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Technical Report

Universal Mobile Telecommunications System (UMTS); Concept groups for the definition of the UMTS Terrestrial Radio Access (UTRA) (UMTS 30.04 version 3.0.1)

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Foreword

This ETSI Technical Report has been produced by ETSI Special Mobile Group (SMG) to provide historical information.

This TR describes the original proposals for concept groups for the definition of the UMTS Terrestrial Radio Access UTRA.

This report has been produced directly from **ETSI SMG#22 Temporary document SMG 480/97.**

The contents of this TR is subject to continuing work within SMG and may change following formal SMG approval.

Version 3.x.y

where:

3 indicates UMTS;

x the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

y the third digit is incremented when editorial only changes have been incorporated in the specification;

1 Scope

SMG2 have according to the UTRA definition procedure elaborated proposal for concept groups for the definition of the UMTS Terrestrial Radio Access UTRA. This work have resulted in the following five concept groups:

α - concept: Wideband CDMA

Allocated to this groups are the following original proposals:

- FRAMES FMA mode 2 (CSEM/Pro Telecom, Ericsson, France Telecorn/CNET, Nokia, Siemens)
- Wideband Code Division Multiple Access (W-CDMA) (Fujitsu Europe Telecom R&D Centre)
- Wideband Direct Sequence (DS) CDMA, (NEC Technologies (UK) Ltd)
- DS-CDMA Utilising FDD and TDD, (Panasonic (Matsushita Europe & Matsushita Comm. Ind. Ltd))

β- concept: OFDM

Allocated to this groups are the following original proposals:

- Band Division Multiple Access (BDMA) (OFDM & SFH-TDMA), (Sony International (Europe) Gmbh)
- Orthogonal Frequency Division Multiple Access (OFDMA) (Telia Research)
- OFDMA (Lucent Technologies)

γ - concept: Wideband TDMA

Allocated to this groups are the following original proposals:

- Frames FMA mode 1 without spreading (CSEM/Pro Telecom, Ericsson, France Telecom/CNET, Nokia, Siemens)

δ - concept: Wideband TDMA/CDMA

Allocated to this groups are the following original proposals:

- Code Time Division Multiple Access (CTDMA) (Swiss Telecom PTT)
- Frames FMA mode 1 with spreading (CSEM/Pro Telecom, Ericsson, France Telecom/CNET, Nokia, Siemens)

ε - concept: ODMA

Allocated to this groups are the following original proposals:

- Opportunity Driven Multiple Access (ODMA) (Vodafone LTD., Salbu R&D (Pty) Ltd.)

The following proposals are considered relevant for more than one Concept Group:

For the β, γ, δ concept groups are allocated the proposal Flexible Frames Structure (Philips Consumer Communications/Philips Research Laboratories).

For all concept groups are allocated the proposal Multi-Dimensional Packet Reservation Multiple Access (MD PRMA) (NEC technologies (UK) Ltd., Kings College London).

Templates describing the key attributes of the proposals contained in the five concept groups follow.

2 Concept Group Alpha -Wideband Direct-Sequence CDMA

ETSI SMG2#22 Tdoc SMG2 234/97

In the procedure to define the UMTS Terrestrial Radio Access (UTRA), the wideband DS-CDMA concept group will develop and evaluate a multiple access concept based on direct sequence code division. This group currently includes the DS-CDMA proposals from FRAMES Mode 2, Fujitsu, NEC and Panasonic. The main radio transmission technology (RTT) parameters of these proposals are described in Table 1 below. The proposals are designed to operate with multiple bandwidths, including bandwidths supporting wideband services.

Glossary of abbreviations used:

BS	Base station
DL	Downlink (forward link)
DS-CDMA	Direct-Sequence Code Division Multiple Access
FDD	Frequency Division Duplexing
Mcps	Mega chips per second
TDD	Time Division Duplexing
UL	Uplink (reverse link)

