



Sisteme de Comunicatii Mobile (SCMB) - curs 10 -



Continutul prezentarii


- **Interfata radio terestra 3G - WCDMA**
 - Capacitatea unei celule
 - Controlul puterii
 - Receptorul RAKE
 - Comparatie GSM, WCDMA , CDMA 2000

- Fazele standardizarii 3G
- Schema bloc a unui terminal 3G
- Codarea vocii – AMR (Adaptative MultiRate)
- Tipuri de handover: softer, soft, hard, inter-sistem
- Canale

- **Rețele Bluetooth**

WCDMA – capacitatea celulei

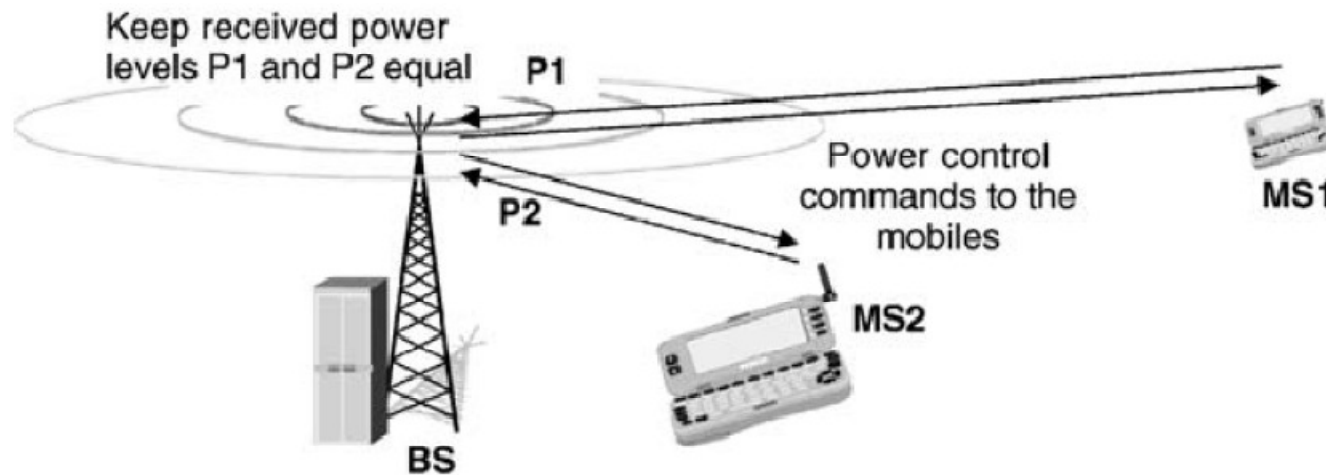
- Receptia este cu atat mai buna cu cat valoarea raportului E_b/N_0 este mai mare
 - E_b – energie per bit [W/Hz], N_0 – densitate spectrala zgomot [W/Hz]
- Pt. un receptor CDMA $E_b = P_i/D$
 - P_i – puterea emisa de mobilul i , D – debitul fluxului de date emis
- Pt. N mobile (fiecare emite cu aceasi putere P_i) rezulta:
 $N_0 = (N-1) * P_i/B$ (B – banda semnalului, 5MHz)
- Se demonstreaza ca:
 $E_b/N_0 = B/D * (N - 1)$
 $N_users \sim (B/D) * (E_b/N_0)^{-1}$
- Daca se ia $E_b/N_0 = 6\text{dB}$ tipic, $D = 12,2\text{kbps}$ (voce UMTS) se obtine un $N_users \sim 100$ (100 utilizatori per celula)



WCDMA - observatii

- Capacitatea WCDMA se **degradeaza** daca la receptie *puterile P_i nu sunt egale*
- In GSM, 1 celula cu 1 frecventa ($B \approx 800\text{KHz}$) avea capacitatea de 7 convorbiri, in UMTS 1 celula cu 1 frecventa ($B \approx 5\text{MHz}$) suporta 100 convorbiri

WCDMA – controlul puterii (1)



Problema “near-far” - specifica CDMA – puterile receptionate la BS (RBS) trebuie sa fie egale (UPLINK)

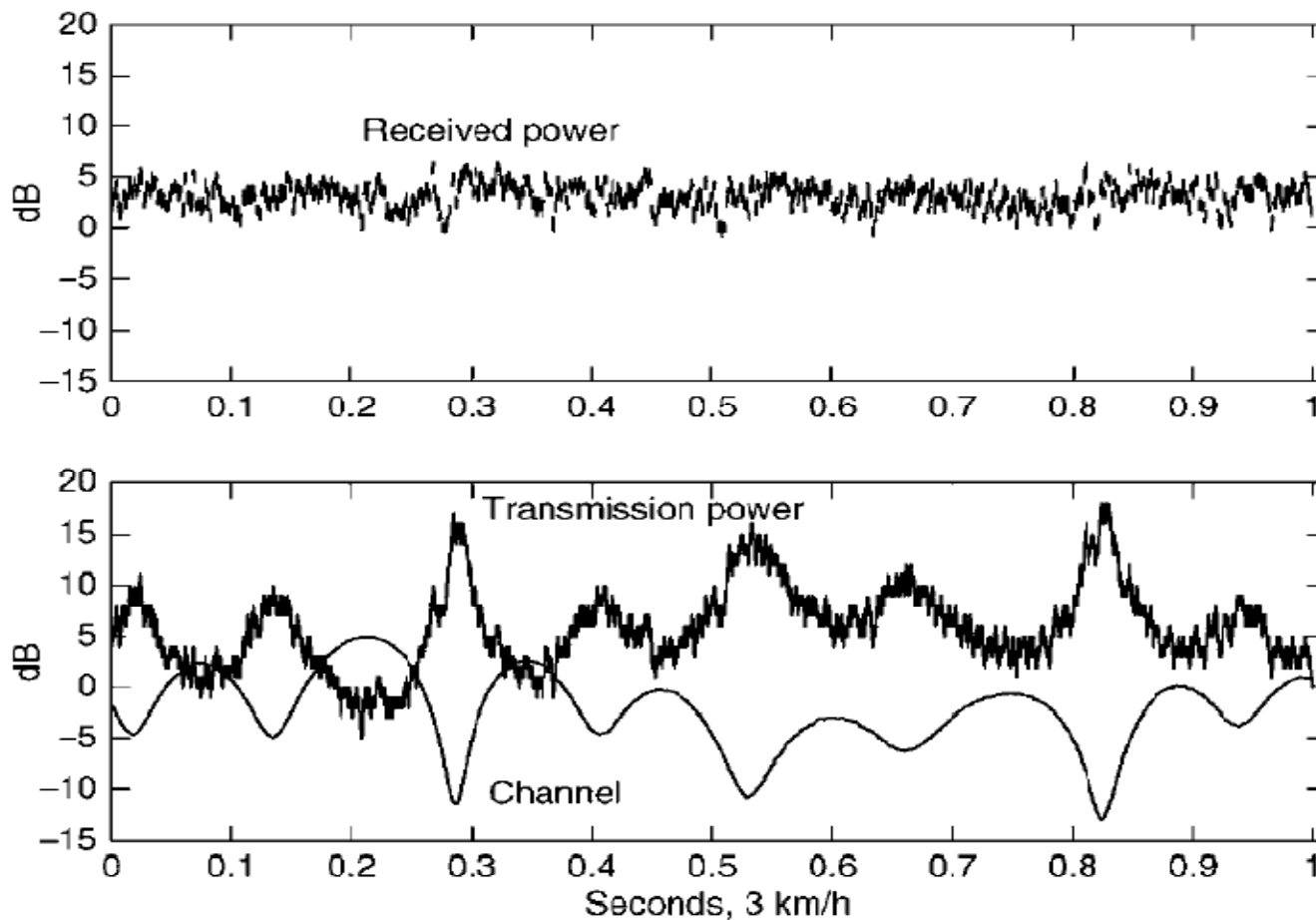
Solutie: control al puterii in bucla inchisa, 1500 ori pe secunda (BS masoara puterea si comanda MS)



