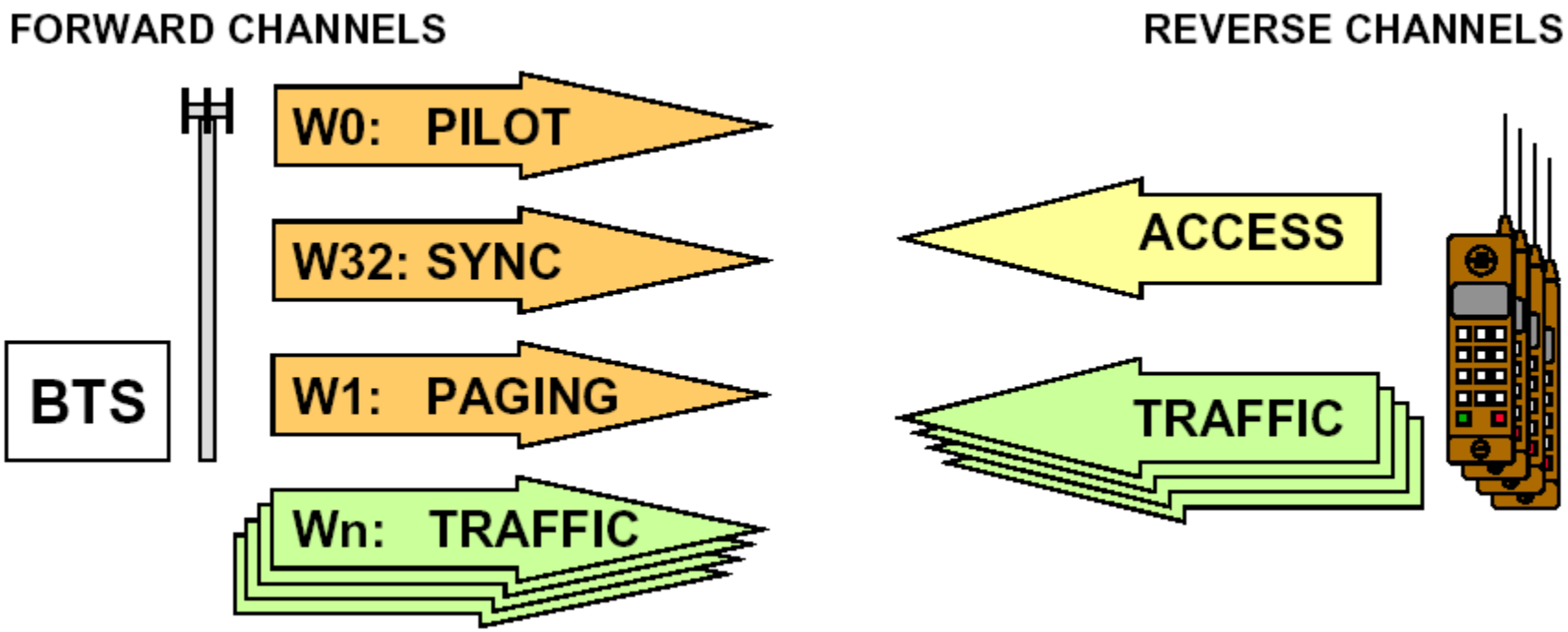
# CDMA Part 3

Kaiser.juniv.edu

# IS-95 CDMA Channels



# Pilot Channel

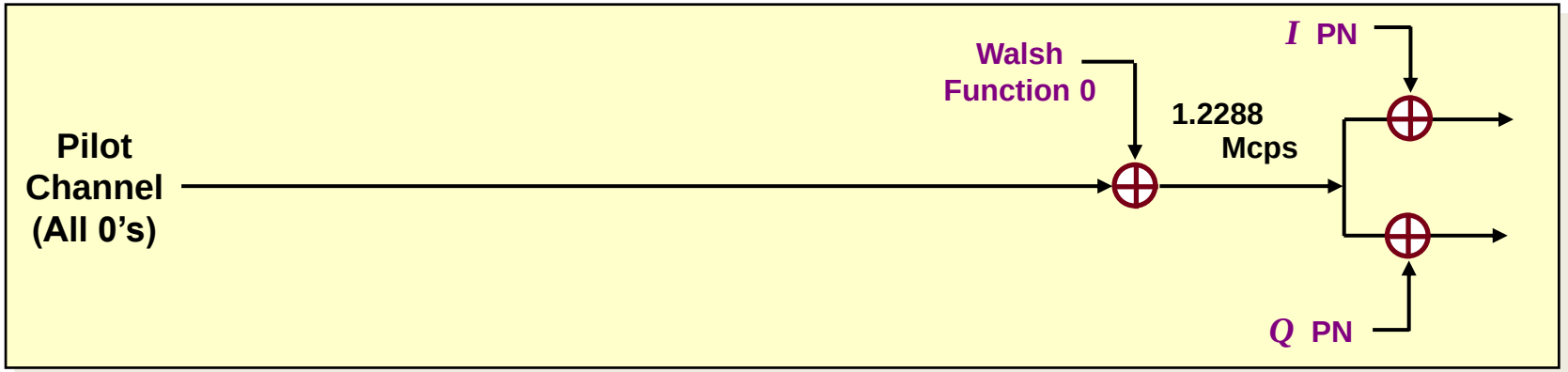
Function:

- obtains a phase offset by short PN sequences,in order to identify different base station.
- obtains basis timing information
- assisted handoff:mobile station use pilot strength(signal strength comparisons between base stations) to identify handoff candidates and to perform soft handoffs

Characteristic:

- Uncoded natured of pilot signal,that means the pilot is a “structural beacon”which does not contain a character steam.
- transmitted constantly by the base station
- use Walsh code 0.

# Pilot Channel Generation




- The Walsh code zero spreading sequence is applied to the Pilot
- The use of short PN sequence offsets allows for up to 512 distinct Pilots per CDMA channel
- The PN offset index value (0-511 inclusive) for a given pilot PN sequence is multiplied by 64 to determine the actual offset
  - Example: 15 (offset index) x 64 = 960 PN chips
  - Result: The start of the pilot PN sequence will be delayed 960 chips x 0.8138 microseconds per chip = 781.25 microsecond

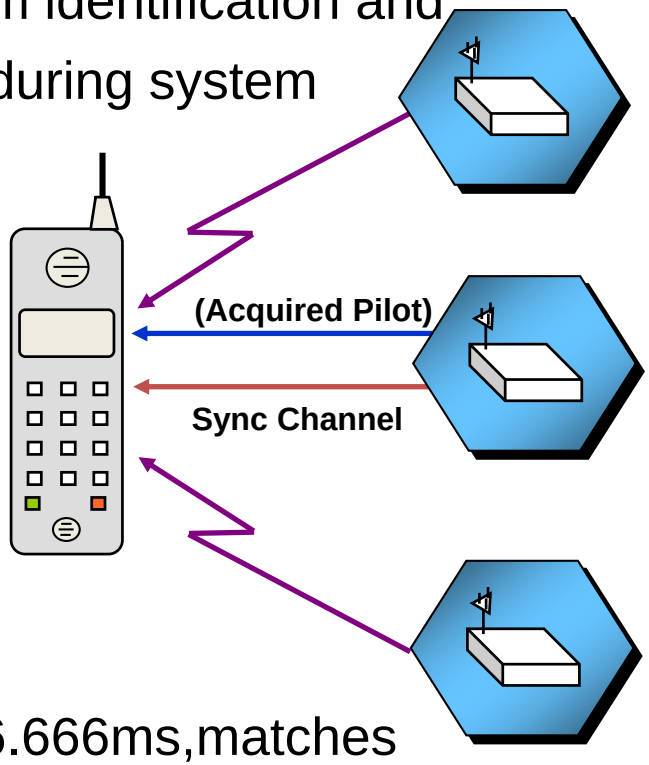
# Sync Channel

- Once a strong pilot channel is located,the mobile station listens to the corresponding sync channel for system information.
- This information transmitted at a rate of 1200bps,is contained in the sync channel message.
- The duration of the sync channel frames matches the period of repetition of the short PN codes transmitted on the pilot channel.
- Therefore,once the mobile station acquires synchronization with the pilot channel,the synchronization with the sync channel is immediately known.
- This action facilitates the acquisition of the sync channel by the mobile station

# Sync Channel(Cont.)

Function:

- Carries a data stream of essential system identification and parameter information used by mobiles during system acquisition stage
  - **PILOT_PN(9bits)**
  - **SYS_TIME(36bits)**
  - **LC_STATE(42bits)**
  - **PRAT(2bits)**




Characteristic:

- Bit rate is 1200 bps
- Sync channel has a frame duration of 26.666ms,matches the the period of Short PN Sequences

# Sync Channel Message

- PILOT_PN(Pilot PN Sequence Offset Index)

  Set to the pilot PN offset for the base station (in units of 64 chips), assigned by the network planner

- LC_STATE ( Long Code State )

  Provides the mobile station with the base station long code state at the time given by the SYS_TIME field, generated dynamically

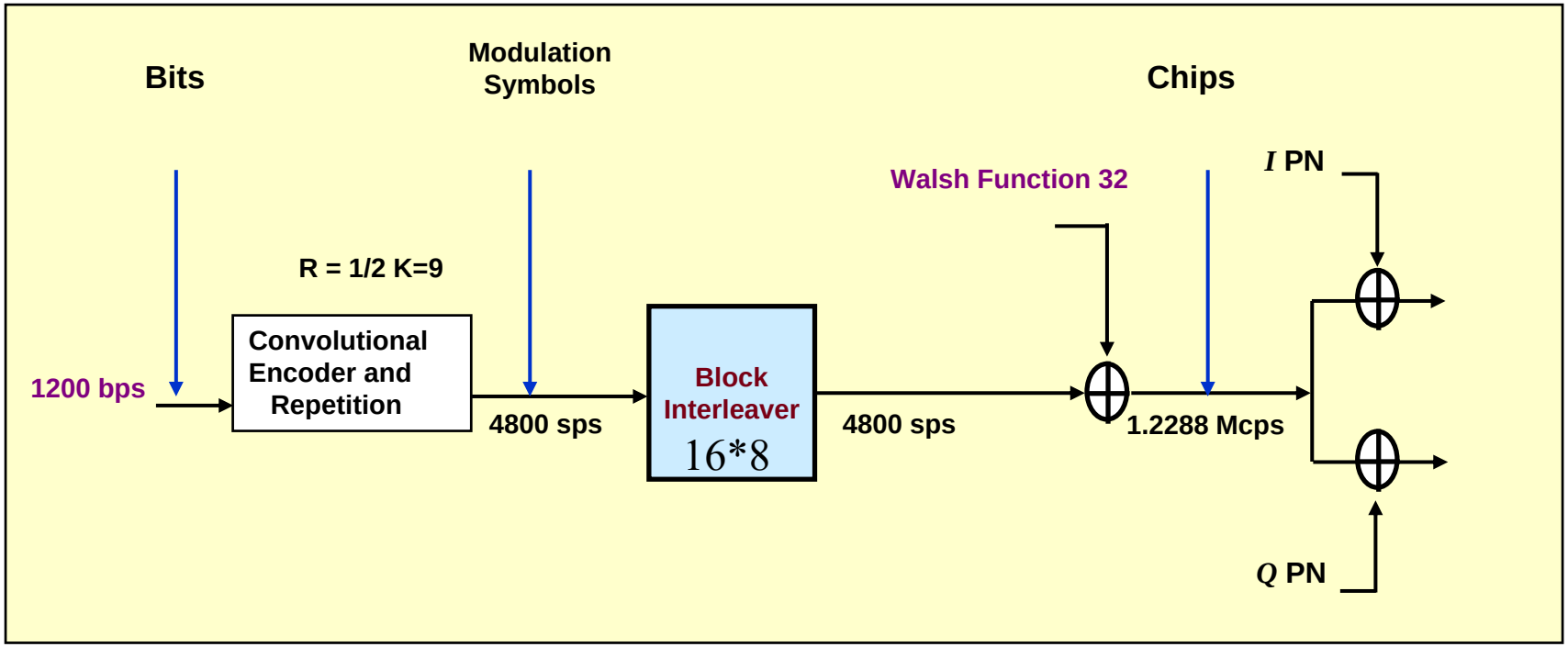
- SYS_TIME (System Time )

  GPS system-wide time as 320 ms after the end of the last super-frame containing any part of this message, minus the pilot PN offset, in units of 80 ms, generated dynamically

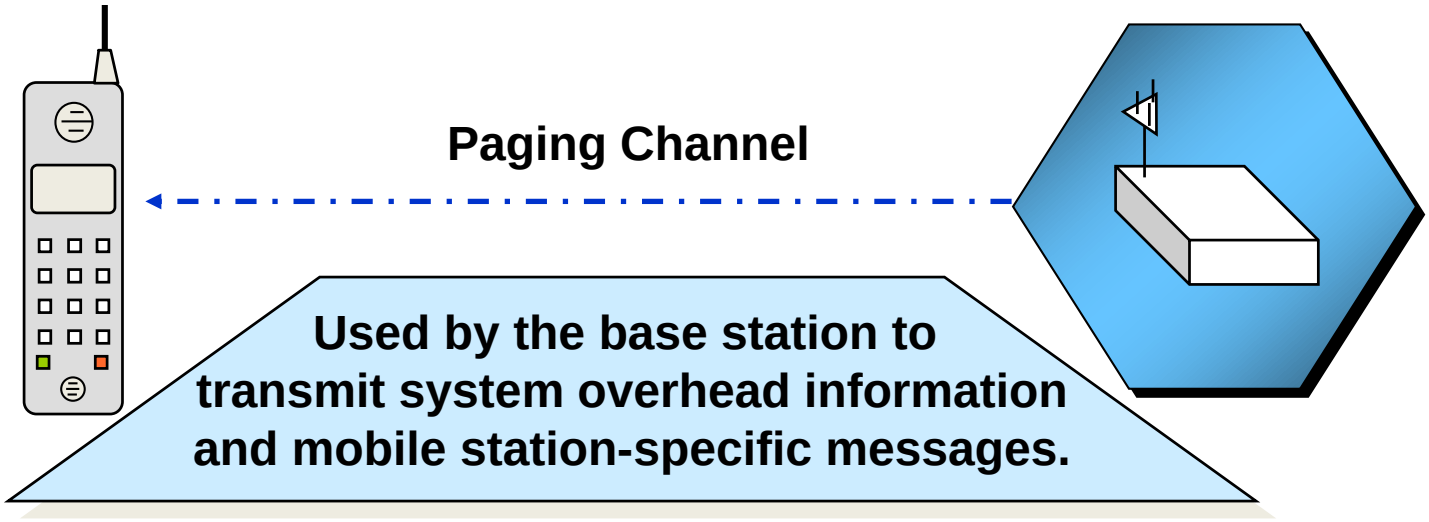
- PRAT (Paging Channel Data Rate )

  The data rate of the paging channel for this system, determined by the network planner,00 if 9600 bps;01 if 4800 bps

# Sync Channel Generation



# Paging Channels




- There is one paging channel per sector per CDMA carrier
- The Paging Channel uses Walsh code 1 up to 7,unused paging channels can be used as forward traffic channel
- Transmits information at a fixed data rate of either 9600 or 4800 bps,as specified by the “PRAT” parameter sent in the sync channel message

# Paging Channels(Cont.)

- The paging channel originates at the base station.A paging channel notifies mobile stations that they are receiving an incoming call.
- Once the mobile station accepts the page,a traffic channel is assigned by the base station for the mobile station to use.
- The base station sends the following messages to all of the paging channels:

  System parameters message

  Access parameters message

  CDMA channel list message

# Paging Channel Overhead Message

System parameters message

Contains the most important CDMA configuration parameters

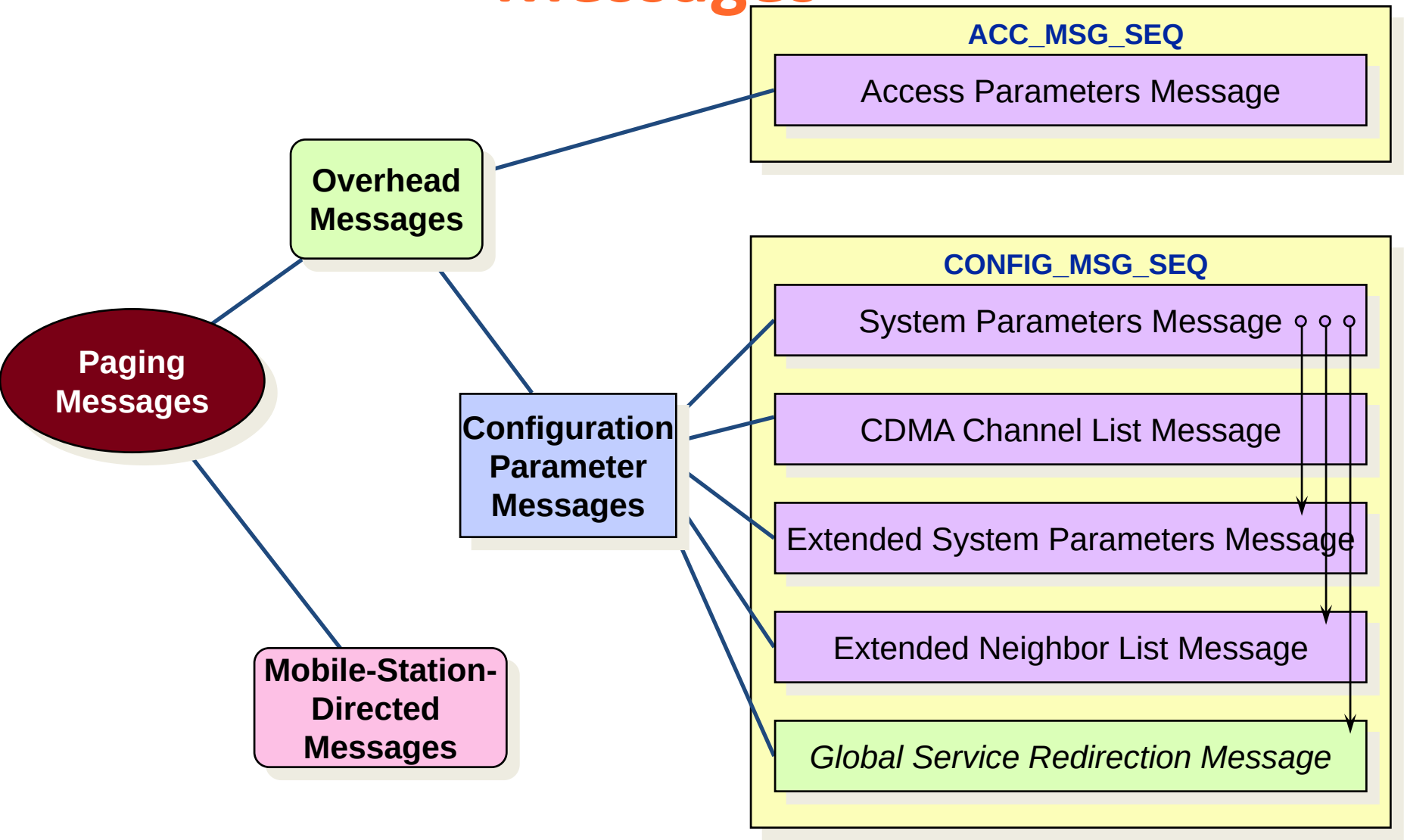
Access parameters message

Defines parameters used by the mobile stations when transmitting to the base station on the access channel

