RADIO LINK ASPECT OF GSM

- The GSM spectral allocation is 25 MHz for base transmission (935 – 960 MHz) and 25 MHz for mobile transmission
  - With each 200 KHz bandwidth, total number of channel provided is 125 full duplex channels
    - Modulate at rate 270.833 kbps
  - Using TDMA, each 200 KHz channel is used to provide 8 logical channels
  - GSM uses a complex hierarchy of TDMA frames
    - The lowest level of slot is called as time slot. Each slot has duration of approximately 0.577 ms
    - With rate of 270.833 kbps, each slot has length of = bits
    - The next level of slot, called as frame, which is made up 8 time slots, will have duration of = seconds

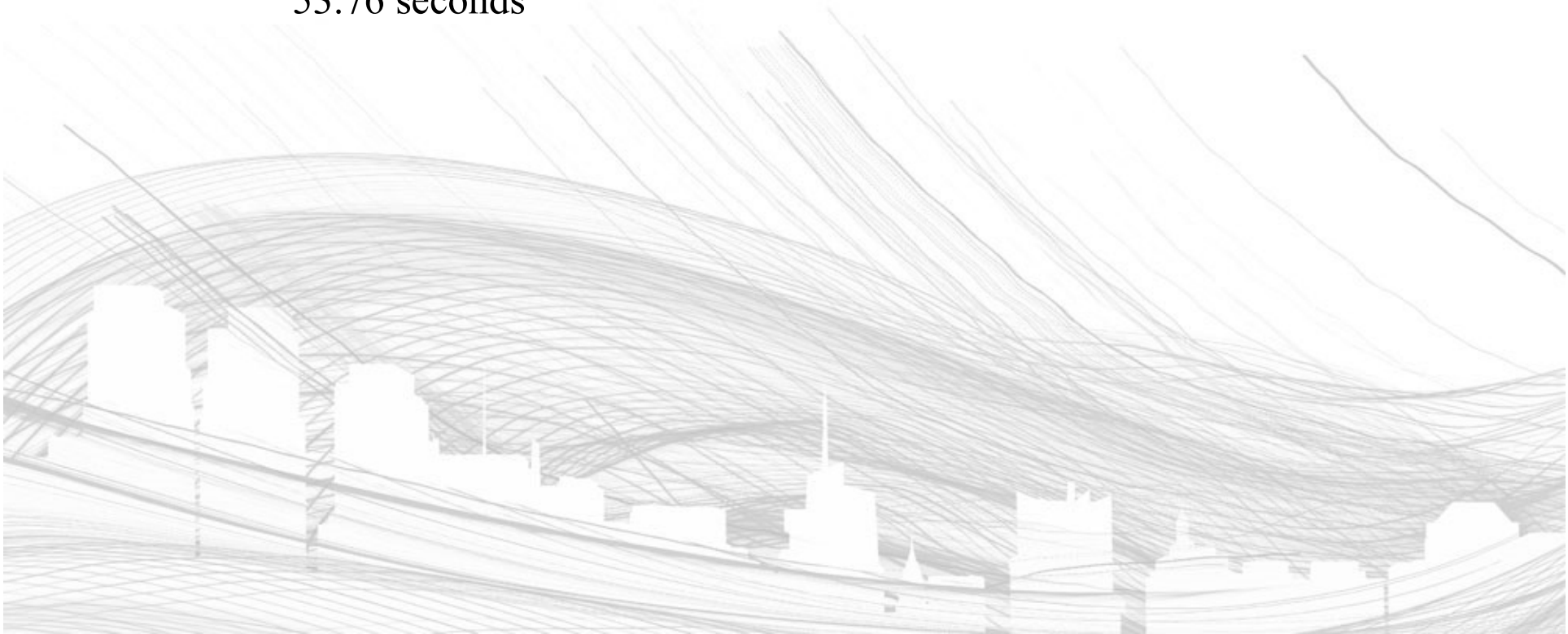
RADIO LINK ASPECT OF GSM

- In each time slot, only 114 bits out of 156 bits used for data traffic
  - The resulting gross rate is about 22.8 Kbps for each traffic multi-frame
- A set of frames forms a multi-frame
  - One multi-frame comprises either 26 or 51 frames
  - A 26 frames multi-frame is called as Traffic multi-frame, while a 51 frames multi-frame is called as control traffic multi-frame
  - For 26 frame version, one of the frames is used for controlling signal and another is currently unused, which results in 24 frames for data traffic.
  - Total duration of one multi-frame of 24 frame is = seconds
- A set of multiframe form a superframe
  - One superframe comprises either 51 multiframes or 26 multiframes
  - For Traffic channels, a superframe comprises 51 multiframes, while Control traffic contains multiframes

