

A Comparative Study of UMTS (WCDMA) and cdma2000 Networks

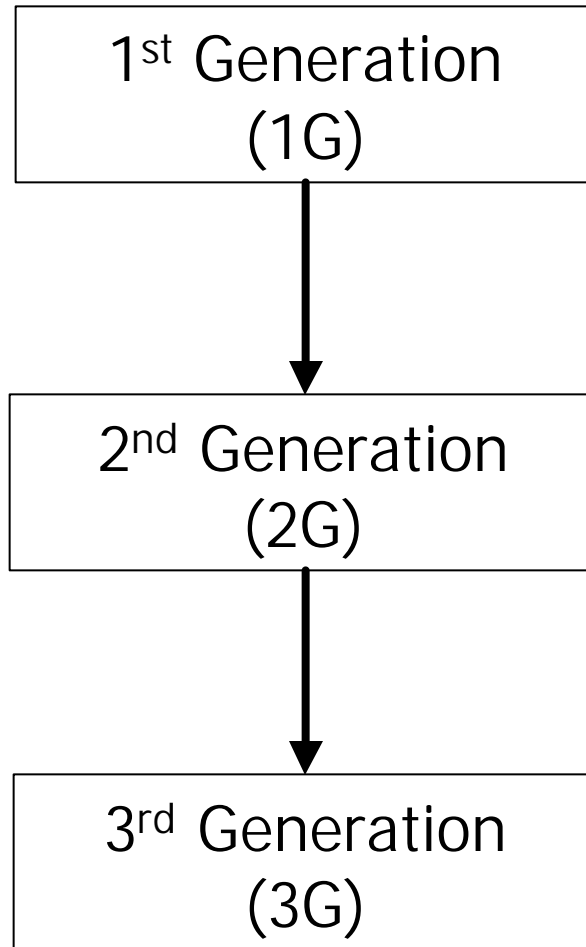
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IEEE METROCON-2001

Outline

- Current scene of Cellular Wireless
- 3G Technology Landscape
- Comparative Study
 - Network Architecture
 - Air Interface
 - Network Interfaces
 - End-to-End Service Flow
- Beyond 3G
- Summary

Evolution of Wireless Technologies

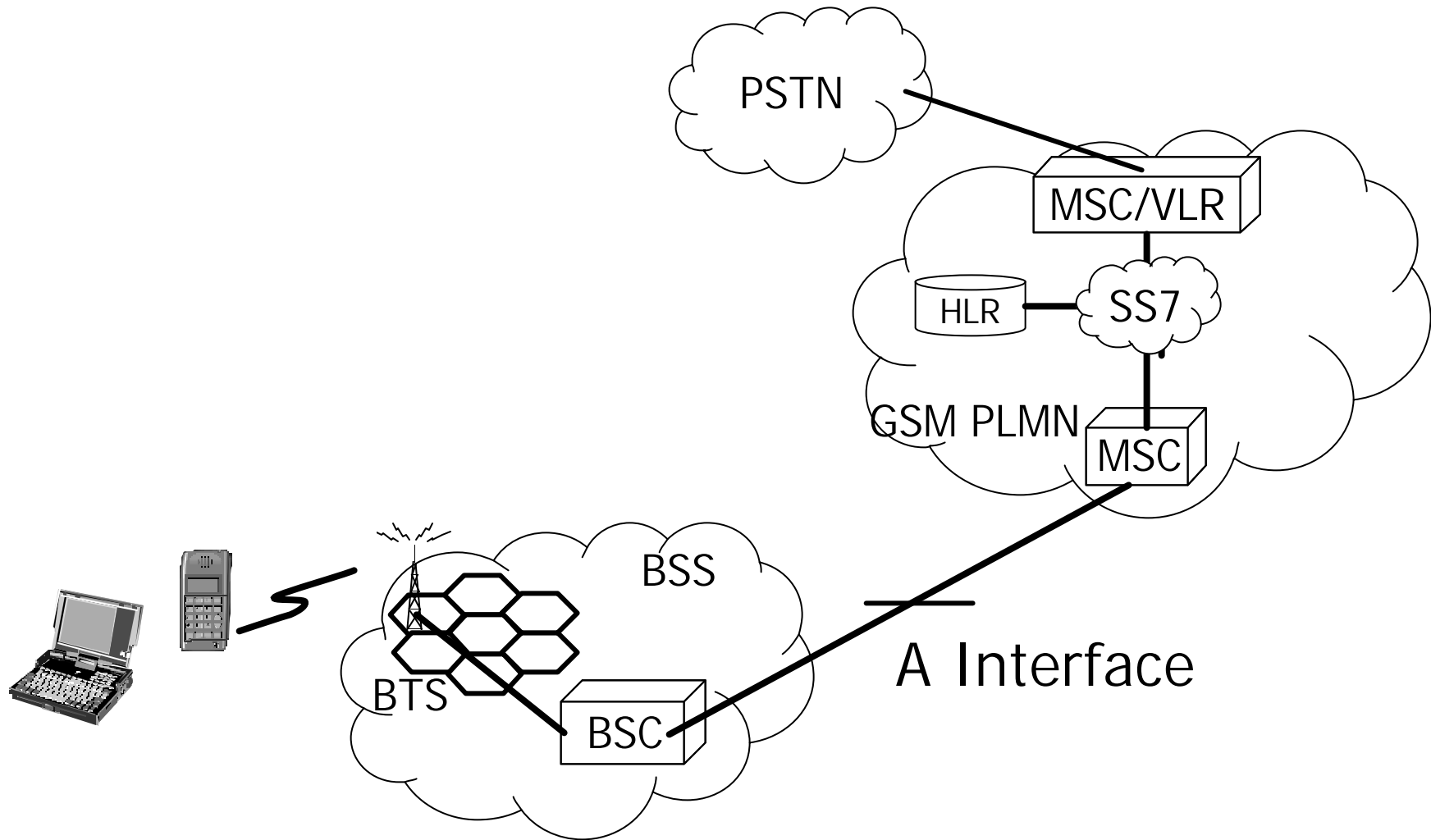


- Analog-based cellular technology
- Services
 - ✓ Voice
- Introduction of digital technologies
- Services
 - ✓ Voice
 - ✓ Low-rate data
- Next generation digital systems
- Services
 - ✓ Voice
 - ✓ High speed data services

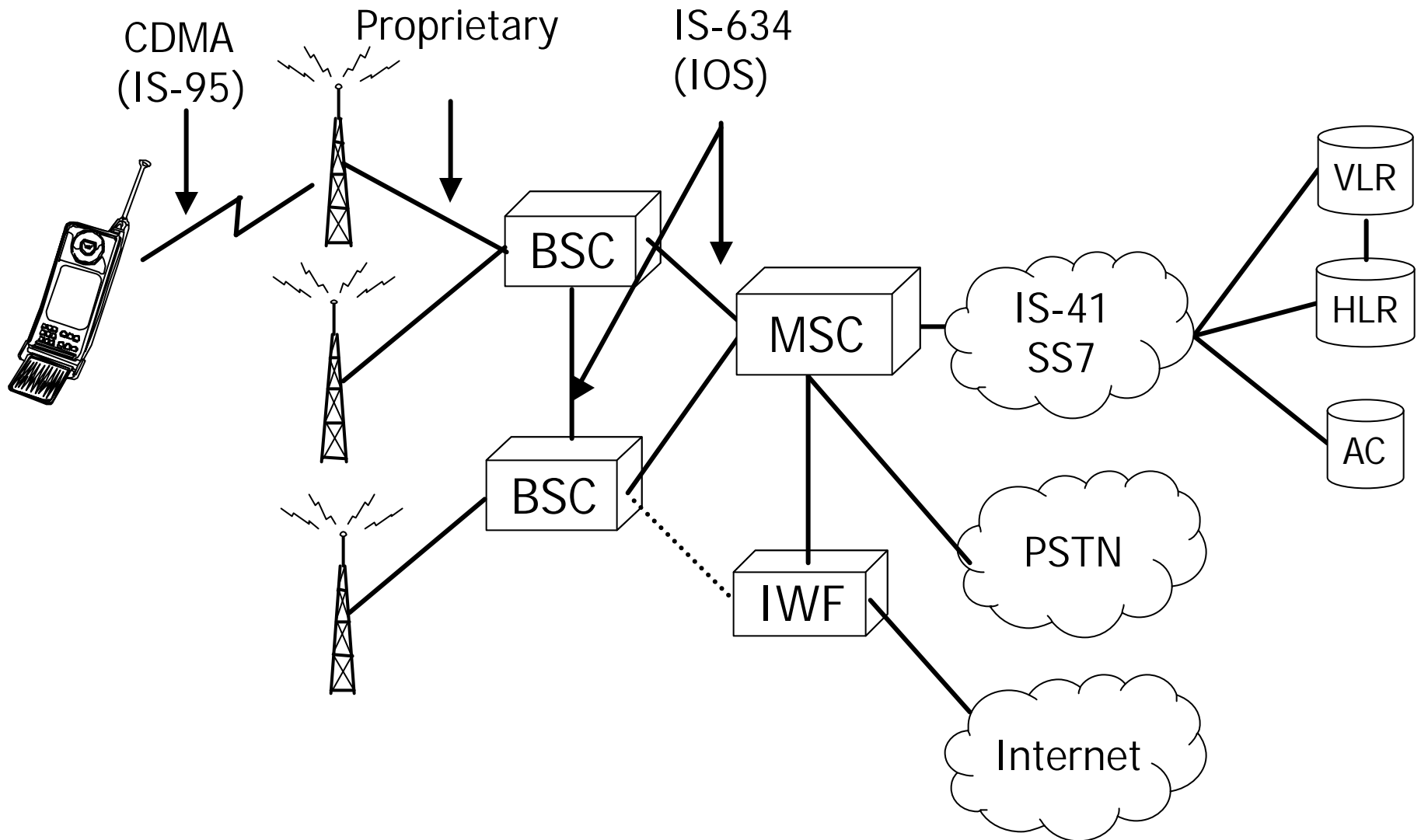
2G Technologies

	AMPS	D-AMPS	GSM	CDMA
Operating Spectrum Frequency	800 MHz	800 & 1900 MHz	900 & 1800 MHz (Europe) 800 & 1900 MHz (US)	800 & 1900 MHz
Channel Width	30 kHz	30 kHz	200 kHz	1.25 MHz
Users Per Channel	1	3	8	About 20
Channel Separation	Frequency	Frequency and Time	Frequency and Time	Frequency and Code
Network Architecture	IS-41	IS-41	GSM-MAP	IS-41

