Evolution for 2.5 G TDMA standards:

4.1 HSCSD for 2.5 G GSM:

- As the name implies, High Speed Circuit Switched Data is a circuit switched technique that allows a single mobile subscriber to use consecutive user time slots in the GSM standard.
- That is, instead of limiting each user to only one specific time slot in the GSM TDMA standard, HSCSD allows individual data users to commandeer **(officially take possession or control)** consecutive time slots in order to offer higher speed data access to the GSM network.
- HSCSD relaxes the error control coding algorithms originally specified in the GSM standard for data transmissions, and increases the available application data rate to 14,400 bps, as compared to the original 9,600 bps in the GSM specification.
- By using up to 4 consecutive time slots, HSCSD is able to provide a raw transmission rate of up to 57.6 kbps to individual users, and this enhanced data offering can be billed as a premium service by the carrier.
- HSCSD is ideal for dedicated streaming internet access or real-time interactive web sessions, and simply requires the service provider to implement a software change at existing GSM base stations.

4.2 GPRS for 2.5 G GSM and IS-136:

- General Packet Radio Service is a packet based data network, which is well suited for non-real time Internet usage, including the retrieval of email, faxes, and asymmetric web browsing, where the user downloads much more data than it uploads on the Internet. GPRS supports multi-user network sharing of individual radio channels and time slots.
- Thus, GPRS can support many more users than HSCSD, but in a burst manner. The GPRS standard provides a packet network on dedicated GSM or IS-136 radio channels. GPRS retains the original modulation formats specified in the original 2G TDMA standards, but uses a completely redefined air interface in order to better handle packet data access.
- When all eight time slots of a GSM radio channel are dedicated to GPRS, an individual user is able to achieve as much as 171.2 kbps (eight time slots multiplied by 21.4kbps of raw uncoded data throughout).
- Applications are required to provide their own error correction schemes as part of the carried data payload in GPRS. Implementation of GPRS merely requires the GSM operate to install new routers and Internet gateways at the base

station, along with new software that redefines the base station air interface standard for GPRS channels and time slots- no new base station RF hardware is required.

- The dedicated peak 21.4 kbps per channel data rate specified by GPRS works well with both GSM and IS-136 and has successfully been implemented.

4.3 EDGE for 2.5vg GSM and IS-136:

- EDGE, which stands for Enhanced Data rates for GSM (or global) Evolution is a more advanced upgrade to the GSM standards, and requires the addition of new hardware and software at existing base stations.
- EDGE was developed from the desire of both GSM and IS-136 operates to have a common technology path for eventual 3G high speed data access. EDGE introduces a new digital modulation format, 8-PSK (octal phase shift keying), which is used in addition to GSM's standard GMSK modulation.
- EDGE allows for nine different (autonomously and rapidly selectable) air interface formats, known as multiple modulation and coding schemes (MCS), with varying degrees of error control protection.
- Because of the higher data rates and relaxed error control covering in many of the selectable air interface formats, the coverage range is smaller in EDGE than in GPRS.
- EGDE is sometimes referred to as Enhanced GPRS, or EGPRS. The adaptive capability of EDGE to select the "best" air interface is called incremental redundancy, whereby packets are transmitted first with maximum error protection and maximum data rate throughput, and then subsequent packets are transmitted with less error protection (usually using punctured convolutional codes) and less throughput, until the link has an unacceptable outage or delay.
- Rapid feedback between the base station and subscriber unit then restores the previous acceptable air interface state, which presumably at an acceptable level but with minimum required coding and minimum bandwidth and power drain.

4.4 IS-95B for 2.5G CDMA:

- Unlike the several GSM and IS -136 evolution paths to high speed data access, CDMA (often called cdmaOne) has a single upgrade path for eventual 3G operation.
- The interim data solution for CDMA is called IS-95B is already being deployed worldwide, and provides high speed packet and circuit switched data access on

a common CDMA radio channel by dedicating multiple orthogonal user channels (Walsh functions) for specific users and specific purposes.

- Each IS-95 CDMA radio channel supports up to 64 different users channels. The original IS-95 throughput rate specification of 9600 bps was not implemented in practice, but was improved to the current rate of 14,400bps as specified in IS-95A. The 2.5G CDMA solution, IS-95, supports medium data rate (MDR) service by allowing a dedicated user to command up to eight different user Walsh codes simultaneously and in parallel for an instantaneous throughput of 115.2 kbps per user (8*14.4 kbps).
- However only about 64 kbps of practical throughput is available to a single user in IS-95B due to the slotting techniques of the air interface IS-95B also specifies hard handoff produces that allow subscriber units to search different radio channels in the network without instruction from the switch so that subscriber units can rapidly tune to different base stations to maintain link quality.
- Prior to IS-95B, the link quality experienced by each subscriber had to be reported back to the switch through the serving base station several times per second, and at the appropriate moment, the switch would initiate a soft-handoff between the subscriber and candidate base stations.
- The new hard handoff capability of IS-95B is more efficient for multiple channel systems now being used in today's more congested CDMA markets.

