

CDMA Overview

By: Raj Pratap Singh

Introduction

- ❑ CDMAOne and CDMA2000 are the wireless standards proposed by 3GPP2. CDMAOne is a collective name given to IS95A, IS95B and IS95C.
 - ❑ IS95A operates in the Cellular Band whereas the IS95B operates in the PCS band. IS95C is an upgrade to both these standards and operates in both bands.
 - ❑ The point in favour of CDMA 1x is that it requires narrow band CDMA (1.25Mhz) to operate.
 - ❑ In CDMA each user (the MS) is assigned a unique code (in radio environment terms, it is unique spreading waveform). This unique code distinguishes different users in the radio environment.
 - ❑ Spreading the user waveform (small bit rate) with code (fast bit rate) is called Spread Spectrum.
 - ❑ Spread Spectrum is accomplished before transmission through the use of a code that is independent of data sequences. The same code is used at the receiver to despread the received signal so that the original data sequence may be recovered.
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Band of Operation

There are 2 CDMA common air interface standards:

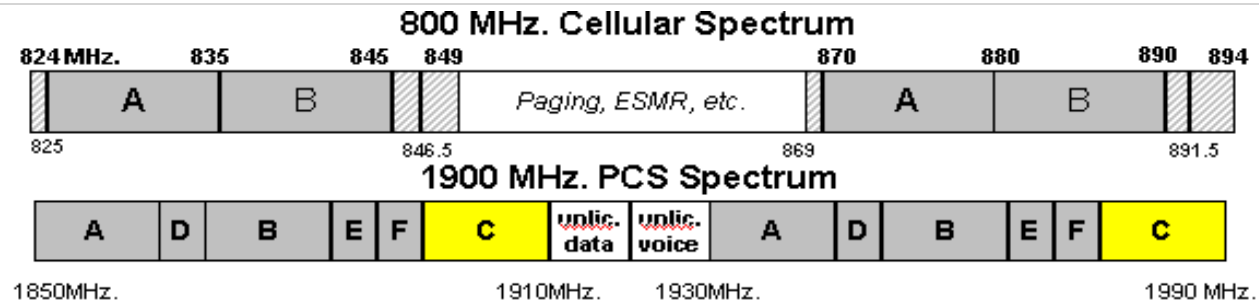
- Cellular (824-894 MHz) - **IS-95A**
- PCS (1850-1990 MHz) - **Joint-STD-008**

Cellular Band

- 45 MHz** spacing for forward & reverse channel
- Frequency assignments are on 30 kHz increments

PCS Band

- 80 MHz spacing for forward & reverse channel
- Frequency assignments are on 50 kHz increments



Cell Configuration in CDMA

- In Wireless communication we divide a whole geographical area into smaller chunks called cells. A single BS services each of these cells. These cells are grouped into groups of 3 –7 cells to form a cluster.
- Groups of clusters are put under a single Base Station Controller (BSC). All the BSCs in PLMN are controlled by a MSC (Master Switching center).



7 Cells forming a Cluster. Each Cell is activated by a base station.
Hexagons are used since of all the figures we can use the least hexagons to pack in a given area.

Walsh, Short PN and Long PN Codes

Walsh Code: These codes are also used for spreading on a forward link.

- In IS-95A and IS-95B we use 64 orthogonal codes and in CDMA-2000 we use 128 orthogonal codes.
- These codes follow the orthogonal property of vector i.e. auto-correlation of a code is 1 and correlation with any other code is 0.

Short PN Code: This is a 16 bit short PN Code used to identify the BS and hence the cell.

Long PN Code: This code on the reverse link is used for spreading meaning identifying the mobile station. It is a 42-bit code. On the forward link it is used for data scrambling.

IS-95 Logical Channels

Forward Link: The Forward Link is divided into 64 code channels. The logical structure is described below.

Pilot Channel: This channel is all zeros – carrying no data information. This channel is the beacon channel that defines the radius of the cell and hence is transmitted with the largest power. is assigned W0

Synchronization Channel: Used by the mobile during system acquisition to receive the system time, system identification and parameter information and state of the Long Code. Sync Channel is W32. This operates at 1200 bps.

Paging Channel: This channel carries overhead messages, pages, call setup messages and orders. The bps (4800 or 9600bps) of this channel is got from the Sync. Channel. The paging channel is assigned Walsh codes W1-W7.

Traffic Channel: The traffic channels are assigned to individual users to carry call traffic.

Continued...

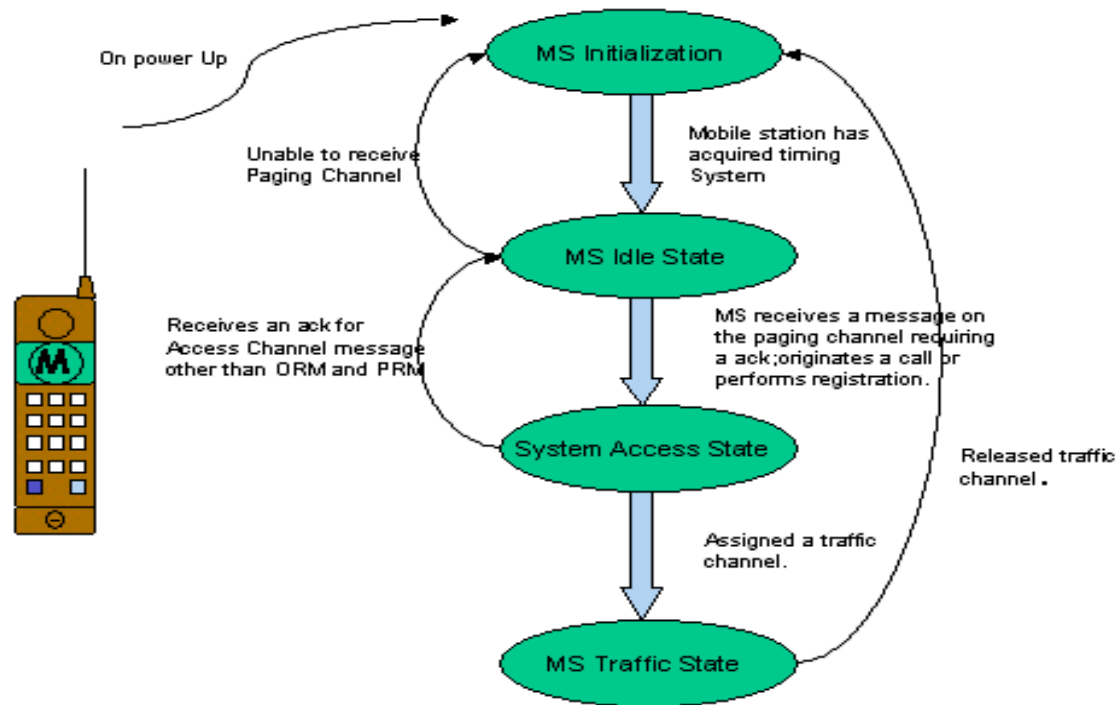
Reverse Link: Reverse CDMA Channel consists of 2^{42-1} logical channels. One of the logical channels is permanently and uniquely associated with each MS. The channel does not change upon handoff.

