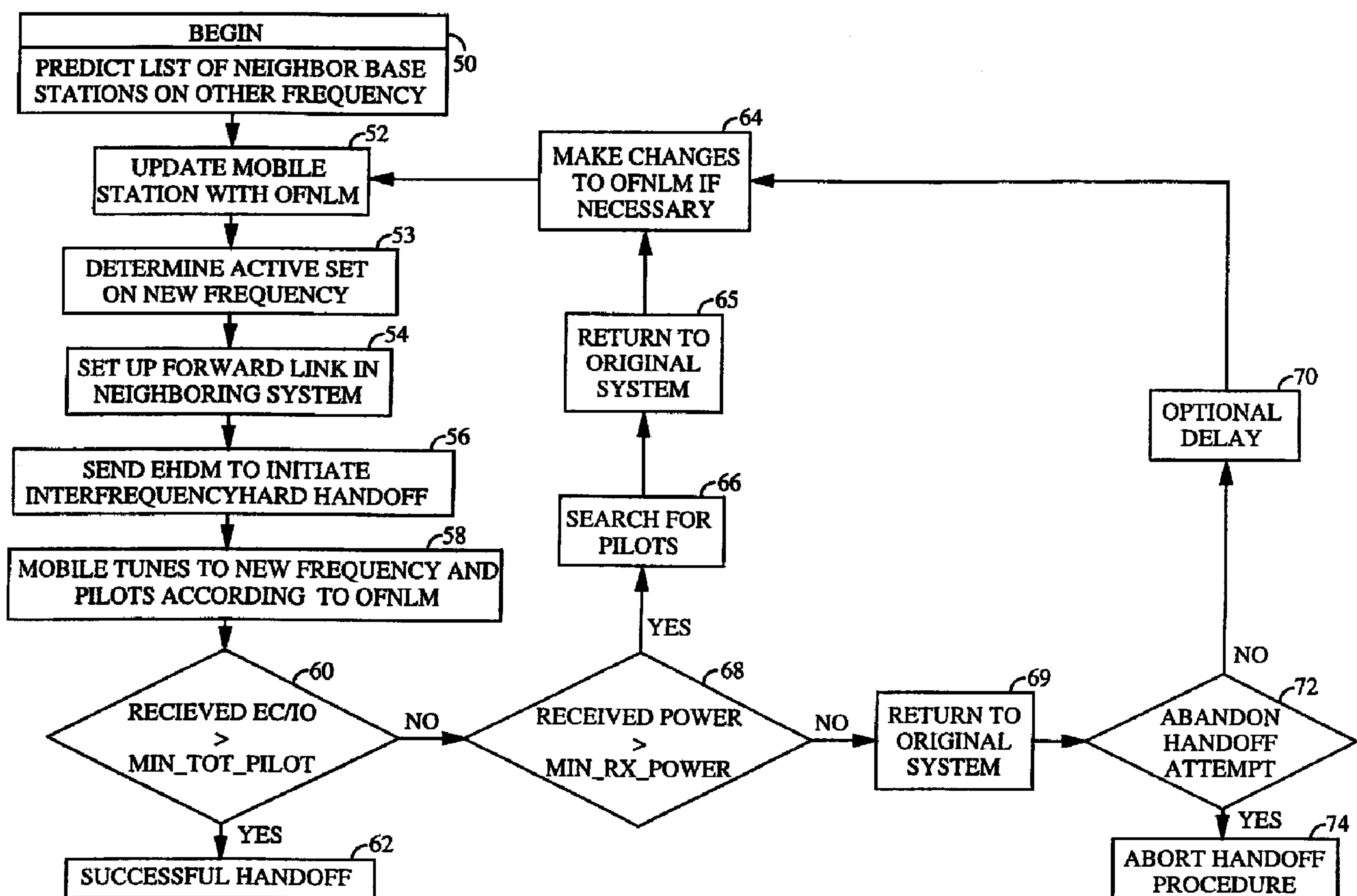




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(54) Titre : PROCEDE ET APPAREIL D'EXECUTION DE TRANSFERT SUR ASSISTE PAR STATION MOBILE ENTRE
DES SYSTEMES DE TELECOMMUNICATIONS
(54) Title: METHOD AND APPARATUS FOR PERFORMING MOBILE ASSISTED HARD HANDOFF BETWEEN
COMMUNICATION SYSTEMS



(57) Abrégé/Abstract:

A method and apparatus for performing inter-system hard handoff between communication systems (S1, S2) or inter-frequency hard handoff within a CDMA communication system is disclosed. The purpose of this invention is to reduce the probability of



