measurement needed for handover support, maintenance and quality of service monitoring. Some of these measurements should be reported to the opposite side of the air link on a periodic basis, and/or upon request.~~]~~

5.17.~~5~~6 Connection/Session Management

~~From 1283 (IEEE): [~~The IMT-Advanced systems~~' air interface shall~~should support multiple protocol states with fast and dynamic transitions among them. It will provide efficient signaling schemes for allocating and de-allocating resources, which may include logical in-band and/or out-of-band signaling, with respect to resources allocated for end-user data. The air interface shall provide power conservation features to improve battery life for idle mobile terminals.~~]~~

5.17.7 Network Entry/Re-entry

Proposals for IMT-Advanced systems shall describe network entry and re-entry procedures.

5.17.8 Cell Selection and Reselection

Proposals for IMT-Advanced systems shall describe cell selection and reselection procedures.

5.17.9 Dynamic Load Control and Multi-carrier Support

The IMT-Advanced systems should support dynamic load control and multi-carrier operation at the base station. The latter feature would allow support of very wide bandwidths through aggregation of contiguous or non-contiguous bands.

5.17.10 Multi-Radio Coexistence

Depending on the bands where IMT-Advanced systems are expected to be deployed, different coexistence requirements should be envisioned.

1. IMT-Advanced system and non-IMT-Advanced systems may be deployed in the same licensed band. Adjacent channels may be used for deployment of IMT-Advanced system and non-IMT-Advanced systems.

2. IMT-Advanced system may be deployed in a licensed band adjacent to an unlicensed band in which non-IMT-Advanced systems are deployed. Hence additional coexistence mechanisms may be required to reduce interference.

5.17.11 Base Station Coordination

Proposals for IMT-Advanced systems shall describe base station coordination and synchronization functions.

5.18 Interference ~~m~~Mitigation within ~~r~~Radio ~~i~~Interface

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

~~From 1283 (IEEE): [~~Interference mitigation technology can be used to avoid or decrease inter-cell or intra-cell interference. ~~There are usually three types of mitigation schemes:~~ Examples include inter-cell-interference ~~randomisation~~randomization, inter-cell-interference cancellation and inter-cell-interference coordination.~~]~~

5.19 Synchronization

~~From 1283 (IEEE): [It is very important and necessary for user terminals to acquire time and frequency synchronization with a cell. Flexible and reliable inter-site time synchronization should also be supported provided these bring sufficient benefits. for example, avoiding system failure due~~ MS ~~to reliance on single synchronization method.]~~

The IMT-Advanced systems shall support the ability to synchronize frame timing and frame counters across the entire system deployed in a given geographic area, including synchronization among all base stations, relay stations, and mobile stations operating on the same or on different carrier frequencies and among neighboring IMT-Advanced systems, whether operated by the same operator or not. The requirement for frame timing synchronization is crucial to coexistence of TDD systems and would be useful, but not essential, for FDD systems, as well.

5.20 Power eEfficiency

The IMT-Advanced systems shall provide support for enhanced power saving functionality to help reduce power consumption in mobile devices for all services and applications.

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

From 1268 (Korea): [Advanced transmitter/receiver technologies for enhancing link budget should be considered. Examples of candidate technologies are as follows:

- Multiple antenna transmission/reception
- Advanced FEC including Turbo and LDPC codes
- Advanced receivers such as iterative receivers
- Physical channel structure design for taking into account power efficiency
- Cost and battery efficiency of user equipment]

From 1254 (New Zealand): [The maximum transmission power should be the minimum required to meet the required cell area coverage whilst maintaining the required grade of service and quality of service objectives.]

5.21 Control Channel Structure

Proposals for IMT-Advanced systems shall describe control channel structure of the radio air interface.

5.22 Layer 1 and Layer 2 Overhead Estimation

Proposals for IMT-Advanced systems shall describe and account for all layer 1 (PHY) and layer 2 (MAC) overhead and provide an accurate estimate that includes static and dynamic overhead.

5.23 Measurement and Reporting

Proposals for IMT-Advanced systems shall describe base station and mobile station measurement and reporting including channel quality measurement and reporting models.

6 Required technology criteria for evaluation

Editorial note: includes the minimum requirements plus any parameters that are useful for evaluation.

Note that some criteria may only be evaluated qualitatively.

6.1 Minimum requirement parameters

These are the requirements detailed in chapter 4 and clearly shall be included in the evaluation. Further details can be found in chapter 4.

- Cell spectral efficiency
- Peak data ratespectral efficiency
- Cell edge user throughput
- Latency
  - Control plane
  - Transport delay (Data/User plane latency)
  - QoS
- Mobility

Handover

- Handover support
- Handover Interruption Time

6.2 Other parameters for evaluation

6.2.1 VoIP Capacity

~~From 1283 (IEEE): [The above VoIP capacity assumes a 12.2 kbits/s codec with a 40% activity factor such that the percentage of users in outage is less than 3% where outage is defined as 97% of the VoIP packets are delivered successfully to the users within the delaybound of 80 msec.]~~

IMT-Advanced systems shall support a minimum of 60 active VoIP users/FDD MHz/Cell or equivalently 30 active VoIP users/TDD MHz/Cell This requirement shall be met with a minimum of 2 transmit and 2 receive antennas in the base station and 1 transmit and 2 receive antennas in the mobile station. Higher order antenna configurations may also be considered which results in higher VoIP capacities.

VoIP capacity assumes a 12.2 kbps AMR codec with a 50% activity factor such that the percentage of users in outage is less than 2% where a user is defined to have experienced a voice outage if less than 98% of the VoIP packets have been delivered successfully to the user within a delay bound of 50 ms.

The packet delay is defined based on the 98 percentile of the CDF of all individual users 98 packet delay percentiles (i.e., first for each user the 98 percentile of the packet delay CDF is determined then the 98 percentile of the CDF that describes the distribution of the individual user delay percentiles is obtained).