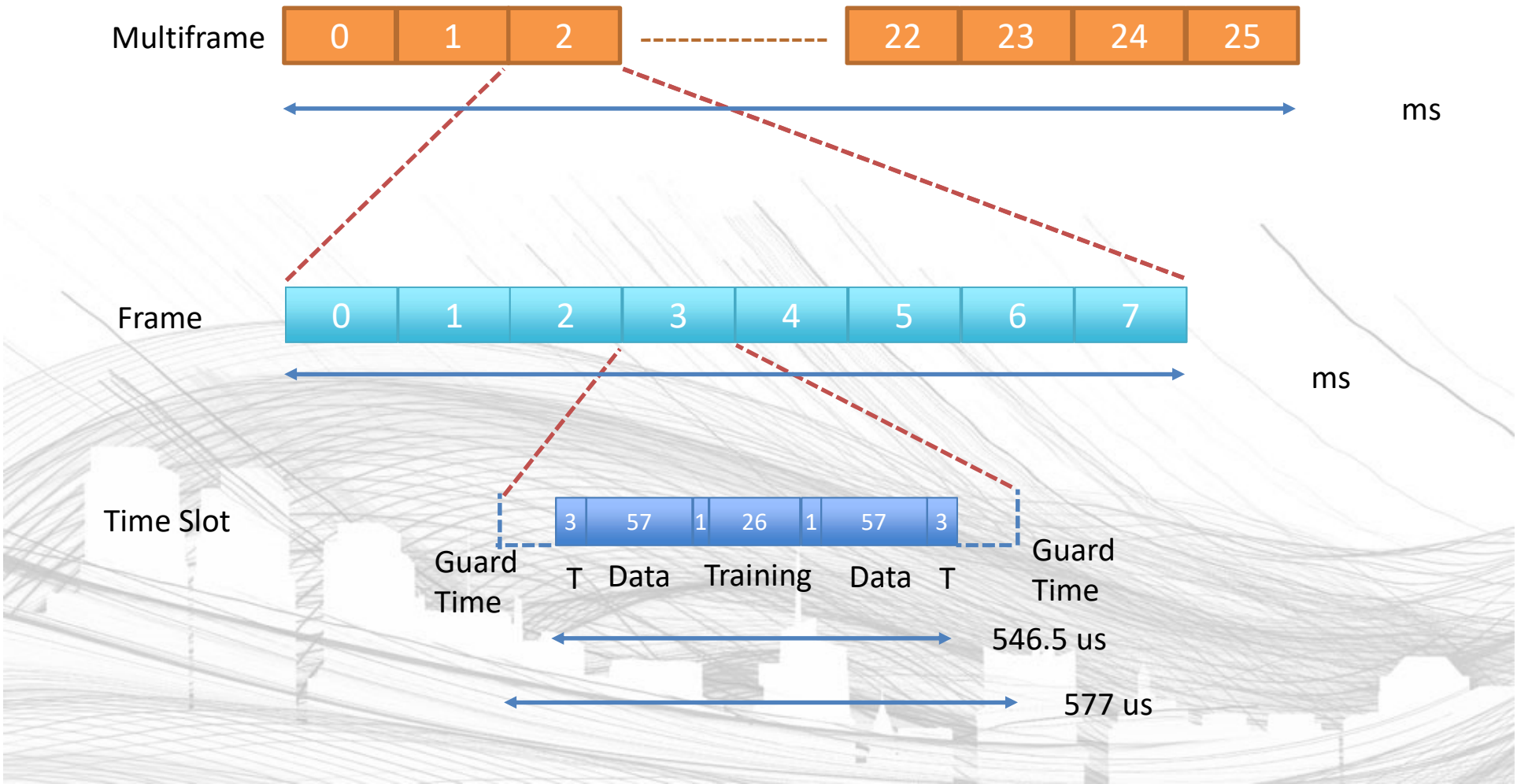
RADIO LINK ASPECT OF GSM

- The duration of a Traffic channel superframe would be = seconds

– A set of superframes forms a hyperframe
  - Consist of 2048 superframes with duration of 3 hours 28 minutes, 53.76 seconds