(57) **Abrégé(suite)/Abstract(continued):**

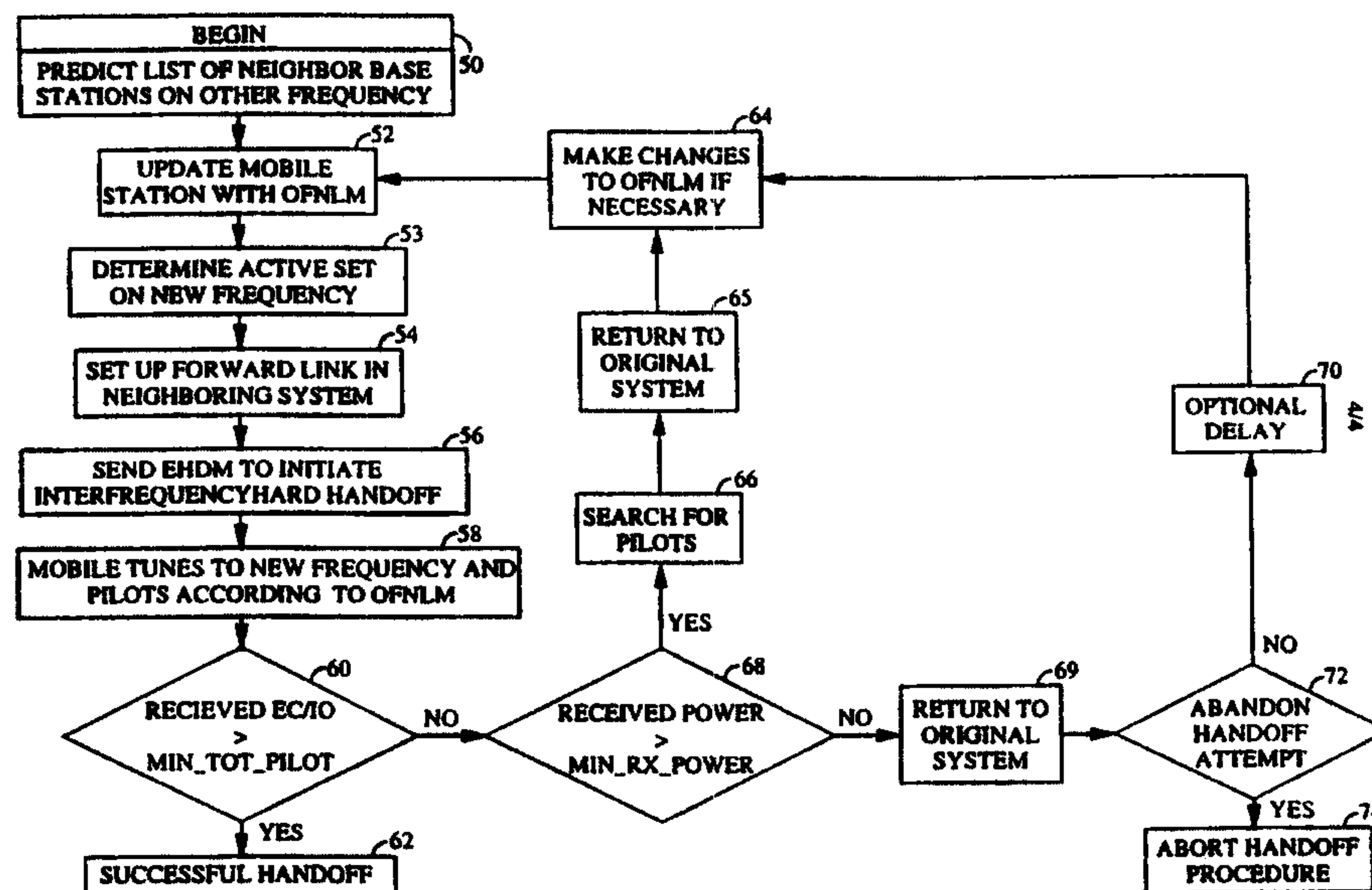
dropped calls during intersystem hard handoff. In the event that a hard handoff attempt is unsuccessful, the mobile station (18) will return to the original system (S1) with information which the communication system of the present invention uses to assist in the performance of future handoff attempts. Alternatively, with no handoff attempt made, the mobile station (18) monitors the destination system (S2), then returns to the original system (S1) with information used to assist in subsequent handoff attempts. The information returned from monitoring a CDMA system consists of results of a search for one or more pilots given at offsets in a specific list provided to the mobile station (18) by the base station (B1-B5) or a set of offsets based upon a predetermined search algorithm.

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(54) Title: METHOD AND APPARATUS FOR PERFORMING MOBILE ASSISTED HARD HANDOFF BETWEEN COMMUNICATION SYSTEMS



(57) Abstract

A method and apparatus for performing inter-system hard handoff between communication systems (S1, S2) or inter-frequency hard handoff within a CDMA communication system is disclosed. The purpose of this invention is to reduce the probability of dropped calls during intersystem hard handoff. In the event that a hard handoff attempt is unsuccessful, the mobile station (18) will return to the original system (S1) with information which the communication system of the present invention uses to assist in the performance of future handoff attempts. Alternatively, with no handoff attempt made, the mobile station (18) monitors the destination system (S2), then returns to the original system (S1) with information used to assist in subsequent handoff attempts. The information returned from monitoring a CDMA system consists of results of a search for one or more pilots given at offsets in a specific list provided to the mobile station (18) by the base station (B1-B5) or a set of offsets based upon a predetermined search algorithm.

