

Course 344

1xEV-DO RF Performance Optimization

This course can be downloaded free from our website:

www.howcdmaworks.com/344.pdf

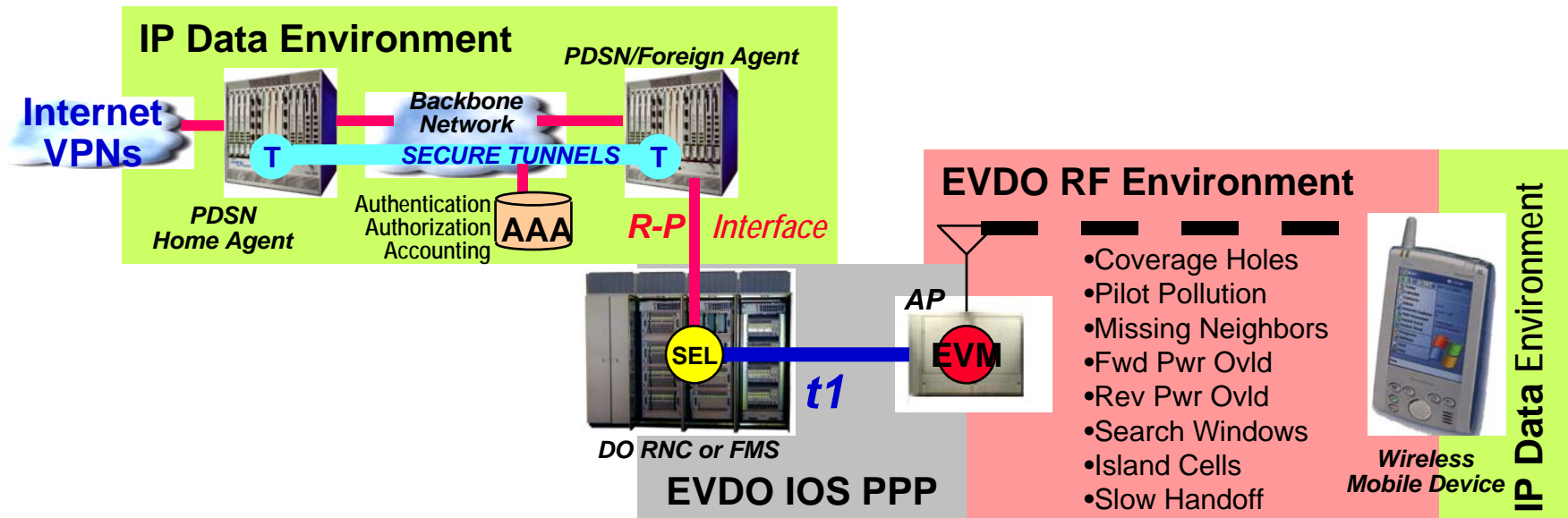
Outline

- 1xEV-DO Key Performance Indicators
- Air Interface Review
- Layer-3 Messages in EV-DO
- System Acquisition and Synchronization
- Following a Connection
- Backhaul and Related Considerations
- Optimizing the RF Interface
- Session and Connection Setup Performance
- Forward Link Throughput Optimization
- Reverse Link Throughput Performance
- Optimizing Interoperability

1xEV-DO

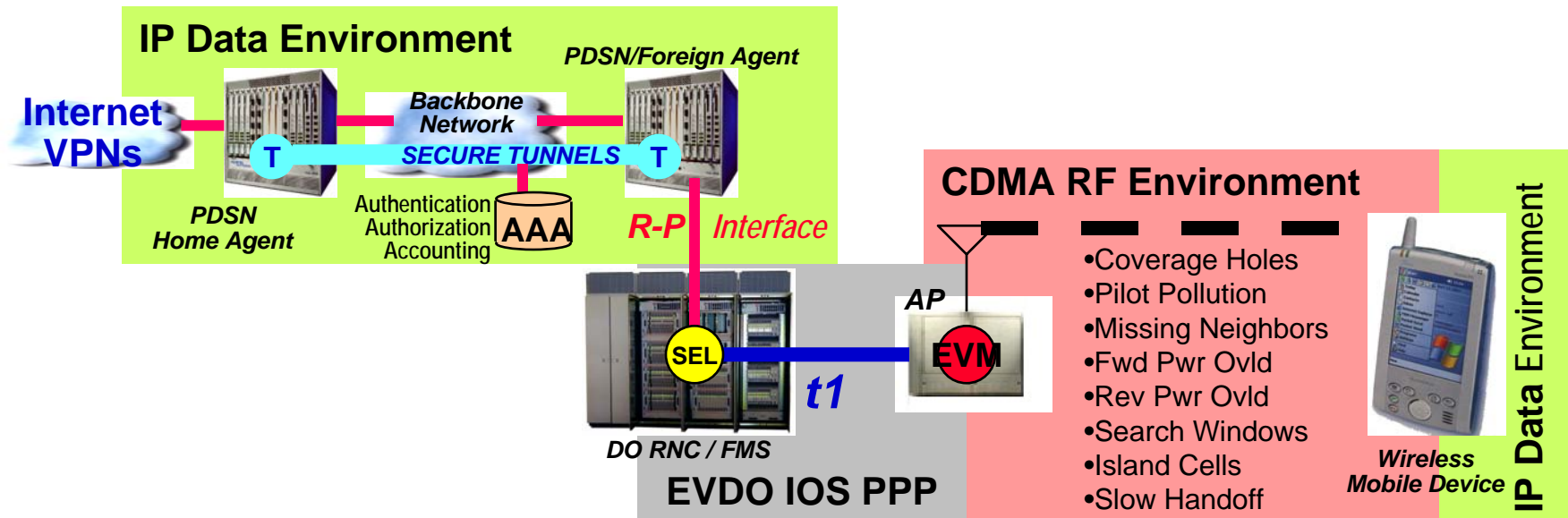
Key Performance Indicators

Latency



- Latency can occur because of RF channel congestion or from IP network causes
 - RF overload can delay availability of supplemental channels
 - IP network congestion can delay availability of packets
- Ping and loopback tests with local PDSN and servers can identify whether problem is in backbone network
- Does latency correlate with independent evidence of RF congestion?

Throughput



■ Throughput can be limited by RF and IP causes

- Traditional RF problems limit capacity of the channel
- Congestion in the IP network can limit speed of data available

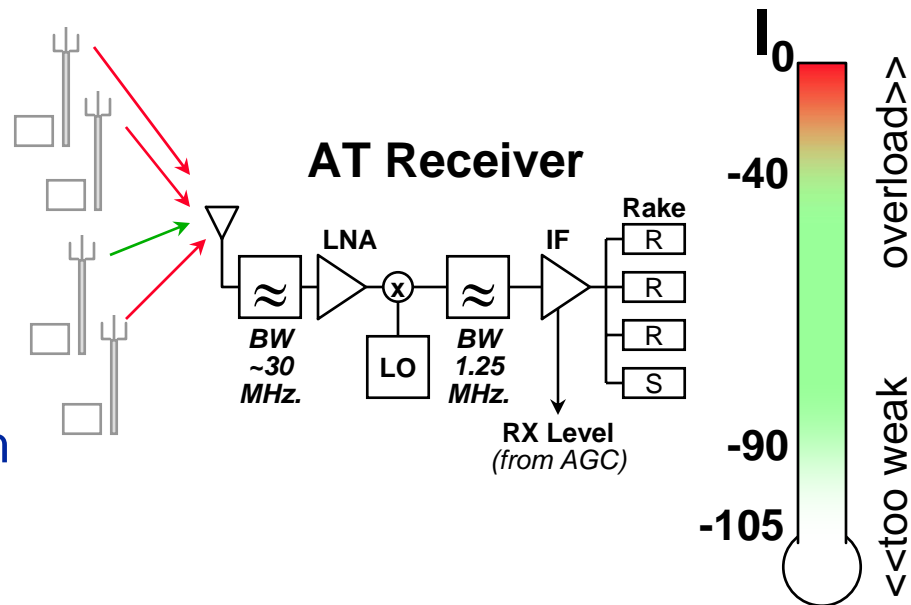
■ Does low throughput correlate with independent RF indicators?

■ Does low throughput correlate with independent IP pings and tests?

I_0 , Total AT Receive Power

■ AT Receive Power

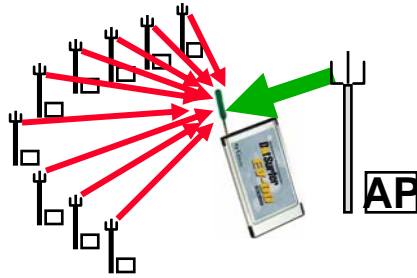
- usually expressed in dBm
- measured derived from handset IF AGC voltage
- broadband, “unintelligent” measurement: includes all RF in the carrier bandwidth regardless of source, *not* just RF from serving BTS



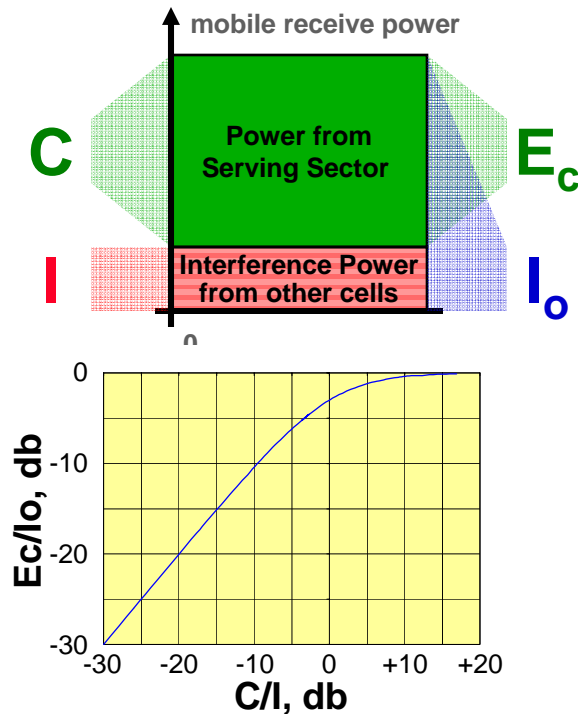
■ AT power is important, but it's exact value isn't critical

- too much received signal (-35 dbm or higher) could drive the AT's sensitive first amplifier into overload, causing intermod and code distortion on received CDMA signals
- too little received signal (-105 or weaker) would leave too much noise in the signal after de-spreading, resulting in symbol errors, bit errors, packet errors, and other problems

Ec/Io and C/I



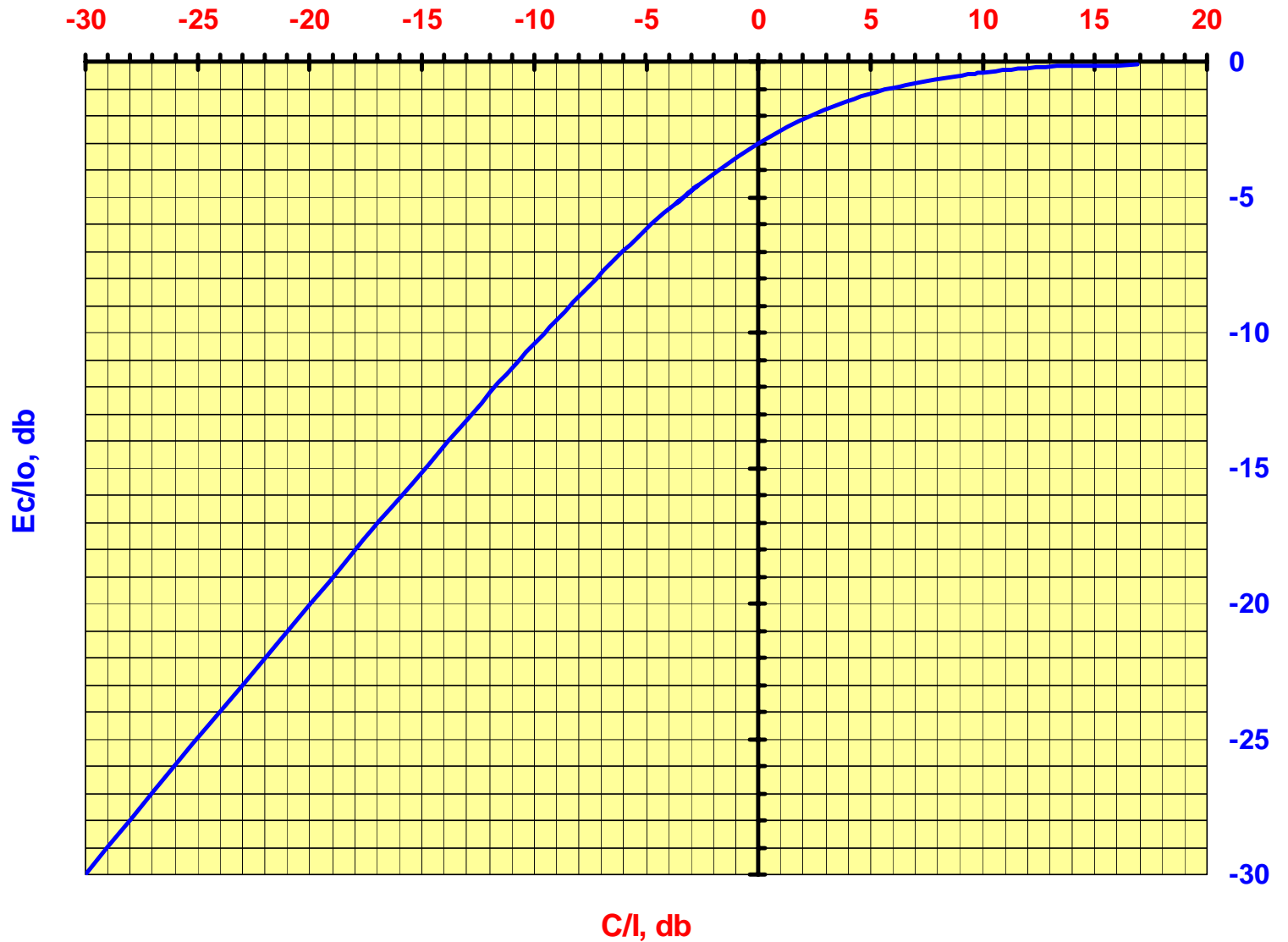
Relationship of C/I and E_c/I_o For EV-DO Signals