IMT 2000

4.5 IMT 2000 Vision and Evolution Aspects:

- The International Telecommunication Union (ITU), the United Nations organization responsible for global telecommunications standards, has been working since 1986 toward developing an international standard for wireless access to worldwide telecommunication infrastructure.
- This standard is known as IMT- 2000, for International Mobile Telecommunications 2000, where 2000 indicates the target availability date (year 2000) as well as the operational radio frequency band (2000 MHz range) for the standard. Until 1997, IMT-2000 was known as Future Public Land Mobile Telecommunication Systems (FPLMTS).

IMT-2000 Vision

- Common spectrum worldwide (1.8-2.2 GHz band)
- Multiple radio environments (cellular, cordless, satellite, LANs)
- Wide range of telecommunications services (voice, data, multimedia, internet)
- Flexible radio bearers for increased spectrum efficiency
- Data rates up to 2 Mb/s (phase 1)—for indoor environments
- Maximum use of IN capabilities (for service provision and transport)
- Global seamless roaming
- Enhanced security and performance
- Integration of satellite and terrestrial systems

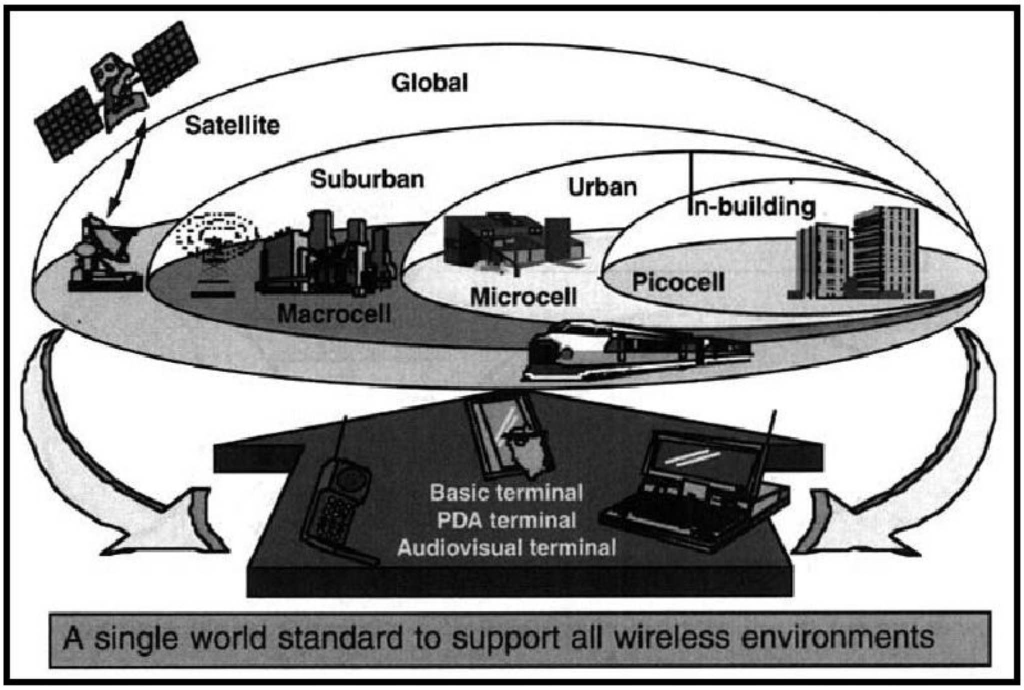

Figure: Scope of mobile services environments for IMT-2000.

In scope, IMT-2000 service environments will address the full range of mobile and personal communication applications shown in Figure: in-building (picocell), urban (microcell), suburban (macrocell), and global (satellite), as well as communications types that include voice, data, and image. Support of communication needs for developing countries in the form of fixed wireless access (FWA) applications is also included in the scope of IMT-2000.

IMT-2000 Evolution Aspects:

- Whereas the vision for IMT-2000 implies significant departures from the second- generation mobile and personal communication systems in terms of range of environments and services, as well as seamless global mobility, it is expected that IMT-2000 systems will essentially evolve from existing wireless and wireline systems as illustrated in Figure.