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METHOD AND APPARATUS FOR PERFORMING MOBILE ASSISTED HARD HANDOFF BETWEEN COMMUNICATION SYSTEMS

5 BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to communications systems. More
10 particularly, the present invention relates to a novel and improved method
for hard handoff between different wireless communication systems.

II. Description of the Related Art

15 In a code division multiple access (CDMA) spread spectrum
communication system, a common frequency band is used for
communication with all base stations within that system. An example of
such a system is described in the TIA/EIA Interim Standard IS-95-A entitled
"Mobile Station-Base Station Compatibility Standard for Dual-Mode
20 Wideband Spread Spectrum Cellular System". The generation
and receipt of CDMA signals is disclosed in U.S.

Patent No. 4,901,307 entitled "SPREAD SPECTRUM MULTIPLE ACCESS
COMMUNICATION SYSTEMS USING SATELLITE OR TERRESTRIAL
REPEATERS" and in U.S. Patent No. 5,103,459 entitled "SYSTEM AND
25 METHOD FOR GENERATING WAVEFORMS IN A CDMA CELLULAR
TELEPHONE SYSTEM" both of which are assigned to the assignees of the
present invention.

Signals occupying the common frequency band are discriminated at
the receiving station through the spread spectrum CDMA waveform
30 properties based on the use of a high rate pseudonoise (PN) code. A PN code
is used to modulate signals transmitted from the base stations and the
remote stations. Signals from different base stations can be separately
received at the receiving station by discrimination of the unique time offset
that is introduced in the PN codes assigned to each base station. The high
35 rate PN modulation also allows the receiving station to receive a signal
from a single transmission station where the signal has traveled over
distinct propagation paths. Demodulation of multiple signals is disclosed in
U.S. Patent No. 5,490,165 entitled "DEMODULATION ELEMENT
ASSIGNMENT IN A SYSTEM CAPABLE OF RECEIVING MULTIPLE
40 SIGNALS" and in U.S. Patent No. 5,109,390 entitled "DIVERSITY RECEIVER

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IN A CDMA CELLULAR TELEPHONE SYSTEM", both of which are assigned to the assignee of the present invention.

The common frequency band allows simultaneous communication
5 between a remote station and more than one base station, a condition known as soft handoff disclosed in U.S. Patent No. 5,101,501 entitled "SOFT HANDOFF IN A CDMA CELLULAR TELEPHONE SYSTEM" and U.S. Patent No. 5,267,261 entitled "MOBILE STATION ASSISTED SOFT HANDOFF IN A CDMA CELLULAR COMMUNICATIONS SYSTEM", both
10 assigned to the assignee of the present invention. Similarly, a remote station can be simultaneously communicating with two sectors of the same base station, known as softer handoff as disclosed in copending U.S. Patent Application entitled "METHOD AND APPARATUS FOR PERFORMING HANDOFF BETWEEN
15 SECTORS OF A COMMON BASE STATION", Ser. No. 08/405,611, filed March 13, 1995, assigned to the assignee of the present invention. Handoffs are described as soft and softer because they make the new connection before breaking the existing one.

If a mobile station travels outside the boundary of the system with
20 which it is currently communicating, it is desirable to maintain the communication link by transferring the call to a neighboring system, if one exists. The neighboring system may use any wireless technology, examples of which are CDMA, NAMPS, AMPS, TDMA or FDMA. If the neighboring system uses CDMA on the same frequency band as the current system, an
25 inter-system soft handoff can be performed. In situations where inter-system soft handoff is not available, the communication link is transferred through a hard handoff where the current connection is broken before a new one is made. Examples of hard handoffs are those from a CDMA system to a system employing an alternate technology or a call transferred
30 between two CDMA systems which use different frequency bands (inter-frequency hard handoff).

Inter-frequency hard handoffs can also occur within a CDMA system. For example, a region of high demand such as a downtown area may require a greater number of frequencies to service demand than the suburban region
35 surrounding it. It may not be cost effective to deploy all available frequencies throughout the system. A call originating on a frequency deployed only in the high congestion area must be handed off as the user travels to a less congested area. Another example is that of a microwave or other service operating on a frequency within the system's boundaries. As

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users travel into an area suffering from interference from the other service, their call may need to be handed off to a different frequency.

Handoffs can be initiated using a variety of techniques. Handoff techniques, including those using signal quality measurements to initiate
5 handoff, are found in copending U.S. Patent Application number 08/322,817 entitled "METHOD AND APPARATUS FOR HANDOFF BETWEEN DIFFERENT CELLULAR COMMUNICATIONS SYSTEMS", filed October 16, 1994, assigned to the assignee of the present invention.

Further disclosure on handoffs, including
10 measurement of round-trip signal delay to initiate handoff, is disclosed in copending U.S. Patent Application number 08/652,742 entitled "METHOD AND APPARATUS FOR HARD HANDOFF IN A CDMA SYSTEM", filed May 22, 1996, assigned to the assignee of the present invention.