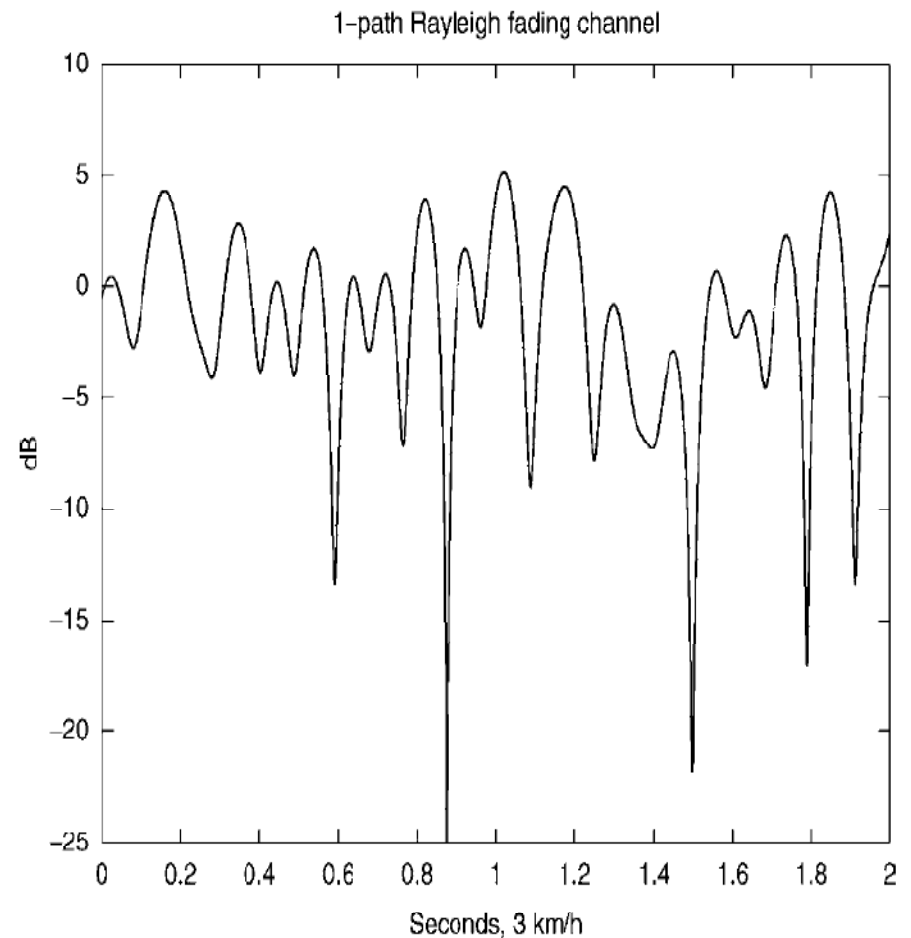
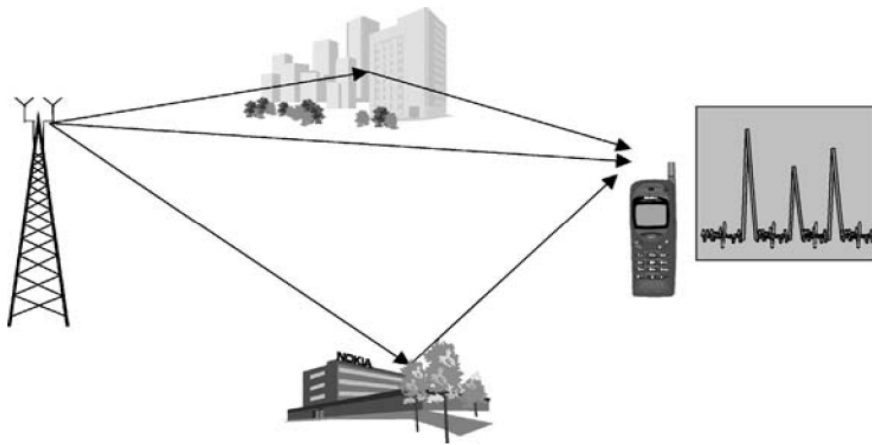
WCDMA – controlul puterii (2)

- Controlul puterii este una dintre problemele esentiale CDMA (**uplink si downlink**)
 - O putere mare emisa de un MS apropiat de BS poate bloca celula (genereaza interferenta)
- Solutie - control in bucla inchisa:
 - BS estimeaza SIR (Signal to Interference Ratio) pentru un anumit MS si il compara cu un prag
 - BS comanda cresterea/scaderea puterii dupa cum valoarea este sub/peste prag
 - Cuanta de putere pentru control - **tipic 1dB**

WCDMA – puterea emisa si cea receptionata



Propagarea multicala si fadingul rapid (Rayleigh)



Delay: 1-2 μ S urban, 20 μ s coline

- minim suportat: 0,26 μ s pentru ca receptorul sa poata separa undele, $d > 78$ m

Suprapunere unde => fading



Receptia WCDMA: probleme si solutii

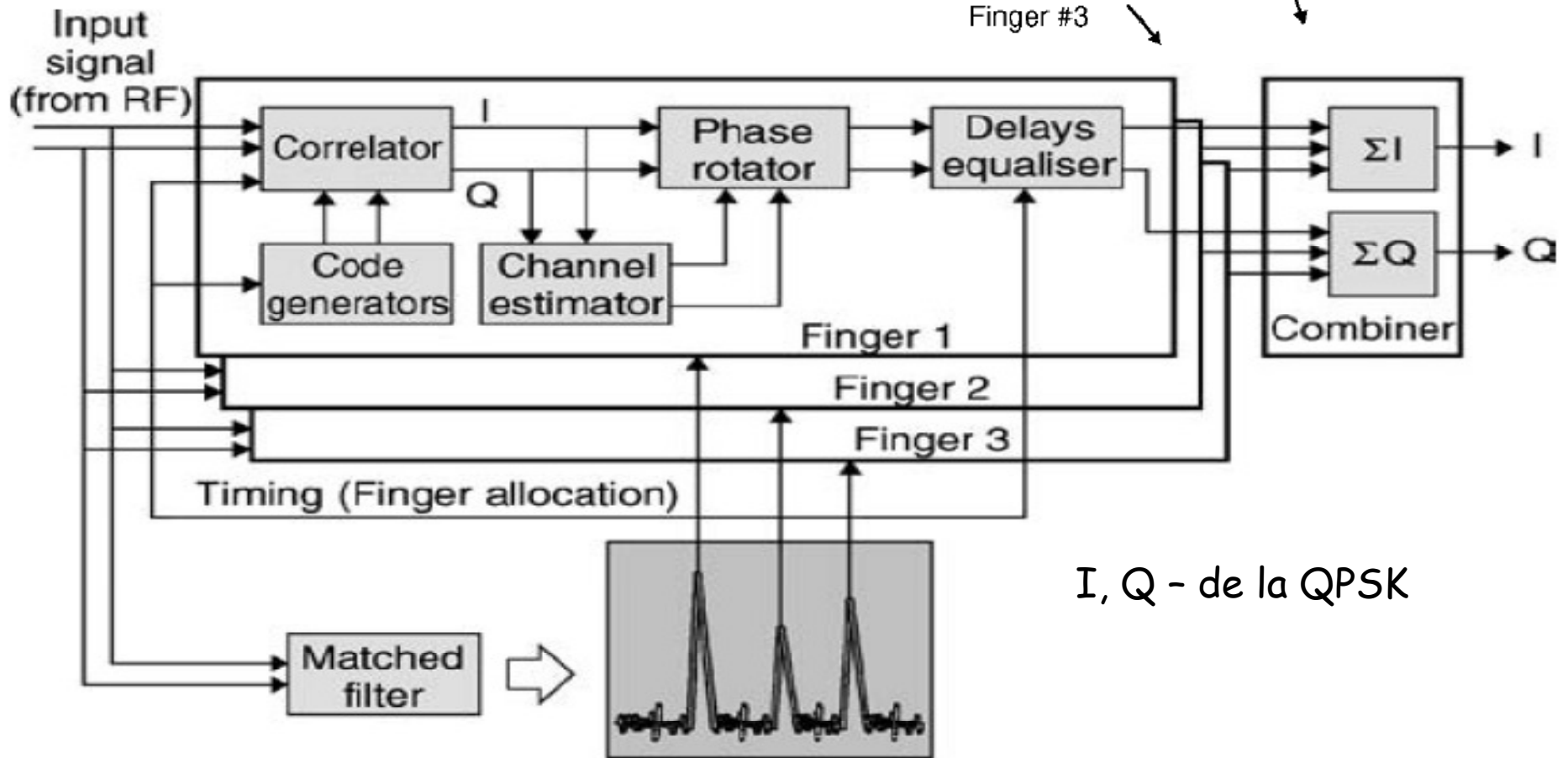
- **P1**: receptia repetata
 - **S1**: receptorul RAKE, folosirea repetiției ca forma de diversitate
- **P2**: fadingul
 - **S2.1**: controlul rapid al puterii
 - **S2.2**: utilizarea de coduri de protecție la erori puternice (turbo-coduri)