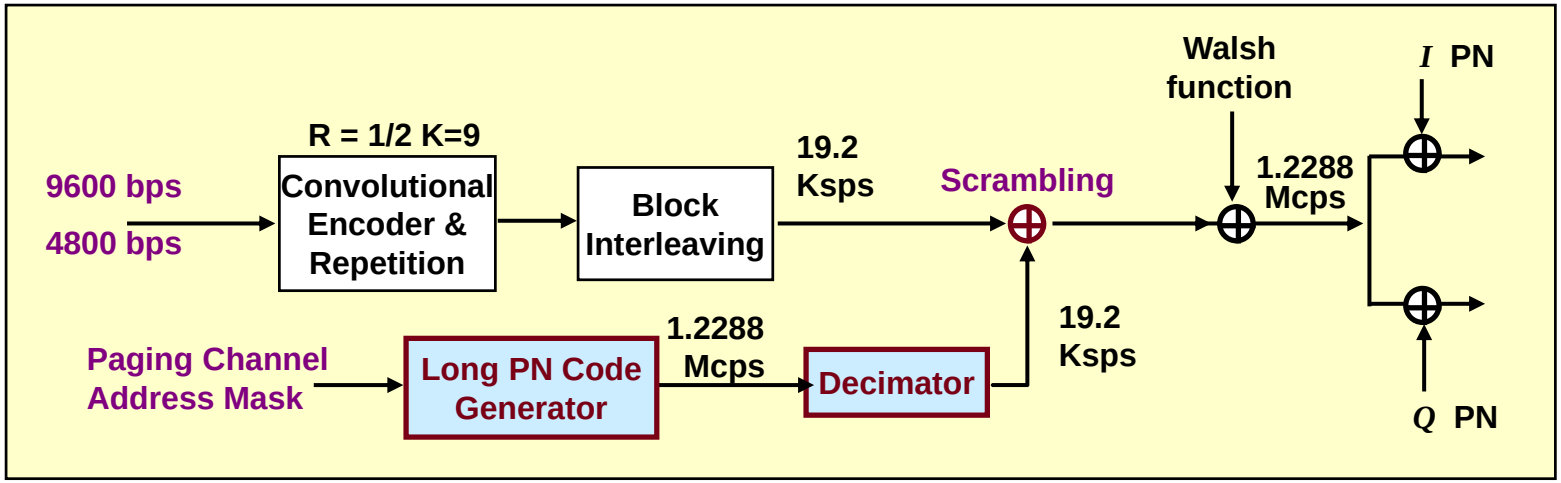
CDMA channel list message

Defines all the CDMA(frequency)channels supported by this base station

# Paging Channel Overhead Messages



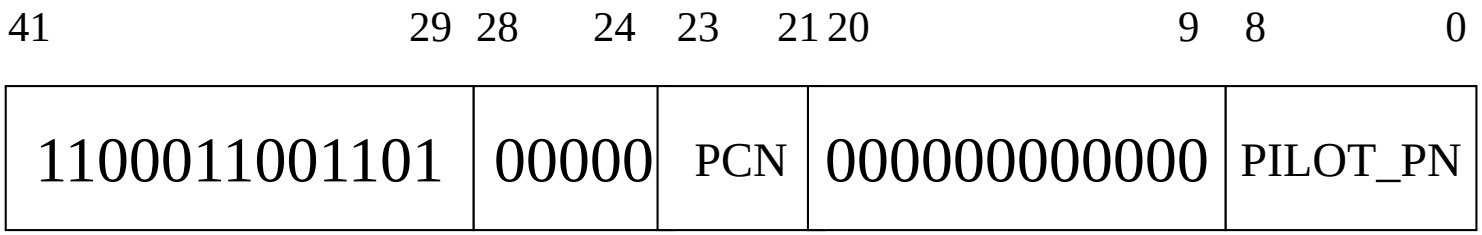
# Paging Channel Generation




- Walsh code #1 is used to spread the data. This results in an increase to 1.2288 Mcps
- The Rate 1/2 convolutional encoder doubles the bit rate.
- If the 4800 bps rate is used, the repetition process doubles the rate again, so that, at either rate, 384 modulation symbols per Paging Channel frame result
- 384 modulation symbols per frame times 50 frames per second = 19.2Ksps

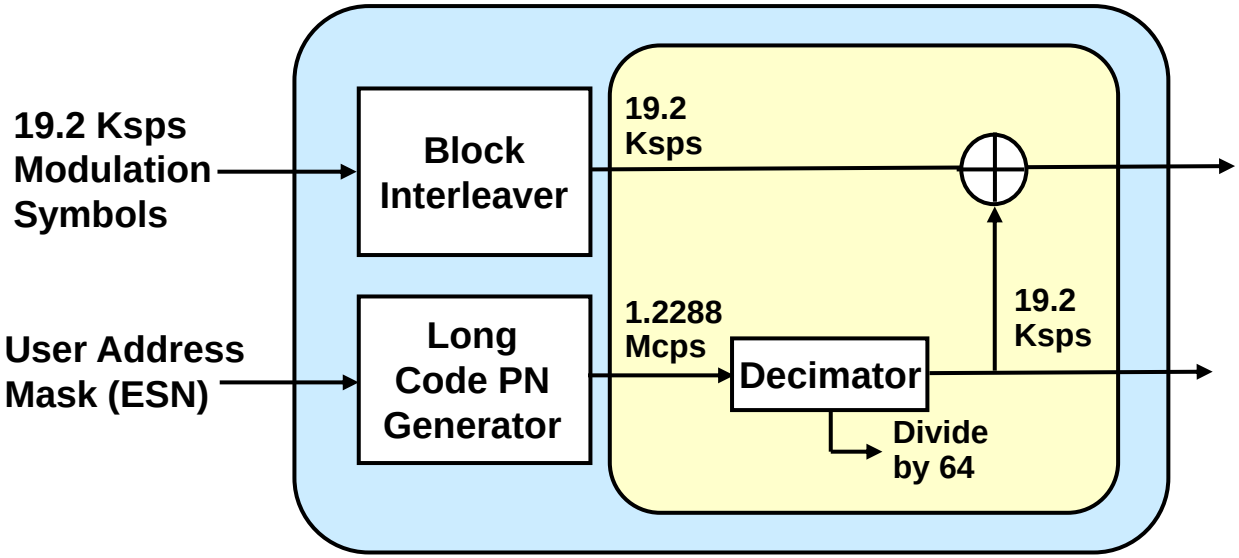
# Paging Channel Mask

Paging Channel is scrambled by the long code,offset by a mask constructed as follows:




PCN: Paging channel number
PILOT_PN: Pilot short PN code offset index

# Data Scrambling

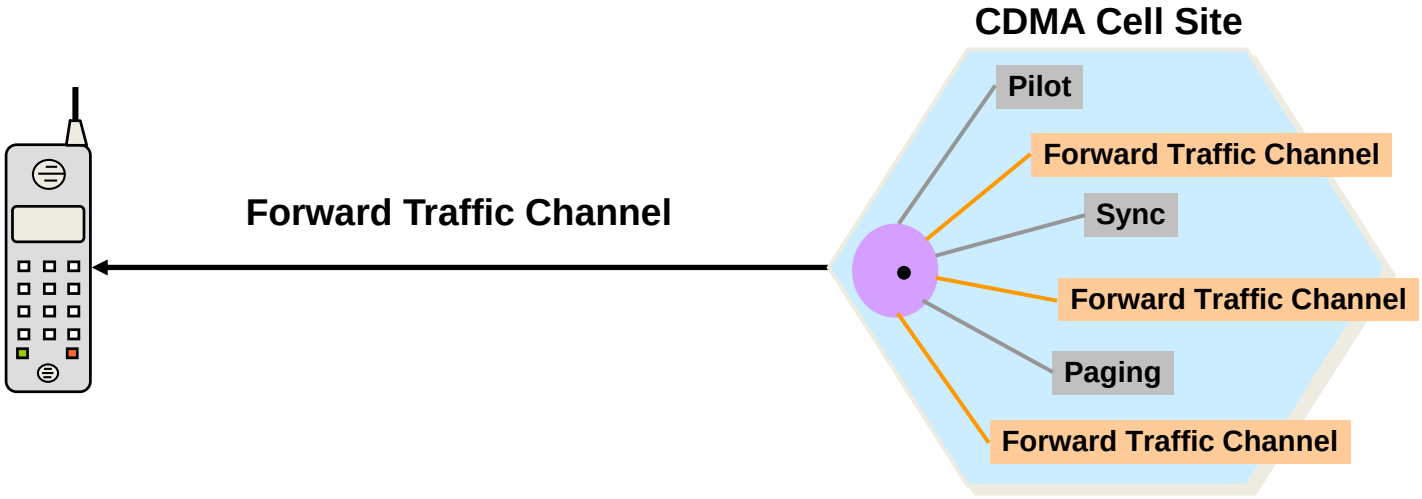



Data scrambling function:

Because the paging channel includes many important information such as user's IMSI,in order to assure the use's information secret,we use the data scrambling.

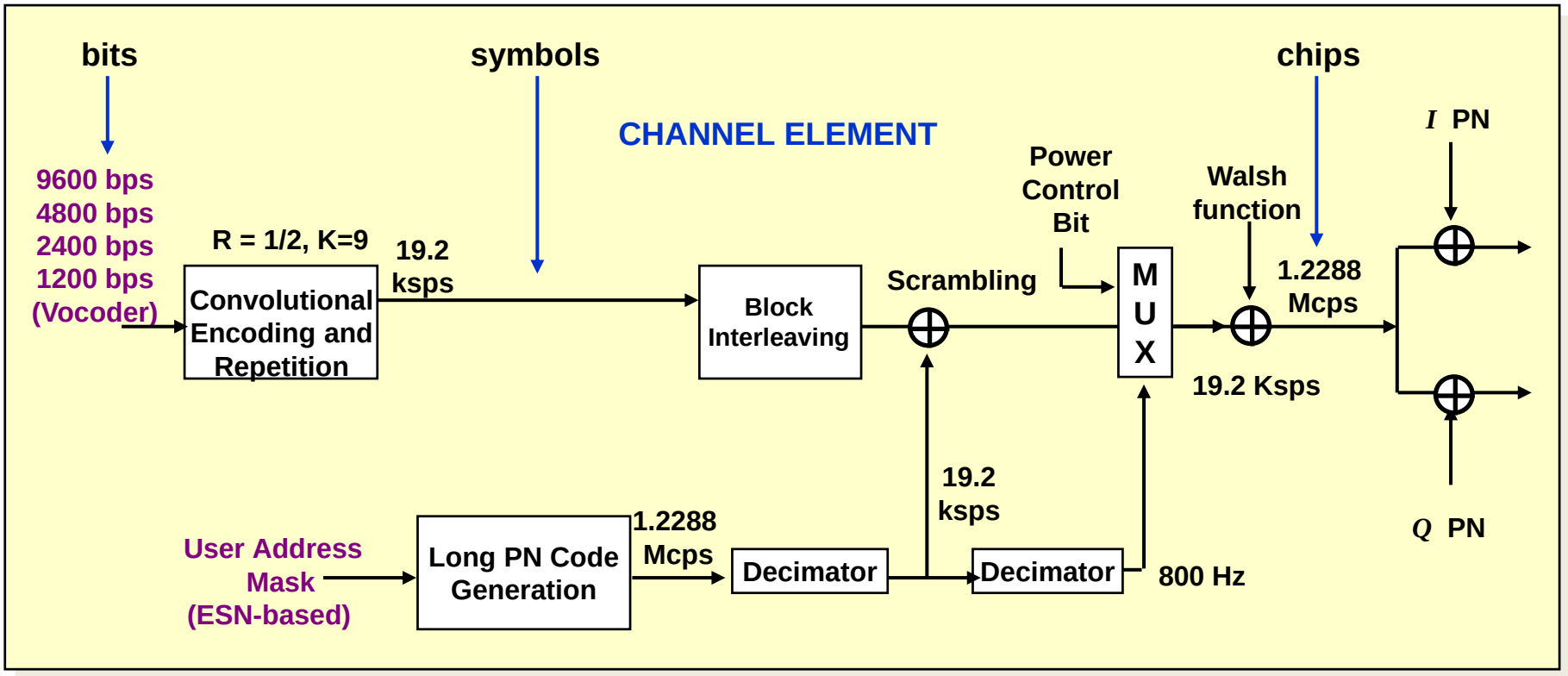
- Data scrambling is accomplished by modulo-2 addition(XOR),one input is a modulation symbol(19.2ksps) coming out of the block interleaver,another input is a random sequence,which created by decimator on long code generation.That means,Use the 64 times decimator to pickup the first chip of each 64 chips to form a random sequence.So the random sequence rate is 19.2kcps.(1.2288/64)

# Forward Traffic Channels

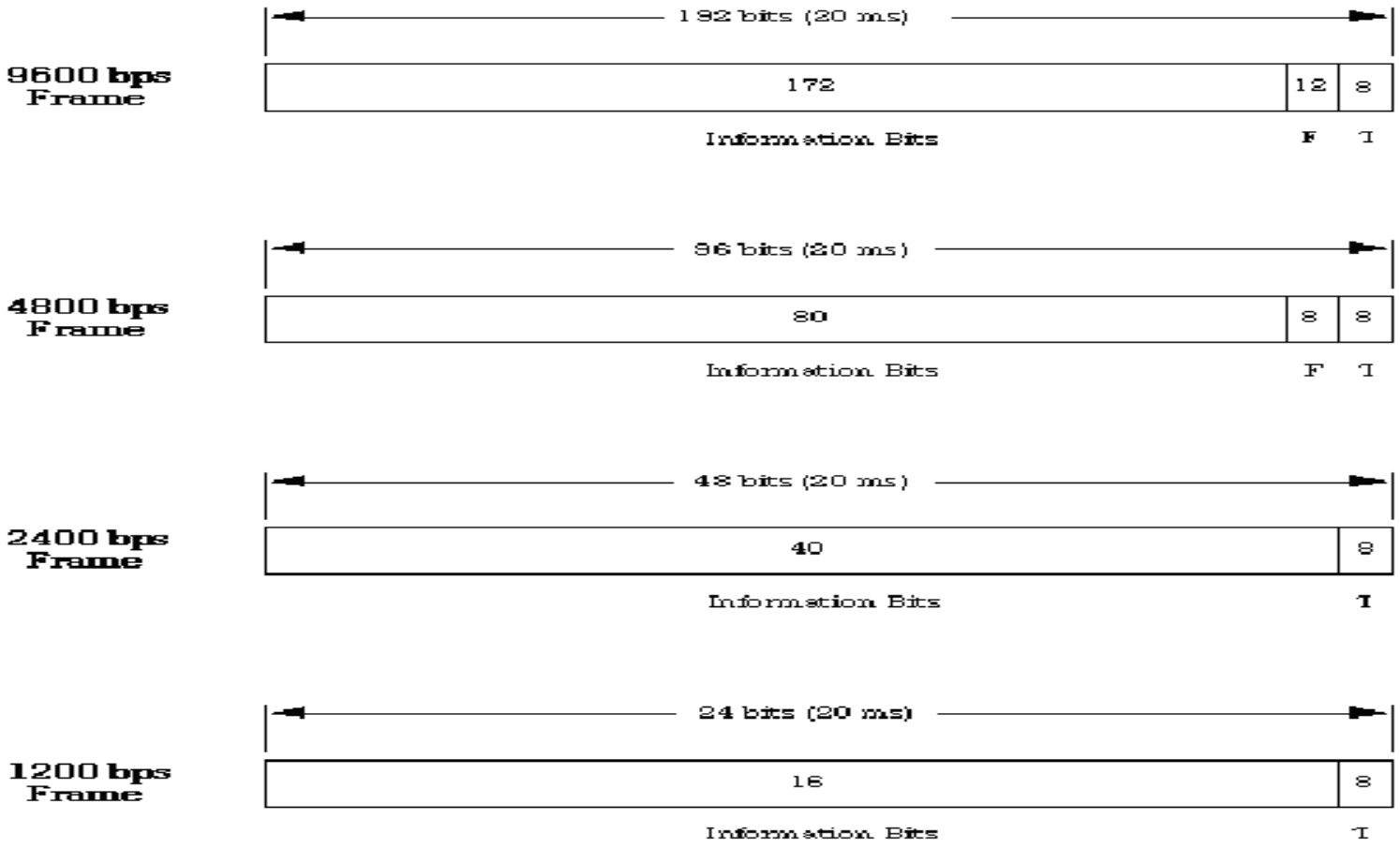



- Used for the transmission of user and signaling information to a specific mobile station during a call.
- Maximum number of traffic channels: 64 minus one Pilot channel, one Sync channel,  and 1 Paging channel.
  - This leaves each CDMA frequency with at least 55 traffic channels.
  - Unused paging channels can provide up to 6 additional channels.

# Forward Traffic Channel Generation

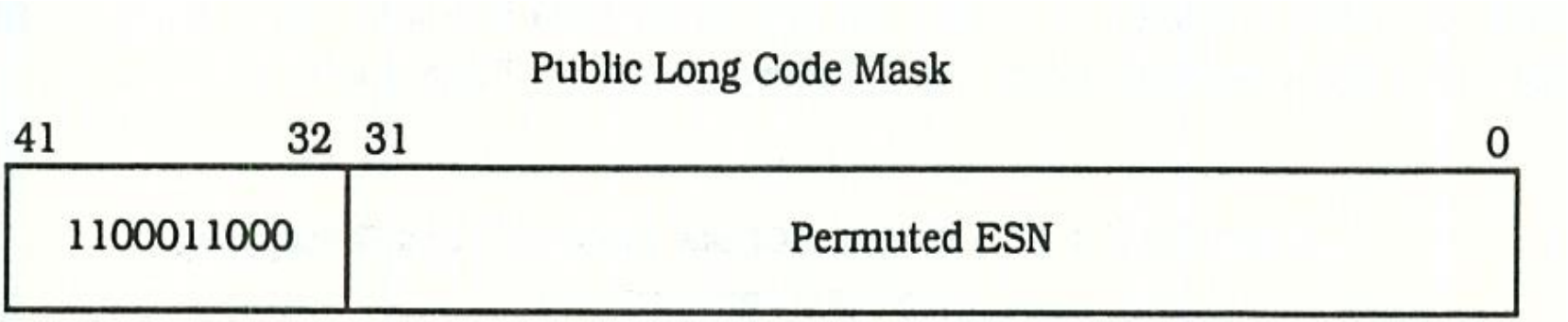


# Forward traffic channel frame structure



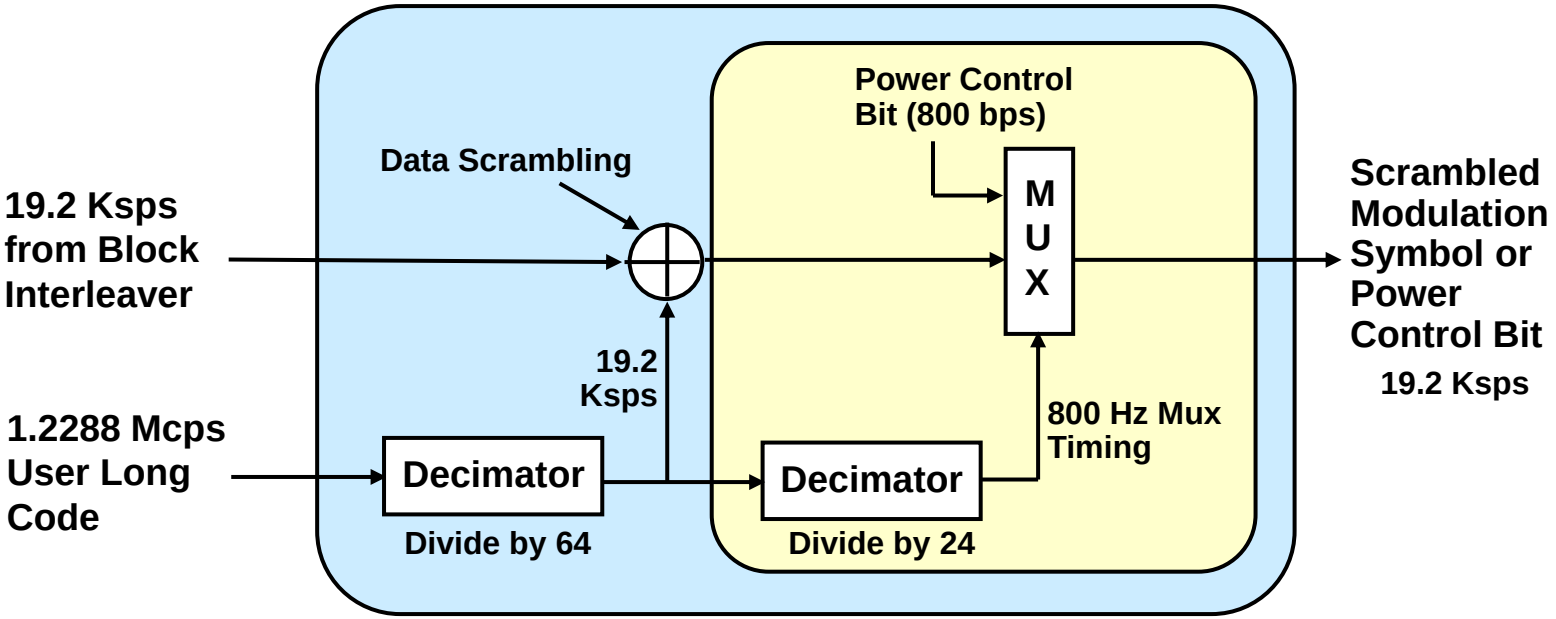
# Forward Traffic Channel Mask

A forward traffic channel is scrambled with the long code,offset by a mask constructed as follows:




Permuted ESN=E0,E31,E22,….E27,E18,E9

# Power Control Sub-channel




- Base station receiver estimates received signal strength of mobile over a 1.25 ms period (800/s)
- A power control subchannel is transmitted continuously to MS
  - A power up/down command is sent 800 times a second
- Uncoded to ensure rapid detection and response by the MS