Table 1: Wideband DS-CDMA proposals

	FRAMES FMA Mode 2	Fujitsu W-CDMA	NEC W-CDMA	Panasonic	
Multiple access method	DS-CDMA	DS-CDMA	DS-CDMA	DS-CDMA	
Duplexing method	FDD	FDD	FDD	FDD/TDD	
Channel spacing	4.8/9.6 MHz [1]	5/20 MHz	1.25/5 MHz	1.25/5/10/20 MHz	
Carrier chip rate	3.84/7.68 Mcps [1]	4.096/16.384 Mcps	1.024/4.096 Mcps	1.024/4.096/8.192/16.384 Mcps	
Frame length	10 ms	10 ms	20 ms	10 ms	
Multirate concept	UL: Variable spreading DL: Multicode	UL & DL: Variable spreading and/or multicode	UL & DL: Variable spreading and/or multicode	UL & DL: Variable spreading and/or multicode	
FEC codes	UL: Convolutional code, rate1/2, puncturing/repetition DL: Convolutional code, rate 1/3, puncturing/repetition	Convolutional code, rate 1/3 for 4.096 Mcps, rate 1/2 for 16.384 Mcps	UL & DL: Convolutional code, rate 1/3 (+ Outer Reed-Solomon code option)	Convolutional code, rate 1/3 or 1/2, K=9 Puncturing/repetition for variable rate Reed-Solomon coding added for data	
Interleaving	Intra-frame/inter frame interleaving	Intra-frame/inter-frame interleaving	Intra-frame/inter-frame interleaving	Intra-frame interleaving for convolutional Inter-frame interleaving for Reed-Solomon	
Spreading factors	2 to 256	8 to 512	16 to 64	4 to 64 @ 1.024 Mcps, 4 to 256 @ 4.096 Mcps, 4 to 512 @ 8.192 Mcps, 4 to 1024 @ 16.384 Mcps	
Spreading codes	Short codes	Extended Gold sequences for short and long codes	Short codes and long codes	Short codes and long codes	
Modulation	UL: O-QPSK DL: QPSK	UL: O-QPSK DL: QPSK	UL: π/4 - QPSK DL: QPSK	UL: QPSK DL: QPSK	
Pulse shaping	Root Raised Cosine, roll-off = 0.2	Root Raised Cosine, roll-off = 0.22	Root Raised Cosine, roll-off = 0.22	Root Raised Cosine, roll-off = 0.22	
Handover	Mobile controlled soft handover	Soft handover supported	Soft handover	Diversity handover	
IF handover	Supported within specification	[TBD]	Supported within specification	Fast handover	
Detection	UL: Coherent detection (reference symbol based) DL: Coherent detection (pilot code or reference symbol based)	UL: Coherent detection (pilot symbol assisted) DL: Coherent detection (pilot channel or pilot symbol assisted)	UL & DL: Coherent detection (reference symbol based)	UL & DL: Coherent detection (based on time multiplexed pilot symbol)	
Interference reduction	Short codes supports multi-user detection	Interference canceller (option) Digital beamforming (option)	Multi-user detection (option)	Interference canceller for UL (option) Digital beamforming (option)	
Power control	UL: Open loop and fast closed loop DL: Fast closed loop	Open loop and closed loop	UL: Open loop and fast closed loop DL: At least open loop	FDD UL: SIR based fast closed loop DL: SIR based fast closed loop Outer loop added	TDD UL: fast open loop DL: slow closed loop Outer loop added
Diversity	RAKE, UL antenna diversity	UL & DL: RAKE and antenna diversity	UL & DL: RAKE and antenna diversity	UL: path, antenna ,site DL: path, antenna, site	UL: path, antenna, site DL: path, antenna, site, BS TX antenna diversity
Base station synchronisation	Asynchronous operation	Asynchronous operation	Asynchronous operation	Asynchronous	Synchronised

[1] Harmonisation with FMA Mode 1 parameters has been taken into account in the choice of these parameters.

3 β-The OFDM concept group

ETSI SMG2#22 Tdoc SMG2 __/97

Introduction

The OFDM concept group will develop and evaluate a multiple access concept based on the use of a discrete Fourier transform for modulation and demodulation, the group currently includes complete proposals from Telia and Sony, and a proposal for some aspects of the system from Lucent Technologies. The main RTT parameters of these proposals are described in the table below.

This document is intended as a starting point for work within the OFDM concept group.