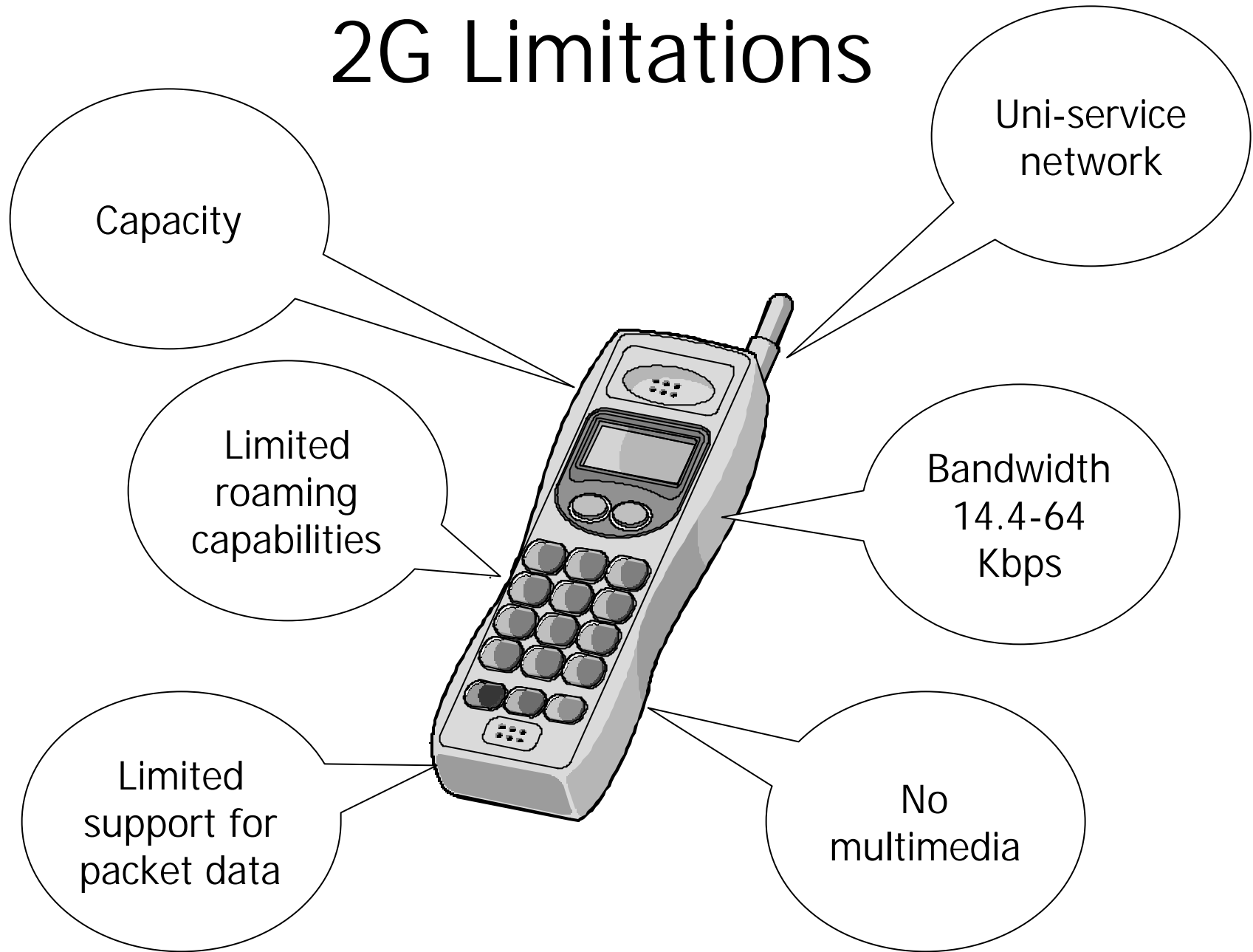
GSM Network Architecture



IS-95-Based 2G Network



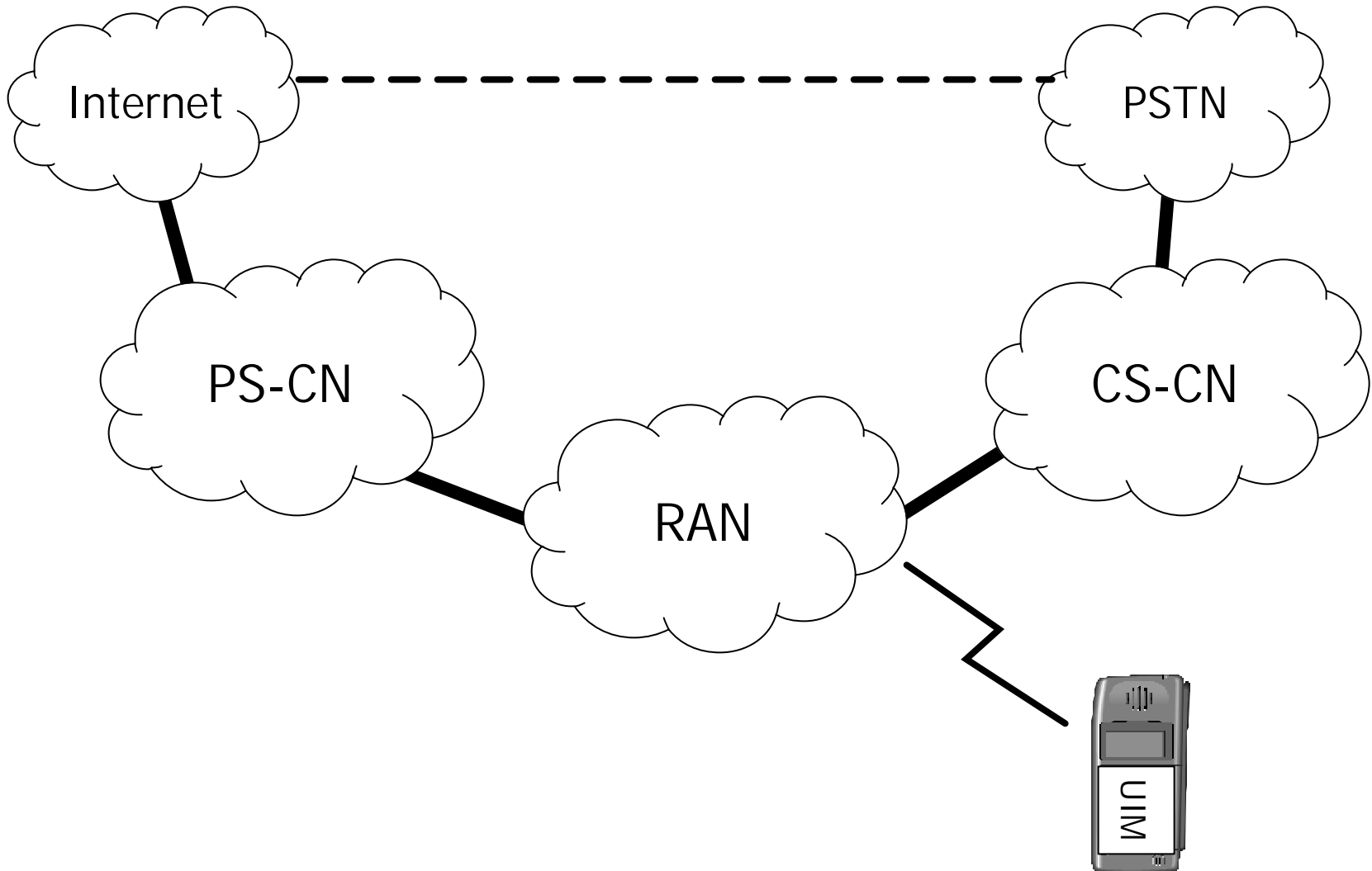
2G Limitations



3G Requirements

- Radio Network requirements
 - Support up to 2 Mbps data rates
 - Support flexible operating environments
 - High spectral efficiency/capacity
 - Support multimedia services
- Core Network requirements
 - Packet Data Network and IP Mobility
 - Global Roaming
 - Virtual Home Environment
 - Quality of Service
 - Interoperability with 2G Networks

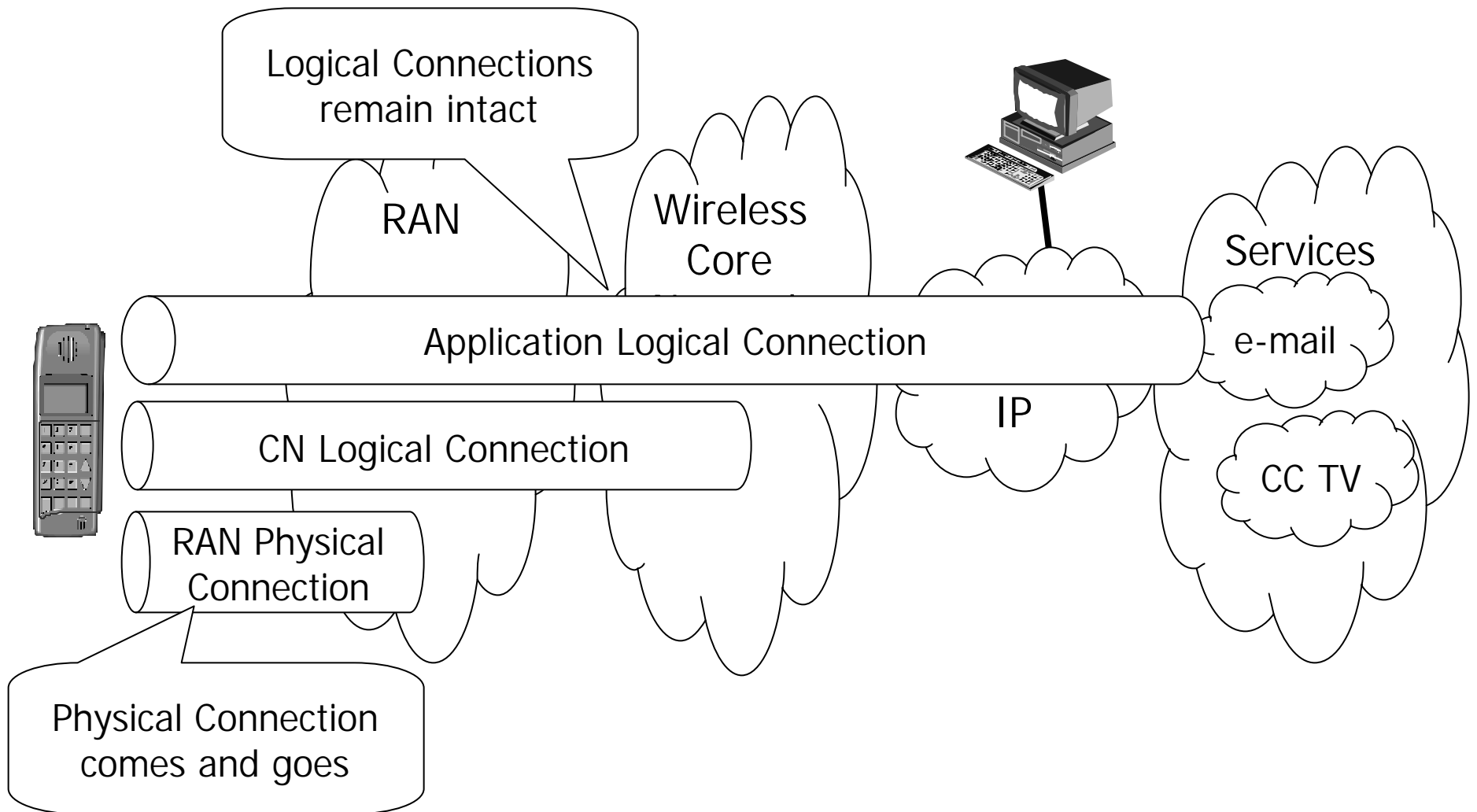
3G Network Architecture



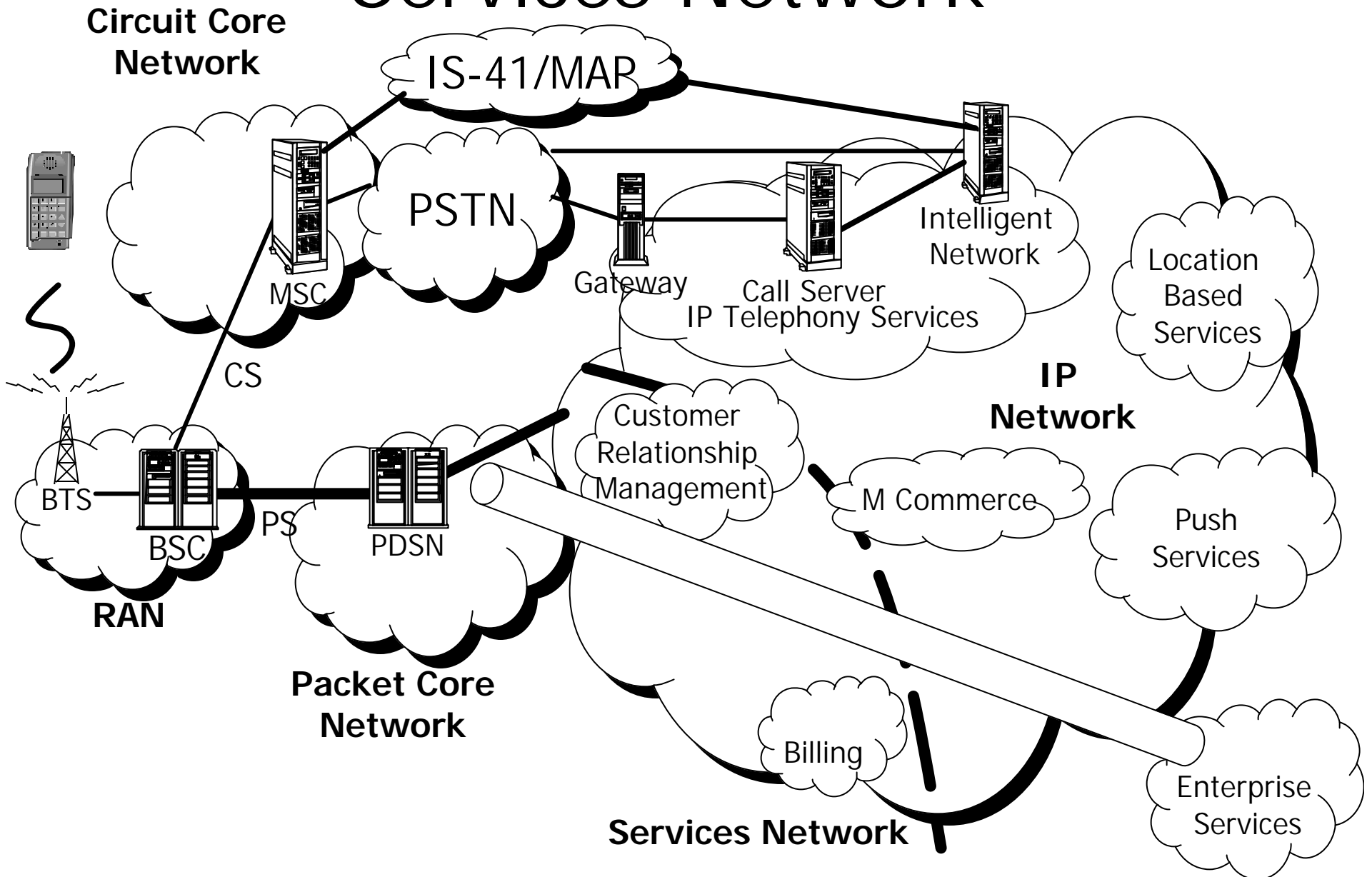
IP Mobility

- Ability to move with an IP address while the connection using the IP address is active
- IP Mobility may be provided by a combination of “RAN mobility” and “CN mobility”
- Radio Access Network IP mobility
 - Handoff/handover
 - Cell selection/reselection
- Core Network IP mobility
 - Mobile IP, GPRS