# Power Control Sub-channel

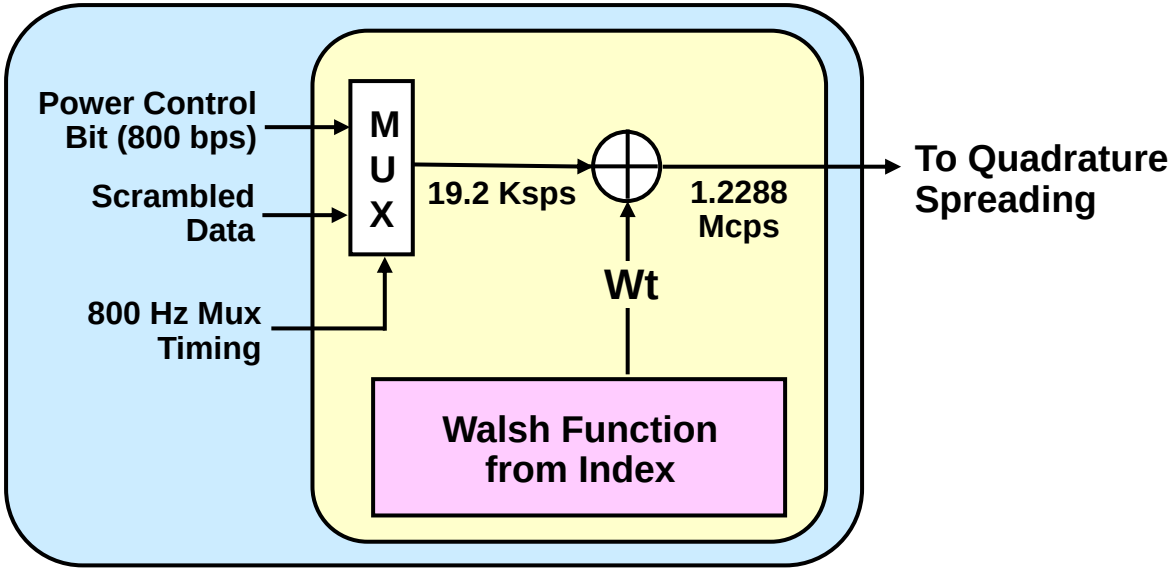
- The power control subchannel is included by forward traffic channel,by use a power control bit to indicate power up/down of MS transmit power.
- Each traffic channel frame(20ms) consist of 16 power control group(each group length 1.25ms),so the rate of power control is 16*(1s/20ms)=800bps

1.Every 1.25ms(800 times per second)the BS estimates the received signal strength on the reverse traffic channel of a particular mobile station

2.Based on this estimation,the base station determines whether that mobile station should increase or decrease its transmission power

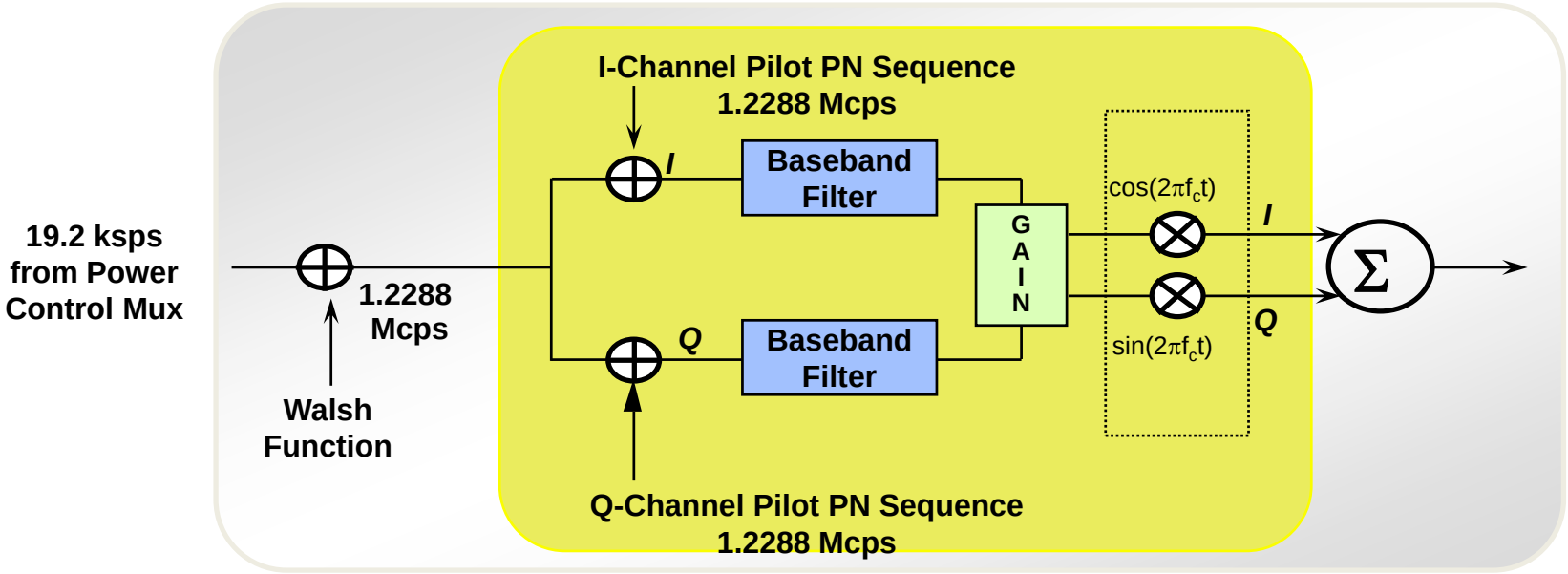
3.A power up(0) or power down(1) one-bit command is sent by the base station to that mobile station 800 times a second on the corresponding forward traffic channel.This constitutes the “Power control subchannel” for that mobile station.

# Orthogonal Spreading




- Each symbol output from the Mux is exclusive XORed by the assigned Walsh function
- Walsh function has fixed chip rate of 1.2288 Mcps
- Channels are distinguished from each other by Walsh function
- Bandwidth used greatly exceeds source rate

# Quadrature Spreading & Baseband Filtering




- The forward traffic channel is combined with two different PN sequences: "I" and "Q"
- Baseband filtering ensures the waveforms are contained within the 1.25 MHz frequency range
- The final step is to convert the two baseband signals to radio frequency (RF) in the 800 MHz or 1900 MHz range

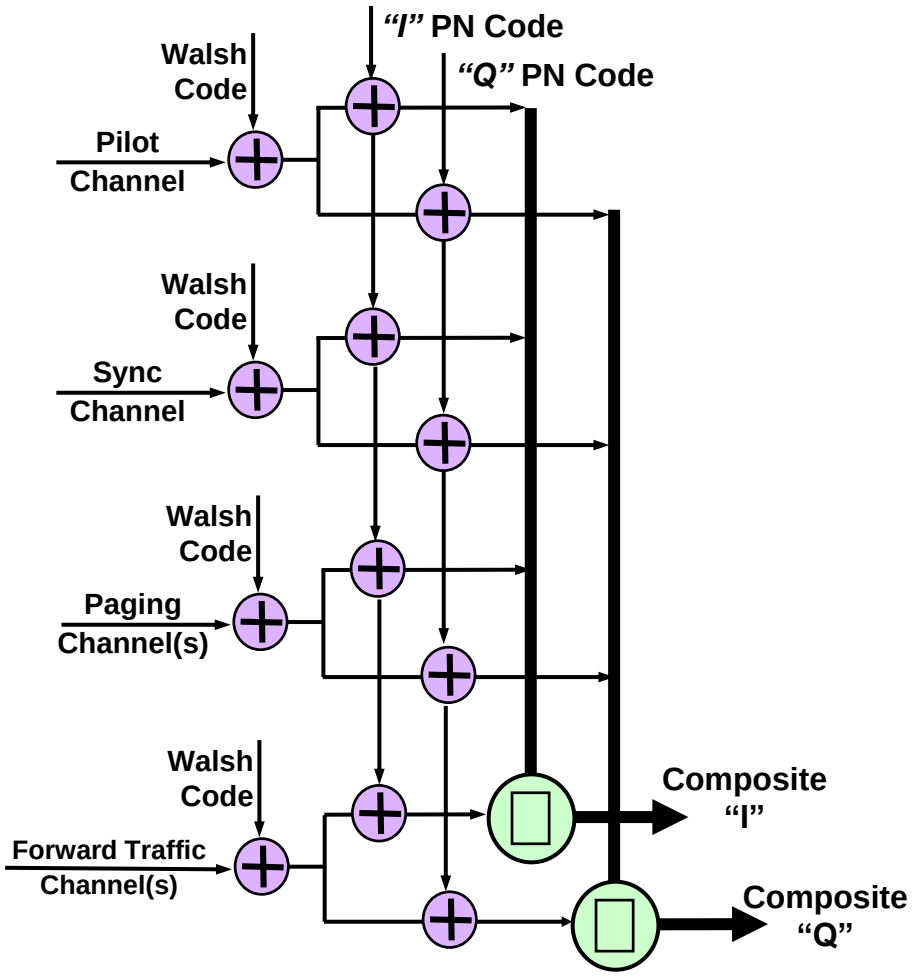
# QPSK Modulation

## Quadri-Phase Shift Key (QPSK) Modulation

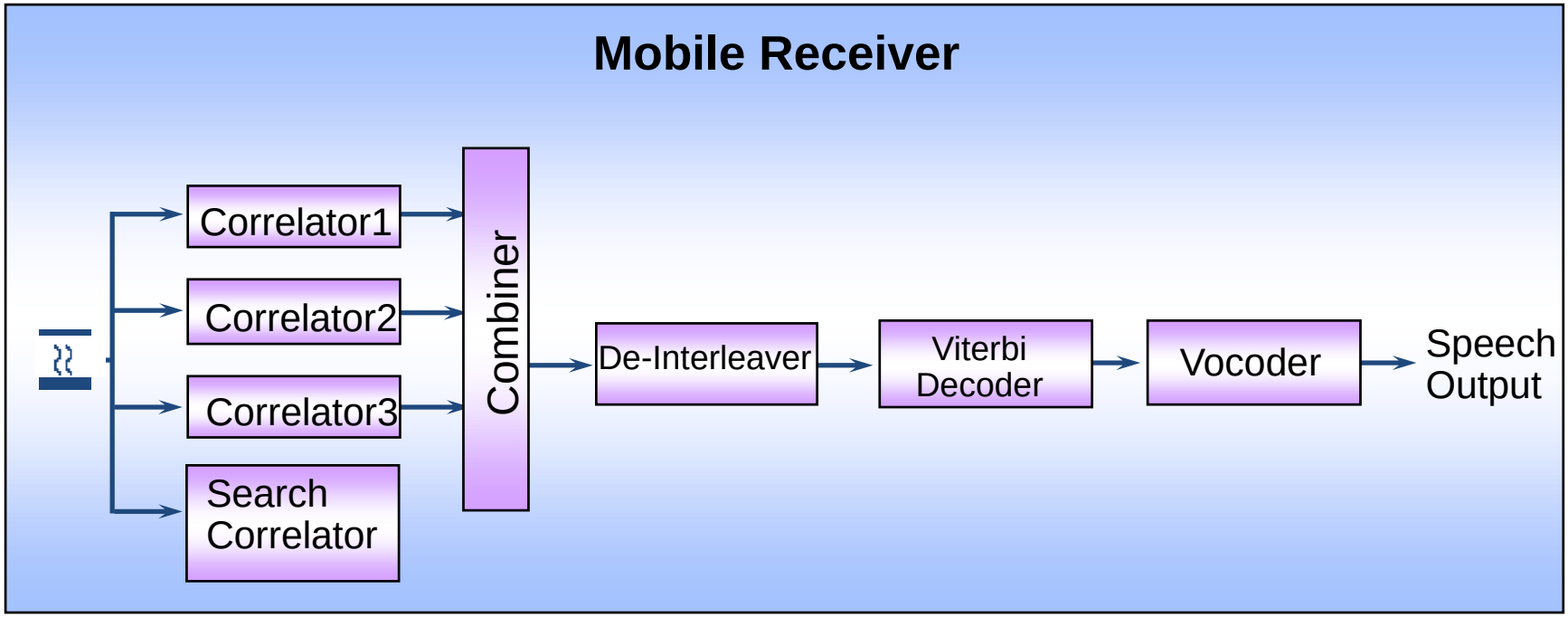
- BASEBAND: The total frequency band occupied by the aggregate of all the information signals used to modulate a carrier
- FILTER:Electronic circuit devised to modify the frequency distribution of a signal spectrum
- BASEBAND FILTER:filter(used in quadrature modulation)that limits the input signal to the SyQuest band +-T/2,where T is the transmitted pulse rate.
- GAIN CONTROL: the gain of the overhead channels(pilot,sync,and paging)in the composite I and Q is set.The gain of each forward traffic channel is constantly adjusted by the reverse link power control process.

# Composite “I” and “Q”

- Each channel card has a combiner and works in a serial array to combine the I and Q signals for all forward channels in a partition sector or cell.
- The baseband I and Q signals for all channel cards are sent to the CORE module to be multiplexed together based on the PN offset.
- This ensures that a mobile station does not mistakenly decode the signal from a channel with the same Walsh code from the wrong base station.



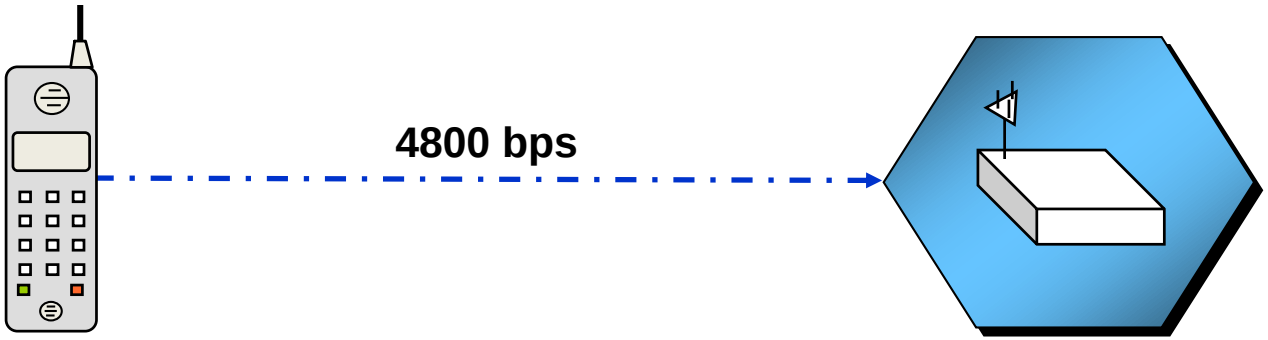
# Forward Channel Demodulation




**IS-95A/J-STD-008 requires a minimum of four processing elements that can be independently directed:**

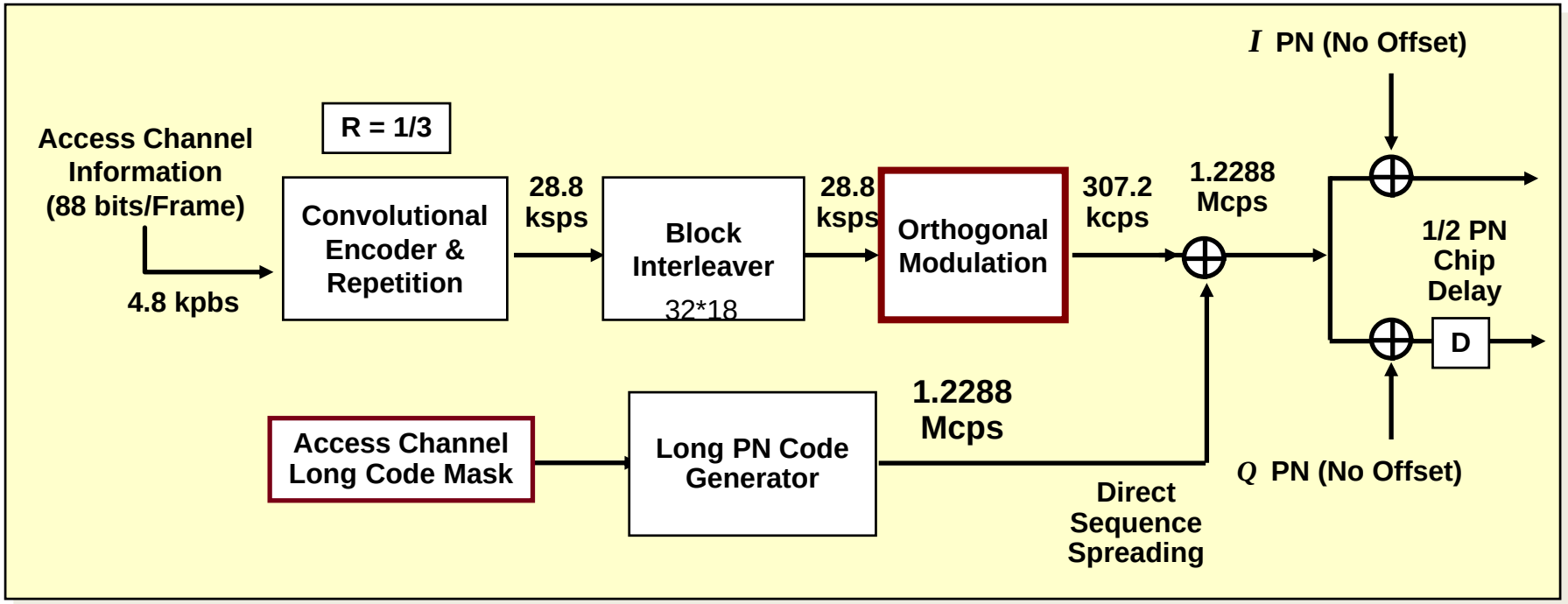
- Three elements must be capable of demodulating multipath components
- One must be a "searcher" that scans and estimates signal strength at each pilot PN sequence offset

# Access Channels



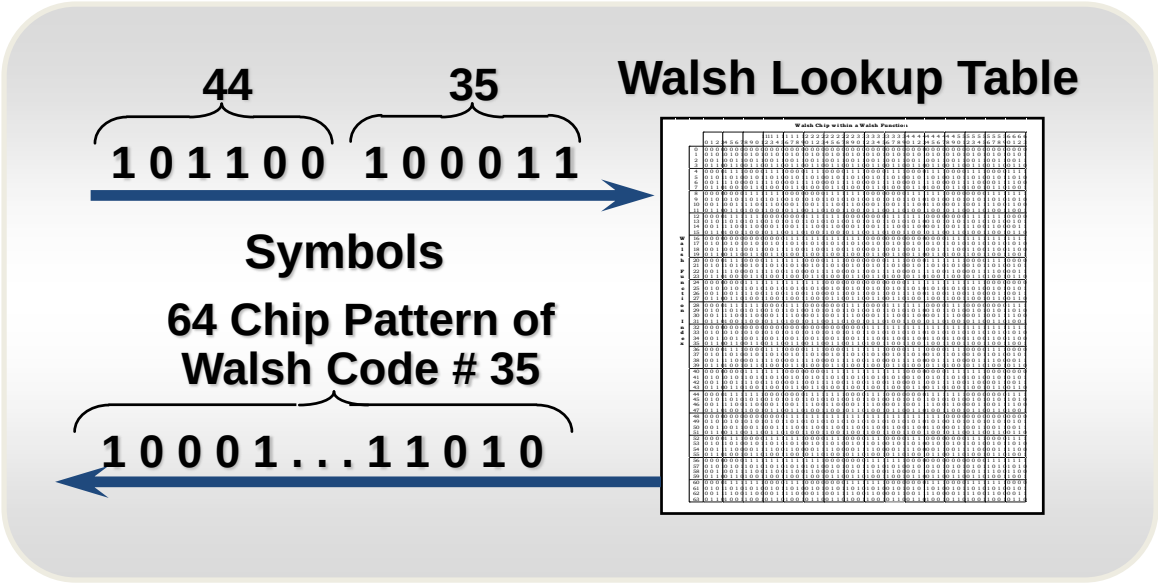

- Used by the mobile station to:
  - Initiate communication with the base station not yet in a Call (such as transmit registration requests, call setup requests/origination message )
  - Respond to Paging Channel messages
- Has a fixed data rate of 4800 bps
- Although a sector can have up to seven paging channels, and each paging channel can have up to 32 access channels, nearly all systems today use only one paging channel per sector and only one access channel per paging channel.

