

POLYTECHNIC UNIVERSITY
EL501: WIRELESS PERSONAL COMMUNICATIONS

IS-95 CDMA CELLULAR SYSTEM

CDMA technical challenges

- Synchronization
 - All base stations in synch
 - Variable bit rate speech transmission
 - Soft handoff
 - Pilot signal
- Near-far effect
 - Open and closed loop power control

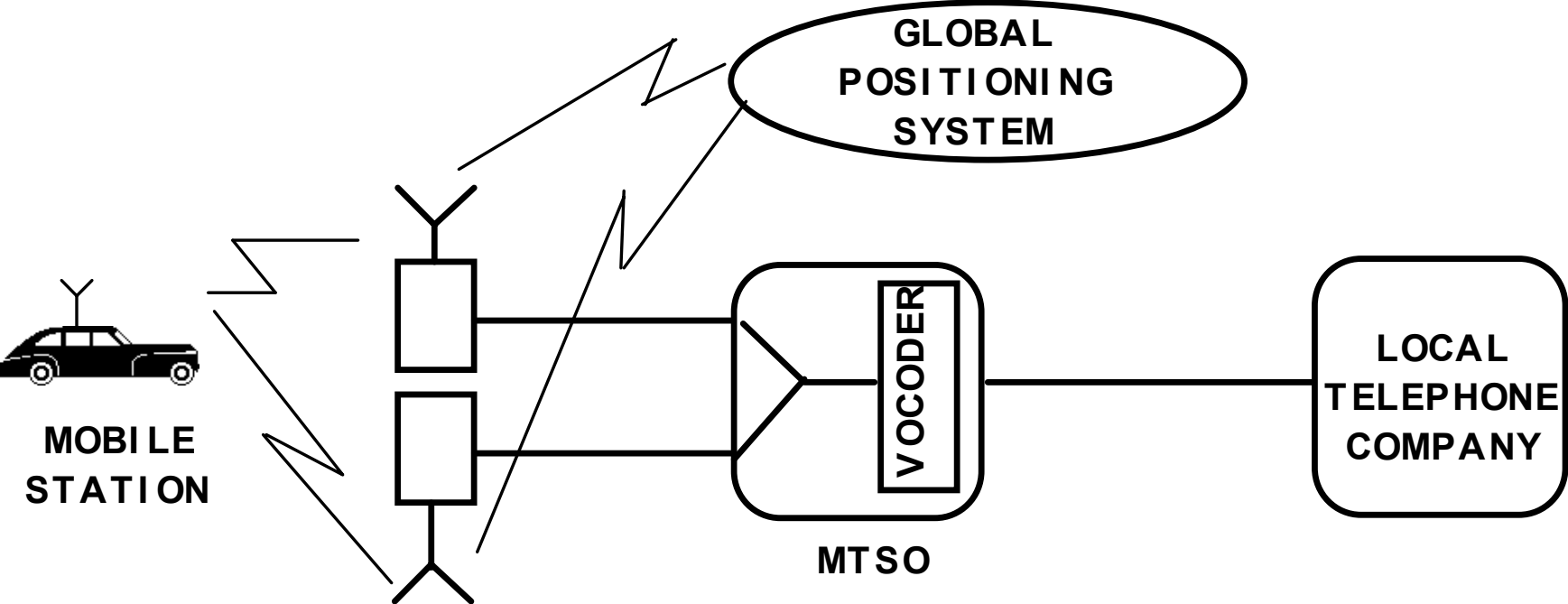
IS-95 CDMA CELLULAR SYSTEM

- HIGH TOLERANCE TO INTERFERENCE: REUSE FACTOR=1
- SYNCHRONIZED BASE STATIONS
- ORTHOGONAL DIGITAL CARRIERS (CODES) ON FORWARD CHANNELS
- INTERFERING DIGITAL CARRIERS (CODES) ON REVERSE CHANNELS
- POWERFUL CONVOLUTIONAL ERROR-CORRECTING CODES

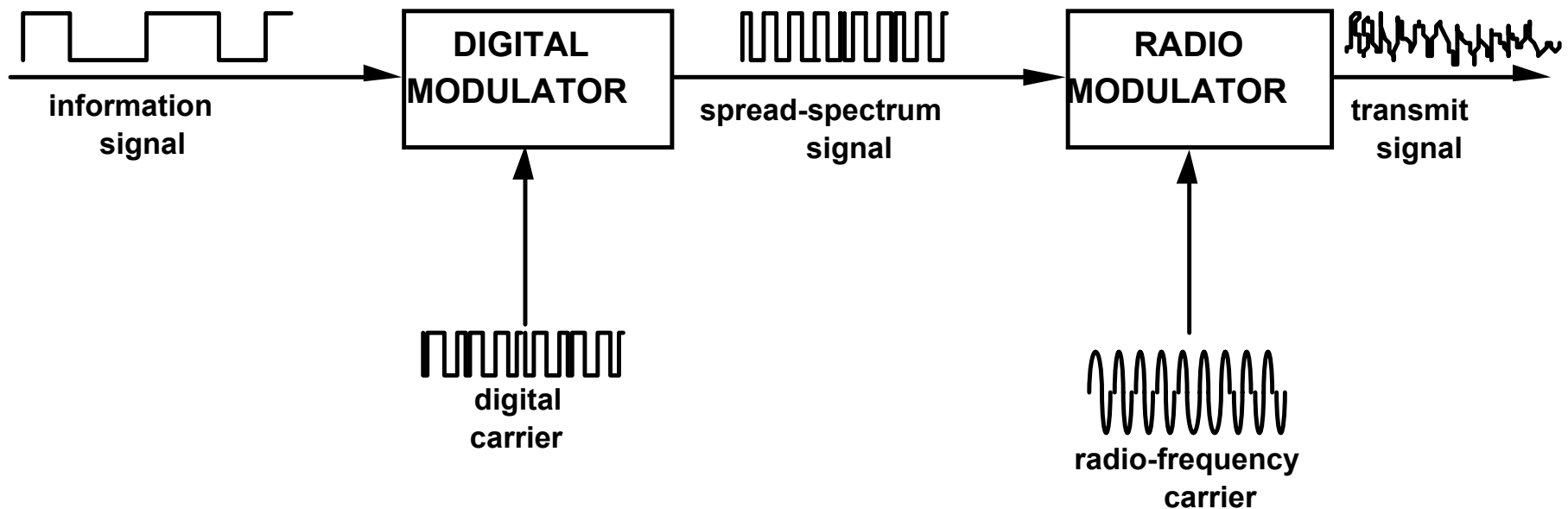
IS-95 CDMA CELLULAR SYSTEM

- RAKE RECEIVERS FOR TIME DIVERSITY
- LOTS OF DATA SCRAMBLING
- OPEN AND CLOSED LOOP POWER CONTROL
- SPEECH ACTIVITY DETECTION
- SOFT HANDOFF
- SOFT CAPACITY