Access Channel: Access channels are used by mobiles to transmit signaling information. Access channels are paired to Paging Channels. Each paging channel can have up to 32 access channels. These channels operate at 4800 bps.

Reverse Traffic Channel: The reverse traffic channel are used by individual users during their actual calls to transmit traffic to the BTS .

CALL PROCESSING

Mobile Station States

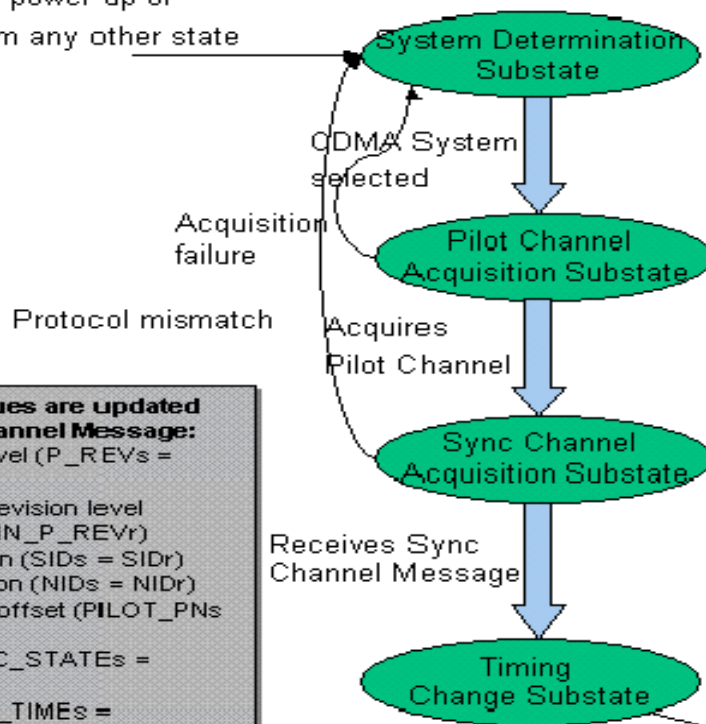


Note : Transitions arising from error conditions are not shown in the diagram.

MS-Initialization State

MS Initialization State

On power up or
from any other state



The following values are updated from the Sync Channel Message:

Protocol revision level (P_REVs = P_REVr)
Minimum protocol revision level (MIN_P_REVs = MIN_P_REVr)
System identification (SIDs = SIDr)
Network identification (NIDs = NIDr)
Pilot PN sequence offset (PILOT_PNs = PILOT_PNr)
Long code state (LC_STATES = LC_STATEr)
System Time (SYS_TIMES = SYS_TIMER)
Paging Channel data rate (PRATs = PRATr)

Does system selection. Updates the registration parameters ZONE_LIST(SID,NID). Update the value of CDMABAND and CDMACH. **Enters the next state if the selected system is a CDMA system.**

- The mobile station shall tune to the CDMA Channel number equal to CDMACHs.
- Searches for Pilot in T20ms

- Receives the Sync Channel Message in T21ms.
- Compares the value of MOB_P_REV and sets the value of PRAT.

- The mobile station synchronizes its long code timing and system timing to those of the CDMA system, using the PILOT_PNs, LC_STATES, and SYS_TIMES.
- Set PAGECHs to the Primary Paging Channel.

MS Idle State

Note : Transitions arising from error conditions are not shown in the diagram.

MS-Idle state

The MS enters this state and listens to the Primary Paging Channel with the PRAT read from the Sync channel message.

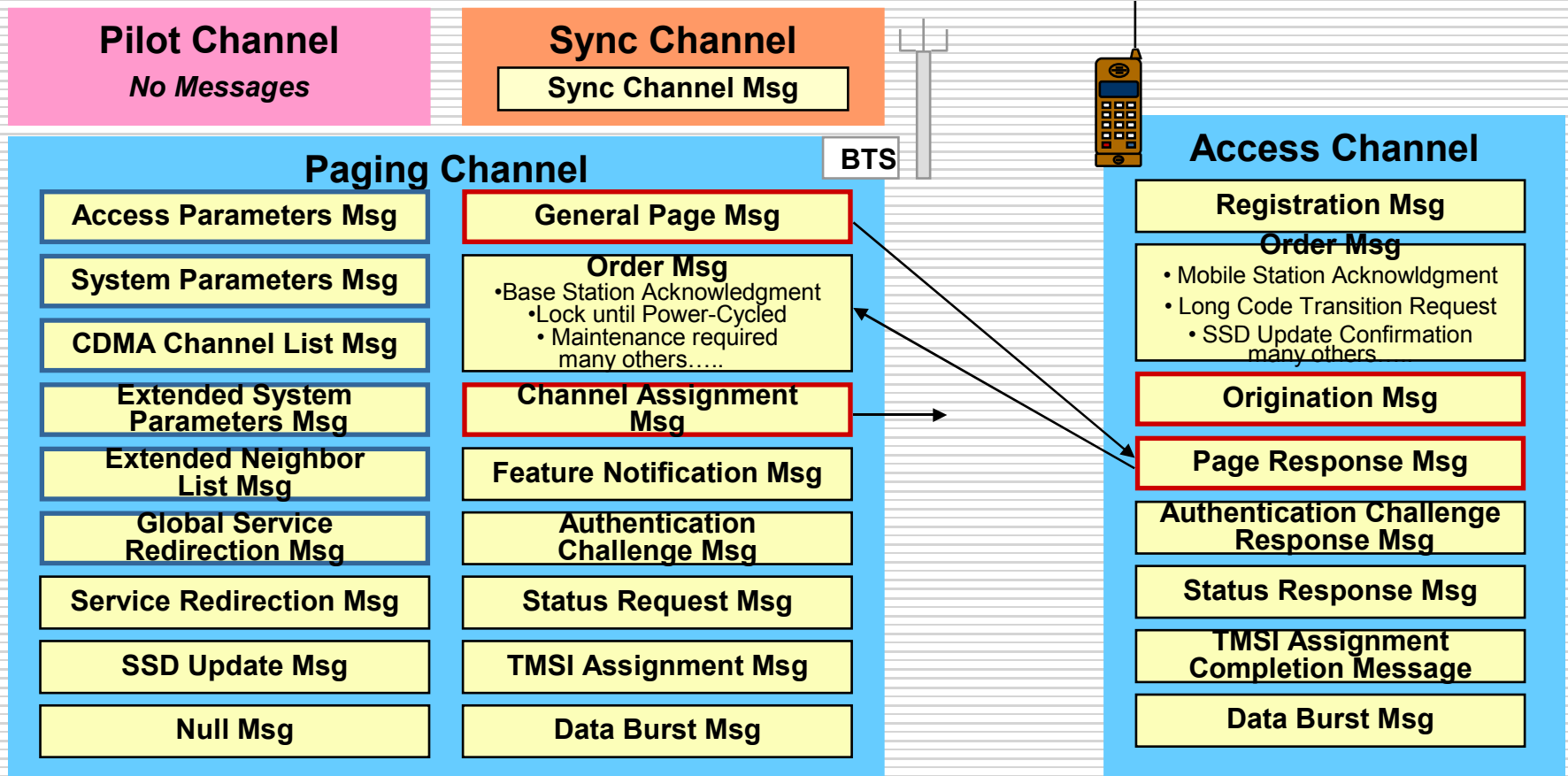


Call Processing

Messages in CDMA

- In CDMA, most call processing events are driven by messages
 - Some CDMA channels exist for the sole purpose of carrying messages; they never carry user's voice traffic
 - Sync Channel (a forward channel)
 - Paging Channel (a forward channel)
 - Access Channel (a reverse channel)
 - On these channels, there are only messages, continuously all of the time
 - Some CDMA channels exist just to carry user traffic
 - Forward Traffic Channel
 - Reverse Traffic Channel
 - On these channels, most of the time is filled with traffic and messages are sent only when there is something to do
 - All CDMA messages have very similar structure, regardless of the channel on which they are sent
-