# Access Channel Generation




- Message attempts are randomized to reduce probability of collision
- Two message types:
  - A response message (in response to a base station message)
  - A request message (sent autonomously by the mobile station)

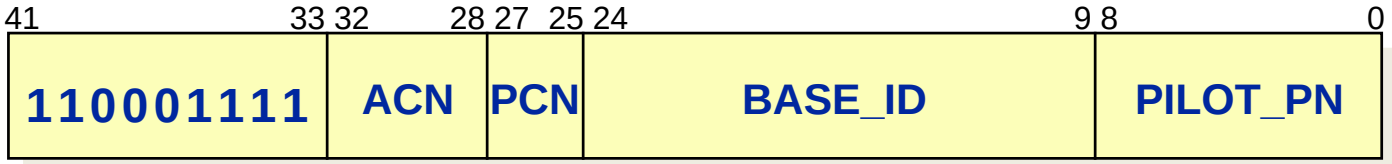
# 64-ary Orthogonal Modulation




- Out of the block interleaver,the data rate is 28800bps,for every six symbols input,one Walsh code is output
  - Six code symbols are converted to a decimal number from 0~63
  - This number is used as an index into a Walsh lookup talbe
  - The 64 Walsh chips corresponding to that index are output
  - after orthogonal modulation,the symbol rate is 28800/6 ×64＝307.2kbps.

# Access Channel Long Code Mask

**An Access Channel is scrambled by the long code, offset by a mask constructed as follows:**




*Where:*

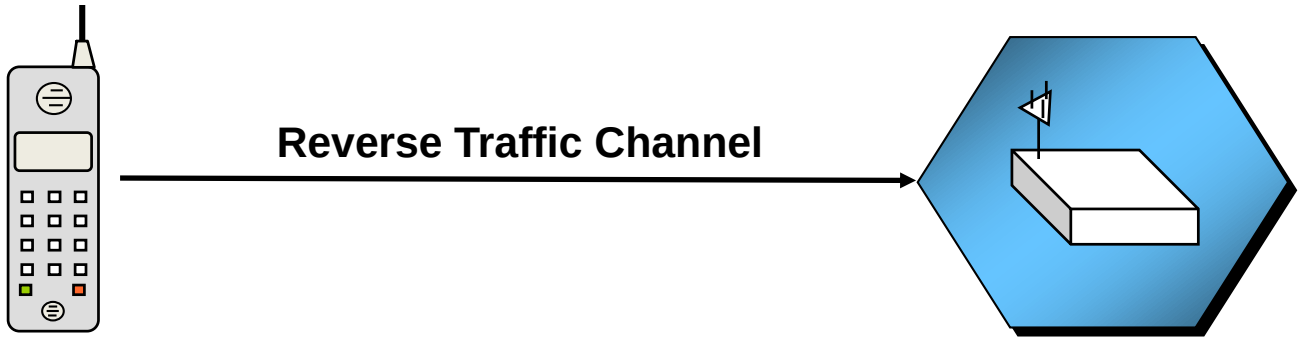
*ACN is the Access Channel Number,*

*PCN is the Number of the associated Paging Channel*

*BASE_ID is the base station identification number, and*

*PILOT_PN is the Pilot short PN code offset index*

# Reverse Traffic Channels

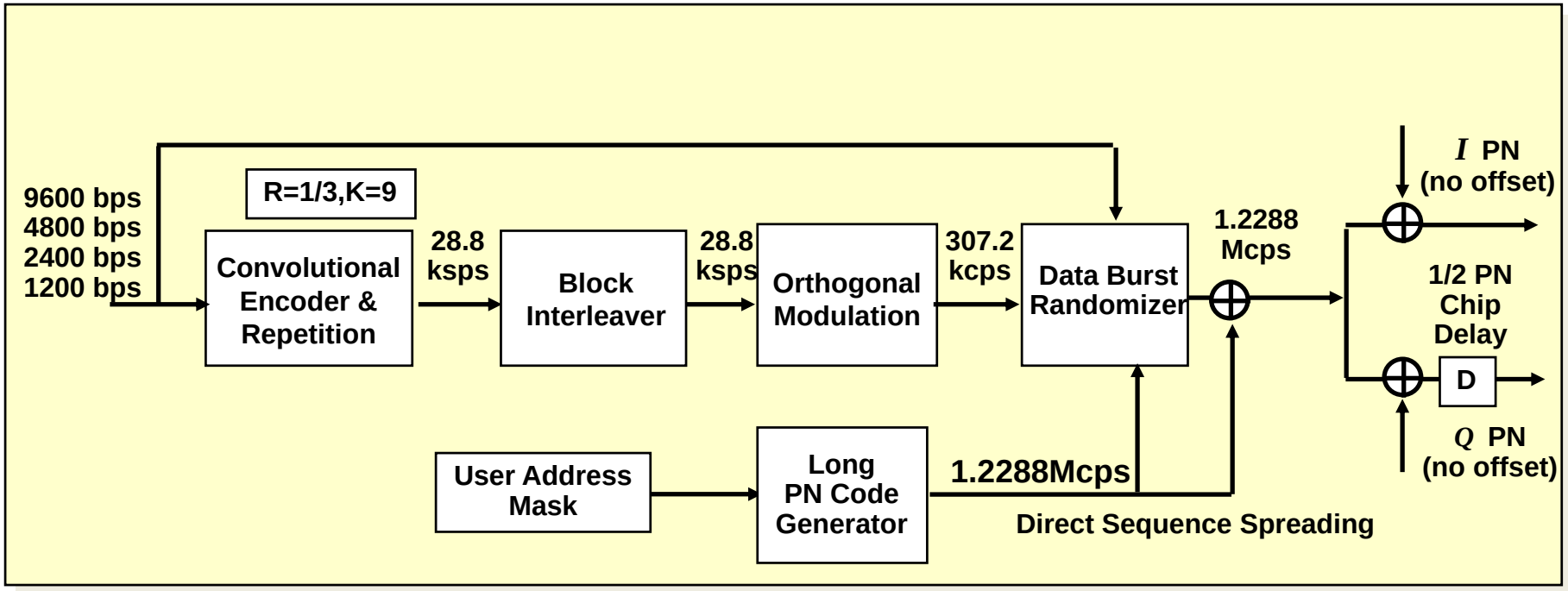



- Used when a call is in progress to send:
  - Voice traffic from the subscriber
  - Response to commands/queries from the base station
  - Requests to the base station
- Supports variable data rate operation for:
  - A mobile station using the 8kb vocoder transmits information on the reverse traffic channel at variable data rates

    Rate Set 1 - 9600, 4800, 2400 and 1200 bps
  - 13 Kbps vocoder

    Rate Set 2 - 14400, 7200, 3600, 1800 bps

# Reverse Traffic Channel Generation



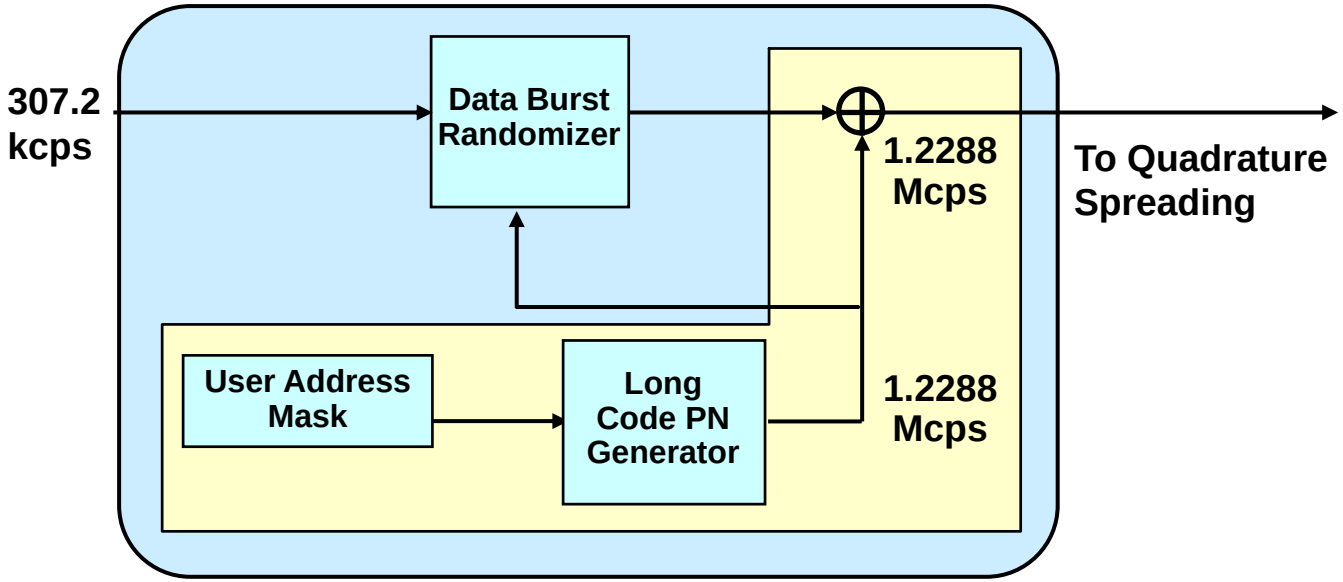

- Uses Rate 1/3 Convolutional Encoder
- Uses 32*18 block interleaving array
- 64-ary Orthogonal Modulation
- Data burst randomizing

# Data Burst Randomizing

- Reapted symbols are deleted
  - Output stream of interleaver is gated with a time filter,During "gate-off"periods,transmit power is reduced
  - Gate cycle varies with the transmit data rate

- Randomizing transmitted data provides the effect of dispersing in time the power received at the cell site from the mobile stations
  - Easier de-spreading can occur when fewer interfering signals are present

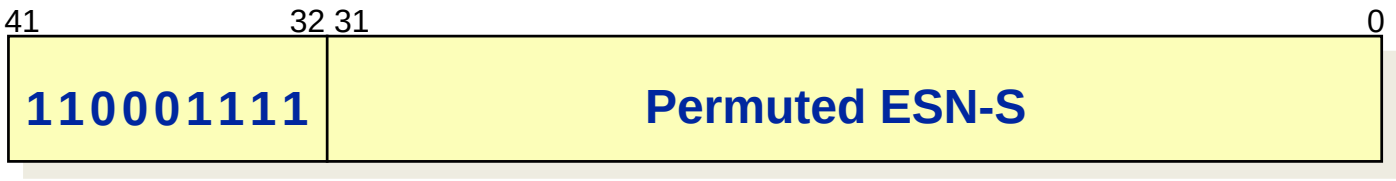
# Direct Sequence Spreading




- Output of the randomizer is direct sequence spread by the long code
- Each mobile station spreads its reverse traffic channel using the same long PN code but with a different offset,which is determined by a unique 42-bit mask.
- The mobile station can use one of two unique long code masks:
  - A public long code mask based on the ESN
  - A private long code mask

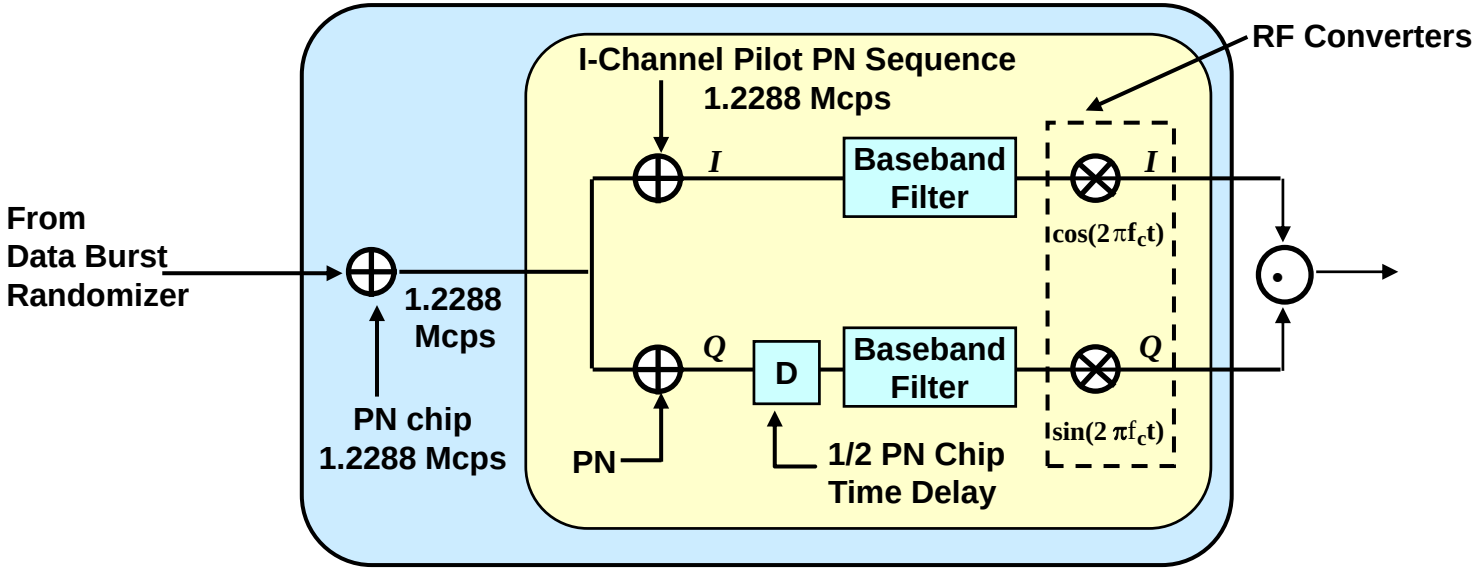
# Reverse Traffic Channel Long Code Mask

**A Reverse Traffic Channel can be spread using the "public long code mask"which is constructed as follows:**




*The other option is to use a "private long code mask" based on the current contents of the 128-bit Shared Secret Data register.*

# OQPSK & Baseband Filtering




- The channel is spread by a pilot PN sequence with a zero offset
- Baseband filtering ensures that the waveform is contained within the required frequency limits
- Baseband signals converted to radio frequency (RF) in the 800 MHz or 1900 MHz range

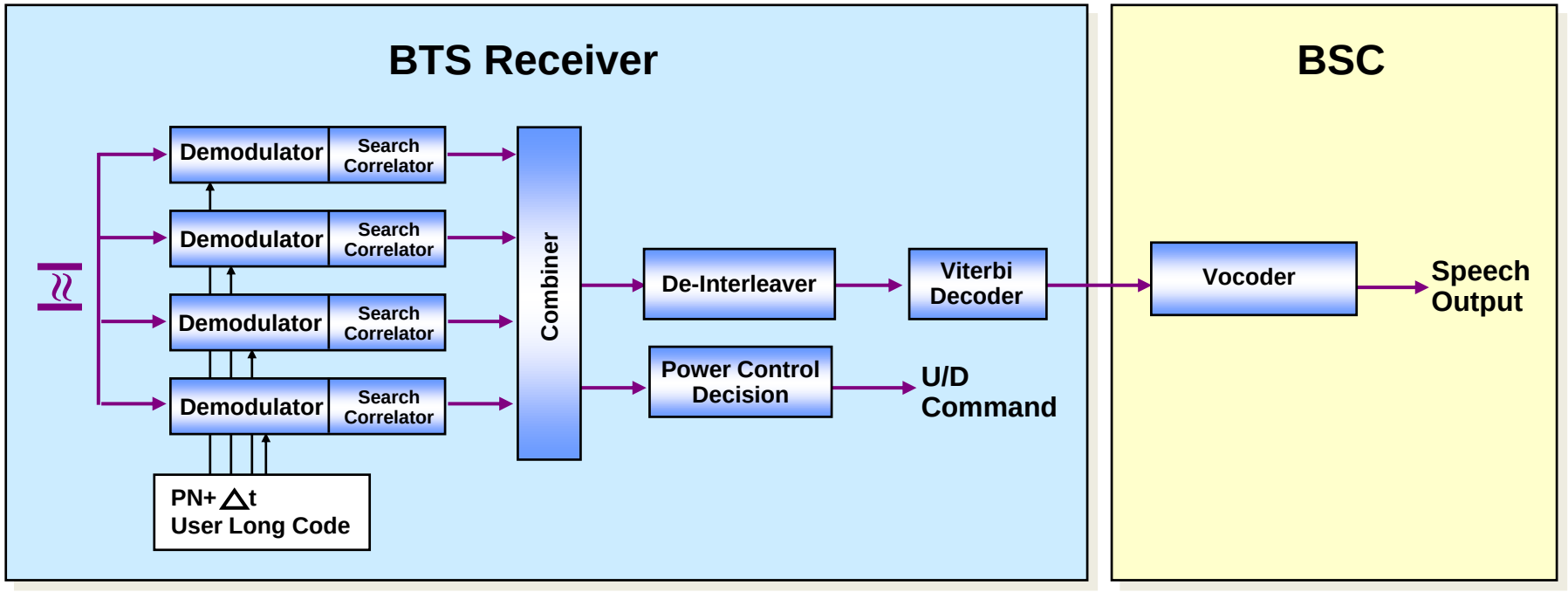
# OQPSK

The reverse traffic channel data after direct sequence spreading is spread in quadrature by adding modulo-2.This stream with the zero-offset I and Q PN short code sequences is used on the forward CDMA channel.

Why a half chip delay in the Q Component?

The data spread by the Q PN short code sequence is delayed by half a PN chip time,406.901ns,with respect to the data spread by the I PN short code sequence. This prevents the I and Q to change value simultaneously,thus eliminating diagonal transitions

# Reverse Channel Demodulation




- IS-95A/J-STD-008 requires a process that is complementary to the mobile station modulation process
- CDMA processing benefits from multipath components
  - Signals from several receive elements can be combined to improve receive signal quality

# Summary(1)

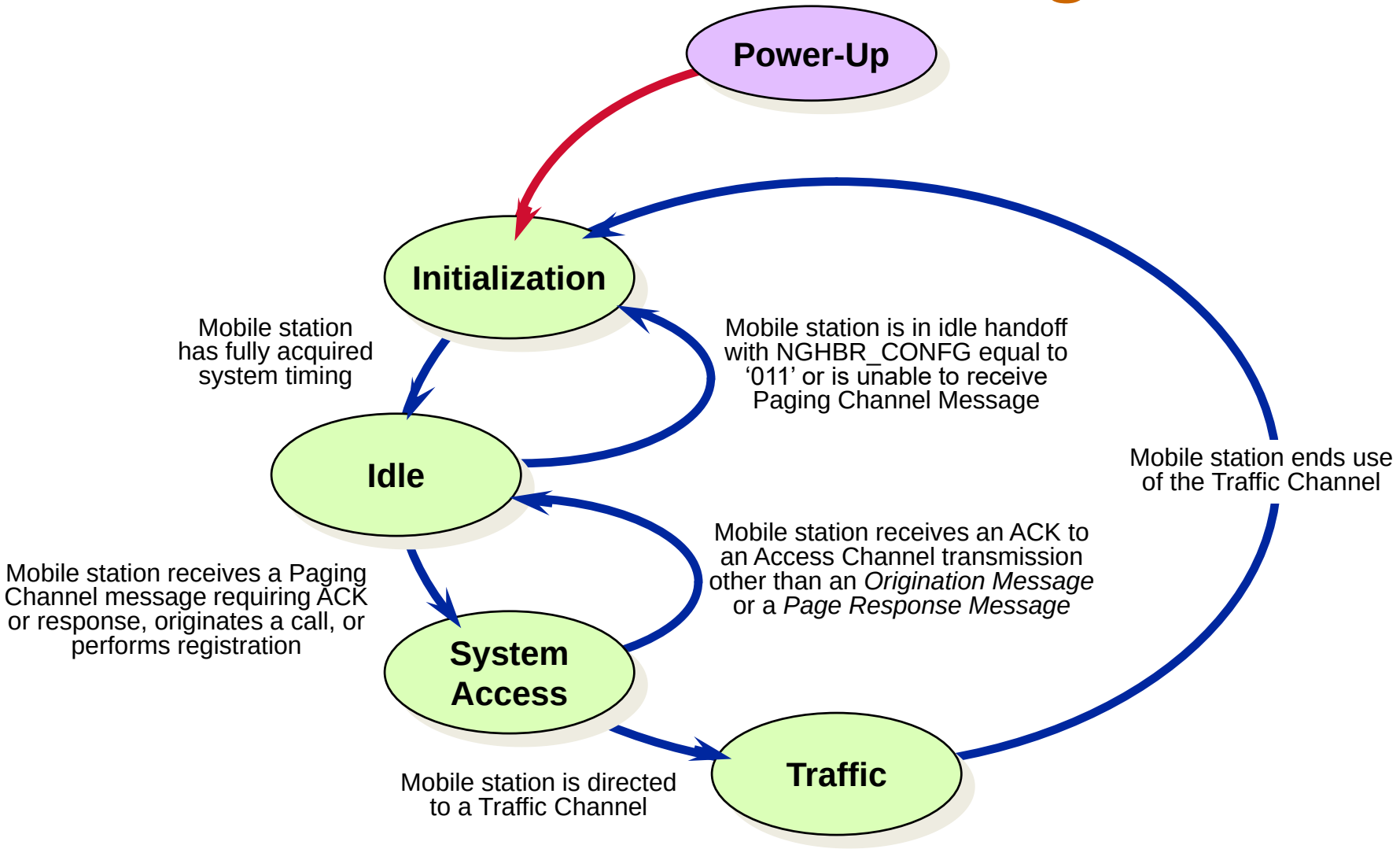
| Code sequence | Length | Application | | Purpose | Code rate |
|---|---|---|---|---|---|
| Long PN | $2^{42} - 1$ | Reverse | Access channel<br>traffic channel | Direct sequence ss<br>MS identification | 1.2288Mcps |
| | | Forward | Paging channel<br>traffic channel | Data scramble | 19.2Kbps |
| Short PN | $2^{15}$ | All Reverse channel | | Orthogonal spread frequency for modulation | 1.2288Mcps |
| | | All Forward channel | | Base station identification | |
| Walsh code | 64 | All Reverse channel | | orthogonal modulation | 307.2Kbps |
| | | All Forward channel | | Orthogonal spread frequency,forward channel identification | 1.2288Mcps |