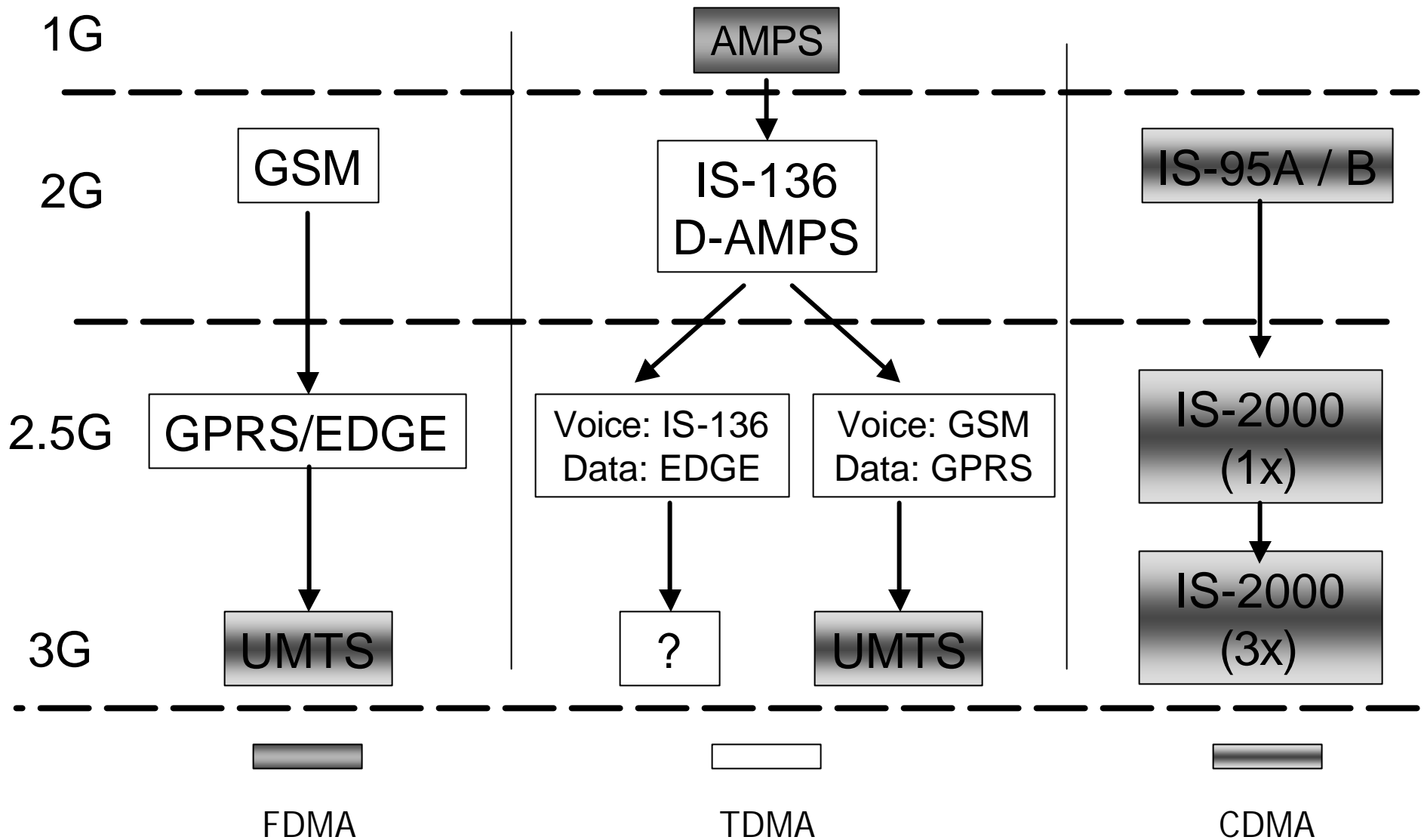
Always Connected



Services Network



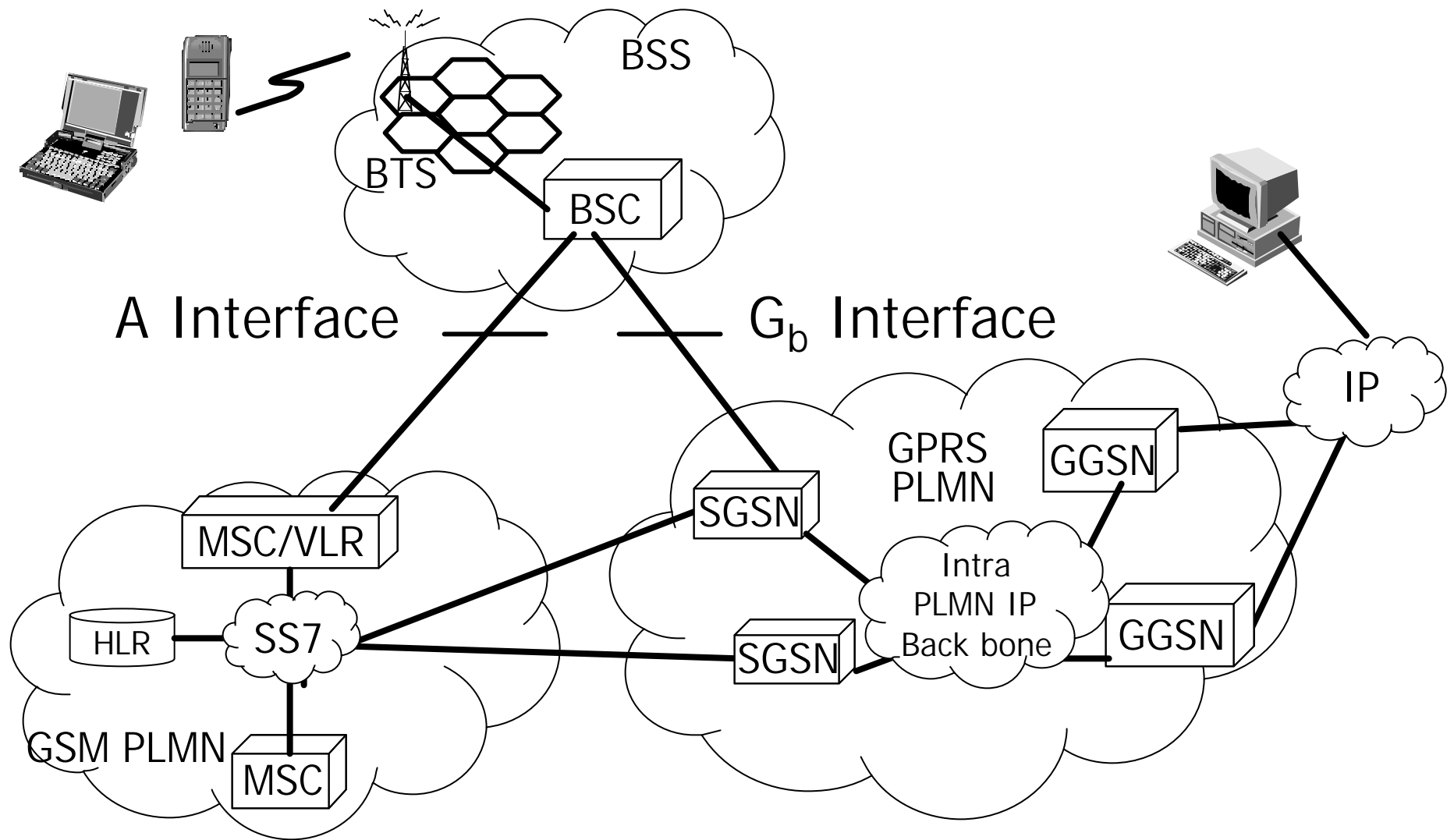
3G Technology Landscape



GSM → GPRS

	Summary of Changes
New	Packet Core Network Nodes (SGSN, GGSN) New Interface – Gb (BSC – SGSN)
Modification	BSC Hardware and Software
No Changes	Circuit Core Network (MSC/HLR/AuC) Air Interface (MS, BTS) A-Interface (BSC-MSC)

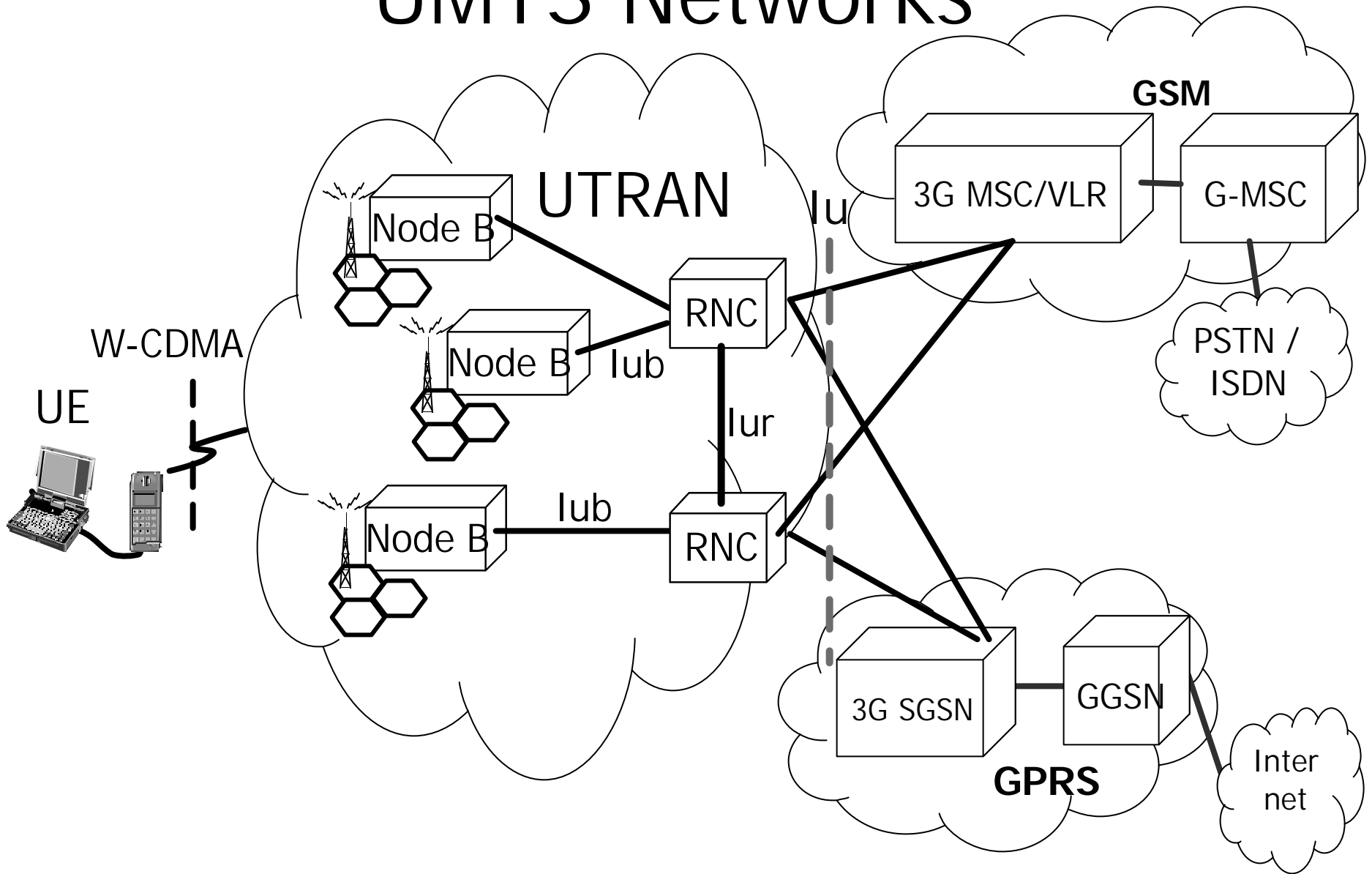
2.5G GSM/GPRS Networks



GSM/GPRS → UMTS

	Summary of Changes
New	WCDMA Air Interface (UE–Node B) RAN Interfaces Iub (Node B – RNC), Iur (RNC – RNC) CN Interface – Iu (MSC–RNC & SGSN–RNC)
Modification	MSC and SGSN for Iu Interface
No Changes	Circuit Core Network (HLR/AuC) Packet Core Network (GGSN)

