


3G: HSPA, cdma 2000

David Tipper
Associate Professor


Graduate Telecommunications
and Networking Program
University of Pittsburgh
2700 Slides 12



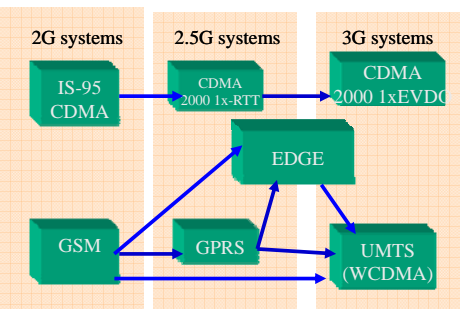
Third Generation Standards

- ITU approved suite of four 3G standards
- EDGE (Enhanced Data rates for Global Evolution)
 - TDMA standard with advanced modulation and combined timeslots
 - Provides unification of NA-TDMA and GSM
 - Only meets some of the 3G requirements (2.75G?)
- UMTS (Universal Mobile Telephone Service) also called WCDMA (wideband CDMA)
 - Dominant standard outside of US and leading standard for 3G worldwide
 - Viewed as 3G migration path for GSM/GPRS/EDGE systems
- CDMA 2000
 - Also called (3X and cdma three): competes directly with W-CDMA up to 2 Mb/s
 - Evolutionary path for IS-95 which is the dominant standard in the US
- TD-SCDMA : Stand alone standard developed in China

Telcom 2720 2



Evolution Path to 3G



Telcom 2700 3

HIGH SPEED DOWNLINK PACKET ACCESS (HSDPA)



- HSDPA \approx 3.5G system upgrade of UMTS
- Standardised in 3GPP Release 5
- Objective is to support *delay-tolerant* services in *low mobility* scenarios with enhanced *resource efficiency* and *service quality*
 - support for background, interactive and (to some extent) streaming services
 - low mobility
 - enable *downlink* peak rates of 8-10 Mbits/s \gg 3G requirements
 - lower resource consumption per transferred delay-tolerant bit

Telcom 2720

4

HIGH SPEED DOWNLINK PACKET ACCESS



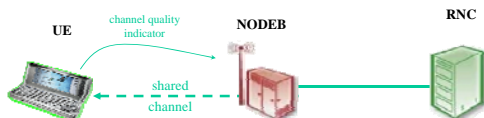
- HSDPA upgrade of UMTS similar to EDGE upgrade of GPRS
 - completely backwards compatible
 - no new spectrum needed
 - reuse existing infrastructure and 5MHz channels
 - primarily software and minor hardware upgrades
 - coexistence of HSDPA- and non-HSDPA-enabled terminals
 - coexistence of HSDPA- and non-HSDPA-enabled NODE-Bs
 - data flows on HS-DSCH moving from non-HSDPA-cell to HSDPA-cell are automatically switched to a supported transport channel, e.g. DCH
 - gradual hot-spot-based network upgrades possible
 - cost-effective



Telcom 2720

5

HSDPA Architecture



- Upgrade UMTS downlink channels to a HS version:
 - *higher-order modulation*: QPSK and 16-QAM
 - *fast link adaptation*: adaptive modulation and coding
 - *fast channel-aware scheduling*: centered at the **node B**
 - *fast hybrid ARQ on downlink*: combines FEC and selective ARQ
 - *reduced TTI of 2 ms*: to facilitate better tracking of channel variations
 - HS channels typically transmits at relatively fixed power

Telcom 2720

6

NEW PHYSICAL CHANNELS

•PHYSICAL CHANNELS

- HS-PDSCH downlink SF 16 data only (up to 15 streams to a user)
- HS-SCCH(s) downlink MAC-hs signalling, H-ARQ,etc.
- HS-DPCCH uplink SF 256 CQI, (N)ACK