6.2.2 [Technology ~~c~~Complexity]

~~From 1268 (Korea): [Technology complexity should be within the state-of-art hardware implementation not only for specifications but also for future commercialization.]~~
~~From Attch. 2 to 1292 (Finland):~~
~~[This criterion expresses the impact of a given RTT on complexity (and hence on cost) of implementation (equipment, infrastructure, installation, etc.) i.e., the less complex the better. In order to achieve the minimum cost and best reliability of equipment, the technologies selected should have a level of complexity consistent with the state of technology, the desired service objectives and the radio environment. Some technologies have several possible methods of implementation which allow a compromise between complexity/cost and performance.~~
~~The installed and ongoing cost of IMT is influenced by both the transmission technology and the level of quality and reliability. At a given quality level, it is impacted by the complexity of the radio hardware, the other necessary network infrastructures, and the ongoing operational aspects of IMT.]~~
~~From 1246 (Japan): [This criterion expresses the impact of a given Radio interface technology on complexity (and hence on cost) of implementation (equipment, infrastructure, installation, etc.) i.e., the less complex the better. In order to achieve the minimum cost and best reliability of equipment, the technologies selected should have a level of complexity consistent with the state of technology, the desired service objectives and the radio environment. Some technologies have several possible methods of implementation which allow a compromise between complexity/cost and performance.~~

The installed and ongoing cost of IMT-Advanced is influenced by both the transmission technology and the level of quality and reliability. At a given quality level, it is impacted by the complexity of the radio hardware, the other necessary network infrastructures, and the ongoing operational aspects of IMT-Advanced.]
From 1283 (IEEE): [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.]

The IMT-Advanced systems should minimize complexity of the architecture and protocols and avoid excessive system complexity. It should enable interoperability of access networks, support low cost devices and minimize total cost of ownership. In addition, the complexity of mobile station, relay stations, and base stations shall be minimized by adhering to the following:

The performance requirements shall be met with mandatory features only.
Optional features shall be considered only if they provide significant functional and performance improvements over mandatory features.
Support of multiple mandatory features which are functionally similar and/or have similar impact on performance shall be avoided.
The number of states of protocols and procedures should be minimized.

6.2.3 Cell Coverage

From 1259 (China): [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]
[In IMT-ADVANCEDsystems, the minimum number of BSs per square kilometre for a given frequency assignment to offer a certain amount of traffic with the required coverage is an important figure, at low traffic levels. At low loading, the system will be noise limited and the number of base stations constrained by the maximum range achievable by the technology.
At low loading, range and coverage efficiency are the major considerations, while at high loading, capacity and spectrum efficiency are more important.
Technologies providing the desired level of coverage with fewer base sites for a specific test environment are defined as having higher coverage efficiency.]
From 1268 (Korea): [A cell radius over 35 km should be supported by proper configuration of the system parameters.
The system should be flexible enough to support the various cell coverage scenarios that meet the performance target. To maintain the balance of the coverage, the cell coverage is considered to be the same between the downlink and the uplink. The performance requirements with respect to cell range are as followings:

Up to 5km: The specified performance requirements above must be achieved.

Up to 35km: Graceful degradation

Symmetrical coverage between uplink and downlink
And the performance requirements of the nomadic wireless access are as followings:

Up to 100m: The specified performance requirements above must be achieved.
Up to 500m: Graceful degradation.]

From Attch 2 to 1292 (Finland): [In terrestrial systems, the minimum number of BSs per square kilometre for a given frequency assignment to offer a certain amount of traffic with the required coverage is an important figure, at low traffic levels. At low loading, the system will be noise limited and the number of base stations constrained by the maximum range achievable by the technology.

At low loading, range and coverage efficiency are the major considerations, while at high loading, capacity and spectrum efficiency are more important.

Technologies providing the desired level of coverage with fewer base sites for a specific test environment are defined as having higher coverage efficiency.]

From 1246 (Japan): [A cell radius over 50 km should be supported by proper configuration of the system parameters.]

From 1254 (New Zealand): [A cell radius over 50km should be supported by proper configuration of the system parameters]

[Tables 15a and 15b of Report ITU-R M.2078 describe cell areas with allowances for cases where penetration loss is and isn't taken into account. The values of these cell areas specified in the software implementation used in the spectrum estimation process is given in the table below.

RE	**Teledensity**		
	Dense urban	**Sub-urban**	**Rural**
Macro cell	0.65	1.5	8.0
Micro cell[(1)]	0.1	0.1	0.1
Pico cell[(1)]	1.6E-3	1.6E-3	1.6E-3
Hot spot[(1)]	6.5E-5	6.5E-5	6.5E-5

[*] This example is not applicable to the scenario of large areas with low teledensity coverage.

[(1)] It is assumed that the cell size of these environments is not teledensity dependent.

]

From 1283 (IEEE):[Support for larger cell sizes should not compromise the performance of smaller cells. Specifically, IMT-Advanced systems shall support the deployment scenarios in Table 10 in terms of maximum cell range.

IMT-Advanced systems shall provide significantly improved coverage with respect to the IMT-2000 systems. IMT-Advanced systems shall support legacy cell sizes (of existing IMT-2000 systems), allowing for co-location of IMT-Advanced systems with IMT-2000 deployments.

Support for larger cell sizes should not compromise the performance of smaller cells. It is also required to support increased number of simultaneous users and enhanced user penetration rates. Specifically, IMT-Advanced systems shall support the deployment scenarios captured in the following Table in terms of maximum cell range.

IMT-Advanced systems should be sufficiently flexible to support a variety of coverage scenarios for which the performance targets can be met. Reference scenarios shall be defined that are representative of current IMT-2000 deployments.

Note that cell coverage is calculated based on both control channel and traffic channel coverage in the uplink and downlink.

