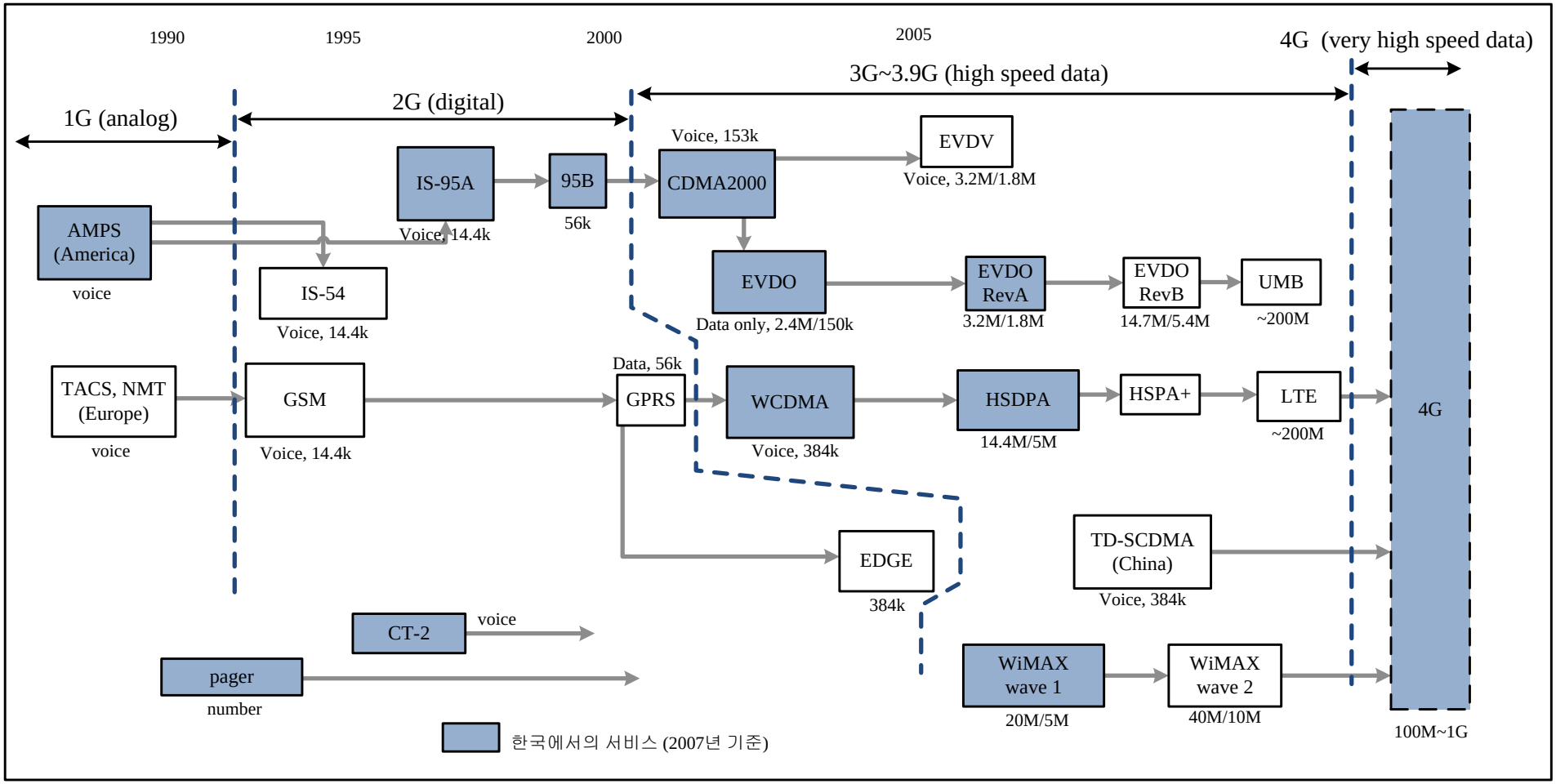
Evolution of Wireless Mobile Communication



1G and 2G cellular Systems

- Advanced Mobile Phone System (AMPS)
  - Developed by Bell Labs in the 1970s and first used commercially in the United States in 1983. It operates in the 800 MHz band (1G) by AT&T
  - Full duplex (FDX) operation : simultaneous two-way communication
    - two 30 kHz channels (forward & reverse)
  - Analog frequency modulation (FM) used exclusively
  - Frequency Division Multiple Access (FDMA)
    - one channel per pair of users

2G cellular Systems

- 2G Overview
  - The European Global System for Mobile Communications (GSM), is introduced in 1992
  - The North American Digital AMPS (D-AMPS), is introduced in 1994
    - IS-54: FDMA/TDMA access mode
    - IS-95: CDMA access mode
  - The First CDMA commercial service was started in Korea in 1996
  - The Japanese Digital Cellular (JDC) system, is introduced in 1992, PDC (Personal Digital Cellular)
  - The North American Personal Communication System operating at 1900 MHz (PCS 1900)

GSM Overview

- Global System for Mobile (GSM) Communication
  - GSM is a second generation cellular standard developed to cater to voice services and data delivery using digital modulation
  - Digital Communication technology
  - GSM networks operate in a number of different frequency ranges
    - Most 2G GSM networks :900 MHz or 1800 MHz bands.
    - Some countries in the Americas: 850 MHz and 1900 MHz bands
    - Most 3G GSM networks in Europe operate in the 2100 MHz frequency band.