WCDMA – principiul de receptie MRC (Maximal Ratio Combining)

- Estimarea canalului se face pe baza unui semnal *pilot*
- Se cauta varfurilor de energie ale semnalului receptionat (pas cautare: $\frac{1}{4}$, $\frac{1}{2}$ din Tchip)
- Se extrag/elimina componentele de amplitudine si faza (fading) care se modifica rapid (1ms)
- Se aduna (ponderat) semnalele (repetate) receptionate dupa co-fazarea acestora

Receptorul RAKE

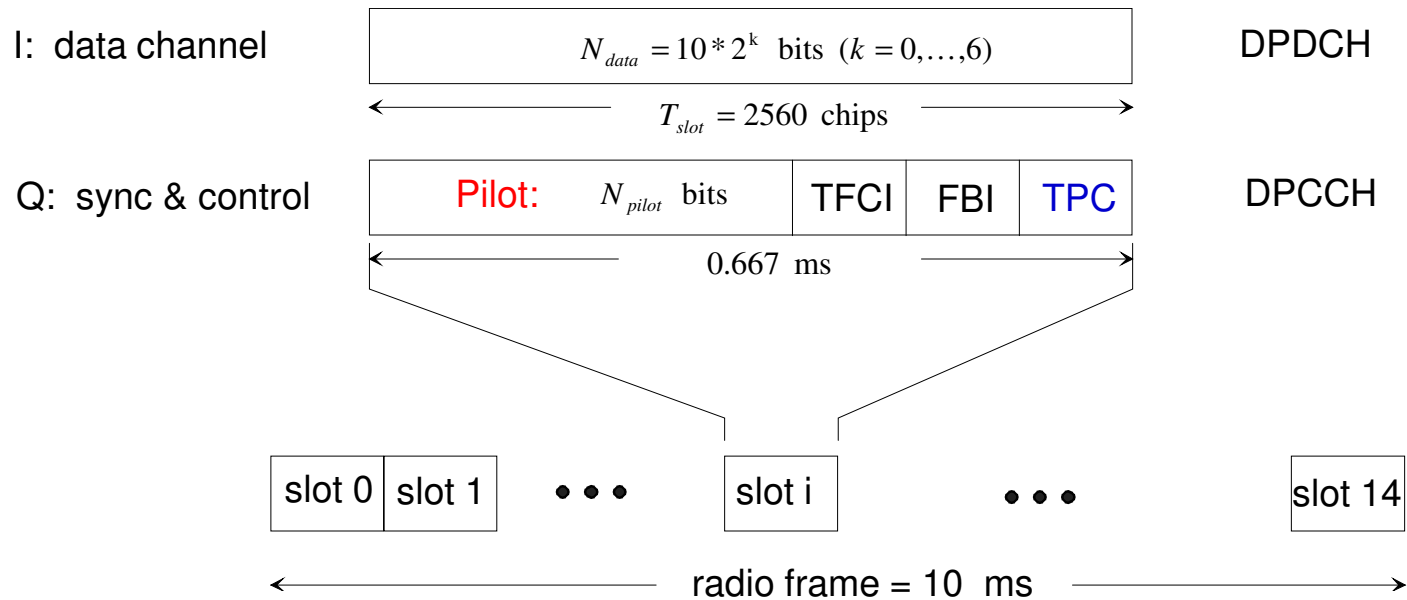




RAKE -functionare

- Estimatorul de canal foloseste semnalul *pilot* pentru a determina modelul canalului
- *Co-fazare* : se modifica (roteste) faza semnalului receptionat inainte de combinare
- Tot inainte de combinare se compenseaza si intarzierile multicale (*delay*)
- Combinorul insumeaza semnalele obtinand un semnal mai bun (**diversitate!**)

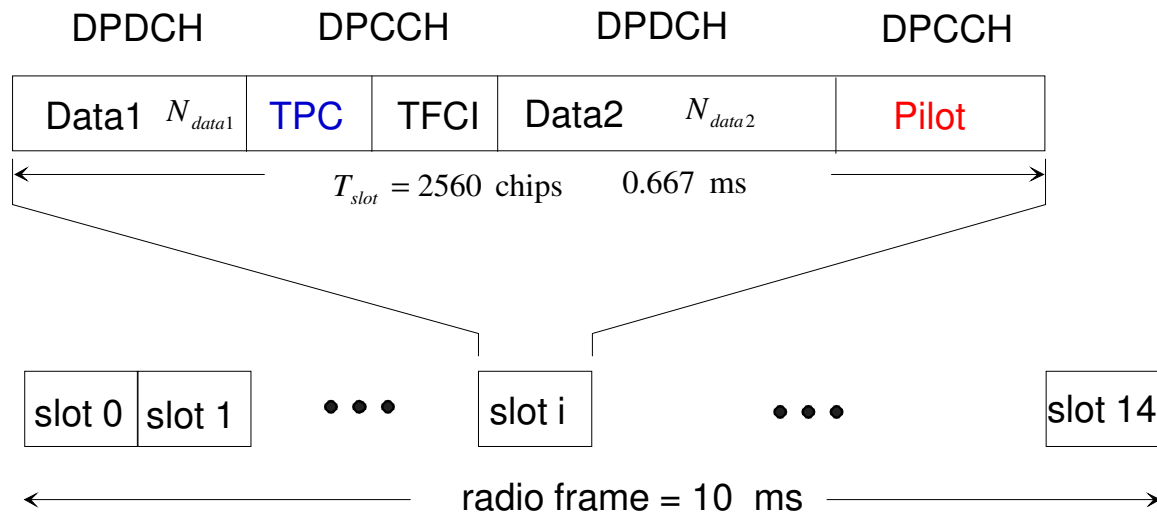
Structura cadru uplink



TFCI = transmit format combination indicator
 FBI = feedback information
 TPC = transmit power control

DPDCH = dedicated physical data channel
 DPCCH = dedicated physical control channel

Structura cadru downlink





Comparatie WCDMA - GSM

	WCDMA	GSM
Carrier spacing	5 MHz	200 kHz
Frequency reuse factor	1	1–18
Power control frequency	1500 Hz	2 Hz or lower
Quality control	Radio resource management algorithms	Network planning (frequency planning)
Frequency diversity	5 MHz bandwidth gives multipath diversity with Rake receiver	Frequency hopping
Packet data	Load-based packet scheduling	Time slot based scheduling with GPRS
Downlink transmit diversity	Supported for improving downlink capacity	Not supported by the standard, but can be applied