CDMA NETWORK ELEMENTS



DIGITAL MODULATOR & RADIO MODULATOR

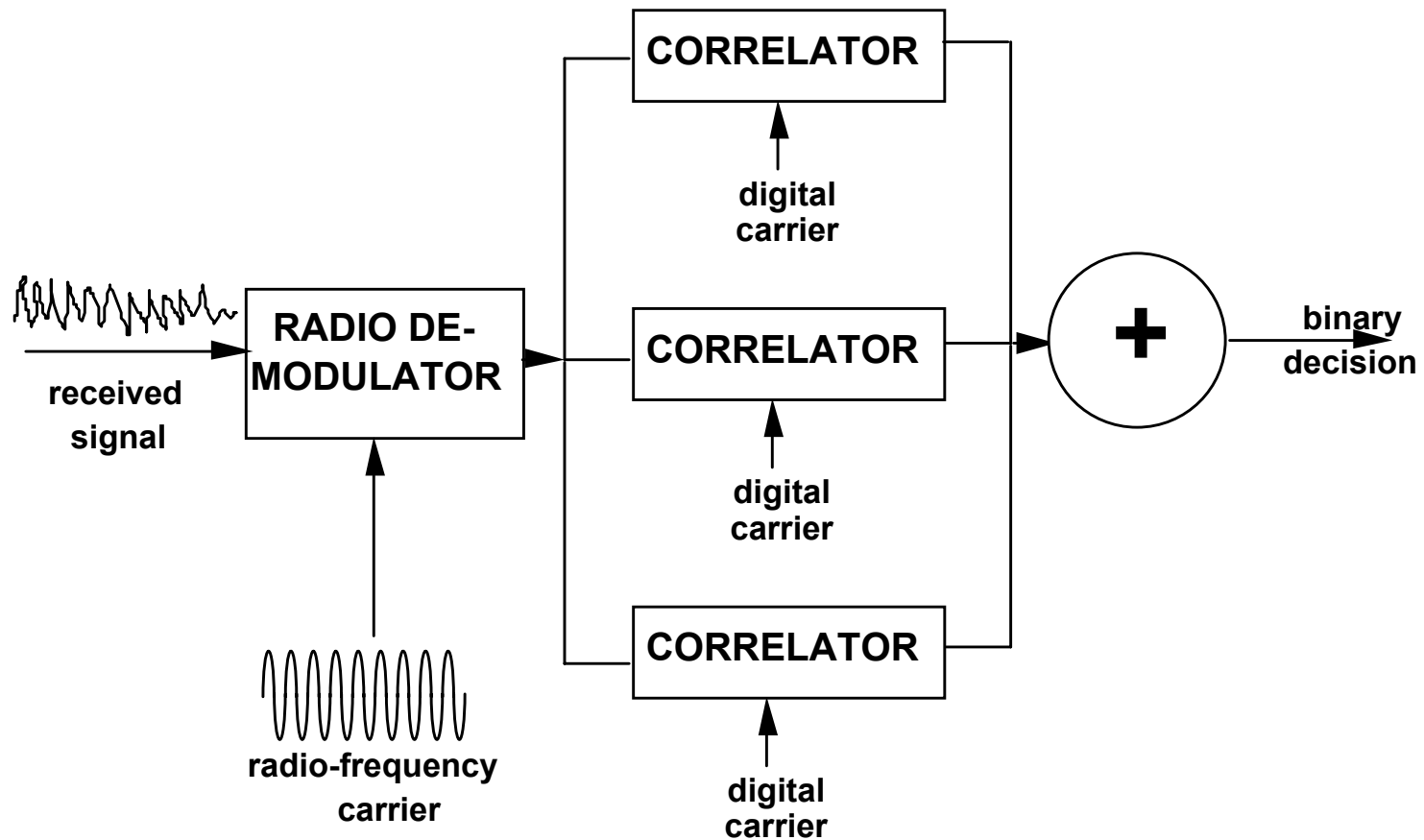


MODULATION AND
MULTIPLE ACCESS

MODULATION AND
FREQUENCY TRANSLATION

RAKE RECEIVER

CORRELATORS SYNCHRONIZED TO SIGNAL PATHS

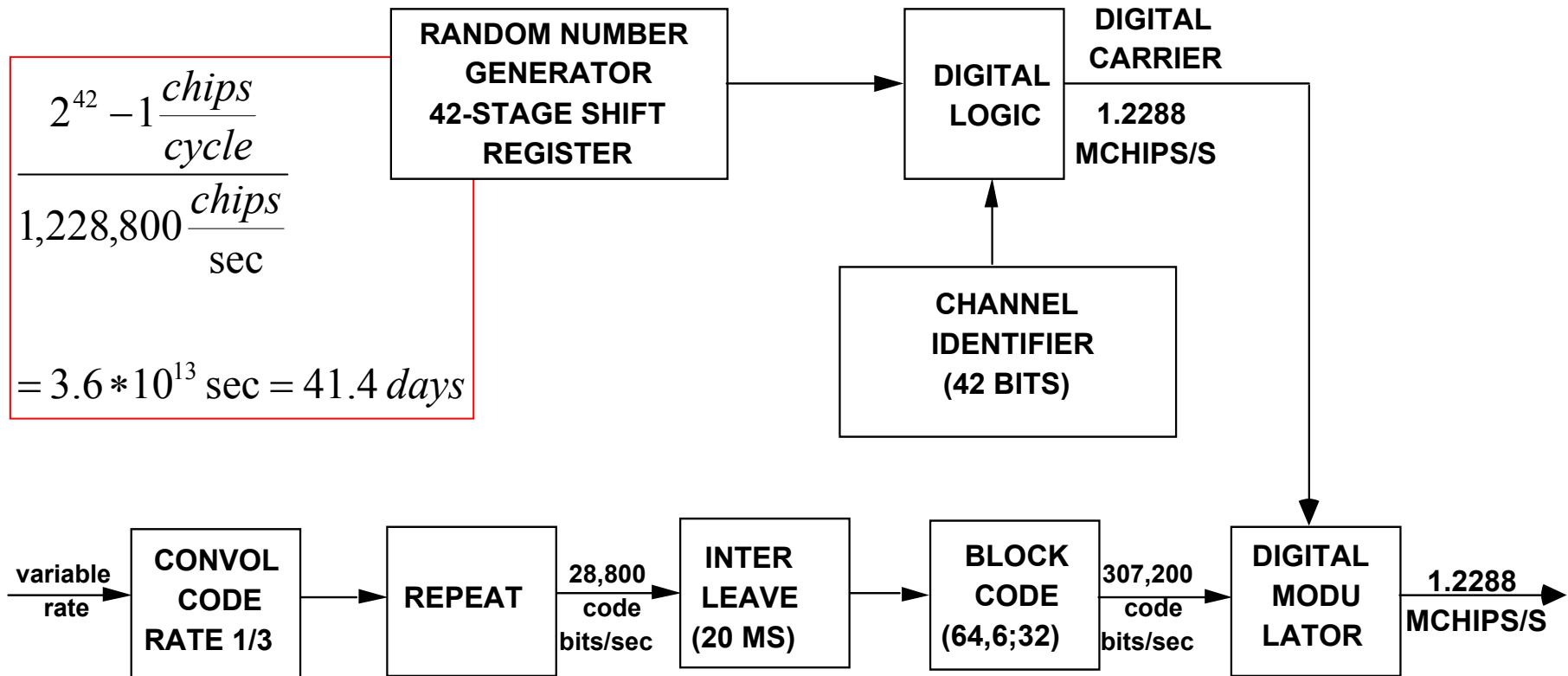


CDMA forward and reverse transmissions

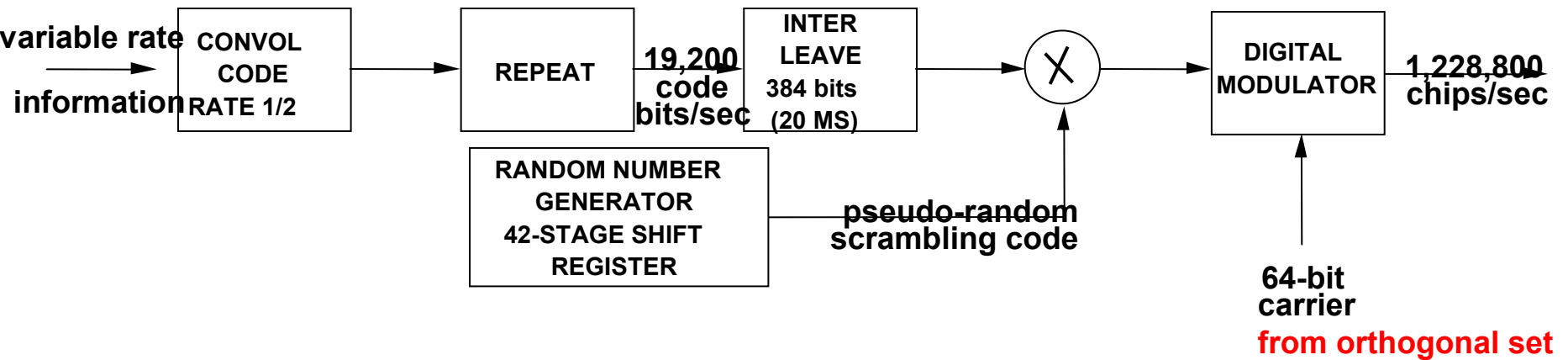
	Forward	Reverse
Digital carriers	64 (orthogonal) Walsh functions	Scrambled user identifier
Convolutional code	Rate 1/2 (punctured)	Rate 1/3
Variable rate	Repetition, reduced power	Intermittent, full power
Modulation	QPSK coherent receiver	OQPSK, non-coherent receiver