- History
  - Developed by Group Spéciale Mobile (founded 1982) which was an initiative of CEPT (Conference of European Post and Telecommunication)
  - Developed to replace the incompatible analog system
  - Presently the responsibility of GSM standardization resides with special mobile group under ETSI(European telecommunication Standards Institute)
  - Full set of specifications phase-I became available in 1990 . Under ETSI, GSM is named as " Global System for Mobile communication "

GSM System (cont'd)

- Advantages
  - Worldwide used with over millions of subscribers.
  - International roaming
  - Robust to channel noise compared to FDMA
  - GSM's maturity means engineers cut their teeth on the technology, creating an unconscious preference.
  - The availability of Subscriber Identity Modules, which are smart cards that provide secure data encryption give GSM advantages.
- Disadvantages
  - Low Data rate
  - Strict synchronization and guard time needed
  - Still susceptible to jamming, and other-cell interference

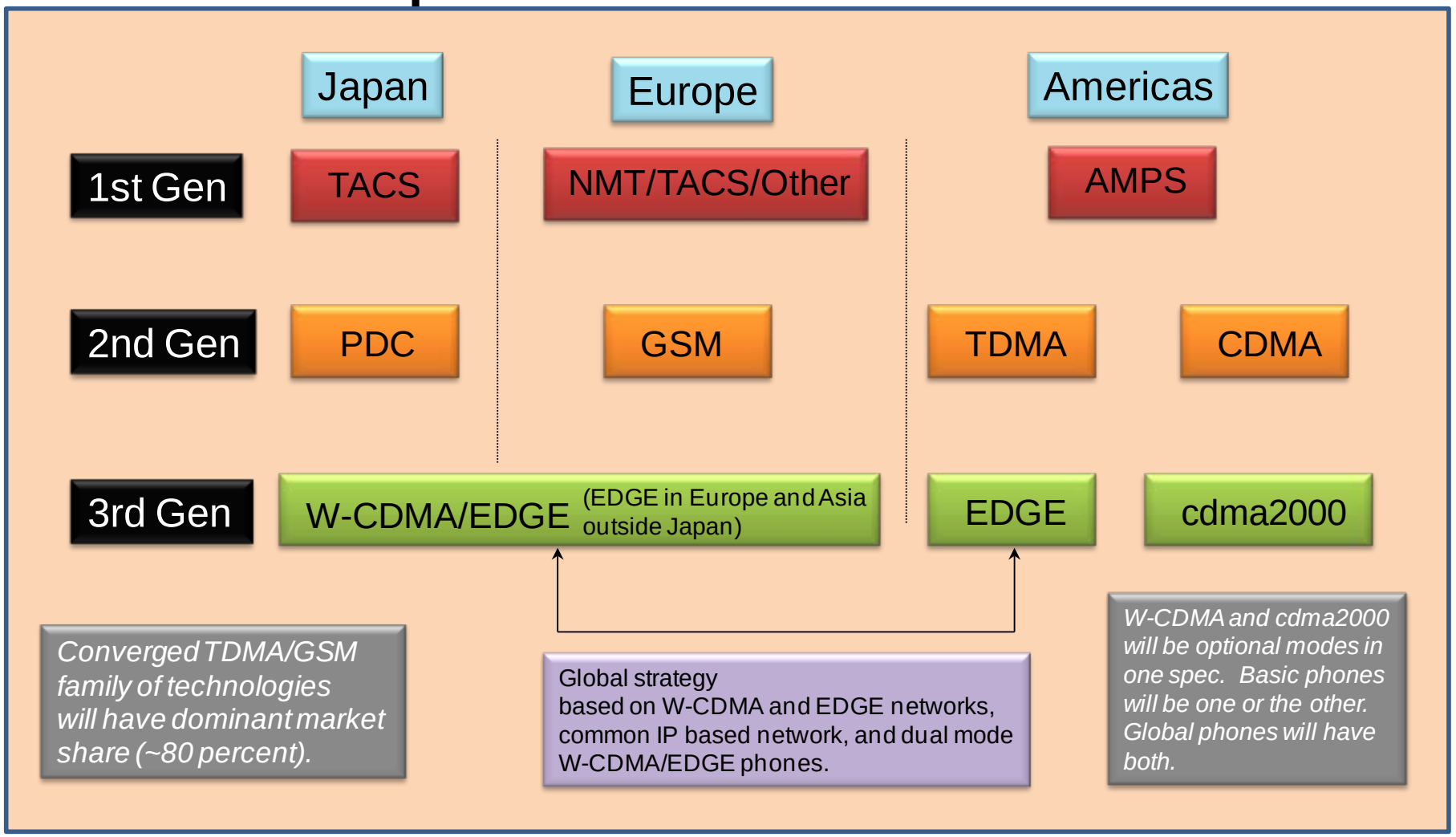
CDMA System

- History
  - In 1993, TIA recognized CDMA as an IS-95 Standard
  - Korea government promote to commercialize the technology in two parts
    - ETRI and Qualcomm took charge of switch design, prototype development and base transmit station
    - Handset manufactures developed new mobile handsets and switching system
  - Core chip for CDMA communication was successfully developed by Qualcomm
    - Power control was a key issue
    - A complex high tech chip of the times
- Keypoint
  - "multiple access" : a large number of users share a common pool of radio channel bandwidth and any user can gain access to any channel
  - Idea derived from military & developed by Qualcomm, USA around late 1980's
  - Use Spreading Sequence for spreading gain
  - One common frequency band for all users
  - Separation between users can be done by user-specific code