Message Vocabulary: Acquisition & Idle States



Message Vocabulary: Conversation State

Forward Traffic Channel

Order Msg

- Base Station Acknowledgment
- Base Station Challenge Confirmation
- Message Encryption Mode

Authentication Challenge Msg

TMSI Assignment Msg

Send Burst DTMF Msg

Set Parameters Msg

Power Control Parameters Msg.

Retrieve Parameters Msg

Analog Handoff Direction Msg

SSD Update Msg

Mobile Station Registered Msg

Alert With Information Msg

Service Request Msg

Service Response Msg

Service Connect Msg

Service Option Control Msg

Status Request Msg

Flash With Information Msg

Data Burst Msg

Extended Handoff Direction Msg

Neighbor List Update Msg

In-Traffic System Parameters Msg

Reverse Traffic Channel

Service Request Msg

Service Response Msg

Service Connect Completion Message

Service Option Control Message

Status Response Msg

Flash With Information Msg

Data Burst Message

Pilot Strength Measurement Msg

Handoff Completion Msg

Origination Continuation Msg

Authentication Challenge Response Msg

TMSI Assignment Completion Message

Send Burst DTMF Msg

Parameters Response Message

Power Measurement Report Msg

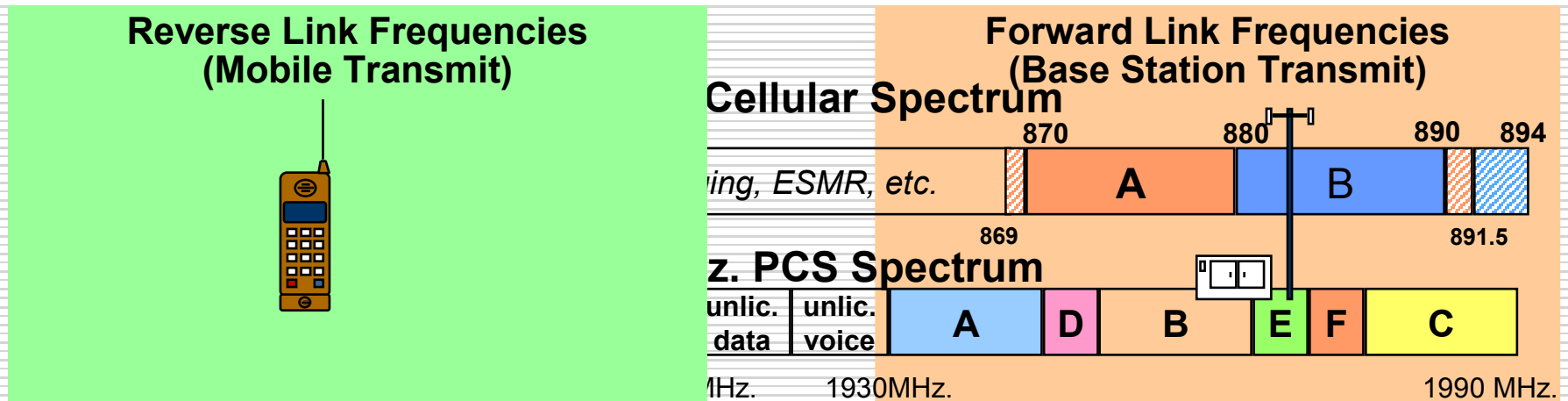
Order Message

- Mobile Sta. Acknowledgment
- Long Code Transition Request
- SSD Update Confirmation
- Connect



Acquire the System

Find a Frequency with a CDMA RF Signal



Mobile scans forward link frequencies:
(Cellular or PCS, depending on model)

History List

Preferred Roaming List

until a CDMA signal is found.

NO CDMA?! power-saving standby mode

FREQUENCY LISTS:

HISTORY LIST

Last-used:

Freq
Freq
Freq
Freq
Freq
etc.

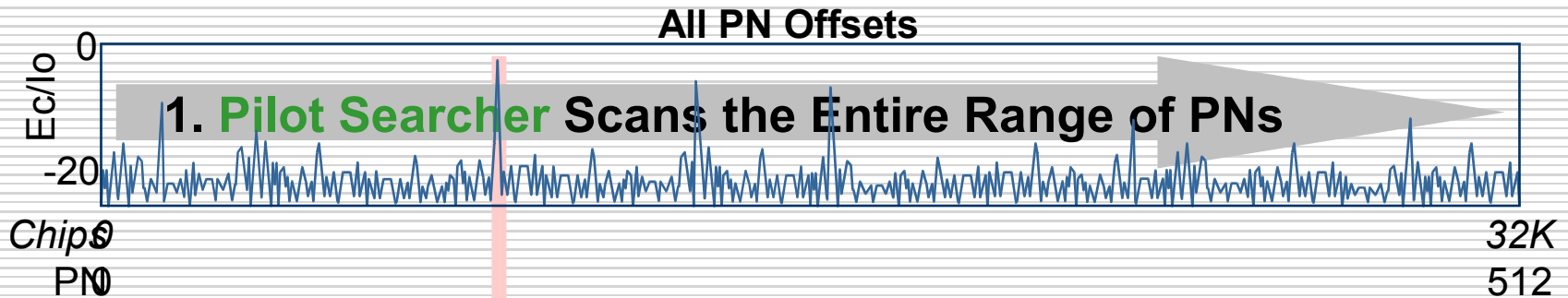


PREFERRED ROAMING LIST

Freq/SID 1
Freq/SID 2
Freq/SID 3
Freq/SID 4
Freq/SID 5
etc.