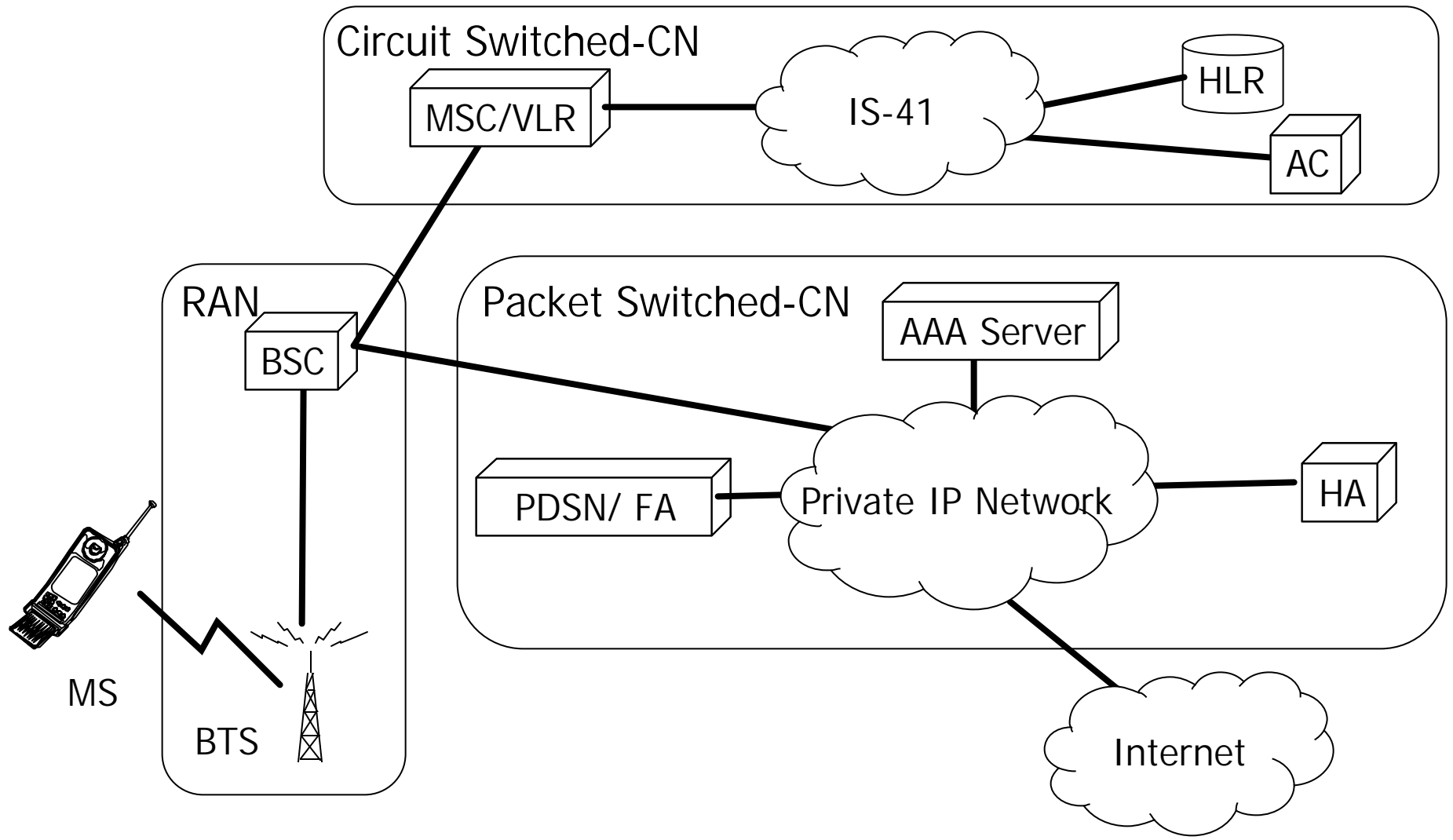
UMTS Networks



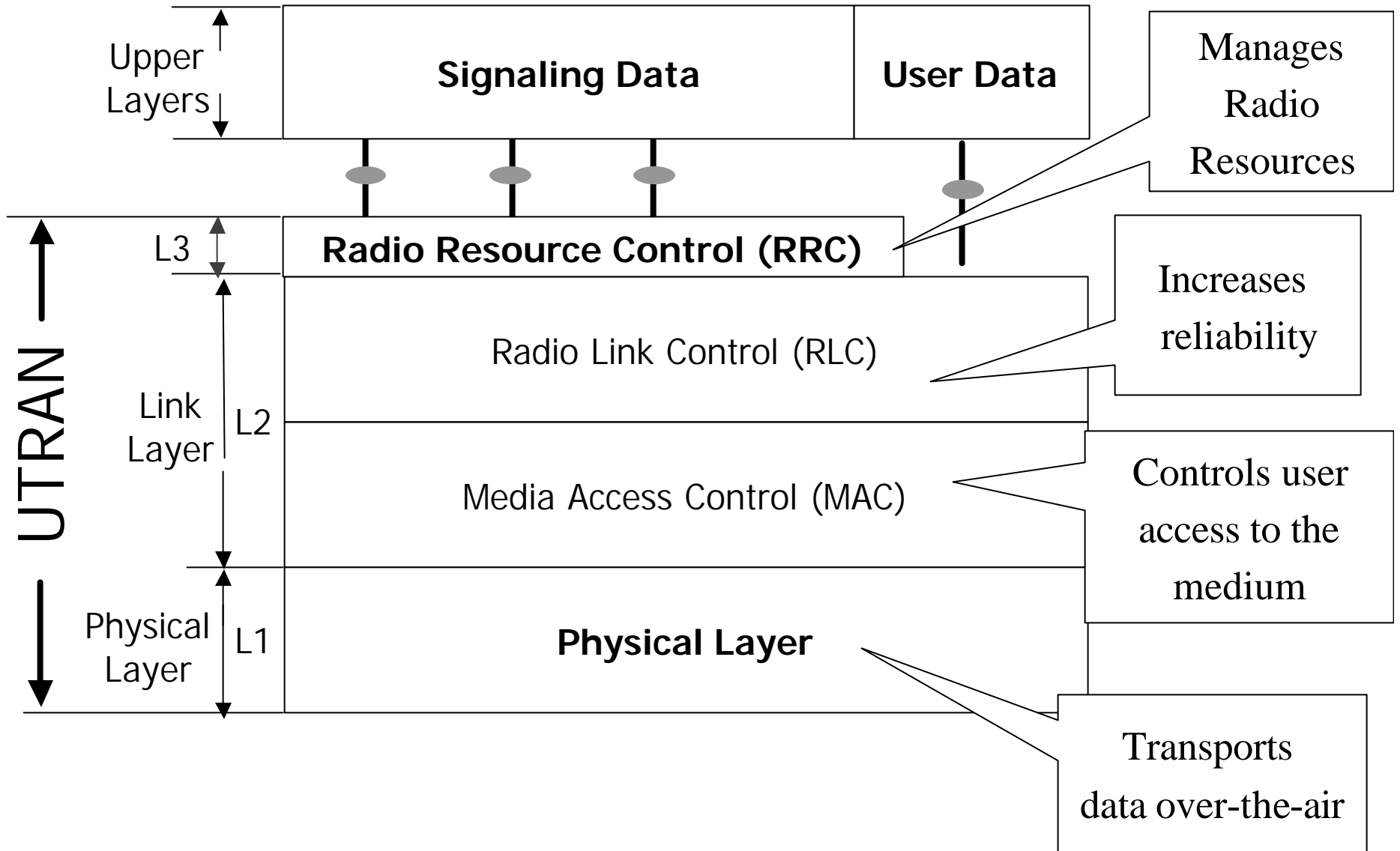
IS-95 → cdma2000

	Summary of Changes
New	Packet Core Network (PDSN, AAA, HA/FA) New Interface (R-P) – BS - PDSN
Modification	Air Interface (MS – BS) Network Interface (BS – MSC)
No Changes	Core Network Nodes (HLR, AC)

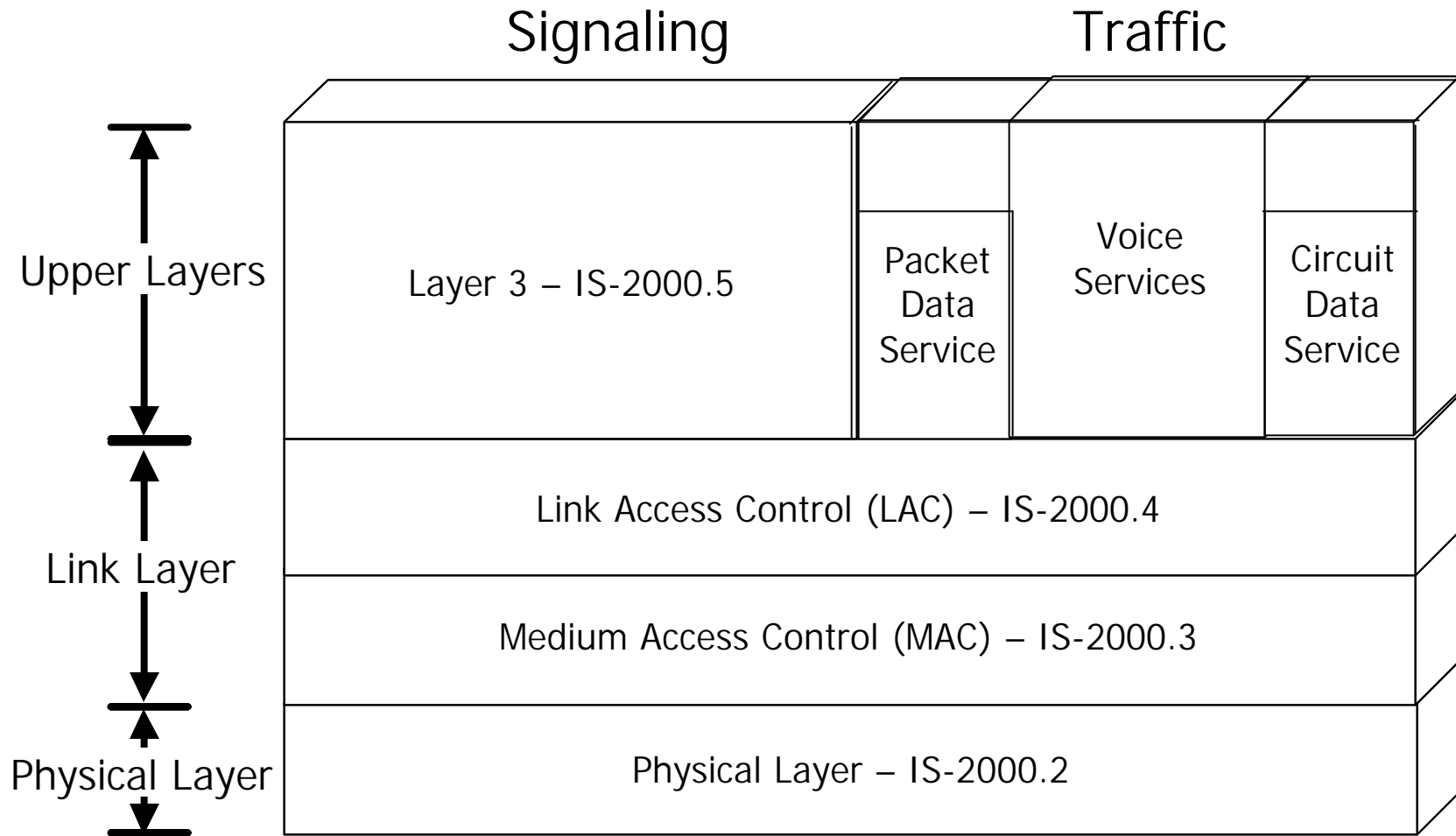
cdma2000 Network Architecture



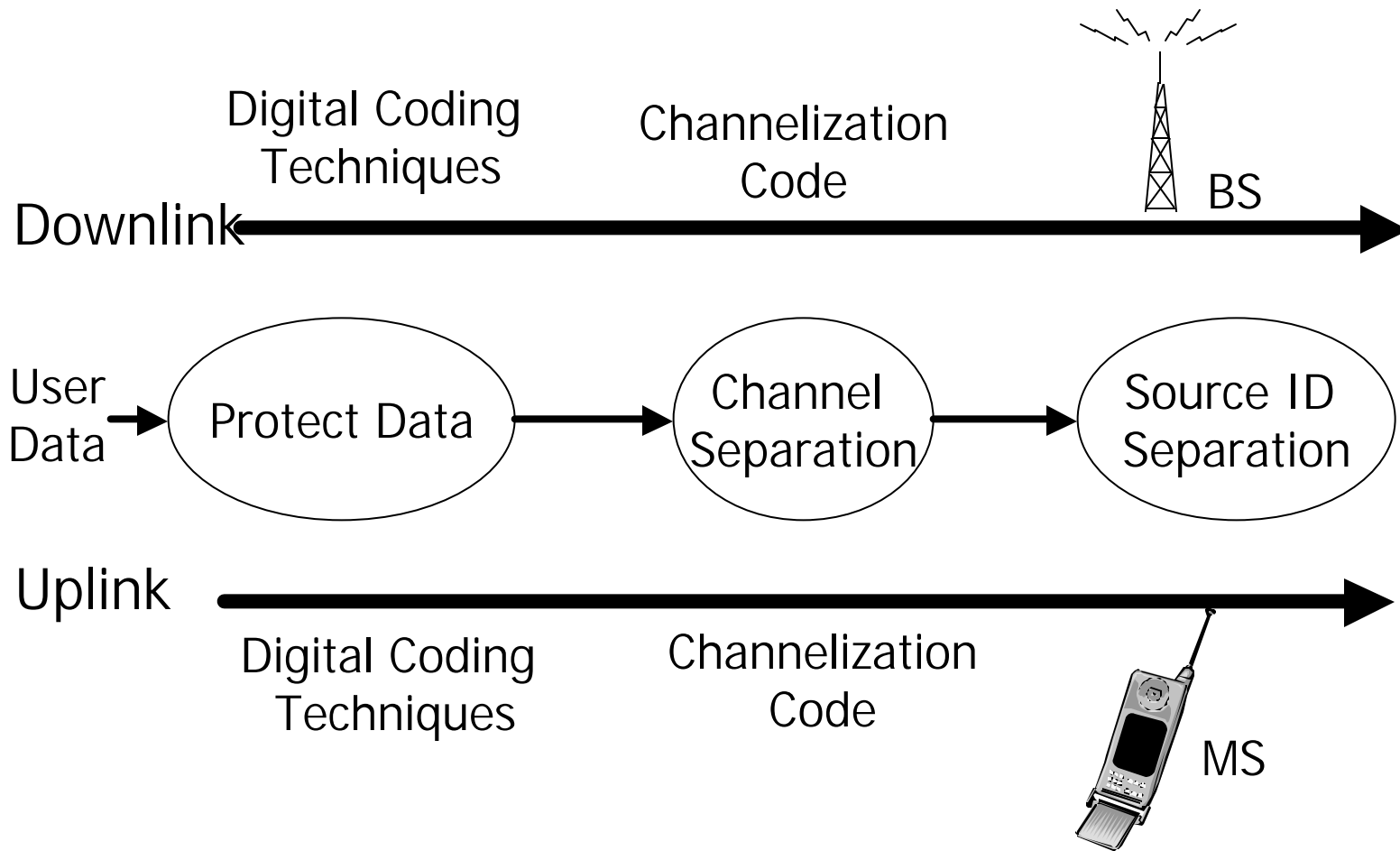
W-CDMA Protocol Stack



cdma2000 Protocol Stack



CDMA Physical Layer Functions



Bandwidth and spreading

	Bandwidth	Spreading	Channelization codes
cdma2000	1.25 MHz (1x) 3.75 MHz (3x)	1.2288 Mcps 3 * 1.2288 or 3.6864 Mcps	4-128 bits (1x) 4-256 bits (3x)
UMTS	5 MHz	3.84 Mcps	4-256 bits

Air Interface Parameters (1)

	UMTS	cdma2000
Spreading rate	3.84 Mcps	1.2288 Mcps
Bandwidth	5 MHz	1.25 MHz
Synchronization between cell sites	Asynchronous	Synchronous
Configuration	Direct spread configuration	Direct spread (1x) Multi-carrier (3x forward link)
Channel coding	Convolutional Turbo (Parameters flexible)	Convolutional Turbo (Parameters fixed in the standard)

Air Interface Parameters (2)

	UMTS	cdma2000
Modulation	QPSK in both directions	QPSK in forward BPSK in reverse
Frame size	10 msec for physical layer 10,20,40 and 80 msec for transport layer	5 (for signaling), 20, 40 and 80 msec physical layer frames
Modes	FDD and TDD Mode	Only FDD Mode
Transmit Diversity schemes	Time Switched Transmit Diversity Space Time Block Coded Transmit Diversity	Orthogonal Transmit Diversity Space Time Spreading