CDMA vs. GSM

Note	CDMA (Code Division Multiple Access)	GSM (Global System for Mobile Com.)
Adopted year	1996	1989
Users rate (`05)	20%	70%
Region	America, South-Korea, Mongol	Europe, South America, Most country
3G	CDMA-2000	W-CDMA

Development from 2G to 3G



IMT-2000

- International Mobile Telecommunication (IMT)-2000
  - Better known as 3G or 3rd Generation, is a family of standards for mobile telecommunications defined by the International Telecommunication Union
  - Which includes GSM EDGE, UMTS, and CDMA2000 as well as DECT and WiMAX
  - Compared to 2G and 2.5G services, 3G allows simultaneous use of speech and data services and higher data rates (up to 14.0 Mbit/s on the downlink and 5.8 Mbit/s on the uplink with HSPA+)
  - Thus, 3G networks enable network operators to offer users a wider range of more advanced services while achieving greater network capacity through improved spectral efficiency

2G vs. 3G

	2G		3G(IMT-2000)
Service	Low-speed Data service(Voice)		High-quality Data service(Multi-media)
User	Customer > Customer		Customer<->Customer, IP<-> Customer
Traffic trend	Land to Mobile		Mobile to Land
Mobility	domestic, limited global roaming		Global roaming
Frequency band	Mobile	824 ~ 849MHz 869 ~ 894MHz	1885 ~ 2025MHz 2110 ~ 2200MHz
	PCS	1750 ~ 1780MHz 1840 ~ 1870MHz	
Standard	CDMA, TDMA		W-CDMA, CDMA2000
Minimum bandwidth	1.25MHz, 30KHz		5MHz

3G Technologies

- Two key Technologies : All based on CDMA technology
- Synchronous Vs. Asynchronous
  - Synchronous (3GPP2)
    - Synchronous method that obtain standard time using GPS
    - Each Base Station uses the same PN code
    - Base Station classification PN code with time epoch difference
    - CDMA2000 1X, EV-DO, EV-DV
  - Asynchronous (3GPP)
    - Asynchronous method with different PN code for each Base Station
    - W-CDMA, HSPA, HSPA+