- There are two main ways of expressing signal quality in 1xEV-DO
- C/I is the ratio of serving sector power to everything else
 - C/I determines the forward data rate
 - mobiles measure C/I during the pilot burst period, then from it decide what data rate to request on the DRC
- E_c/I_o is the ratio of one sector's pilot power to the total received power
- E_c/I_o and C/I are related, and one can be calculated from the other
- EVDO E_c/I_o is close to 0 db near a sector, and ranges down to -10 at a cell's edge
- EVDO C/I can be above +10 db near a sector, and -20 or lower at the edge

Relationship of E_c/I_o and C/I in 1xEV-DO Systems

E_c/I_o , db	C/I , db
-0.04	20
-0.14	15
-0.17	14
-0.21	13
-0.27	12
-0.33	11
-0.41	10
-0.51	9
-0.64	8
-0.79	7
-0.97	6
-1.19	5
-1.46	4
-1.76	3
-2.12	2
-2.54	1
-3.01	0
-3.54	-1
-4.12	-2
-4.76	-3
-5.46	-4
-6.97	-6
-8.64	-8
-10.41	-10
-12.27	-12



Statistical EVDO Indications

■ RF Connection failures

- Mobile does not reach an assigned traffic channel

■ RF Connection Losses

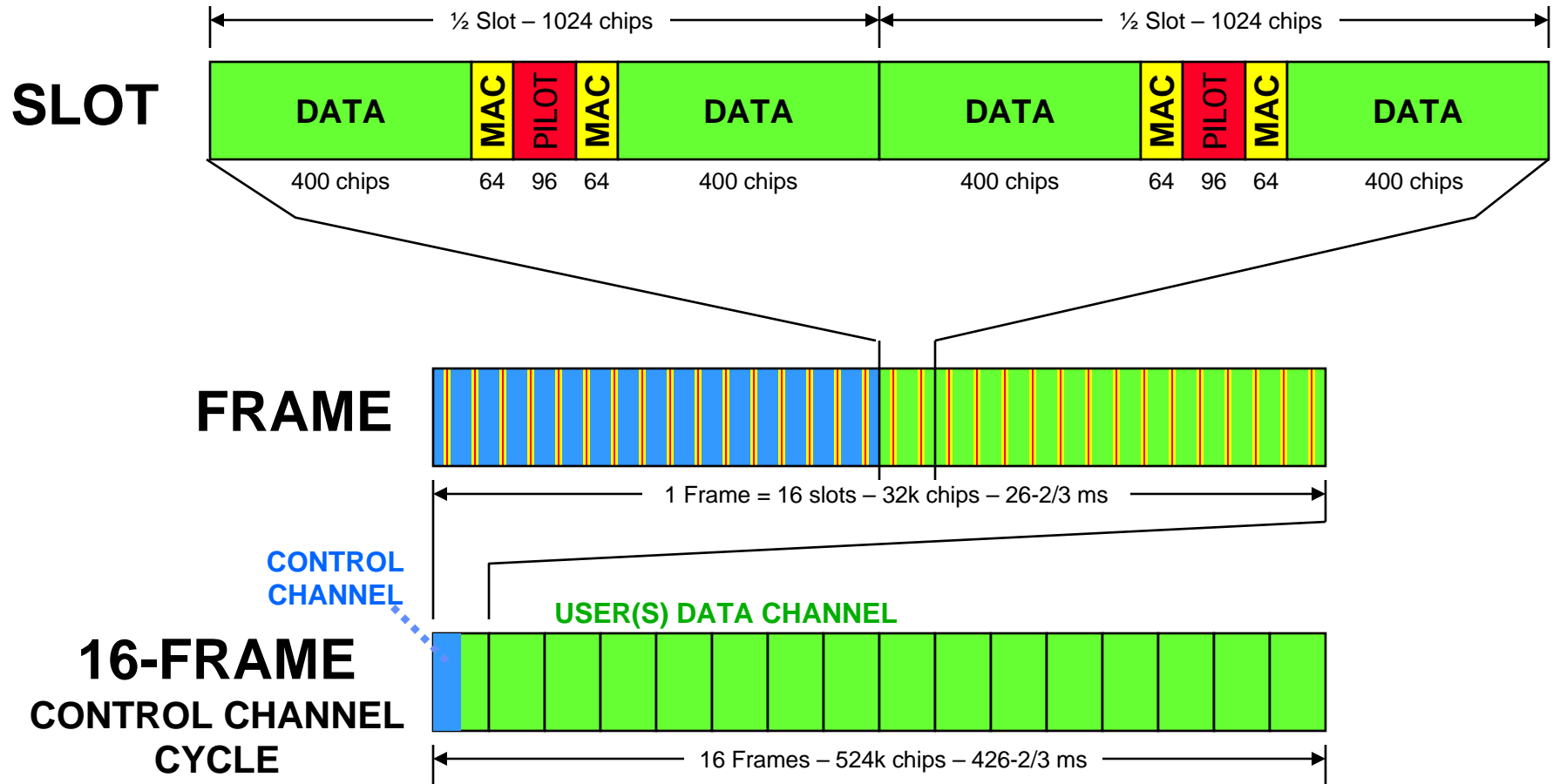
- Existing connection is lost due to failure of forward or reverse link

■ RF Blocking

- Due to MAC index, backhaul, or other congestion

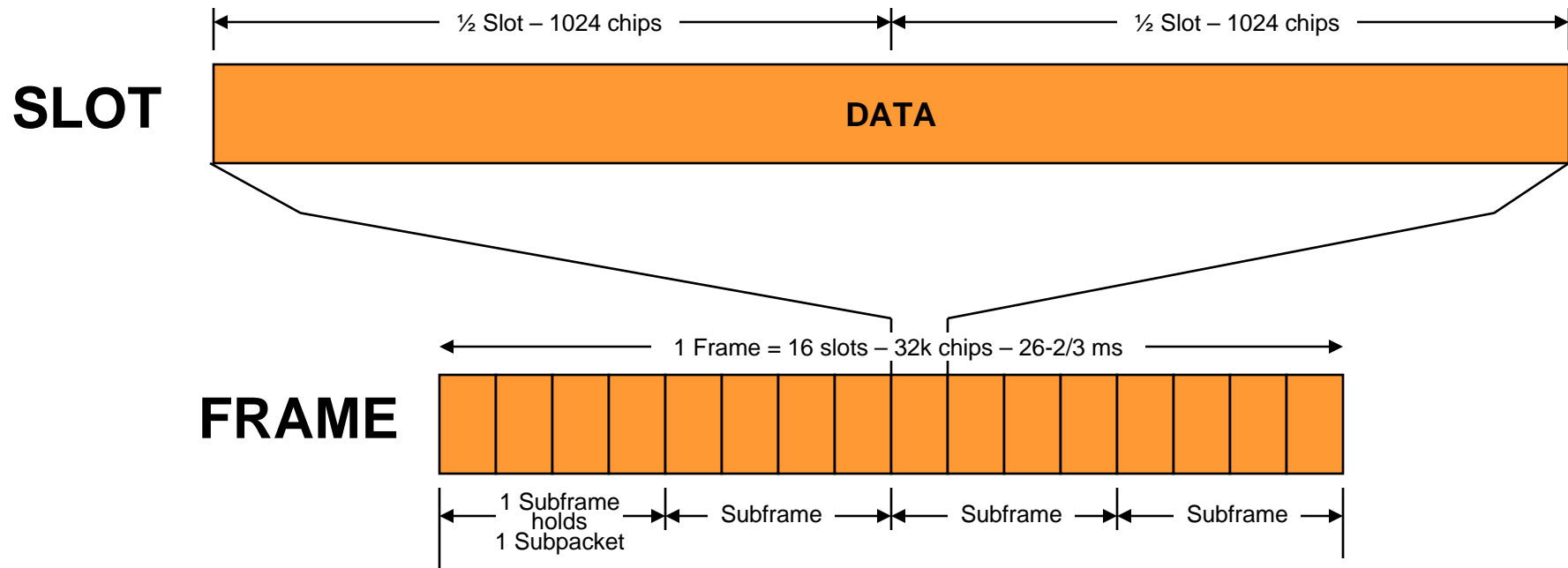
1xEV-DO Air Interface Review

Forward Link Frame and Slot Structure: “Big Picture” Summary



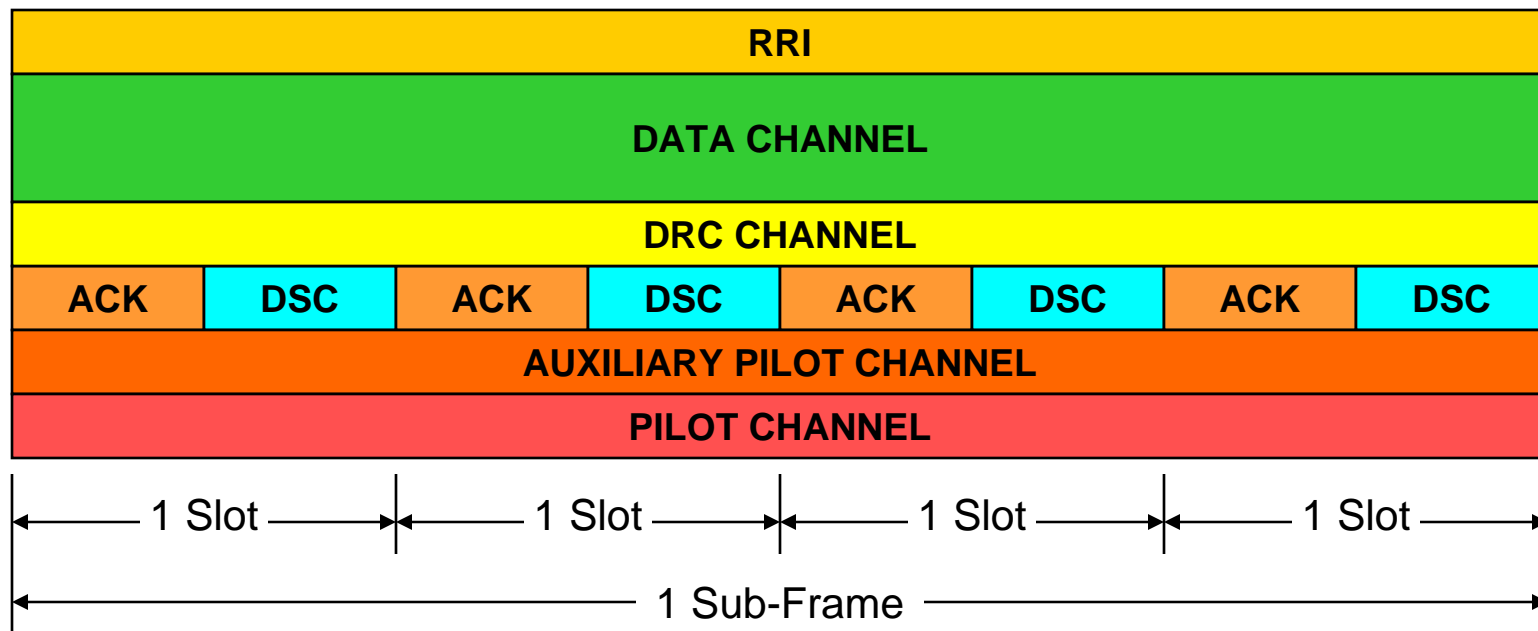
■ Slots make Frames and Frames make Control Channel Cycles!