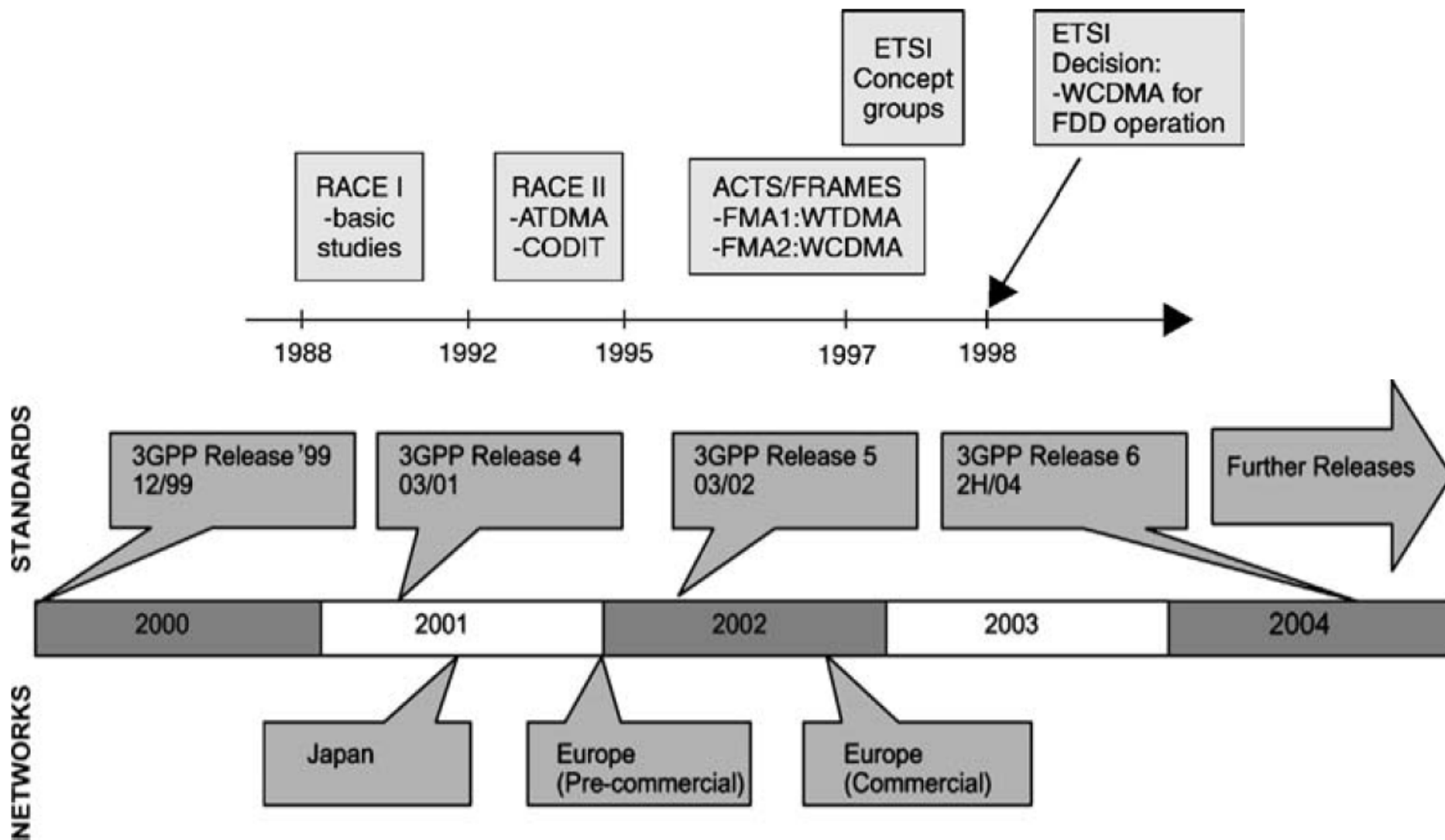
WCDMA versus CDMA2000 1x

	WCDMA	1X
Carrier spacing	5 MHz	1.25 MHz
Chip rate	3.84 Mcps	1.2288 Mcps
Power-control frequency	1500 Hz, both uplink and downlink	Uplink: 800 Hz, downlink: –800 Hz
Base-station synchronisation	Not needed	Yes, typically obtained via GPS
Inter-frequency handovers	Yes, measurements with slotted mode	Possible, but measurement method not specified
Efficient radio resource management algorithms	Yes, provides required quality of service	Not needed for speech-only networks
Packet data	Load-based packet scheduling	Packet data transmitted as short circuit switched calls
Downlink transmit diversity	Mandatory support of closed and open loop methods	Optional support of open loop method

Alte date comparative...

	cdma2000	GSM EFR	WCDMA	
MS TX power (dBm)	23	30	21	EFR - Enhanced Full Rate
BS sensitivity (dBm)	-124	-110	-124	
BS ant diversity gain (dB)	3	4	3	
Interference margin (dB)	3	0	3	
Fast fading margin (incl. SHO gain) (dB)	4	0	2	
BS antenna gain (dBi)	18	18	18	
Cable loss incl. MHA gain	0	0	0	
Body loss for speech terminal (dB)	3	3	3	
MS antenna gain (dB)	0	0	0	
Maximum pathloss (dB)	158	159	158	

Fazele standardizarii 3G



**Before 3GPP
Release '99**

Voice	Circuit switched
SMS	
WAP	
E-mail	

3GPP Release '99

Voice	Circuit switched
Video	
SMS	Packet switched
WAP	
E-mail	
Web	
MMS	
Streaming	

New packet
switched services

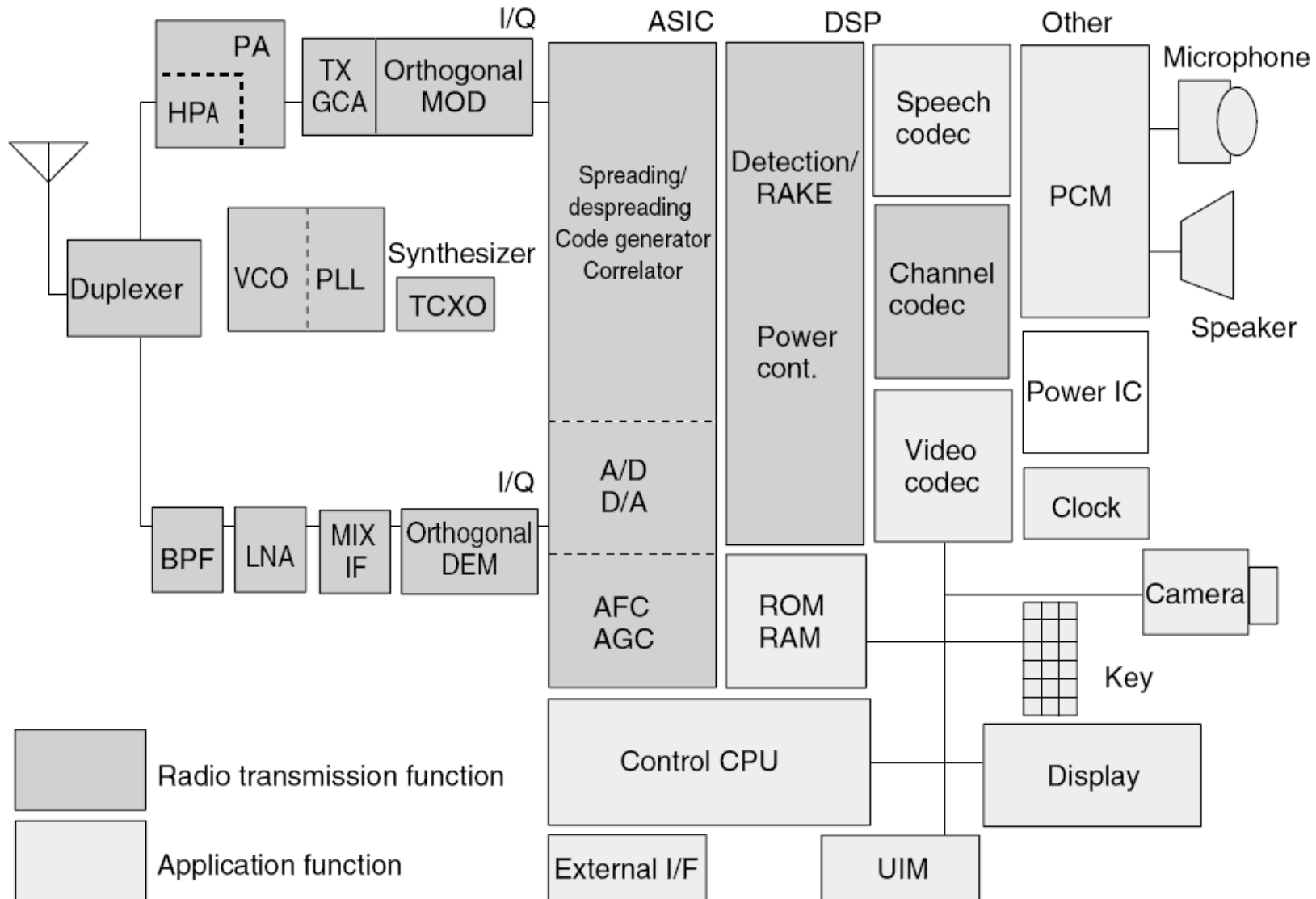
SMS = Short message service
WAP = Wireless application protocol
MMS = Multimedia message service