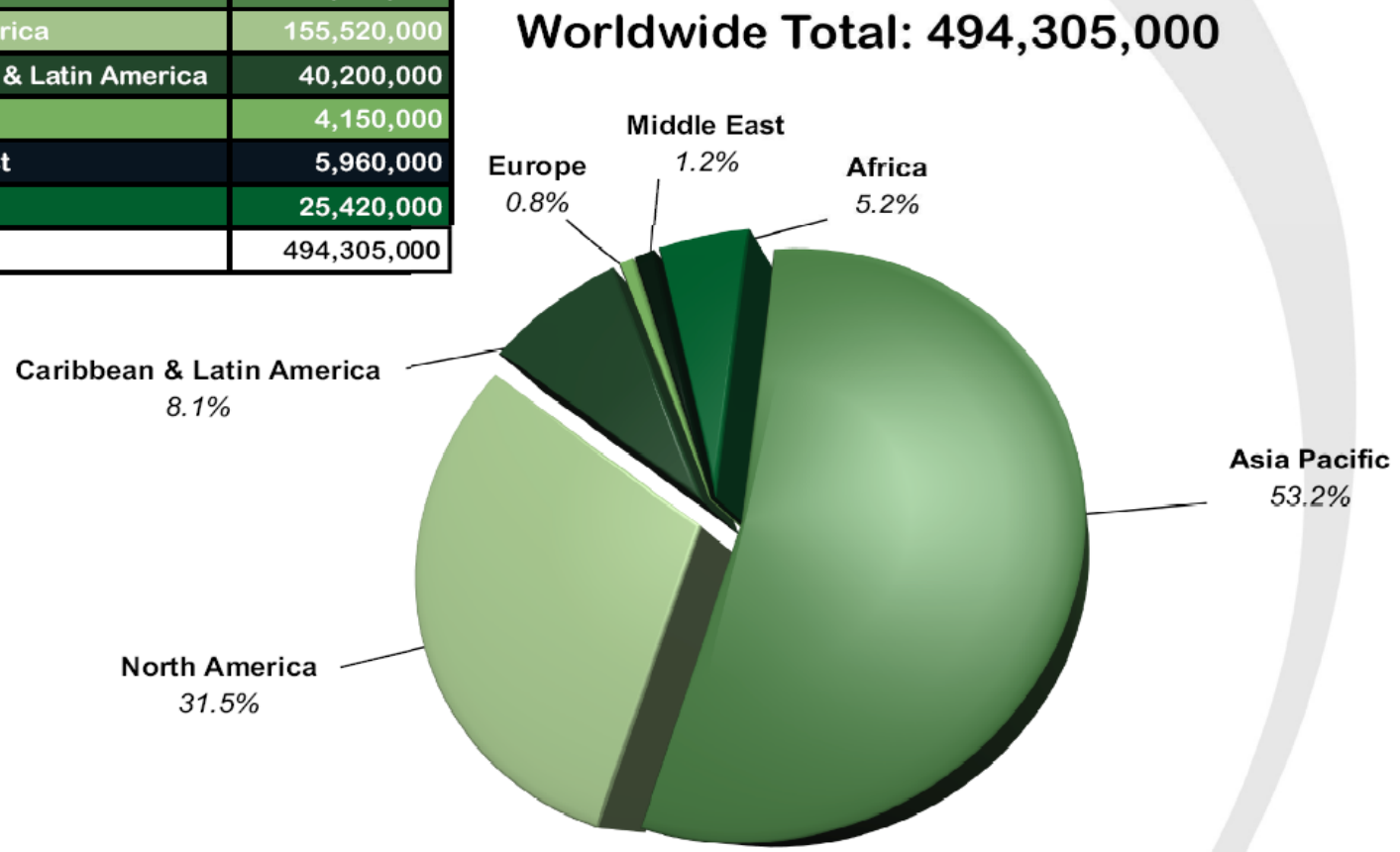
3G Technologies

	W-CDMA	CDMA2000
Leading area	Europe, Japan	North America
Standard organization	3GPP	3GPP2
Sync. Between BS	Asynchronous method with different PN code for each base station	Synchronous method that obtain standard time using GPS
Initial time Sync.	Relatively long	Relatively short(Same PN code)
Cell Planning	Relatively easy (Asynchronous BS does not consider neighbor BS and cell radius)	Relatively difficult (Synchronous BS considers time-offset of neighbor BS's PN code)