Reverse Link Frame and Slot Structure: “Big Picture” Summary



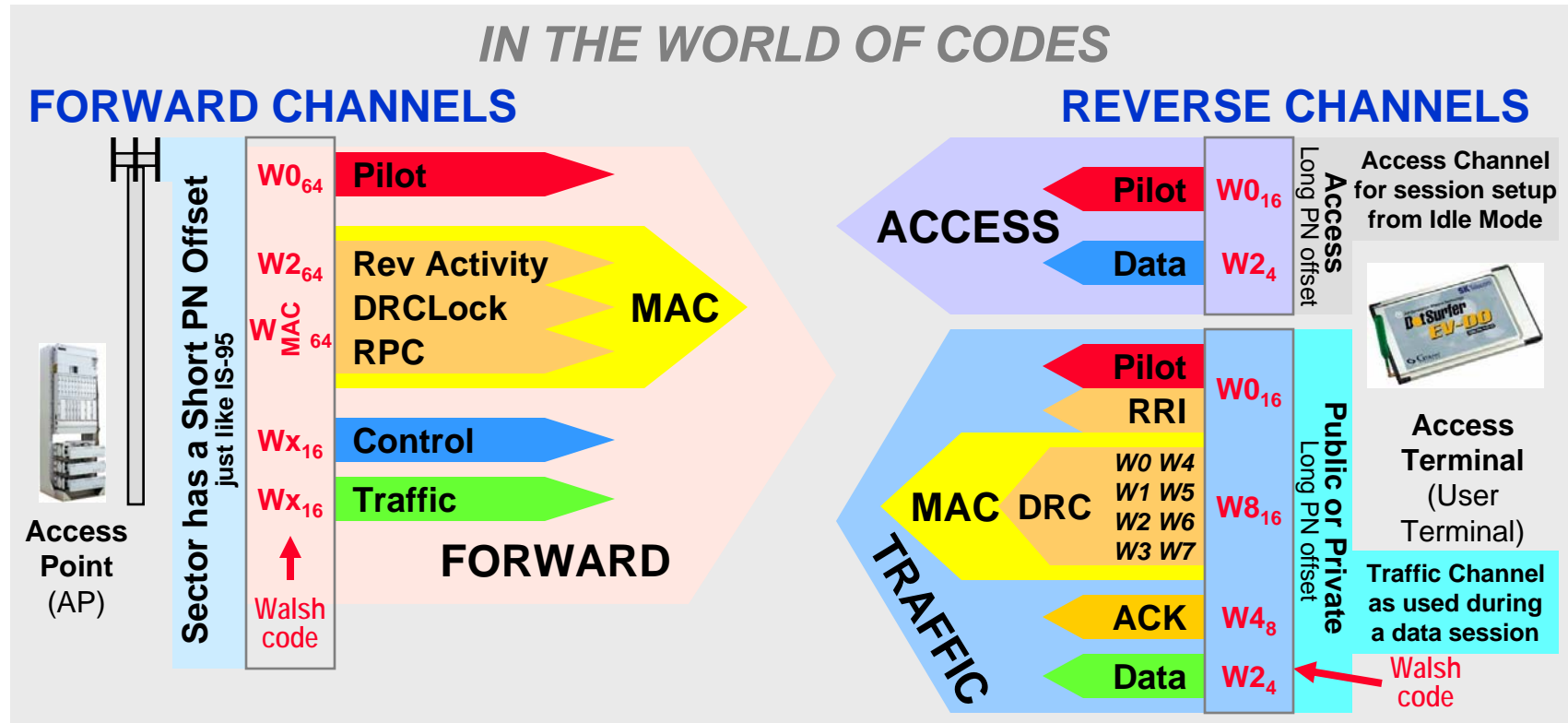
- Reverse Link frames are the same length as forward link frames
- The mobile does not include separate MAC and Pilot bursts
 - Its MAC and pilot functions are carried inside its signal by simultaneous walsh codes
- There is no need for slots for dedicated control purposes since the mobile can transmit on the access channel whenever it needs

Rev. A Reverse Channel Sub-Frame Structure



- The mobile transmits sub-packets occupying four reverse link slots, called a reverse link “sub-frame”.
- If multiple subpackets are required to deliver a packet, the additional subpackets are spaced in every third subframe until done

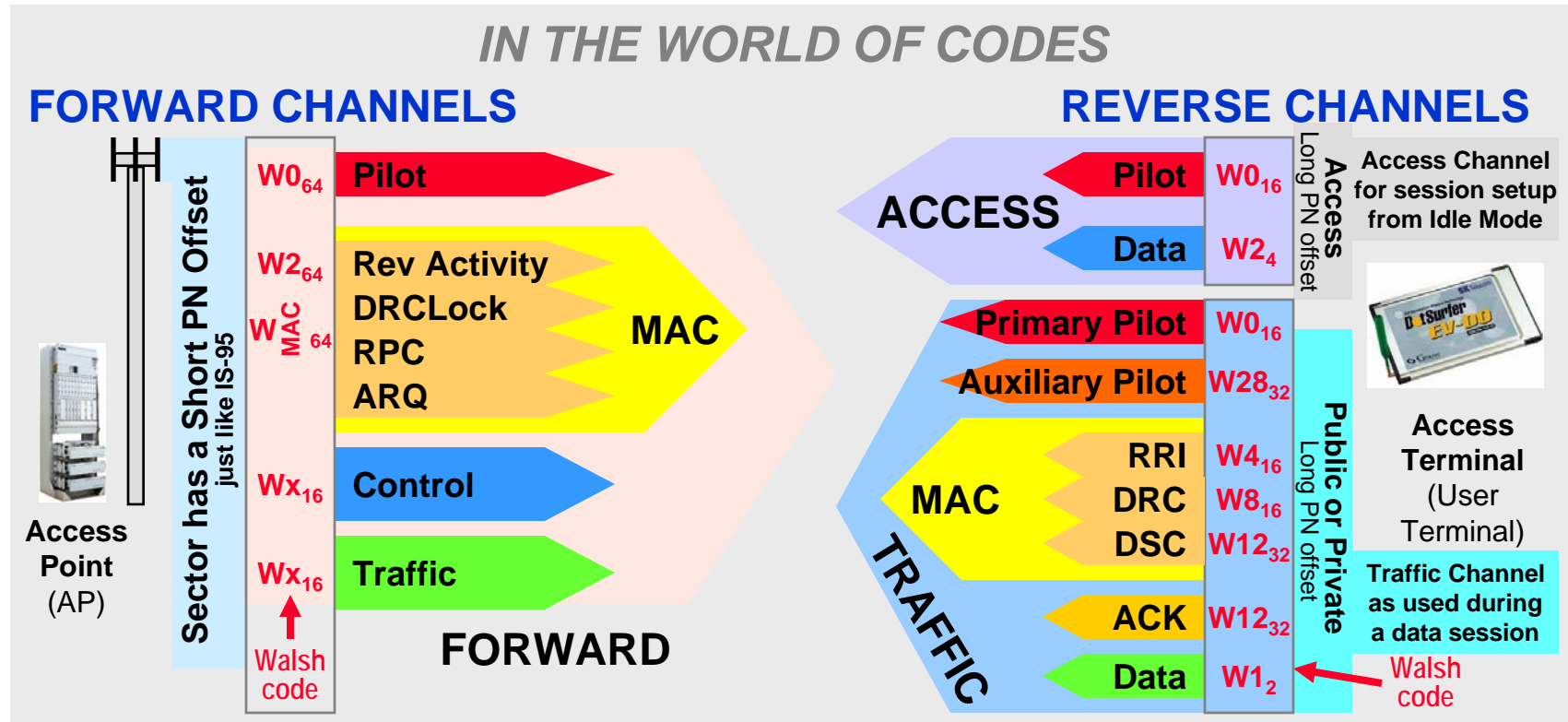
The 1xEV-DO Rev. 0 Channels



■ These channels are NOT CONTINUOUS like IS-95 or 1xRTT!

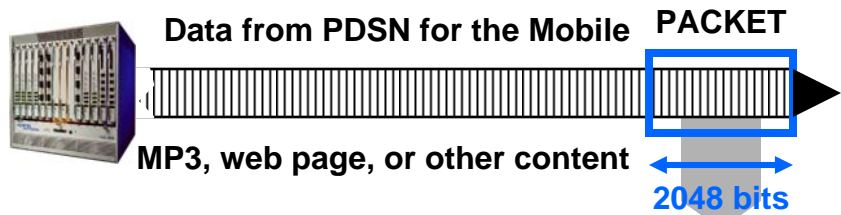
- They are made up of SLOTS carrying data subpackets to individual users or control channel subpackets for everyone to monitor
- Regardless of who “owns” a SLOT, the slot also carries two small generic bursts containing PILOT and MAC information everyone can monitor

EV-DO Rev. A Channels



- The channels are not continuous like ordinary 1xRTT CDMA
- Notice the differences between the MAC channels and the Rev. 0 MAC channels – these are the heart of the Rev. 0/A differences

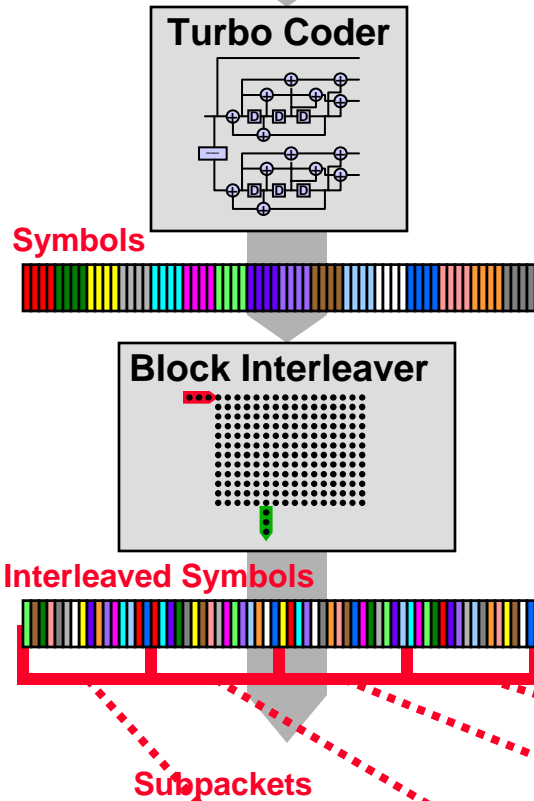
Transmission of a Packet over EV-DO



When the AP is ready, the first subpacket is actually transmitted in a slot. The first subpacket begins with a **preamble** carrying the user's MAC index, so the user knows this is the start of its sequence of subpackets, and how many subpackets are in the sequence..

The user keeps collecting subpackets until either:

- 1) it has been able to reverse-turbo decode the packet contents early, or
- 2) the whole schedule of subpackets has been transmitted.



DRC Index	Slots	Modulation	Preamble Chips	Payload Bits	Raw kb/s	C/I db
0x0	n/a	QPSK	n/a	0	null rate	n/a
0x1	16	QPSK	1024	1024	38.4	-11.5
0x2	8	QPSK	512	1024	76.8	-9.2
0x3	4	QPSK	256	1024	153.6	-6.5
0x4	2	QPSK	128	1024	307.2	-3.5
0x5	4	QPSK	128	2048	307.2	-3.5
0x6	1	QPSK	64	1024	614.4	-0.6
0x7	2	QPSK	64	2048	614.4	-0.5
0x8	2	QPSK	64	3072	921.6	+2.2
0x9	1	QPSK	64	2048	1,228.8	+3.9
0xa	2	16QAM	64	4096	1,228.8	+4.0
0xb	1	8PSK	64	3072	1,843.2	+8.0
0xc	1	16QAM	64	4096	2,457.6	+10.3
0xd	2	16QAM	64	5120	1,536.0	in Rev. A
0xe	1	16QAM	64	5120	3,072.0	in Rev. A



SLOTS

Layer-3 Messages Formats, Parameters, Channels

Dissecting a Layer-3 Message

- 1xEV-DO messages on both forward and reverse traffic channels are normally sent via dim-and-burst
- Messages include many fields of binary data
- The first byte of each message identifies message type: this allows the recipient to parse the contents
- To ensure no messages are missed, all 1xEV-DO messages bear serial numbers and important messages contain a bit requesting acknowledgment
- Messages not promptly acknowledged are retransmitted several times. If not acknowledged, the sender may release the call
- Field data processing tools capture and display the messages for study

