


The image shows a presentation slide with a blue background. At the top left is the Marmara University logo, which is a circular emblem containing a stylized 'm' and the text 'MARMARA UNIVERSITY' and '1883'. To the right of the logo, the text 'Marmara University, 2021' is displayed in white. A thick white horizontal line separates the header from the main content area. Below this line, the title 'Wireless and Mobile Networks' is written in large, bold, white font. Another thick white horizontal line is positioned below the title. Further down, the text 'Subject 9' and 'CDMA Systems' is shown in a yellow font. At the bottom of the slide, the name 'Mujdat Soyuturk, Ph.D.' and the title 'Associate Professor' are written in white font.

The image shows a presentation slide with a white background and a thin black border. At the top left, the word 'Contents' is written in a large, black, sans-serif font. In the top right corner, there is a circular logo for Marmara University, featuring a stylized 'M' and the text 'MARMARA UNIVERSITY' and '1988'. Below the title, there is a bulleted list of three items: 'CDMA Systems', 'cdmaOne System', and 'CDMA2000 Systems'. At the bottom of the slide, there is a black horizontal bar containing the text '9 - 2' on the left and 'Mujdat Soy Turk, Wireless and Mobile Networks, Spring 2021, Marmara University' on the right.

Contents

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INTRODUCTION

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Introduction

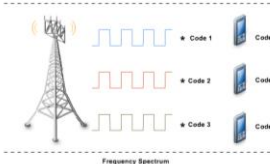



CDMA technology

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Introduction



The diagram illustrates a radio tower on the left, emitting signals. To its right, the frequency spectrum is shown, divided into three distinct bands. Each band contains a unique waveform: a blue square wave for 'Code 1', a red square wave for 'Code 2', and a green square wave for 'Code 3'. To the right of each waveform is a small icon of a mobile phone, labeled 'Code 1', 'Code 2', and 'Code 3' respectively. The entire frequency spectrum section is enclosed in a dashed rectangular border.

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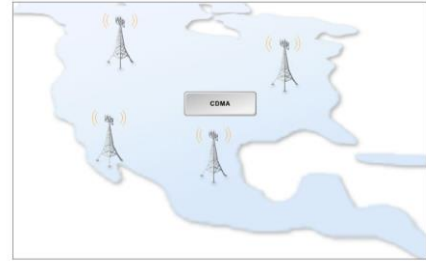
Introduction

CDMA SYSTEMS

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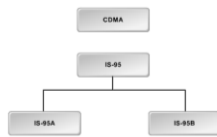
Evolution of Code Division Multiple Access (CDMA) Standards



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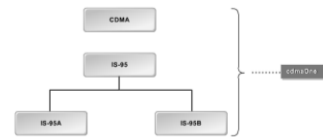
Evolution of Code Division Multiple Access (CDMA) Standards



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Evolution of Code Division Multiple Access (CDMA) Standards



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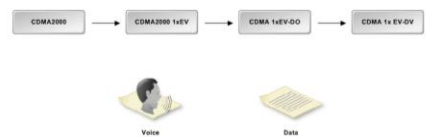
Evolution of Code Division Multiple Access (CDMA) Standards



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Evolution of Code Division Multiple Access (CDMA) Standards



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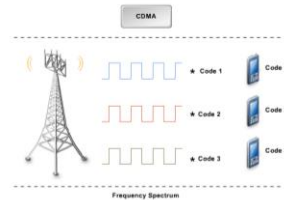
Direct Sequence Spread Spectrum (DSSS) Technique



Direct Sequence Spread Spectrum

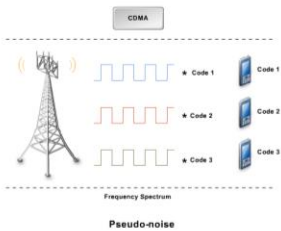
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Direct Sequence Spread Spectrum (DSSS) Technique



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Direct Sequence Spread Spectrum (DSSS) Technique



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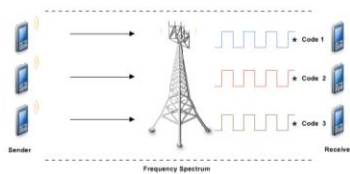
Direct Sequence Spread Spectrum (DSSS) Technique



More than one signal can be transmitted over the same frequency or time span without interference