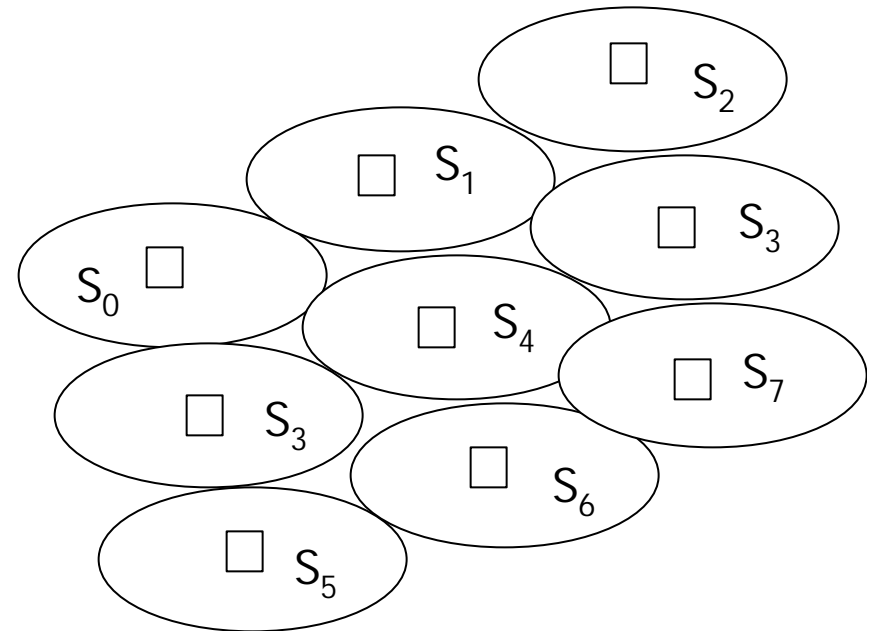
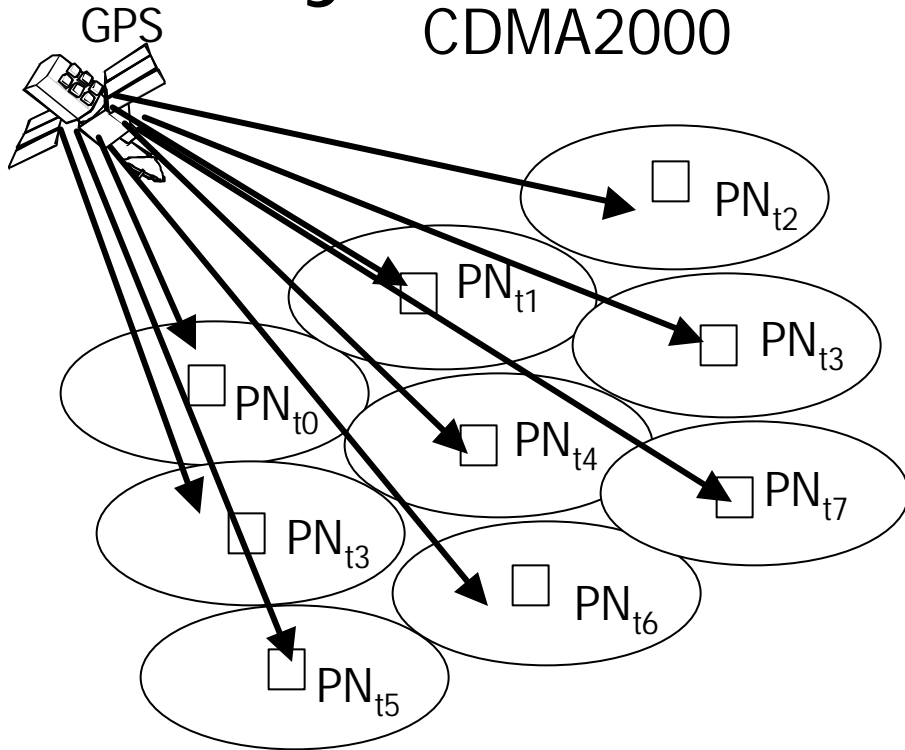
Channelization & Source Identification Codes

	UMTS	cdma2000
Channelization codes	Orthogonal Variable Spreading Factor (OVSF) codes from 4-256 bits	Walsh codes (same as OVSF) codes from 4-128 bits
Source identification code for Sector	512 unique scrambling codes each identifying a sector (38,400 bits)	One PN code (32,768 bits) 512 unique offsets are generated using PN offsets
Source identification for mobiles	Unique scrambling codes assigned by sector	One long PN code (2^{42} bits). Unique offsets are generated based on ESN. Not assigned by sector

Asynchronous Cell Operations

CDMA2000

UTRA-FDD



PN_{t0-n} - Time offset scrambling code

- Cell sites transmission and reception are synchronized through GPS timing
- Adjacent cell sites use different time offsets of same scrambling code for spreading

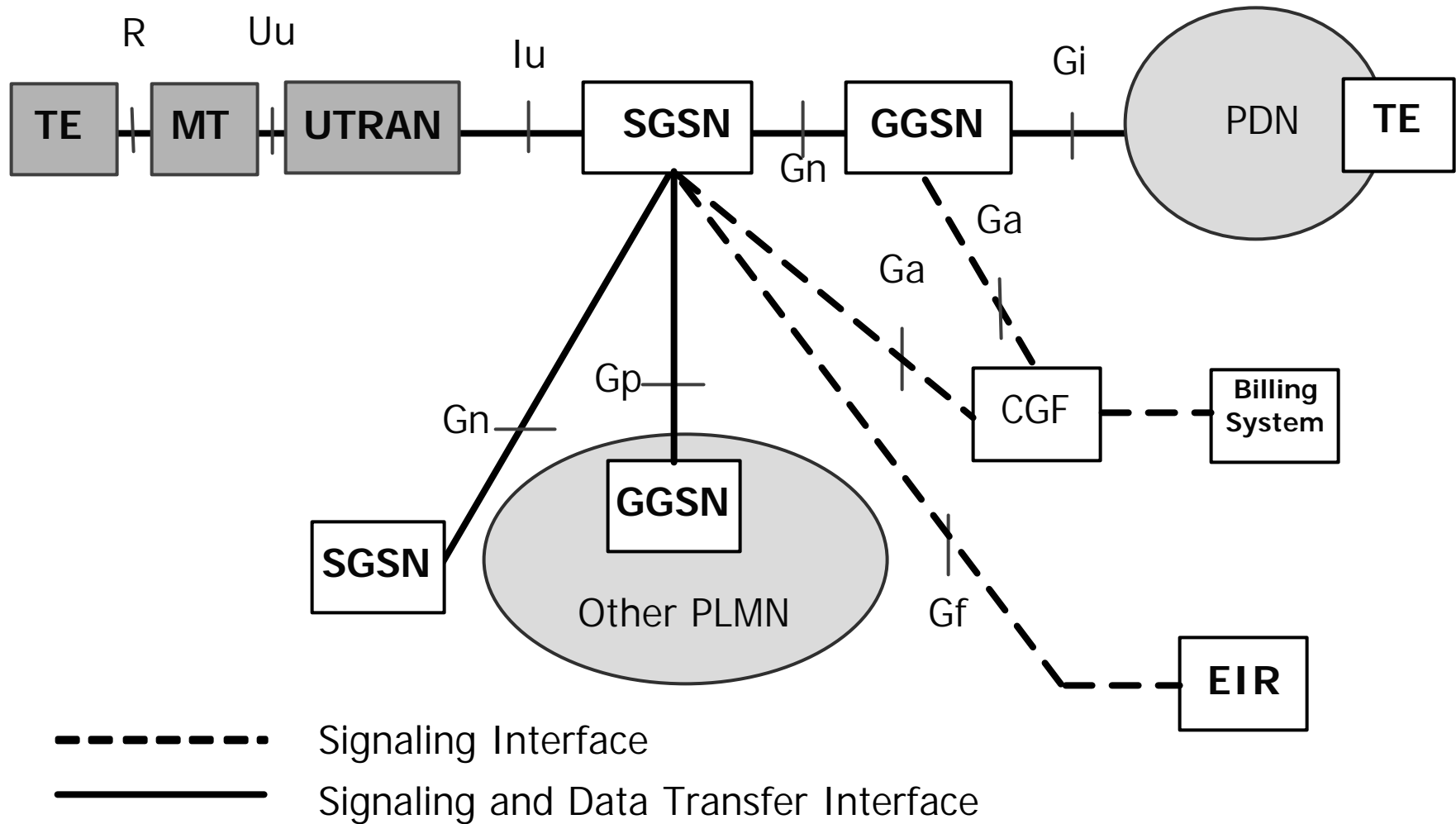
S_{1-n} - Scrambling codes

- Cell sites are not synchronized
- Each cell site uses a different scrambling code for spreading

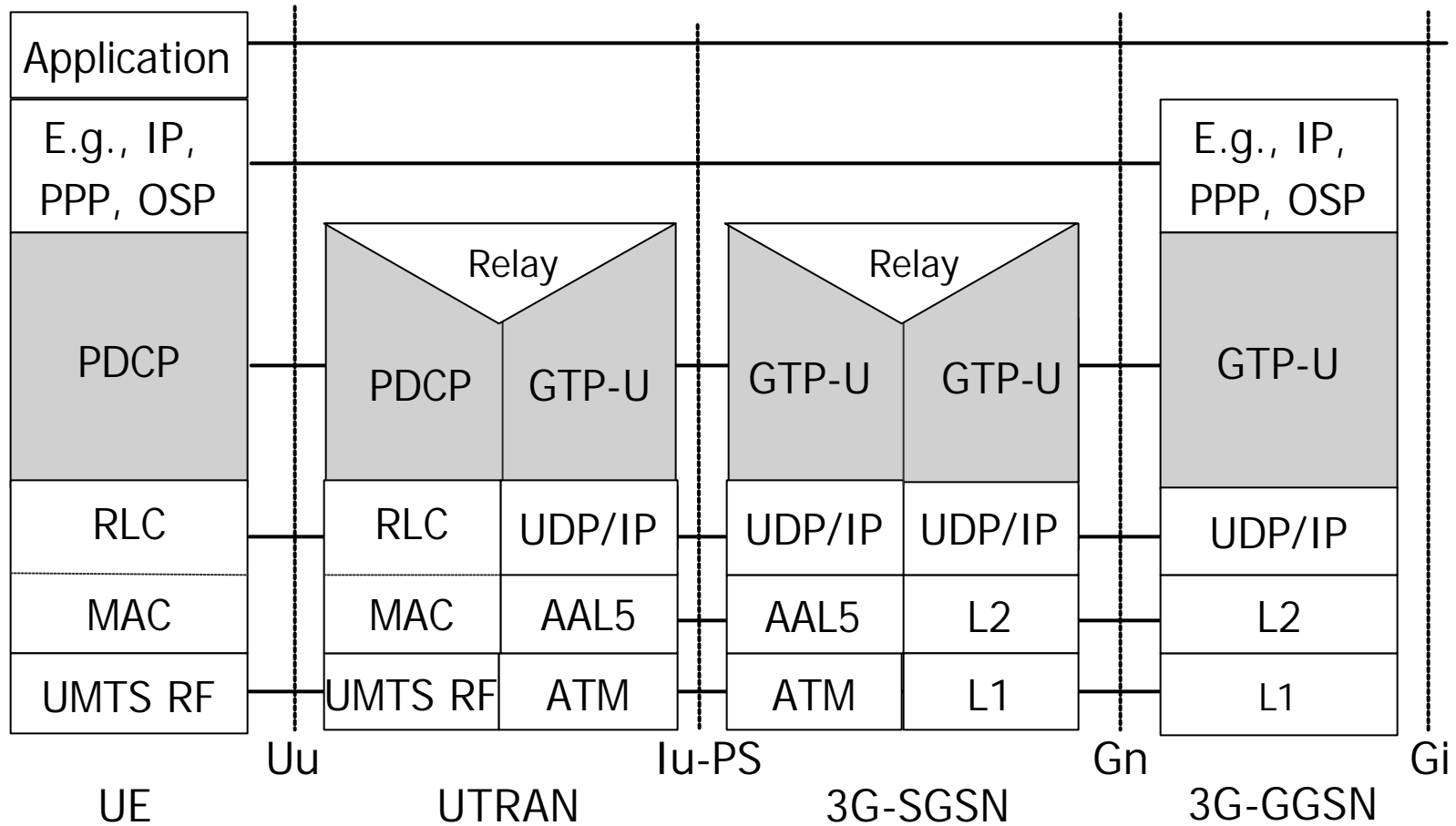
Power Control

	UMTS	cdma2000
Open loop Power control for System Access	ö	ö
Forward link Power control	1500/sec	800/sec
Reverse link Power control	1500/sec	800/sec