EXAMPLE:
**TRAFFIC CHANNEL
 ASSIGNMENT
 MESSAGE**

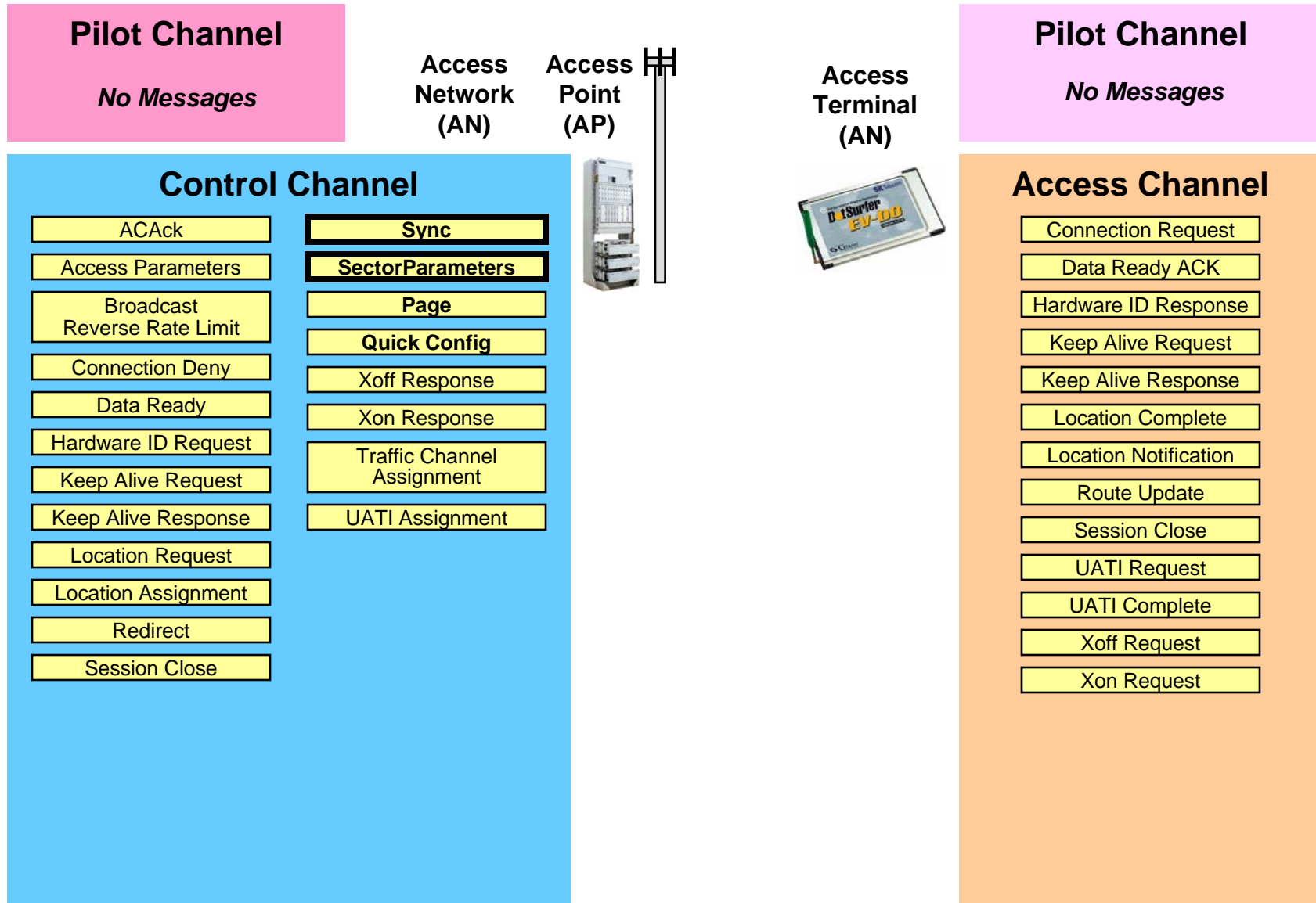
Field	Length (in bits)
MESSAGE ID	8
MESSAGE SEQUENCE	8
CHANNEL INCLUDED	1
CHANNEL	0 or 24
FRAME OFFSET	4
DRC LENGTH	2
DRC CHANNEL GAIN	6
ACK CHANNEL GAIN	6
NUM PILOTS	4

NUMPILOTS occurrences of this block:

PILOT PN	9
SOFTER HANDOFF	1
MAC INDEX	6
DRC COVER	3
RAB LENGTH	2
RAB OFFSET	3



Message Vocabulary: Acquisition & Idle States



Message Vocabulary: Connected State

Forward Traffic Channel

Access Point (AP)



ANKey Complete	Session Close
Attribute Override	Traffic Channel Assignment
Configuration Complete	UATI Assignment
Configuration Request	Unicast Reverse Rate Limit
Configuration Response	Xoff Response
Configuration Start	Xon Response
Connection Close	
Data Ready	
Hardware ID Request	
Keep Alive Request	
Keep Alive Response	
Key Request	
Location Assignment	
Location Request	
Nak	
Neighbor List	
Redirect	
Reset	
Reset ACK	
Reset Report	
RTC ACK	

Reverse Traffic Channel

Access Terminal (AT)



ATKey Complete	Session Close
Attribute Override Response	Traffic Channel Complete
Configuration Complete	UATI Complete
Configuration Request	Xoff Request
Configuration Response	Xon Request
Connection Close	
Data Ready ACK	
Fixed Mode Enable	
Fixed Mode X Off	
Hardware ID Response	
Keep Alive Request	
Keep Alive Response	
Key Response	
Location Complete	
Location Notification	
Nak	
Redirect	
Reset	
Reset ACK	
Route Update	

Message			Sent on Channels								
Name	ID	Inst.	CC	Syn	SS	AC	FTC	RTC	SLP	Addressing	Pri.
ACAck	0x00	1	CC						Best Effort	Unicast	10
Access Parameters	0x01	1	CC						Best Effort	Broadcast	30
ANKey Complete	0x02	1					FTC		Reliable	Unicast	40
ATKey Complete	0x03	1						RTC	Reliable	Unicast	40
Attribute Override	0x05	1					FTC		Best Effort	Unicast	40
Attribute Override Response	0x06	1						RTC	Best Effort	Unicast	40
Broadcast Reverse Rate Limit	0x01	1	CC						Best Effort	Broadcast	40
Configuration Complete	0x00	1					FTC	RTC	Reliable	Unicast	40
Configuration Request	0x50	24					FTC	RTC	Reliable	Unicast	40
Configuration Response	0x51	24					FTC	RTC	Reliable	Unicast	40
Configuration Start	0x01	1					FTC		Best Effort	Unicast	40
ConnectionClose	0x00	1					FTC	RTC	Best Effort	Unicast	40
ConnectionDeny	0x02	1	CC						Best Effort	Unicast	40
ConnectionRequest	0x01	1				AC			Best Effort	Unicast	40
DataReady	0x0b	1	CC				FTC		Best Effort	Unicast	40
DataReadyACK	0x0c	1				AC		RTC	Best Effort	Unicast	40
Fixed Mode Enable	0x00	1						RTC	Best Effort	Unicast	40
Fixed Mode X off	0x01	1						RTC	Best Effort	Unicast	40
Hardware ID Request	0x03	2	CC				FTC		Best Effort	Unicast	40
Hardware ID Response	0x04	1				AC		RTC	Rel, Best Eff	Unicast	40
Keep Alive Request	0x02	1	CC			AC	FTC	RTC	Best Effort	Unicast	40
Keep Alive Response	0x03	1	CC			AC	FTC	RTC	Best Effort	Unicast	40
Key Request	0x00	1					FTC		Reliable	Unicast	40
Key Response	0x01	1						RTC	Reliable	Unicast	40
Location Assignment	0x05	1	CC				FTC		Best Effort	Unicast	40
Location Complete	0x06	1				AC		RTC	Rel, Best Eff	Unicast	40
Location Request	0x03	1	CC				FTC		Best Effort	Unicast	40
Location Notification	0x04	1				AC		RTC	Rel, Best Eff	Unicast	40
Nak	0x00	1					FTC	RTC	Best Effort	Unicast	50
Neighbor List	0x00	1					FTC		Reliable	Unicast	40
Page	0x00	1			SS				Best Effort	Unicast	20
Quick Config	0x00	1			SS				Best Effort	Broadcast	10
Redirect	0x00	1	CC				FTC	RTC	Best Effort	Bcst, Unicst	40
Reset	0x00	2					FTC	RTC	Best Effort	Unicast	40
Reset ACK	0x01	2					FTC	RTC	Best Effort	Unicast	40
Reset Report	0x03	1					FTC		Reliable	Unicast	40
Route Update	0x00	1				AC		RTC	Rel, Best Eff	Unicast	20
RTCAck	0x00	1					FTC		Reliable	Unicast	10
SectorParameters	0x01	1	CC	SYN	SS				Best Effort	Broadcast	30
Session Close	0x01	1	CC			AC	FTC	RTC	Best Effort	Unicast	40
Sync	'00'	1	CC	SYN	SS				Best Effort	Broadcast	30
Traffic Channel Assignment	0x01	1	CC				FTC		Rel, Best Eff	Unicast	20
Traffic Channel Complete	0x02	1						RTC	Reliable	Unicast	40
UATI Assignment	0x01	1	CC				FTC		Best Effort	Unicast	10
UATI Complete	0x02	1				AC		RTC	Rel, Best Eff	Unicast	10
UATI Request	0x00	1				AC			Best Effort	Unicast	10
Unicast Reverse Rate Limit	0x02	1					FTC		Reliable	Unicast	40
Xoff Request	0x09	1				AC		RTC	Best Effort	Unicast	40
Xoff Response	0x0a	1	CC				FTC		Best Effort	Unicast	40
Xon Request	0x07	1				AC		RTC	Best Effort	Unicast	40
Xon Response	0x08	1	CC				FTC		Best Effort	Unicast	40

All the Messages of 1xEV-DO rev. 0

- In 1xEV-DO, most call processing events are driven by messages
- The MAC channels in both directions are used to carry messages or specific Walsh Masks to convey commands and selection options
- Messages have priority and delivery protocols
- Each message has a channel or channels on which it may be sent
- The structure of all the 1xEV-DO messages is defined in IS-856

Name	ID	CC	SYN	SS	AC	FTC	RTC	SLP	Addressing	Priority
Access Parameters	0x01	CC						Best	Broadcast	30
ANKeyComplete	0x02					FTC		REL	Unicast	40
Application Data	N/A	CC			AC	FTC	RTC	Best	Unicast	=data
ATKeyComplete	0x03						RTC	REL	Unicast	40
Attribute Override	0x05					FTC		Best	Unicast	40
Attribute Override Response	0x06						RTC	Best	Unicast	40
Attribute Update Accept	0x53					FTC	RTC	REL	Unicast	40
Attribute Update Reject	0x54					FTC		REL	Unicast	40
Attribute Update Request	0x52					FTC	RTC	REL	Unicast	40
Broadcast Reverse Rate Limit	0x01	CC						Best	Unicast	40
Configuration Complete	0x00					FTC	RTC	REL	Unicast	40
Configuration Request	0x50					FTC	RTC	REL	Unicast	40
Configuration Response	0x51					FTC	RTC	REL	Unicast	40
Configuration Start	0x01					FTC		Best	Unicast	40
Connection Close	0x00					FTC	RTC	Best	Unicast	40
Connection Deny	0x02	CC						Best	Unicast	40
Connection Failure Report	0x02						RTC	Best	Unicast	40
Connection Failure Report ACK	0x02					FTC		Best	Unicast	40
Connection Request	0x01				AC			Best	Unicast	40
Data Over Signaling	0x14	CC			AC	FTC		Best	Unicast	20.50
Data Over Signaling ACK	0x15	CC			AC	FTC	RTC	Best	Unicast	40
Data Ready	0x0b	CC				FTC		Best	Unicast	40
Data Ready ACK	0x0c				AC		RTC	Best	Unicast	40
Delete Personality	0x07	CC				FTC		REL,Best	Unicast	40
Fixed Mode Enable	0x00						RTC	Best	Unicast	40
Fixed Mode Xoff	0x01						RTC	Best	Unicast	40
Fwd Reservation Ack	0x24				AC		RTC	Best	Unicast	40
Fwd Reservation Off	0x22	CC				FTC		Best	Unicast	40
Fwd Reservation On	0x23	CC				FTC		Best	Unicast	40
Grant	0x03	CC				FTC		Best	Unicast	50
Hardware ID Request	0x03	CC				FTC		Best	Unicast	40
Hardware ID Response	0x04				AC		RTC	REL, Best	Unicast	40
Keep Alive Request	0x02	CC			AC	FTC	RTC	Best	Unicast	40
Keep Alive Response	0x03	CC			AC	FTC	RTC	Best	Unicast	40
Key Request	0x00					FTC		REL	Unicast	40
Key Response	0x01						RTC	REL	Unicast	40
Location Assignment	0x05	CC				FTC		Best	Unicast	40
Location Complete	0x06				AC		RTC	REL, Best	Unicast	40
Location Notification	0x04				AC		RTC	REL, Best	Unicast	40
Location Request	0x03	CC				FTC		Best	Unicast	40
Lock Configuration	0x03					FTC		Best	Unicast	40
Lock Configuration ACK	0x04						RTC	Best	Unicast	40

