Cellular Wireless Networks

3G Systems (part 2)

IMT-2000

UMTS

CDMA2000

EDGE

Outline

- Last Lecture
    - IMT2000
    - UMTS
        - Releases
        - Architecture
        - Spreading and scrambling
        - Frame structure
        - Channels
        - Mobility Support

- This Lecture
    - UMTS
        - Power control [HT 04], [HT 07]
        - Power control in Soft Handover [HT 04], [HT 07]
        - UMTS services
    - CDMA2000
    - EDGE

Power Control in UMTS [HT 04]

- Fast power control is a very important aspect in WCDMA, in particular in the uplink, because of the near-far problem of CDMA
- Open loop power control mechanisms make a rough estimate of path loss by means of a downlink beacon signal
  - far too inaccurate
  - fast fading is essentially uncorrelated between uplink and downlink (large separation of the bands)
  - It is used in WCDMA only to provide a initial power setting of the MS at the beginning of a connection

Power Control in UMTS [HT 04]

- Open loop power control
  - it is applied only prior to initiating the transmission on the RACH
  - Rate of commands is 10 - 100 per second
  - It is not very accurate
    - large deviations due to variation in the component properties, environmental conditions (temperature)
    - the transmission and reception occur at different frequencies
    - the internal accuracy inside the terminal is the main source of uncertainty

Power Control in UMTS [HT 04]

- Fast closed loop power control
  - In closed loop power control, the BS performs frequent estimates of the received Signal-to-Interference Ratio (SIR) in the uplink and compares it to a target SIR
  - If the measured SIR is higher than the target SIR, the BS will command the MS to lower the power; if it is too low it will command the MS to increase its power
  - This measure-command-react cycle is executed 1500 times per second for each MS
    - faster than any significant change of path loss could happen
    - faster than the speed of fast Rayleigh fading for low to moderate mobile speeds

Power Control in UMTS [HT 04]

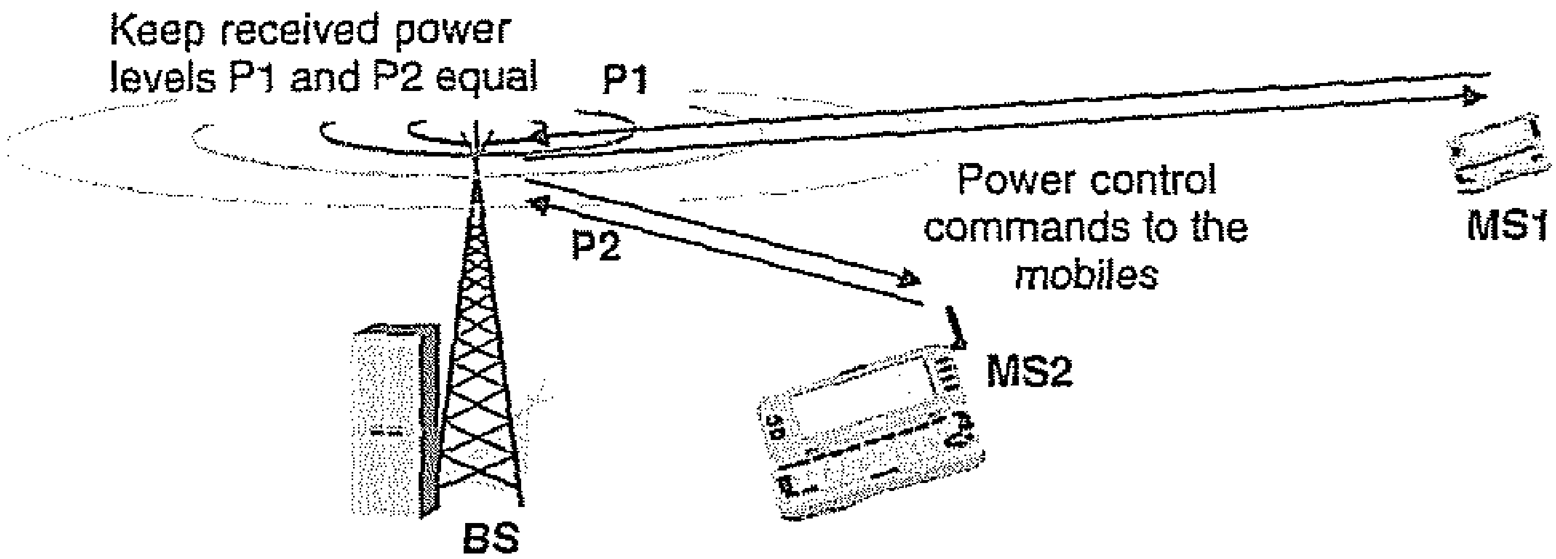


Figure 3.8. Closed loop power control in CDMA

Next slide shows how uplink closed loop power control works on a fading channel at low speed

Power Control in UMTS [HT 04]