Telcom 2720 7

PHYSICAL LAYER PROCESSING

• Physical Layer Processing

Telcom 2720 9

ADAPTIVE MODULATION AND CODING

• LINK ADAPTATION: channel-dependent AMC

- typically more efficient for services that tolerate short-term data rate variations
- with only power-controlled channels, it is difficult to exploit all resources
- AMC can exploit resources better, at the cost of transfer rate jitter
- Fixed spreading factor SF but variable number of streams and bits per channel symbol

MODULATION	SPREADING FACTOR	TURBO CODE RATE	BITS/BLOCK/CODE	DATA RATE (15 CODES)
QPSK	16	1/4	240	1.8 Mbps
	16	1/2	470	3.6 Mbps
	16	3/4	711	5.3 Mbps
16-QAM	16	1/2	950	7.2 Mbps
	16	3/4	1440	10.8 Mbps

Telcom 2720 10

HSDPA Upgrades



- Infrastructure
 - NODE-B
 - a new MAC sublayer (MAC-hs) is standardised and needs to be implemented in the NODE-B
 - depending on the legacy NODE-B capabilities, this update may be done via remote software downloads or may possibly require hardware upgrades as well
 - RNC is largely maintains the UMTS Release '99 functionality
 - a software-only upgrade is required, e.g. to enable assignment of data flows to the HS-DSCH (~ channel switching)
 - no substantial impact on the CORE network is expected
 - New Mobile Terminals
 - Support physical interface, higher data rates and H-ARQ
- HSDPA deployments began 2006 in Europe, Canada, etc. Over 100 deployments

VoIP
Rich Call
Gaming



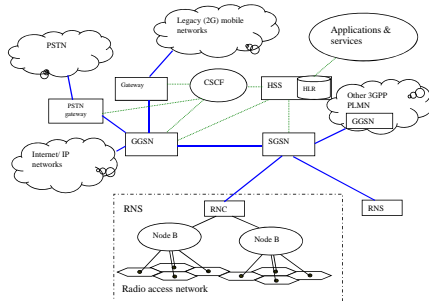
HSUPA



- High Speed Uplink Packet Access
- Similar to HSDPA – advanced coding and modulation techniques with hybrid ARQ to improve data rate on uplink channel in UMTS
- Now called Enhanced Uplink (EUL) (3GPP)
- Data rates from .73Mbps – 5.76Mbps, 11.5Mbps being tested
- Uses new Enhanced versions of Signaling and physical channels
- Focus of UMTS now on IP in the backhaul



3GPP IP Reference Architecture



The 3GPP IP reference architecture – all traffic IP - with QoS Classes

UMTS



- UMTS is most popular 3G technology
 - Upgrade path from GPRS/EDGE – primarily in air interface to WCDMA standard
 - Now called 3GSM
 - WCDMA – variable power/spreading cdma
 - Provides standard benefits of cdma technology (frequency reuse factor 1, soft handoff, etc.)
 - Deployed throughout the world
 - Upgrade path to HSPDA and HSUPA and all IP in the core defined - over 62.5 million HSPA users

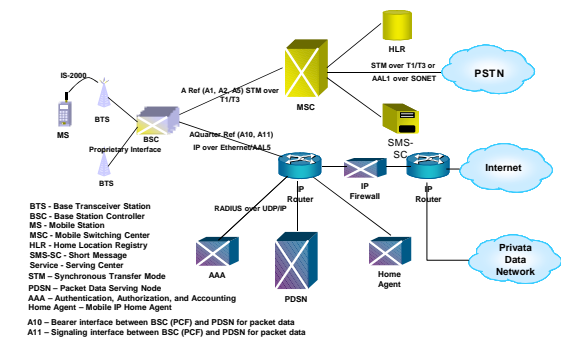


cdma2000



- cdma2000
 - Goal: provide 2.5G and 3G services over TIA/EIA-41 systems which include IS-95a, b, cdmaone systems
 - Evolutionary path
 - cdma2000-1xRTT uses multiple codes on same 1.25 MHz carrier of IS-95 and slight change to the modulation to provide packet data – up to 78 Kbps (basically 2.5G standard)
 - cdma2000-1x-EVDO – a 1.25 MHz radio carrier is dedicated to data only (DO) more Walsh codes per carrier (256) – high data rates – 646 kbps
 - Cdma 2000 1x-EV-DV – carriers supports both data and packetized voice, all IP backhaul network
 - CDMA 2000 3x RTT called multi-carrier mode CDMA
 - Extension of IS-95 – uses multiple x 1.25Mhz IS-95 channels
 - On hold until market demands it.
 - IS-41 or GSM MAP signalling in core