REVERSE CHANNEL

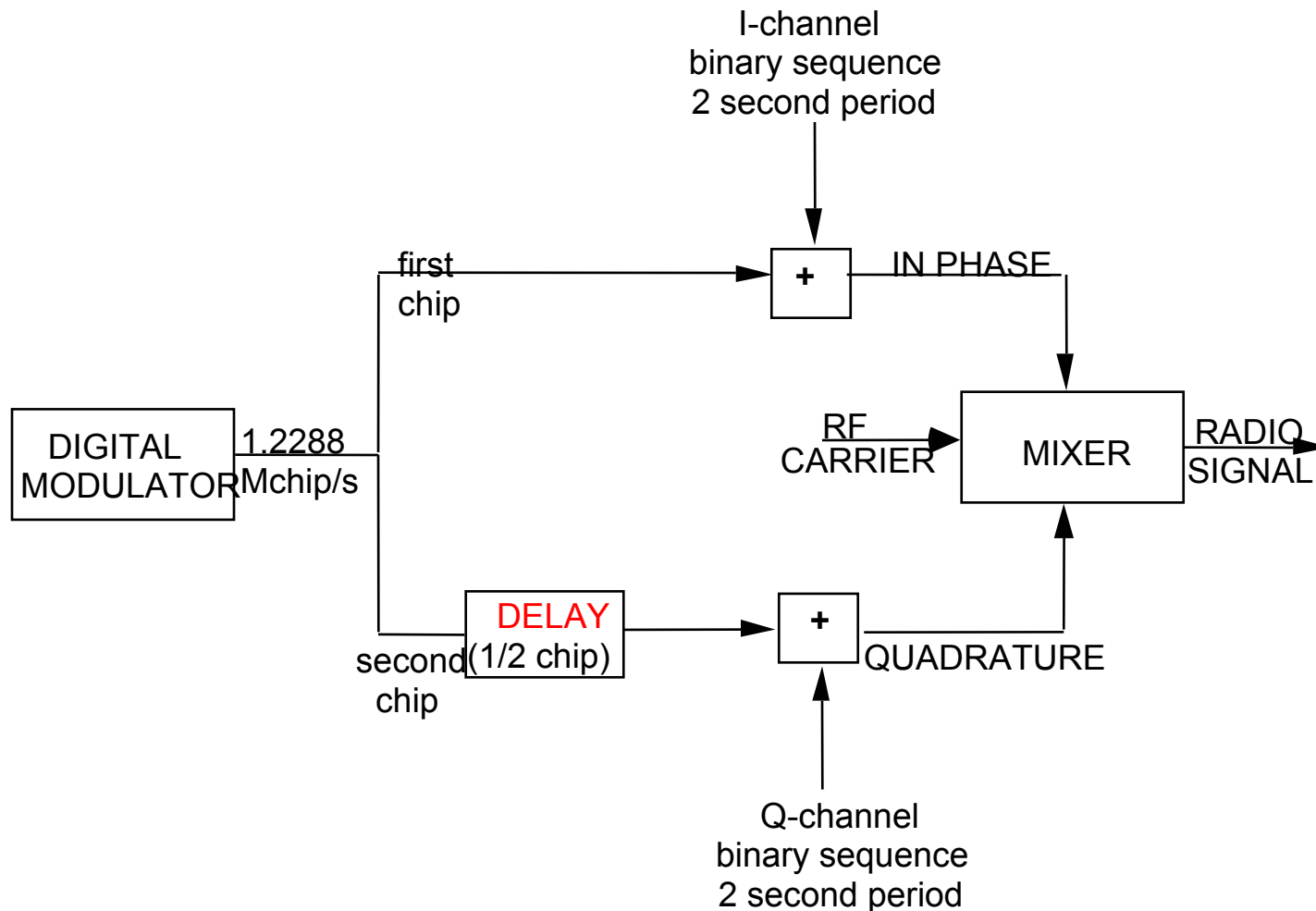
CODING, DIGITAL MODULATION, INTERLEAVING



FORWARD CHANNEL CODING, DIGITAL MODULATION, INTERLEAVING

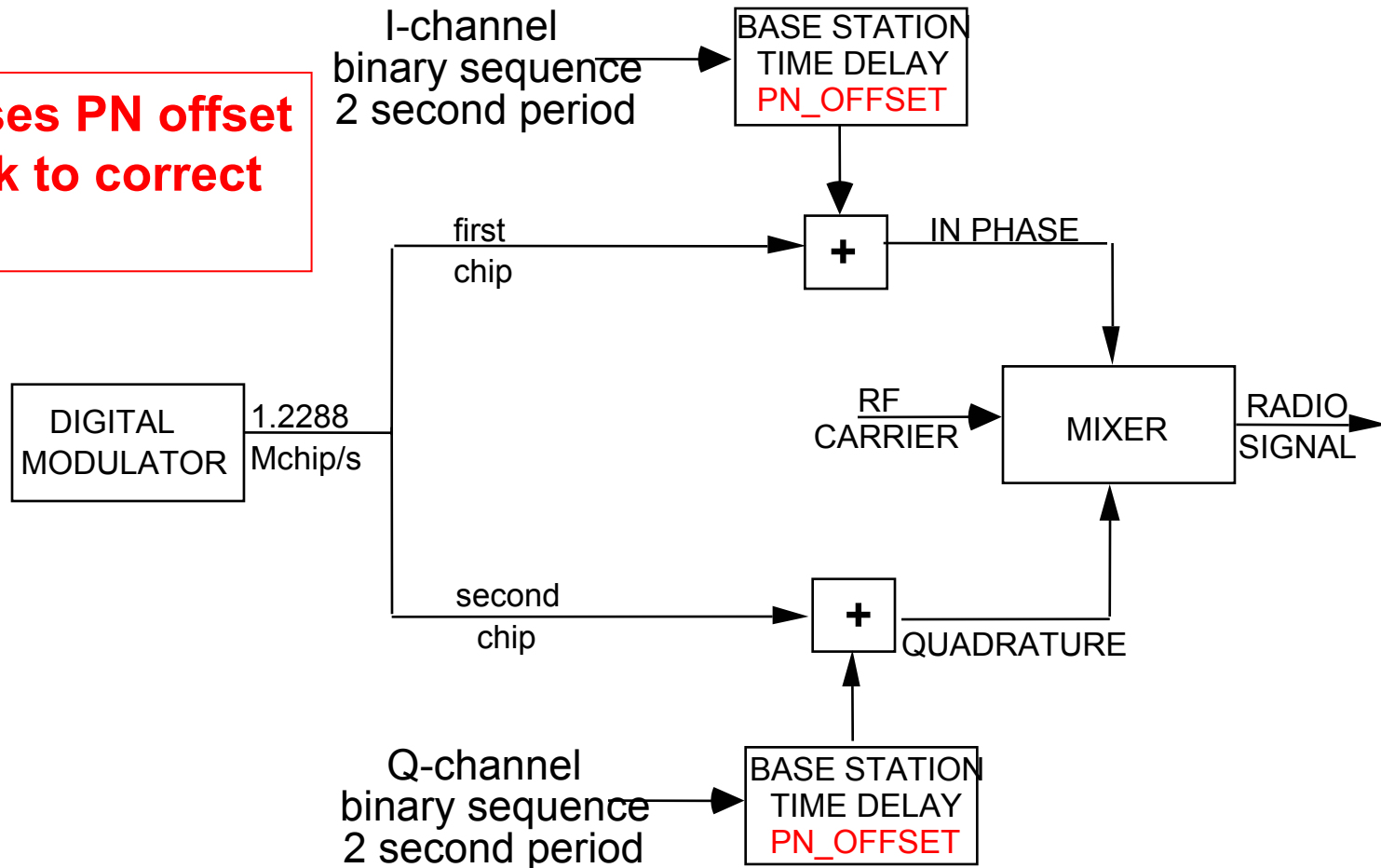


Reverse channel radio modulation



Forward channel radio modulation

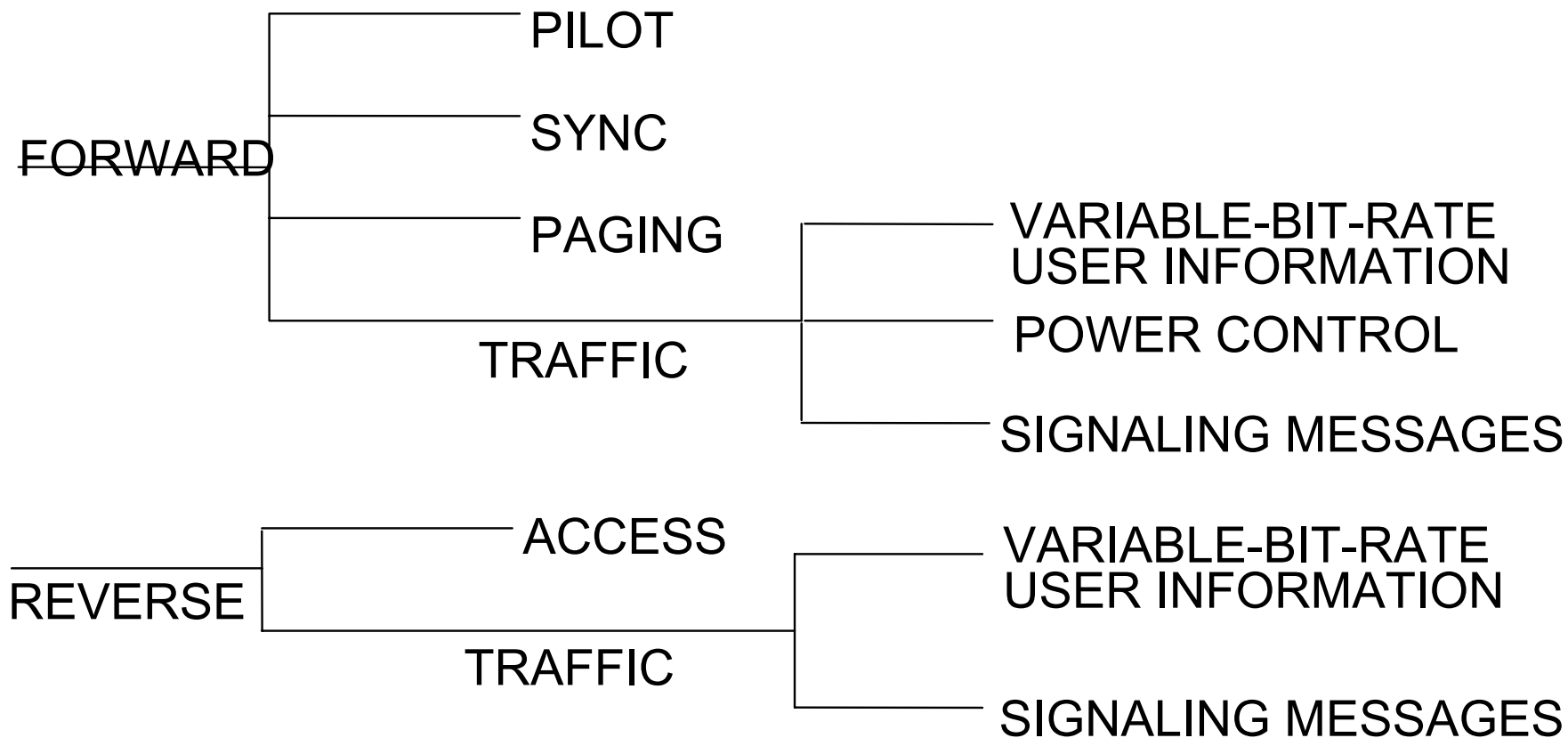
MS uses PN offset to lock to correct BS



I and Q channel scrambling

- Maximal length sequences: period = 2^{15} chips
- 2 different 15-stage feedback shift registers
- Repetition rate = $2^{15}/1,228,800$ ch/s = $2/75$ sec
- PN offsets are multiples of $2^6=64$ chips
- There are $2^{15}/2^6=2^9=512$ possible offsets
- Terminal locks to a BS by synchronizing to PN offset

IS-95 Logical channels



Forward channel multiplex

- 64 orthogonal digital carriers ($W_0 - W_{63}$)
- Pilot signal on $W_0=0,0,0,\dots,0$
 - Transmitted at high power
 - Lock MS to carrier frequency
 - Acquire bit timing at MS
- Synch channel on $W_{32}=000,\dots,0,1,1,1,\dots,1$

System ID	System time
Network ID	Leap seconds
PN offset	Offset of local time
Long code state	Paging channel rate (4.8 or 9.6 kb/s)

Forward channel multiplex

- Up to 7 paging channels on W_1-W_n $n \leq 7$
 - **Broadcast information**
 - System parameters access parameters
 - Neighbor list channel list
 - **Mobility management, security**
 - Registration channel assignment
 - Authentication SSD update
 - **Call management**
 - Paging alerting
- Traffic channels on W_8-W_{31} and $W_{33}-W_{63}$ and $W_{n+1}-W_7$ (if $n < 7$)