# Mobile Station Call Processing States

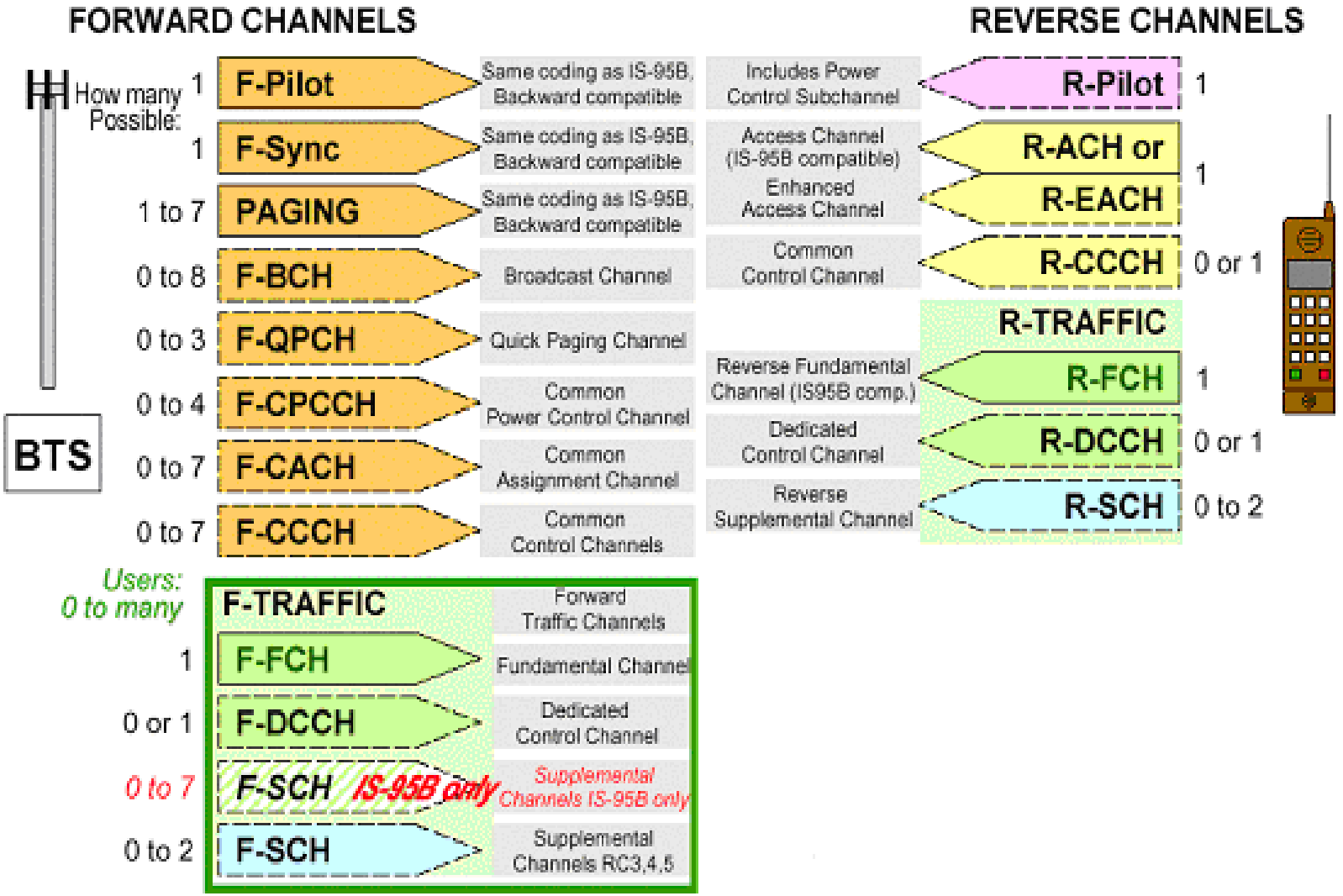
During call processing,many messages flow between the mobile and the base station.The mobile station may be in any of the following states:

- **Mobile Station Initialization State**:Pilot Channel acquisition,sync short PN code.Receive Sync channel Message,obtains LC_STATE, SYS_TIME，PRAT system information,implement long PN code sync
- **Mobile Station Idle State**:MS monitors messages on the paging channel to receive configuration parameters from base station
- **System Access State**:MS sends message to the BS on the access channel
- **Mobile Station Control on the traffic channel State**:MS communicates with the base station using the forward and reverse traffic channel

# CDMA MA Call Processing



# Cdma2000 1xRTT Channel



# Spreading Rates & Radio Configurations

| Spreading Rate | Radio Configuration | Forward Link | Data Rates | Radio Configuration | Reverse Link | Data Rates |
|---|---|---|---|---|---|---|
| SR1 1xRTT 1 carrier 1.2288 MCPS | RC1 | Required. IS-95B Compatible No CDMA2000 coding features | 9600 | RC1 | Required. IS-95B Compatible No CDMA2000 coding features | 9600 |
| | RC2 | Compatible with IS-95B RS2 No CDMA2000 coding features | 14400 | RC2 | Compatible with IS-95B RS2 No CDMA2000 coding features | 14400 |
| | RC3 | Quarter-rate convolutional or Turbo Coding, base rate 9600 | 9600<br>153600 | RC3 | ¼ rate conv or Turbo coding<br>½ rate conv or Turbo coding<br>base rate 9600 | 9600<br>153600<br>307200 |
| | RC4 | Half-rate convolutional or Turbo Coding, base rate 9600 | 9600<br>307200 | | | |
| | RC5 | Quarter-rate convolutional or Turbo Coding, base rate 14400 | 14400<br>230400 | RC4 | ¼ rate convolutional or Turbo Coding, base rate 14400 | 14400<br>230400 |

# Spreading Rates & Radio Configurations

Spreading Rate

Identify the PN code rate which used for the Forward Link or Reverse Link

- ✓ SR1（”1x”，1.2288Mcps）
- ✓ SR3（”3x”，3.6864Mcps）

Radio Configure

Identify a serial working mode of Forward link or reverse link,each RC can support a set of data rate, the different of each RC is diversified parameters used in channel,such as SR and modulation performance

- Forward Link:RC1～RC5
- Reverse Link:RC1～RC4

# Channel List: 1xRTT vs. IS-95

- IS-95B built on the IS-95A channels, and introduced two new channels
  - Fundamental channel was the same as IS-9A traffic channel
  - Supplemental code channels assigned to support rates above 14.4Kbps
- IS-2000 1xRTT continue to build on the IS-95 channels
  - IS-95 channels continue to be supported in IS-2000 to support IS-95 mobiles

| | Forward | Reverse |
|---|---|---|
| **IS-95A** | **Pilot channel**<br>**Sync channel**<br>**Paging channel**<br>**Forward Traffic Channel** | <br><br>**Access channel**<br>**Reverse Traffic Channel** |
| **IS-95B** | **Fundamental channel**<br>**Supplemental Code channel (F-SCCH)** | **Fundamental channel**<br>**Supplemental Code channel (R-SCCH)** |
| **1xRTT** | **Supplemental channel (F-SCH)**<br>**Quick Paging channel (F-QPCH)** | **Supplemental channel (R-SCH)**<br>**Reverse Pilot channel (R-PICH)** |

# Additional Channel in 1X Commercial System

- Forward Quick Paging Channel(F-QPCH)
- Forward Supplemental Channel(F-SCH)
- Reverse Pilot Channel
- Reverse Supplement Channel(R-SCH)

# Paging Channel Modes

- Non-slotted Mode Operation
  - The mobile station continuously monitors the Paging Channel
  - Paging and control message can be received on any slot by MS
- Slotted Mode Operation
  - MS only operates in the slotted mode when it is in the “idle state”
  - A mobile station that monitors the paging channel only during certain assigned slots
  - The mobile station can “sleep”or reduce power consumption(for the power conservation) during non-active states(during the slots when the paging channel is not being monitored)

# F-QPCH Functions

- Base Station use F-QPCH's signaling to inform MS which is surrounding of its coverage and work in slotted mode and just in idle state.
- Mobile monitors QPCH to determine if there is a paging forthcoming on paging channel in its slot (looks at 1-bit paging indicator)
- If no flag, then mobile continues to sleep; if have flag, the mobile monitors appropriate slot and decodes general page message
- Without QPCH, mobile must monitor regular paging channel slot and decode several fields to determine whether page is for it or not; this drains mobile batteries quickly

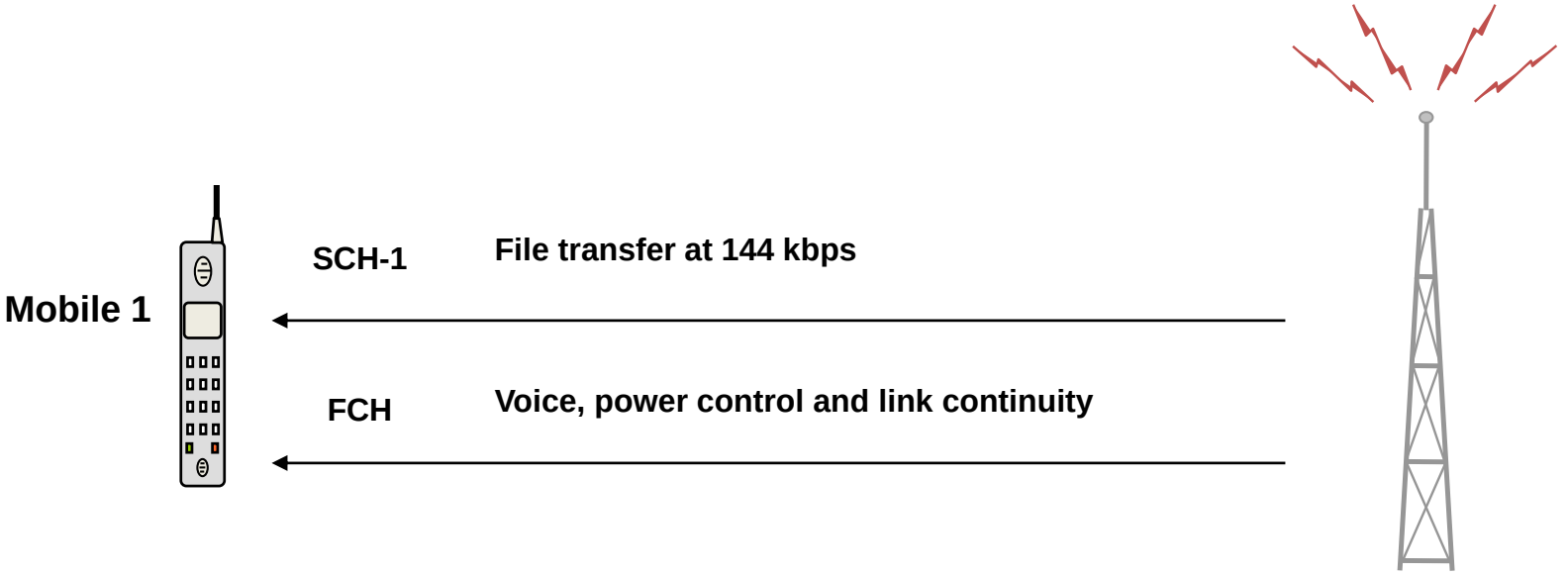
# F-QPCH Functions(Cont.)

- As long as there's no configuration change information for the mobile to capture, the mobile's only going to be monitoring 2 bits vs. an entire slot. This equates to up to 40% decrease in the amount of battery power used to monitor an IS-95 paging channel with slotted paging implemented.

**The main purpose of QPCH is to save mobile battery life.**

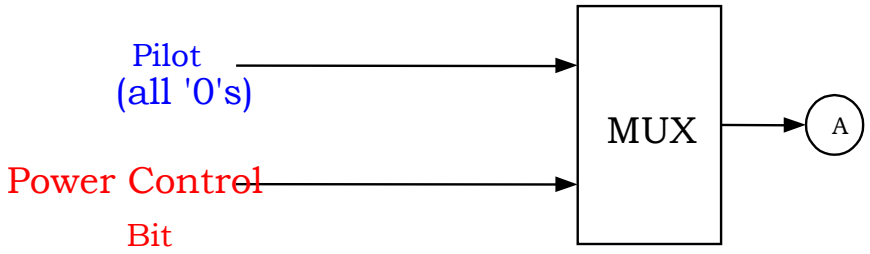
# Forward Supplemental Channel (F-SCH)

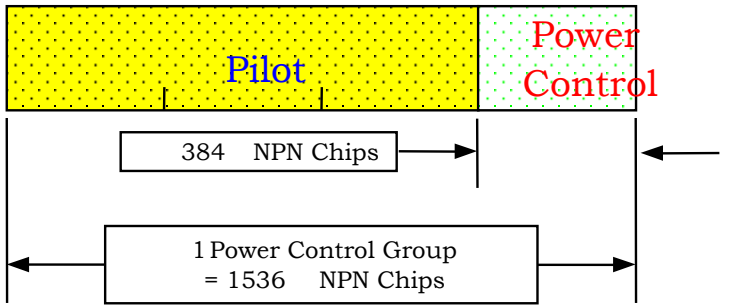
- Assigned for high-speed packet data (>9.6 kbps) in the forward direction;  (FCH is always assigned to each call)
- Up to 2 F-SCH can be assigned to a single mobile
  - SCH cannot exist without having a fundamental channel established



# Reverse Pilot Channel (R-PICH)

- Implement Quick Power Control on the Forward Link
- Allows base station to do timing corrections without having to guess where mobile is (in search window)
- Mobile can transmit at lower power, reducing interference to others
- The Reverse Pilot Channel is an unmodulated spread spectrum signal used to assist the base station in detecting a mobile station transmission.




N is the Spreading Rate number

# Reverse Supplemental Channel (R-SCH)

- Used for high-speed packet data (>9.6 kbps)
- Difference between F-SCH and R-SCH is in Walsh code based spreading
  - F-SCH supports Walsh code lengths of 4 to 128 (1xRTT) or 1024 (3xRTT) depending on data rate and chip rate
  - R-SCH uses either a 2-digit or 4-digit Walsh code; rate matching done by repetition of encoded and interleaved symbols
    - Walsh code allocation sequence is pre-determined and common to all mobiles
    - Users are differentiated using long PN code with user mask

# Benefits of the CDMA2000 1x

- Increased MS standby battery life (via Quick Paging Channel)
- Use Forward Quick Power Control(via Reverse Pilot channel)
- Total backward compatibility to reuse switch and call processing features
- 2-3 dB better coverage
- Provides High speed 153.6 kbps packet data capabilities

# Why Power Control

- CDMA is an interference-limited system based on the number of users, the interference comes mainly from nearby users
  - each user is a noise source on the shared channel,this creates a practical limit to how many users a system will sustain,so CDMA also called soft capacity limit
- The goal is to keep each MS at the absolute minimum power level necessary to ensure acceptable service quality
  - Ideally the power received at the base station from each mobile station should be the same(minimum signal to interference)
  - MS which transmit excessive power increase interference to other Mobile station

# Power Control Types

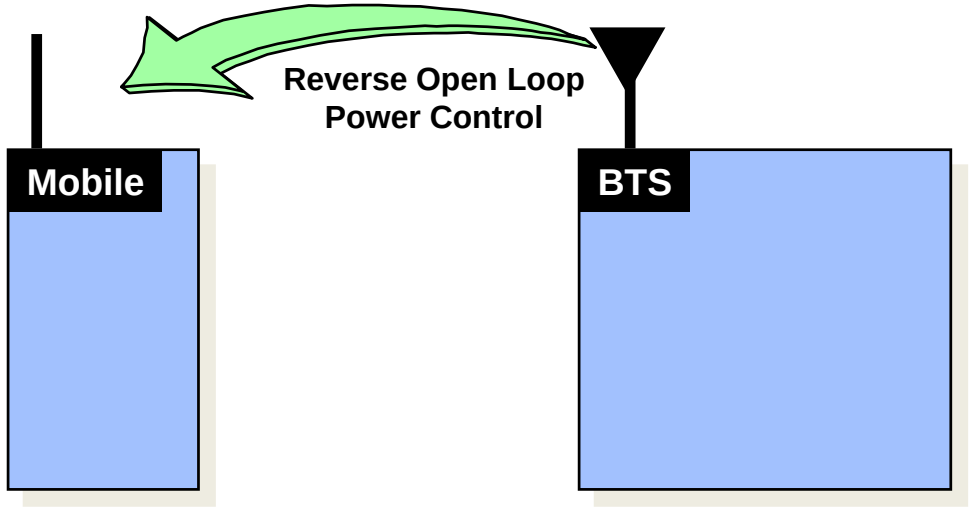
## Reverse Power Control

- Open-loop Power Control
- Closed-loop Power Control (Forward traffic Channel)
  - ✓Outer-loop Power Control
  - ✓Inner-loop Power Control

## Forward Power Control

- IS-95 Power Control
- IS-2000 Fast Power Control (Reverse Pilot Channel)
  - ✓Outer-loop Power Control
  - ✓Inner-loop Power Control

# Reverse Open-loop Power Control

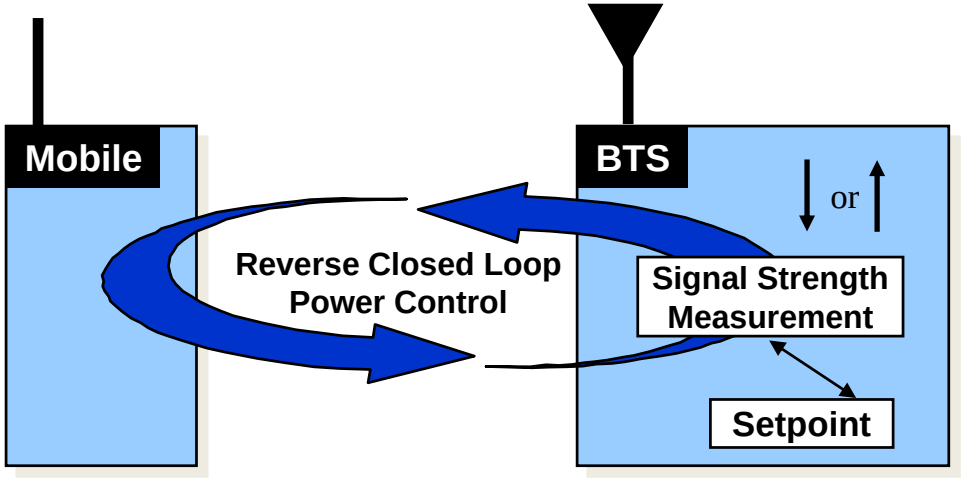



- Reverse open loop power is mobile station controlling its transmit power
- Reverse open loop power control consists of :
  - estimating how strong the mobile station should transmit based on a coarse measurement of how much power it is receiving from the base station
  - some correcting parameters delivered in the access parameters message
- The Reverse open loop method of power control provides a quick response to changes in signal conditions.