Find Strongest Pilot, Read Sync Channel



2. Put Rake finger(s) on strongest available PN, decode Walsh 32, and read Sync Channel Message

Active Pilot

Rake Fingers



Reference PN

SYNC CHANNEL MESSAGE

98/05/24 23:14:09.817 [SCH]

Sync Channel Message

MSG_LENGTH = 208 bits

MSG_TYPE = Sync Channel Message

P_REV = 3

MIN_P_REV = 2

SID = 179

NID = 0

PILOT_PN = 168

Offset Index

LC_STATE = 0x0348D60E013

SYS_TIME = 98/05/24 23:14:10.160

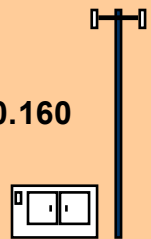
LP_SEC = 12

LTM_OFF = -300 minutes

DAYLT = 0

PRAT = 9600 bps

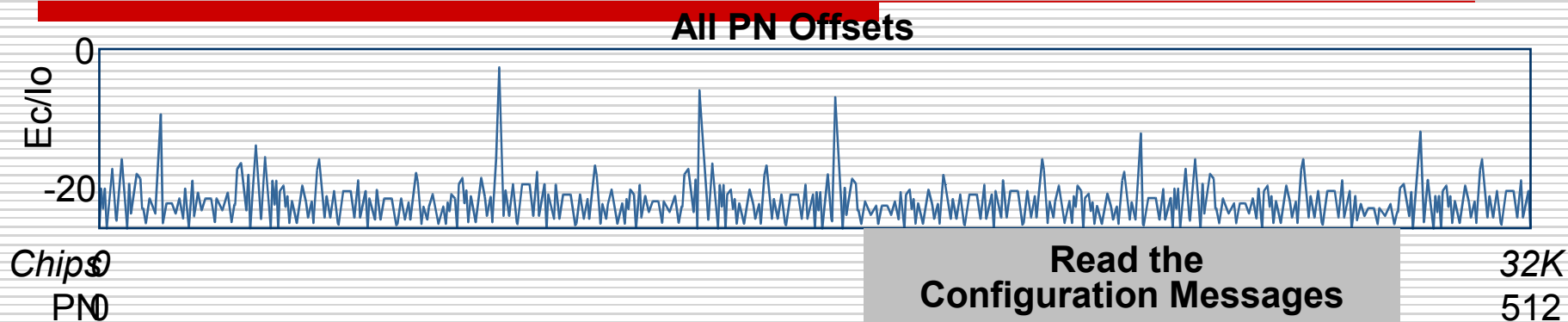
RESERVED = 1



The Configuration Messages

- After reading the Sync Channel, the mobile is now capable of reading the Paging Channel, which it now monitors constantly
 - Before it is allowed to transmit or operate on this system, the mobile must collect a complete set of configuration messages
 - Collection is a short process -- all configuration messages are repeated on the paging channel every 1.28 seconds
 - The configuration messages contain sequence numbers so the mobile can recognize if any of the messages have been freshly updated as it continues to monitor the paging channel
 - Access parameters message sequence number
 - Configuration message sequence number
 - If a mobile notices a changed sequence number, or if 600 seconds passes since the last time these messages were read, the mobile reads all of them again
-

Go to Paging Channel, Get Configured



Keep Rake finger(s) on strongest available PN, decode Walsh 1, and monitor the Paging Channel

Read the Configuration Messages

Access Parameters Msg

System Parameters Msg

CDMA Channel List Msg

Extended System Parameters Msg (*opt.)

(Extended*) Neighbor List Msg

Global Service Redirection Msg (*opt.)

Two Very Important Configuration Messages

ACCESS PARAMETERS MESSAGE

```
98/05/24 23:14:10.427 [PCH]
MSG_LENGTH = 184 bits
MSG_TYPE = Access Parameters Message
PILOT_PN = 168 Offset Index
ACC_MSG_SEQ = 27
ACC_CHAN = 1 channel
NOM_PWR = 0 dB INIT_PWR = 0 dB PWR_STEP = 4 Db
NUM_STEP = 5 Access Probes Maximum
MAX_CAP_SZ = 4 Access Channel Frames Maximum
PAM_SZ = 3 Access Channel Frames
Persist Val for Acc Overload Classes 0-9 = 0
Persist Val for Acc Overload Class 10 = 0
Persist Val for Acc Overload Class 11 = 0
Persist Val for Acc Overload Class 12 = 0
Persist Val for Acc Overload Class 13 = 0
Persist Val for Acc Overload Class 14 = 0
Persist Val for Acc Overload Class 15 = 0
Persistence Modifier for Msg Tx = 1
Persistence Modifier for Reg = 1
Probe Randomization = 15 PN chips
Acknowledgement Timeout = 320 ms
Probe Backoff Range = 4 Slots Maximum
Probe Sequence Backoff Range = 4 Slots Max.
Max # Probe Seq for Requests = 2 Sequences
Max # Probe Seq for Responses = 2 Sequences
Authentication Mode = 1
Random Challenge Value = Field Omitted
Reserved Bits = 99
```

SYSTEM PARAMETERS MESSAGE

```
98/05/24 23:14:11.126 [PCH] System Parameter Message
MSG_LENGTH = 264 bits
MSG_TYPE = System Parameters Message
PILOT_PN = 168 Offset Index
CONFIG_MSG_SEQ = 0
SID = 179 NID = 0
REG_ZONE = 0 TOTAL_ZONES = 0 ZONE_TIMER = 60 min
MULT_SIDS = 0 MULT_NID = 0 BASE_ID = 8710
BASE_CLASS = Public Macrocellular
PAGE_CHAN = 1 channel
MAX_SLOT_CYCLE_INDEX = 0
HOME_REG = 0 FOR_SID_REG = 0 FOR_NID_REG = 1
POWER_UP_REG = 0 POWER_DOWN_REG = 0
PARAMETER_REG = 1 REG_PRD = 0.08 sec
BASE_LAT = 00D00'00.00N BASE_LONG = 000D00'00.00E
REG_DIST = 0
SRCH_WIN_A = 40 PN chips
SRCH_WIN_N = 80 PN chips
SRCH_WIN_R = 4 PN chips
NGHBR_MAX_AGE = 0
PWR_REP_THRESH = 2 frames
PWR_REP_FRAMES = 56 frames
PWR_THRESH_ENABLE = 1
PWR_PERIOD_ENABLE = 0
PWR_REP_DELAY = 20 frames
RESCAN = 0
T_ADD = -13.0 Db T_DROP = -15.0 dB T_COMP = 2.5 dB
T_TDROP = 4 sec
EXT_SYS_PARAMETER = 1
RESERVED = 0
GLOBAL_REDIRECT = 0
```

Four Additional Configuration Messages

CDMA CHANNEL LIST MESSAGE

98/05/24 23:14:10.786 [PCH] CDMA Channel List Message
MSG_LENGTH = 72 bits
MSG_TYPE = CDMA Channel List Message
PILOT_PN = 168 Offset Index
CONFIG_MSG_SEQ = 0
CDMA_FREQ = 283
RESERVED = Field Omitted

NEIGHBOR LIST

98/05/24 23:14:11.486 [PCH] Neighbor List Message
MSG_LENGTH = 216 bits
MSG_TYPE = Neighbor List Message
PILOT_PN = 168 Offset Index
CONFIG_MSG_SEQ = 0
PILOT_INC = 4 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 220 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 52 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 500 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 8 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 176 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 304 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 136 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 384 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 216 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 68 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 328 Offset Index
NGHBR_CONFIG = 0 NGHBR_PN = 112 Offset Index
RESERVED = 0