3GPP Release 5-6

Voice	Packet switched
Video	
SMS	
WAP	
E-mail	
Web	
MMS	
Streaming	

All services in
packet domain =
All-IP

Schema bloc a unui terminal 3G

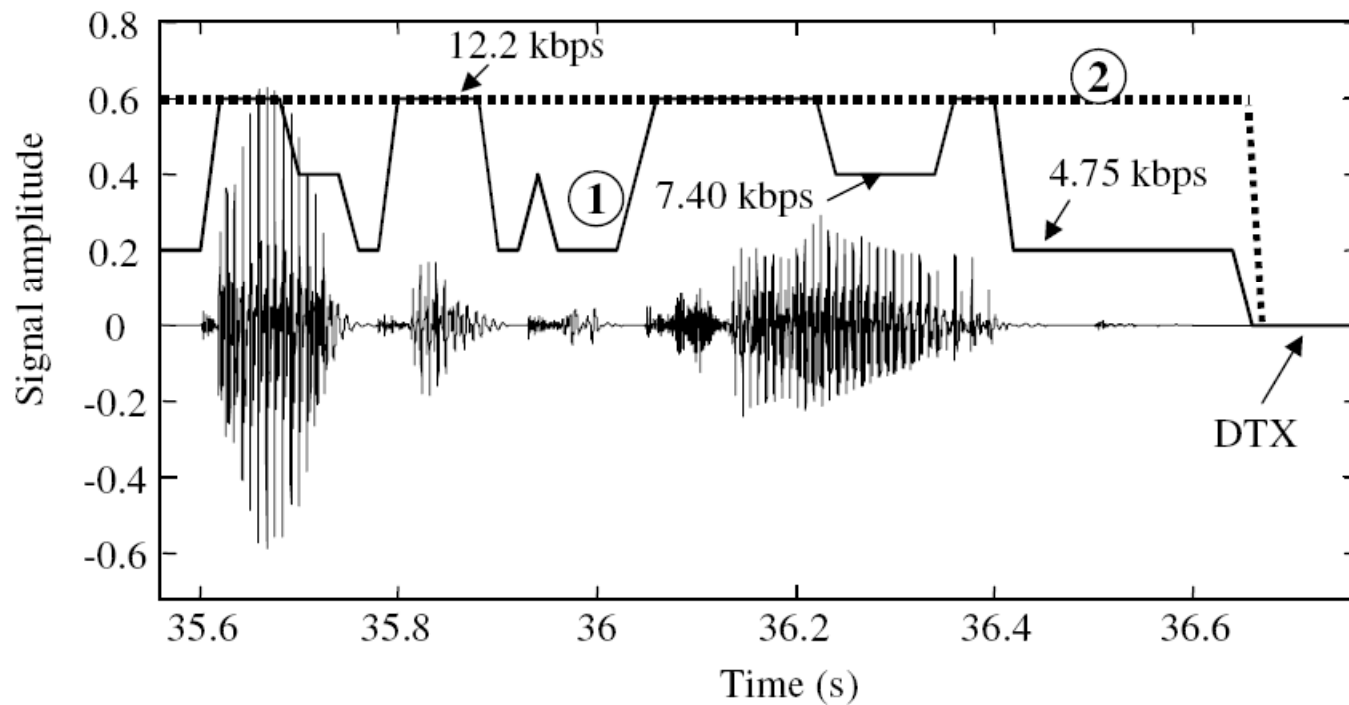




Codarea vocii: AMR – Adaptive MultiRate

- Debit variabil (4.5Kbps – 12.2Kbps), se poate schimba la fiecare segment de 20 ms
- Schimbarea debitului se semnalizeaza (in-band)
- Foloseste VAD (Voice Activity Detection) detectie voce/liniste
- Algoritm codare ACELP (Algebraic Code Excited Linear Prediction Coder),
 - Bitii se impart in trei categorii A, B, C
 - Toleranta la erori FER (Frame Error Rate): 1% pt. biti clasa A, < 0.0001 pt. clasele B, C
- Adaptarea debitului se face in functie de:
 - traficul in celula,
 - conditiile de propagare,
 - calitatea dorita pentru voce

AMR – adaptarea debitului



- ① = AMR with source adaptation changes its bit rate according to the input signal
② = AMR with fixed bit rate (+DTX)

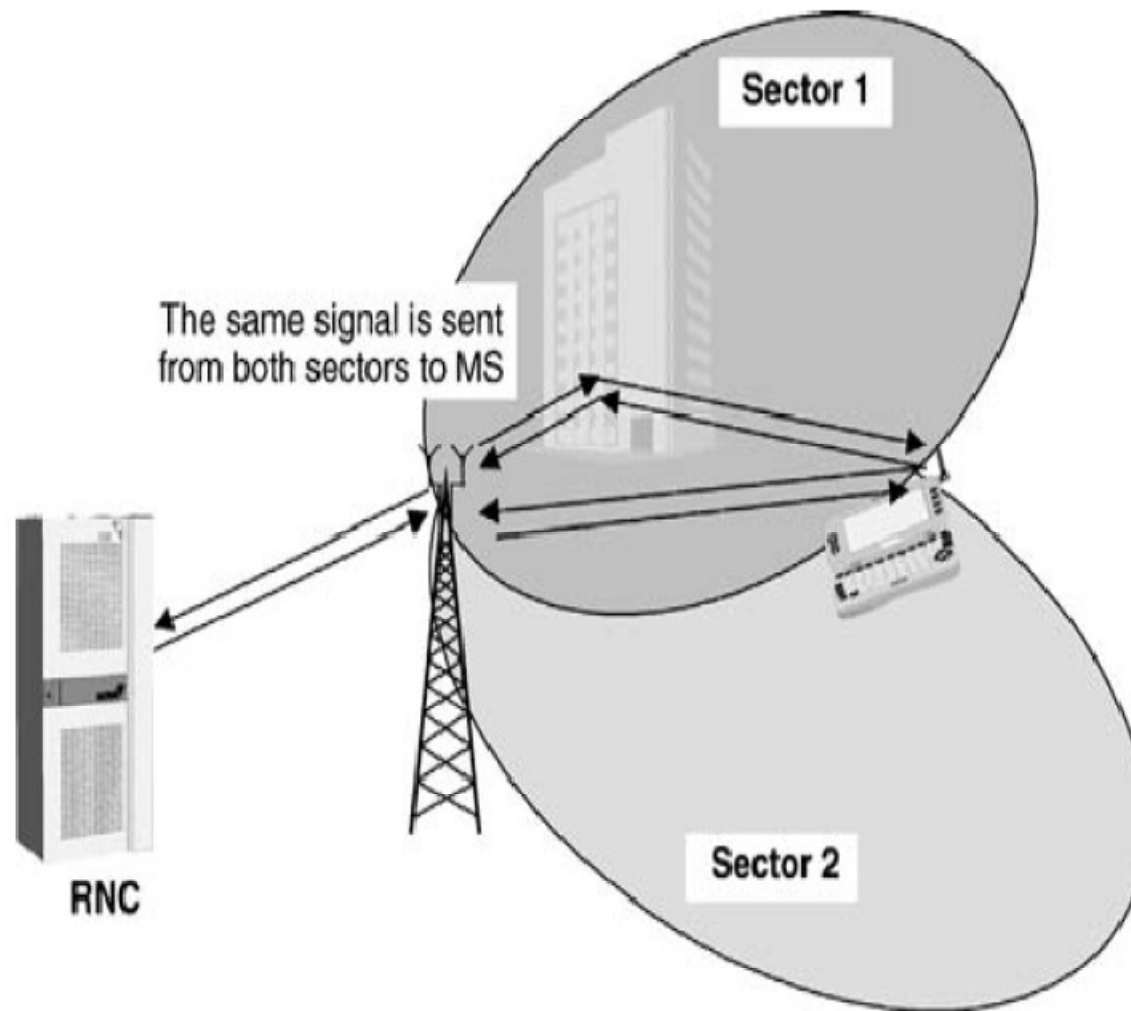


WCDMA – tipuri de handover (1)

■ **Softer handover**

- MS aflat in zona de suprapunere a doua sectoare ale aceleiași celule (comunica cu o statie de baza)
- MS recepționează simultan doua semnale (in aceeași banda de frecvente)
- Reprezinta 5 – 15 % din situatiile de handover
- Receptorul RAKE poate gestiona recepția multipla