CDMA2000 1x Network



2G System IS-95 (cdmaone)

- Cdmaone
- 2G system
- Voice 14 Kbps or variable rate 9.6 Kbps
- Data 14.4 Kbps
- 1.25 MHz carrier
- 64 Walsh codes per carrier

Legend:

- BTS - Base Transceiver Station
- BSC - Base Station Controller
- MS - Mobile Station
- MSC - Mobile Switching Center
- HLR - Home Location Registry
- SMS-SC - Short Message Service - Serving Center
- STM - Synchronous Transfer Mode

Interface Definitions:

- A1 - Signaling interface for call control and mobility Management between MSC and BSC
- A2 - 64 kbps bearer interface for PCM voice
- A3 - Signaling interface for inter-BSC mobile handoff
- A4 - Full duplex bearer interface byte stream (SMS)
- A5 - Bearer interface for inter-BSC mobile handoff

Telcom 2720
18

Cdma2000 – 1X RTT

Legend:

- BTS - Base Transceiver Station
- BSC - Base Station Controller
- MS - Mobile Station
- MSC - Mobile Switching Center
- HLR - Home Location Registry
- SMS-SC - Short Message Service - Serving Center
- STM - Synchronous Transfer Mode
- PDSN - Packet Data Serving Node
- AAA - Authentication, Authorization, and Accounting
- Home Agent - Mobile IP Home Agent

Interface Definitions:

- A10 - Bearer interface between BSC (PCM) and PDSN for packet data
- A11 - Signaling interface between BSC (PCM) and PDSN for packet data

Telcom 2720
19

Packet Data Serving Node (PDSN)

- PDSN – similar to SGSN in GPRS
- Establish, maintain, and terminate PPP sessions with mobile station
- Support simple and mobile IP services
 - Act as mobile IP Foreign Agent for visiting mobile station
- Handle authentication, authorization, and accounting (AAA) for mobile station
 - uses RADIUS protocol
- Route packets between mobile stations and external packet data networks
- Collect usage data and forward to AAA server

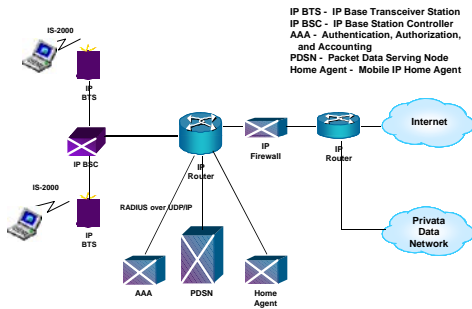
Telcom 2720
20

AAA Server and Home Agent

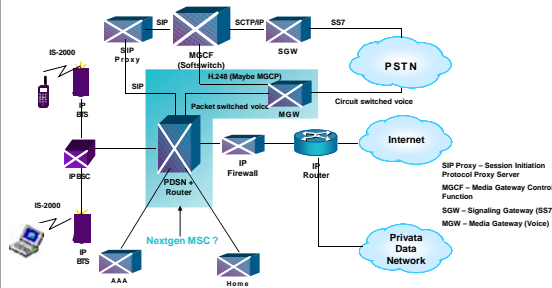


- AAA server
 - Authentication: PPP and mobile IP connections
 - Authorization: service profile and security key distribution and management
 - Accounting: usage data for billing
- Mobile IP Home Agent
 - Track location of mobile IP subscribers when they move from one network to another
 - Receive packets on behalf of the mobile node when node is attached to a foreign network and deliver packets to mobile's current point of attachment