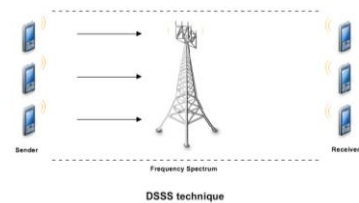
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Direct Sequence Spread Spectrum (DSSS) Technique



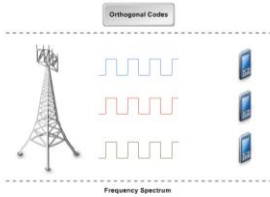
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Direct Sequence Spread Spectrum (DSSS) Technique



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Orthogonal Codes



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Orthogonal Codes



Orthogonal Codes

Code A	1	-1	-1	1
Code B	1	-1	1	-1
Product	1	1	-1	-1
Sum = 1 + 1 - 1 - 1 = 0				

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Orthogonal Codes



Orthogonal Codes

Code A	1	-1	-1	1
Code B	1	-1	1	-1
Product	1	1	-1	-1
Sum = 1 + 1 - 1 - 1 = 0				

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Orthogonal Codes



Orthogonal Codes

Code A	1	-1	-1	1
Code B	1	-1	1	-1
Product	1	1	-1	-1
Sum = 1 + 1 - 1 - 1 = 0				

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Orthogonal Codes



Orthogonal Codes

Code A	1	-1	-1	1
Code B	1	-1	1	-1
Product	1	1	-1	-1
Sum = 1 + 1 - 1 - 1 = 0				

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Orthogonal Codes



Orthogonal Codes

Code A	1	-1	-1	1
Code B	1	-1	1	-1
Product	1	1	-1	-1
Sum = 1 + 1 - 1 - 1 = 0				

Code → Data Channel

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Orthogonal Codes



Orthogonal Codes

Code A	1	-1	-1	1
Code B	1	-1	1	-1
Product	1	1	-1	-1
Sum = 1 + 1 - 1 - 1 = 0				

Orthogonal codes help in transmitting a large number of data channels on the same signal

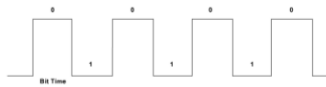
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Digital Representations in CDMA-Based Systems



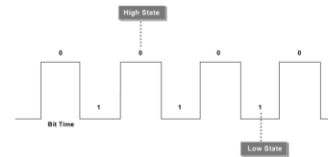
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Digital Representations in CDMA-Based Systems



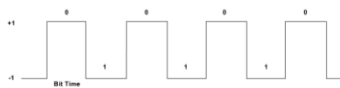
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Digital Representations in CDMA-Based Systems



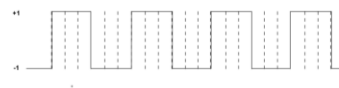
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Digital Representations in CDMA-Based Systems



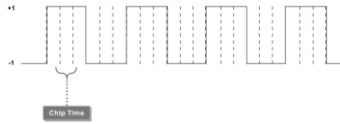
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Digital Representations in CDMA-Based Systems



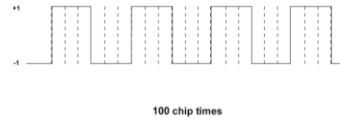
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Digital Representations in CDMA-Based Systems



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Digital Representations in CDMA-Based Systems



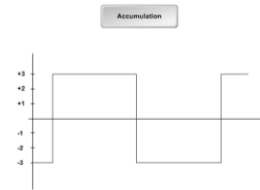
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Digital Representations in CDMA-Based Systems



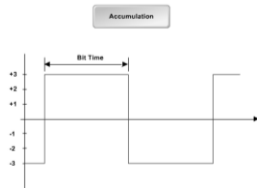
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Accumulation



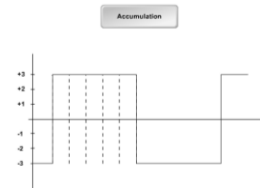
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Accumulation