EXTENDED SYSTEM PARAMETERS

98/05/24 23:14:10.946 [PCH]
Extended System Parameters Message
MSG_LENGTH = 104 bits
MSG_TYPE = Extended System Parameters Message
PILOT_PN = 168 Offset Index
CONFIG_MSG_SEQ = 0 RESERVED = 0
PREF_MSID_TYPE = IMSI and ESN
MCC = 000 IMSI_11_12 = 00
RESERVED_LEN = 8 bits
RESERVED_OCTETS = 0x00
BCAST_INDEX = 0
RESERVED = 0

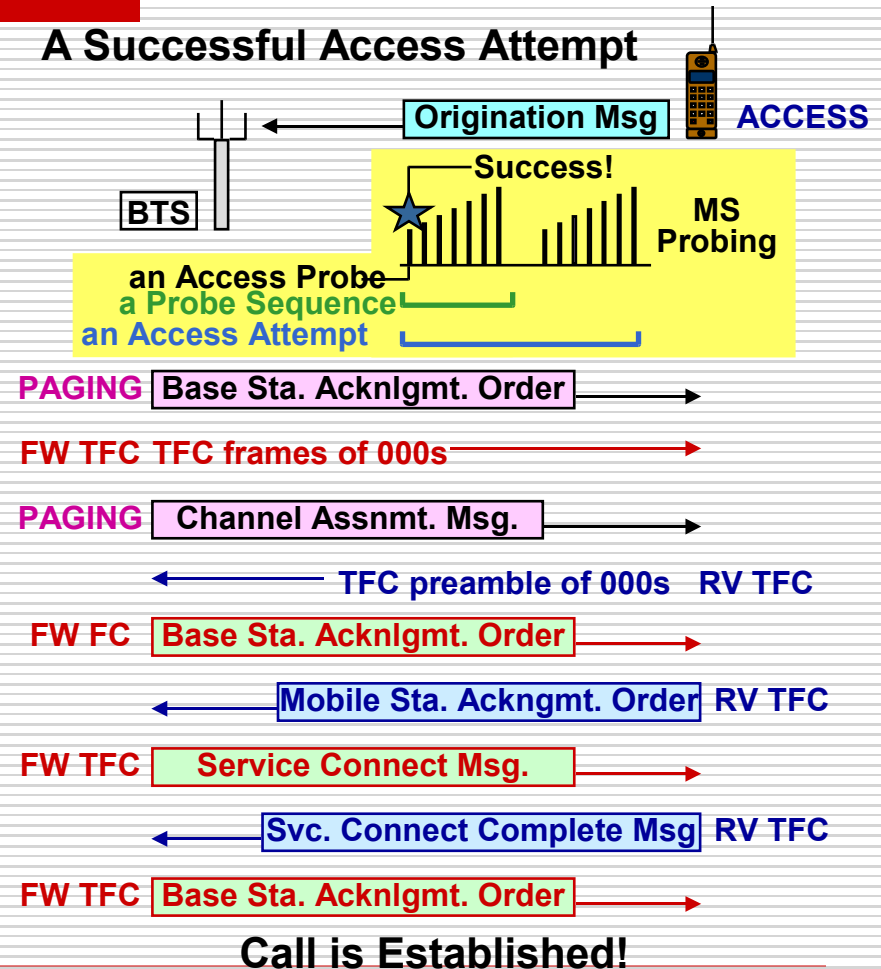
GLOBAL SERVICE REDIRECTION

98/05/17 24:21.566 Paging Channel: Global Service Redirection
PILOT_PN: 168, MSG_TYPE: 96, CONFIG_MSG_SEQ: 0
Redirected access overload classes: { 0, 1 }, RETURN_IF_FAIL: 0,
DELETE_TMSI: 0,
Redirection to an analog system:
EXPECTED_SID = 0
Do not ignore CDMA Available indicator on the redirected analog system
Attempt service on either System A or B with the custom system
selection process

Phone Operation on the Access Channel

- A sector's Paging Channel announces 1 (typ) to 32 (max) Access Channels: PN Long Code offsets for mobiles to use if accessing the system.
 - For mobiles sending Registration, Origination, Page Responses
 - Base Station always listening!
- On the access channel, phones are not yet under BTS closed-loop power control!
- Phones access the BTS by "probing" at power levels determined by receive power and an open loop formula
 - If "probe" not acknowledged by BTS within ACC_TMO (~400 mS.), phone will wait a random time (~200 mS) then probe again, stronger by PI db.
 - There can be 15 max. (typ. 5) probes in a sequence and 15 max. (typ. 2) sequences in an access attempt
 - most attempts succeed on first probe!
- The Access Parameters message on the paging channel announces values of all related parameters

A Successful Access Attempt





Registration

Registration

- Registration is the process by which an idle mobile lets the system know it's awake and available for incoming calls
 - this allows the system to inform the mobile's home switch of the mobile's current location, so that incoming calls can be delivered
 - registration also allows the system to intelligently page the mobile only in the area where the mobile is currently located, thereby eliminating useless congestion on the paging channels in other areas of the system
 - There are many different conditions that could trigger an obligation for the mobile to register
 - there are flags in the System Parameters Message which tell the mobile when it must register on the current system
-

Registration

SYSTEM PARAMETERS MESSAGE

```
18:26.826 [PCH] System Parameters Message
Pilot_PN: 32
CONFIG_MSG_SEQ: 14  SID: 16420  NID: 0,
REG_ZONE: 0  TOTAL_ZONES: 0  Zone timer length (min): 1
MULT_SIDS: 0  MULT_NIDS: 0
BASE_ID: 1618  BASE_CLASS: Reserved
PAG_CHAN: 1  MAX_SLOT_CYCLE_INDEX: 2
HOME_REG: 1  FOR_SID_REG: 1  FOR_NID_REG: 1,
POWER_UP_REG: 1  POWER_DOWN_REG: 1  PARAMETER_REG: 1
Registration period (sec): 54
Base station  0°00'00.00" Lon., 0°00'00.00" Lat.  REG_DIST: 0
SRCH_WIN_A (PN chips): 28  SRCH_WIN_N (PN chips): 100,
SRCH_WIN_R (PN chips): 130  NGHBR_MAX_AGE: 2
PWR_REP_THRESH: 2  PWR_REP_FRAMES (frames): 15
PWR_THRESH_ENABLE: 1  PWR_PERIOD_ENABLE: 0,
PWR_REP_DELAY: 1 (4 frames)  RESCAN: 0,
T_ADD: -14.0dB  T_DROP: -16.0dB  T_COMP: 2.5dB, T_TDROP: 4s
EXT_SYS_PARAMETER: 1
EXT_NGHBR_LIST: 1
GLOBAL_REDIRECT: 0
```

The System Parameters Message tells all mobiles when they should register. This mobile notices that it is obligated to register, so it transmits a Registration Message.