TABLE 10

IMT-Advanced Deployment Scenarios

Cell Range	Performance target
Up to 100 m	Nomadic performance, up to 1 Gbit/s
Up to 5 km	Optimized Pperformance targets defined in section 5.2.14 should be met
5-30 km	Graceful degradation in system/edge spectrum efficiency
30-100 km	System should be functional (thermal noise limited scenario)

]

[Editor's note: service types removed as assumed to be covered by WG Services]

6.2.4 ccdf of uUser Tthroughput

[Editor's note: text to describe this criterion is needed]

6.2.5 QoS

[Editor's note: consideration should be given to including the 4 classes from M.1079 and reference to ITU-T Y.1541]

Proposals for IMT-Advanced systems shall describe the QoS classes and how the QoS requirements of various applications and services are met.

6.2.6 Capacity Cconsiderations/ Supported Uuser Ddensity

[Description of capacity, e.g. how many users could be supported in different scenarios, such as rural, urban and hotspot.] should be provided.

7 Conclusions

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

8 Terminology, aAbbreviations and Acronyms

From 1246 (Japan):

[

BS	Base Station
CCDF	Complementary CDF
CDF	Cumulative Distribution Function
CDMA	Code Division Multiple Access
CIR	Carrier to Interference Ratio
DL	Downlink
FDD	Frequency Division Duplex
IWF	Inter-Working Function
MAC	Medium Access Control
MS	Mobile Station
OFDMA	Orthogonal Frequency Division Multiplex Access
PHY	Physical Layer
QoS	Quality of Service
RAT	Radio Access Techniques Technology
RRM	Radio Resource Management
SDMA	Space Division Multiple Access
SIR	Signal-to-Interference Ratio
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
UL	Uplink

]9 Basic Definitions

From 1283 (IEEE): [*Active users* - An active user is a terminal that is registered with a cell and is using or seeking to use air link resources to receive and/or transmit data within a short time interval (e.g., within 100 ms).

Aggregate Throughput - Aggregate throughput is defined as the total throughput to all users in the system (user payload only).

Air Interface

1. The air interface is the radio-frequency portion of the transmission path between the wireless terminal (usually portable or mobile) and the active base station or access point.
2. The air interface is the shared boundary between a wireless terminal and the base station or access point.

Cell - The term “cell” refers to one single-sector base station or to one sector of a base station deployed with multiple sectors.

Cell sizes - The maximum distance from the base station to the mobile terminal over which an acceptable communication can maintained or before which a handover would be triggered determines the size of a cell.

Contention based multiple access method - An access method that allows multiple uncoordinated users to share the same spectrum by defining the events that must occur when two or more transmitters attempt to simultaneously access the same channel and establishing rules by which a transmitter provides reasonable opportunities for other transmitters to operate.

~~*Coverage Enhancing Technologies* - In the context of wireless communications - technologies that augment the radio signal, in areas within the boundary of a cell, where the BS/MS transmit signal is obstructed and significantly attenuated by terrain or man-made structures.~~

Intra-technology handover (Horizontal Handover) - Handover of active sessions between two network points of attachment or between two radio channels within same link or radio technology.

Inter-technology handover (Vertical Handover) - Handover of active sessions between two different network interfaces defined as part of IMT-Advanced system or between different network interfaces from IMT-Advanced system and IMT-2000 system.

~~*Licensed bands below 3.5 GHz* - This refers to bands that are allocated to the mobile service and licensed for use by mobile cellular wireless systems operating below 3.5 GHz.~~

Network selection - The process by which a mobile station or a network entity makes decision to connect to a specific network (possibly out of many available) based on policy configured in the mobile station and/or obtained from the network.

~~*Peak data rates per user (or peak user data rate)* - The peak data rate per user is the highest theoretical data rate available to applications running over the radio interface and assignable to a single mobile station. The peak data rate per user can be determined from the combination of modulation constellation, coding rate and symbol rate that yields the maximum data rate.~~

Seamless handover - Handover of active session characterized by a mobile node changing the network interface point of attachment, on the same or different radio link technology, within the recommended delay constraints of service interruption and without a noticeable loss in service quality.

Service continuity - Transparent maintenance of an active service during handover while the mobile station transitions across coverage area of different networks.

Service Flow - A service flow is a MAC transport service that provides unidirectional transport of packets either to uplink packets transmitted by the MS or to downlink packets transmitted by the BS. A service flow is characterized by a set of QoS parameters such as latency, jitter, and throughput assurances.

~~*System spectrum efficiency* - The ratio of the aggregate throughput (in bit/s) to all users in the system divided by the total size of the spectrum blocks (in Hz) assigned to the system and divided by the number of sectors in the system. System spectrum efficiency calculation shall~~

~~exclude PHY and MAC overhead from the aggregate throughput to all users. System spectrum efficiency is defined independently for the uplink and downlink. When calculating the uplink or downlink system spectrum efficiency, the assigned spectrum block size (used in the denominator) shall be scaled in proportion to the time/frequency resources assigned to the uplink or downlink, respectively.]~~

Appendices

The following 2 appendices illustrate technology enablers which can be used for IMT-Advanced Radio Interface(s). The third appendix includes text that was contributed to 22nd meeting of WP8F for the deleted section 4 – General Requirements – from document 8F/1170 attachment 6.2.

Appendix 1

Overview of major new technologies (informative)

1 Spectrum and deployment

[Editor ~~note~~Note: Technologies that can improv~~inge~~e spectrum efficiency, flexibility and sharing possibility could be included in this section.]