Key parameters for OFDM concept group

	SONY	TELIA	LUCENT TECHNOLOGIES
Multiple Access Method	BDMA (OFDM & SFH-TDMA)	OFDMA	OFDMA
Duplexing Method	FDD (TDD option)	FDD	FDD (TDD option)
Required bandwidth to support a 2 Mbit/s peak bit rate	Minimum 1.6 MHz with 8DPSK modulation	4 MHz	
Channel Spacing	100 kHz (Multiple of 100 kHz supported)	125 kHz (Multiples of 125 kHz supported)	
Maximum User Bitrate	at least 2Mbit/s	2.5 Mbit/s[1]	at least 2 Mbit/s
Subcarrier Spacing	4.167 kHz (=100kHz/24)	5 kHz	
Symbol Duration	288.46 μs	235.6 μs	
Frame Length	4.6154/4ms (4-TDMA), 4.6154/2 (8-TDMA), 4.6154ms (16-TDMA)	15.5 ms	
Multirate concept	Multi-Bandslot & Multi-Timeslot	Variable block allocation	Variable block/slot allocation
FEC codes	Convolutional Codes, RS-Codes, BCH-Codes	Rate 1/2, Constraint length 7, conv.code	PAPR reducing coding schemes
Interleaving	Bearer/Service specific (e.g. voice 18.46 ms)	Bearer/Service specific	
Modulation	Frequency Domain Differential QPSK (multilevel modulation possible)	Coherent QPSK	QPSK + QAM option for suitable channels
Windowing	Full Cosine Roll Off (a=0.036)	Raised Cosine (Tukey)	Conventional + Peak Windowing
Detection	Differential Detection (Coherent possible)	Coherent, Pilot assisted	Coherent in suitable channels
Power Control	Closed Loop Power Control (Step: -1, 0, +1dB;1.153ms/control)	For Further Study	
Diversity	Time-, Frequency-, Interference Diversity Antenna Diversity recommended for Up- & Downlink	Time and Frequency	
Handover	Seamless handover (soft handover not required)	Seamless handover (soft handover not required)	
IF Handover	Supported	Supported	Supported
Base Station Synchronisation	Preferable	Not needed	Not required for unlicensed use. Preferable for licensed use.
Interference Reduction	Interference Diversity (by SFH)	DCA (OFDM orthogonal within one cell)	SFH for licensed use. DRA (DCA) for unlicensed use.
Frequency Reuse Factor	1 Frequency Reuse supported (also 3, 5, 7, 9,...)	Not applicable due to DCA	1 Frequency Reuse supported (also 3, 5, 7, 9, ...)

[1] Assuming a 5 MHz bandwidth for each cell layer, 10 % guardband and 20 % signalling overhead.

4 Concept group Gamma - Wideband TDMA

ETST SMG2#22 Tdoc SMG2 254/97

When the SMG2 UTRA grouping process was defined at the SMG2 UMTS ad hoc meeting in Le Mans, the result to achieve at Milestone 1 was defined (SMG2 Tdoc 22/97). It was stated as a prerequisite that "The proposals being grouped are available in sufficiently described form". At SMG2 #20 and SMG2 #21, several proposals have been presented and elaborate descriptions of these are available. However, it is necessary to take a high level view of the proposal at hand and identify the basic RTTs proposed. This can be done by summarising each proposal in a short table describing the "essence" of the proposals. In the Luleå ad hoc meeting a template for the SMG2 UTRA grouping procedure (Tdoc SMG2 UMTS 26/97) was proposed and it was agreed that the concept groups should present the main multiple access parameters, physical layer structure and other RTT features to SMG 2 according to this template.

This document presents the parameters for Frames FMA1 (SMG2 # 21 Tdoc 45/97) and Philips (SMG2 # 22 Tdoc 199/97) proposals that form the Wideband TDMA concept group.

Main MA parameters	FMA 1 without spreading	Philips
Multiple access method	TDMA	TDMA[1]
Duplexing method	FDD and TDD	FDD and TDD
Channel spacing	1.6 MHz	~ 1.5 MHz
Carrier chip/bit rate	2.6 Mbit/s/5.2 Mbit/s	Any meeting emission mask
Physical layer structure		
Time slot structure	16 or 64 slots/TDMA frame	Flexible slot structure
Frame length	4.615 ms	~ 5 ms
Multirate concept	Multislot	Slot duration
FEC codes	Convolutional codes R = 1/2 and 1/3, punctured	Adaptive
Interleaving	Inter-slot interleaving	Inter slot/inter frame
Modulation	B-OQAM/Q-OQAM	Adaptive
Pulse shaping	Root Raised Cosine, roll-off = 0.35	
Detection	Coherent, based on midamble	
Additional diversity means	Frequency hopping per frame or slot, Time hopping	Frequency hopping per frame
Other RTT features		
Power control	Slow power control, 50 dB dynamic range	
Handover	Mobile assisted hard handover	Soft handover supported
IF handover	Mobile assisted hard handover	Soft handover supported
Interference reduction	Joint detection	
Channel allocation	Slow and fast DCA supported	DCA preferred

[1] Within the slot structure, in the uplink also other methods, e.g. CDMA, can be used