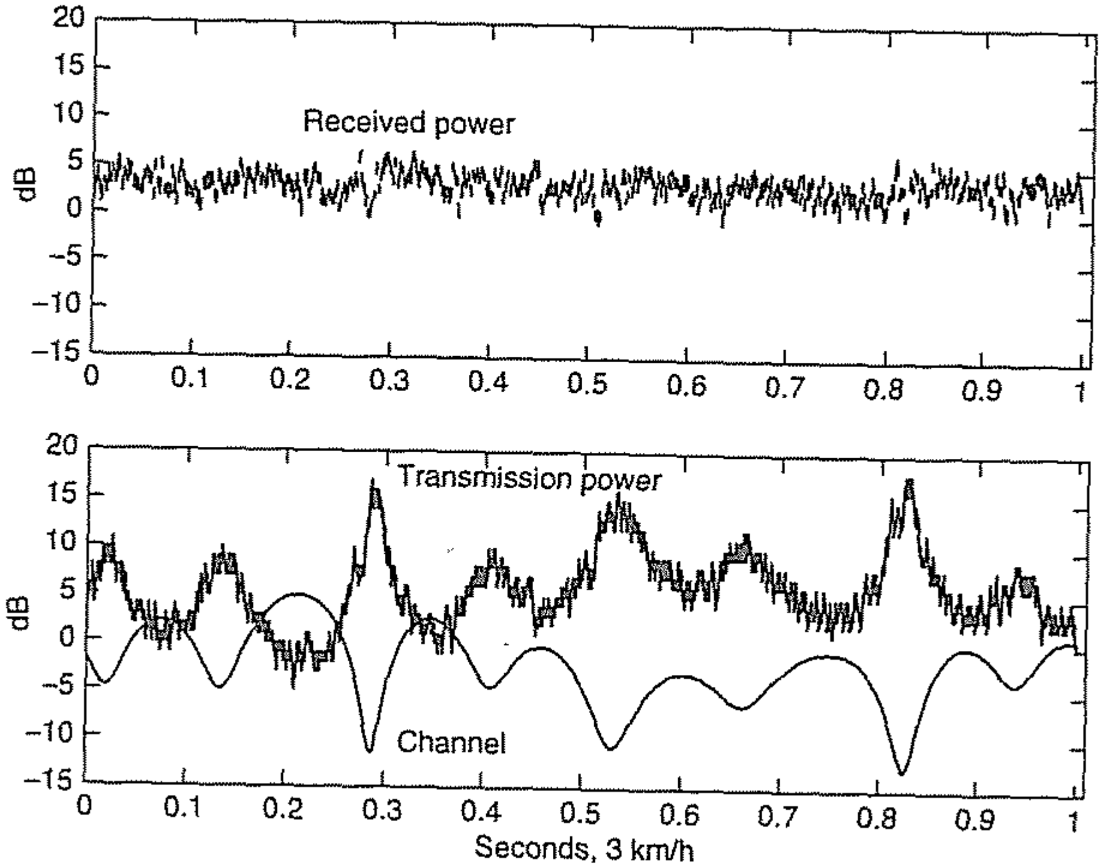


Figure 3.9. Closed-loop power control compensates a fading channel

Power Control in UMTS [HT 04]

- Fast power control operation operates on a basis of one command per slot (1500 Hz command rate)
- The basic step size is 1 dB
  - Multiples of that step size can be used and smaller step sizes can be emulated
  - The emulated step size means that the 1 dB step is used, for example, only every second slot, thus emulating the 0.5 dB step size
- Fast power control operation has two special cases: operation with soft handover and with compressed mode
  - In soft handover the main issue for terminals is how to react to multiple power control commands from several sources
    - The terminal combines the commands but also takes the reliability of each individual command decision into account in deciding whether to increase or decrease the power

Power Control in UMTS [HT 04]

- The SIR target for closed loop power control is set by the outer loop power control
- Outer Loop power control adjusts the target SIR in the BS according to the needs of the individual radio link
  - It aims at a constant quality, usually defined as a certain BER or BLER
  - The required SIR (say BLER = 1%) depends on the mobile speed and the multipath profile
  - SIR set for the worst case (i.e. high mobile speeds)
    - waste much capacity for connections at low speeds
    - best strategy is to let the target SIR float around the minimum value that just fulfils the required target quality

Power Control in UMTS [HT 04]

- Outer Loop power control (cont.)
  - There is a tag for each uplink user data frame with a frame reliability indicator, such as a CRC (Cyclic Redundancy Check) check result obtained during decoding of that particular user data frame
    - If the frame quality indicator indicates to the RNC that the transmission quality is decreasing, the RNC will command the BS to increase the target SIR
  - The control resides in the RNC because this function should be performed after a possible soft handover combining

Power Control in UMTS [HT 04]