2 Radio Access Interface and Network

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

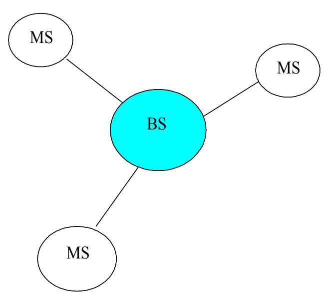
2.1 Network topology

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~~Operation mode of radio access network – Single Hop Mode



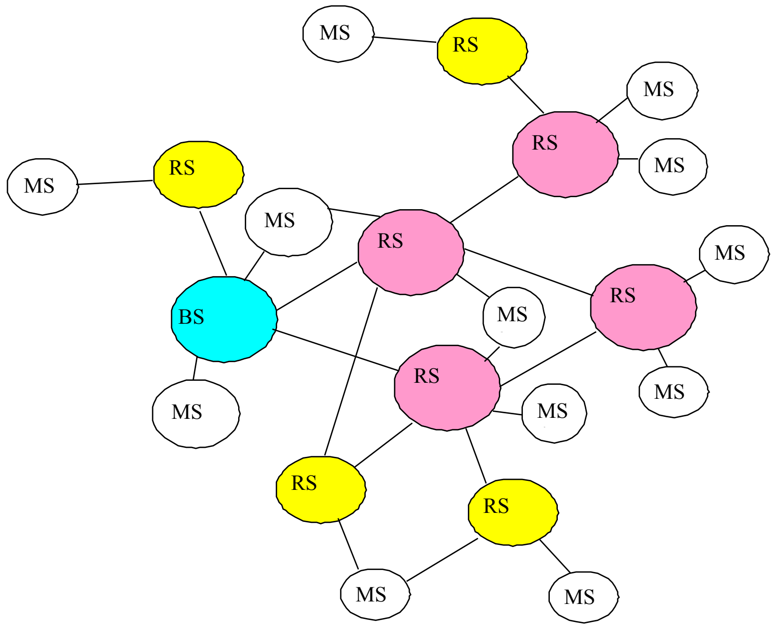
2.1.2 Multi-hop mode

The direct communications between BSs and the data transportation through multi-hop across BSs should be considered.

The information is transmitted between radio access ~~point~~points 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~~Operation mode of radio access network – Multi Hop Mode

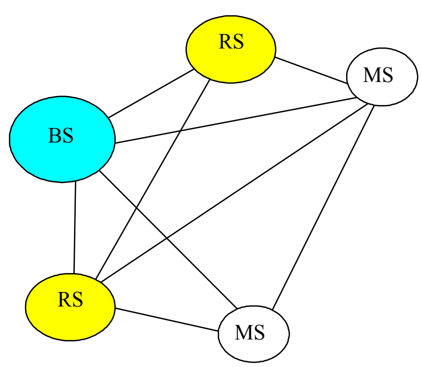


2.1.3 Mesh mode

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~~Operation mode of radio access network – Mesh Mode

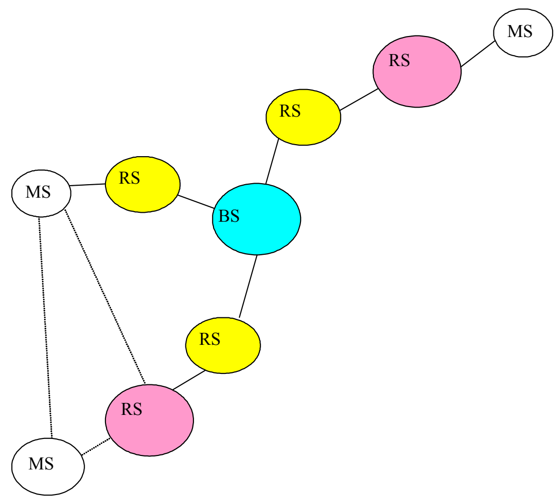


2.1.4 Peer-to-peer mode

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~~Operation mode of radio access network – Peer-to-Peer Mode



2.2 Duplexing schemes

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 efficiently 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 (H-FDD)

The H-FDD is low-complexity implementation of FDD where the device DL and UL transmissions are not overlapping, eliminating the need for RF duplexer and allowing reuse of TX and RX building blocks (e.g., FFT module). The H-FDD terminals can have lower power consumption and smaller form factor compared to that of FDD devices. Note that the BS is operating in FDD mode; that is DL transmissions and UL reception of the BS occurs at the same time.

Therefore, the BS scheduler should take into consideration that the H-FDD MS cannot receive and transmit at the same time. Also the BS should allow a gap between any DL to UL and UL to DL switching for a particular H-FDD MS.