System developer	Ericsson, Nokia, NTT DoCoMo	Qualcomm, Lucent, Motorola
Core Network	GSM-MAP	ANSI-41
Base technology	GSM	IS-95
Chip rate	3.84Mcps	3.6864Mcps

CDMA2000 (3GPP2)

CDMA2000 Subscriber Statistics: June 2009

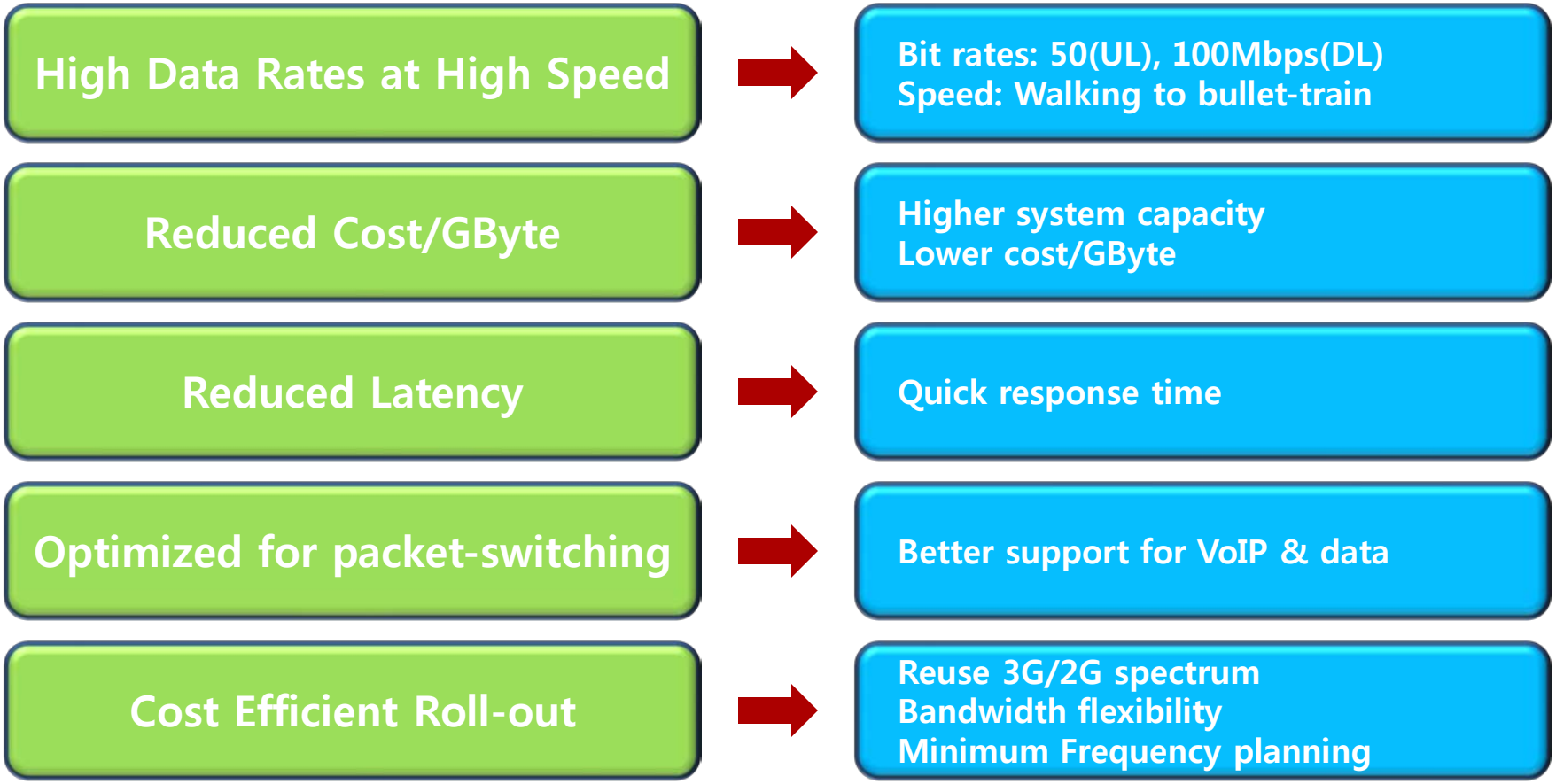
Asia Pacific	263,055,000
North America	155,520,000
Caribbean & Latin America	40,200,000
Europe	4,150,000
Middle East	5,960,000
Africa	25,420,000
Total	494,305,000