Handoffs from CDMA system to alternate
15 technology systems are disclosed in copending U.S. Patent Application number 08/413,306 ('306 application) entitled "METHOD AND APPARATUS FOR MOBILE UNIT ASSISTED CDMA TO ALTERNATIVE SYSTEM HARD HANDOFF", filed March 30, 1995, assigned to the assignee of the present invention. In the '306 application, pilot
20 beacons are placed at the boundaries of the system. When a mobile station reports these pilots to the base station, the base station knows that the mobile station is approaching the boundary.

When a system has determined that a call should be transferred to another system via hard handoff, a message is sent to the mobile station
25 directing it to do so along with parameters that enable the mobile station to connect with the destination system. The system has only estimates of the mobile station's actual location and environment, so the parameters sent to the mobile station are not guaranteed to be accurate. For example, with beacon aided handoff, the measurement of the pilot beacon's signal strength
30 can be a valid criteria for triggering the handoff. However, the appropriate cell or cells in the destination system which are to be assigned to the mobile station (known as the Active Set) are not necessarily known. Moreover, including all the likely possibilities may exceed the maximum allowable in the Active Set.

35 In order for the mobile station to communicate with the destination system, it must lose contact with the old system. If the parameters given to the mobile station are not valid for any reason, i.e. changes in the mobile station's environment or lack of precise location information at the base station, the new communication link will not be formed, and the call may

be dropped. After an unsuccessful handoff attempt, the mobile station can revert back to the previous system if it is still possible to do so. With no further information and no significant change in the mobile station's environment, repeated attempts to hand off will also fail. Thus, there is a
5 need felt in the art for a method for performing additional hard handoff attempts with greater probability of success.

SUMMARY OF THE INVENTION

10 The purpose of this invention is to reduce the probability of dropped calls during inter-system hard handoff. In the event that a hard handoff attempt is unsuccessful, the mobile station will return to the original system with information which the communication system of the present invention uses to assist in the performance of future handoff attempts.

15 Prior to handoff, the original base station will have a rough estimate of the most likely base stations of a destination system to provide service to a mobile station as it travels into the destination system. In the exemplary embodiment, a message will be sent from the base station to the mobile station containing this list of neighboring base stations in the destination
20 system, a minimum total received power threshold, and a minimum pilot energy threshold. When the base station in the original system has determined that a hard handoff is appropriate, it signals the neighboring base stations in the destination system to begin transmitting forward link traffic to the mobile station entering the system. A first hard handoff is
25 attempted after a message is received by the mobile station from the base station initiating the inter-system hard handoff. The mobile station switches to the frequency of the destination system and attempts to acquire the base stations of the destination system in accordance with the acquisition parameters provided (i.e. the pilot PN offsets). If the minimum pilot energy
30 threshold is exceeded, the handoff is deemed to be successful and the mobile station remains on the destination system.

If the minimum pilot energy threshold is not exceeded, recovery techniques begin. The mobile station measures the total in-band energy of the destination system and compares that to the total received power
35 threshold. If the minimum total received power threshold is not exceeded, the handoff is abandoned immediately. The mobile station returns to the original system and reports that no significant power was detected at the new frequency. If the minimum total received power is exceeded, it is likely that the destination system is available, but that the neighboring base

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stations provided by the original system (referred to as the new Active Set) is not acceptable for communication. The mobile station then performs a search to locate viable pilot signals in the destination system. In general, a list of offsets to search provided to the mobile station will be sufficient to locate available pilots, although other search algorithms can be employed. Upon completion of the search, the mobile station returns to the original system and reports the failure and any pilot signals found in the search which exceeded a third threshold.

If no significant received power was detected or there were no pilots found in the search, the system controller can opt to delay a second attempt at handoff in hopes of a beneficial change in the mobile station's environment. In the alternative, the mobile station can abandon the hard handoff attempt altogether, which would likely result in the eventual dropping of the call. However, in those cases where the destination system is present, the system controller can update the Active Set based on the returned search information, and the destination system can modify the base stations transmitting to the mobile station accordingly. Then a second hard handoff attempt message can be sent to the mobile station. Unless the environment has changed, this second attempt is likely to be successful.

According to a first aspect of the present invention, there is provided in a wireless communication system wherein a mobile station is moving from an area covered by an origination system into an area covered by a first destination system and wherein said mobile station has attempted to acquire said first destination system has failed, a method for avoiding a loss of communication with said mobile station, comprising the steps of: attempting to

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acquire said first destination system by said mobile station; if said attempting to acquire said first destination system failed, then transmitting parameter data from said mobile station to said origination system;
5 receiving at said origination system said parameter data; generating at said origination system a search list of alternative-destination-systems in accordance with said parameter data; and attempting to acquire one of said alternative destination systems in accordance with said
10 search list of alternative destination systems.