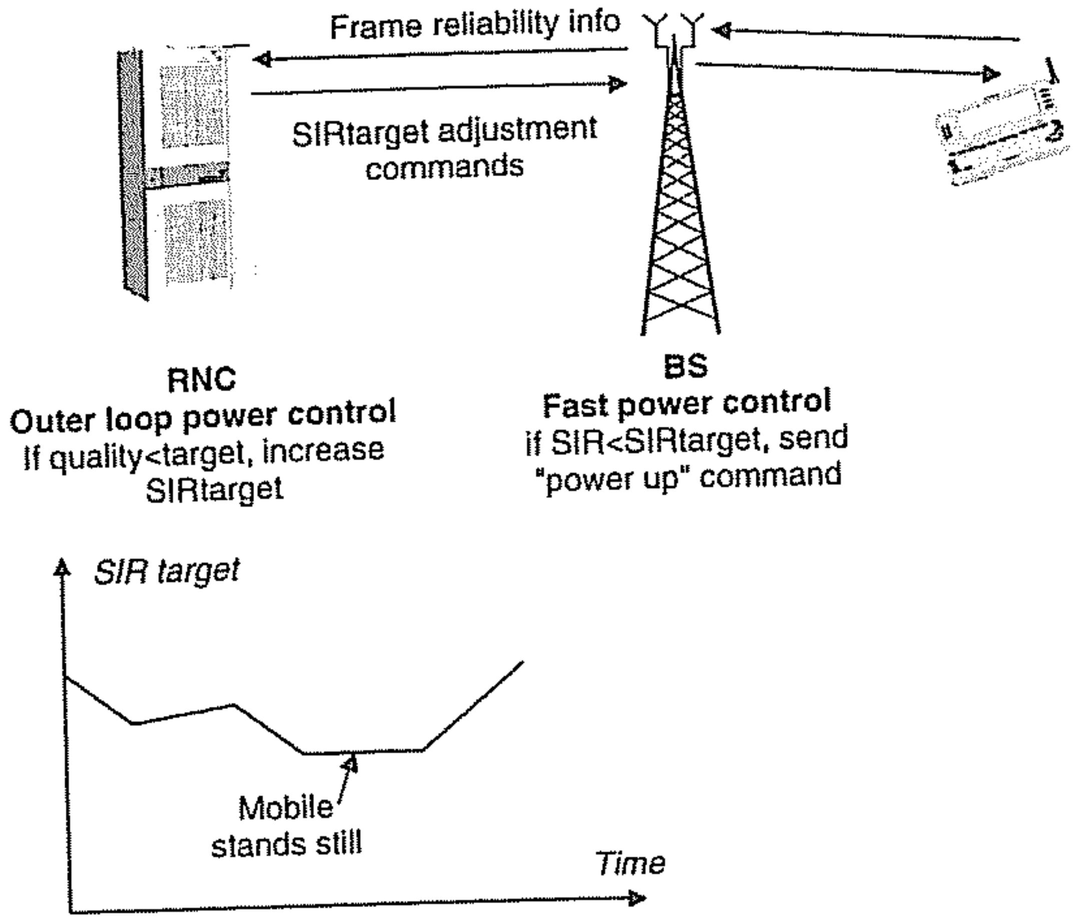


Figure 3.10. Outer loop power control

Power Control in UMTS [HT 04]

- Fast closed loop power control technique is also used on the downlink
  - motivation is different: on the downlink there is no near-far problem
  - But it is desirable to provide a marginal amount of additional power to mobile stations at the cell edge, as they suffer from increased other-cell interference
  - Also a method of enhancing weak signals caused by Rayleigh fading with additional power is needed at low speeds when other error-correcting methods based on interleaving and error correcting codes do not yet work effectively

Power control in Soft handover [HT 04]

- Downlink Power Drifting
  - The UE sends a single command to control the downlink transmission powers; this is received by all Node Bs in the active set
  - The Node Bs detect the command independently, due to signalling errors in the air interface, the Node Bs may detect this power control command in a different way
  - It is possible that one of the Node Bs lowers its transmission power to that UE while the other Node B increases its transmission power
    - The downlink powers can start drifting apart
  - Power drifting is not desirable (degrades the downlink soft handover performance)
  - It can be controlled via RNC
    - The simplest method is to set relatively strict limits for the downlink power control dynamics
    - Or RNC can receive information from the Node Bs concerning the transmission power levels which are averaged over a number of power control commands, based on those measurements, RNC can send a reference value for the downlink transmission powers to the Node Bs reducing the power drifting
  - Power drifting can happen only if there is fast power control in the downlink

Power control in Soft handover [HT 04]