~~TBD~~

2.3 Multiple-Access technologies

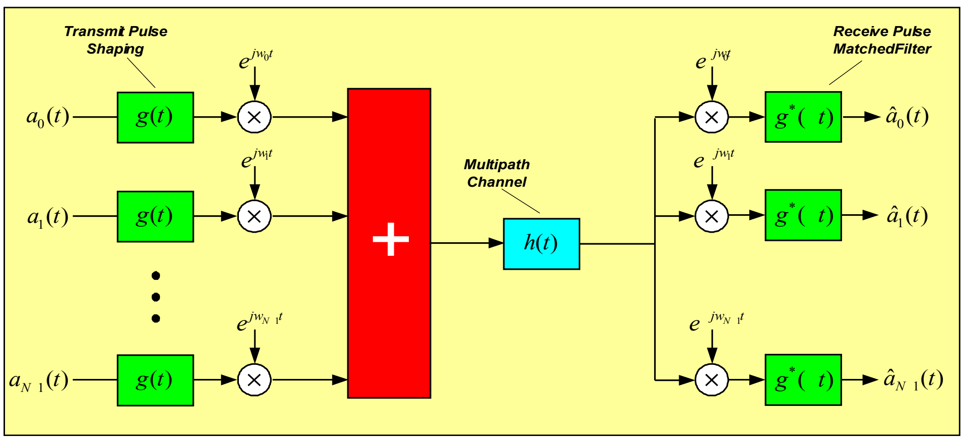
2.3.1 Single-carrier transmission

TBD

2.3.1 Multi-carrier transmission

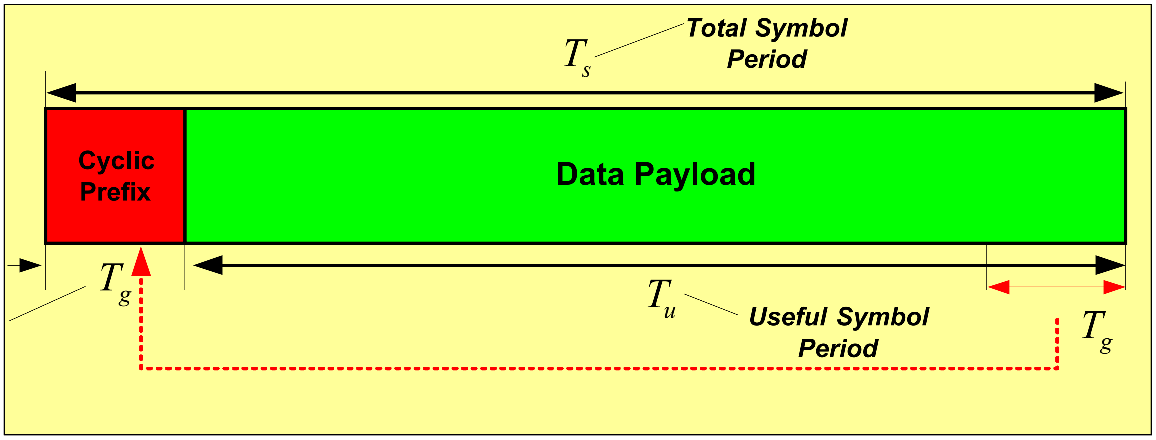
2.3.1.1 OFDMA

Orthogonal Frequency Division Multiplexing (OFDM) is a multiplexing technique that subdivides the bandwidth into multiple frequency sub-carriers as shown in the following figure. In an OFDM system, the input data stream is divided into several parallel sub-streams of reduced data rate (thus increased symbol duration) and each sub-stream is modulated and transmitted on a separate orthogonal sub-carrier. The increased symbol duration improves the robustness of OFDM to delay spread. Furthermore, the introduction of the cyclic prefix (CP) can completely eliminate Inter-Symbol Interference (ISI) as long as the CP duration is longer than the channel delay spread.



Basic Architecture of an OFDM System

The CP is typically a repetition of the last samples of data portion of the block that is appended to the beginning of the data payload as shown in the following figure. The CP prevents inter-block interference and makes the channel appear circular and permits low-complexity frequency domain equalization. A perceived drawback of CP is that it introduces overhead, which effectively reduces bandwidth efficiency. While the CP does reduce bandwidth efficiency somewhat, the impact of the CP is similar to the “roll-off factor” in raised-cosine filtered single-carrier systems. Since OFDM signal power spectrum has a very sharp fall of at the edge of channel, larger fraction of the allocated channel bandwidth can be utilized for data transmission, which helps to moderate the loss in efficiency due to the cyclic prefix.

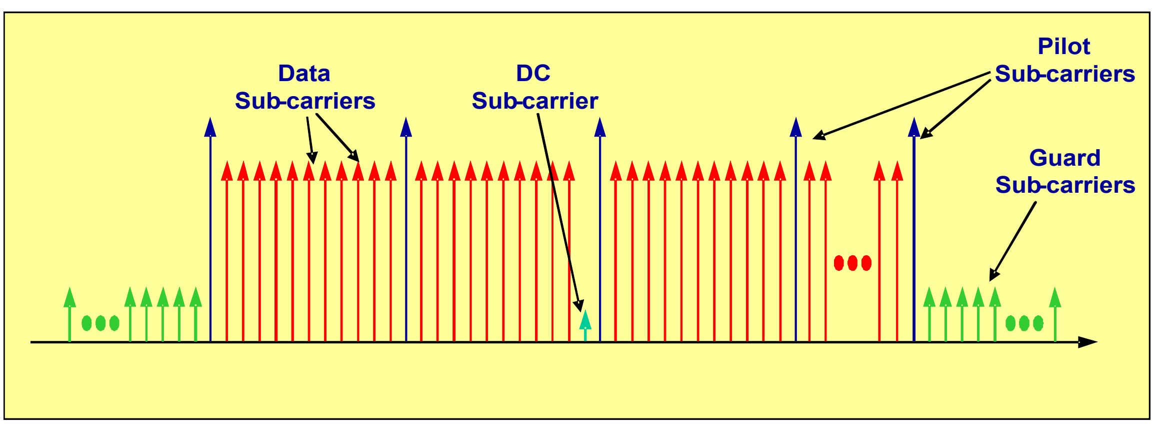


Insertion of Cyclic Prefix (CP)

OFDM exploits the frequency diversity of the multipath channel by coding and interleaving the information across the sub-carriers prior to transmissions. OFDM modulation can be realized with efficient Inverse Fast Fourier Transform (IFFT), which enables a large number of sub-carriers with low complexity. In an OFDM system, resources are available in the time domain by means of OFDM symbols and in the frequency domain by means of sub-carriers. The time and frequency resources can be organized into sub-channels for allocation to individual users. Orthogonal Frequency Division Multiple Access (OFDMA) is a multiple-access/multiplexing scheme that provides multiplexing operation of data streams from multiple users onto the downlink sub-channels and uplink multiple access by means of uplink sub-channels.

The OFDMA symbol structure consists of three types of sub-carriers as shown in the following figure:

- Data sub-carriers for data transmission
- Pilot sub-carriers for estimation and synchronization purposes
- Null sub-carriers for no transmission; used for guard band and DC sub-carriers



OFDMA Sub-Carrier Structure

Active (data and pilot) sub-carriers are grouped into subsets of sub-carriers called sub-channels. Scalable OFDMA supports a wide range of bandwidths to flexibly address the need for various spectrum allocation and usage model requirements. The scalability is supported by adjusting the

FFT size while fixing the sub-carrier spacing and thereby OFDM useful symbol duration regardless of the operating bandwidth.

2.3.1.2 Multi-carrier CDMA

2.4 Multiple-Antenna technologies

2.4.1 MIMO ~~(MTMR)~~

2.4.1.1 Single-User MIMO (SU-MIMO)

2.4.1.2 Multi-User MIMO (MU-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 T~~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 H-ARQ (IR-–H-ARQ).