5 Concept Group Delta - Wideband TDMA/CDMA

ETSI STC SMG2#22 Tdoc SMG2 241 /97

Template of Concept Group Delta - Wideband TDMA/CDMA

Main MA parameters	FMA 1 with spreading (FRAMES)	CTDMA (Swiss Telecom PTT)
Multiple Access Method	TDMA/CDMA	CTDMA (CDMA/TDMA)
Duplexing Method	FDD (and TDD)	FDD,TDD
Channel Spacing	1.6 MHz	0.6000, 2.4000, 9.6000 MHz
Carrier chip/bit rate	2.167 MChips/s	0.9984, 3.9936, 15.9744 MChips/s
Physical layer structure		
Time slot structure	8 slots/TDMA frame	1 -13 slots (dynamically)
Spreading	Orthogonal, 16 chips/symbol	length- 13 Barker sequence adaptive Walsh-Hadamard codes (orthogonal even in multipath environments)
Frame length	4.615ms	5ms
Multirate concept	multislot and multicode	various modulation levels, multiple codes, multiple time slots
FEC codes	R = 1/2 and 1/3 (convolutional, punctured)	R = 1/2 (convolutional), R = 3/4 (TCM)
Interleaving	inter-slot interleaving	inter-frame
Modulation	QPSK/16QAM (2Mbps)	BPSK, QPSK, 16-PSK or 16-QAM
Spreading modulation	linearized GMSK	BPSK
Pulse shaping	(linearized GMSK)	root raised cosine, roll-off = 0.2
Defection	coherent, based on midamble	coherent, based on pilot symbols
Additional diversity means	frequency hopping per frame or slot time hopping	Aetna diversity directive antennas
Other RTT features		
Power control	slow, 50dB dynamic range	slow, 50dB dynamic range, 5dB step size
Handover	mobile assisted hard handover	mobile assisted hard handover
IF handover	mobile assisted hard handover	mobile assisted hard handover
Interference reduction	joint detection	maximum-likelihood detection
Channel allocation	slow and fast DCA supported	slow and fast DCA supported
Random accessing (RA)		easy implementation of Spread Aloha RA
Intracell interference	suppressed by joint detection	none (in most environments) little (when long channel excess delays)
Intercell interference	like in other CDMA systems	like in other CDMA systems

6 Concept Group ε: ODMA

SMG2 May 12-16 1997 TDOC SMG2 242/97

In the procedure to define the UMTS Terrestrial Radio Access (UTRA) the ODMA concept group (ε) will develop and evaluate a multiple access concept based on ODMA principles. The group includes proposals from Vodafone Ltd.

ODMA uses intelligent nodes which measure and evaluate their communications options and adapt to exploit the optimum opportunity.

Table 1 gives the main Radio Transmission Technology (RTT) parameters of the ODMA system proposal

Table 1: ODMA (system) RTT Parameters

Main MA Parameters	
Multiple access method	TDMA/FDMA - (without time slot synchronism)
Duplexing method	TDD
Channel spacing	Variable 200 KHz, 2 MHz, 5 MHz
Carrier chip/bit rate	Variable 270 KBPS, 2.7 MBPS, 6.75 MBPS (Use of adaptive multicarrier)
Physical Layer Structure	
Time slot structure	Adaptive time slot length - adaptive packet length.
Spreading	option - to improve efficiency
Frame length	Adaptive packet length
Multirate concept	Variable rate, adaptive segments within packets, adaptive time slots, adaptive frequency, adaptive coding.
FEC codes	Convolutional codes R = 1/2 and 1/3, punctured
Interleaving	Within packet
Modulation	GMSK (alternatives for further study)
Pulse shaping	Root Raised Cosine, roll-off = 0.35
Detection	Coherent, based on preamble
Additional diversity means	Opportunistically on packet by packet basis, space via relaying, time hopping and frequency hopping.
Other RTT Features	
Power control	Fast open loop and fast closed loop on a packet by packet basis
Handover	Mobile assisted soft handover on a packet by packet basis - multi relay.
IF handover	
Interference reduction	Intelligent detection and avoidance at mobile and each relay.
Channel allocation	Fully dynamic and adaptive

ODMA has been proposed to SMG2 in the form of 3 papers i.e.;

[l] Vodafone and Salbu "ODMA-Opportunity Driven Multiple Access" SMG2 UMTS Workshop - Sophia Antipolis 1996.

[2] Vodafone and Salbu "Characteristics of Opportunity Driven Multiple Access" SMG2 UMTS 30/97.

[3] Vodafone and Salbu "ODMA System Gain from Fast Fading" SMG2 163/97.

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