4G Wireless -3GPP LTE

- 3GPP LTE (Long Term Evolution)
  - the last step toward the 4th generation (4G) of radio technologies designed to increase the capacity and speed of mobile telephone networks
  - Considered as 3.5G system
  - Uses Orthogonal Frequency Division Multiple Access(OFDMA) on the downlink
  - Downlink peak rates of at least 100 Mbps, an uplink of at least 50 Mbit/s
  - RAN round-trip times of less than 10 ms
  - Supports scalable carrier bandwidths, from 20 MHz down to 1.4 MHz
  - Supports both FDD and TDD
  - Adopted all-IP signaling and networking
    (A significant departure from 3G W-CDMA, which adopts circuit switching)

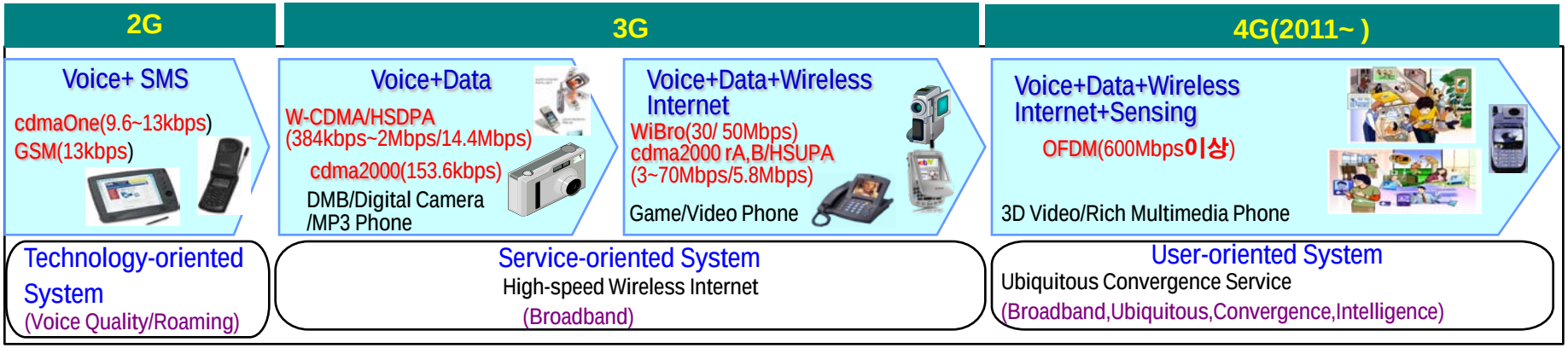
3GPP LTE

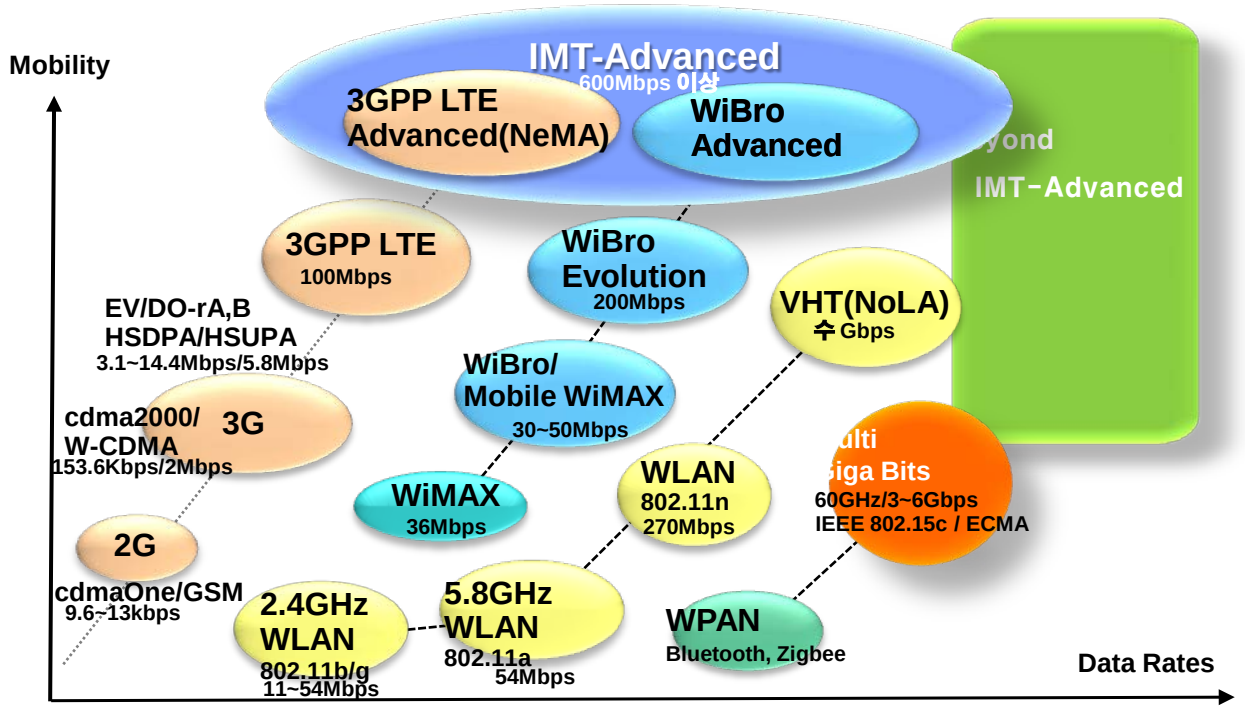

High Data Rates at High Speed
Bit rates: 50(UL), 100Mbps(DL)
Speed: Walking to bullet-train
Reduced Cost/GByte
Higher system capacity
Lower cost/GByte
Reduced Latency
Quick response time
Optimized for packet-switching
Better support for VoIP & data
Cost Efficient Roll-out
Reuse 3G/2G spectrum
Bandwidth flexibility
Minimum Frequency planning

3GPP LTE

		3G and Enhanced 3G			4G
		R99/R4	Mid-term evolution	3G LTE	New mobile access
Spectrum		3G spectrum (2GHz band the additional band(s))			New spectrum
Radio aspect		WCDMA	HSDPA, EDCH etc	Ultimate enhancement	New spectrum
	Radio Access	Direct-Sequence CDMA		Ultimate enhancement	New radio Interface
	Min. TTI (Latency)	10msec	2ms	=< 0.5ms	
	Carrier Bandwidth	5MHz		5-20MHz Fit in 5MHz	100MHz
	Data rate	384k-2Mbps	14Mbps	30-100Mbps	100Mbps-1Gbps
NW aspect		CS and PS		PS only	
		GTP(tunneling) [IP routing in CN]		IP routing In CN and RAN	