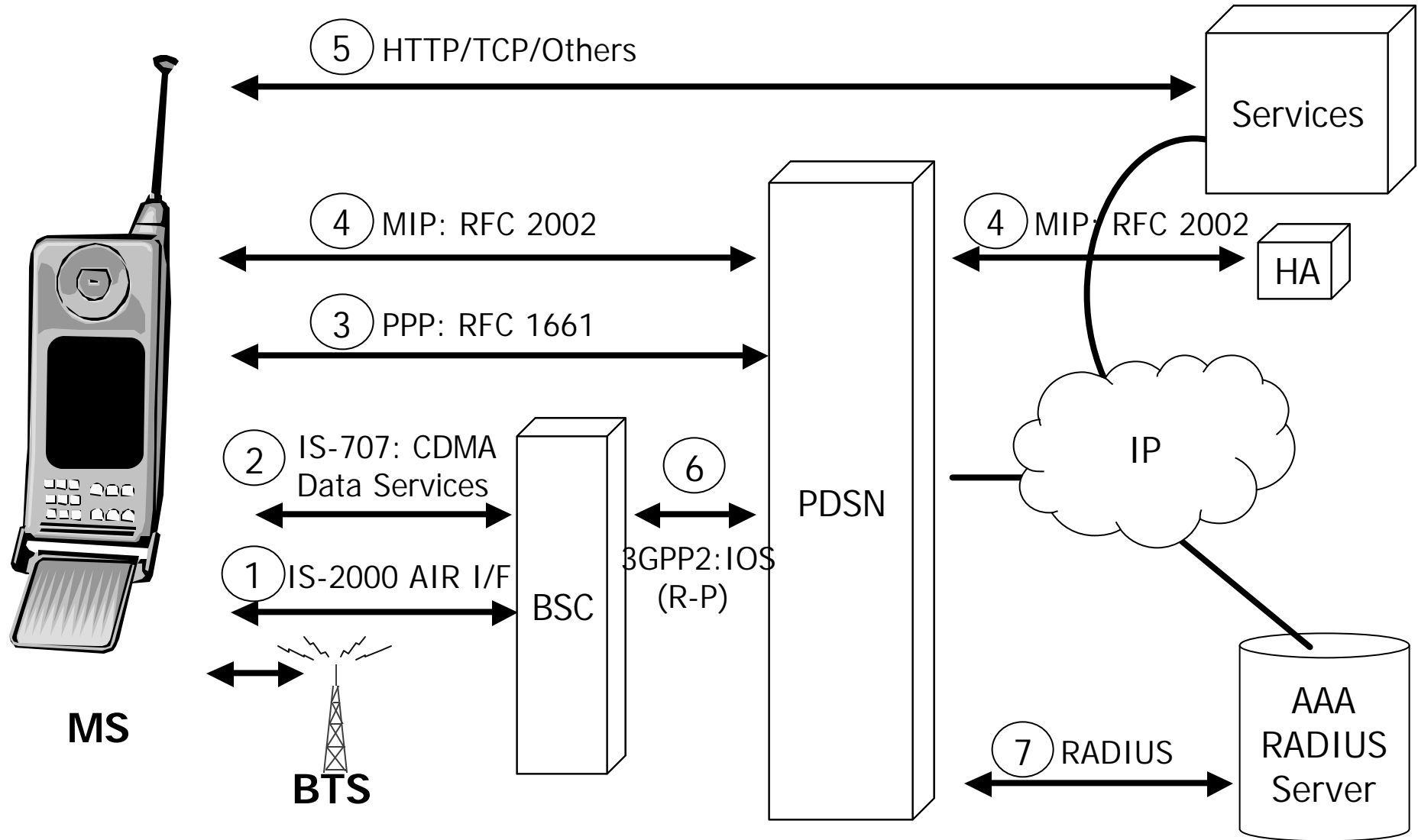
UMTS Packet data Network Architecture



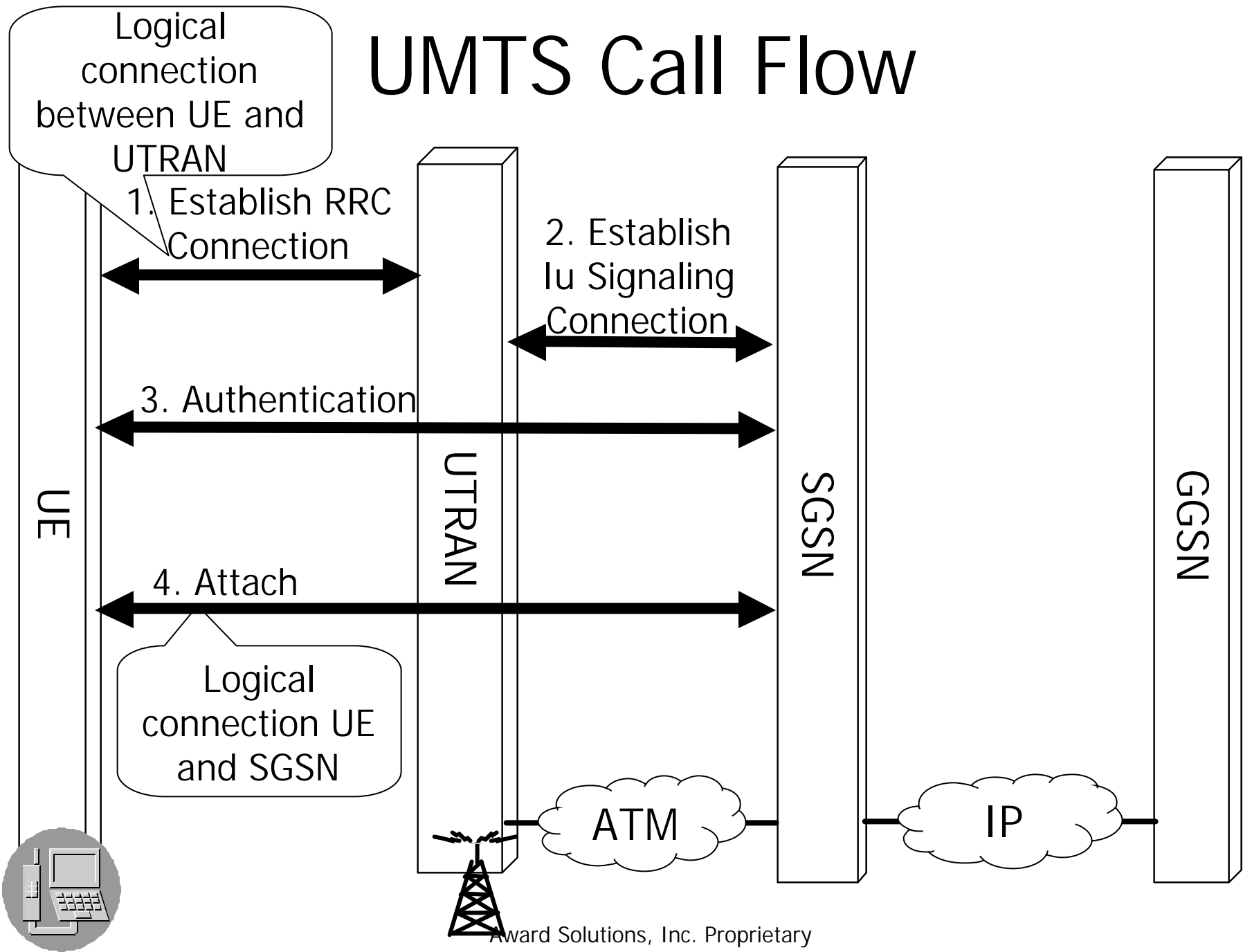
UMTS protocol model



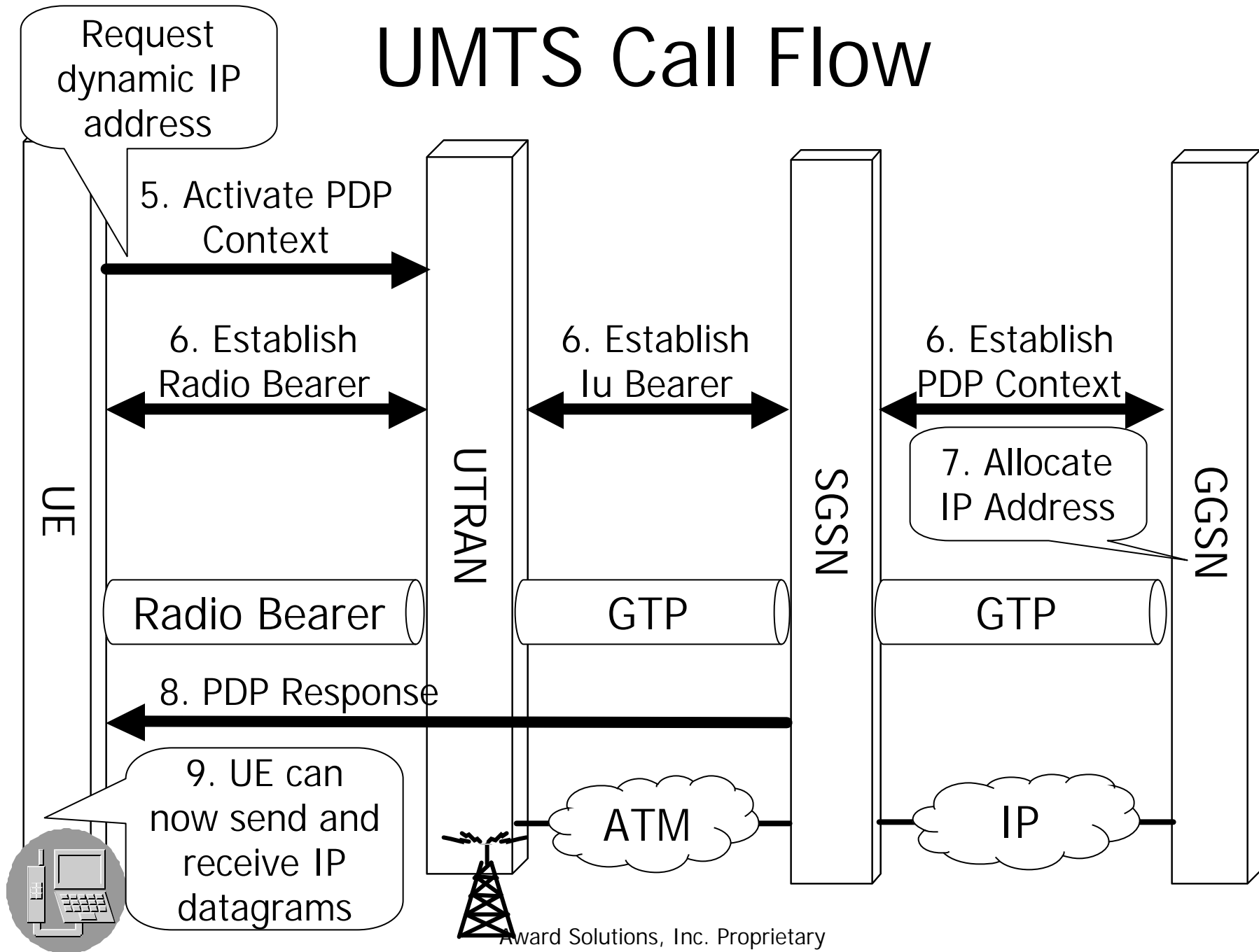
cdma2000 Packet Data Network Architecture