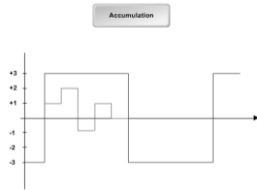
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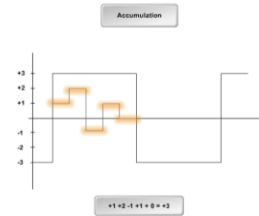
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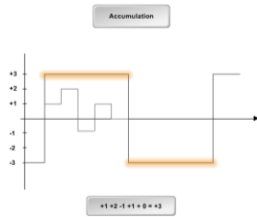
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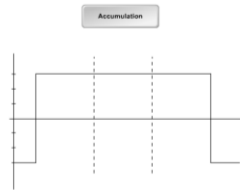
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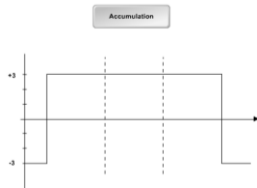
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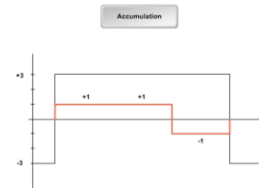
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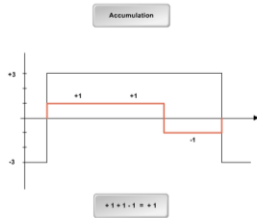
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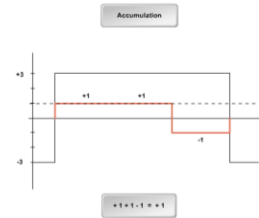
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Accumulation



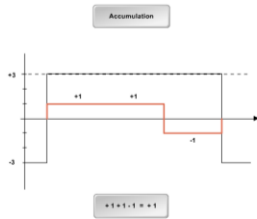
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Accumulation



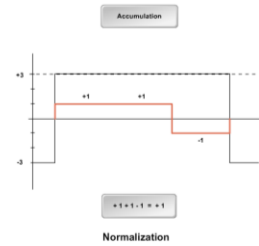
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Accumulation



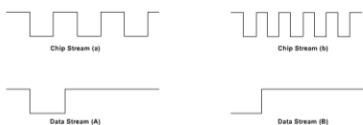
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Accumulation



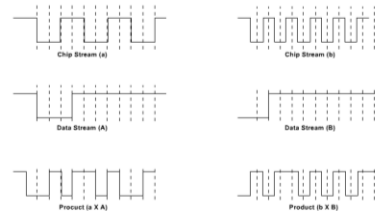
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Process of Transmission of Signal in a CDMA-based System



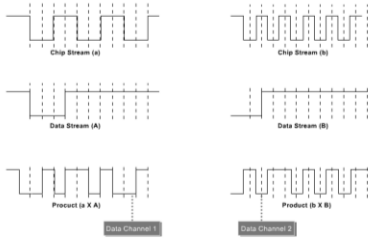
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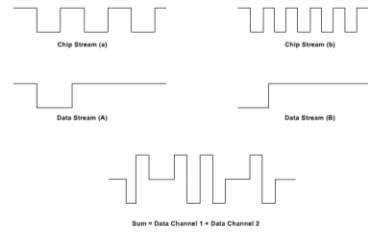
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Process of Transmission of Signal in a CDMA-based System



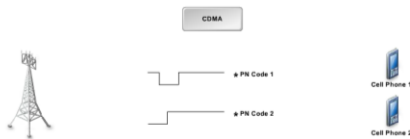
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Process of Transmission of Signal in a CDMA-based System



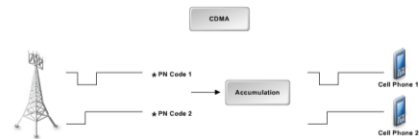
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Process of Reception of Signal in a CDMA-based System



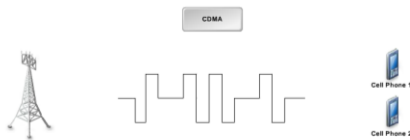
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Process of Reception of Signal in a CDMA-based System



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Process of Reception of Signal in a CDMA-based System



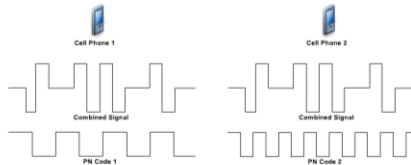
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Process of Reception of Signal in a CDMA-based System



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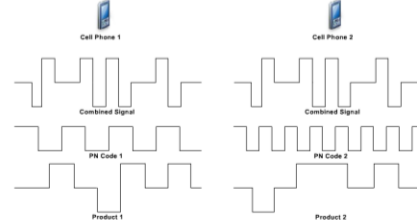
Process of Reception of Signal in a CDMA-based System