Rev. A Layer-3 Messages Part 1

Rev. A Layer-3 Messages Part 2

Name	ID	CC	SYN	SS	AC	FTC	RTC	SLP	Addressing	Priority
Nak	0x02					FTC	RTC	Best	Unicast	50
Neighbor List	0x04					FTC		Best	Unicast	40
Page	0x00	CC	SYN					Bestl	Unicast	20
Quick Config	0x00	CC	SYN					Best	Broadcast	10
Redirect	0x00	CC				FTC		Best	Unicast,Broadcast	40
Request	0x01						RTC	Best	Unicast	50
Reservation Accept	0x18	CC			AC	FTC	RTC	Best	Unicast	40
Reservation Off Request	0x17				AC		RTC	Best	Unicast	40
Reservation On Request	0x16				AC		RTC	Best	Unicast	40
Reservation Reject	0x19	CC				FTC		Best	Unicast	40
Reset	0x00					FTC		Best	Unicast	40
Reset ACK	0x01						RTC	Best	Unicast	40
Reset Report	0x03					FTC		Best	Unicast	40
Reset RX Complete	0x0f					FTC	RTC	REL	Unicast	50
Reset RX Indication	0x01					FTC	RTC	REL	Unicast	50
Reset TX Complete	0x0e					FTC	RTC	REL	Unicast	50
Reset TX Indication	0x00					FTC	RTC	REL	Unicast	50
Reset TX Indication ACK	0x0d					FTC	RTC	REL	Unicast	50
Rev Reservation Off	0x1b	CC				FTC		Best	Unicast	40
Rev Reservation On	0x1a	CC				FTC		Best	Unicast	40
Route Update	0x00				AC		RTC	REL, Best	Unicast	20
Route Update Request	0x07	CC				FTC		Best	Unicast	40
RTC Ack	0x00					FTC		Best	Unicast	10
Sector Parameters	0x01	CC	SYN					Best	Broadcast	30
Session Close	0x01	CC			AC	FTC	RTC	Best	Unicast	40
Soft Configuration Complete	0x02					FTC		REL	Unicast	40
Storage BLOB Assignment	0x12	CC				FTC		Best	Unicast	40
Storage BLOB Complete	0x13				AC		RTC	Best	Unicast	40
Storage BLOB Notification	0x11	CC				FTC		Best	Unicast	40
Storage BLOB Request	0x10	CC				FTC		Best	Unicast	40
Sync	00	CC	SYN					Best	Broadcast	30
Traffic Channel Assignment	0x01	CC				FTC		REL, Best	Unicast	20
Traffic Channel Complete	0x02						RTC	Best	Unicast	40
UATI Assignment	0x01	CC				FTC		Best	Unicast	10
UATI Complete	0x02				AC		RTC	REL, Best	Unicast	10
UATI Request	0x00				AC		RTC	Best	Unicast	10
Unicast Reverse Rate Limit	0x02					FTC		Best	Unicast	40
Unlock Configuration	0x05					FTC		Best	Unicast	40
Unlock Configuration ACK	0x06						RTC	Best	Unicast	40
Xoff Request	0x09				AC		RTC	Best	Unicast	40
Xoff Response	0x0a	CC				FTC		Best	Unicast	40
Xon Request	0x07				AC		RTC	Best	Unicast	40
Xon Response	0x08	CC				FTC		Best	Unicast	40

System Acquisition and Synchronization

Sync Message

1/32 chip counter	1/32 Chip Counter		4	
1.25 msec counter	1.25 msec Counter	0xAD 2A BD D6 98 00		01/06/2006 01:46:28
Frequency Band	Band		1	
CDMA Channel Nbr	ChanNum		25	
Pilot PN Offset	PilotPN		216	
Half-slot Reference Counter	HSTR		0	
IS-890 Signaling	Is_hdris890		0	NOT IS-890
Seq Nbr Valid	SeqValid		0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid		0	AckSeqNo is not valid
Packet Fragmented	Frgmented		0	Packet NOT fragmented
Signaling Link Protocol	Reliable		0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo		255	
Seq Nbr of Ack	AckSeqNo		255	
Synchronous Control Channel	SyncCCFlag		1	Synchronous Control Channel Capsule
In Configuration Bit	InConfiguration		0	
Type	Type		11	CONNECTION: Initialization State Protocol
Message ID	MessageID		0	Sync
Maximum Revision	MaximumRevision		1	
Minimum Revision	MinimumRevision		1	
Pilot Pn	Pilot Pn		216	
SystemTime	SystemTime	0x07 39 50 86 F0		

- The Sync message gives the mobile system time and the Pilot PN, along with basic signaling link details.
- After reading this message, the mobile can receive the control channel messages

Access Parameters Message

1/32 chip counter	1/32 Chip Counter	16384	
1.25 msec counter	1.25 msec Counter	0x03 2C BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	1	Synchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	2	MAC: Access Channel MAC Protocol
Message ID	MessageID	1	Access Parameters
Access Cycle Duration	AccessCycleDuration	64	
Access Signature	AccessSignature	0	
Open Loop Adjust	OpenLoopAdjust	79	
Probe Initial Adjust	ProdeInitialAdjust	0	
Probe Num Step	ProdeNumStep	5	
Power Step	PowerStep	8	
Preamble Length	PreambleLength	2	
Capsule Length Max	CapsuleLengthMax	2	
APersistence	APersistence	0	
APersistence	APersistence	0	
APersistence	APersistence	0	
APersistence	APersistence	0	
Reserved	Reserved	0	

- The Access Parameters message tells the mobile everything it needs to know to transmit probes correctly on the access channel

Quick Config Message

1/32 chip counter	1/32 Chip Counter		3	
1.25 msec counter	1.25 msec Counter	0xAD 2A BD D6 98 00		01/06/2006 01:46:28
Frequency Band	Band		1	
CDMA Channel Nbr	ChanNum		25	
Pilot PN Offset	PilotPN		216	
Half-slot Reference Counter	HSTR		0	
IS-890 Signaling	Is_hdris890		0	NOT IS-890
Seq Nbr Valid	SeqValid		0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid		0	AckSeqNo is not valid
Packet Fragmented	Frgmented		0	Packet NOT fragmented
Signaling Link Protocol	Reliable		0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo		255	
Seq Nbr of Ack	AckSeqNo		255	
Synchronous Control Channel	SyncCCFlag		1	Synchronous Control Channel Capsule
In Configuration Bit	InConfiguration		0	
Type	Type		15	CONNECTION: Overhead Messages Protocol
Message ID	MessageID		0	Quick Config
Color Code	ColorCode		30	
SectorID 24 LSBits	SectorID24		53506	
Sector Signature	SectorSignature		0	
Access Signature	AccessSignature		0	
Redirecting Terminals away from this Network	Redirect		0	Invalid
Max Nbr of RPC Channels Supported by Sector	RPCCount		0	

- The Quick Config message tells the mobile the sector identify (color code, sector ID, Sector Signature, and Access Signature)
- The redirection flag can be used to send mobiles to a different carrier frequency or network, much like the GSRM in CDMA2000

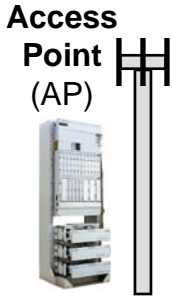
1/32 chip counter	1/32 Chip Counter	49156	
1.25 msec counter	1.25 msec Counter	0xAD 2A BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	1	Synchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	15	CONNECTION: Overhead Messages Protocol
Message ID	MessageID	1	Sector Parameters
Country Code	Country Code	1	
Sector Address Identifier	SectorID	0x00 84 0A C0 00 00 00 00 00 0A 04 0C A8 00 D1 02	
Subnet Mask	SubnetMask	104	
Sector Signature	SectorSignature	0	
Latitude	Latitude	0	00D00'00.00N
Longitude	Longitude	0	00D00'00.00E
Route Update Radius	RouteUpdateRadius	0	
Leap Seconds	LeapSeconds	13	
Local Time Offset	LocalTimeOffset	1568	26 Hours 08 Minutes
Reverse Link Silence Duration	ReverseLinkSilenceDuration	0	0 Frames
Reverse Link Silence Period	ReverseLinkSilencePeriod	0	
Channels Available	ChannelCount	1	
System Type	SystemType	0	System compliant to IS-856
Band Class	BandClass	1	1900MHz Band
Channel Nbr	ChannelNbr	25	
Neighboring Sectors	NeighborCount	14	
Neighbor Pilot PN	NeighborPilotPN	435	
Neighbor Pilot PN	NeighborPilotPN	48	
Neighbor Pilot PN	NeighborPilotPN	384	
Neighbor Pilot PN	NeighborPilotPN	285	
Neighbor Pilot PN	NeighborPilotPN	99	
Neighbor Pilot PN	NeighborPilotPN	321	
Neighbor Pilot PN	NeighborPilotPN	477	
Neighbor Pilot PN	NeighborPilotPN	291	
Neighbor Pilot PN	NeighborPilotPN	267	
Neighbor Pilot PN	NeighborPilotPN	309	
Neighbor Pilot PN	NeighborPilotPN	144	
Neighbor Pilot PN	NeighborPilotPN	159	
Neighbor Pilot PN	NeighborPilotPN	180	
Neighbor Pilot PN	NeighborPilotPN	132	
Neighbor Channel Included	NeighborChannelIncluded	0	Not Included
Neighbor Search Window Size Included	Neighbor SearchWindowSizeIncluded	1	Included
Search Window Size (14)	SearchWindowSize	8	60 Chips
Neighbor Search Window Offset Included	Neighbor SearchWindowOffsetIncluded	0	Not Included

Sector Parameters Message

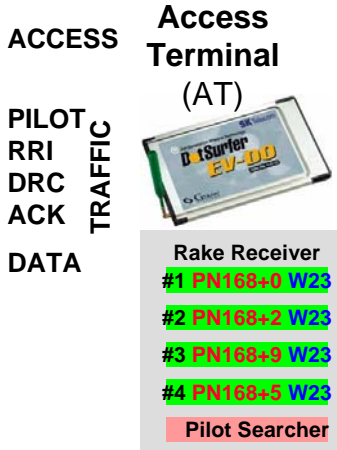
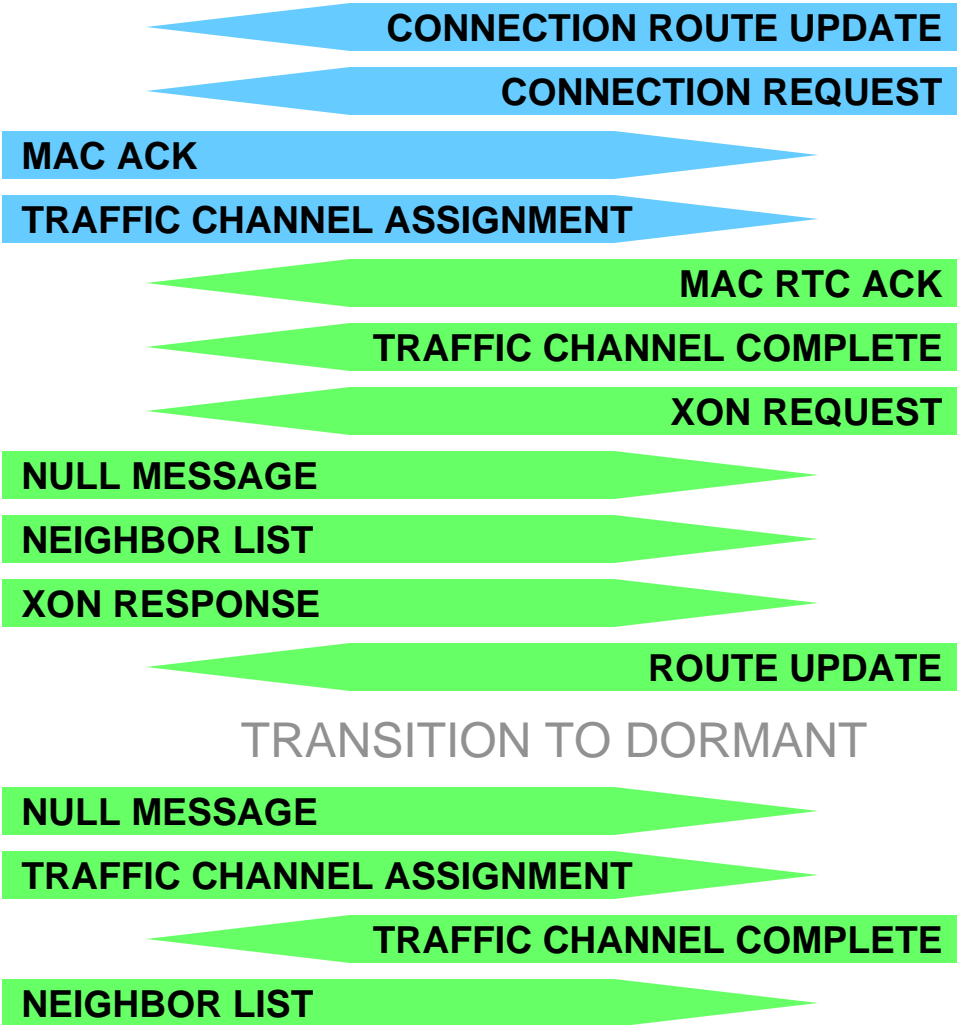
- Gives full details of the sector configuration:
- ID, subnet mask, Lat/Lon, leap sec and local time offset, RL silence, Channels available, system type, band, channel#, neighbor list and search windows/offset