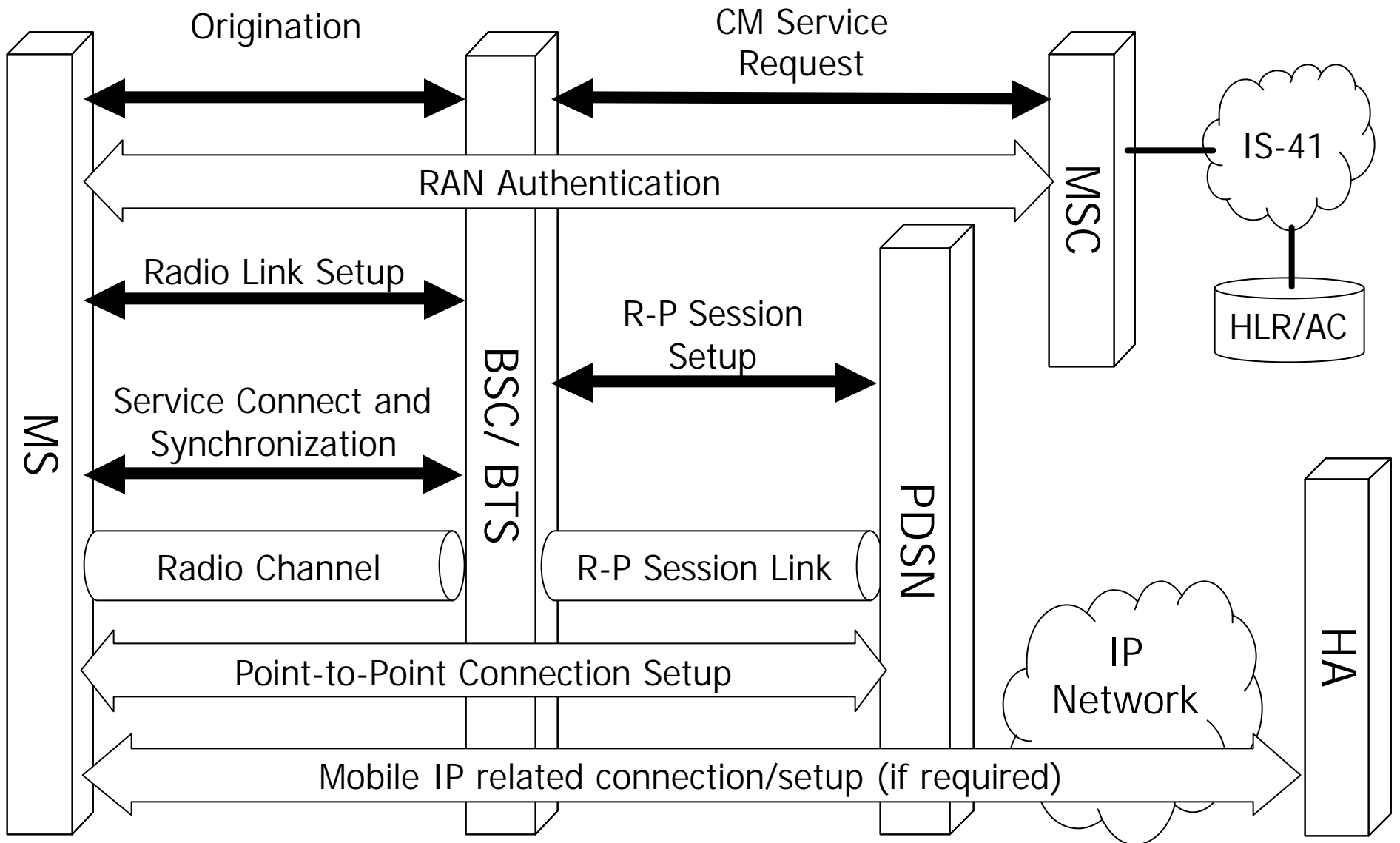
UMTS Call Flow



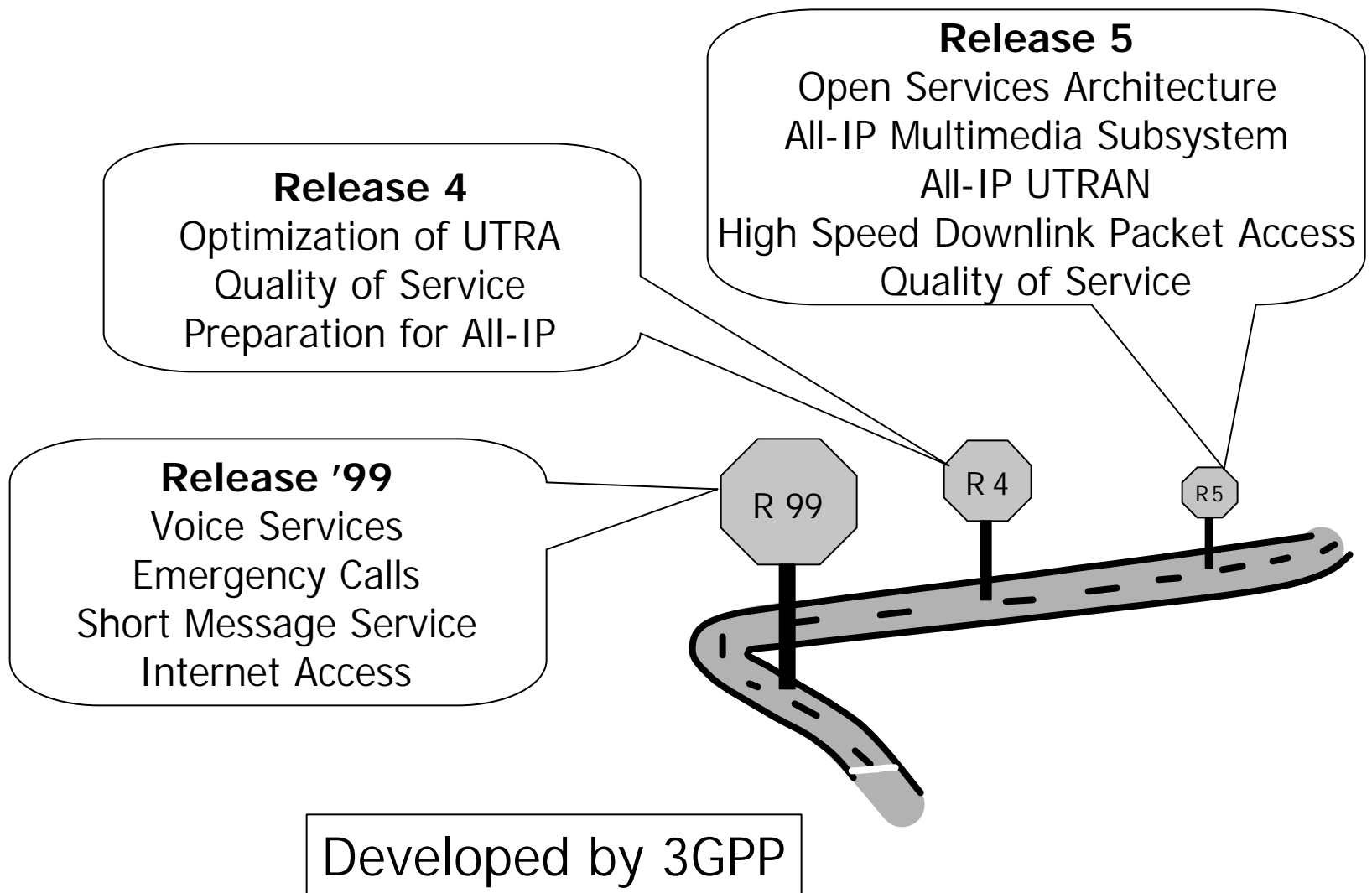
UMTS Call Flow



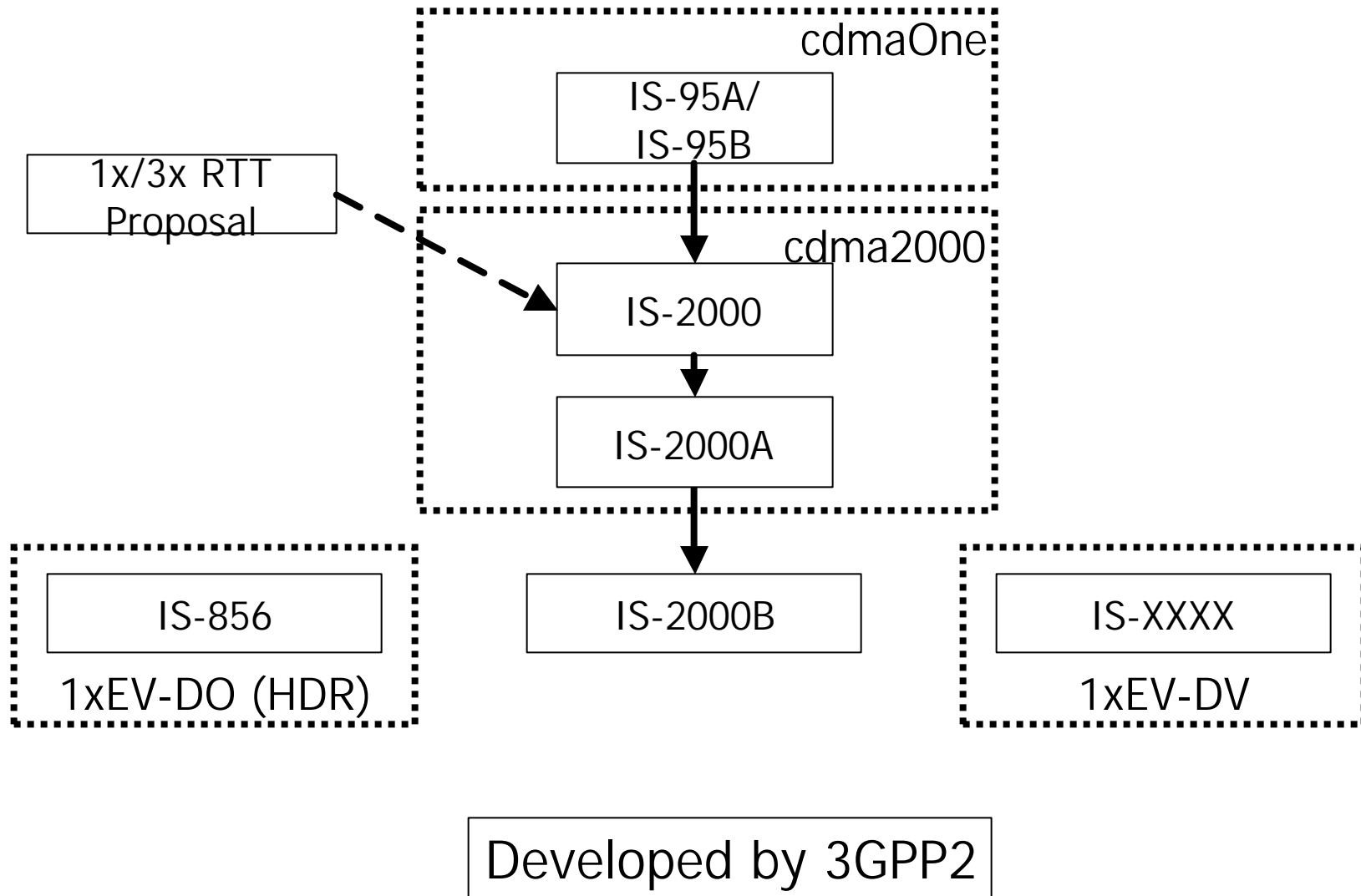
cdma2000 call flow



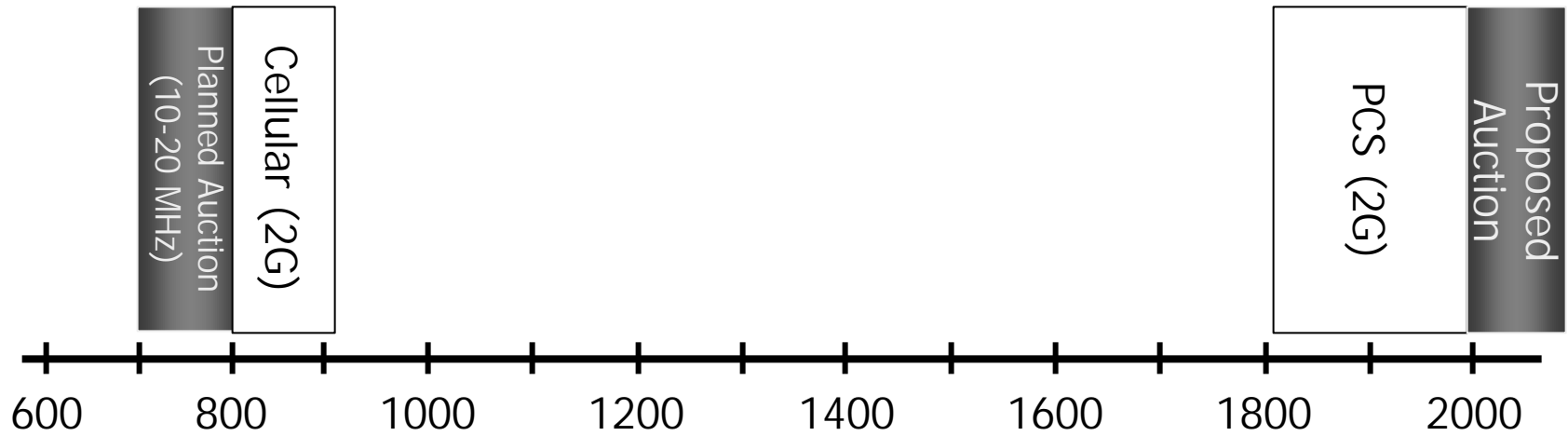
Status of UMTS standards



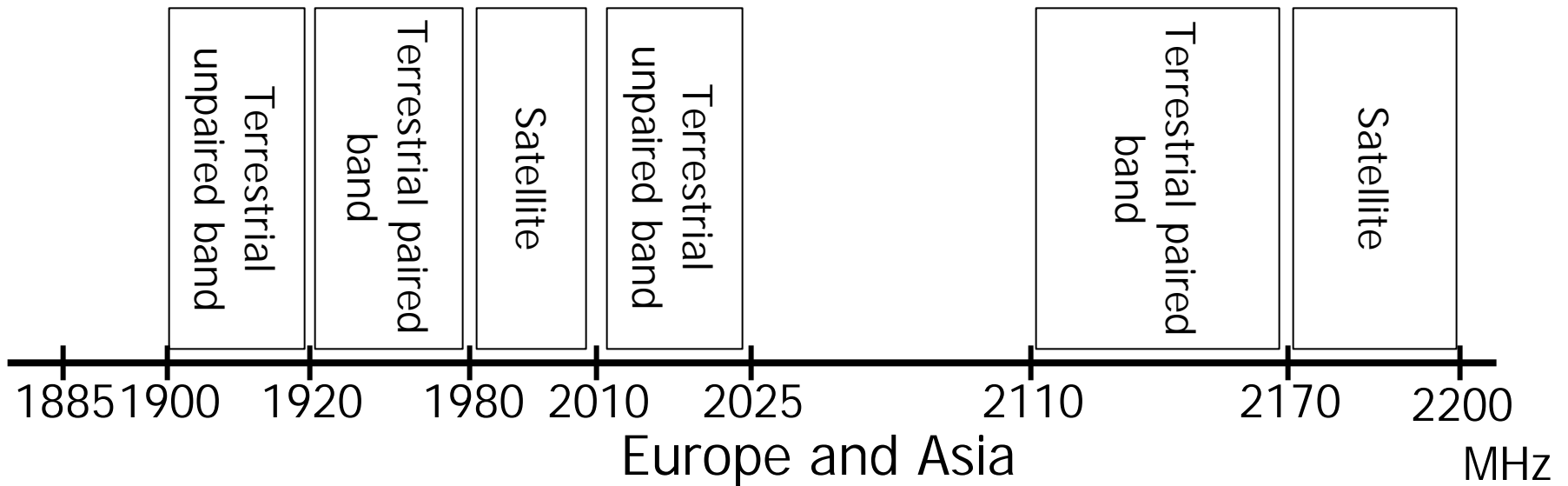
Status of cdma2000 standards



Spectrum allocation



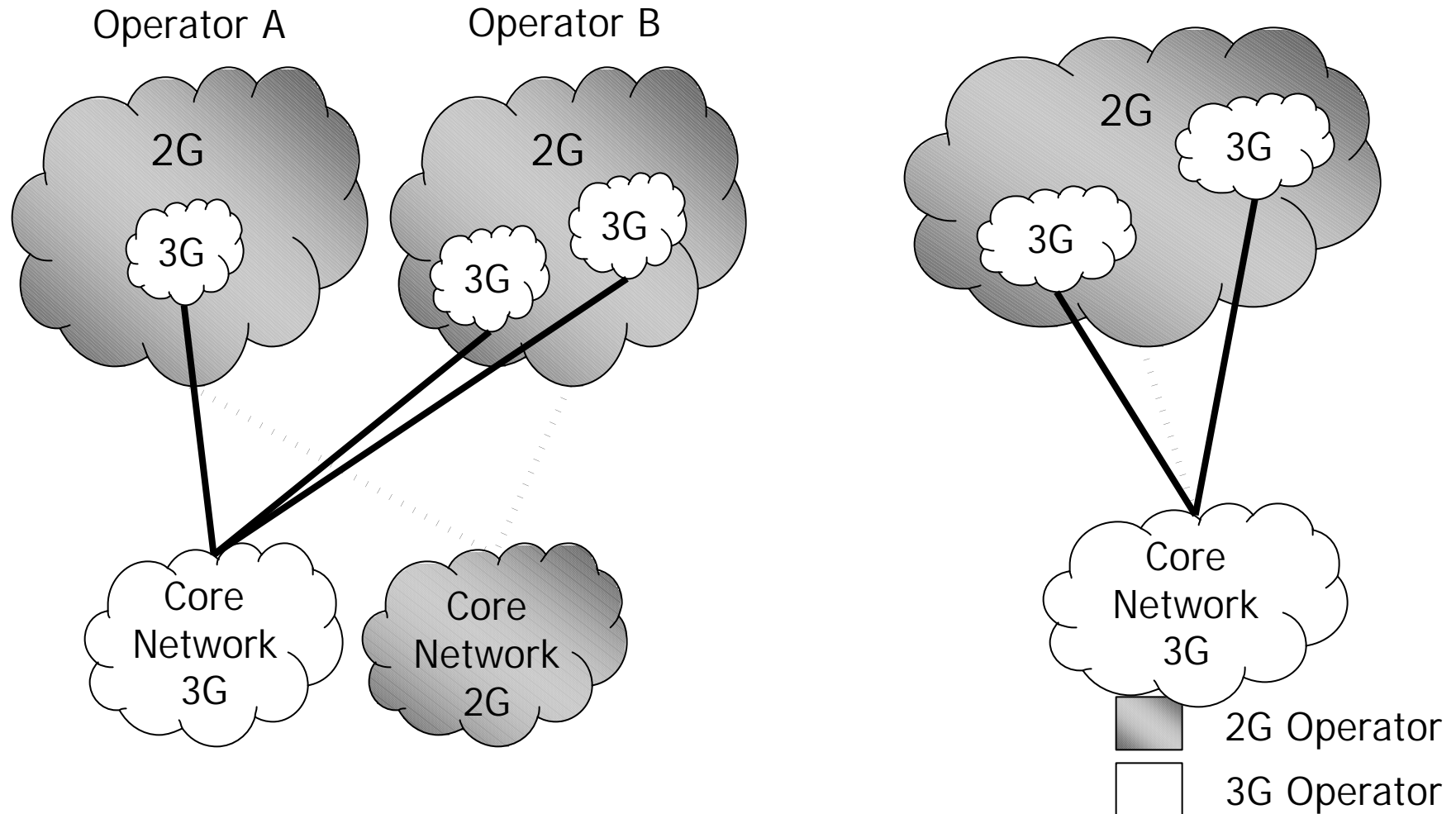
North America



3G Deployment

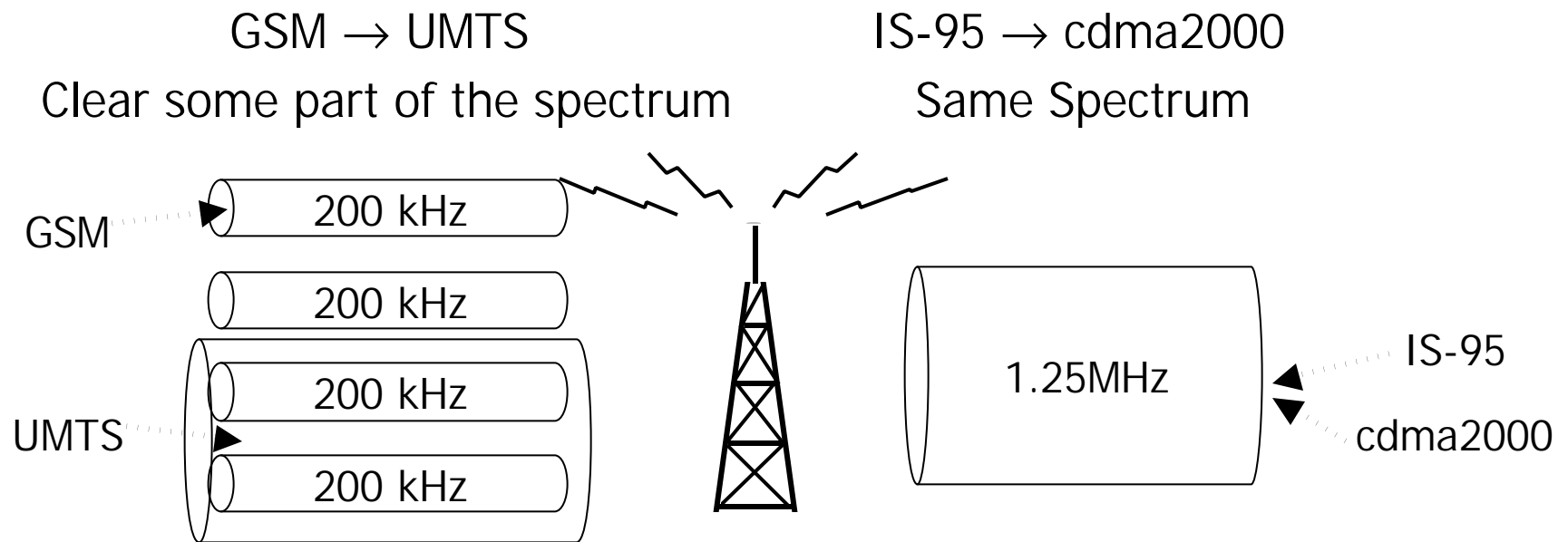
New Operator, New Spectrum

2G Operator, New Spectrum



3G Deployment

2G Operator, Existing Spectrum



- Shared Infrastructure (Core Network, Management Systems, Billing System)
- Dual Mode phone (2G and 3G)

Deployment Status

	UMTS	cdma2000
Japan	Oct-2001	2002
Korea	2003	SKT – Oct 2000 KTF – Dec 2000
Europe	GPRS Started	Not announced
	UMTS in 2002	
USA	GPRS in trials	2001
	UMTS Not announced	

Major Players

- UMTS (3GPP)

- Vendors

- Ericsson
- Nokia
- Nortel
- Motorola
- Alcatel, Lucent, ...