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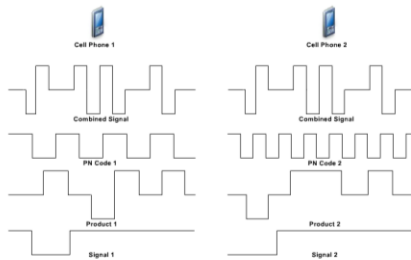
Process of Reception of Signal in a CDMA-based System



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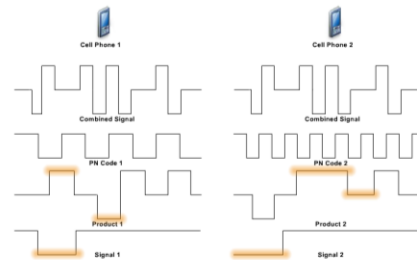
Process of Reception of Signal in a CDMA-based System



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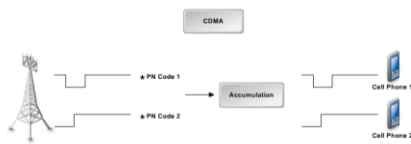
Process of Reception of Signal in a CDMA-based System



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Process of Reception of Signal in a CDMA-based System



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Access method CDMA



- CDMA (Code Division Multiple Access)
 - all terminals send on the same frequency probably at the same time and can use the whole bandwidth of the transmission channel
 - each sender has a PN code, the sender XORs the signal with this PN code
 - the receiver can "tune" into this signal if it knows the PN code, tuning is done via a correlation function
- Disadvantages:
 - higher complexity of a receiver (receiver cannot just listen into the medium and start receiving if there is a signal)
 - all signals should have the same strength at a receiver
- Advantages:
 - all terminals can use the same frequency, no planning needed
 - huge code space (e.g. 2^{23}) compared to frequency space
 - interferences (e.g. white noise) is not coded
 - forward error correction and encryption can be easily integrated

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cdmaOne SYSTEM

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Types of cdmaOne Spreading Codes

Spreading Code	Description
Short PN code	
Long PN code	
Walsh code	

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Types of cdmaOne Spreading Codes

Spreading Code	Description
Short PN code	This code is 32768 chips long. A short PN code takes 26.667 ms to finish one cycle. Short code is a m-sequence of length $2^{15}-1$ (created using a 15 bit LFSR register) and is used for synchronization purpose in the forward as well as reverse links. The short code is also used to identify cell/base station connection in the forward link. It repeats approx 75 times in 2 seconds. Each base station is assigned a cyclically shifted version of same short code sequence to differentiate the base stations. This is also called PN offset in CDMA jargon. Since the cyclically shifted versions of a same m-sequence offer poor correlation, it is easier to differentiate between different base station links.
Long PN code	
Walsh code	During the initial call setup stage, a mobile phone tries to find a base station (in 2 seconds max allowed time). If it find a base station, the mobile phone is validated using a database by the base station and is assigned a PN Short code sequence. This PN short code sequence uniquely identifies the connection between the particular base station and the mobile devices served under that base station.

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Types of cdmaOne Spreading Codes

Spreading Code	Description
Short PN code	
Long PN code	This code is $2^{31}-1$ chips long. The long PN codes are used for encrypting the signals on the traffic channel. A long PN code takes about six weeks to finish one cycle. This being a long code, the cell phone finds it difficult to synchronize itself with the code. The cell phone might have to wait for about six weeks for the code to start, so that the cell phone can retrieve information. This problem is solved by passing on a synchronization message to the cell phone indicating the state or position of the long PN code. It is used for both encryption and spreading. Encryption is achieved by using a mask called Long Code mask which is a created using a 64-bit authentication key called A-key (assigned by CAVE protocol) and Electronic Serial Number (ESN - assigned each user based on the mobile number). The Long code changes each time a new connection is created.
Walsh code	

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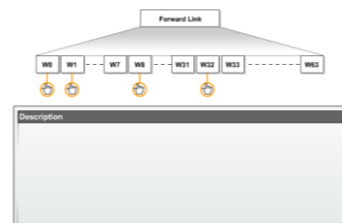
Types of cdmaOne Spreading Codes

Spreading Code	Description
Short PN code	This code is 64 chips long. The code repeats the sequence every 64 chips. A Walsh code takes 52 micro-seconds to finish one cycle. They are numbered as Walsh code 0 to Walsh code 63.
Long PN code	In IS-95 CDMA, 64 Walsh codes are used per base station. This enables to create 64 separate channels per base station (i.e. a base station can handle maximum 64 unique users at a given time). In CDMA-2000 standard, 256 Walsh codes are used to handle maximum 256 unique users under a base.
Walsh code	In cdmaOne, out of the 64 available Walsh codes, Walsh code 0 is reserved for pilot channel, 1 to 7 are assigned for synch channel and paging channels and the remaining 8-63 are assigned for users (traffic channel).