Following a Connection

EV-DO Connection



TRAFFIC CONTROL
MAC
PILOT



Connection: Route Update Message

1/32 chip counter	1/32 Chip Counter	49157	
1.25 msec counter	1.25 msec Counter	0x04 2C BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	14	CONNECTION: Route Update Protocol
Message ID	MessageID	0	Route Update
Message Seq	MessageSeq	136	
Pilot	ReferencePilotPn	216	
Pilot Ec/Io	ReferencePilotStrength	4	0.6 dB
Keep Reference Pilot	ReferenceKeep	1	
Nbr of Pilots	NumPilots	0	

- The Route Update message is really a request for the sectors the mobile wants to have in its active set
 - much like the pilot strength measurement message in CDMA2000
- In this example the mobile asks for only one sector, PN216
 - “Num Pilots 0” means there is just one pilot

Connection Request Message

1/32 chip counter	1/32 Chip Counter	49152	
1.25 msec counter	1.25 msec Counter	0x05 2C BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	12	CONNECTION: Idle State Protocol
Message ID	MessageID	1	Connection Request
Transaction ID	TransactionID	32	
Request Reason	RequestReason	0	Access Terminal Initiated
Reserved	Reserved	0	

- The Connection Request Message is sent by an idle mobile to request entry into active state, creating or joining a session
- This message is sent on the Access Channel. The mobile expects:
 - To hear an acknowledgment on the control channel, or it will send another probe using the access protocol
 - To hear a channel assignment message

AC Ack Message

1/32 chip counter	1/32 Chip Counter	49155	
1.25 msec counter	1.25 msec Counter	0x9A 2C BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	2	MAC: Access Channel MAC Protocol
Message ID	MessageID	0	AC Ack

- The Access Channel ACK message is sent on the forward control channel to tell the mobile its recent probe has been heard by the system
- After hearing this message, the mobile knows it does not to send any further repeated copies of its probe
 - The mobile now waits for some form of channel assignment message

Traffic Channel Assignment Message

1/32 chip counter	1/32 Chip Counter	49153	
1.25 msec counter	1.25 msec Counter	0xB1 2C BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	1	Synchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	14	CONNECTION: Route Update Protocol
Message ID	MessageID	1	Traffic Channel Assignment
Message Seq	MessageSeq	0	
Channel Included	ChannelIncluded	0	Not Included
Frame Offset	FrameOffset	8	
Slots used to Transmit 1 DRC Value	DRCLength	1	2 Slots
DRC Channel Gain	DRCChannelGain	61	30.5 dB
Ack Channel Gain	AckChannelGain	8	4.0 dB
Nbr of Pilots	NumPilots	1	
Pilot Pn	PilotPn	216	
SofterHandoff	SofterHandoff	0	
MacIndex	MacIndex	63	
DRCCover	DRCCover	1	
RAB Length	RABLength	2	32 Slots
RAB Offset	RABOffset	0	0 Slots

- The traffic channel assignment message tells the mobile the sectors in the active set and the MAC index for each, along with DRC length/cover, RAB length/offset, and frame offset

RTC Ack Message

1/32 chip counter	1/32 Chip Counter		2	
1.25 msec counter	1.25 msec Counter	0x00 2D BD D6 98 00		01/06/2006 01:46:28
Frequency Band	Band		1	
CDMA Channel Nbr	ChanNum		25	
Pilot PN Offset	PilotPN		216	
Half-slot Reference Counter	HSTR		0	
IS-890 Signaling	Is_hdris890		0	NOT IS-890
Seq Nbr Valid	SeqValid		1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid		0	AckSeqNo is not valid
Packet Fragmented	Frgmented		0	Packet NOT fragmented
Signaling Link Protocol	Reliable		1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo		0	
Seq Nbr of Ack	AckSeqNo		0	
Synchronous Control Channel	SyncCCFlag		0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration		0	
Type	Type		4	MAC: Reverse Traffic Channel MAC Protocol
Message ID	MessageID		0	RTC Ack

- The mobile sends the RTC Ack message to confirm it has received the channel assignment and is working to apply it

Traffic Channel Complete Message

1/32 chip counter	1/32 Chip Counter		0	
1.25 msec counter	1.25 msec Counter	0x19 2D BD D6 98 00		01/06/2006 01:46:28
Frequency Band	Band		1	
CDMA Channel Nbr	ChanNum		25	
Pilot PN Offset	PilotPN		216	
Half-slot Reference Counter	HSTR		0	
IS-890 Signaling	Is_hdris890		0	NOT IS-890
Seq Nbr Valid	SeqValid		1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid		1	AckSeqNo is valid
Packet Fragmented	Frgmented		0	Packet NOT fragmented
Signaling Link Protocol	Reliable		1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo		0	
Seq Nbr of Ack	AckSeqNo		0	
Synchronous Control Channel	SyncCCFlag		0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration		0	
Type	Type		14	CONNECTION: Route Update Protocol
Message ID	MessageID		2	Traffic Channel Complete
MessageSeq	MessageSeq		0	

- The mobile sends the Traffic Channel Complete message to confirm it has implemented the Traffic Channel assignment given to it by the system.
- Now the system can proceed with any additional signaling for configuration and the actual connection can proceed

X On Request

1/32 chip counter	1/32 Chip Counter		1	
1.25 msec counter	1.25 msec Counter	0x19 2D BD D6 98 00		01/06/2006 01:46:28
Frequency Band	Band		1	
CDMA Channel Nbr	ChanNum		25	
Pilot PN Offset	PilotPN		216	
Half-slot Reference Counter	HSTR		0	
IS-890 Signaling	Is_hdris890		0	NOT IS-890
Seq Nbr Valid	SeqValid		0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid		0	AckSeqNo is not valid
Packet Fragmented	Frgmented		0	Packet NOT fragmented
Signaling Link Protocol	Reliable		0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo		255	
Seq Nbr of Ack	AckSeqNo		0	
Synchronous Control Channel	SyncCCFlag		0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration		0	
Type	Type		22	APPLICATION: Stream 2 Application
Message ID	MessageID		7	XonRequest

- The mobile now requests that data transmission begin, by transmitting an X On request.

Null Message

1/32 chip counter	1/32 Chip Counter	16387	
1.25 msec counter	1.25 msec Counter	0x4C 2D BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	1	AckSeqNo is valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule

■ Null Message

Neighbor List Message

1/32 chip counter	1/32 Chip Counter	32772	
1.25 msec counter	1.25 msec Counter	0x4C 2D BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo	1	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	14	CONNECTION: Route Update Protocol
Message ID	MessageID	4	Neighbor List
Neighbor Count	Count	14	
Pilot PN	PilotPN	435	
Pilot PN	PilotPN	48	
Pilot PN	PilotPN	384	
Pilot PN	PilotPN	285	
Pilot PN	PilotPN	99	
Pilot PN	PilotPN	321	
Pilot PN	PilotPN	477	
Pilot PN	PilotPN	291	
Pilot PN	PilotPN	267	
Pilot PN	PilotPN	309	
Pilot PN	PilotPN	144	
Pilot PN	PilotPN	159	
Pilot PN	PilotPN	180	
Pilot PN	PilotPN	132	
Channel Included (14)	ChannelIncluded	0	Not Included
Search Window Size Included	SearchWindowSizeIncluded	1	Included
Search Window Size (14)	SearchWindowSize	8	60 Chips
Search Window Offset Included	SearchWindowOffsetIncluded	0	Not Included

■ Neighbor PNs, channels, search window sizes and offsets

X On Response

1/32 chip counter	1/32 Chip Counter	16389	
1.25 msec counter	1.25 msec Counter	0x4C 2D BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	22	APPLICATION: Stream 2 Application
Message ID	MessageID	8	XonResponse

- The system confirms whether it has implemented the X On request from the mobile

Route Update Message

1/32 chip counter	1/32 Chip Counter		0
1.25 msec counter	1.25 msec Counter	0x59 2D BD D6 98 00	01/06/2006 01:46:28
Frequency Band	Band		1
CDMA Channel Nbr	ChanNum		25
Pilot PN Offset	PilotPN		216
Half-slot Reference Counter	HSTR		0
IS-890 Signaling	Is_hdris890		0 NOT IS-890
Seq Nbr Valid	SeqValid		1 SeqNo is valid
AckSeqNo valid Ack	AckSeqValid		1 AckSeqNo is valid
Packet Fragmented	Frgmented		0 Packet NOT fragmented
Signaling Link Protocol	Reliable		1 Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo		1
Seq Nbr of Ack	AckSeqNo		1
Synchronous Control Channel	SyncCCFlag		0 Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration		0
Type	Type		14 CONNECTION: Route Update Protocol
Message ID	MessageID		0 Route Update
Message Seq	MessageSeq		137
Pilot	ReferencePilotPn		216
Pilot Ec/Io	ReferencePilotStrength		4 0.6 dB
Keep Reference Pilot	ReferenceKeep		1
Nbr of Pilots	NumPilots		0

- The mobile again reports its desired active pilot set
 - This can include additional desired sectors, or ask to drop unwanted sectors
 - In this example, no change is being made

Broadcast Reverse Rate Limit

1/6/2006 1:46		MAC: Reverse Broadcast Reverse Rate Limit	
1/32 chip counter	1/32 Chip Counter	49152	
1.25 msec counter	1.25 msec Counter	0xB8 2E BD D6 98 00	01/06/2006 01:46:29
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	1	Synchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	4	MAC: Reverse Traffic Channel MAC Protocol
Message ID	MessageID	1	Broadcast Reverse Rate Limit
RPC Count	RPCCount	1	
Rate Limit	RateLimit	5	153.6 kbps
Reserved	Reserved	0	

■ The Broadcast Reverse Rate Limit message tells EV-DO rev. 0 mobiles the maximum permitted reverse link transmit rate

- Mobiles start at 9600 bps and dynamically creep upward in speed until they reach this limit, or until the system asks for every mobile to reduce by setting the Reverse Activity bit

■ EV-DO rev. B mobiles use a different mechanism for speed control

Nak Message

1/32 chip counter	1/32 Chip Counter		0
1.25 msec counter	1.25 msec Counter	0xD9 56 BD D6 98 00	01/06/2006 01:46:42
Frequency Band	Band		1
CDMA Channel Nbr	ChanNum		25
Pilot PN Offset	PilotPN		216
Half-slot Reference Counter	HSTR		0
IS-890 Signaling	Is_hdris890		0 NOT IS-890
Seq Nbr Valid	SeqValid		0 SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid		0 AckSeqNo is not valid
Packet Fragmented	Frgmented		0 Packet NOT fragmented
Signaling Link Protocol	Reliable		0 Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo		255
Seq Nbr of Ack	AckSeqNo		0
Synchronous Control Channel	SyncCCFlag		0 Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration		0
Type	Type		22 APPLICATION: Stream 2 Application
Message ID	MessageID		2 Nak

- Mobile sends Application NAK message
 - This indicates the end of transmission

Nak Message

1/32 chip counter	1/32 Chip Counter	32771	
1.25 msec counter	1.25 msec Counter	0x20 47 BD D6 98 00	01/06/2006 01:46:37
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	216	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	22	APPLICATION: Stream 2 Application
Message ID	MessageID	2	Nak

- System sends Application NAK message in response to the mobile
 - Mobile goes to idle state

Page Message

1/32 chip counter	1/32 Chip Counter	49156	
1.25 msec counter	1.25 msec Counter	0x12 C0 BF D6 98 00	01/06/2006 01:49:59
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	1	Synchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	12	CONNECTION: Idle State Protocol
Message ID	MessageID	0	Page

- Forward control channel Page pages mobile to return to active state

AC Ack Message

1/32 chip counter	1/32 Chip Counter		1	
1.25 msec counter	1.25 msec Counter	0xA5 C0 BF D6 98 00		01/06/2006 01:49:59
Frequency Band	Band		1	
CDMA Channel Nbr	ChanNum		25	
Pilot PN Offset	PilotPN		12	
Half-slot Reference Counter	HSTR		0	
IS-890 Signaling	Is_hdris890		0	NOT IS-890
Seq Nbr Valid	SeqValid		0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid		0	AckSeqNo is not valid
Packet Fragmented	Frgmented		0	Packet NOT fragmented
Signaling Link Protocol	Reliable		0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo		255	
Seq Nbr of Ack	AckSeqNo		255	
Synchronous Control Channel	SyncCCFlag		0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration		0	
Type	Type		2	MAC: Access Channel MAC Protocol
Message ID	MessageID		0	AC Ack

- Control Channel MAC protocol sends this Access Channel AC Ack message to confirm the mobile's probe has been heard

RTC Ack Message

1/32 chip counter	1/32 Chip Counter	16384	
1.25 msec counter	1.25 msec Counter	0x9B C1 BF D6 98 00	01/06/2006 01:50:00
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo	0	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	4	MAC: Reverse Traffic Channel MAC Protocol
Message ID	MessageID	0	RTC Ack