# Reverse Open-loop Power Control

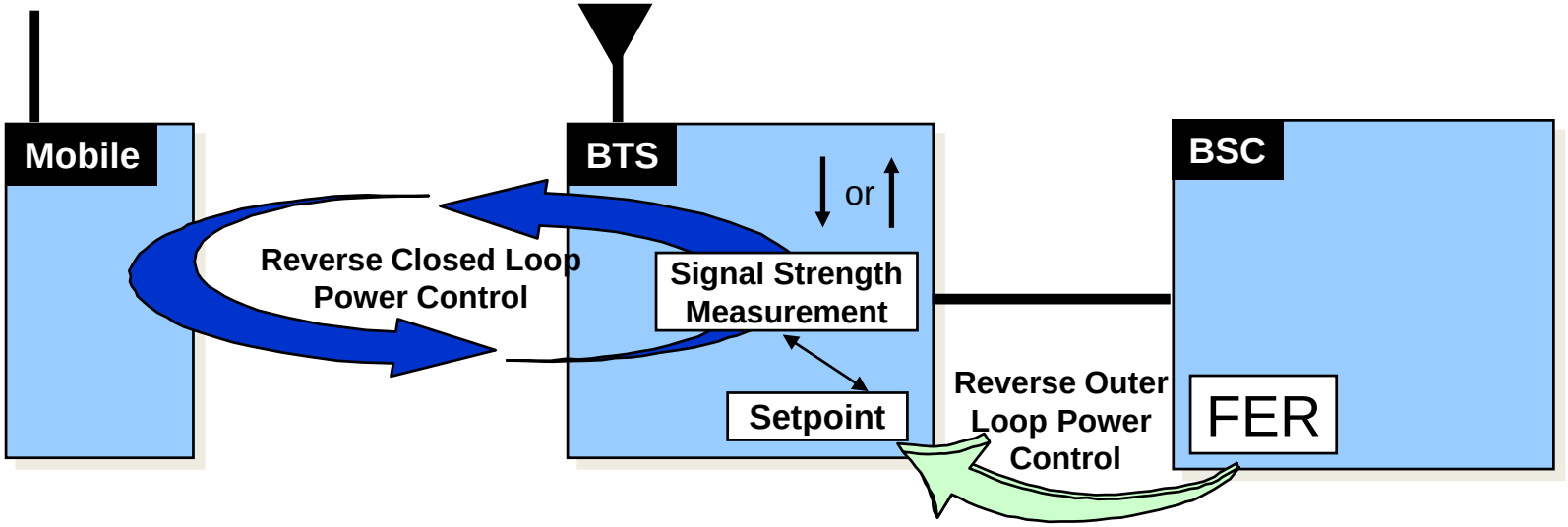
- Problems with Reverse Open Loop Power Control
  - Assumes same exact path loss in both directions; therefore, cannot account for asymmetrical path loss
  - Estimates are based on total power received; therefore the power received from other cell sites by mobile station introduces inaccuracies

# Reverse Closed Loop Power Control




- Compensates for asymmetries between the forward and reverse paths
- Consists of power up (0) & power down (1) commands sent to the mobile stations, based upon their signal strength measured at the Base Station and compared to a specified threshold(setpoint)
- Each command requests a 1dB increase or decrease of the mobile station transmit power
- Transmitted 800 times per second, always at full power
- Allows to compensate for the effects of fast fading

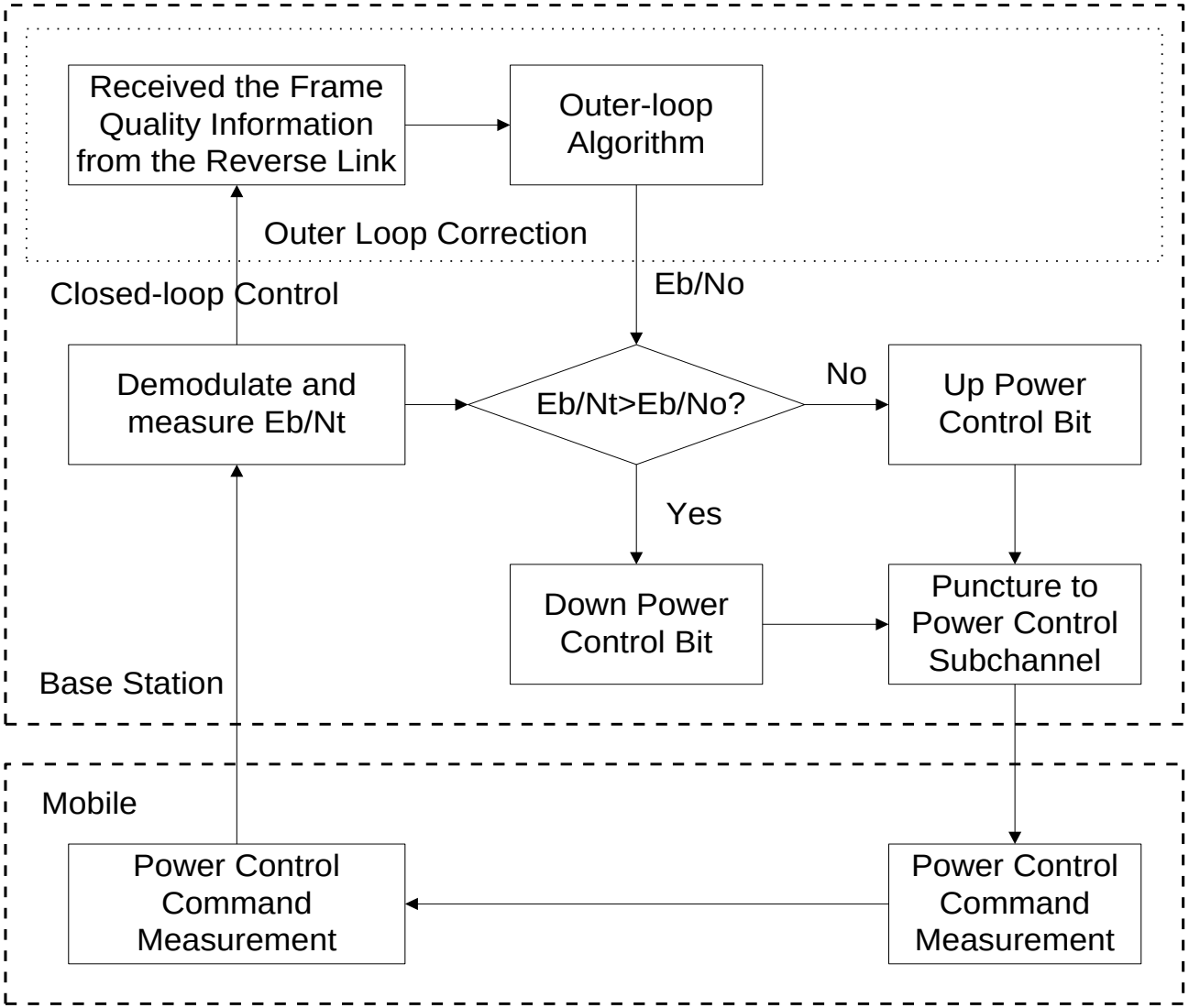
# Reverse Outer Loop Power Control




- Most gradual form of reverse link power control
  - Setpoint is varied/dynamic according to the FER on the Reverse Traffic Channel (determined at the Base Station Controller)
  - Sampled at a rate of 50 frames per second (20 ms / frame)
  - Setpoint adjusted every 1-2 seconds

- The goal of outer loop power control is adjusting the setpoint(Eb/No) based on the reverse traffic channel FER value
  - If the received power from the mobile station,as measured at the base station,is below the specified S/N threshold(setpoint),the base station sends a “0”power control bit directing the MS to raise its output power;if it is higher,it sends a “1” power control bit directing the mobile station to lower its output power
  - The setpoint itself is raised or lowered by the reverse outer loop power control to guarantee the desired frame error rate(FER) level,typically 1%
- Output power control bit is transmitted on the power control subchannel in forward traffic channel

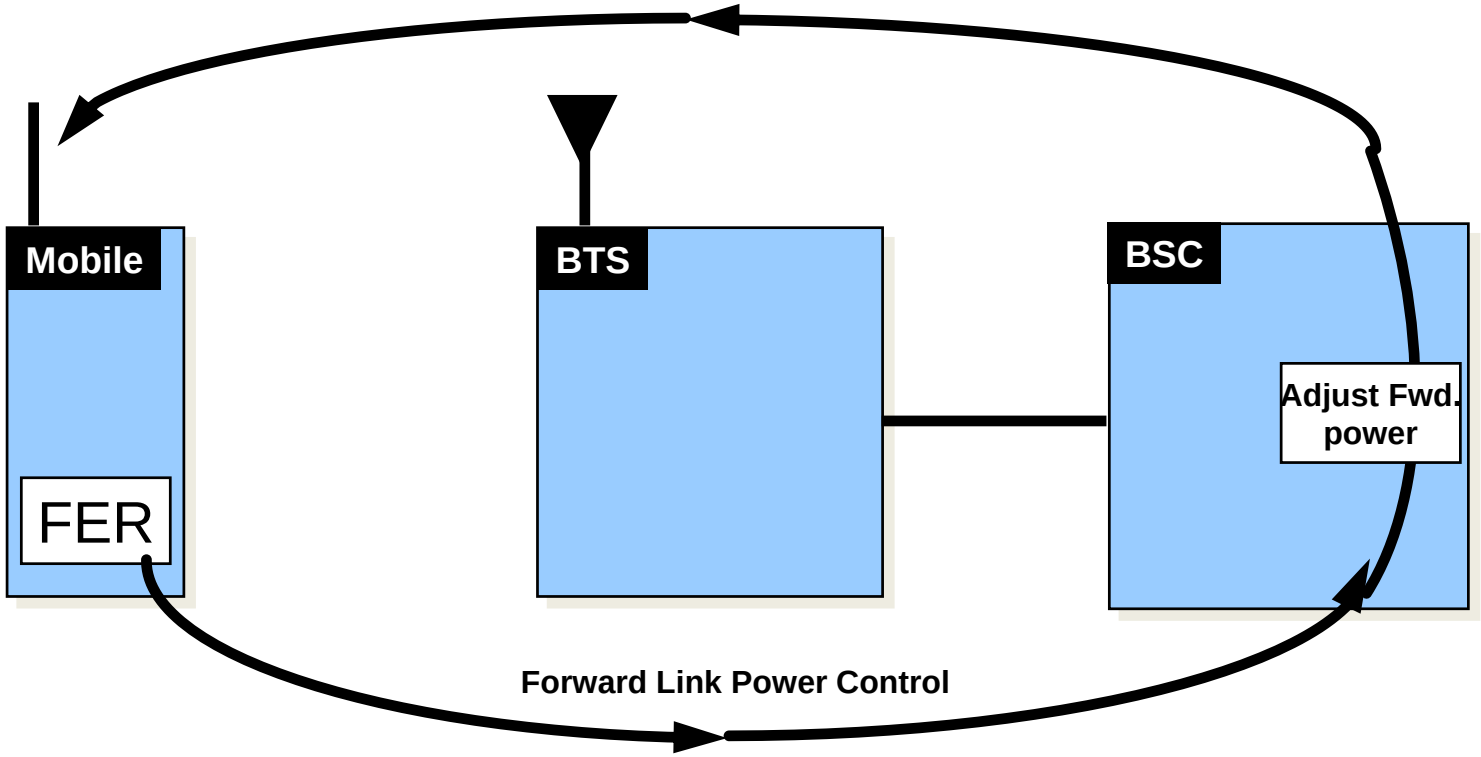
# Closed-loop Power Control Procedure



# Reverse Power Contro

- The open loop power control is implemented in mobile station
- The outer loop power control algorithm is implemented in SVE module of BSC, the output Eb/No is sent to Channel Card
- The closed loop power control algorithm is implemented in Channel Card, the output power control command is punctured in the forward Fundamental Channel (traffic channel).

# Forward Power Control in IS-95



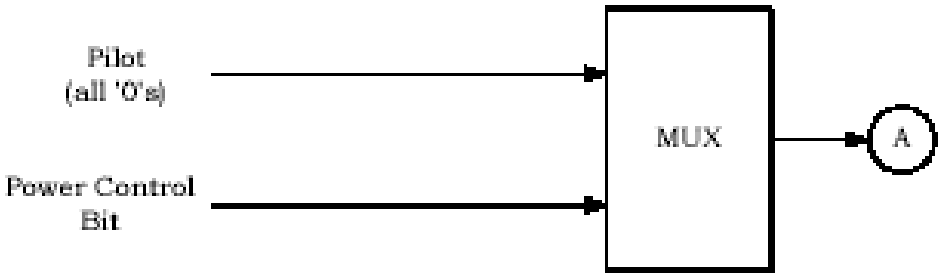

- The base station continually and slowly decreases power to each mobile station(each user's forward traffic channel)
- As the FER (determined at the mobile station) increases, the mobile station requests a Forward Traffic Channel power increase

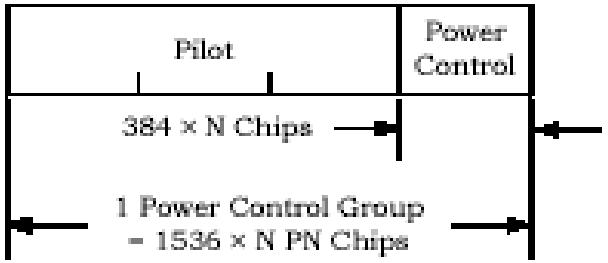
# Forward Power Control in IS-95(Cont.)

- The power control frequency is maximum 50Hz
- Power Control based on Messages for Radio Configuration 1
- Power Control based on EIB for Radio Configuration 2

# Forward Quick Power Control in IS-2000

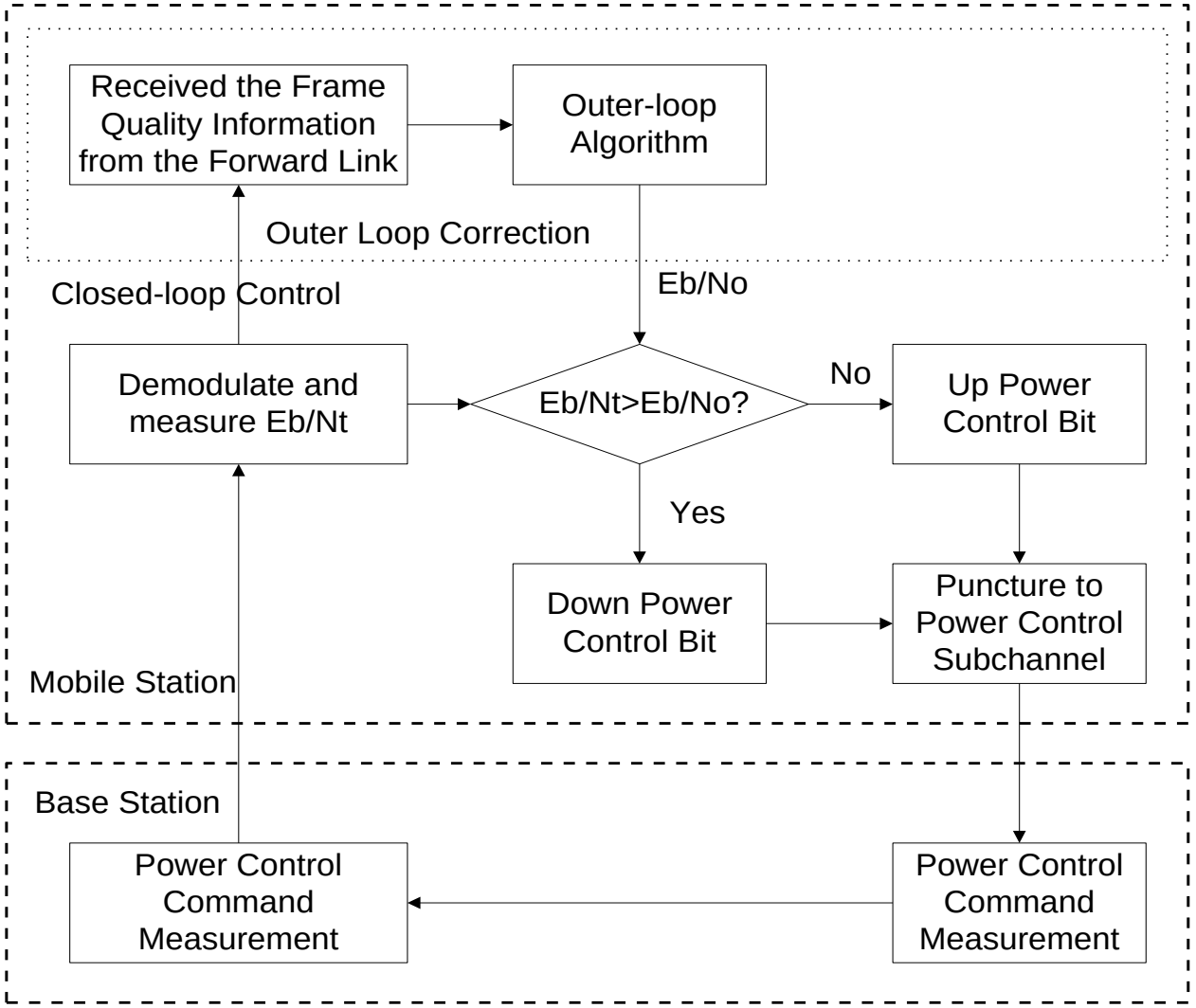
- In CDMA2000, there is a fast method used for Forward Pov Control operating much like tl 95 Reverse Link Power contr described next
- In order to implement Forwar Link Quick Power Control,we Reverse Pilot channel which includes power control subch