Overview of Mobile Communication





HSDPA: High-Speed Downlink Packet Access

HSUPA: High-Speed Uplink Packet Access

WPAN: Wireless Personal Area Network

NeMA: New Mobile Access

NoLA: New Nomadic/Local Area Wireless Access

OFDM: Orthogonal Frequency Division Multiplexing

MIMO: Multiple Input Multiple Output

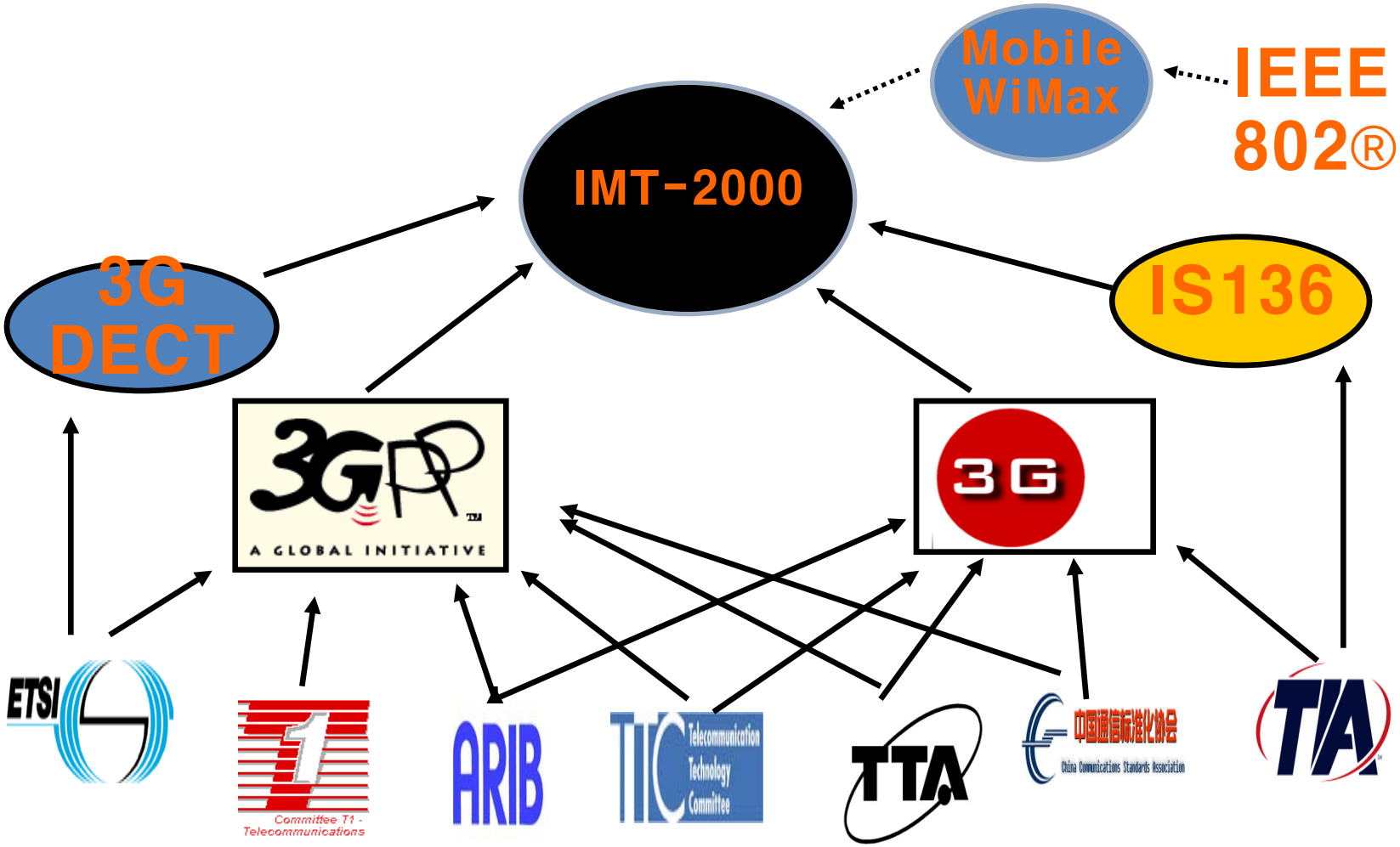
SDR: Software Defined Radio

3GPP LTE : 3GPP Long Term Evolution

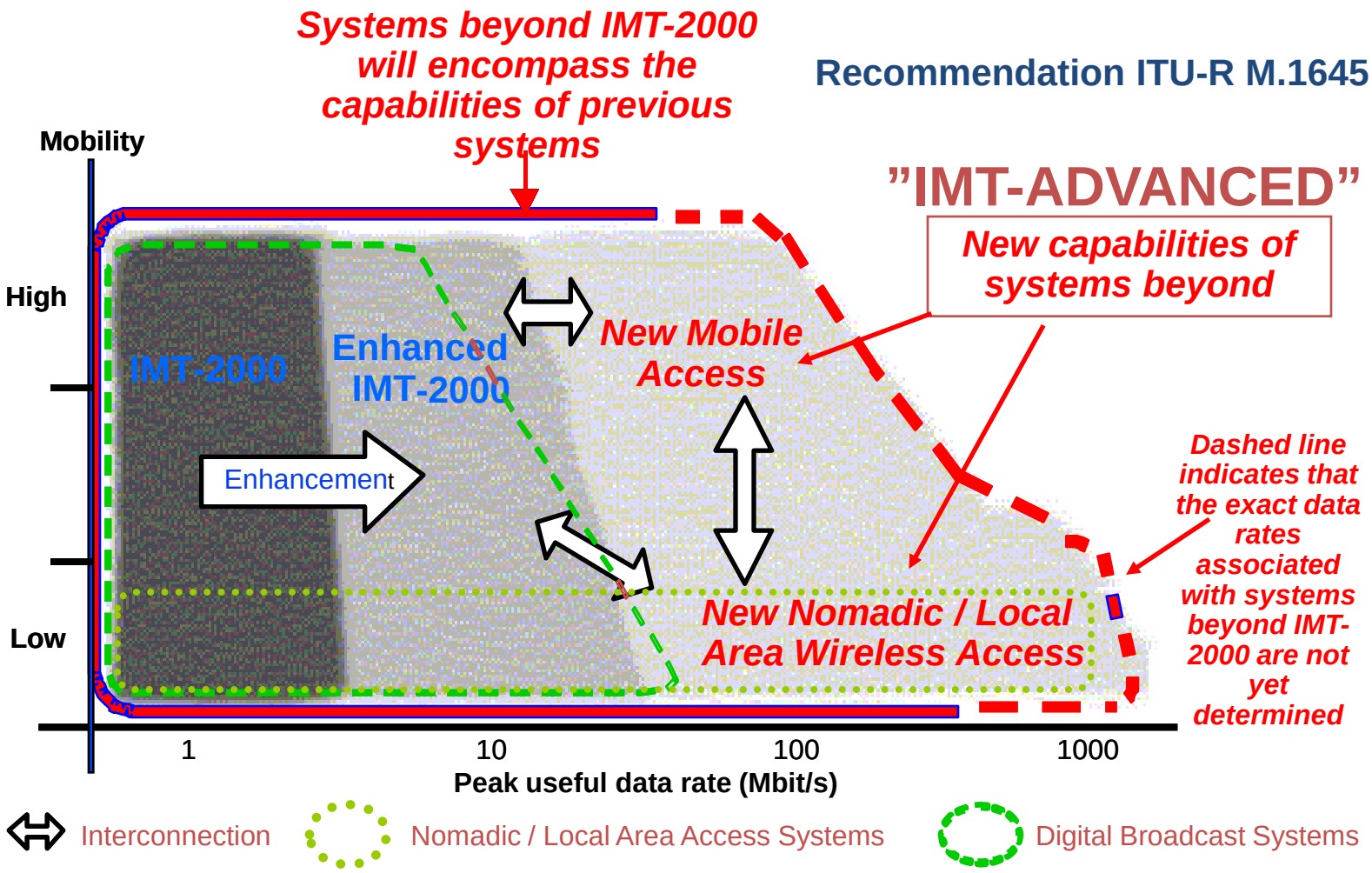
GSM : Global System for Mobile Communications