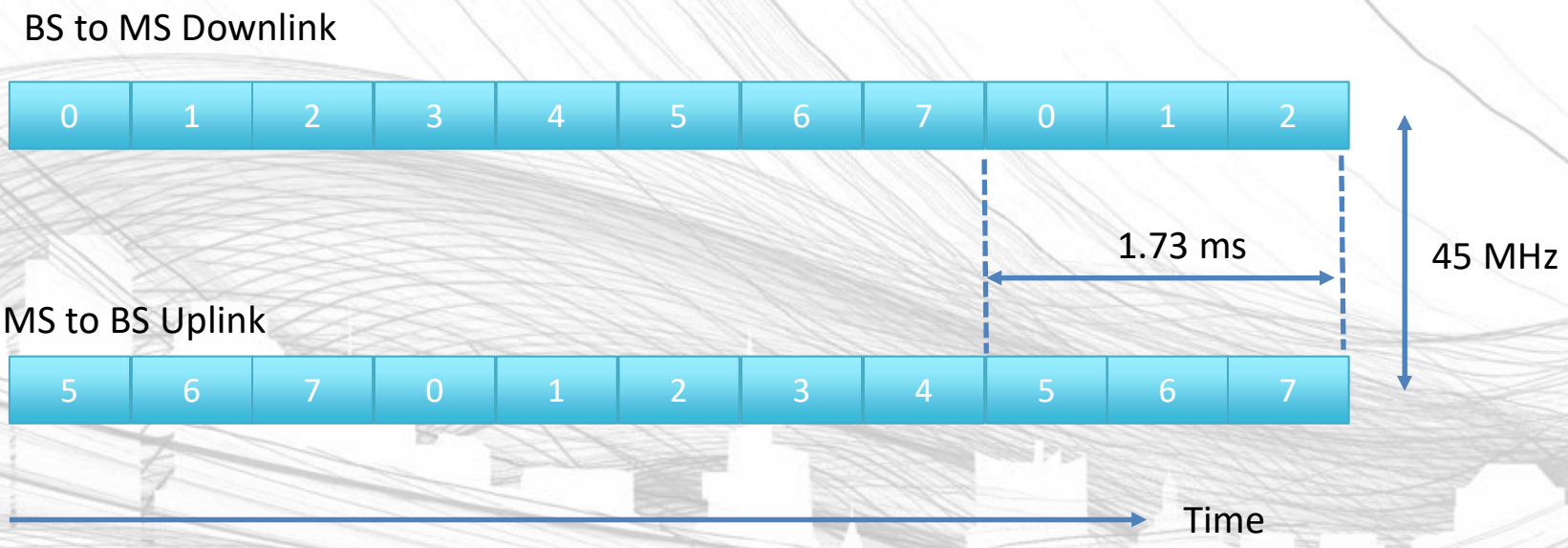


FRAMES TO MULTIFRAME IN GSM : ILLUSTRATED



RADIO LINK ASPECT OF GSM

- Uplink and Downlink channels has 3 slot offset
  - So that MS doesn't have to transmit and receive simultaneously
  - MS can also take measurements during this offset time and delay between next frame



LOGICAL CHANNELS IN GSM

- The complex hierarchy of frames defines for GSM physical channel
  - Physical channel are mapped into two types of logical channels, namely traffic channels and control channels
  - Traffic Channels
    - TCHF : Full rate traffic channel
    - TCHH : Half rate traffic channel
  - Control Channels are grouped into three logical control channels
    - BCH : Broadcast Channel, point to multipoint downlink only
    - CCCH : Common Control Channel, for paging and access
    - DCCH : Dedicated Control Channel, bidirectional point to point signalling

CHANNELS IN GSM

- Broadcast Channels
  - BCCH (Broadcast Control Channel) : send cell identities, organization info about common control channels, cell service available
  - FCCH (Frequency Correction Channel) : send frequency correction data burst due to frequency shift
  - SCH (Synchronization Channel) : contains TDMA frame number and base station identity
- Common Control Channel
  - PCH (Paging channel)
  - AGCH (Access Grant Channel) : Assign MS to standalone dedicated control channels
  - RACH (Random Access Channel) : Used by MS to send request for a dedicated connections

CHANNELS IN GSM

- Dedicated Control Channels : Main signaling channels
  - SDCCH (Standalone Dedicated Control Channel) : for service request, subscriber authentication, equipment validation, assignment to traffic channel
  - SACCH (Slow Associated Control Channel) : Signaling associated to a traffic channel, such as signal strength measurement
  - FACCH (Fast Associated Control Channel) : preemptive signaling on a traffic channel