According to a second aspect of the present invention, there is provided a method of providing handoff for wireless communication wherein a mobile station is moving from an area covered by an origination system to an
15 area covered by at least one destination system, comprising: predicting first destination systems at the origination system; attempting by the mobile station to connect to said first destination systems; searching for alternate destination systems based on a failure to connect to said
20 first destination systems; attempting to connect the mobile station to said alternate destination systems located by said searching; and reconnecting to the origination system based on a failure to connect to the alternate destination systems located by said searching.

25 According to a third aspect of the present invention, there is provided a mobile station for avoiding a loss of communication in a wireless communication system when said mobile station moves from an area covered by an origination system into an area covered by a first
30 destination system, said mobile station comprising: means for attempting to acquire said first destination system; means for transmitting to said origination system parameter data if means for attempting to acquire said first

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destination system fails to acquire said first destination system; means for receiving from said origination system a search list of alternative destination systems generated by said origination system in accordance with said parameter
5 data; and means for attempting to acquire one of said alternative destination systems in accordance with said search list of alternative destination systems.

According to a fourth aspect of the present invention, there is provided a system for avoiding a loss of
10 communication in a wireless communication system when a mobile station moves from an area covered by said system into an area covered by a first destination system, said system comprising: means for providing coverage to said mobile station within said area covered by said system;
15 means for receiving parameter data from said mobile station if an attempt by said mobile station to acquire said first destination system failed; and means for generating a search list of alternative destination systems in accordance with said parameter data for said mobile station to use in
20 attempting to acquire one of said alternative destination systems.

According to a fifth aspect of the present invention, there is provided a mobile station for providing handoff for wireless communication when said mobile station
25 moves from an area covered by an origination system to an area covered by at least one destination system, said mobile station comprising: means for attempting to connect to first destination systems predicted by said origination system; means for searching for alternate destination systems based
30 on a failure to connect to said first destination systems; means for attempting to connect to said alternate destination systems located by said means for searching for alternate destination systems; and means for reconnecting to

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the origination system based on a failure to connect to the alternate destination systems located by said means for searching for alternate destination systems.

According to a sixth aspect of the present invention, there is provided a system for providing handoff for wireless communication when a mobile station moves from an area covered by said system to an area covered by at least one destination system, said system comprising: means for providing coverage to said mobile station within said area covered by said system; means for predicting first destination systems; and means for reconnecting the mobile station to the system based on a failure to connect the mobile station to alternate destination systems located by searching, after the mobile system attempted to connect to said first destination systems and searched for said alternate destination systems based on a failure to connect the mobile station to said first destination systems.

According to a seventh aspect of the present invention, there is provided in a wireless communication system wherein a mobile station is moving from the coverage area of an origination system operating at a first frequency into the coverage area of a destination system operating at a second frequency, a method for providing handoff from said origination system to said destination system, the method comprising: predicting at least one PN offset associated with the destination system; transmitting, at the first frequency, from said origination system to said mobile station a set of search parameter data associated with the at least one PN offset; determining at said mobile station the availability of said destination system in accordance with said set of search parameter data; transmitting from said mobile station to said origination system a message indicative of the received strength of signals associated

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with the at least one PN offset measured at the mobile station; generating at said origination system a set of acquisition parameters in accordance with said message from said mobile station; and attempting at said mobile station
5 to acquire said destination system in accordance with said set of acquisition parameters.

According to an eighth aspect of the present invention, there is provided a method of providing handoff of a mobile station from an origination system operating at
10 a first frequency to a destination system operating at a second frequency, comprising: receiving from the origination system at least one PN offset associated with the destination system and a minimum total received pilot value; tuning, at the mobile station, to the second frequency;
15 determining a pilot energy associated with the at least one PN offset received at the mobile station; comparing the determined pilot energy with the minimum total received pilot value; and sending, from the mobile station to the origination system, a message based on said comparing.

20 According to a ninth aspect of the present invention, there is provided a method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising: receiving from the origination
25 system at least one PN offset associated with the destination system and a received power threshold; tuning, at the mobile station, to the second frequency; determining a pilot energy associated with the at least one PN offset received at the mobile station; measuring in-band energy
30 received by the mobile station at the second frequency; comparing the measured in-band energy with the received power threshold; and sending, from the mobile station to the origination system, a message based on said comparing.

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According to a tenth aspect of the present invention, there is provided a method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising: sending from the origination system to the mobile station at least one PN offset associated with the destination system and a minimum total received pilot value; sending from the origination system to the mobile station a message directing the mobile station to perform a hard handoff to the destination system; receiving at the origination system from the mobile station a message based on a total received pilot value measured by the mobile station at the second frequency; and sending to the mobile station at least one adjusted PN offset having a different value than said at least one PN offset based on said message.

According to an eleventh aspect of the present invention, there is provided a method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising: sending from the origination system to the mobile station at least one PN offset associated with the destination system and a received power threshold; sending from the origination system to the mobile station a message directing the mobile station to perform a hard handoff to the destination system; receiving at the origination system from the mobile station a message based on a received power measured by the mobile station at the second frequency; and sending to the mobile station at least one adjusted PN offset having a different value than said at least one PN offset based on said message.