1xEVDO -- Data Only on some carriers



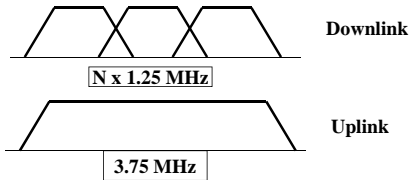
1xEVDO -- IP Data and Voice



Multicarrier CDMA (CDMA2000 – 3x)



- Deployed in the same frequency spectrum as IS-95
- 144 Kbps – 384 Kbps high-mobility access
- 2048 Kbps limited coverage
- Uplink: Single wideband carrier with chip rate 3.6864 Mcps
- Downlink: Multiple (up to 12) narrow band carriers (1.2288 Mcps)
- Same architecture at cdma2000 1XEVDV – requires base station and MS equipment changes



Telcom 2720

CDMA2000 Parameters

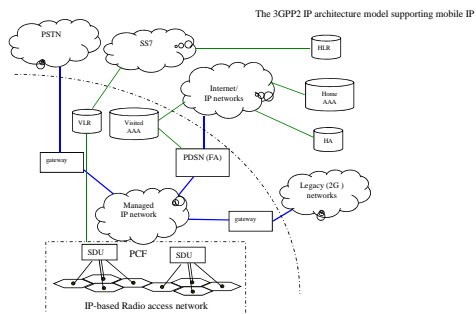


Channel bandwidth	1.25, $N \times 1.25 \text{ MHz}$, UL = 3.75 MHz
Channel structure	Direct spread spectrum or multicarrier spread spectrum
Chip rate	3.6864 Mcps for direct spread $n \times 1.2288 \text{ Mcps}$ ($n = 1, 3, 6, 9, 12$) for multicarrier
Frame length	20ms for data and control, 5 ms for control information on the fundamental and dedicated control channel
Handover	Soft handover and interfrequency handover

Telcom 2720

25


3GPP2 IP Architecture Model



Telcom 2720

Wireless Access Provider Network


26



Systems Comparison

	CDMA 2000	UMTS	GSM	IS-95
Physical Channel	1 to N x 1.25 MHz channels DL, UL 3.75 MHz	5 MHz	200 kHz	1.23 MHz
Modulation	OQPSK	QPSK	GMSK	OQPSK
Channel rate	N x 1.288 Mcps in downlink, 3.6864 Mcps uplink	3.84 Mcps	270.833kbs	1,228.8kcps
Modulation Efficiency (b/s/Hz)	1	.768	1.4	1.0


Telcom 2720 27



Systems Comparison

	CDMA 2000	WCDMA	GSM	IS-95
Power Control	800 Hz up and down link	1500 Hz up and down link	2Hz	800 Hz uplink
Base Station Synch	Yes using GPS	No	No	Yes, using GPS
Load Based Scheduling	Somewhat with coding and multiple carriers	Yes variable Spreading and coding, TDD mode	Voice only	Voice only
System standard	Air only at this time	Complete System	Complete System	Air only
Security	Spread Spectrum + AAA IP (eventually)	F1-F9 algorithms + USIM card	A3, A5, A8 algorithm + SIM card	Spread Spectrum + optional CAVE

Telcom 2720 28



Pros and Cons

- CDMA2000
 - Pros: Better migration story from 2G to 3G
 - cdmaOne operators don't need additional spectrum
 - 3x promises higher data rates than UMTS, i.e. W-CDMA
 - Cons: CDMA2000 core network less mature
 - cmdaOne interfaces were vendor-specific
 - hopefully CDMA2000 vendors will comply w/ 3GPP2
- UMTS/3GSM
 - Pros: Largest market share
 - First to market with new equipment/phones
 - All the advantages of CDMA
 - Higher data rates with HSPA
 - Cons: Need new/more spectrum (5MHz channels)
 - Expensive to implement

Telcom 2720 29