GENERALIZED PACKET RADIO SERVICE (GPRS)

- Phase 2 of GSM
- Provides a datagram switching capability to GSM
  - Instead of sending data traffic over a voice connection which requires setup, sending data, and teardown
  - GPRS allows users to open a persistent data connection
  - Also has a new system architecture for data traffic
  - 21.4 kbps from a 22.8 kbps gross data rate
  - Can combine up to 8 GSM connections
    - Overall throughputs up to 171.2 kbps

ENHANCED DATA RATES FOR GSM EVOLUTION (EDGE)

- The next generation of GSM
  - Not yet 3G, so called "2.G"
- Three-fold increase in data rate
  - Up to 3 bits/symbol for 8-PSK from 1 bit/symbol for GMSK for GSM.
  - Max data rates per channel up to 22.8 × 3 = 68.4 kbps per channel
  - Using all eight channels in a 200 kHz carrier, gross data transmission rates up to 547.2 kbps became possible
    - Actual throughput up to 513.6 kbps.
- A later release of EDGE (3GPP Release 7) increased downlink data rates over 750 kbps and uplink data rates over 600 kbps

SECOND GENERATION : CDMA SYSTEMS

- Advantages of CDMA for Cellular systems
  - Frequency diversity – frequency-dependent transmission impairments have less effect on signal
  - Multipath resistance – chipping codes used for CDMA exhibit low cross correlation and low autocorrelation
  - Privacy – privacy is inherent since spread spectrum is obtained by use of noise-like signals
  - Graceful degradation – system only gradually degrades as more users access the system

DRAWBACKS OF CDMA CELLULAR

- Self-jamming – arriving transmissions from multiple users not aligned on chip boundaries unless users are perfectly synchronized
- Near-far problem – signals closer to the receiver are received with less attenuation than signals farther away
  - Power control are crucial in a CDMA system

MOBILE WIRELESS CDMA DESIGN CONSIDERATIONS

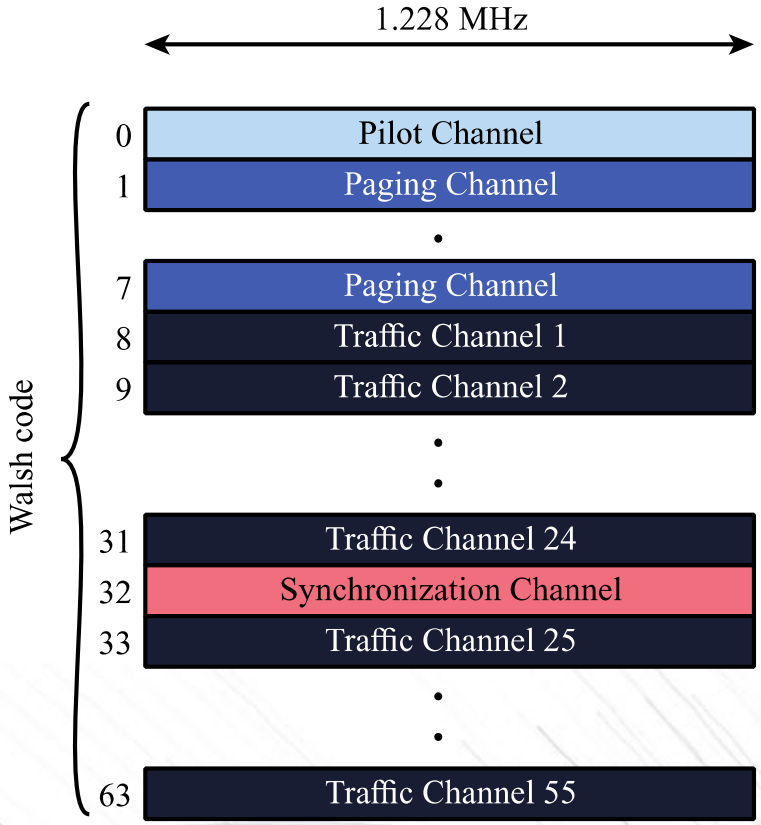
- RAKE receiver – when multiple versions of a signal arrive more than one chip interval apart, RAKE receiver attempts to recover signals from multiple paths and combine them
- Soft Handoff – mobile station temporarily connected to more than one base station simultaneously
  - Requires that the mobile acquire a new cell before it relinquishes the old
  - More complex than hard handoff used in FDMA and TDMA schemes