According to a twelfth aspect of the present invention, there is provided a mobile station apparatus

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comprising: a receiver configured to tune to one of at least two system frequencies based on a frequency control signal; and a control processor configured to generate the frequency control signal directing said receiver to tune to a first
5 frequency associated with an origination system, to receive from the origination system at a first frequency at least one PN offset associated with a destination system and a minimum total received pilot value, to direct said receiver to tune to a second frequency associated with the
10 destination system, to compare a pilot energy measured at the second frequency with the minimum total received pilot value to generate a comparison, to direct said receiver to tune back to the first frequency based on the comparison, and to generate a message for the origination system based
15 on the comparison.

According to a thirteenth aspect of the present invention, there is provided a mobile station apparatus comprising: a receiver configured to tune to one of at least two system frequencies based on a frequency control signal;
20 and a control processor configured to generate the frequency control signal directing said receiver to tune to a first frequency associated with an origination system, to receive from the origination system at a first frequency at least one PN offset associated with a destination system and a
25 received power threshold, to direct said receiver to tune to a second frequency associated with the destination system, to compare a received power measured at the second frequency with the received power threshold to generate a comparison, to direct said receiver to tune back to the first frequency
30 based on the comparison, and to generate a message for the origination system based on the comparison.

According to a fourteenth aspect of the present invention, there is provided a method of providing handoff

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of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, the method comprising: receiving from the origination system a first message directing the mobile station to perform a hard handoff to the destination system; tuning, at the mobile station, to the second frequency; measuring, at the mobile station, a total received pilot energy received at said second frequency; and sending at said first frequency from the mobile station to the origination system a second message based on the total received pilot energy.

According to a fifteenth aspect of the present invention, there is provided a method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, the method comprising: receiving from the origination system a first message directing the mobile station to perform a hard handoff to the destination system; tuning, at the mobile station, to the second frequency; measuring, at the mobile station, a total received power received at said second frequency; and sending at said first frequency from the mobile station to the origination system a second message based on the total received power.

According to a sixteenth aspect of the present invention, there is provided a computer readable medium containing computer-executable instructions embodying a method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising: receiving from the origination system at least one PN offset associated with the destination system and a minimum total received pilot value; tuning, at the mobile station, to the second frequency; determining a pilot energy

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associated with the at least one PN offset received at the mobile station; comparing the determined pilot energy with the minimum total received pilot value; and sending, from the mobile station to the origination system, a message
5 based on said comparing.

According to a seventeenth aspect of the present invention, there is provided a computer readable medium containing computer-executable instructions embodying a method of providing handoff of a mobile station from an
10 origination system operating at a first frequency to a destination system operating at a second frequency, comprising: receiving from the origination system at least one PN offset associated with the destination system and a received power threshold; tuning, at the mobile station, to
15 the second frequency; determining a pilot energy associated with the at least one PN offset received at the mobile station; measuring in-band energy received by the mobile station at the second frequency; comparing the measured in-band energy with the received power threshold; and sending,
20 from the mobile station to the origination system, a message based on said comparing.

According to an eighteenth aspect of the present invention, there is provided a computer readable medium containing computer-executable instructions embodying a
25 method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising: sending from the origination system to the mobile station at least one PN offset associated with the
30 destination system and a minimum total received pilot value; sending from the origination system to the mobile station a message directing the mobile station to perform a hard handoff to the destination system; receiving at the

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origination system from the mobile station a message based on a total received pilot value measured by the mobile station at the second frequency; and sending to the mobile station at least one adjusted PN offset having a different value than said at least one PN offset based on said message.

According to a nineteenth aspect of the present invention, there is provided a computer readable medium containing computer-executable instructions embodying a method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising: sending from the origination system to the mobile station at least one PN offset associated with the destination system and a received power threshold; sending from the origination system to the mobile station a message directing the mobile station to perform a hard handoff to the destination system; receiving at the origination system from the mobile station a message based on a received power measured by the mobile station at the second frequency; and sending to the mobile station at least one adjusted PN offset having a different value than said at least one PN offset based on said message.

According to a twentieth aspect of the present invention, there is provided a digital signal processing apparatus for performing handoff from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising: memory; and a digital signal processing unit communicatively coupled to said memory, the digital signal processor capable of executing instructions and data to perform the handoff by: receiving from the origination system a first message directing the mobile station to perform a hard handoff to

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the destination system; tuning, at the mobile station, to the second frequency; measuring, at the mobile station, a total received power received at said second frequency; and sending at said first frequency from the mobile station to
5 the origination system a second message based on the total received power.

According to a twenty-first aspect of the present invention, there is provided a digital signal processing apparatus for performing handoff from an origination system
10 operating at a first frequency to a destination system operating at a second frequency, comprising: memory; and a digital signal processing unit communicatively coupled to said memory, the digital signal processor capable of executing instructions and data to perform the handoff by:
15 receiving from the origination system at least one PN offset associated with the destination system and a minimum total received pilot value; tuning, at the mobile station, to the second frequency; determining a pilot energy associated with the at least one PN offset received at the mobile station;
20 comparing the determined pilot energy with the minimum total received pilot value; and sending, from the mobile station to the origination system, a message based on said comparing.