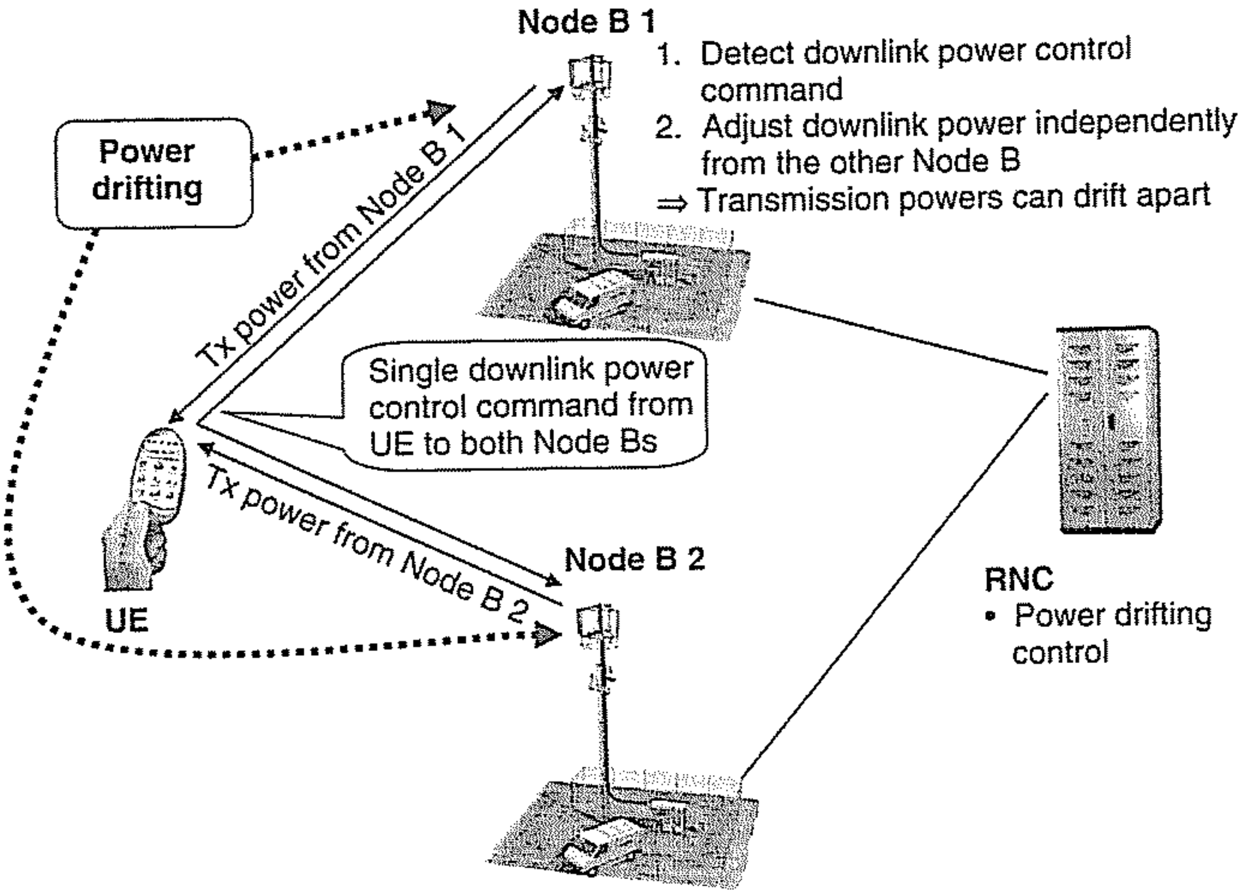


Figure 9.6. Downlink power drifting in soft handover

Power control in Soft handover [HT 04]

- Reliability of Uplink Power Control Commands
  - All the Node Bs in the active set send an independent power control command to the UEs to control the uplink transmission power
  - It is enough if one of the Node Bs in the active set receives the uplink signal correctly. Then, the UE can lower its transmission power if one of the Node Bs sends a power-down command
  - Maximal ratio combining can be applied to the data bits in soft handover in the UE, because the same data is sent from all soft handover Node Bs, but not to the power control bits because they contain different information from each of the Node Bs
    - Therefore, the reliability of the power control bits is not as good as for the data bits, and a threshold in the UE is used to check the reliability of the power control commands
    - Very unreliable power control commands should be discarded because they are corrupted by interference

Power control in Soft handover [HT 04]