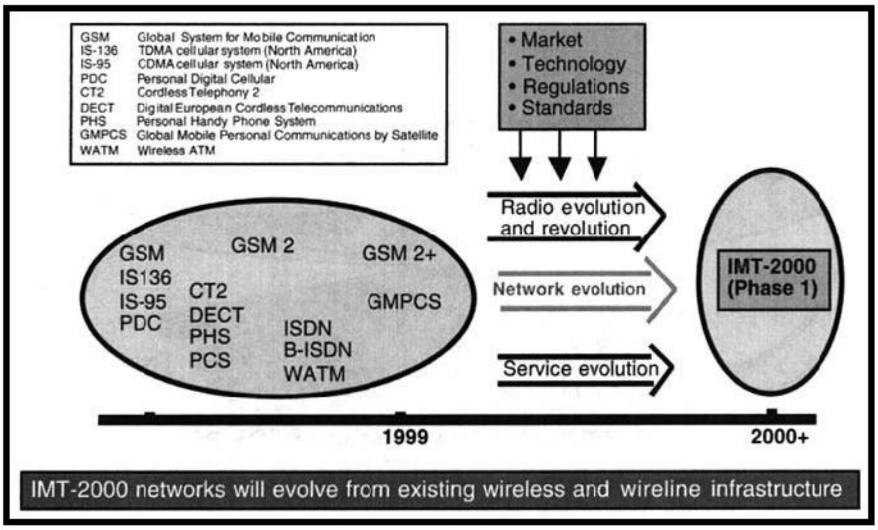

Figure: Evolution of IMT 2000

- To provide required spectrum efficiency and capacity, the choice of the radio interface or radio transmission technology (RTT) for IMT-2000 may require a step change from the radio transmission technologies deployed in the current wireless/PCS systems.
- A number of radio transmission technologies have been developed for IMT-2000 in various parts of the world and were submitted to ITU-R for evaluation and for final selection by the end of 1999.
- The IMT-2000 networks, on the other hand, will need to evolve from the existing wireless and wireline networks, because it is not economical to replace existing network infrastructures by a completely new one.
- The pace of such an evolution will be determined by factors related to market demand, technology,regulation, and standardization. The IMT-2000 family of systems concept adopted in the ITU-T reflects the industry view that there will be multiple IMT-2000 systems, each one being a member of the IMT-2000 family (e.g., GSM-based family members, ANSI-41-based family members).
- Whereas systems belonging to different family member groups will interoperate via ITU-defined interfaces to provide seamless global roaming and service delivery, systems belonging to the same family member group will continue to interoperate via interface definitions developed by the relevant regional/national standards forum.

4.6 IMT-2000 RADIO ASPECTS:

Radio Spectrum for IMT-2000:

- Uplink 1885-2025 MHz (1980-2010 MHz for mobile satellite service)
- Downlink 2110-2200 MHz (2170-2200 MHz for mobile satellite service)
- **Transmission Modes:**
    - Terrestrial wide-area systems like cellular mobile and the satellite applications will require paired bands for frequency division duplex (FDD) transmission, but short-range systems used for indoor and pedestrian-type applications can use unpaired asymmetrical band with time division duplex (TDD) transmission.
    - To prevent traffic asymmetry and the resultant loss in spectrum efficiency, an optimal combination of FDD and TDD transmissions must be utilized. To maximize system capacity while maintaining flexibility, the exact split between paired and unpaired band spectra needs to be considered carefully.
- **Duplex Direction:**
    - The lower band of frequencies is identified for uplink (mobile to base station) and the upper band for the downlink (base station to mobile). This is considered to be the normal FDD duplex direction for the following reasons:
    - It relaxes the transmit power requirements (hence increases battery life) for mobile stations because assigning the lower frequency provides a lower propagation loss.
    - The commonality of the frequency usage plans between the satellite component and the FDD-based terrestrial component of IMT-2000 greatly facilitates the use of dual-mode mobile terminals supporting both satellite and terrestrial communications.
- **Spectrum Efficiency and Sharing:**

Four main factors affect spectrum efficiency:

- **radio transceiver technology** which includes access technology, modulation and coding, adaptive interference management, diversity techniques, and smart antenna technology
- **applications and services technology** including the use of packet transmission, asymmetry management, and data compression techniques
- **traffic management** via delay management and the use of tariffs to reduce peak-to-average traffic ratios
- **radio channel access management** by real-time management of access to the spectrum (to maximize spectrum utilization during peak traffic loads)

Radio Transmission Technologies (RTTs) for IMT-2000:

- basic requirement is the need for IMT-2000 terminals to be able to roam globally and receive telecommunications services offered by IMT-2000 networks. Key features of the radio access for IMT-2000 therefore include the following:
  - high level of flexibility
  - cost-effectiveness in all operating environments
  - commonalty of design worldwide
  - operation within the designated MT-2000 frequency bands
- The choice of the technical criteria is intended to provide a good assessment of the IMT-2000 system aspects that are dependent on radio transmission technologies. These technical criteria include the following:
  - spectrum efficiency
  - technology complexity—cost of installation and operation
  - quality of service
  - flexibility
  - impact on network interfaces
  - performance and capacity impacts on handheld terminals
  - coverage efficiency
  - power efficiency
- for a single, flexible standard that will support multiple modes including the following harmonized CDMA modes:
  - **CDMA/FDD Direct Sequence**
  - **CDMA/FDD Multi Carrier**
  - The harmonized chip rate proposed for CDMA/FDD Direct Sequence mode is 0.96 X 4 = 3.84 Mcps (as opposed to 4.096 Mcps in the original proposals), whereas the chip rate of 1.2288 X 3 = 3.6864 Mcps is retained for the CDMA/FDD Multi Carrier mode.
- The global radio control channel (physical or logical implementation) is expected to carry information of the following types:
  - bands used for IMT-2000, including extension bands
  - frequency rasters
  - modulation characteristics
  - identification of bands for public and private use
  - guard bands
  - duplex direction and spacing
  - list of available services in the network
  - applicable tariffs (if available).