According to a twenty-second aspect of the present invention, there is provided a mobile station apparatus for
25 performing handoff from an origination system operating at a first frequency to a destination system operating at a second frequency, the mobile station apparatus comprising: means for receiving from the origination system at least one PN offset associated with the destination system and a minimum total
30 received pilot value; means for tuning, at the mobile station, to the second frequency; means for determining a pilot energy associated with the at least one PN offset received at the mobile station; means for comparing the

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determined pilot energy with the minimum total received pilot value; and means for sending a message to the origination system based on said comparing.

According to a twenty-third aspect of the present invention, there is provided a mobile station apparatus for performing handoff from an origination system operating at a first frequency to a destination system operating at a second frequency, the mobile station apparatus comprising: means for receiving from the origination system at least one
5 PN offset associated with the destination system and a received power threshold; means for tuning, at the mobile station, to the second frequency; means for determining a pilot energy associated with the at least one PN offset received at the mobile station; means for measuring in-band
10 energy received by the mobile station at the second frequency; means for comparing the measured in-band energy with the received power threshold; and means for sending a message based on said comparing to the origination system at the first frequency.

According to a twenty-fourth aspect of the present invention, there is provided a communication system apparatus comprising: means for sending at a first frequency to a mobile station a minimum total received pilot value and at least one PN offset associated with a destination system
25 operating at a second frequency; means for receiving from the mobile station a message based on a total received pilot value measured by the mobile station at the second frequency; and means for sending to the mobile station at least one adjusted PN offset having a different value than
30 said at least one PN offset based on said message.

According to a twenty-fifth aspect of the present invention, there is provided a communication system apparatus

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comprising: method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising: means for sending at a first frequency to a mobile station a
5 received power threshold and at least one PN offset associated with a destination system operating at a second frequency; means for receiving from the mobile station a message based on a received power measured by the mobile station at the second frequency; and means for sending to the mobile station at least
10 one adjusted PN offset having a different value than said at least one PN offset based on said message.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed
15 description set forth below when taken in conjunction with the drawing in which like reference characters identify correspondingly throughout and wherein:

FIG. 1 is a schematic overview of an exemplary spread spectrum CDMA communications system in accordance with
20 the present invention;

FIG. 2 is a representation of example scenarios whereby the various situations responded to by this invention can be described;

FIG. 3 is an illustration of an exemplary base
25 station;

FIG. 4 is an illustration of an exemplary mobile station; and

FIG. 5 is a flow chart illustrating the operation of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 depicts an embodiment of a communication system employing the present invention. A typical CDMA communications system consists of a system controller and switch 10 in communication with one or more base stations, examples of which are 12, 14, and 16. System controller and switch 10 also connects with the Public Switched Telephone Network (PSTN) (not shown) and with other communication systems (not shown). Mobile station 18 is an example subscriber with forward links 20B, 22B, and 24B, and reverse links 20A, 22A, and 24A. The system controller and switch 10 controls soft handoffs and inter-frequency hard handoffs within the system, and in conjunction with neighboring systems controls inter-system soft handoff as well as inter-system hard handoffs. The exemplary embodiment of the present invention deals with CDMA system to CDMA system inter-frequency hard handoffs. It will be understood by one skilled in the art that the teachings of the present invention can be applied to handoffs using multiple access schemes and for handoff between systems using different modulation schemes.

FIG. 2 depicts three different scenarios possible in the use of the present invention. Three mobile stations, M1, M2, and M3 are traveling from the system where their respective calls originated, S1, to a neighboring system of differing frequency, S2. Initially, all the mobile stations M1 - M3 are in communication with one or more base stations (not shown) in system S1. As each mobile station travels across the boundary of S1 into S2, a hard handoff attempt will be made. The destination system, S2, contains base stations B1 - B5 each which cover a cell area C1 - C5, respectively. System S2 may have other base stations (not shown) which do not affect the scenarios given. As shown, some cells intersect with other cells. In that overlapping region, a mobile station can be in communication with either base station or both simultaneously if the mobile station is in soft handoff. Also shown are obstructions O1 - O3. These obstructions distort the coverage areas that otherwise would be circular shaped cells. Cell C5 is shown shaded to clearly indicate its unusual shape.