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_H-ARQ.

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. H-ARQ).

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~~Note: This section includes 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 a~~Application of ~~multi-input-multi-output~~MIMO technology in IMT-Advanced systems (informative)

[Editors note: Particular terms such as "~~Node~~BBS" and "~~UE~~MS" are being discussed in SWG Radio Aspects and discussion will continue in the correspondence activity which takes place between WP 8F Meetings #22 and #23]

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~~ Improved 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 ~~.~~(MIMO techniques will not be effective in this scenario).

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

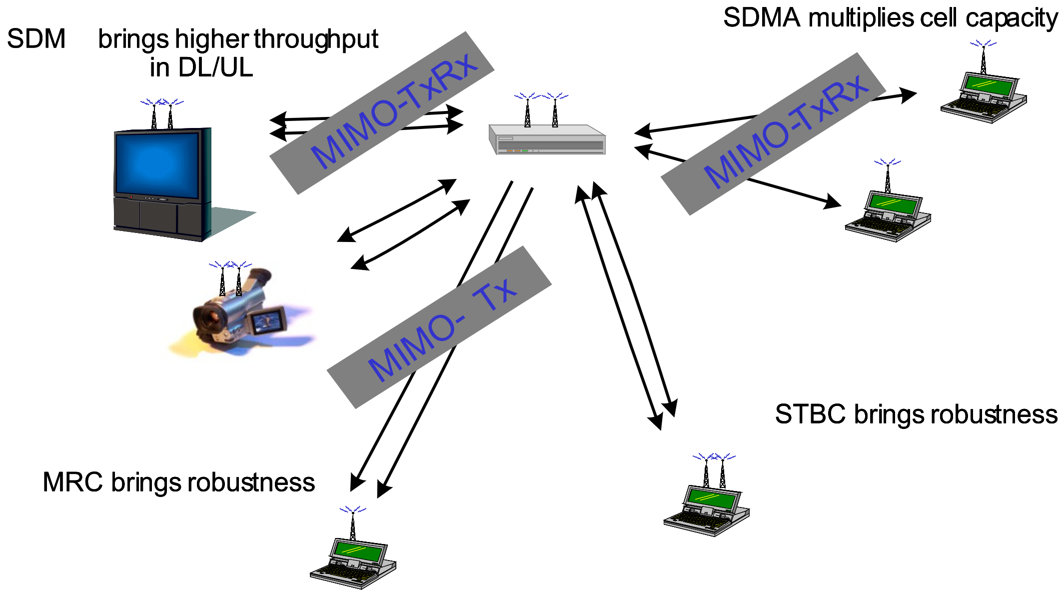
Since MIMO techniques may need channel information feedback between receiving and transmitting stations, based on present feedback mechanism, when MS moves at high speeds (e.g. velocity > 50 km/h),.

~~Because MIMO technical may need channel information feedback between receiving and transmitting, based on present feedback mechanism, when UE~~ MS ~~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.~~

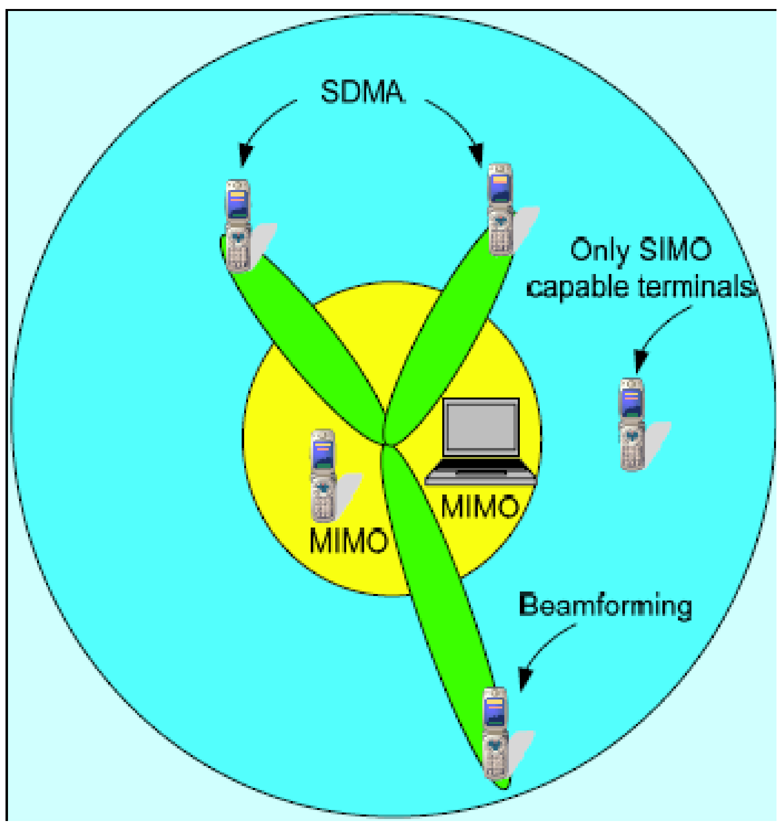
In addition, the micro honeycomb environment with rich multi-diameter condition can maximize the MIMO antenna gain, therefore the multi-antenna technology more suits for the micro honeycomb scenario such as the crowded city, the city, the room and so on. One kind of intelligent MIMO system based on the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

FIGURE 1

~~The application of smart MIMO in different scenarios~~



The application of MIMO in different scenarios (courtesy of 3GPP2 C30-20060911-035)