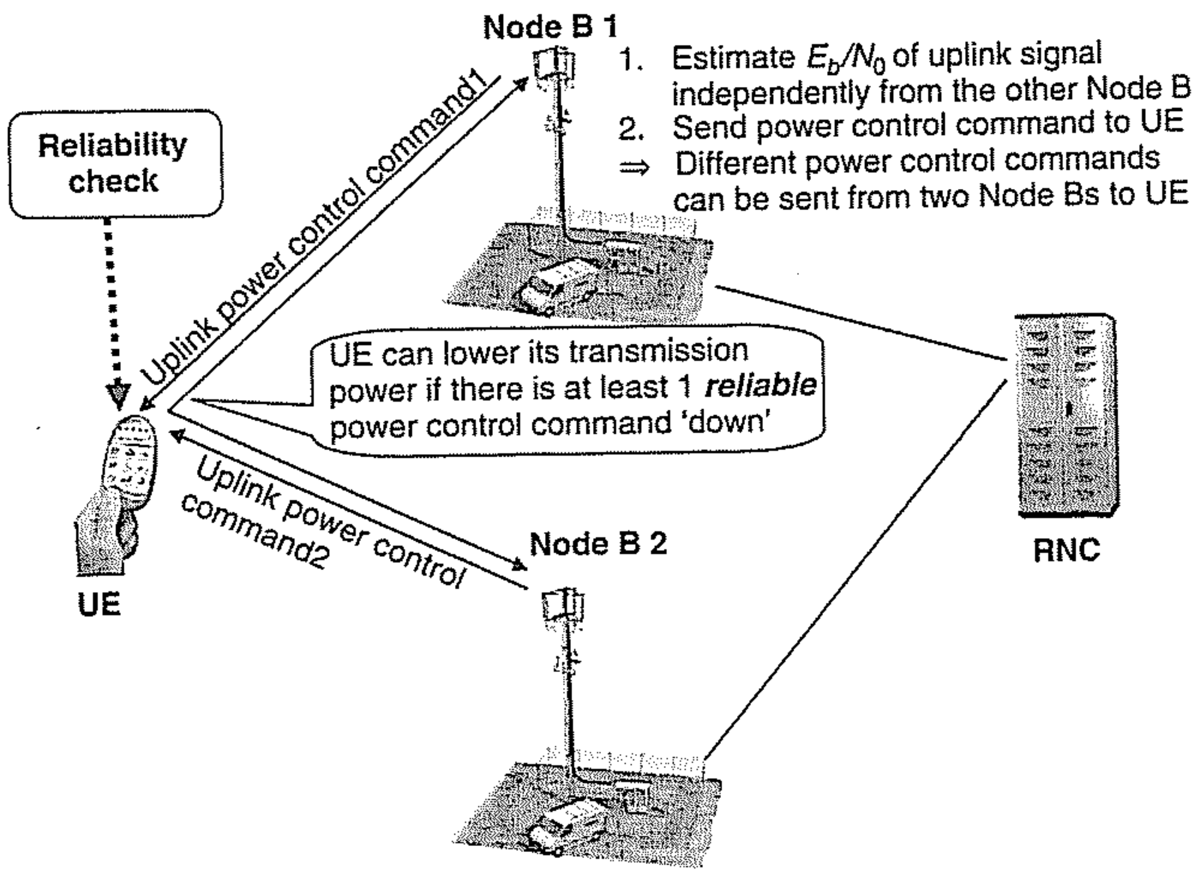


Figure 9.7. Reliability check of the uplink power control commands in UE in soft handover

Power control in Soft handover [HT 04]

- Improved Power Control Signalling Quality
  - The power control signalling quality can be improved by setting a higher power for the dedicated physical control channel (DPCCH) than for the dedicated physical data channel (DPDCH) in the downlink if the UE is in soft handover
  - This power offset between DPCCH and DPDCH can be different for different DPCCH fields: power control bits, pilot bits and TFCI

Power control in Soft handover [HT 04]