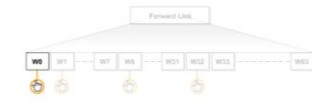
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Forward Link Channels



Forward Link Channels



W0 - Pilot channel
The first channel that a cell phone accesses once turned on. The pilot channel has the strongest power level since it is the channel used by the cell phone to acquire the network.
The data stream on the pilot channel consists of a stream of zeros, which is spread using Walsh code 0, which is also a stream of zeros. Therefore, the resulting data stream is also a stream of zeros. This data stream is further spread with the short PN code. The resultant signal on the paging channel is the short PN code only.
A single short PN code is used across all base stations or cell sectors. In order to distinguish the short PN code used for each cell sector, each short PN code is offset by a certain amount in time.

Pilot channel is a reference channel. It uses the mobile station to acquire the time and as a phase reference for coherent demodulation. It is continuously transmitted by each base station on each active CDMA frequency. And, each mobile station tracks this signal continuously.

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Forward Link Channels



W1-W7 - Paging channel
Used to send paging information to the cell phone, either when it initiates the call or receives a call. The paging channel uses Walsh code 1 to Walsh code 7. It has a data rate of either 4.8 kbps or 96 kbps. The paging channel transmits a list of neighboring base stations along with their timing offsets for their respective short PN code.
Paging Channel's main objective is to send out pages, that is, notifications of incoming calls, to the mobile stations. The base station uses these pages to transmit system overhead information and mobile station specific messages.

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Forward Link Channels



W0-W31 and W32-W63 - Forward traffic channel
Used to transmit voice and data signals. It uses Walsh code 8 to Walsh code 31 and Walsh code 32 to Walsh code 63.

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Forward Link Channels



W32 - Synchronization channel
Provides timing information to the cell phone. It uses Walsh code 32, which is a sequence of thirty-two 0s followed by thirty-two 1s. This channel is synchronized with all other channels of the base station.
The synchronization channel transmits at 1200 bits per second. The slow bit rate ensures a higher accuracy rate, since the cell phone gets sufficient time to decode the message. The sync channel messages include the service provider's ID, the ID of the current metropolitan area, the system time, the position of the long PN code, and the data rate of the paging channel.
Synchronization channel carries a single, repeating message, which gives the information about the time and system configuration to the mobile station. Likewise, the mobile station can have the exact system time by the means of synchronizing to the short code.

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Reverse Link Channels

Reverse Link Channel	Description
Access channel	
Reverse traffic channel	

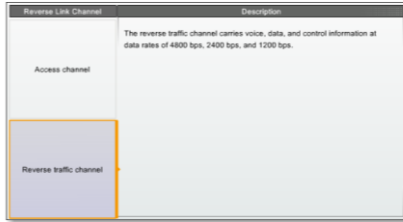
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Reverse Link Channels

Reverse Link Channel	Description
Access channel	The cell phone uses this channel to contact the base station before any traffic channels are assigned to it. It is used in the call origination process. Access channels are also used to respond to the paging channel messages. There are up to 32 access channels for each paging channel. Each access channel uses the short PN codes that are shifted in time to differentiate each access channel.
Reverse traffic channel	Access channel is used by mobile stations to establish a communication with the base station or to answer Paging Channel messages. The access channel is used for short signaling message exchanges such as call-ups, responses to pages and registrations.