■ Mobile acknowledges system

Traffic Channel Complete

1/32 chip counter	1/32 Chip Counter	32771	
1.25 msec counter	1.25 msec Counter	0xAD C1 BF D6 98 00	01/06/2006 01:50:00
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid	1	AckSeqNo is valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo	0	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	14	CONNECTION: Route Update Protocol
Message ID	MessageID	2	Traffic Channel Complete
MessageSeq	MessageSeq	0	

■ Mobile acknowledges it is using the traffic channel

Null Message

1/32 chip counter	1/32 Chip Counter	32770	
1.25 msec counter	1.25 msec Counter	0xEB C1 BF D6 98 00	01/06/2006 01:50:00
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	1	AckSeqNo is valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule

■ Forward Traffic Channel

Neighbor List Message

1/32 chip counter	1/32 Chip Counter	49155	
1.25 msec counter	1.25 msec Counter	0xEB C1 BF D6 98 00	01/06/2006 01:50:00
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo	1	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	14	CONNECTION: Route Update Protocol
Message ID	MessageID	4	Neighbor List
Neighbor Count	Count	9	
Pilot PN	PilotPN	267	
Pilot PN	PilotPN	495	
Pilot PN	PilotPN	180	
Pilot PN	PilotPN	99	
Pilot PN	PilotPN	312	
Pilot PN	PilotPN	45	
Pilot PN	PilotPN	159	
Pilot PN	PilotPN	132	
Pilot PN	PilotPN	63	
Channel Included (9)	ChannellIncluded	0	Not Included
Search Window Size Included	SearchWindowSizeIncluded	1	Included
Search Window Size (9)	SearchWindowSize	8	60 Chips
Search Window Offset Included	SearchWindowOffsetIncluded	0	Not Included

■ Forward traffic channel

Route Update Message

1/32 chip counter	1/32 Chip Counter	16387	
1.25 msec counter	1.25 msec Counter	0x02 C2 BF D6 98 00	01/06/2006 01:50:00
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid	1	AckSeqNo is valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo	1	
Seq Nbr of Ack	AckSeqNo	1	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	14	CONNECTION: Route Update Protocol
Message ID	MessageID	0	Route Update
Message Seq	MessageSeq	141	
Pilot	ReferencePilotPn	12	
Pilot Ec/Io	ReferencePilotStrength	18	0.1 dB
Keep Reference Pilot	ReferenceKeep	1	
Nbr of Pilots	NumPilots	1	
Pn Offset	PilotPnPhase	31690	
Channel Included	ChannellIncluded	0	Not Included
Ec/Io	PilotStrength	19	0.1 dB
Pilot Drop Timer Not Expired	Keep	1	

- The mobile requests its desired active set.
- This time there are two pilots, PN offset 12 and PN phase 31690

Null Message

1/32 chip counter	1/32 Chip Counter	32769	
1.25 msec counter	1.25 msec Counter	0x42 C2 BF D6 98 00	01/06/2006 01:50:00
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	1	AckSeqNo is valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	1	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule

■ Forward traffic channel null message

Traffic Channel Assignment Message

1/32 chip counter	1/32 Chip Counter	49157	
1.25 msec counter	1.25 msec Counter	0x52 C2 BF D6 98 00	01/06/2006 01:50:00
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo	2	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	14	CONNECTION: Route Update Protocol
Message ID	MessageID	1	Traffic Channel Assignment
Message Seq	MessageSeq	1	
Channel Included	ChannelIncluded	0	Not Included
Frame Offset	FrameOffset	7	
Slots used to Transmit 1 DRC Value	DRCLength	2	4 Slots
DRC Channel Gain	DRCChannelGain	58	29.0 dB
Ack Channel Gain	AckChannelGain	8	4.0 dB
Nbr of Pilots	NumPilots	2	
Pilot Pn	PilotPn	12	
SofterHandoff	SofterHandoff	0	
MacIndex	MacIndex	63	
DRCCover	DRCCover	1	
RAB Length	RABLength	2	32 Slots
RAB Offset	RABOffset	0	0 Slots
Pilot Pn	PilotPn	495	
SofterHandoff	SofterHandoff	0	
MacIndex	MacIndex	62	
DRCCover	DRCCover	2	
RAB Length	RABLength	2	32 Slots
RAB Offset	RABOffset	0	0 Slots

■ Forward Traffic Channel. Note PNs, MAC indices, DRC and RA

Traffic Channel Complete

1/32 chip counter	1/32 Chip Counter	49155	
1.25 msec counter	1.25 msec Counter	0x57 C2 BF D6 98 00	01/06/2006 01:50:00
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	1	SeqNo is valid
AckSeqNo valid Ack	AckSeqValid	1	AckSeqNo is valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	1	Signaling Link Protocol delivery mechanism was reliable
Seq Nbr of Message	SeqNo	2	
Seq Nbr of Ack	AckSeqNo	2	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	14	CONNECTION: Route Update Protocol
Message ID	MessageID	2	Traffic Channel Complete
MessageSeq	MessageSeq	1	

■ Reverse traffic channel

Connection Close Message

1/32 chip counter	1/32 Chip Counter	32773	
1.25 msec counter	1.25 msec Counter	0x5E C3 C0 D6 98 00	01/06/2006 01:51:22
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	255	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	13	CONNECTION: Connected State Protocol
Message ID	MessageID	0	Connection Close
Reason for Close	CloseReason	0	Normal Close
Suspend Enable	SuspendEnable	0	Disabled

■ Forward traffic channel closes the connection

- Note “Normal Close”, i.e., “this was my idea”

Connection Close Message

1/32 chip counter	1/32 Chip Counter	16389	
1.25 msec counter	1.25 msec Counter	0x73 C3 C0 D6 98 00	01/06/2006 01:51:22
Frequency Band	Band	1	
CDMA Channel Nbr	ChanNum	25	
Pilot PN Offset	PilotPN	12	
Half-slot Reference Counter	HSTR	0	
IS-890 Signaling	Is_hdris890	0	NOT IS-890
Seq Nbr Valid	SeqValid	0	SeqNo is not valid
AckSeqNo valid Ack	AckSeqValid	0	AckSeqNo is not valid
Packet Fragmented	Frgmented	0	Packet NOT fragmented
Signaling Link Protocol	Reliable	0	Signaling Link Protocol delivery mechanism NOT reliable
Seq Nbr of Message	SeqNo	255	
Seq Nbr of Ack	AckSeqNo	0	
Synchronous Control Channel	SyncCCFlag	0	Asynchronous Control Channel Capsule
In Configuration Bit	InConfiguration	0	
Type	Type	13	CONNECTION: Connected State Protocol
Message ID	MessageID	0	Connection Close
Reason for Close	CloseReason	1	Close Reply
Suspend Enable	SuspendEnable	0	Disabled

- Reverse traffic channel. Note “Close Reply” i. e., “it wasn’t my idea but we will since you want to”

Backhaul and Related Considerations

Rate Limitations from Backhaul

- Wireless sites are commonly connected using T-1s or E-1s, depending on local availability
 - In the case of T-1s, the raw rate is 1.544 megabits/second.
 - Accounting for overhead, this translates into a maximum steady throughput of roughly 400 to 450 kb/s per sector on a 3-sector, 1-carrier EV-DO site.
 - If one sector is busy while the other two are only lightly loaded, throughput of roughly 1 mb/s can be obtained on one sector
 - However, early 1xEV-DO cards without support for multiple ARQ instances can only achieve about 400 kb/s throughput even without backhaul limitations
- Solutions under study to relieve backhaul congestion include fiber-based ATM to the sites; multiple-T1s; sites linked by Cable Modems, and other methods

Optimizing the RF Air Interface

Dealing With RF Coverage Anomalies

- It is difficult to build a system without encountering a few coverage holes and without having some sectors that cover more than planned
 - The techniques for identifying and resolving these problems are similar to IS-95 and 1xRTT, with a few modifications
- Detection methods: Area sweeps with EV-DO PN scanners and EV-DO terminals
 - If a sector is in the active set of mobiles in places beyond the line joining its surrounding tier of sites, reduce its coverage
 - Site RF parameters, antenna downtilt, or antenna height
 - If a sector fails to cover its intended area, look for obvious hardware or environmental reasons
 - Repair or correct any such impairments, and if unsuccessful, look for other serving sectors
 - Reradiators are feasible for EV-DO, but setup is tricky

Generating and Optimizing Neighbor Lists

- After coverage of each sector has been studied and adjusted if necessary, neighbor relationships are now stable
- Initial neighbor lists can be generated from propagation prediction modeling or even from drive-test results with AT or PN scanners
- The most reliable way to groom neighbor lists is to use system tools to collect route update requests from each sector. These results can be analyzed in matrix form to determine the frequency of requests for each surrounding sector
 - Sectors with more than 5% of requests are usually added
 - Sectors with less than 1% of requests are usually unnecessary
 - Watch out for sectors that are already neighbors of neighbors and would be unnecessary
 - Watch out for special specific cases where unusual relationships exist because of terrain and busy roadways

Optimizing Search Windows

- The pilot searcher of a mobile must be able to see the pilots of any sectors it may encounter – otherwise route update is impossible
- Timing errors affect pilot searching. Sources include:
 - Timing delay from reference sector to mobile
 - This delay is unknown to the mobile, but it goes into the mobile's reference timing without the mobile's knowledge
 - Timing delay from needed neighbor signal to the mobile
 - This delay is also unknown to the mobile, but it can shift the apparent timing of the desired neighbor either ahead or behind the timing the mobile expects
 - The worst-case error in timing is the propagation delay of a straight line between reference sector and desired sector
 - Neighbor search window can be set to this level initially and possibly reduced if accumulated data later allows
- Active search windows “float” on their individual pilots and do not need to be large enough to handle propagation delay. They only need to accommodate delay spread, which is better measured than calculated.

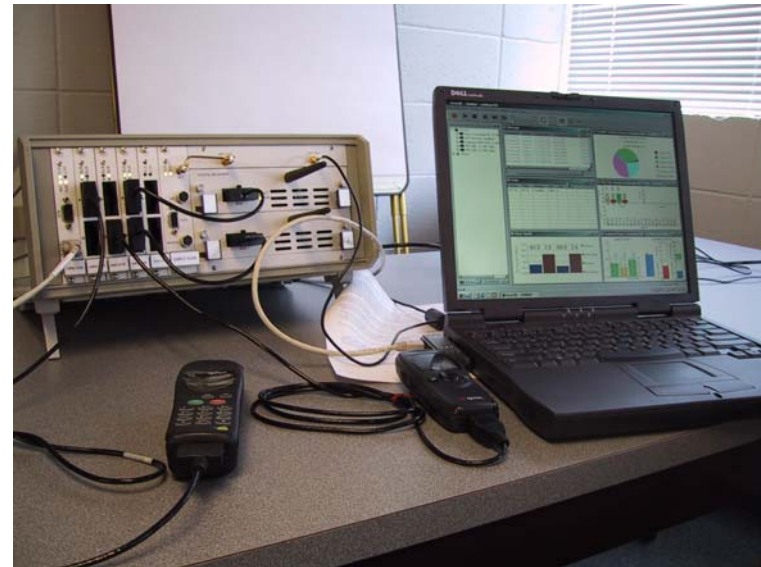
Search Window Offset

Search Window Offset	Offset (PN chips)	-1.5 -1.0 -0.5 0.0 +0.5 +1.0 +1.5
0	0	
1	+0.5 x WindowSize	
2	+1.0 x WindowSize	
3	+1.5 x WindowSize	
4	- 0.5 x WindowSize	
5	-1.0 x WindowSize	
6	-1.5 x WindowSize	
7	reserved	

- Search window offsets make it possible to individually compensate for the great distance of certain sectors from the service area of another
 - The range of adjustment can effectively shift the center of the search window by up to 1.5 times earlier or later than the actual search window width

Andrew's Invex3G Tool

- 100 MB ethernet connection to PC
- the eight card slots can hold receivers or dual-phone cards
- there's also room for two internal PN scanners
- Multiple Invex units can be cascaded for multi-phone load-test applications
- Cards are field-swappable - Users can reconfigure the unit in the field for different tasks without factory assistance