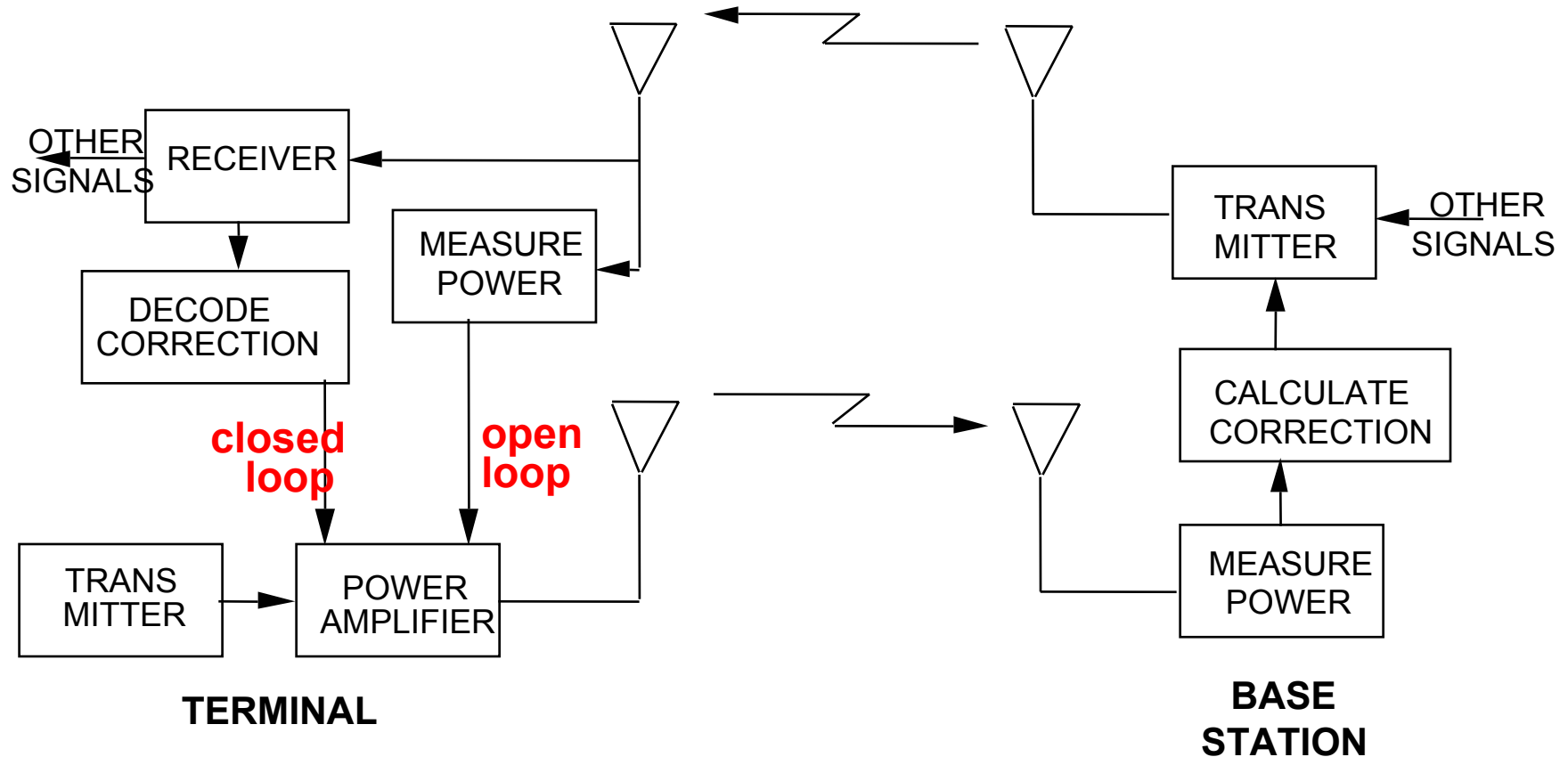
Reverse channel multiplex

- Up to 32 access channels
 - Digital carrier is 5 bit channel number combined with long code.
 - **Mobility management, security**
 - Registration: based on time, location, or area
 - Authentication SSD update
 - **Call management**
 - Originate call page response
- Traffic channels
 - Digital carrier is phone number combined with long code

Signaling and speech multiplex on traffic channel (dim and burst)

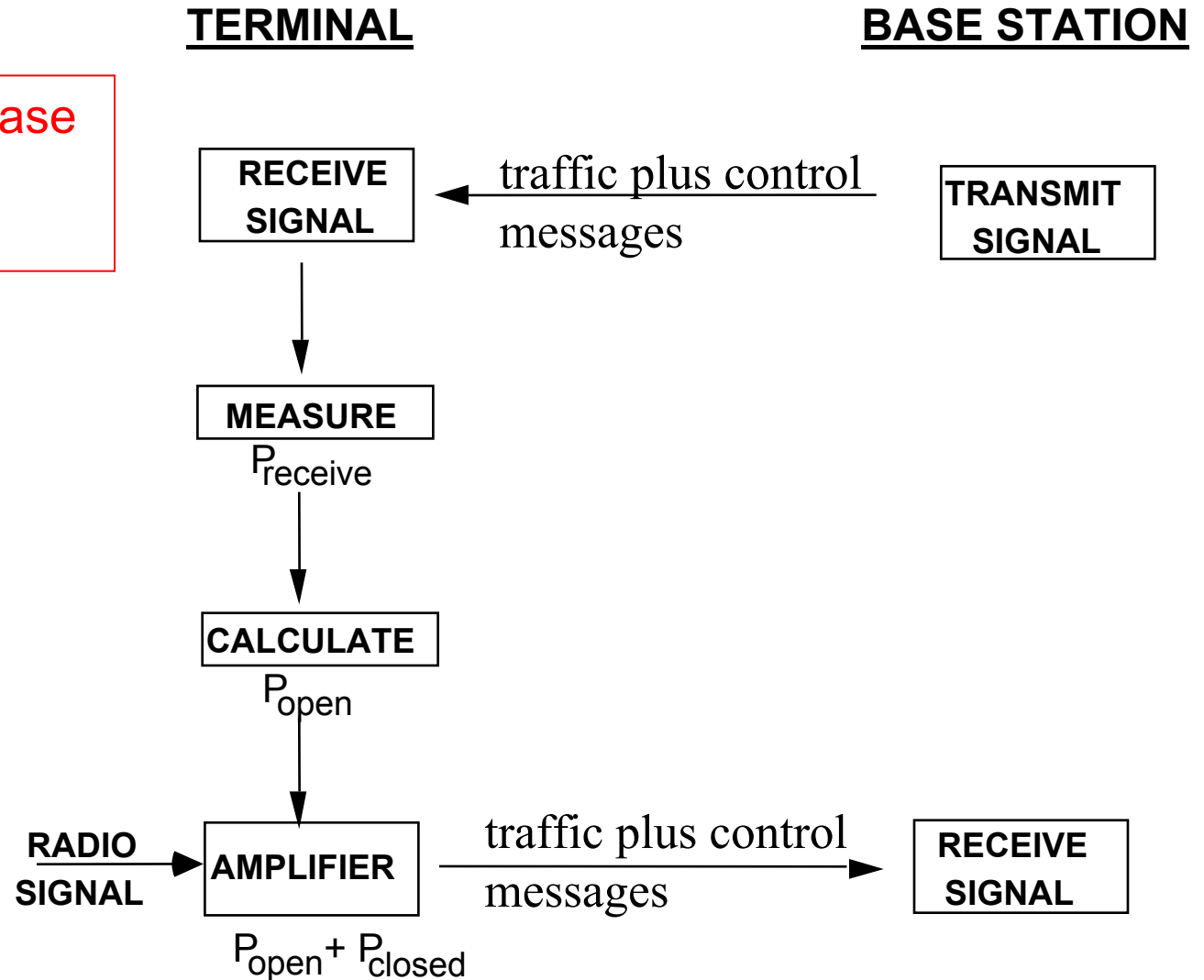
	Blank & Burst	Dim and Burst			Speech Only
Speech	0	16	40	80	171
Speech rate (b/s)	0	800	2000	4000	8550
Control message	168	152	128	88	0
Control rate (b/s)	8400	7600	6400	4400	0
Content indicator	4	4	4	4	1
Parity check	12	12	12	12	12
Coder tail bits	8	8	8	8	8
Information bits	192	192	192	192	192