IS-95 FORWARD LINK

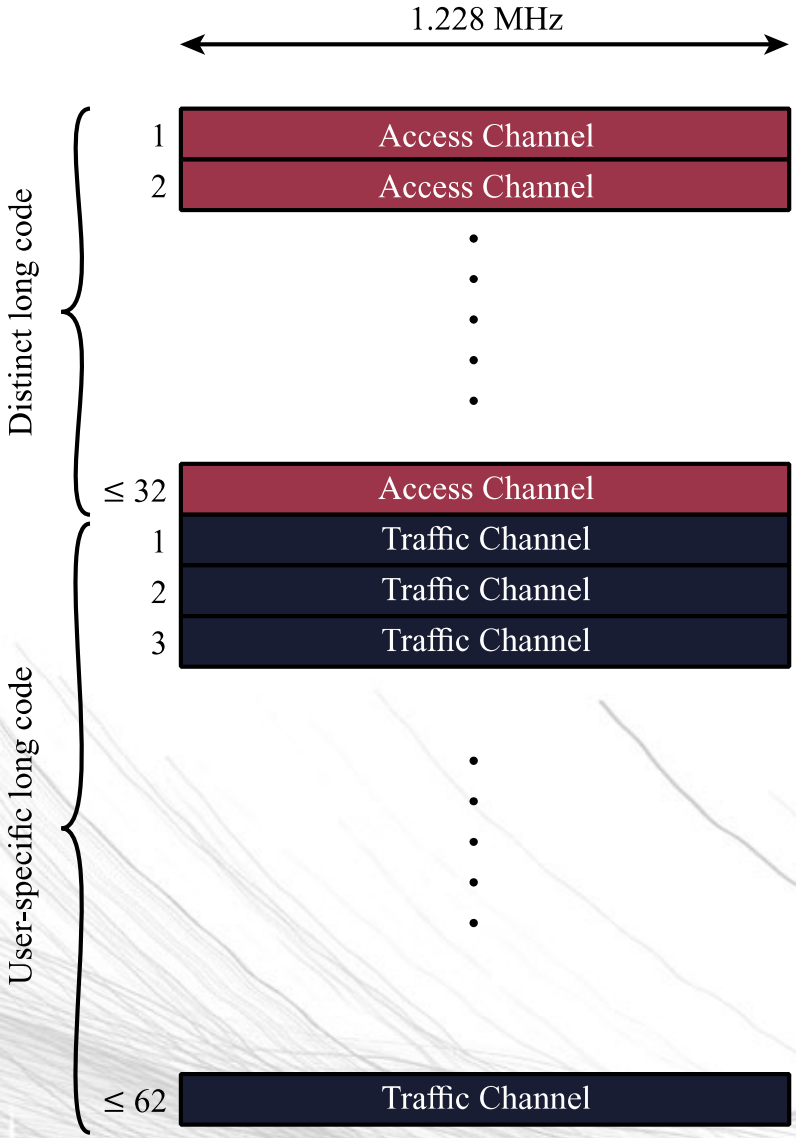
- Most widely used CDMA cellular standard is IS-95, used mainly in North America
- Forward link channels
  - Pilot (channel 0) - allows the mobile unit to acquire timing information, provides phase reference and provides means for signal strength comparison
  - Synchronization (channel 32) - used by mobile station to obtain identification information about cellular system
  - Paging (channels 1 to 7) - contain messages for one or more mobile stations
  - Traffic (channels 8 to 31 and 33 to 63) – the forward channel supports 55 traffic channels
    - 9600 or 14,400 bps
  - Different channel use different chipping code

IS-95 REVERSE LINK

- Consist of up to 94 logical CDMA channel parameter
  - 32 access channels and 62 traffic channels
  - Each occupies the same 1228 KHz bandwidth
  - Access channel is used by mobile unit to initiate the call, respond to a paging channel and for location update
  - Traffic channels are unique to each mobile unit. Each mobile unit has a unique long code mask based on its electronic serial number
    - Its 42 bit wide.