REGISTRATION MESSAGE

```
16:18:27.144 Access Channel: Registration
ACK_SEQ: 7  MSG_SEQ: 1  ACK_REQ: 1  VALID_ACK: 0
ACK_TYPE: 0
MSID_TYPE: 3, ESN: [0x 01 99 0d fc]
MFR 1, Reserved 38, Serial Number 69116,
IMSI: (Class: 0, Class_0_type: 1) [0x 01 8d 31 74 29 36]
00-416-575-0421
AUTH_MODE: 0
REG_TYPE: Timer-based
SLOT_CYCLE_INDEX: 2
MOB_P_REV: 1
EXT_SCM: 1
SLOTTED_MODE: 1
MOB_TERM: 1
```

BASE STATION ACKNOWLEDGMENT

```
16:18:27.506 Paging Channel: Order
ACK_SEQ: 1  MSG_SEQ: 0  ACK_REQ: 0  VALID_ACK: 1
MSID_TYPE: 2  IMSI: (Class: 0, Class_0_type: 3)
[0x 02 47 8d 31 74 29 36]  (302) 00-416-575-0421
Order type: Base Station Acknowledgement Order
```

The base station confirms that the mobile's registration message was received. We're officially registered



Incoming Call

Receiving an Incoming Call

- All idle mobiles monitor the paging channel to receive incoming calls.
 - When an incoming call appears, the paging channel notifies the mobile in a General Page Message.
 - A mobile which has been paged sends a Page Response Message on the access channel.
 - The system sets up a traffic channel for the call, then notifies the mobile to use it with a Channel Assignment Message.
 - The mobile and the base station notice each other's traffic channel signals and confirm their presence by exchanging acknowledgment messages.
 - The base station and the mobile negotiate what type of call this will be -- i.e., 13k voice, etc.
 - The mobile is told to ring and given a "calling line ID" to display.
 - When the human user presses the send button, the audio path is completed and the call proceeds.
-

Page and Page Response

GENERAL PAGE MESSAGE

```
98/05/24 23:14:46.127 [PCH] General Page Message
MSG_LENGTH = 128 bits
MSG_TYPE = General Page Message
CONFIG_MSG_SEQ = 1    ACC_MSG_SEQ = 20
CLASS_0_DONE = 1
CLASS_1_DONE = 1    RESERVED = 0
BROADCAST_DONE = 1  RESERVED = 0
ADD_LENGTH = 0 bits  ADD_PFIELD = Field Omitted
PAGE_CLASS = 0      PAGE_SUBCLASS = 0
MSG_SEQ = 1
IMSI_S = 1071124566
SPECIAL_SERVICE = 1
SERVICE_OPTION = 32768
RESERVED = Field Omitted
```

The system pages the mobile, 1071124566.

PAGE RESPONSE MESSAGE

```
98/05/24 23:14:46.425 [ACH] Page Response Message
MSG_LENGTH = 216 bits
MSG_TYPE = Page Response Message
ACK_SEQ = 1  MSG_SEQ = 2  ACK_REQ = 1
VALID_ACK = 1  ACK_TYPE = 2
MSID_TYPE = IMSI and ESN    MSID_LEN = 9 octets
ESN = 0xD30E415C    IMSI_CLASS = 0
IMSI_CLASS_0_TYPE = 0    RESERVED = 0
IMSI_S = 1071124566
AUTH_MODE = 1
AUTHR = 0x307B5    RANDC = 0xC6    COUNT = 0
MOB_TERM = 1    SLOT_CYCLE_INDEX = 0
MOB_P_REV = 3    SCM = 106
REQUEST_MODE = Either Wide Analog or CDMA Only
SERVICE_OPTION = 32768    PM = 0
NAR_AN_CAP = 0    RESERVED = 0
```

The mobile responds to the page.

BASE STATION ACKNOWLEDGMENT

```
98/05/24 23:14:46.768 [PCH] Order Message
MSG_LENGTH = 112 bits
MSG_TYPE = Order Message
ACK_SEQ = 2  MSG_SEQ = 0  ACK_REQ = 0
VALID_ACK = 1
ADDR_TYPE = IMSI    ADDR_LEN = 40 bits
IMSI_CLASS = 0  IMSI_CLASS_0_TYPE = 0  RESERVED = 0
IMSI_S = 1071124566
ORDER = Base Station Acknowledgement Order
ADD_RECORD_LEN = 0 bits
Order-Specific Fields = Field Omitted    RESERVED = 0
```

The base station confirms that the mobile's page response was received. Now the mobile is waiting for channel assignment, expecting a response within 12 seconds.

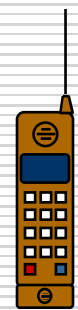
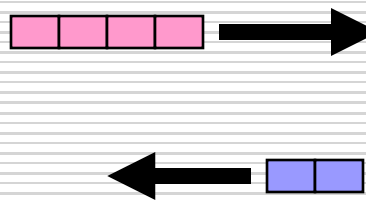
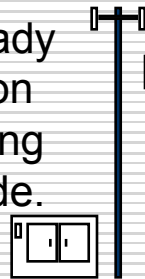
Channel Assignment and Traffic Channel Confirmation

CHANNEL ASSIGNMENT MESSAGE

```
18:14:47.027 Paging Channel: Channel Assignment
ACK_SEQ: 2  MSG_SEQ: 1  ACK_REQ: 0  VALID_ACK: 1
MSID_TYPE: 2  IMSI: (Class: 0, Class_0_type: 0)
[0x 01 f8 39 6a 15] 615-330-0644
ASSIGN_MODE: Traffic Channel Assignment
ADD_RECORD_LEN: 5  FREQ_INCL: 1  GRANTED_MODE: 2
CODE_CHAN: 43  FRAME_OFFSET: 2
ENCRYPT_MODE: Encryption disabled
BAND_CLASS: 800 MHz cellular band
CDMA_FREQ: 283
```

Only about 400 ms. after the base station acknowledgment order, the mobile receives the channel assignment message.

The base station is already sending blank frames on the forward channel, using the assigned Walsh code.



The mobile sees at least two good blank frames in a row on the forward channel, and concludes this is the right traffic channel. It sends a preamble of two blank frames of its own on the reverse traffic channel.



BASE STATION ACKNOWLEDGMENT

```
18:14:47.581 Forward Traffic Channel: Order
ACK_SEQ: 7  MSG_SEQ: 0  ACK_REQ: 1
ENCRYPTION: 0  USE_TIME: 0  ACTION_TIME: 0
Base Station Acknowledgement Order
```

The base station acknowledges receiving the mobile's preamble.

MOBILE STATION ACKNOWLEDGMENT

```
18:14:47.598 Reverse Traffic Channel: Order
ACK_SEQ: 0  MSG_SEQ: 0  ACK_REQ: 0
ENCRYPTION: 0
Mobile Station Acknowledgement Order
```

The mobile station acknowledges the base station's acknowledgment.

Everybody is ready!

Service Negotiation and Mobile Alert

SERVICE CONNECT MESSAGE

18:14:47.760 Forward Traffic Channel: Service Connect
ACK_SEQ: 0 MSG_SEQ: 1 ACK_REQ: 0 ENCRYPTION: 0
USE_TIME: 0 ACTION_TIME: 0 SERV_CON_SEQ: 0
Service Configuration: supported Transmission:
Forward Traffic Channel Rate (Set 2): 14400, 7200, 3600, 1800 bps
Reverse Traffic Channel Rate (Set 2): 14400, 7200, 3600, 1800 bps
Service option: (6) Voice (13k) (0x8000)
Forward Traffic Channel: Primary Traffic
Reverse Traffic Channel: Primary Traffic



Now that both sides have arrived on the traffic channel, the base station proposes that the requested call actually begin.