Power control at mobile station



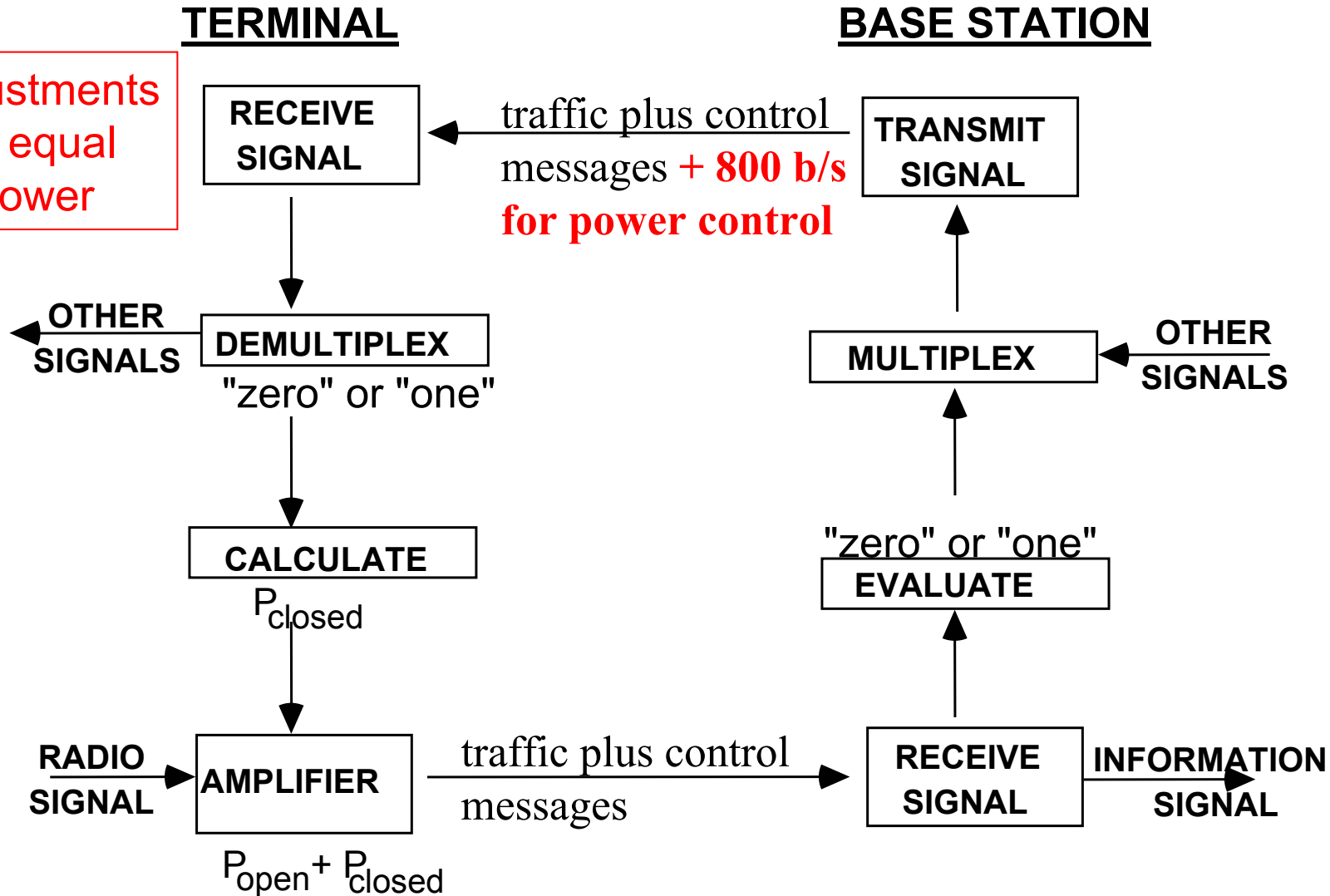
Open loop power control

Rapid power decrease
to prevent severe
interference



Closed loop power control

± 1 dB adjustments
to achieve equal
received power



Variable rate speech coding

- Dim and burst for signaling
- Voice activity detection to reduce interference, extend battery life
- Adapt to changing transmission conditions
 - Tradeoff initial quality for robustness
- Adapt to speech content

Variable bit rate speech

(QCELP 9600 b/s)

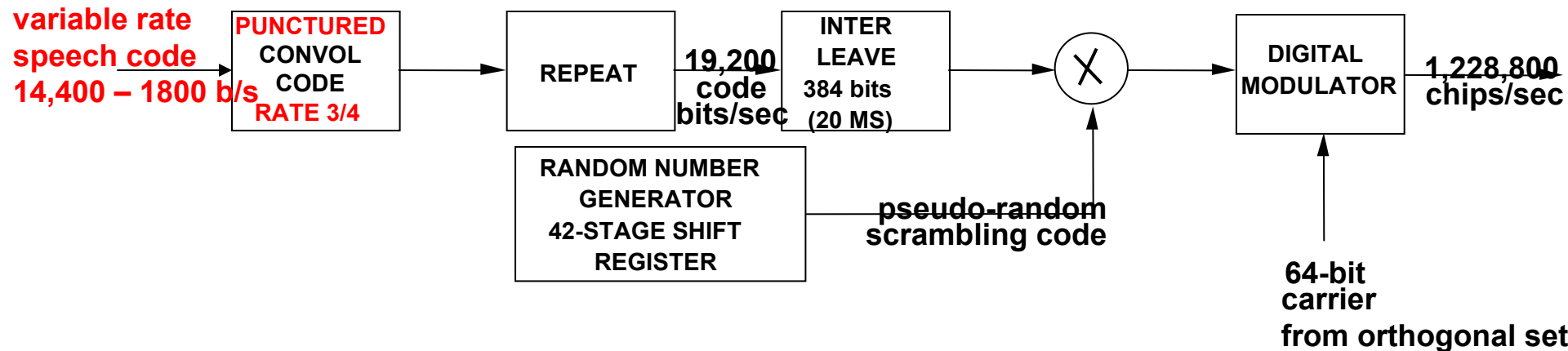
Data rate R b/s	120 0	240 0	480 0	960 0
Information rate R _I b/s	800	200 0	400 0	860 0
Information bits per frame (IBPF)	16	40	80	172
Parity bits per frame (PBPF)	0	0	8	12
Data bits per frame (IBPF+8)	24	48	96	192
Coded bits per frame (CBPF)	48	96	192	384
Repetitions	8	4	2	1
Total bits per frame (BPF)	384	384	384	384

384 output bits
per 20 ms

reduce interference
at lower rates:
reduce power (F)
or intermittent
transmission (R)

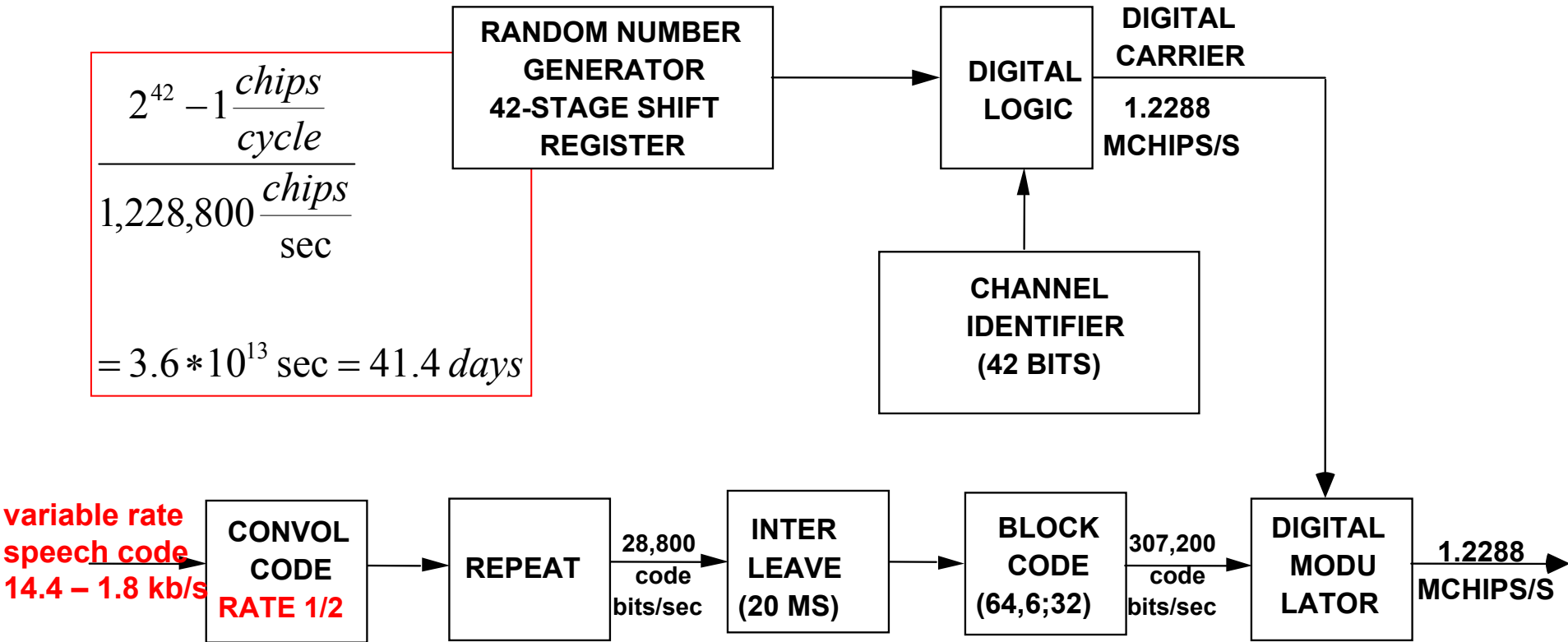
Speech coding at 14,400 b/s

forward traffic channel



Speech coding at 14,400 b/s

reverse traffic channel



CDMA Handoff

- Soft handoff
 - Two or more base stations
 - Same carrier frequency
 - Same MSC
- Softer handoff
 - Same base station, different sectors
 - Same carrier frequency
- Hard handoff
 - Different MSCs or different carrier frequencies
 - Go from CDMA to analog channels
- Also soft-softer