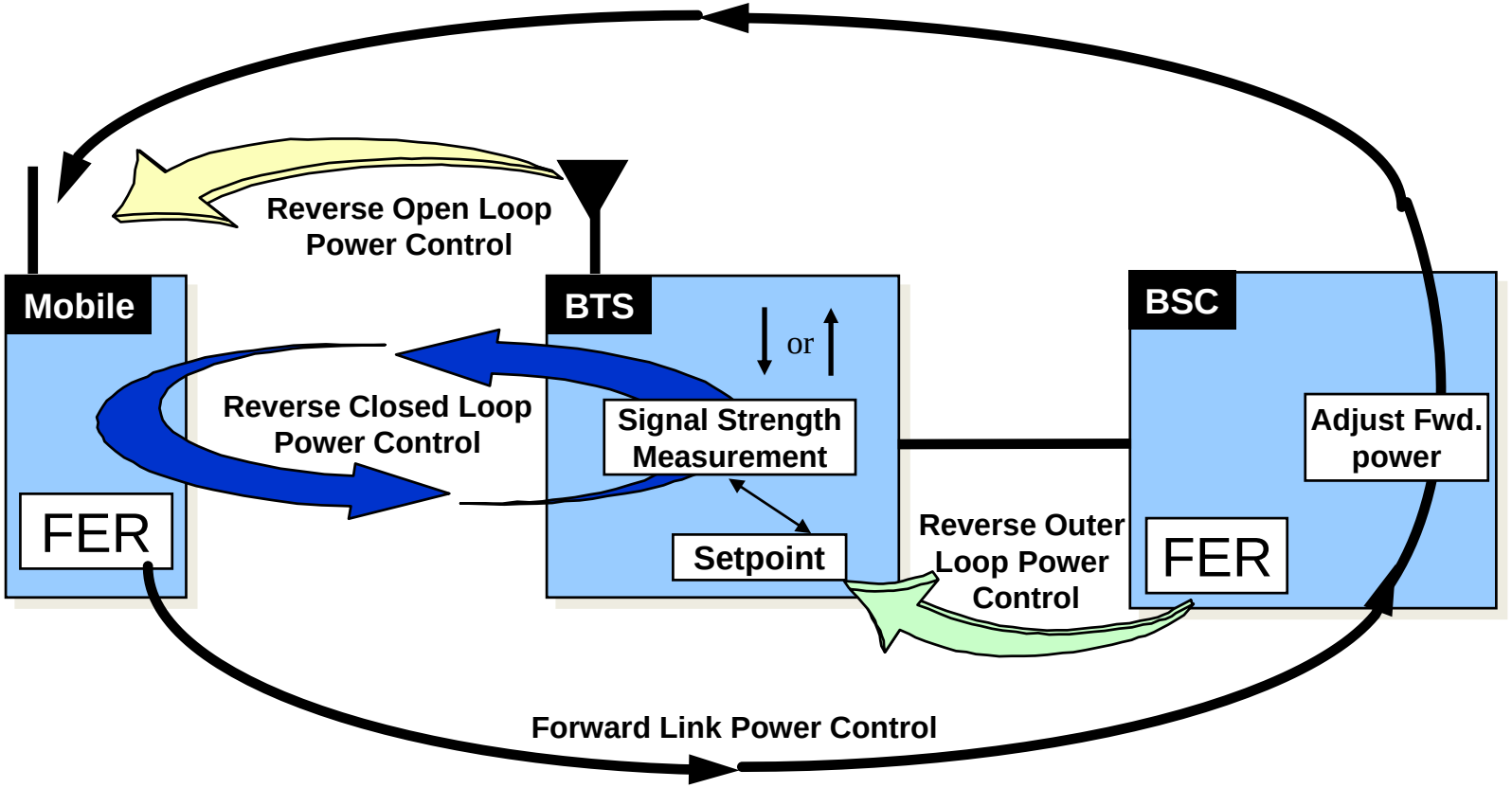




N is the Spreading Rate number

# Forward Quick Power Control



# Summary of Power Control

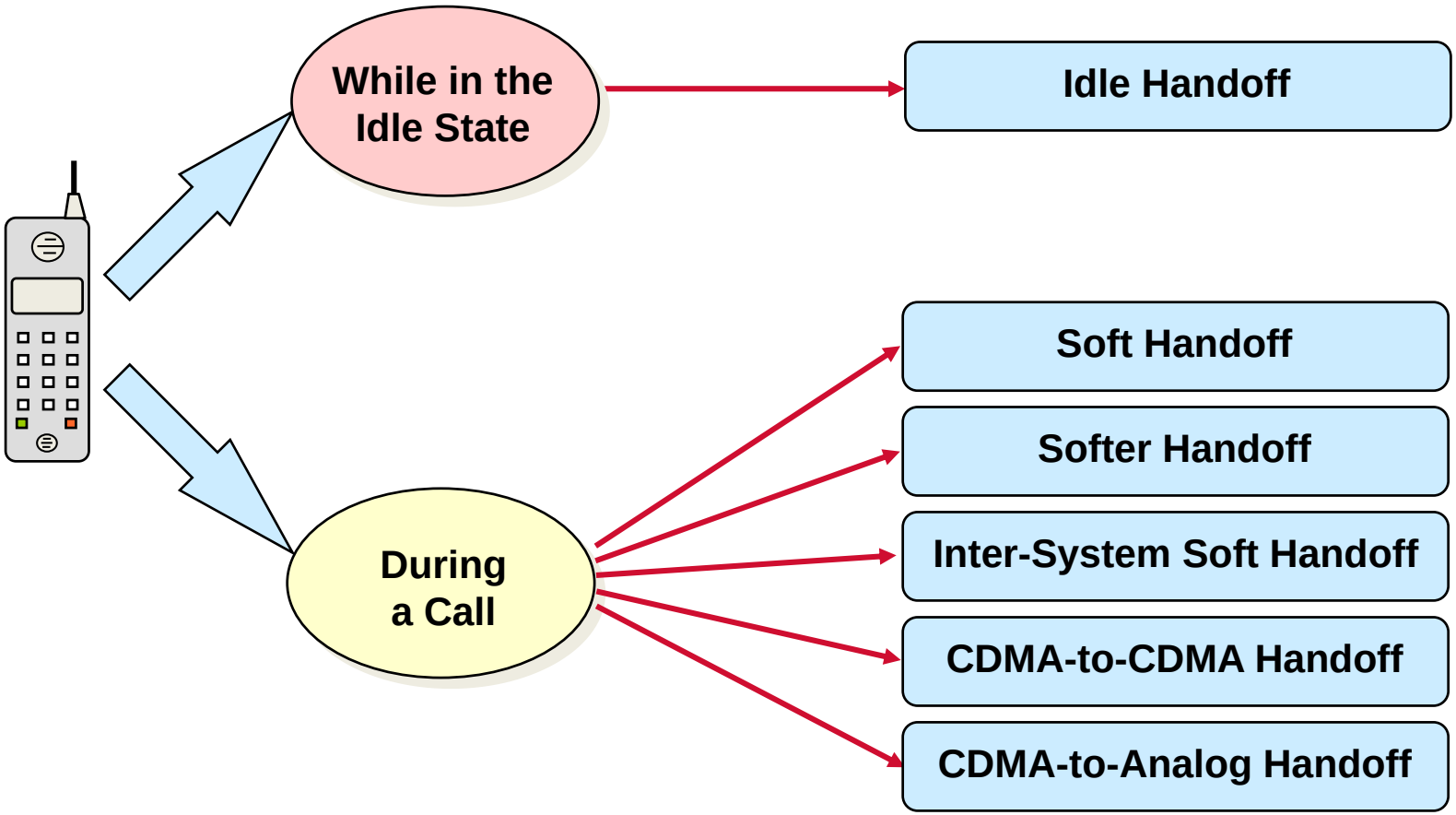



- All types of power control work together to minimizes power consumption at the mobile stations, and increases the overall capacity of the system transmit power.

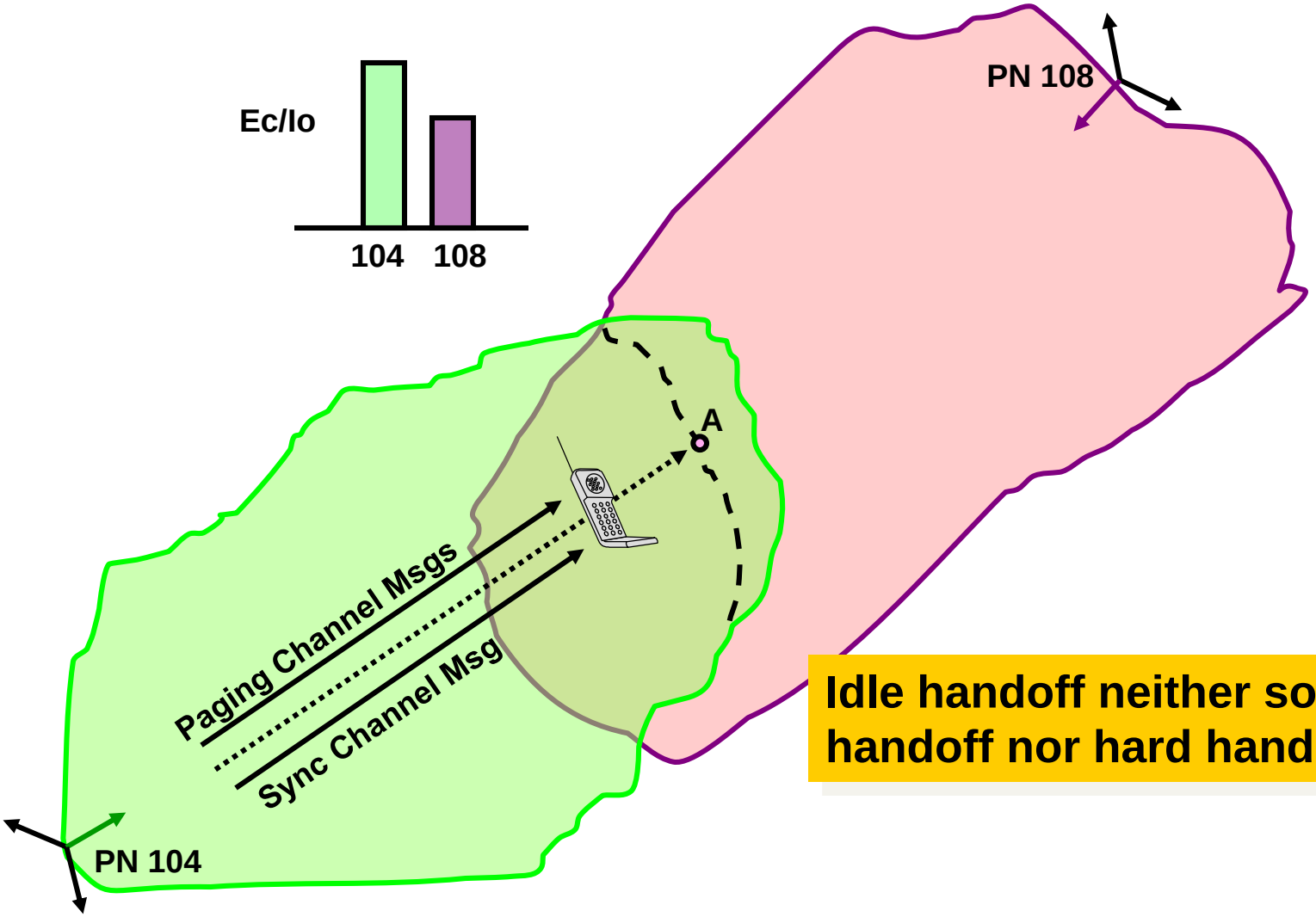
# Handoff

- Handoff is the process by which a mobile station maintains communications with the Mobile Telephone Switching center(MSC), when traveling from the coverage area of one base station to that of another
- Handoff keep the call established during the following conditions:
  - Subscriber crosses the boundaries of a cell
  - Subscriber experiences noise or other interference above a specified threshold
  - A base station component experiences an out-of-service condition during a call

# CDMA Handoffs

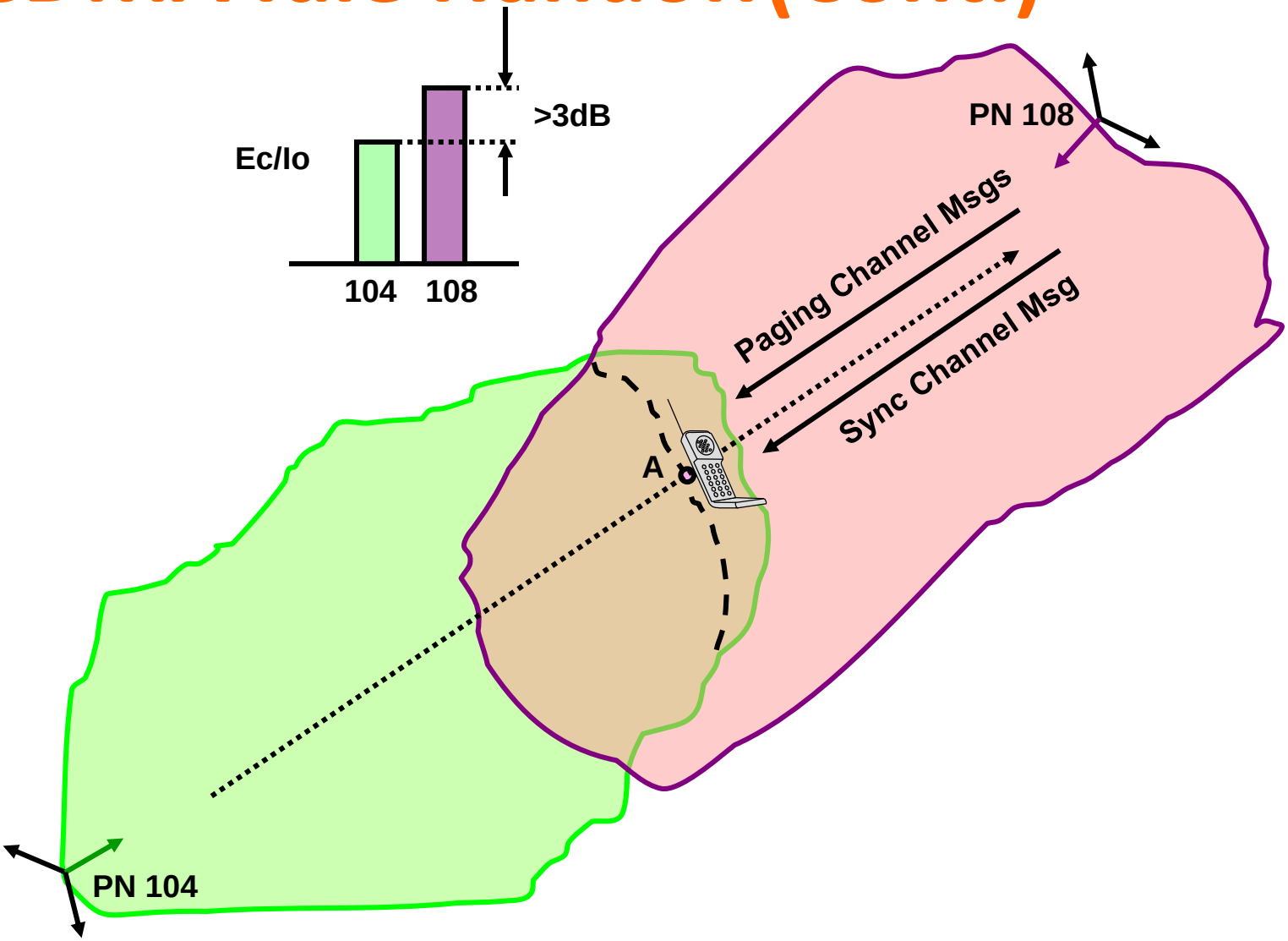


# CDMA Idle Handoff

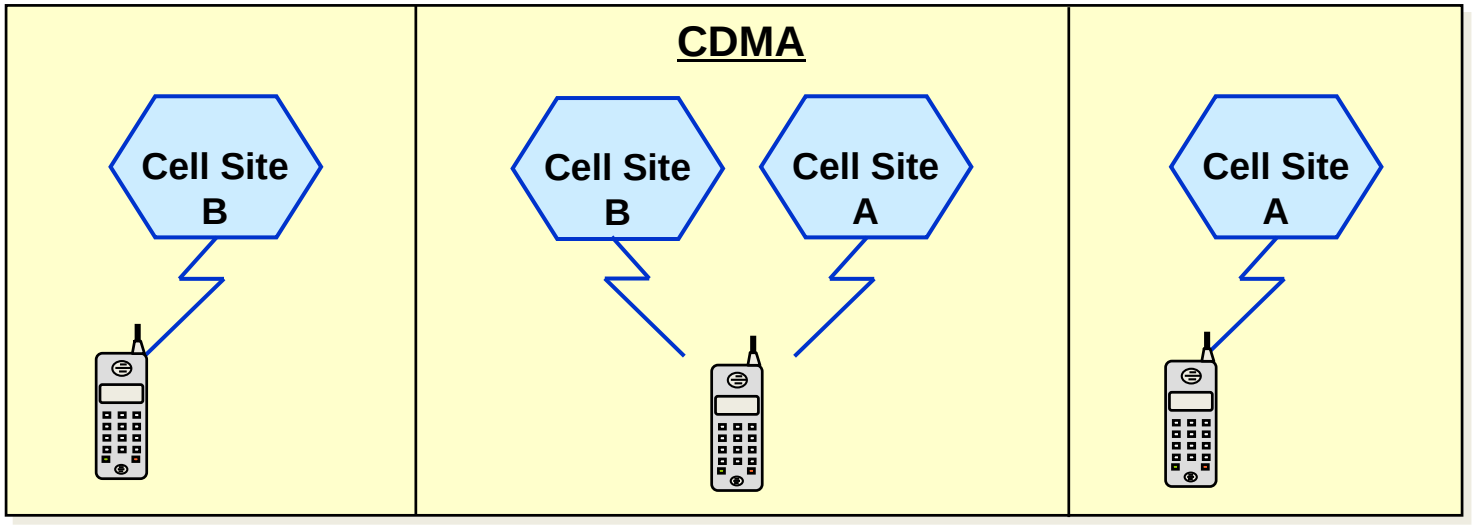



**Idle handoff neither soft handoff nor hard handoff.**

# CDMA Idle Handoff(Cont.)

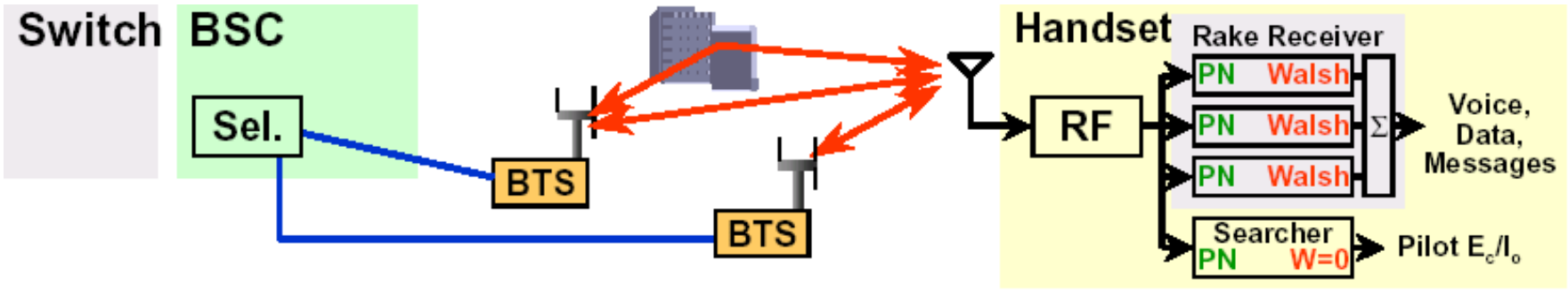


# CDMA Soft Handoff



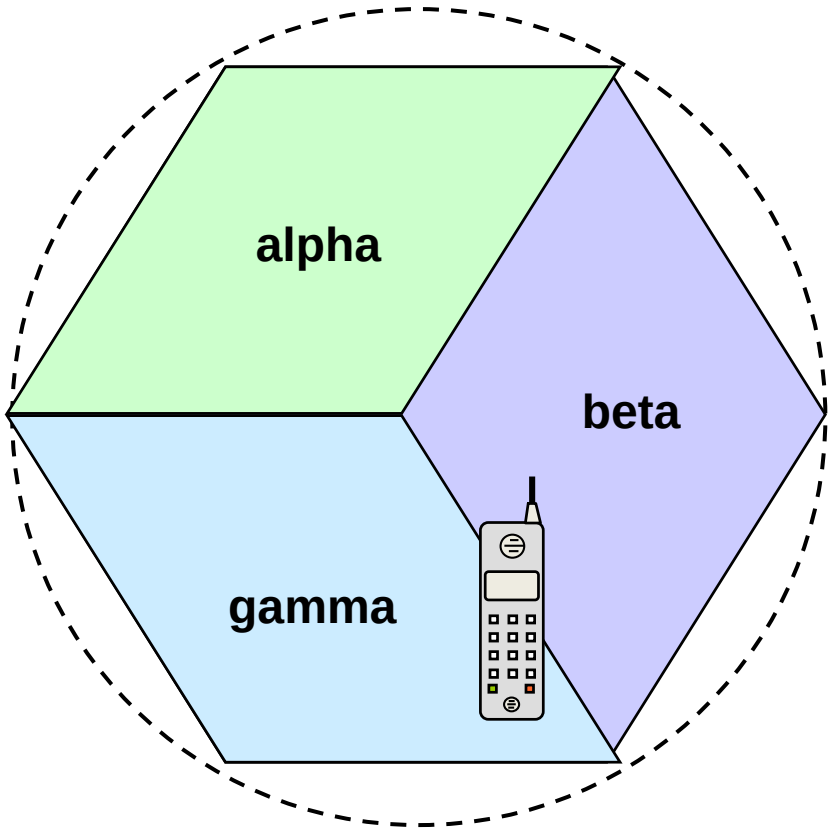

- Soft Handoff:The mobile station starts communications with a target base station without interrupting communications with the current serving base station
  - Make-before-break
  - Directed by the mobile not the base station,Undetectable by user
  - Improves call quality
- Can involve up to three cells simultaneously and use all signals
  - Mobile station combines the frames from each cell

# CDMA Soft Handoff Mechanics



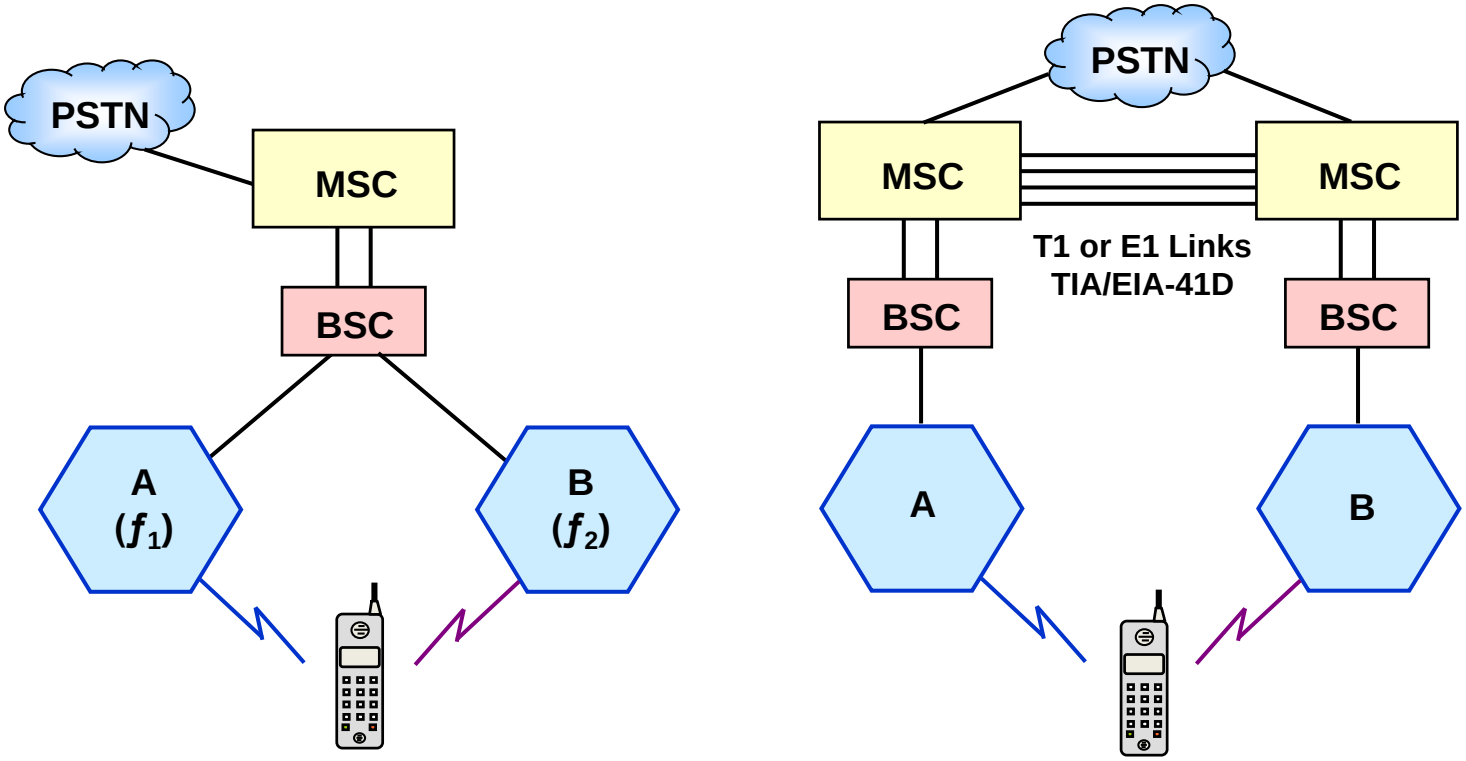

- CDMA soft handoff is driven by the handset
  - Handset continuously checks available pilots
  - Handset tells system pilots it currently sees
  - System assigns sectors (up to 6 max.), tells handset
  - Handset assigns its fingers accordingly
- Each end of the link chooses what works best, on a frame-by-frame basis
  - Users are totally unaware of handoff