SERVICE CONNECT COMPLETE MSG.

18:14:47.835 Reverse Traffic Channel:
Service Connect Completion
ACK_SEQ: 1 MSG_SEQ: 3 ACK_REQ: 1
ENCRYPTION: 0 SERV_CON_SEQ: 0



The mobile agrees and says its ready to play.

ALERT WITH INFORMATION MESSAGE

18:14:47.961 Forward Traffic Channel:
Alert With Information
ACK_SEQ: 3 MSG_SEQ: 1 ACK_REQ: 1 ENCRYPTION: 0
SIGNAL_TYPE = IS-54B Alerting
ALERT_PITCH = Medium Pitch (Standard Alert)
SIGNAL = Long RESERVED = 0
RECORD_TYPE = Calling Party Number
RECORD_LEN = 96 bits
NUMBER_TYPE = National Number
NUMBER_PLAN = ISDN/Telephony Numbering Plan
PI = Presentation Allowed SI = Network Provided
CHARi = 6153000124 RESERVED = 0 RESERVED = 0

SERVICE CONNECT COMPLETE is a major milestone in call processing. Up until now, this was an access attempt. Now it is officially a call.

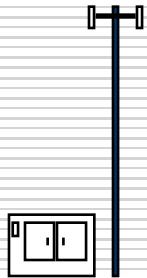
18:14:48.018 Reverse Traffic Channel: Order
ACK_SEQ: 1 MSG_SEQ: 4 ACK_REQ: 0
ENCRYPTION: 0
Mobile Station Acknowledgement Order

The base station orders the mobile to ring, and gives it the calling party's number to display.

The mobile says it's ringing.

The Human Answers! Connect Order

The mobile has been ringing for several seconds. The human user finally comes over and presses the send button to answer the call.



BASE STATION ACKNOWLEDGMENT

18:14:54.920 Forward Traffic Channel: Order
ACK_SEQ: 0 MSG_SEQ: 1 ACK_REQ: 0
ENCRYPTION: 0 USE_TIME: 0 ACTION_TIME: 0
Base Station Acknowledgement Order

CONNECT ORDER

18:14:54.758 Reverse Traffic Channel: Order
ACK_SEQ: 6 MSG_SEQ: 0 ACK_REQ: 1
ENCRYPTION: 0
Connect Order



Now the switch completes the audio circuit and the two callers can talk!

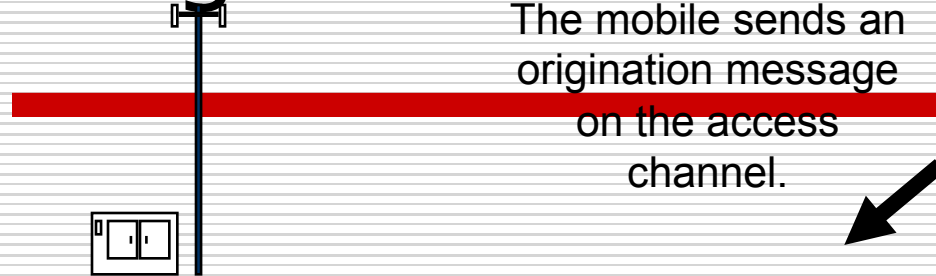


Outgoing Call

Placing an Outgoing Call


- ❑ The mobile user dials the desired digits, and presses SEND.
 - ❑ Mobile transmits an Origination Message on the access channel.
 - ❑ The system acknowledges receiving the origination by sending a base station acknowledgement on the paging channel.
 - ❑ The system arranges the resources for the call and starts transmitting on the traffic channel.
 - ❑ The system notifies the mobile in a Channel Assignment Message on the paging channel.
 - ❑ The mobile arrives on the traffic channel.
 - ❑ The mobile and the base station notice each other's traffic channel signals and confirm their presence by exchanging acknowledgment messages.
 - ❑ The base station and the mobile negotiate what type of call this will be -- I.e., 13k voice, etc.
 - ❑ The audio circuit is completed and the mobile caller hears ringing.
-

Origination



ORIGINATION MESSAGE

```
17:48:53.144 Access Channel: Origination
ACK_SEQ: 7 MSG_SEQ: 6 ACK_REQ: 1
VALID_ACK: 0 ACK_TYPE: 0 MSID_TYPE: 3
ESN: [0x 00 06 98 24] MFR 0 Reserved 1
Serial Number 170020
IMSI: (Class: 0, Class_0_type: 0)
[0x 03 5d b8 97 c2] 972-849-5073
AUTH_MODE: 0 MOB_TERM: 1
SLOT_CYCLE_INDEX: 2 MOB_P_REV: 1 EXT_SCM: 1
DualMode: 0 SLOTTED_MODE: 1 PowerClass: 0
REQUEST_MODE: CDMA only SPECIAL_SERVICE: 1
Service option: (6) Voice (13k) (0x8000) PM: 0
DIGIT_MODE: 0 MORE_FIELDS: 0 NUM_FIELDS: 11
Chari: 18008900829
NAR_AN_CAP: 0
```



BASE STATION ACKNOWLEDGMENT

```
17:48:53.487 Paging Channel: Order
ACK_SEQ: 6 MSG_SEQ: 0 ACK_REQ: 0 VALID_ACK: 1
MSID_TYPE: 2
IMSI: (Class: 0, Class_0_type: 0)
[0x 03 5d b8 97 c2] 972-849-5073
Base Station Acknowledgment Order
```

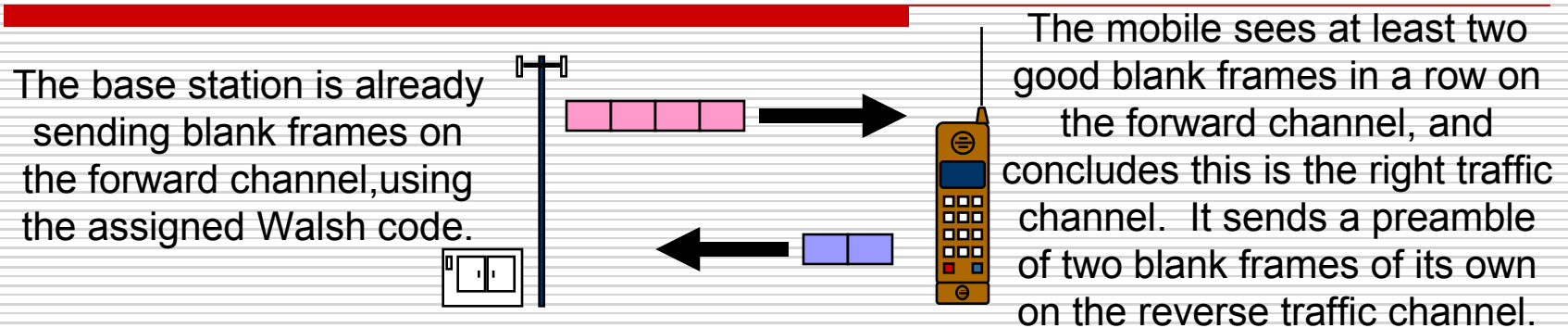
The base station confirms that the origination message was received.