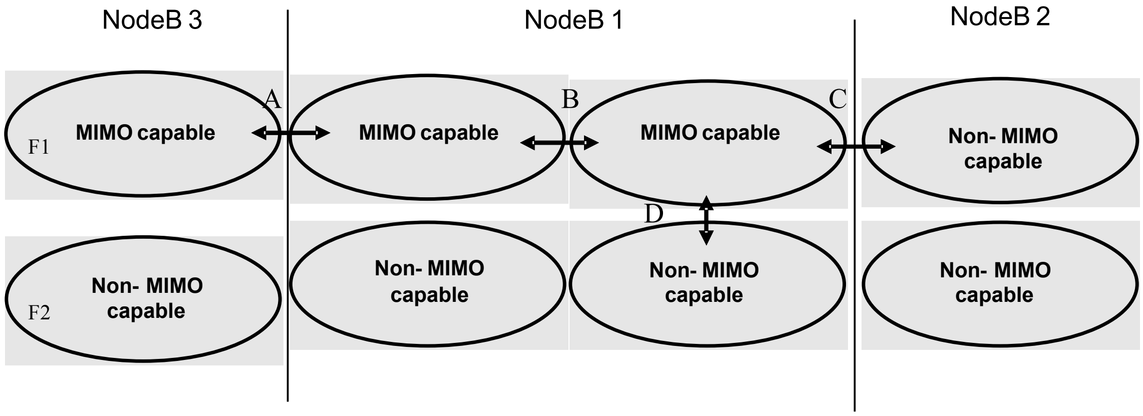


2 The impact of MIMO on mobility~~MIMO's impact on mobility~~

~~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~~neighbor ~~NodeB~~BS and in different frequency within a ~~NodeB~~BS. Because of the mobility of ~~UE~~ MS and payload, that may lead to the following scenario.

FIGURE 2



Mobile stations ~~work~~ operate at the F1 frequency in ~~NodeB~~BS3, and move towards ~~NodeB~~BS1 (Figure 2 A)

- If the current ~~UE~~ MS is MIMO MS~~UE~~, when ~~UE~~ MS moves from ~~NodeB~~BS3 towards ~~NodeB~~BS1, 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~~ MS is MIMO MS~~UE~~, but works at the frequency F2 in ~~NodeB~~BS3, 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~~ MS 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~~ MS 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~~ MS is MIMO MS~~UE~~, whether working at F1 or F2, soft hand-over should be the optimum choice.

When the above example occurs in one ~~NodeB~~BS, the strategy should be the same as the different ~~NodeB~~BS. The only difference is the hand-over is the softer hand-over.

If MIMO ~~UE~~ MS moves into a non-MIMO cell(C), the network side can balance between to hold the MIMO service and to ensure ~~UE~~ MS 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 MSs~~UEs~~ can not produce too large payload to network.

At different frequency in one ~~NodeB~~BS, we also solve the payload balance through blind hand-over in one ~~NodeB~~BS (D). The blind hand-over in one ~~NodeB~~BS can be touched by the change of channel type. This can place the MIMO MSs~~UEs~~ and non-MIMO MSs~~UEs~~ in MIMO cells and non-MIMO cells as possible to ensure the performance of MIMO MS~~UE~~.

Appendix 3

Input text to 22nd meeting of WP 8F on general requirements

[Editor's note: This text is included so that it can be determined if any requirements described could be included into requirements during further discussion. This appendix will deleted before final approval of the report.]

From 1259 (China): For IMT-Advanced system, User expectations are continually increasing with regard to the variety of services and applications. In particular, users will expect a dynamic, continuing stream of new applications, capabilities and services that are ubiquitous and available across a range of devices using a single subscription and a single identity (number or address). Multimedia traffic is increasing far more rapidly than speech, and will increasingly dominate traffic flows. There will be a corresponding change from predominantly circuit-switched to packet-based delivery. This change will provide the user with the ability to more efficiently receive multimedia services, including e-mail, file transfers, messaging and distribution services. These services can be either symmetrical or asymmetrical, and real-time or non real-time. They can consume high bandwidths, resulting in higher data rate requirements in the future. This will complement the enhanced IMT-2000 systems and the other radio systems.

It is predicted that potential new radio interface(s) will need to support data rates of up to approximately 100 Mbit/s for high mobility such as mobile access and up to approximately 1 Gbit/s for low mobility.

From 1268 (Korea): IMT-Advanced systems should support more than 100 Mbps in new mobile access environment and 1 Gbps in new nomadic/local area wireless access environment. For this, performance optimization can be done in either way.

1) One system can be designed to meet both of the new mobile access and the nomadic/local area wireless access requirements together.

2) Separate system can be designed for the new mobile access and the nomadic/local area wireless access requirements.

The IMT-Advanced systems should be designed to provide best-in-class performance attributes such as peak and sustained data rates and corresponding spectral efficiencies, capacity, latency, overall network complexity and quality-of-service management.

The IMT-Advanced systems should support applications that conform to open standards and protocols. The examples of applications are, but not limited to, video, full graphical web browsing, e-mail, file uploading and downloading without size limitations, streaming video and streaming audio, IP Multicast, Location based services, VPN connections, VoIP, instant messaging and on- line multiplayer gaming.

The IMT-Advanced systems should provide the mobile user with an "always-on" experience while also taking into account and providing features needed to preserve battery life. The connectivity from the mobile terminal to the base station should be automatic and transparent to the user as it moves between mobile networks.

End-user requirements

Users wish to receive seamless services in a more convenient and accustomed way from and to various networks through various terminals, and demand the diverse services through advancement, integration and innovation of technology. Advent of ubiquitous era rapidly increases the need of personalized services which are based on awareness of dynamically changing environment of the users. In order to implement these requirements successfully, it is required to exchange, refine and manage personal information and context information efficiently, while thoroughly fulfilling the intention of the users.

The major requirements for the users are as followings:

The system should provide the QoS based differentiated service based on the data transmission rate, data loss rate and real-time service characteristics.

The system should provide the emergency call service which requires higher priority than general communication services.

The system should provide various location based services in the indoor environment through the precision location awareness, as well as the in the outdoor environment where GPS is supported.

The system should support personalization service based on the user profile/preference and context information.

The system should provide service continuity through uninterrupted interconnection in case of movement between various wireless access networks.

The system should guarantee reliability by protecting information security and privacy.