# CDMA Softer Handoff




- Softer Handoff is between sectors of the same cell,that means multiple sectors of one BTS simultaneously serve a handset
- Softer handoff occurs in BTS in a single channel element
- Communications are maintained across both sectors until the mobile station transition has completed
- MSC is aware but does not participate
- All activities are managed by the cell site
- Signals received at both sectors can be combined for improved quality

# CDMA-to-CDMA Hard Handoff

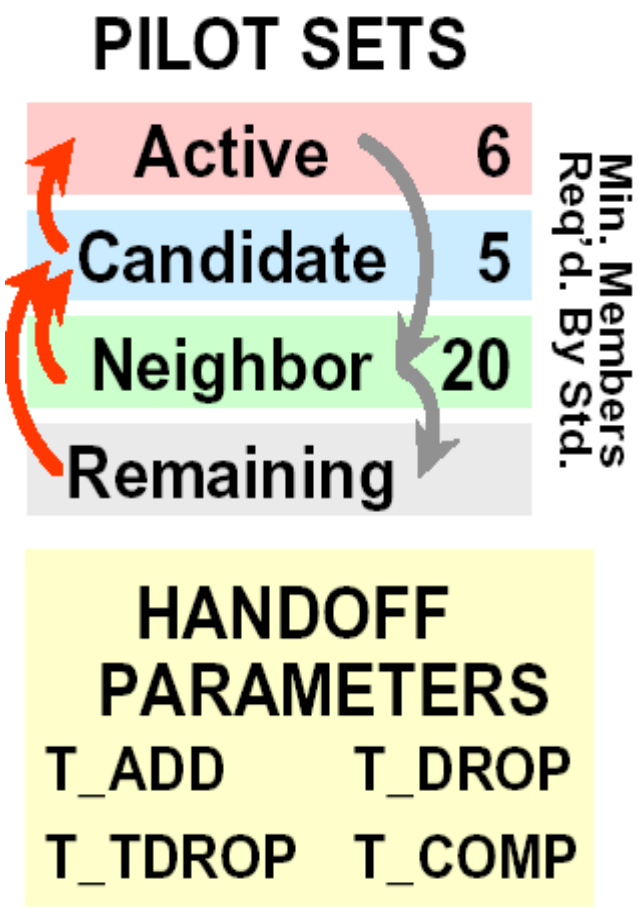



- Between cells operating on different frequencies
- Between cells that could be on the same frequency, but which are subordinated to different MSC

# Pilot Sets

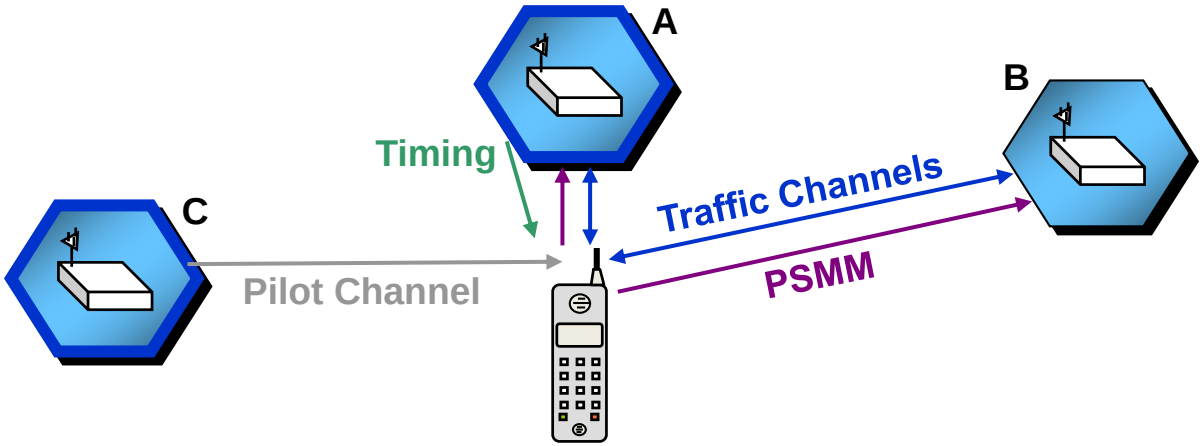
- Pilot sets:the handset considers pilots in **sets**
  - **Active**: Pilots of sectors actually in use (max 6 pilots)
  - **Candidate**:Pilots not currently in the Active Set, but received by the mobile with sufficient strength to indicate that the corresponding forward traffic Channels could be successfully demodulated (max 5 pilots)
  - **Neighbors**: Pilots not currently on the Active or Candidate Sets, it told to mobile by system,as nearby sectors to check(at least 20 pilots)
  - **Remaining**:All other possible pilots used by the current system on the current CDMA frequency,integer multiplies of PILOT_INC ,excluding the pilot in other sets
- All pilots in a set have the same frequency assignment
- These sets can be updated during handoff by the base station

# Rules of Soft Handoff




- The MS assists the BS in the handoff process by measuring and reporting the strengths of received pilots using a **P**ilot **S**trength **M**easurement **M**essage
- Handset sends **PSMM** to the system whenever:
  - It notices a pilot in neighbor or remaining set exceeds **T_ADD**
  - An active set pilot drops below **T_DROP** for **T_TDROP** time
  - A candidate pilot exceeds an active by **T_COMP**

# Pilot Strength Measurement Message

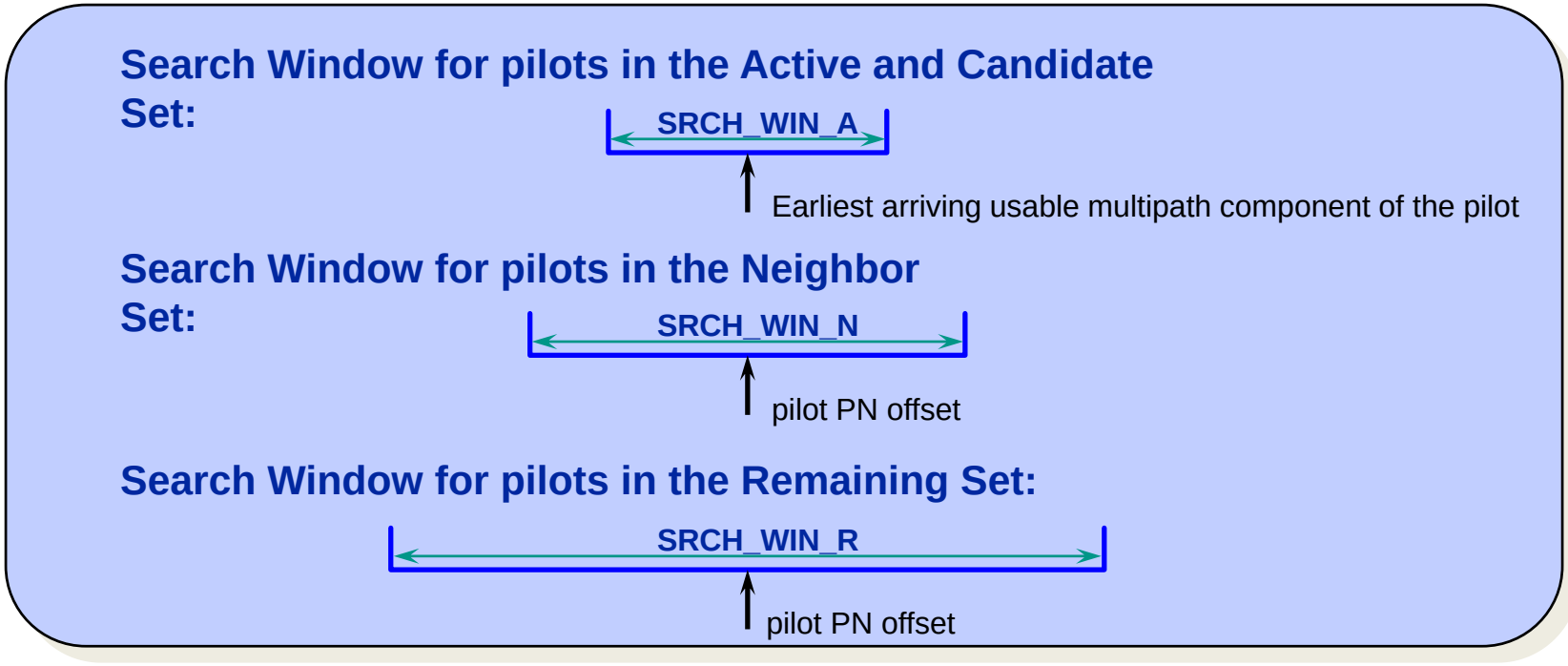



- The Pilot Strength Measurement Message is used by the mobile station to direct the Base Station Controller(BSC) in the handoff process.This message uses in the Reverse Traffic Channel
- A PSMM is sent to the system under one of the following conditions:
  - If MS finds a pilot in Neighbor or Remaining sets exceeds **T_ADD**
  - If an active set pilot drops below **T_DROP** after **T_TDROP** time
  - If a Candidate pilot exceeds an active pilot by **T_COMP**

# Extended Handoff Direction Message

- The Extended Handoff Direction Message(EHODM) is used by the Base Station Controller(BSC) to tell the mobile station on which base stations the BSC has allocated traffic channels for that user
- An EHODM Message uses in the forward traffic channel
- When the mobile station receives the EHODM message from BSC,then it will updates its Active Set and sends a HCM to the BSC.

# Pilot Search Windows

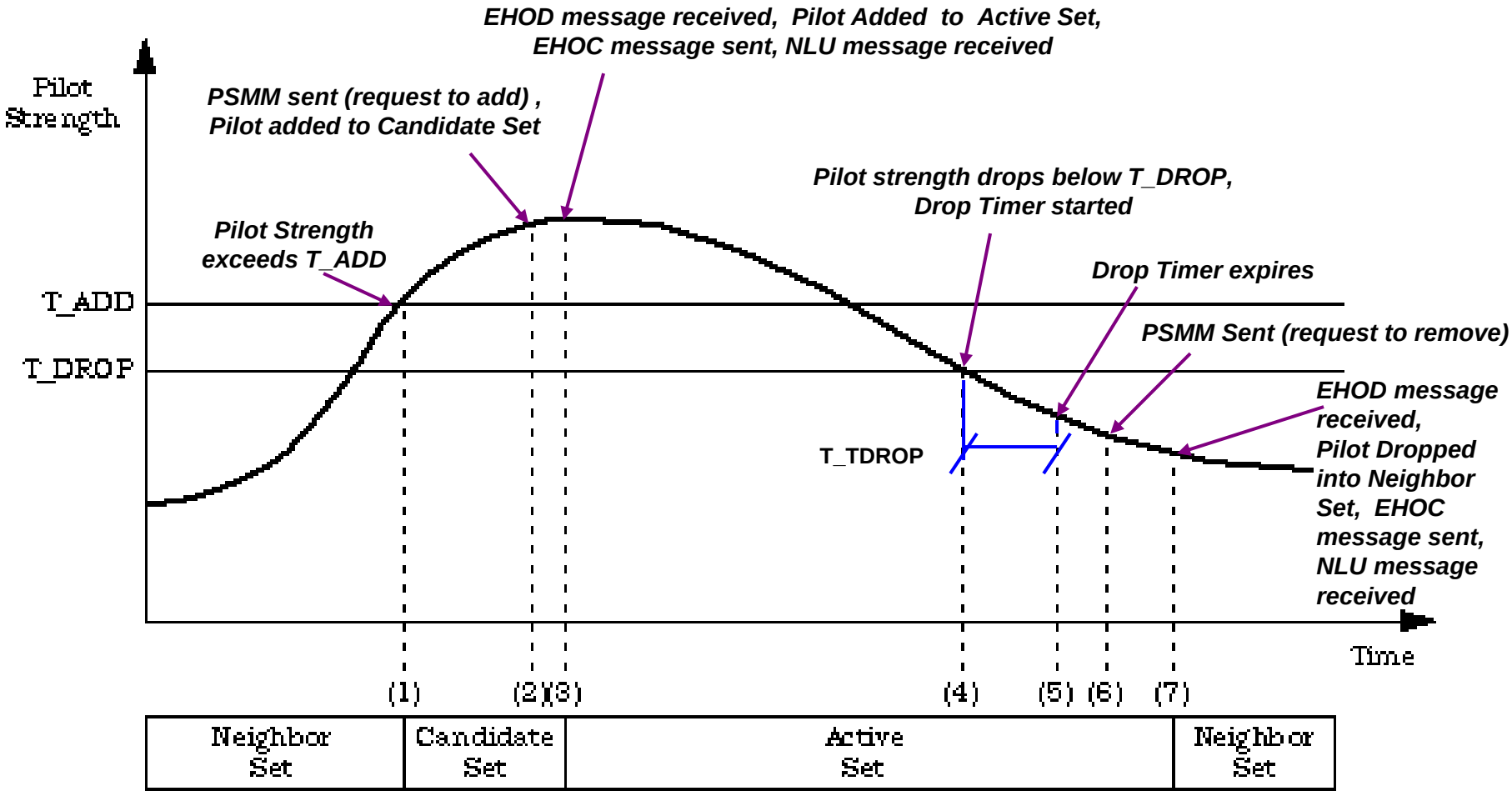



- A search window is a range of PN offsets (measured in chips) where the mobile station searches for usable multipath components of the pilots in a set
  - Usable means that multipath components can be used for demodulation of an associated forward traffic channel by MS

# System Parameters Message

| Field | Length (bits) |
|---|---|
| MSG_TYPE (‘00000001’) | 8 |
| PILOT_PN | 9 |
| CONFIG_MSG_SEQ | 6 |
| SID | 15 |
| NID | 16 |
| REG_ZONE | 12 |
| TOTAL_ZONES | 3 |
| ZONE_TIMER | 3 |
| MULT_SIDS | 1 |
| MULT_NIDS | 1 |
| BASE_ID | 16 |
| BASE_CLASS | 4 |
| PAGE_CHAN | 3 |
| MAX_SLOT_CYCLE_INDEX | 3 |
| HOME_REG | 1 |
| FOR_SID_REG | 1 |
| FOR_NID_REG | 1 |
| POWER_UP_REG | 1 |
| POWER_DOWN_REG | 1 |
| PARAMETER_REG | 1 |
| REG_PRD | 7 |
| BASE_LAT | 22 |
| BASE_LONG | 23 |
| REG_DIST | 11 |
| **SRCH_WIN_A** | **4** |
| **SRCH_WIN_N** | **4** |
| **SRCH_WIN_R** | **4** |
| **NGHBR_MAX_AGE** | **4** |
| PWR_REP_THRESH | 5 |
| PWR_REP_FRAMES | 4 |
| PWR_THRESH_ENABLE | 1 |
| PWR_PERIOD_ENABLE | 1 |
| PWR_REP_DELAY | 5 |
| RESCAN | 1 |
| **T_ADD** | **6** |
| **T_DROP** | **6** |
| **T_COMP** | **4** |
| **T_TDROP** | **4** |
| EXT_SYS_PARAMETER | 1 |
| EXT_NGHBR_LIST | 1 |
| GLOBAL_REDIRECT | 1 |
| RESERVED | 1 |

# IS-95 Soft Handoff Signaling



# IS-95 Soft Handoff Signaling(Cont.)

1.The pilot strength exceeds T_ADD.

2.The mobile station sends a PSMM requesting the strong pilot added to the active set and transfers this pilot to the candidate set.The BSC directs the desired pilot's base station to allocate a forward traffic channel.

3.The current base station sends an EHODM with the new pilot included in the "official" active set list.A Walsh code is designated for the forward traffic channel allocated on the new base station associated with the new pilot.

The mobile station transfers the new pilot from the candidate set to the active set.Then,the mobile station starts demodulating traffic from the new base station and sends a handoff completion message(HCM) on the reverse traffic channel.

# IS-95 Soft Handoff Signaling(Cont.)

4.The pilot strength drops below T_DROP,and the mobile station starts the handoff drop timer.

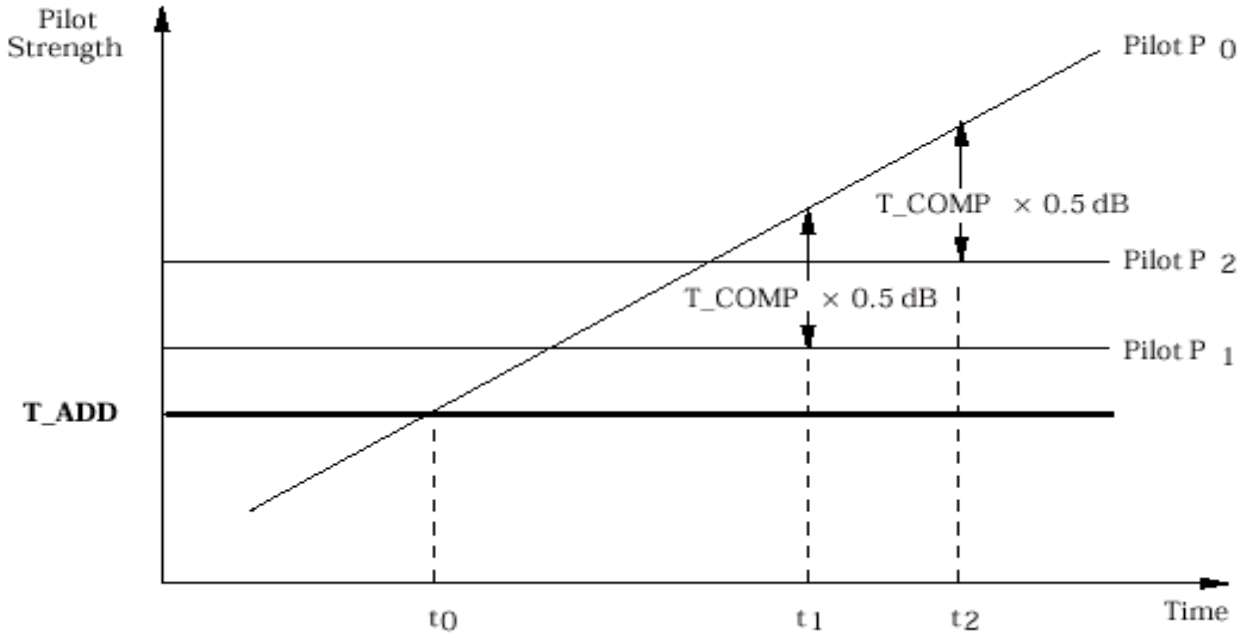
5.When the handoff drop timer expires,the mobile station sends a PSMM requesting the weak pilot removed from the active set.The base station sends an EHODM with the weak pilot removed from the “official” active set list.

6.The mobile station moves the pilot from the active set to the neighbor set(with the AGE counter set to zero),stops demodulating traffic associated with the weak pilot

7.Sends a handoff completion message on the new reverse traffic channel. The BTS sends a neighbor list update message with the composite neighbor list compiled by the BSC.

8.The mobile station updates its neighbor set.

# Active vs. Candidate Set Comparison Threshold




- PSMM are triggered not only when the strength of a pilot from the neighbor set exceeds the T_ADD threshold, but also when it exceeds the strength of a pilot already in the active set by T_COMP*0.5dB

- $t_0$-PSMM sent,$p_0$>T_ADD
- $t_1$-PSMM sent,$P_0$>$p_1$+T_COMP*0.5dB
- $t_2$-PSMM sent,$P_0$>$P_2$+T_COMP*0.5dB

# Power Control during Soft Handoff

- During soft handoff, the mobile station receives power control bits from multiple base stations.
- If two or more power control subchannels are identical, their power control bits are diversity combined into one per 1.25 ms time slot.
- If the mobile station receives different power control bits from different power control subchannels, it decreases its mean power output level by 1 dB.
- Only if the power control bits from ALL power control subchannels request a power increase, the mobile station increases its mean power output level by 1 dB .