(a) Forward channels



(b) Reverse channels

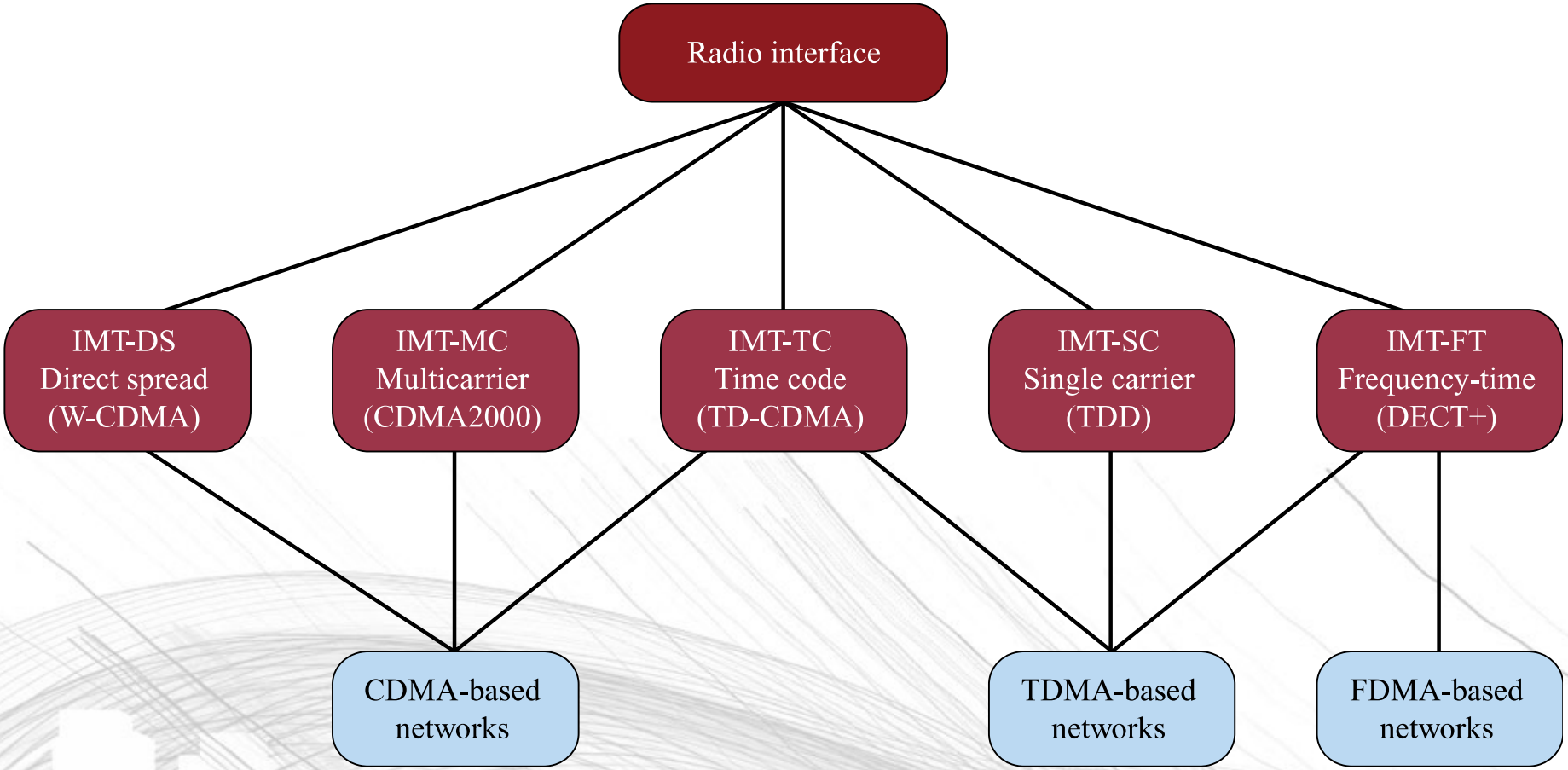
13.10 IS-95 CHANNEL STRUCTURE

ITU'S INITIAL VIEW OF THIRD-GENERATION CAPABILITIES

- The ITU's International Mobile Telecommunications for the year 2000 (IMT-2000) initiative
- Voice quality comparable to the public switched telephone network
- 144 kbps data rate available to users in high-speed motor vehicles over large areas
- 384 kbps available to pedestrians standing or moving slowly over small areas
- Support for 2.048 Mbps for office use
  - Much higher rates were developed