Softer handover



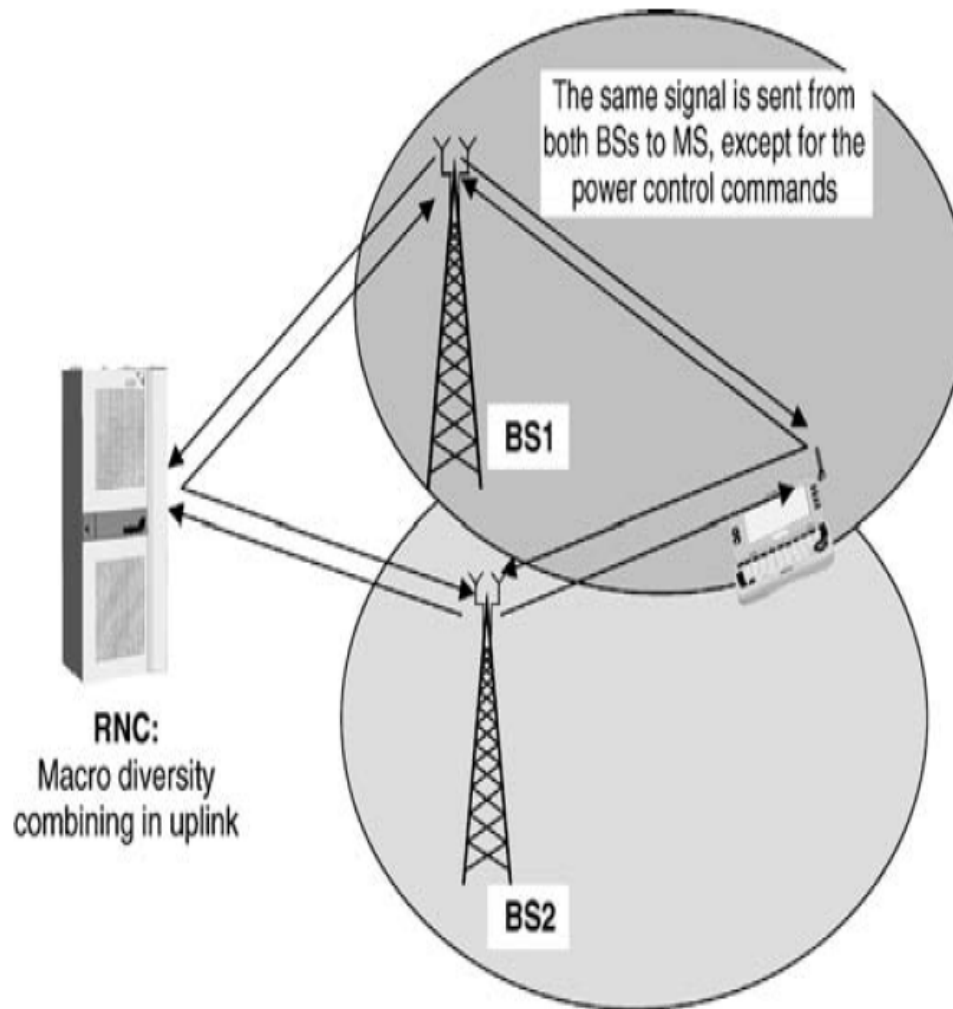


WCDMA – tipuri de handover (2)

■ **Soft handover**

- MS este in zona de suprapunere a doua sectoare care apartin la doua BS diferite
- MS receptioneaza simultan semnale de la cele doua BS (in aceeasi banda)
- Diferente fata de ‘softer’ handover:
 - Sunt implicate doua statii de baza (BS)
 - Softer handover poate fi considera un caz particular de soft handover
 - Semnalele uplink se combina la RNC
 - Controlul puterii se face fata de o singura BS (selectata dupa criteriile de calitate ale semnalului receptionat)
- Reprezinta 20 – 40 % din situatiile de handover

Soft handover





Soft handover – conexiuni radio paralele

- Sens *uplink* – codul de imprastiere este Cs, receptionat de ambele BS
- Sens *downlink* – codurile de imprastiere sunt Cs1, Cs2 pt. comunicarea cu BS1, BS2
- Pot exista pana la 6 astfel de conexiuni radio paralele – ‘active set’
 - Legaturile sunt create/eliminate dinamic pe masura ce mobilul se deplaseaza, exista permanent o conexiune
- Procedura:
 - MS masoara Eb/No al canalului fizic CPICH (Common Pilot Channel) pentru fiecare BS vecin
 - Daca valoarea trece peste un prag_H se creaza o noua conexiune in active set, daca scade sub un prag_L se elimina



WCDMA – tipuri de handover (3)

- **Hard handover**

- MS trece dintr-o celula cu o frecventa (banda) in alta celula dar pe alta frecventa (celule controlate de RNC-uri diferite)
 - Ex. - BS de mare capacitate care are mai multe frecvente

- **Inter-mode si inter-sistem handover**

- Intre modurile TDD si FDD
- Intre WCDMA si GSM, IS-95, etc.



Canale radio WCDMA FDD

- **Logice (L2):**

- Control: BCCH (Broadcast), PCCH (Paging), CCCH (Comune), DCCH (Dedicate)
- Trafic: DTCH (p-to-p), CTCH (p-to-m)

- **Transport (L2, MAC):**

- Dedicate: DCH,
- Comune: BCH, PCH, RACH, FACH (forward access), DSCH (downlink shared)

- **Fizice (L1, PHY):**

- CCTrCH (Coded Composite Transport Channel) multiplexare canala transport / canal fizic
- P-CCPCH (primary common control), S-CCPCH (secondary), PRACH (random access), PDSCH (downlink shared), DPDCH (dedicated data)



Bluetooth

- Retele ad-hoc
 - Origine, utilitate
- Bluetooth
 - Caracteristici
- Servicii
 - Transmisie pachete
 - Formarea si gestiunea retelelor



MANET - Mobile Ad-hoc Networks

- Retele care se pot forma spontan, fara un server central
 - Mod de lucru peer-to-peer
- Aplicatii:
 - Retele de senzori
 - Aplicatii in domeniul 'automotive'
 - Aplicatii industriale, medicale, etc.
 - Aplicatii militare

BT – definitie, caracteristici



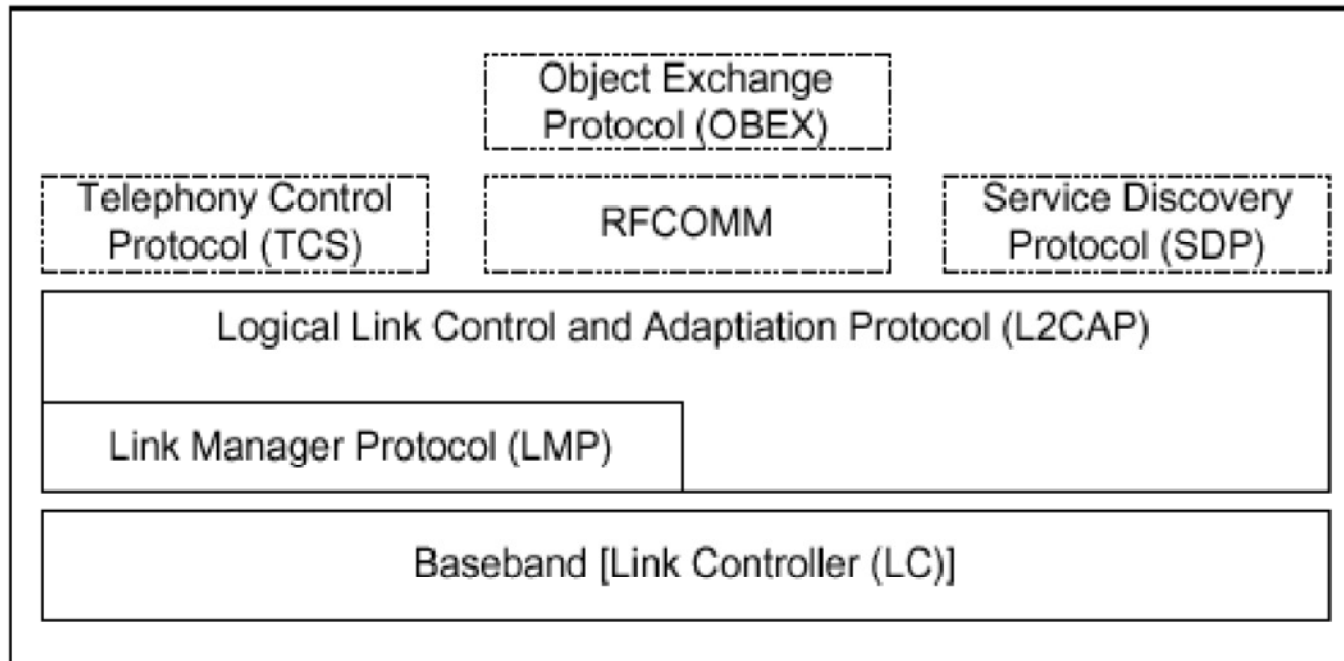
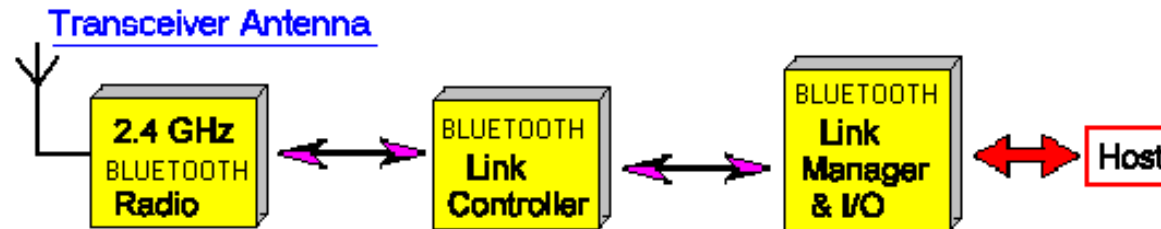
- Motivatie - înlocuirea cablurilor (Ericsson 1994)
- Caracteristici:
 - Servicii: voce, date
 - Protocol pentru rețele ad-hoc
 - Poate lucra în aceeași bandă cu alte sisteme
 - Dimensiune fizică mică, putere mică, cost redus
 - Interfața ‘deschisă’ (open interface standard)
- Destinat în principal dispozitivelor mobile
- Nu înlocuiește WLAN – are o rază de acțiune mai mică



Bluetooth – utilizare

- Periferice PC: Mouse, tastatura, printer
- Fax, camera video, proiector
- Acces email pe mobil, conectare dial-up (iesire prin PC fix)
- Hands-free telefon mobil
- Transfer fisiere (imagini, carti vizita, muzica, etc.)
- Control la distanta
- Sincronizare date PDA
- etc...