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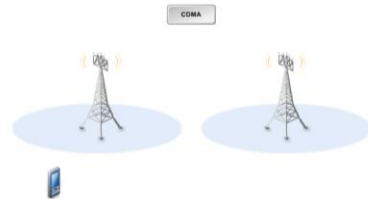
Reverse Link Channels



9 - 79

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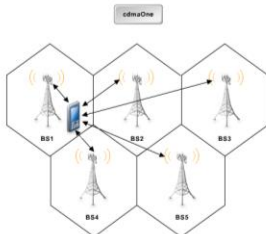
Soft handoff



9 - 80

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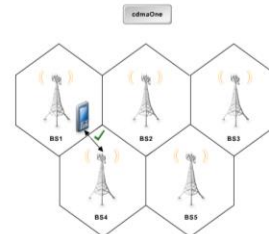
Soft handoff



9 - 81

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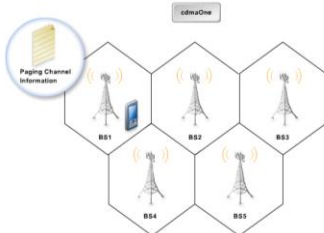
Soft handoff



9 - 82

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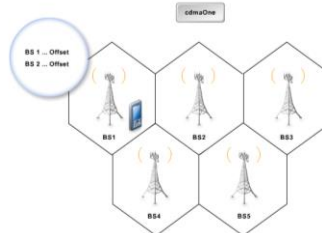
Soft handoff



9 - 83

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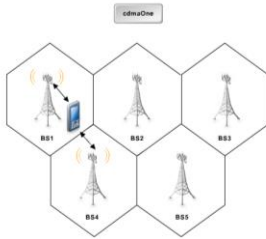
Soft handoff



9 - 84

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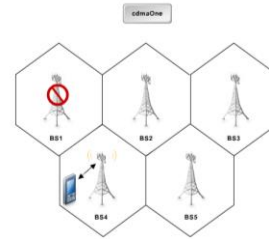
Soft handoff



9 - 85

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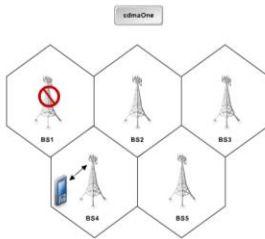
Soft handoff



9 - 86

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Soft handoff

**Soft handoff:**

- Ensures good voice quality.
- Prevents calls from being dropped

9 - 87

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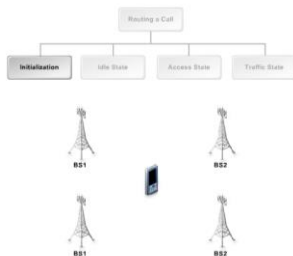
Call Processing in a cdmaOne System



9 - 88

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Call Processing in a cdmaOne System



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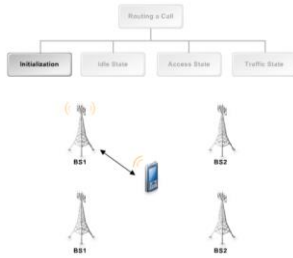
Call Processing in a cdmaOne System



9 - 90

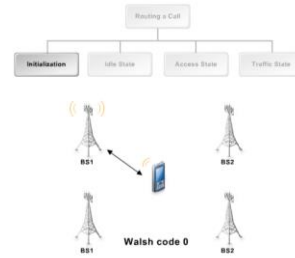
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Call Processing in a cdmaOne System



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Call Processing in a cdmaOne System



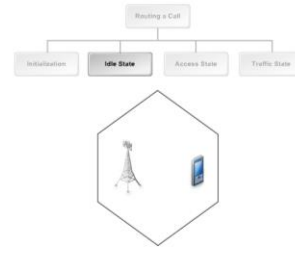
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Call Processing in a cdmaOne System



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Call Processing in a cdmaOne System



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Call Processing in a cdmaOne System



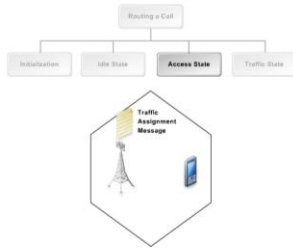
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Call Processing in a cdmaOne System



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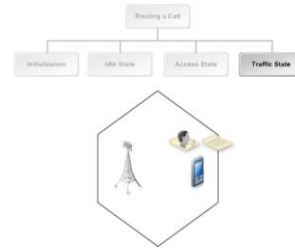
Call Processing in a cdmaOne System



9 - 97

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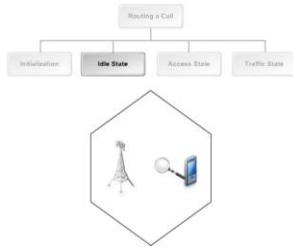
Call Processing in a cdmaOne System