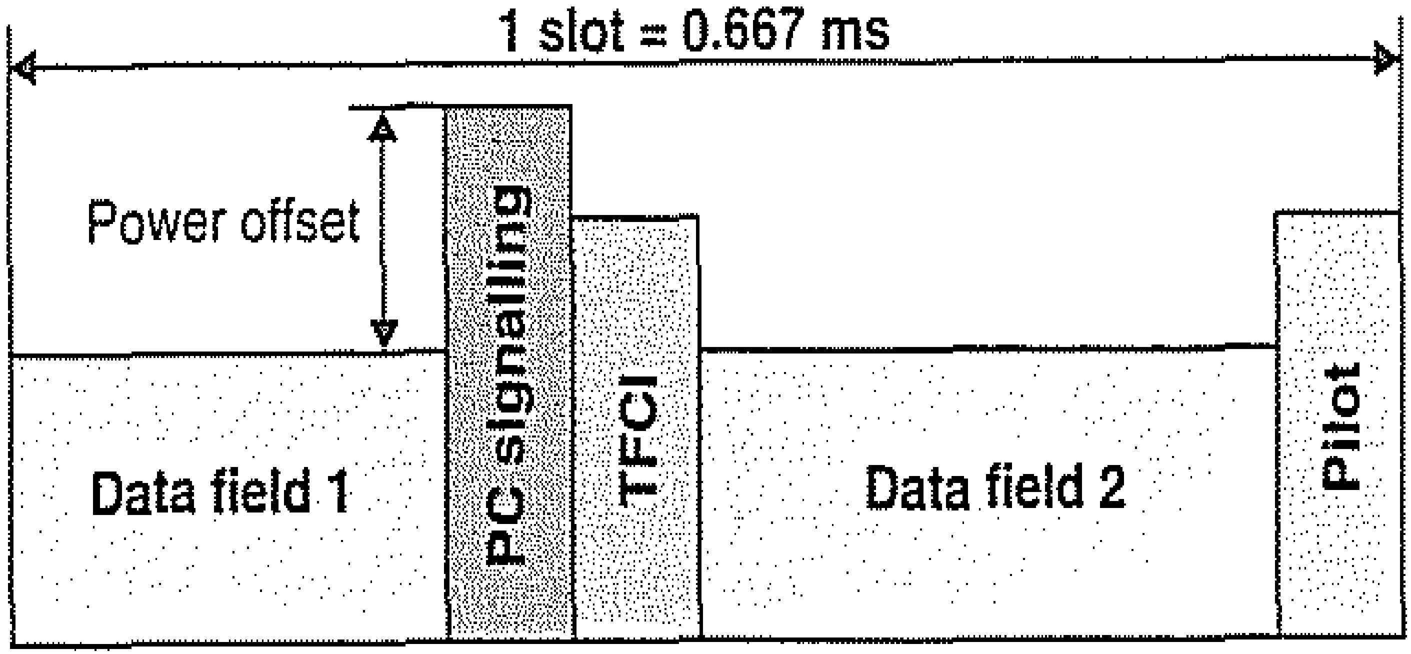


Figure 9.8. Power offset for improving downlink signalling quality

Informative slides

OTHER 3G TECHNOLOGIES

CDMA2000/3GPP2

- Trademark for IS-95 CDMA evolution path
  - IS-95 B offers significant performance improvement and 64kbps packet data, but it is not considered part of CDMA2000
- IS-2000 is the first phase of a 3G evolution
  - Branded as CDMA2000
  - 1xRTT (or 1X) is the first step
  - 1xEV is the second step (EV=Evolution), providing increased data rates
  - 3xRTT (or 3X) is the third step, supporting 3 x 1.2288Mcps
    - Multi-carrier solution, i.e. spreading over a maximum of 1.2288 Mcps

CDMA2000/3GPP2 [HT 04]