BT – arhitectura, protocoale





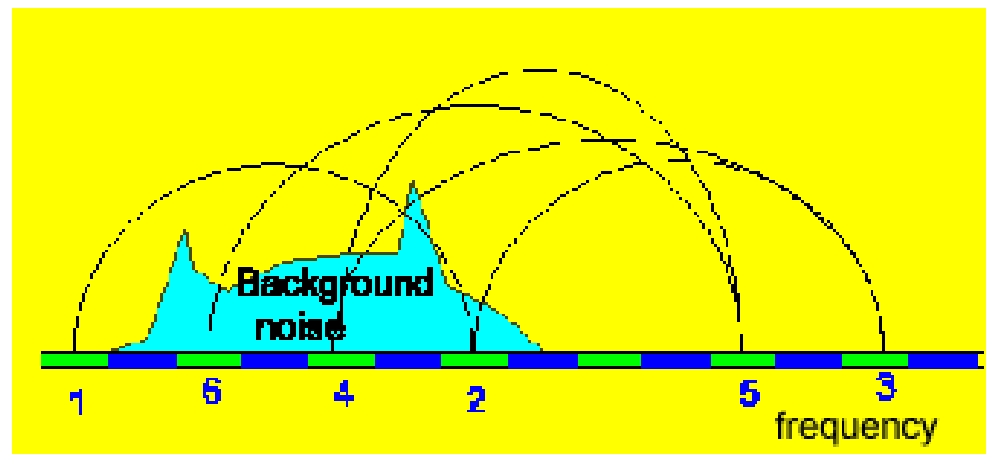
BT – stratul fizic

- 2.4GHz (banda ISM - Industrial, Scientific, Medicine) - intre 2400 si 2483.5 MHz (83.5 MHz)
- 79 canale de radiofrecventa, situate la 1 MHz unul fata de celalalt ($f = 2402 + k \text{ MHz}$, $k=0, \dots, 78$).
- Modulare: GFSK
- Hopping in frecventa, 1600 hop/sec

Type	Power Level	Operating Range
Class 3 Devices	100mW	Up to 100 meters
Class 2 Devices	10mW	Up to 10 meters
Class 1 Devices	1mW	0.1-10 meters

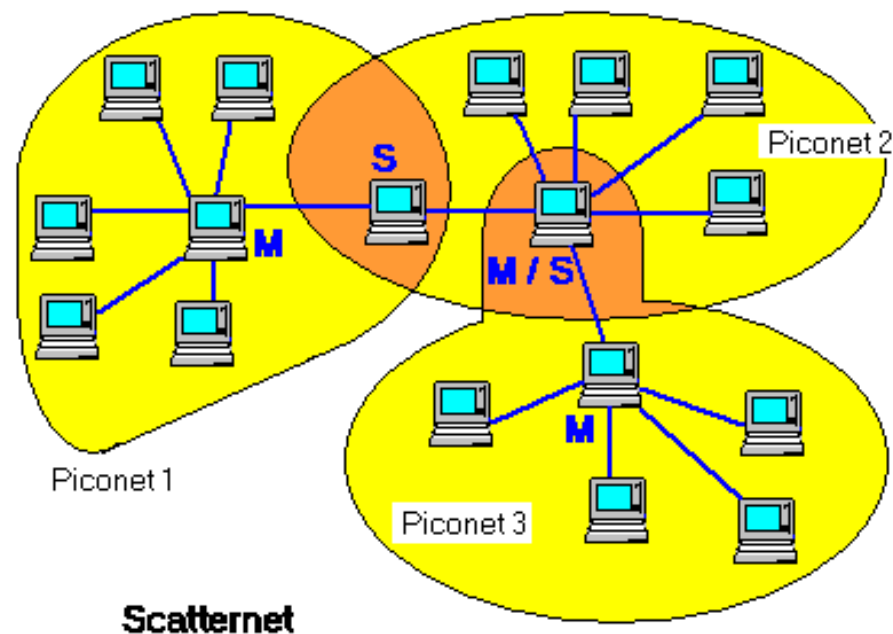
BT – hopping-ul

- Principiu: transmisie in pachete scurte, cu hopping rapid
- Ipoteza: zgomotul nu este uniform in toata banda -> fading-ul nu afecteaza la fel toate frecventele
- Dispozitivul “**master**” selecteaza schema de hopping si o comunica dispozitivelor “**slave**” (1 schema/picoretea)
- Uzual schema foloseste 32 dintre cele 79 canale de frecventa
- Hopping-ul asigura si un plus de securitate

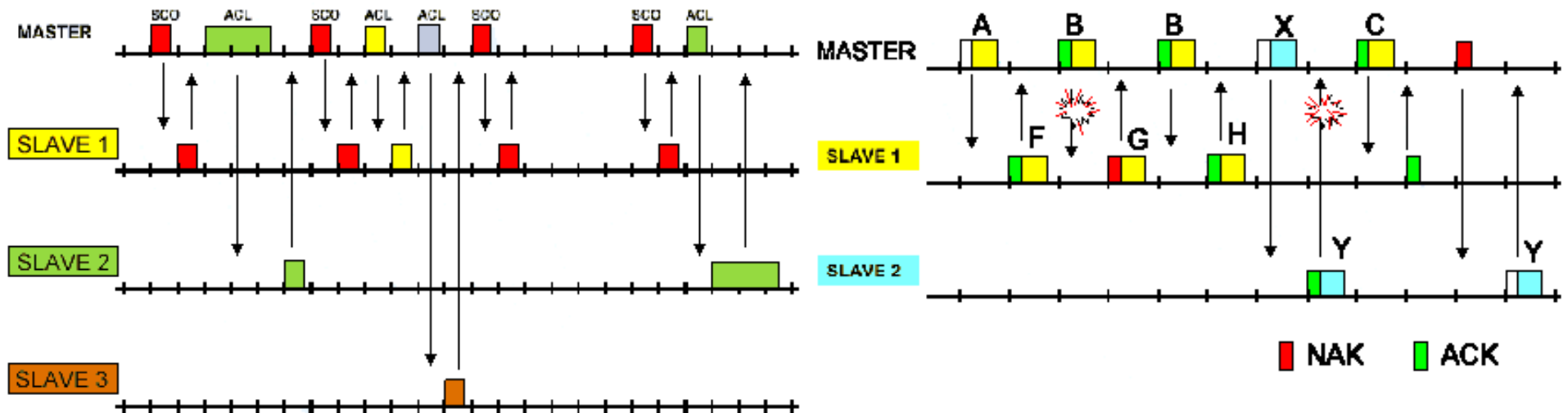


BT – formarea rețelei

- Pico-rețele (piconet), rețele imprastiare (scatternet)
- Proceduri:
 - “Inquiry” – cautarea/scanarea de dispozitive
 - “Paging” – stabilire conexiune, initiatorul devine master