Soft handoff

MS uses 2 (or more) BS at once

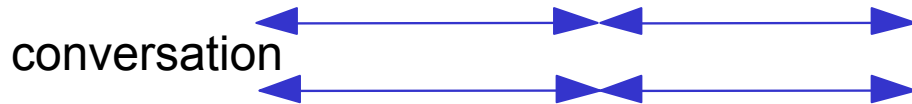
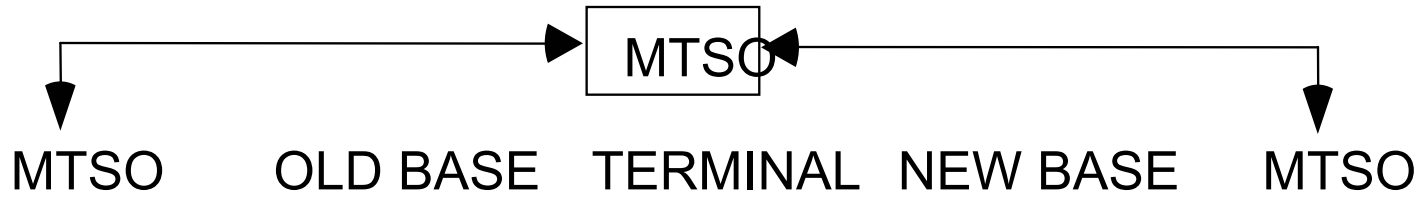
- Mobile assisted
- Mobile initiated
- MSC controlled
- Signals selected at MSC
- Signals added at MS

Soft handoff base station lists

- Active (serving) base stations
- Candidate base stations (available for handoff)
- Neighbor base stations (to be measured)
- Remaining base stations

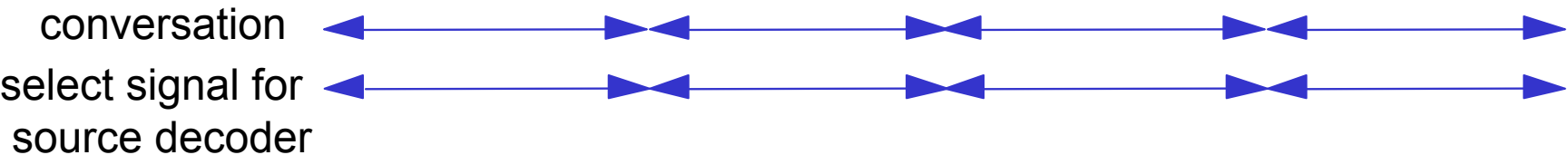
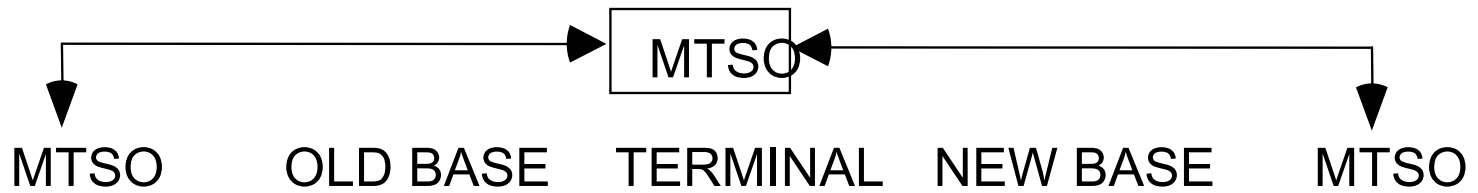
Soft handoff (1)

before

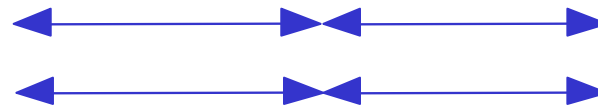
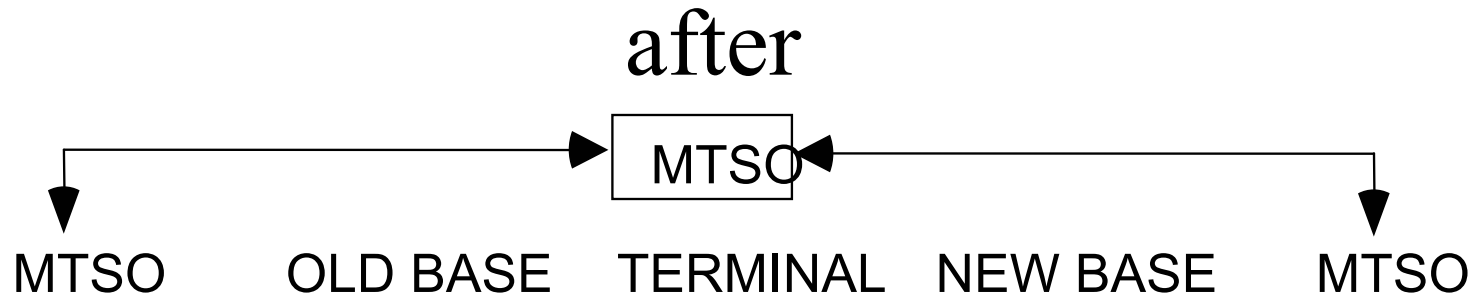


Soft handoff (2)