ECMA: European Computer Manufacturers Association

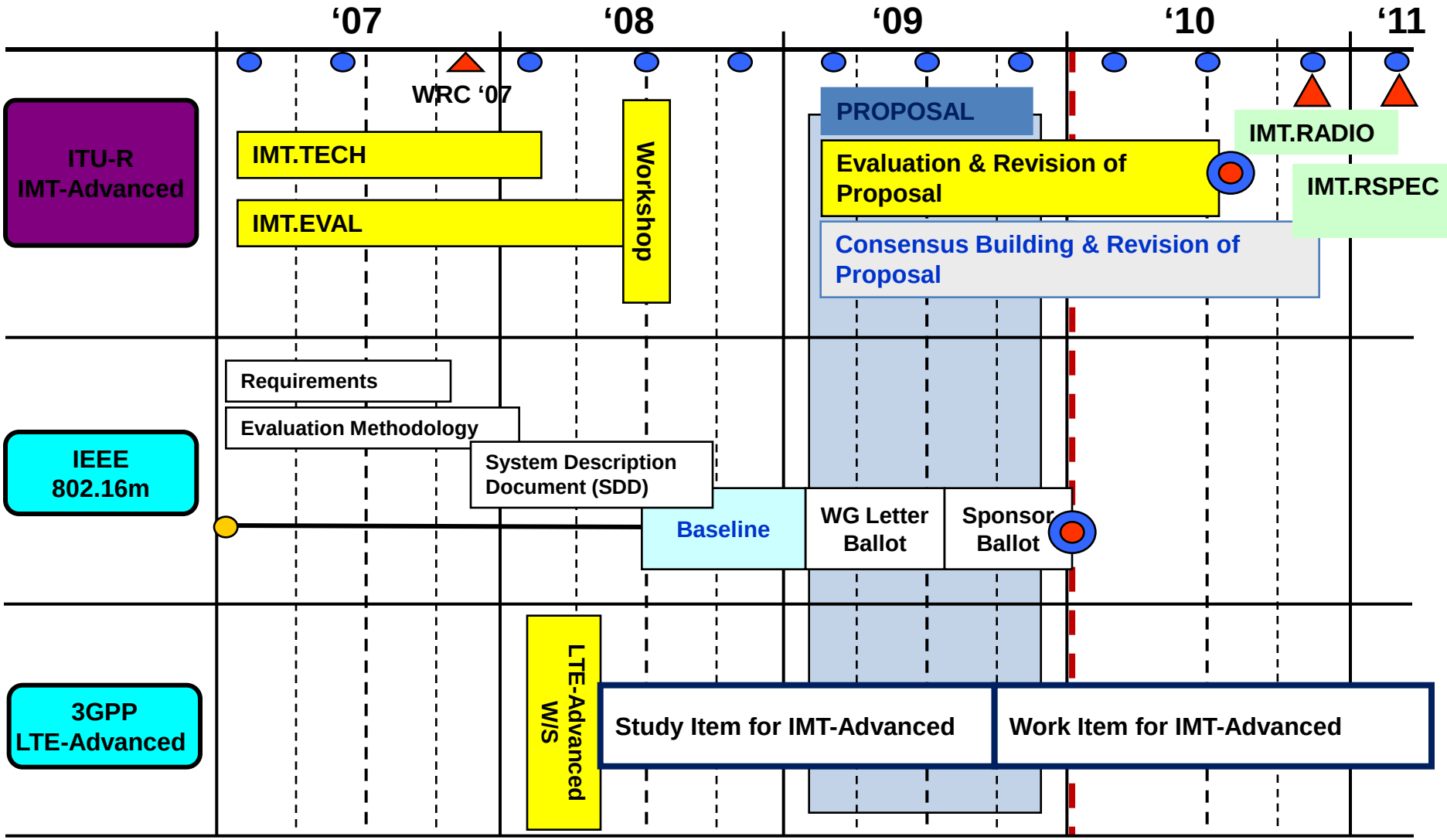
Harmonization of IMT-2000



Capabilities of IMT



Schedule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'08
'09
'10
'11
WRC '07
ITU-R
IMT-Advanced
IMT.TECH
IMT.EVAL
Workshop
PROPOSAL
Evaluation & Revision of Proposal
Consensus Building & Revision of Proposal
IMT.RADIO
IMT.RSPEC
IEEE
802.16m
Requirements
Evaluation Methodology
System Description Document (SDD)
Baseline
WG Letter Ballot
Sponsor Ballot
3GPP
LTE-Advanced
LTE-Advanced W/S
Study Item for IMT-Advanced
Work Item for IMT-Advanced