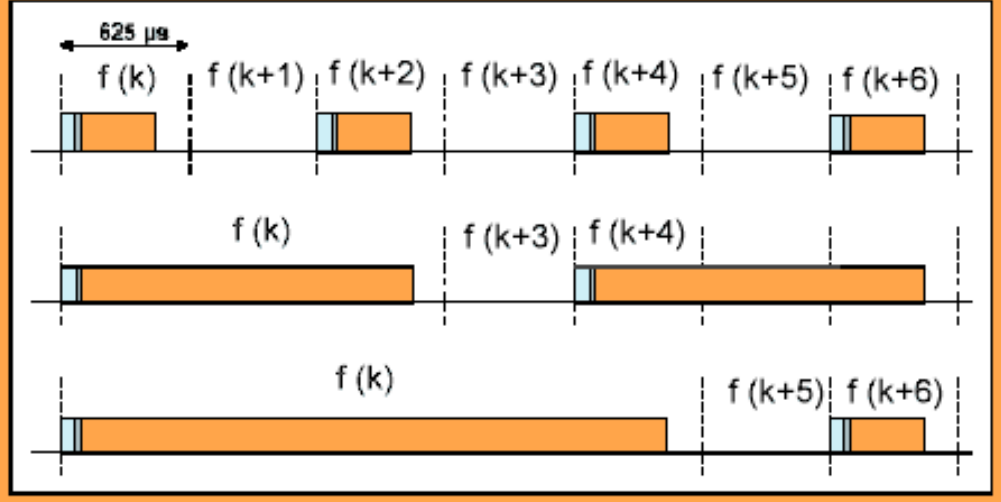
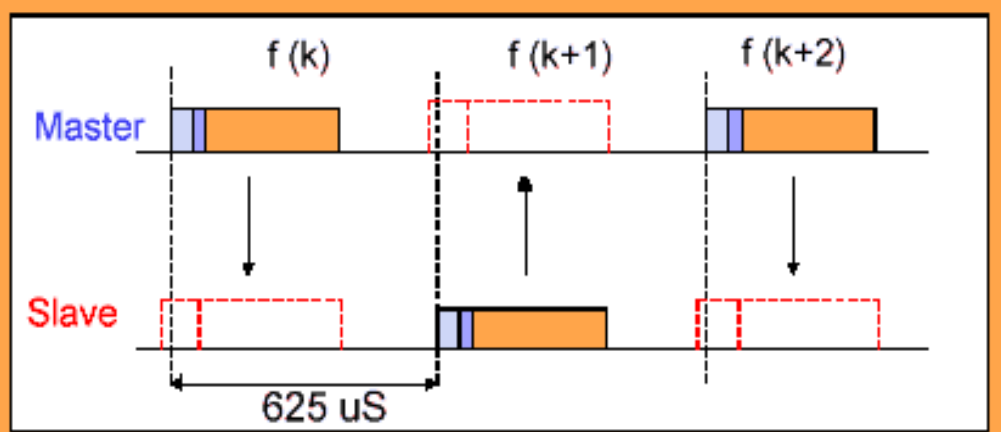
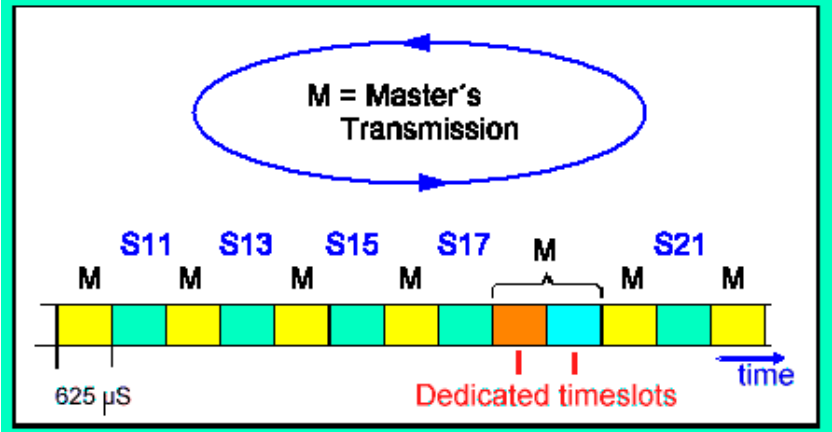


BT – transmiterea pachetelor



- Nu exista comunicare directa intre “slave”: dispozitivul “master” dirijeaza pachetele
- SCO – conexiune sincrona, CO (ex. voce)
- ACL – transmisie asincrona, CL (ex. date)

BT - timeslots



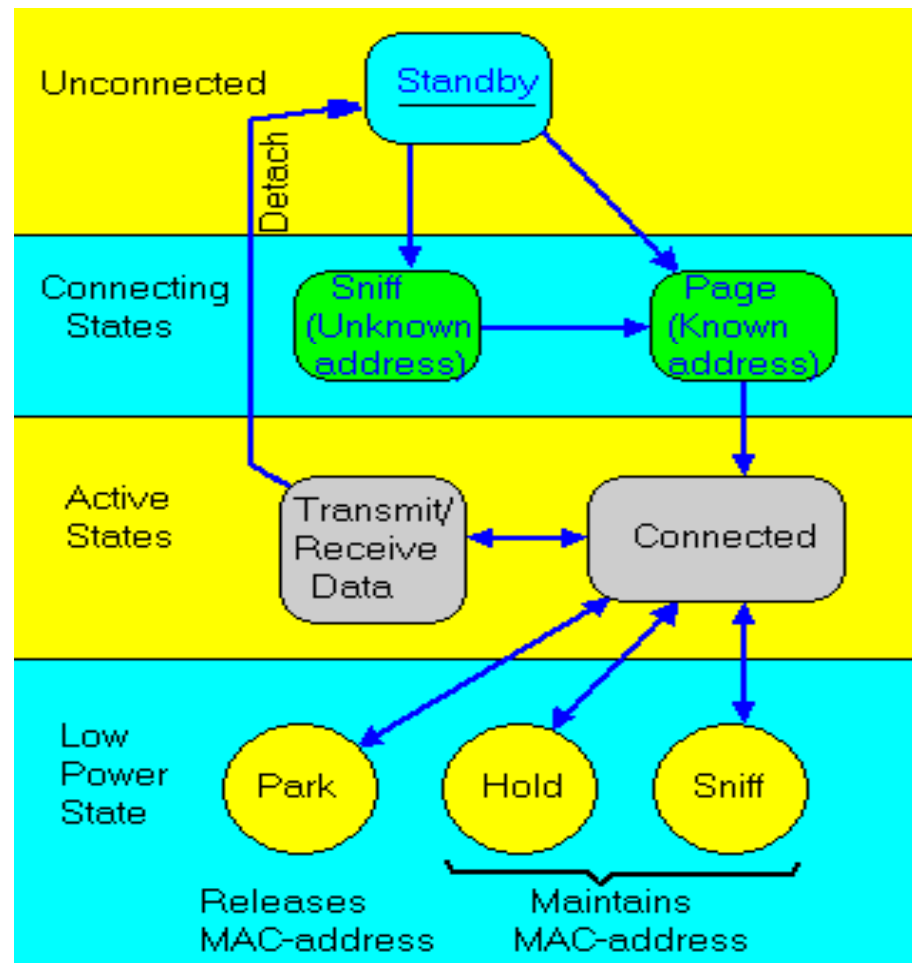
- Master-ul sincronizeaza Slave-urile, acestea transmit apoi in ordine

- Durata $T_{slot} = 625 \mu s$

- 1 pachet se poate transmite pe 1 – 5 timeslot

Obs. : daca pachetul dureaza mai multi timeslots frecventa f_k nu se schimba (nu se face hopping)

BT – stari dispozitive



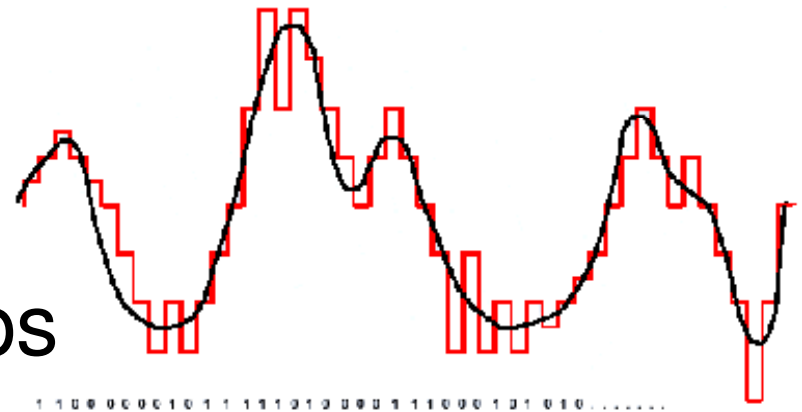
BT - servicii

- Voce PCM sau **CVSD** (Continuous Variable Slope Delta Modulation) 64K

- Date – D_max. 721 kbps

- Posibilitati:

- 1 canal asincron de date
- 1 - 3 canale sincrone de voce
- 1 canal combinat: voce + date





Bibliografie

- **“Comunicatii mobile. Evolutia spre 3G”, Autor: Sorina Zahan, Editura: Albastra**
- **“WCDMA for UMTS. Radio Access for third generation mobile communications”, Editori: Harri Holma, Antti Toskala, NOKIA, Finlanda, Wiley and Sons, 2004**