ITU'S INITIAL VIEW OF THIRD-GENERATION CAPABILITIES

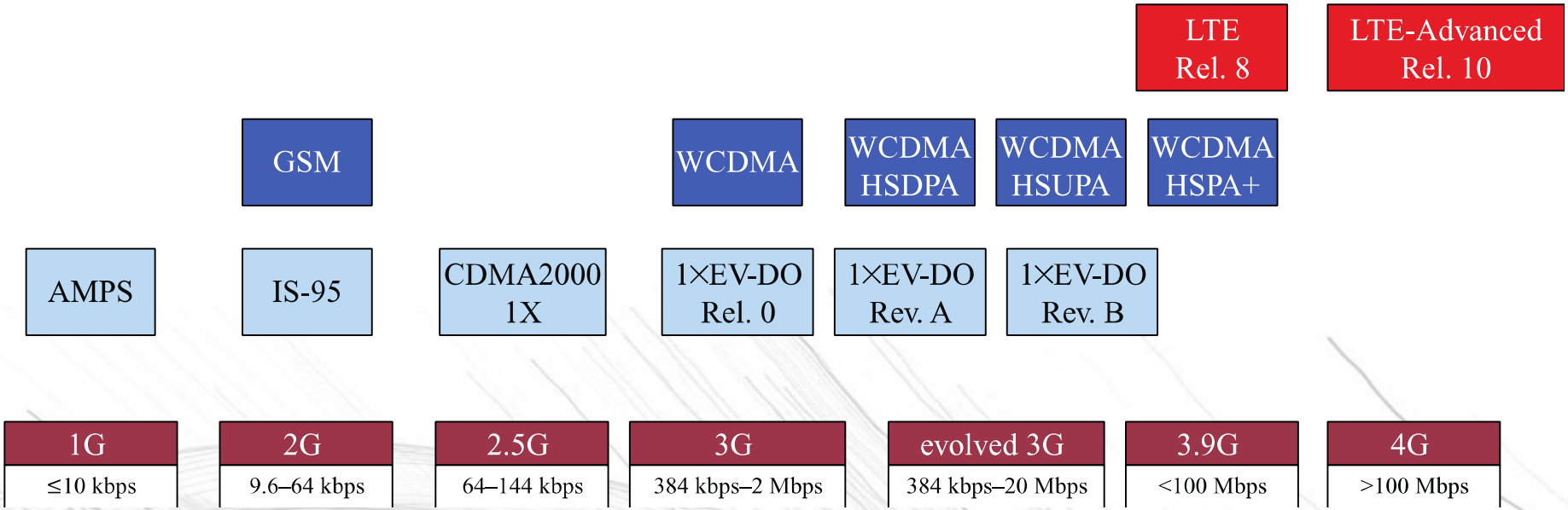
- Symmetrical / asymmetrical data transmission rates
- Support for both packet switched and circuit switched data services
- An adaptive interface to the Internet to reflect efficiently the common asymmetry between inbound and outbound traffic
- More efficient use of the available spectrum in general
- Support for a wide variety of mobile equipment
- Flexibility to allow the introduction of new services and technologies



13.11 IMT-2000 TERRESTRIAL RADIO INTERFACES

DOMINANT TECHNOLOGIES

- The dominant technology for 3G system is CDMA
- European Telecommunications Standard Institute develop a Universal Mobile Telecommunication System (UMTS) as Europe 3G standard
  - Includes two standard, Wideband CDMA and IMT-TC
  - Also part of Third-Generation Partnership Project (3GPP) industry organization
- North American issue another CDMA based system
  - Known as CDMA2000
  - Similar, but incompatible with WCDMA
- These two standards becomes prominent 3G standard