CHANNEL ASSIGNMENT MESSAGE

```
17:48:54.367 Paging Channel: Channel Assignment
ACK_SEQ: 6 MSG_SEQ: 1 ACK_REQ: 0 VALID_ACK: 1
MSID_TYPE: 2
IMSI: (Class: 0, Class_0_type: 0)
[0x 03 5d b8 97 c2] 972-849-5073
ASSIGN_MODE: Traffic Channel Assignment,
ADD_RECORD_LEN: 5 FREQ_INCL: 1 GRANTED_MODE: 2
CODE_CHAN: 12 FRAME_OFFSET: 0
ENCRYPT_MODE: Encryption disabled
BAND_CLASS: 1.8 to 2.0 GHz PCS band
CDMA_FREQ: 425
```

The base station sends a Channel Assignment Message and the mobile goes to the traffic channel.

Traffic Channel Confirmation



BASE STATION ACKNOWLEDGMENT

17:48:54.757 Forward Traffic Channel: Order
ACK_SEQ: 7 MSG_SEQ: 0 ACK_REQ: 1 ENCRYPTION: 0
USE_TIME: 0 ACTION_TIME: 0
Base Station Acknowledgment Order

The base station acknowledges receiving the mobile's preamble.

MOBILE STATION ACKNOWLEDGMENT

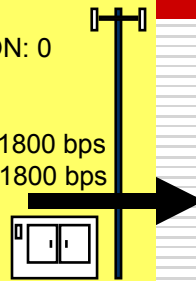
17:48:54.835 Reverse Traffic Channel: Order
ACK_SEQ: 0 MSG_SEQ: 0 ACK_REQ: 0
ENCRYPTION: 0
Mobile Station Acknowledgment Order

The mobile station acknowledges the base station's acknowledgment.
Everybody is ready!

Service Negotiation and Connect Complete

SERVICE CONNECT MESSAGE

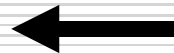
17:48:55.098 Forward Traffic Channel: Service Connect
ACK_SEQ: 7 MSG_SEQ: 1 ACK_REQ: 1 ENCRYPTION: 0
USE_TIME: 0 ACTION_TIME: 0 SERV_CON_SEQ: 0
Service Configuration Supported Transmission:
Forward Traffic Channel Rate (Set 2): 14400, 7200, 3600, 1800 bps
Reverse Traffic Channel Rate (Set 2): 14400, 7200, 3600, 1800 bps
Service option: (6) Voice (13k) (0x8000)
Forward Traffic Channel: Primary Traffic
Reverse Traffic Channel: Primary Traffic



Now that the traffic channel is working in both directions, the base station proposes that the requested call actually begin.

SERVICE CONNECT COMPLETE MSG.

17:48:55.137 Reverse Traffic Channel: Service Connect Completion
ACK_SEQ: 1, MSG_SEQ: 0, ACK_REQ: 1, ENCRYPTION: 0, SERV_CON_SEQ: 0



The mobile agrees and says its ready to play.



BASE STATION ACKNOWLEDGMENT

17:48:55.779 Forward Traffic Channel: Order
ACK_SEQ: 0 MSG_SEQ: 0 ACK_REQ: 0 ENCRYPTION: 0
USE_TIME: 0 ACTION_TIME: 0
Base Station Acknowledgment Order



The base station agrees.

SERVICE CONNECT COMPLETE is a major milestone in call processing. Up until now, this was an access attempt. Now it is officially a call.



Now the switch completes the audio circuit and the two callers can talk!



End Call

Ending A Call

- A normal call continues until one of the parties hangs up. That action sends a Release Order, “normal release”.
 - The other side of the call sends a Release Order, “no reason given”.
 - *If a normal release is visible, the call ended normally.*
 - At the conclusion of the call, the mobile reacquires the system.
 - Searches for the best pilot on the present CDMA frequency
 - Reads the Sync Channel Message
 - Monitors the Paging Channel steadily
 - Several different conditions can cause a call to end abnormally:
 - the forward link is lost at the mobile, and a fade timer acts
 - the reverse link is lost at the base station, and a fade timer acts
 - a number of forward link messages aren't acknowledged, and the base station acts to tear down the link
 - a number of reverse link messages aren't acknowledged, and the mobile station acts to tear down the link
-

A Beautiful End to a Normal Call



BASE STATION ACKNOWLEDGMENT

17:49:21.936 Forward Traffic Channel: Order
ACK_SEQ: 1 MSG_SEQ: 2 ACK_REQ: 0 ENCRYPTION: 0,
USE_TIME: 0 ACTION_TIME: 0
Base Station Acknowledgement Order

BASE STATION RELEASE ORDER

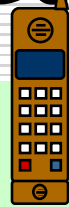
17:49:21.997 Forward Traffic Channel: Order
ACK_SEQ: 1 MSG_SEQ: 3 ACK_REQ: 0 ENCRYPTION: 0
USE_TIME: 0 ACTION_TIME: 0
Release Order (no reason given)

SYNC CHANNEL MESSAGE

17:49:22.517 Sync Channel
MSG_TYPE: 1 Sync Channel Message
P_REV: 1 MIN_P_REV: 1
SID: 4112 NID: 2 Pilot_PN: 183
LC_STATE: 0x318fe5d84a5
SYS_TIME: 0x1ae9683dc
LP_SEC: 9 LTM_OFF: -10 DAYLT: 1
Paging Channel Data Rate: 9600
CDMA_FREQ: 425

MOBILE RELEASE ORDER

17:49:21.715 Reverse Traffic Channel: Order
ACK_SEQ: 1 MSG_SEQ: 1 ACK_REQ: 1
ENCRYPTION: 0
Release Order (normal release)



At the end of a normal call, this mobile user pressed end.

The base station acknowledged receiving the message, then sent a release message of its own.

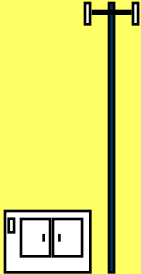
The mobile left the traffic channel, scanned to find the best pilot, and read the Sync Channel Message.

Notification of a Voice Message

Feature Notification

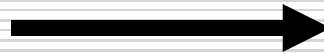
FEATURE NOTIFICATION MESSAGE

```
98/06/30 21:16:44.368 [PCH] Feature Notification Message
MSG_LENGTH = 144 bits
MSG_TYPE = Feature Notification Message
ACK_SEQ = 0
MSG_SEQ = 0
ACK_REQ = 1
VALID_ACK = 0
ADDR_TYPE = IMSI
ADDR_LEN = 56 bits
IMSI_CLASS = 0
IMSI_CLASS_0_TYPE = 3
RESERVED = 0
MCC = 302
IMSI_11_12 = 00
IMSI_S = 9055170325
RELEASE = 0
RECORD_TYPE = Message Waiting
RECORD_LEN = 8 bits
MSG_COUNT = 1
RESERVED = 0
```



The Feature Notification Message on the Paging Channel tells a specific mobile it has voice messages waiting.

There are other record types to notify the mobile of other features.



MOBILE STATION ACKNOWLEDGMENT

The mobile confirms it has received the notification by sending a Mobile Station Acknowledgment Order on the access channel.