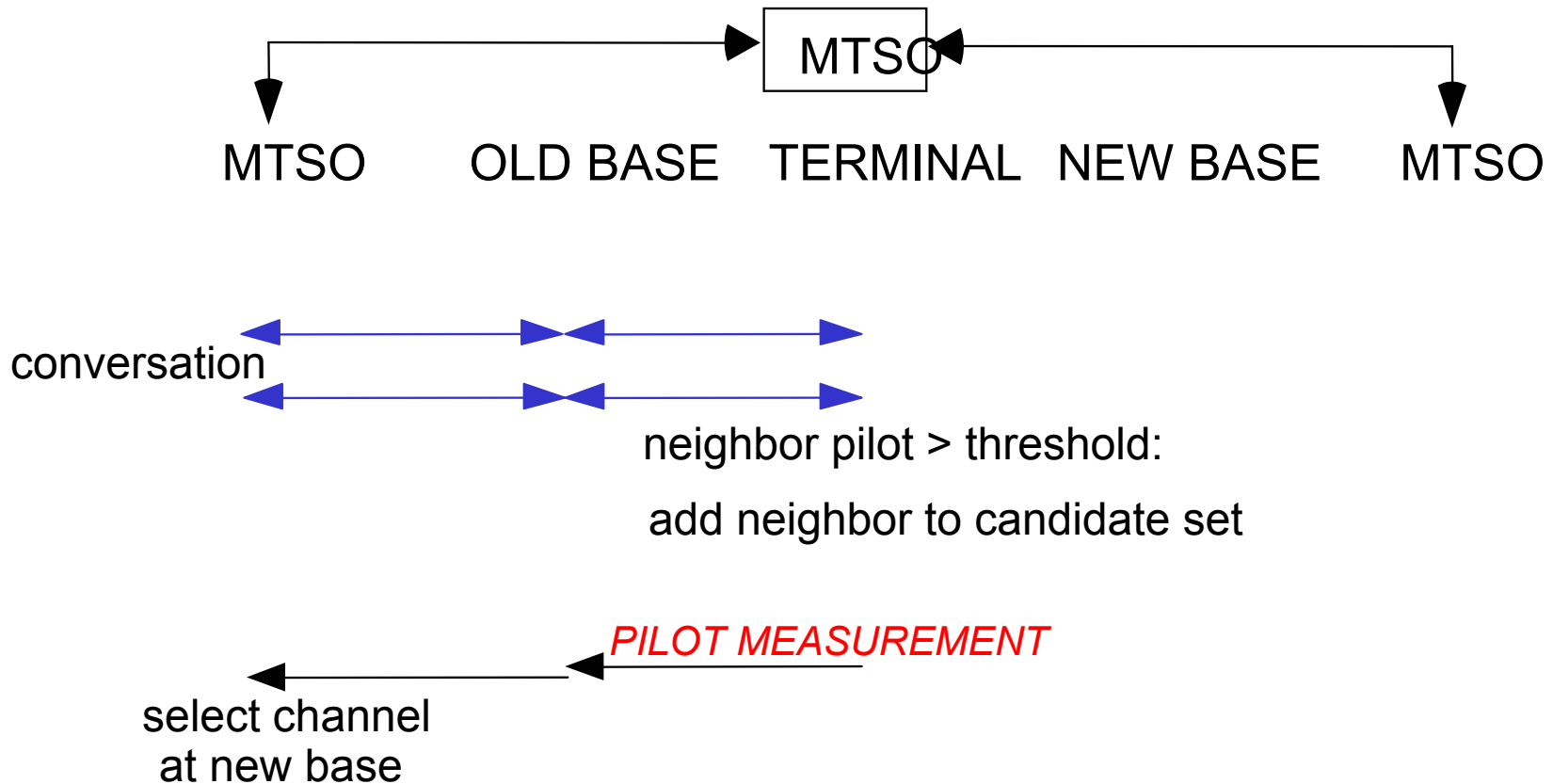
during



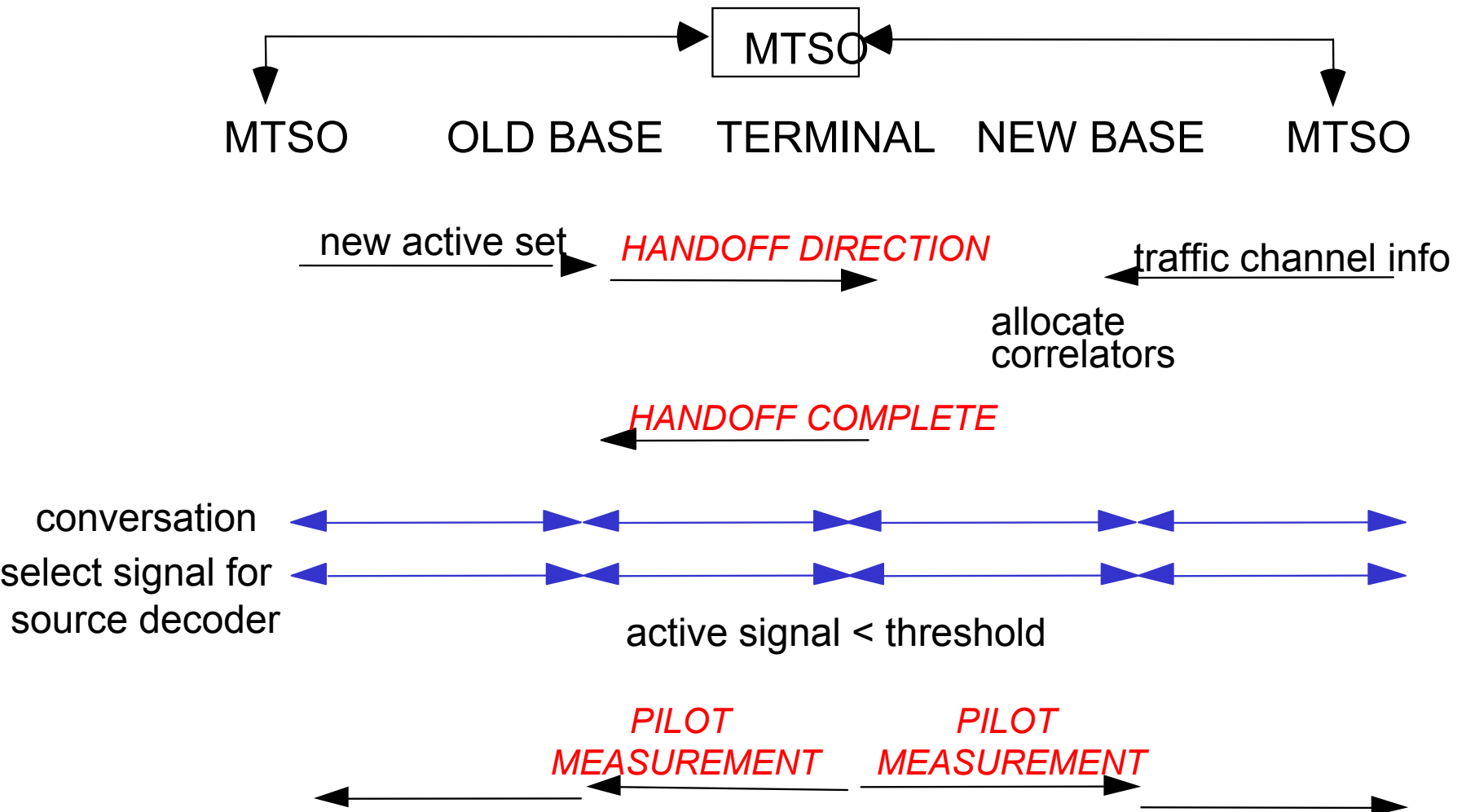
Soft handoff (3)



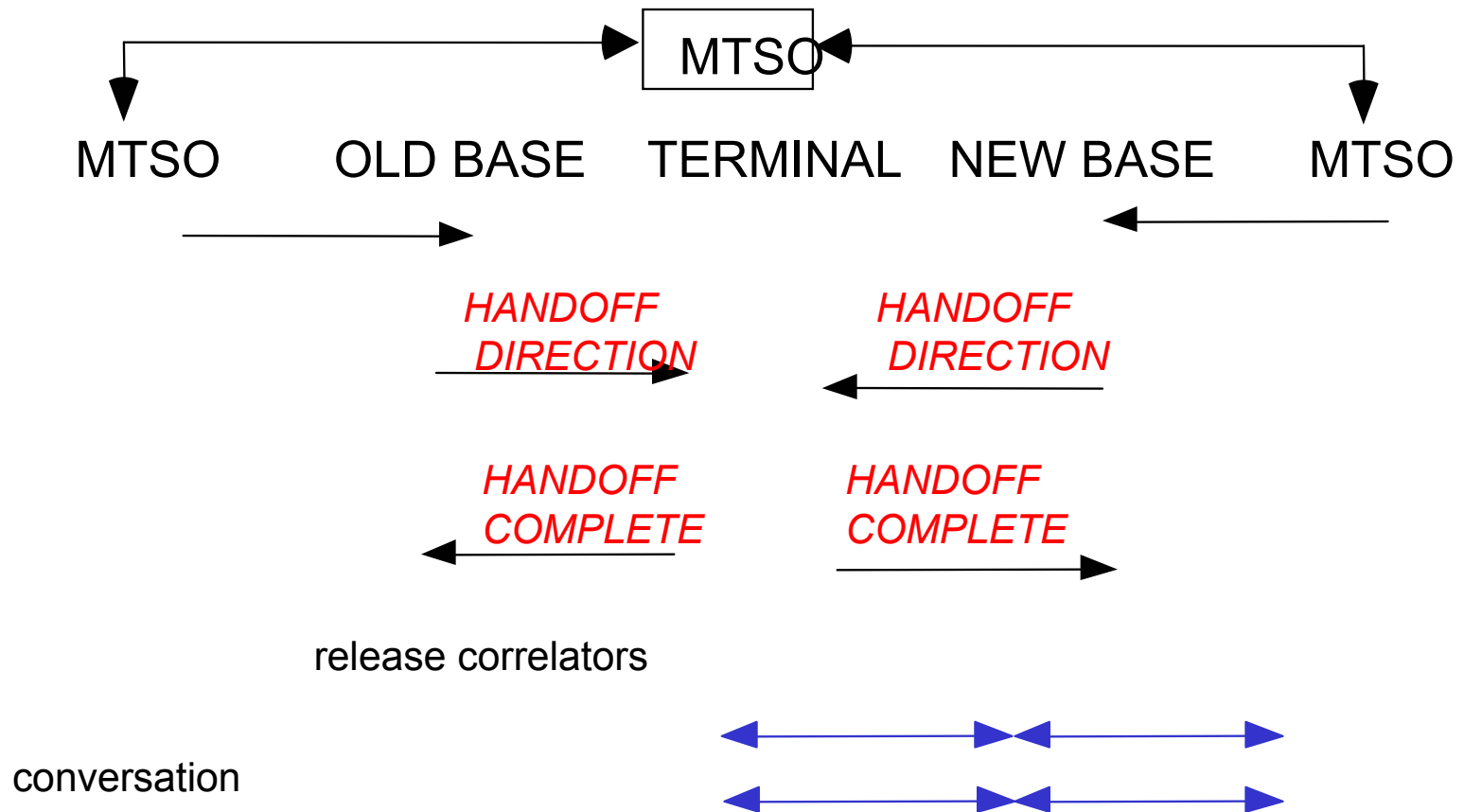
Soft handoff (1)



Soft handoff (2)



Soft handoff (3)



Access protocol