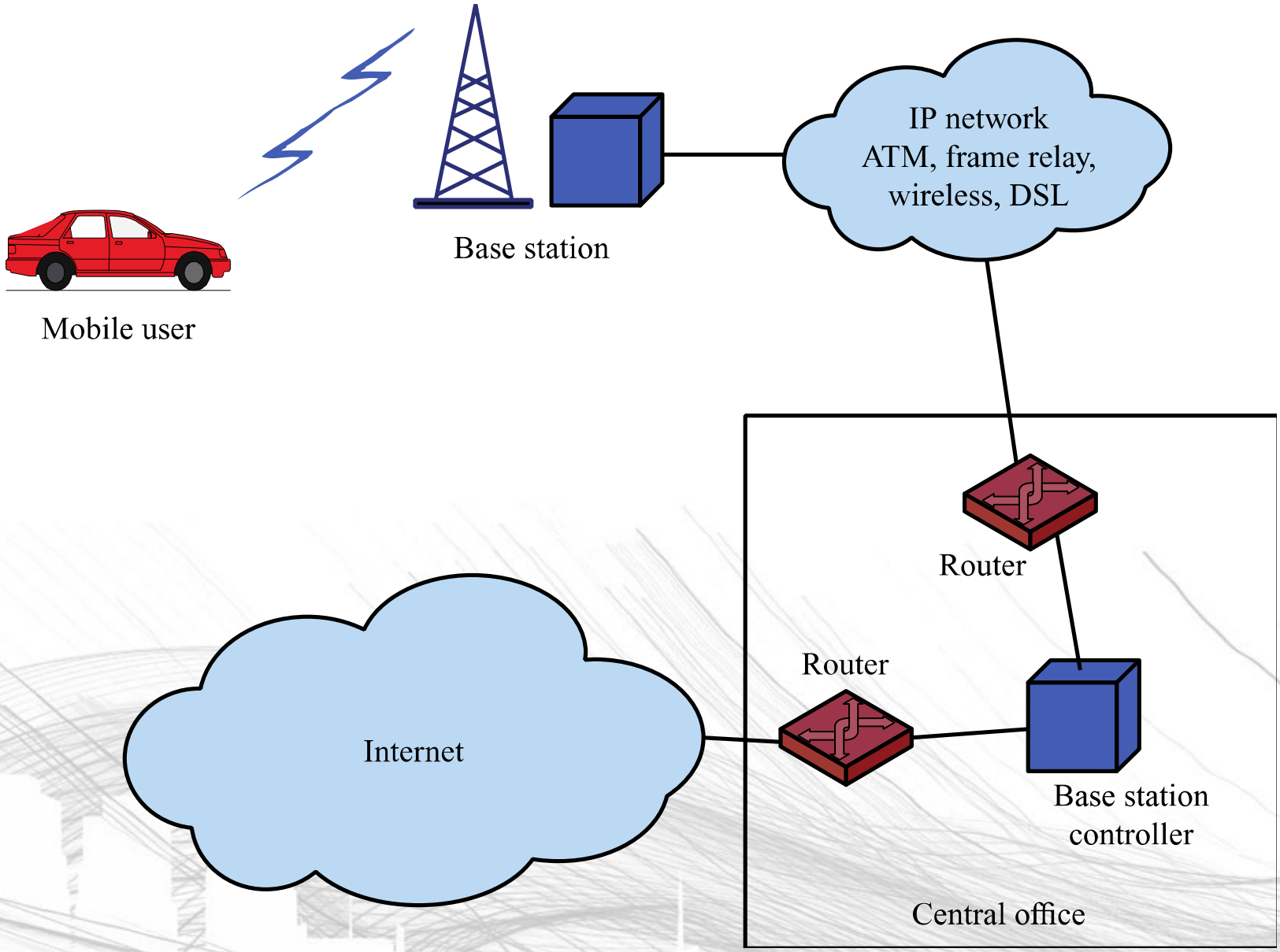
13.13 EVOLUTION OF CELLULAR WIRELESS SYSTEMS

WCDMA AND UMTS

- 144 kbps to 2 Mbps, depending on mobility
- High Speed Downlink Packet Access (HSDPA)
  - Release 5
  - 1.8 to 14.4 Mbps downlink
  - Adaptive modulation and coding, hybrid ARQ, and fast scheduling
- High Speed Uplink Packet Access (HSUPA)
  - Release 6
  - Uplink rates up to 5.76 Mbps
- High Speed Packet Access Plus (HSPA+)
  - Release 7 and successively improved in releases through Release 11
  - Maximum data rates increased from 21 Mbps up to 336 Mbps
  - 64 QAM, 2×2 and 4×4 MIMO, and dual or multi-carrier combinations
- 3GPP Release 8 onwards introduced Long Term Evolution (LTE)
  - Pathway to 4G, Chapter 14

CDMA2000 AND EV-DO

- CDMA2000 first introduced 1xRTT (Radio Transmission Technology)
  - 1 times the 1.2288 Mcps spreading rate of a 1.25 MHz IS-95 CDMA channel
  - Not 3G, so considered by some as "2.5G"
- Evolution-Data Only (1×EV-DO)
  - Also 1×EV-DV (data/voice) which never succeeded
  - 1×EV-DO Release 0
    - 2.4 Mbps uplink, 153 kbps downlink
    - Only using 1.25 MHz of 5 MHz required of CDMA
  - 1×EV-DO Release A
    - 3.1 Mbps downlink, 1.8 Mbps uplink, QoS
  - 1×EV-DO Release B
    - 5 MHz bandwidth, 14.7 Mpbs uplink, 5.4 Mbps downlink
- EV-DO uses only IP, but VoIP can be used for voice



13.14 CDMA2000 1XEV-DO CONFIGURATION ELEMENTS