Terminal requirements

The terminals should provide the user with seamless service at any time in any place on various wireless networks. The major requirements for mobile terminal are as followings:

The terminal should support seamless handover and global roaming in the heterogeneous wireless network as well as in the homogeneous wireless network.

The terminal should work for longer hours than the existing IMT-2000 terminals with less power consumption.

The terminal should provide I/O interface that enhances convenience of the users.

Network requirements

The IMT-Advanced systems should support high-speed multimedia data transmission, as well as improved flexibility, scalability, stability and reliability through IP-based transmission, modular architecture and open service interface. The IMT-Advanced systems consist of core network which is independent of the access technology and wireless access network which is dependent on the access network for control and provisioning of service. However, this distinction becomes ambiguous due to evolution of IP based technology and the traditional functions of core network and wireless access network will be distributed. Especially, under the cell environment where the various wireless networks are overlapped hierarchically, in order to support seamless mobility between multiple wireless access systems, it is required to develop the technique of selecting the optimum network and managing the multiple wireless resources in consideration of service profile of the users and the current system status.

The major requirements for the network are as followings:
The network should provide the fast and reliable packet routing for various connection topologies including point-to-point, point-to-multipoint and multipoint-to-multipoint connection.
The network should provide flexibility of introduction of various systems and evolution scenario.
The network should support scalability of capacity in accordance with change of number of users and traffic.
The network should support the standard interface for cooperation between the communication service providers.
The network should support the capability of selecting the optimum available network and managing the wireless resources efficiently under the various wireless network environments.
The network should support the robust encryption and authentication function against the illegal attack.
From 1246 (Japan):
Recommendation ITU-R M.1645 described that the "systems beyond IMT-2000 will encompass the capabilities of previous systems" and also described new capabilities.
According to the recommendation, the general requirements for IMT-Advanced are following:
a) Mobility Speed
Terrestrial cellular systems including IMT are required to support the environment described in Recommendation ITU-R M.1034 which includes:
- Stationary (0 km/hr i.e can be used as a FWA systems)
- Pedestrian (Up to 10 km/hr)
- Typical Vehicular (Up to 100 km/hr)
- High Speed Vehicular (Up to 500 km/Hr)
b) Inter-Connection to/from other mobile networks/PSTN/ISDN and IP networks.
System employing IMT-Advanced radio interface technologies is required to connect other networks.
As IMT-Advanced is required to encompass the capabilities of previous systems, it needs to inter-connect with other mobile networks/PSTN/ISDN in circuit switched mode and also with other mobile networks/ISDN and IP networks in packet switched mode.
In voice application between PSTN, it is necessary to comply the quality required by PSTN such as maximum ratings, delay performance, circuit noise, grade of service, error performance, etc. which is recommended relevant ITU-T Recommendations.
c) Potential to support larger cell
For supporting low population density area with economical solution, IMT-Advanced radio interface technologies are requested to support lager cell.
d) Cheap terminal for world wide use
For spreading IMT-Advanced systems, cheap user terminal is essential element. It can be achieved by employing less complexity technologies, maximize commonalities among radio interface technologies if several specifications are registered for IMT-Advanced radio interface technologies and by supporting not too many radio interface technologies in one device.
d) Peak bit rate per cell
According to Recommendation ITU-R M.1645, the target peak bit rates per cell in 2 environments are as following:
- More than 1G bit/s for Pedestrian (Up to 10 km/hr)
- More than 100M bit/s for high mobility (Up to 250 km/hr or more)

[Editor's note: These are from description of Figure 2 in Rec. ITU-R M.1645]

e) Mobile user interface

[Editor's note: Text to be added]

f) Ubiquitous Access

[Editor's note: Text to be added]

g) Sophisticated handover capability

Handover need to be accomplished in high speed mobility environment and also handover between different networks or radio interface technologies may be required. It may require simple handover protocol, e.g. small amount of signalling.

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From 1283 (IEEE): IMT-Advanced will support the following general system requirements and features:

Improved performance, in comparison to enhanced IMT-2000 systems (per M.1457-7), with respect to parameters, including:

Spectrum efficiency and peak data rate.

Latency in order to enable new delay-sensitive applications.

Cell size and cell-edge performance.

Support of one or more of the following environments, with increased system performance for low mobility environments:

Stationary (fixed or nomadic terminals).

Pedestrian (Pedestrian speeds up to 3 km/h).

Typical Vehicular (Vehicular speeds up to 120 km/h).

High Speed Vehicular (high-speed trains up to 350 km/h).

Seamless application connectivity to other mobile networks and other IP networks (global roaming capabilities).

Improved unicast and multicast broadcast services.

Network support of multiple radio interfaces, with seamless handover, addressing both the cellular layer and the hot spot layer (and possibly the personal network layer) per ITUR Rec. M.1645.

The IMT Advanced system shall support applications that conform to open standards and protocols. This allows applications including, but not limited to, video, full graphical web browsing, e-mail, file uploading and downloading without size limitations (e.g., FTP), streaming video and streaming audio, IP Multicast, Location based services, VPN connections, VoIP, instant messaging and on- line multiplayer gaming.

The IMT Advanced systems shall provide the mobile user with an "always-on" experience while also taking into account and providing features needed to preserve battery life. The connectivity from the mobile terminal to the base station (BS) shall be automatic and transparent to the user as it moves between mobile networks.

From 1259 (China): In defining the framework and objectives for the future development of IMT-ADVANCED systems, the significant technology requirements need to be considered. This section identifies the technology domains in which trends can be foreseen at the time of preparation of this Report. Depending on their development, evolution, realized capabilities and cost structure, each of these technology trends may or may not have an impact or be used for IMT-ADVANCED systems. It is expected that the research and development of IMT-ADVANCED systems will consider these trends and provide guidance on the applicability or influence they might have on

IMT-ADVANCED systems.

IMT-ADVANCED systems include some technology as below:

- System-related technologies
- Access network and radio interface
- Utilization of spectrum

Mobile terminals
Applications