9 - 98

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Call Processing in a cdmaOne System



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CDMA2000 SYSTEMS

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The CDMA2000 Standard



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The CDMA2000 Standard

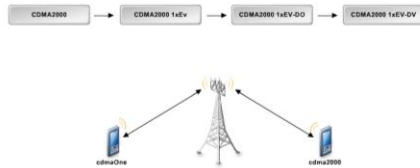


*CDMA 2000 1x EV-DV systems
support high-speed data
and voice transmission*

9 - 102

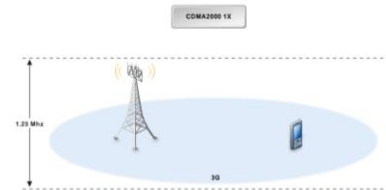
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The CDMA2000 Standard



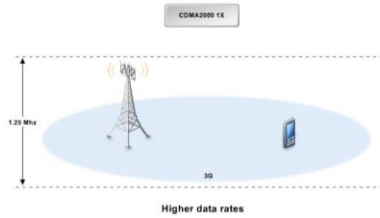
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The CDMA2000 1X Technology



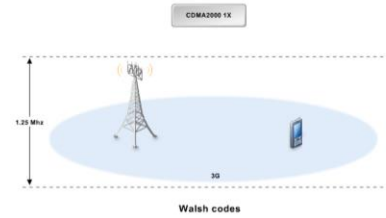
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The CDMA2000 1X Technology



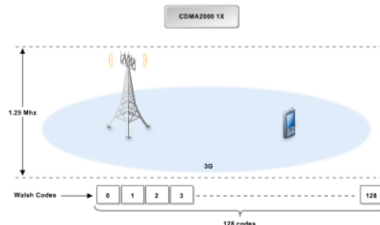
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The CDMA2000 1X Technology



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The CDMA2000 1X Technology



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Beam Formatting

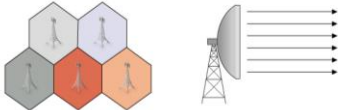


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Beam Formatting



Beam Formatting

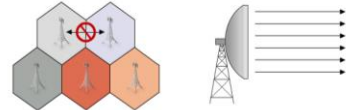


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Beam Formatting



Beam Formatting



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Beam Formatting



Beam Formatting



*Antennas with smaller beams
enable to reuse the same codes*

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Beam Formatting



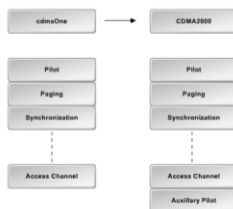
Beam Formatting



Increases data rate

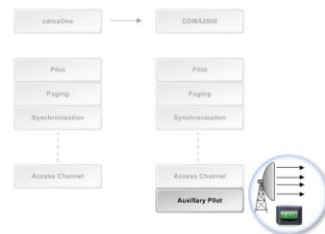
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CDMA2000 Channels



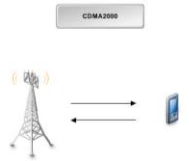
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CDMA2000 Channels



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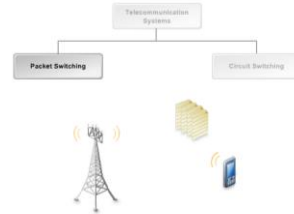
CDMA2000 Channels



Walsh codes differentiate
between different channels

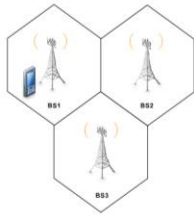
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Packet Switching in CDMA2000 Systems



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CDMA2000 Hanff



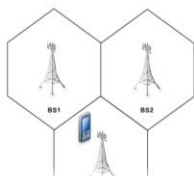
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CDMA2000 Hanff



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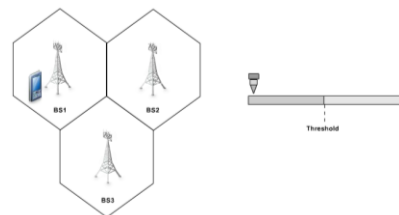
CDMA2000 Hanff



Frequently occurring soft handoffs
hamper network capacity

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CDMA2000 Hanff



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CDMA2000 Hanffoff