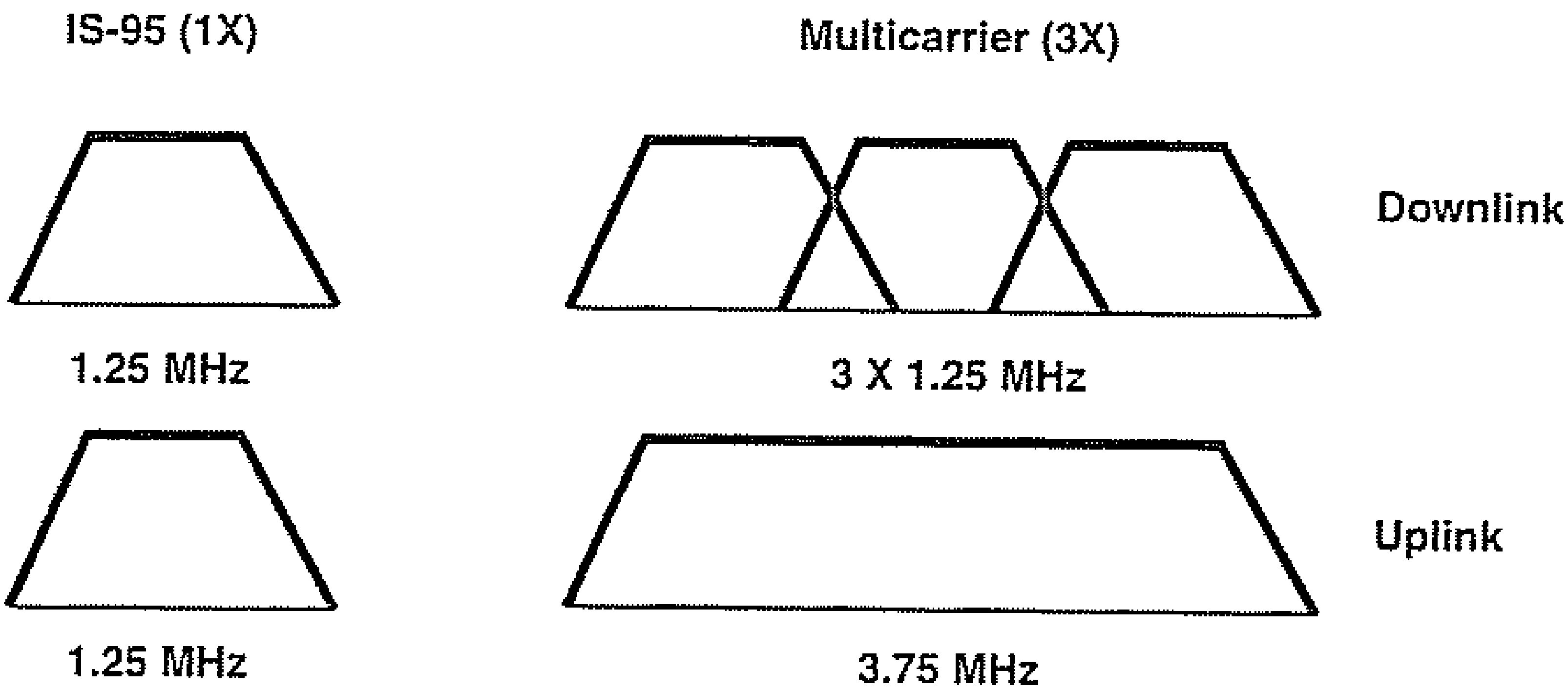


Figure 14.1. Relationship between the MC mode and IS-95 in spectrum usage

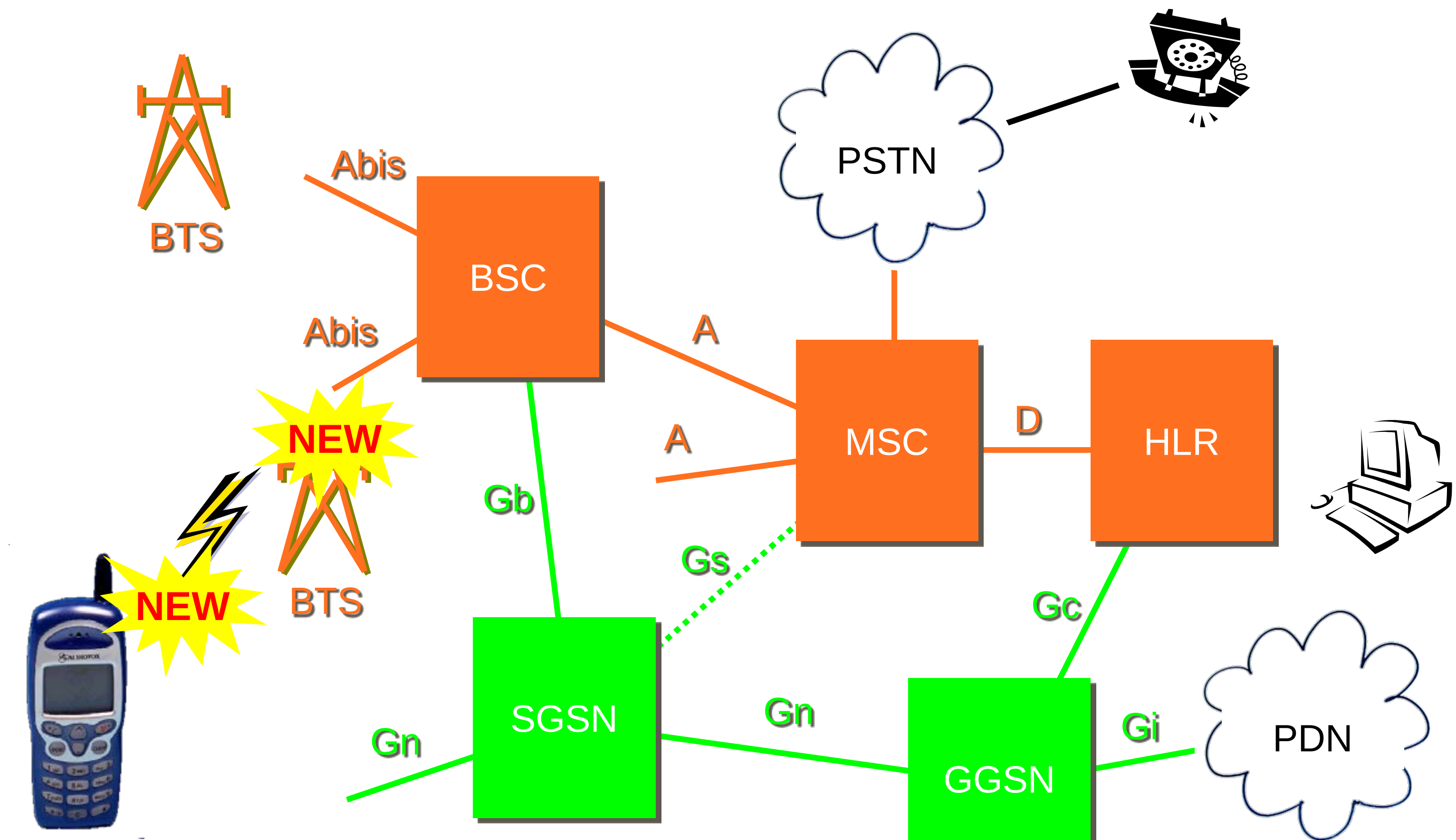
Key Differences between W-CDMA and CDMA2000

Parameter	CDMA2000	W-CDMA
Chip Rate	3.68 Mcps	3.84 Mcps
Spreading	Multi-carrier	Spreading over 5MHz
Synchronisation	Synchronous	Asynchronous
Frame Duration	20ms	10ms
Forward Pilot	Common code multiplexed pilot	Dedicated time division multiplexed pilot
Signalling	ANSI-41	GSM-MAP