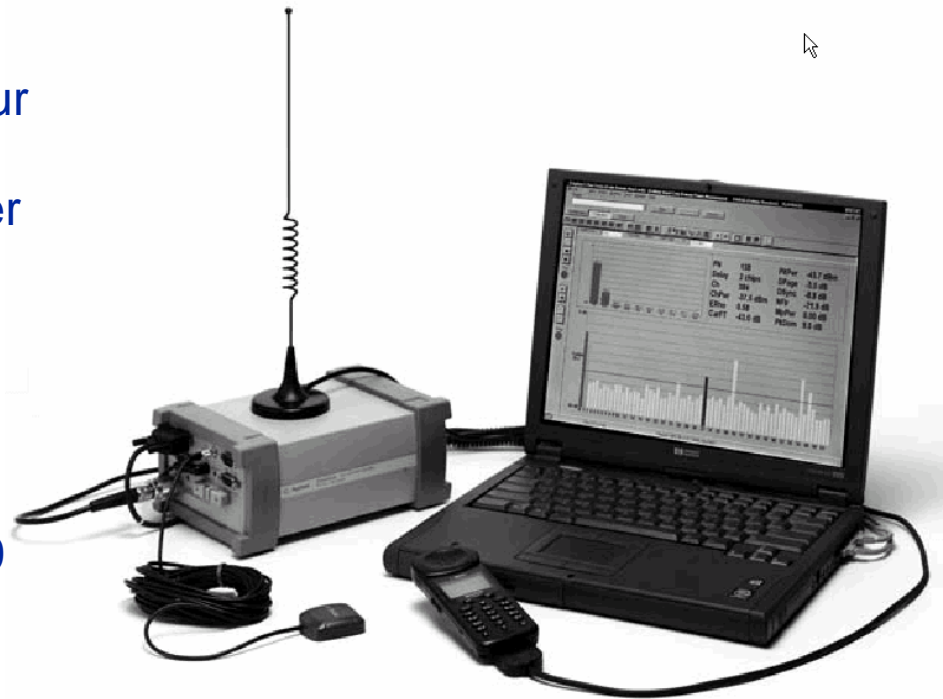


Overview of Field Tool IP Test Capabilities

Application	Description	Purpose
Raw Upload	Uploads data with no overhead (no headers, no handshaking beyond the normal TCP handshaking)	Testing uplink throughput
Raw Download	Downloads data with no overhead (no headers, no handshaking beyond the normal TCP handshaking.)	Testing downlink throughput
Raw Loopback	A loopback (data is sent to the remote server which returns the same data) application with no overhead (no headers, no handshaking beyond the normal TCP handshaking.)	Simultaneous exercise of the uplink and downlink
Ping (ICMP ECHO)	Ping does not use the TCP protocol, but rather uses the connectionless and "unreliable" ICMP protocol. Sends small echo request packets to a remote server, which responds with an echo reply.	Determining round-trip-time between the user and the remote server, as well as general link integrity (by counting the number of missing echo reply packets).
HTTP GET	A standard web page "browse" request.	If Raw Download is unavailable, testing downlink throughput; modeling typical customer use.
HTTP POST	A web-based upload (similar to how web-based email sites allow users to upload files as "attachments").	If Raw Upload is unavailable, testing uplink throughput.
FTP GET	A standard FTP file download. Many file downloads on the Internet use FTP.	If Raw Download and HTTP GET are unavailable, testing downlink throughput; modeling typical customer use.
FTP PUT	A FTP file upload. The file is generated by the Invex3G platform and sent to the server.	If Raw Upload and HTTP POST are unavailable, testing uplink throughput
Mail GET (POP3)	Retrieves all the mail for a given mailbox (e-mail address) from an e-mail server. Note: does not delete the e-mail messages from the mailbox.	Modeling typical customer use.
Wait	Waits a specified amount of time.	Testing idle timers, timeouts, etc.

Agilent Drive-Test Tools

- Agilent offers Drive-Test tools
 - Serial interfaces for up to four CDMA phones or cards
 - A very flexible digital receiver with several modes
- PN Scanner
 - Fast, GPS-locked, can scan two carrier frequencies
- Spectrum Analyzer
 - Can scan entire 800 or 1900 MHz. Bands
- Base-Station Over-Air Tester (BOAT)
 - Can display all Walsh channel activity on a specific sector
 - Useful for identifying hardware problems, monitoring instantaneous traffic levels, etc.
- Post-Processing tool: OPAS32



1xEV-DO Setup Performance: Sessions and Connections

Session Configuration Parameters

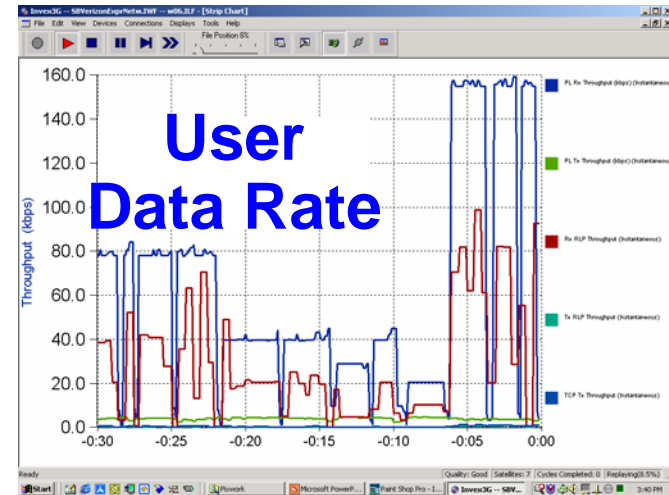
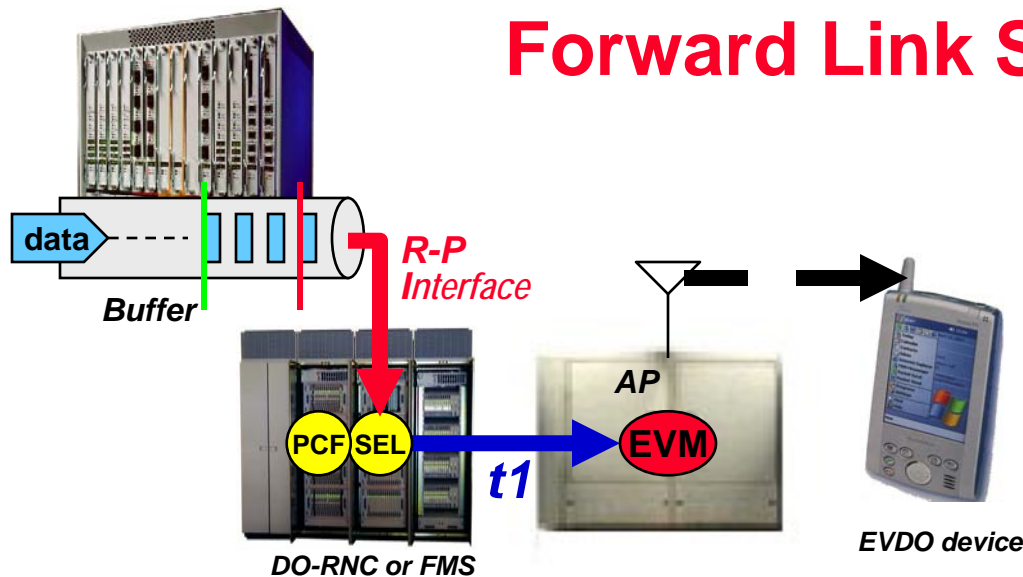
- In initial Session and Connection setup, the access channel and control channel carry the messages
 - If L3 messages and RF indications are available, problems usually can be identified
- Check the access parameters
 - The range of powers should step through a range from the idle-mode noise floor up to about 20 db above it
 - A smaller power range can result in missed probes
 - Check AP/BTS reverse receive levels, peak and average looking for indications of interference
 - Ensure sector size and acquisition search windows are adequate

Long Setup Times and RF Failures

- Long setup times, often seen as bad latency in VOIP and PTT applications, can result when extensive probing occurs. This can be the result of:
 - RF reverse link interference
 - External interference or rogue terminals
 - Incorrect Access Parameters, having mobiles start probing at low RF levels

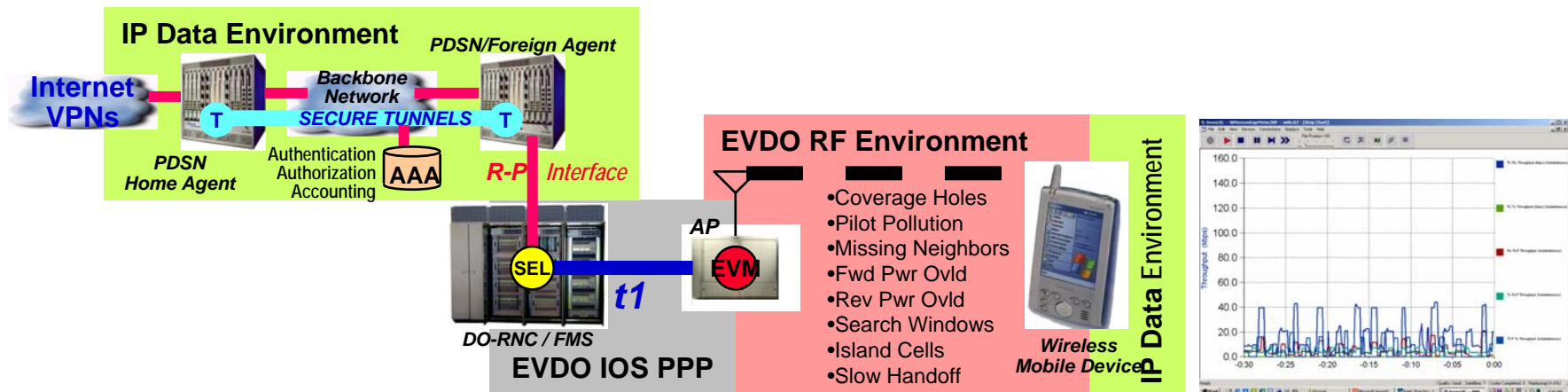
Forward Link Throughput Optimization

Forward Link Scheduler



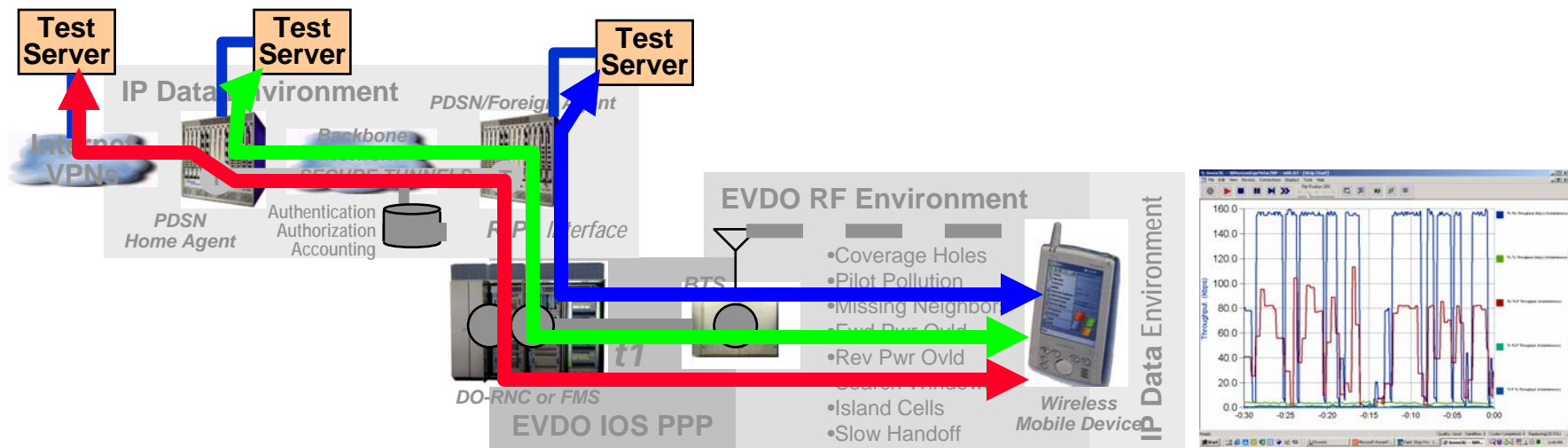
- The main bottleneck is forward link available C/I and timeslots
- Each connected data User has a buffer in the PDSN/PCF complex
 - When data is in the buffer, a “Data Ready” message is sent to the mobile
 - The mobile then requests data from the desired sector on DRC/DSC
 - The scheduler fairly divides slots among the active users
 - “Proportional Fairness” applies, always trying to give slots to each user when that user’s link is better than average
 - This substantially improves (40%+) both user and overall sector throughput
 - QOS (Quality of Service) rules also may be implemented, giving preference to some users and some types of traffic

So S L O W ! ! Where's My Data?!!



- Some sessions have long latency and slow throughput
- Where is the problem? Anywhere between user and distant host:
 - Is the mobile user's data device mis-configured and/or congested?
 - Is the AP congested, with few timeslots available?
 - Poor RF environment, causing low rates and packet retransmission?
 - Congestion in the local IP network (PCU, R-P, PDSN FA)?
 - Congestion in the wireless operator's backbone ('OSSN') network?
 - Congestion in the PDSN HA?
 - Congestion in the outside-world internet or Private IP network?
 - Is the distant host congested, with long response times?

Finding Causes of Latency and Low Throughput



- IP network performance can be measured using test servers
- Problems between mobile a local test server? The problem is local
 - check RF conditions, stats: poor environment, SCH blocking?
 - if the RF is clean, investigate BSC/PCU/R-P/PDSN-FA
- Local results OK, problems accessing test server at PDSN-HA?
 - problem is narrowed to backbone network, or PDSN-HA
- Results OK even through test server at PDSN-HA
 - then the problem is in the public layers beyond.

Reverse Link Throughput Optimization

Reverse Link Rate Control in Rev. A

- Discussion of Reverse Link rate control algorithm
 - Bucket control mechanism
- Available parameters