- Operators

- NTTDoCoMo
- Vodafone, ...

- cdma2000 (3GPP2)

- Vendors

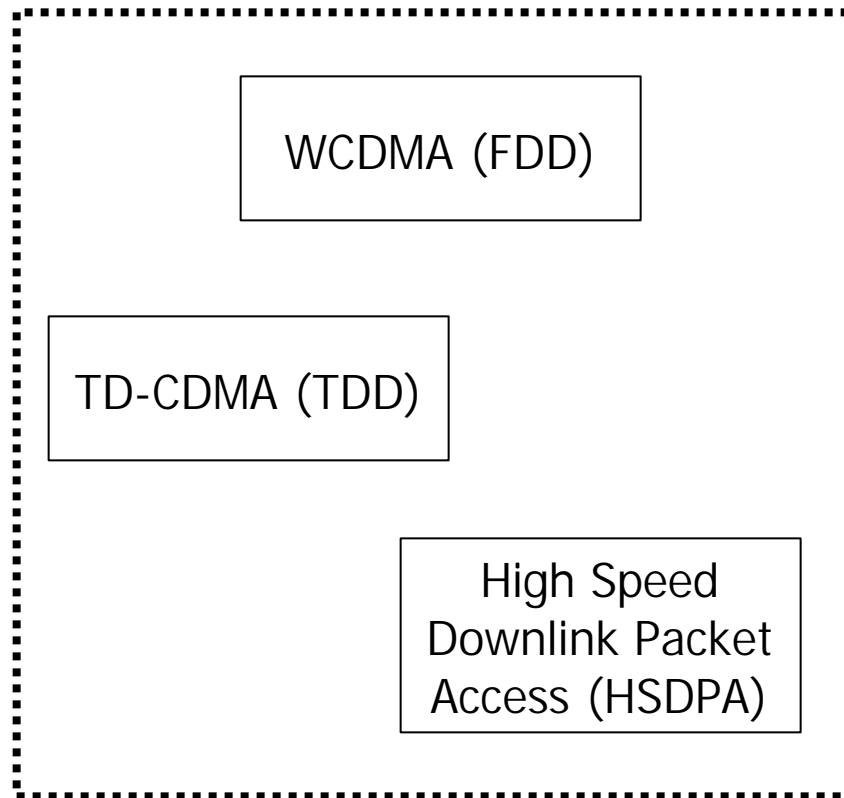
- Qualcomm
- Lucent
- Nortel
- Motorola
- Samsung, Ericsson, ...

- Operators

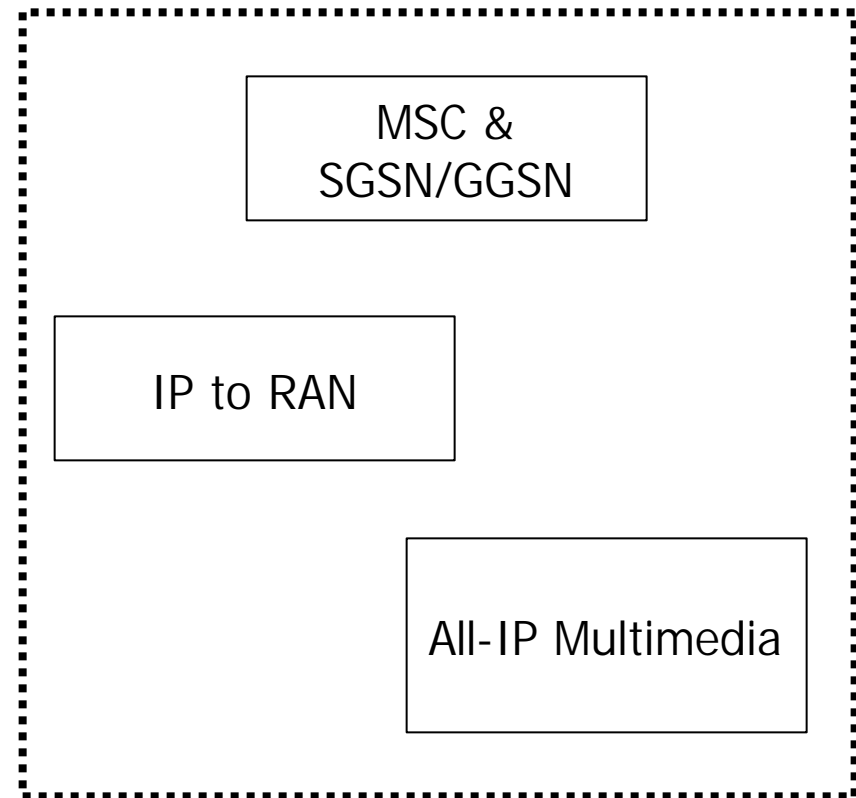
- Sprint PCS
- Verizon, KDDI, SKT...

3G and Beyond - UMTS

Air Interface

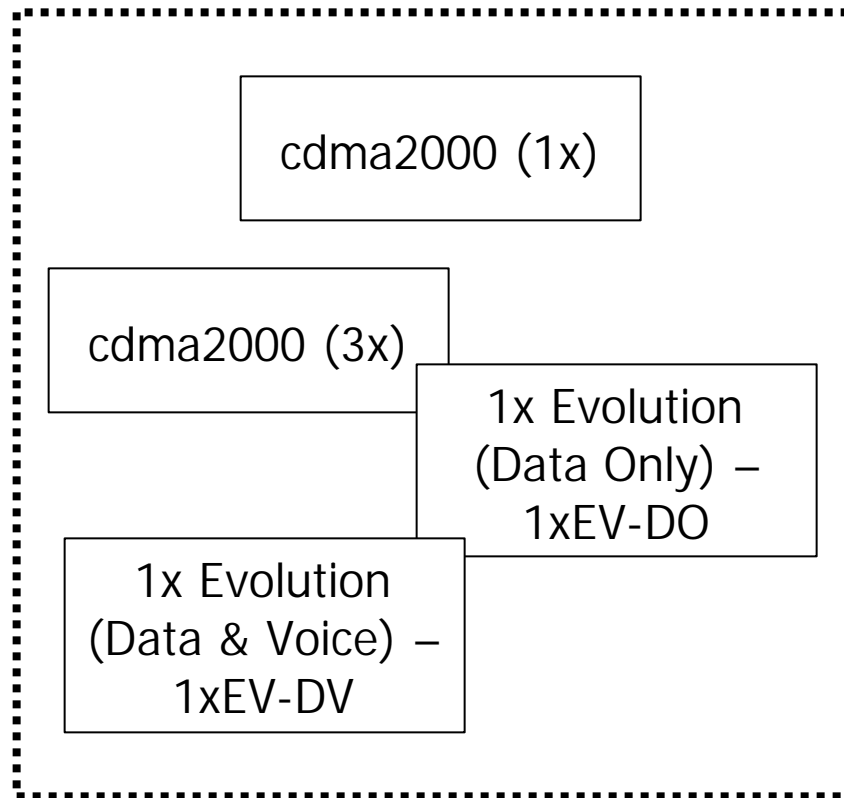


Network

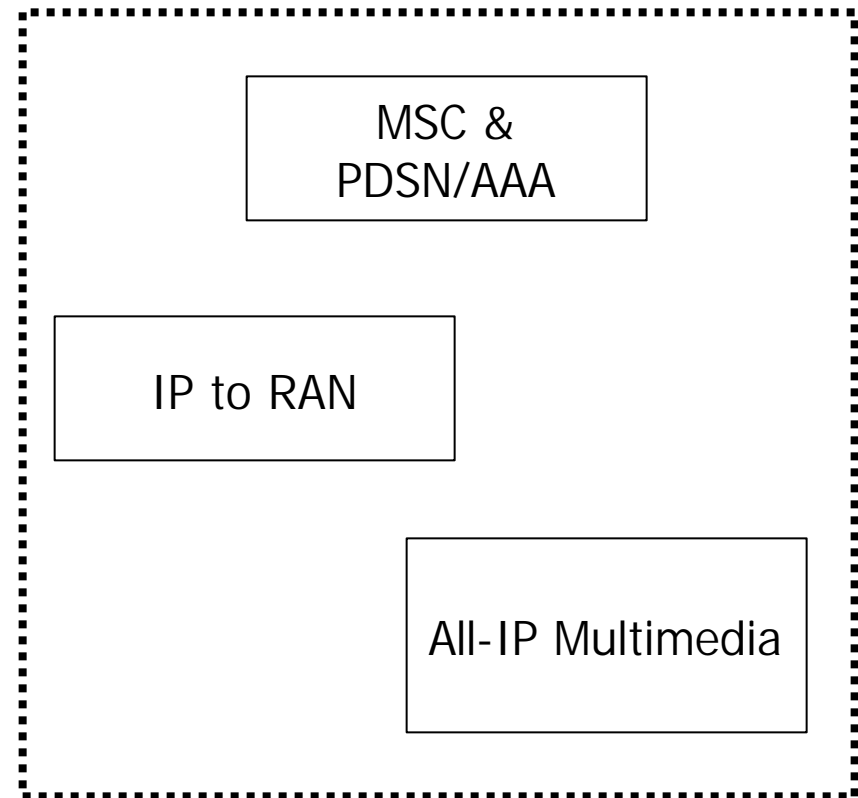


3G and Beyond – cdma2000

Air Interface



Network



Summary – Air Interface

	UMTS	cdma2000
Technology (Bandwidth)	WCDMA (5 MHz)	CDMA (1.25 MHz)
Chip Rate	3.84 Mcps	1.2288 Mcps
Mode of Operation	Asynchronous	Synchronous (GPS)
Peak Data Rate	2 Mbps	614 kbps
Interoperability	GSM – UMTS Handover	Backward Compatible w/IS-95

Summary – Core Network

	UMTS	cdma2000
Circuit Switched	GSM-MAP MSC/HLR/AuC	IS-41 MSC/HLR/AC
Packet Switched	GPRS Based SGSN/GGSN	IETF Based PDSN/AAA/HA/FA
Multimedia	Yes	Yes
Global Roaming	SIM Card	Limited (R-UIM)