EDGE - Enhanced Data rates for GSM Evolution

- Uses a new modulation on the air interface to improve efficiency usage
  - 8 PSK instead of GSM's GMSK and other techniques
- Based on GPRS, EDGE allows "Enhanced GPRS" mode (E-GPRS) offering up to 48kbps on every radio channel
  - Using 8 channel, a transceiver may support up to 384kbps
- Existing BSS infrastructure can be used to offer EDGE, but the new modulation technique does require a new generation of transceiver, a single EDGE transceiver required for each cell

EDGE



Abis
BTS
BSC
PSTN
Abis
A
NEW
A
MSC
D
HLR
Gb
NEW
BTS
Gs
Gc
SGSN
Gn
GGSN
Gi
PDN
Gn

EDGE main features [HMR03]

	8-PSK	GMSK
Symbol rate	270.833kbps	270.833 kbps
Number of bits/symbol	3 bits/symbol	1 bit/symbol
Payload/burst	342 bits	114 bits
Gross rate/timeslot	68.4 kbps	22.8 kbps

Table 1.5 key physical layer parameters for EDGE

- 8-PSK

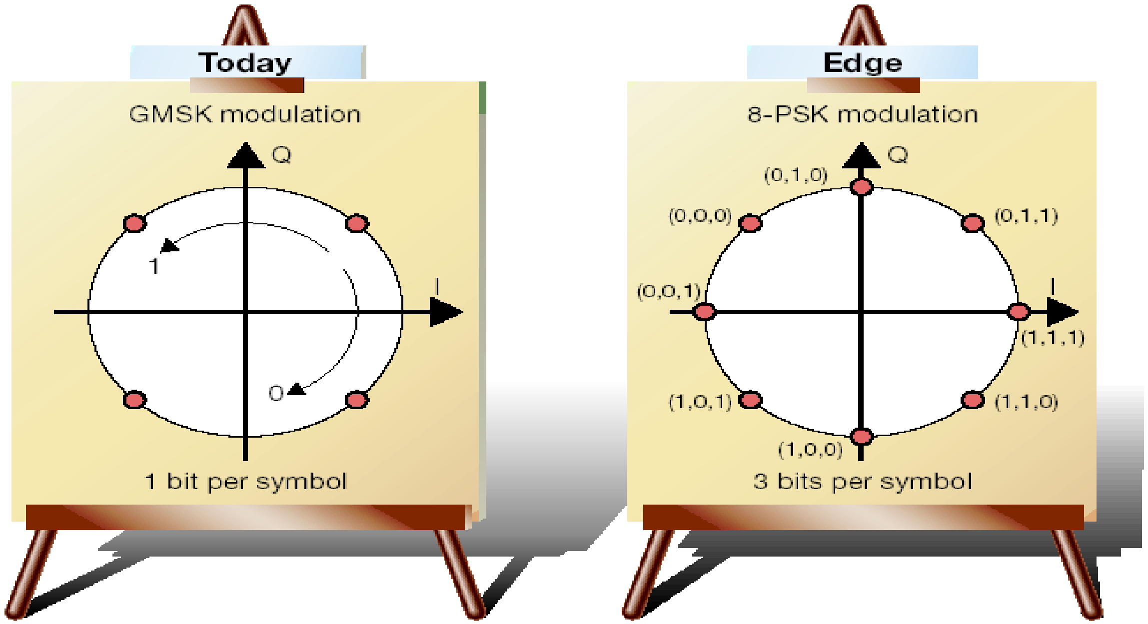


Figure 2
Signal constellations for 8-PSK and GMSK. By extending the signal space from 2 to 8, each symbol contains three times more information.

EDGE main features [HMR03]

- EDGE link controlling function
  - It uses a combination of 2 functionalities :
    - Link adaptation
    - Incremental redundancy

Channel Coding schemes	Throughput/TS	Family	
MCS9	59,2	A	8PSK
MCS8	54,4	A	
MCS7	44,8	B	
MCS6	29,6	A	
MCS5	22,4	B	GMSK
MCS4	17,6	C	
MCS3	14,8	A	
MCS2	11,2	B	
MCS1	8,8	C	

Figure 8. Modulation and coding schemes. (Legend: 8PSK, 8-phase shift keying; GMSK, Gaussian minimum shift keying; MCS, modulation coding scheme)

EDGE

- In Europe, EDGE was never used as a step toward UMTS but operators directly jumped onto UMTS.
- However, EDGE can also be applied to the US IS-136 system and may be a choice for operators that want to enhance their 2G systems (3G Americas, 2002)
- Examples of EDGE adoption [Mob]
  - Cingular Wireless launched the first EDGE services in Indianapolis in June 2003
  - Hong Kong, Thailand and Finland in 2003/2004
  - October 2003, Telefonica Movil Chile became the first Latin American operator to launch EDGE services in its Santiago and Valparaiso markets
  - In the Americas alone, 37 operators are deploying EDGE in 22 countries
  - the first nationwide EDGE deployment in the U.S. was announced by AT&T Wireless on November 18, 2003, covering 215 million potential subscribers

Class Quiz

- How is the power control organised in UMTS?
- What is CDMA2000?
- What is EDGE?

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