Consider first mobile station M1. This is an example of a case which would result in a successful hard handoff in both the state of the art and the current invention. As M1 approaches the S1 - S2 border, origination system S1 predicts the likely neighbors in destination system S2, based on its best guess of the location of M1. S1, through a base station in contact with M1

(not shown) then notifies M1 of the PN offsets of cells in the destination system S2, for example C1, C2, C3, C4, and C5. In the exemplary embodiment, S2 also sends parameters for minimum total received pilot, MIN_TOT_PILOT, and minimum received power, MIN_RX_PWR. In an
5 alternative embodiment, M1 may store values of MIN_TOT_PILOT and MIN_RX_PWR or may be capable of generating the values based on system data. S1 then begins forwarding traffic to system S2 with instructions to set up the appropriate forward link for that data directed to mobile station M1 on base stations B2 and B3. Base stations B2 and B3 are the most likely target
10 base stations and are in the new Active Set. Then S1 sends an initiation message to mobile station M1 to begin the hard handoff process. Owing to the benign propagation environment in the vicinity of mobile station M1, when M1 switches to the new frequency, it will find the pilots and successfully demodulate forward link traffic from the new Active Set, base
15 stations B2 and B3, as predicted by system S1. M1 determines the hard handoff to be successful because the total received pilot exceeds the threshold MIN_TOT_PILOT. System S1 will deallocate resources previously assigned to communicate with mobile station M1 after it is determined that the hard handoff was successful. This determination may
20 be made by receipt of a message from system S2, or based on a prearranged time duration in which no further communication takes place between system S1 and mobile station M1.

Next, consider mobile station M2, which is in an area of inadequate coverage by S2 often referred to as a hole. As mobile station M2 approaches
25 the S1 - S2 border, system S1 predicts that coverage in system S2 is provided in cell C1. The handoff is initiated in the same manner as described above. However, upon switching to the frequency of destination system S2, significant signal energy is not received by mobile station M2 due to the interference caused by obstruction O3. That is, total received pilot is less
30 than the threshold MIN_TOT_PILOT. In current systems, this call would be dropped. In the present invention, the mobile station begins recovery techniques.

Once the mobile station determines that the pilot or pilots predicted by S1 are not available, M2 measures the total received power in the new
35 frequency band and compares it to threshold MIN_RX_PWR. In this example, the only transmitter near M2 is base station B1 and its signal is blocked by obstruction O3, so no significant energy is found in the frequency band of the destination system. Mobile station M2 then abandons the handoff and returns to system S1, notifying it that no system S2 was found.

Assume mobile station M2 continues traveling away from system S1. Since the call was not dropped, as would have been the case using current methods, a number of options exist. At minimum, the call can continue on system S1 until it eventually drops because the distance has become too great. Given that the mobile station environment is susceptible to change, a second handoff attempt after a delay may be successful.

Finally, consider mobile station M3. In like manner to mobile stations M1 and M2 handoff procedures are initiated with cells C1 and C2 being the predicted new Active Set. Due to obstructions O1 and O2, neither predicted cell is available to mobile station M3, hence MIN_TOT_PILOT is not exceeded. Again recovery procedures begin. This time base station B5 is within range, however its offset is not in the new Active Set, nor is it transmitting forward link data directed to M3. As such, although the predicted cells are not available, the minimum received power threshold, MIN_RX_PWR, is exceeded. In the exemplary embodiment of the present invention, since the system appears to be available, a search for available pilots is performed. When the search is complete, mobile station M3 returns to system S1 and notifies it of the failed handoff attempt as well as the available pilots, in this case the pilot for cell C5. In the present invention, S1 sends a message to destination system S2 to set up a forward link on base station B5, then a second attempt at handoff can be made. If the environment has not changed substantially, the second time M3 switches to the new frequency, the call will successfully hand off to base station B5 of destination system S2.

FIG. 3 depicts an exemplary base station. Base station 300 communicates with other systems (not shown) and with system controller and switch 10, shown in FIG. 1, through system interface 310. Inter-frequency handoff is a distributed process, with system controller and switch 10 signaling with the other switch, and base station 300 handling some of the handoff details. System controller 10 determines, in conjunction with base station 300, that an inter-system hard handoff is necessary. There are many alternatives for handoff determination as described above, including mobile station location or pilot beacon reception. The destination system (not shown) is instructed by the origination system to begin transmitting forward link traffic on the destination system's frequency from a select set of base stations. A database (not shown) in control processor 360 may contain the candidate base stations. Alternatively, a suitable list of handoff base station candidates can be returned from the destination system to control processor 360 through system interface 310. In situations where the destination system

is not a CDMA system, other parameters useful for acquiring the destination system can be delivered to control processor 360 through system interface 310.

Parameters and instructions from control processor 360 are formed
5 into messages in message generator 320. Those messages are modulated in modulator 330 and sent to the mobile station through transmitter 340 and antenna 350. In the exemplary embodiment, modulator 330 is a CDMA modulator as described in the aforementioned U.S. Patent Nos. 4,901,307 and 5,103,459. In the exemplary embodiment, the list of neighbor base stations,
10 MIN_TOT_PILOT, and MIN_RX_PWR are combined into a single message, referred to herein as the Other Frequency Neighbor List Message (OFNLM). The base station to mobile station message that signals the mobile station to begin attempting to acquire the destination system contains the destination system Active Set and is called the Extended Handoff Direction Message
15 (EHDM). Additional parameters are envisioned that could be sent to the mobile station to facilitate improved hard handoff in the event of a handoff attempt failure. For example, a specific list of offsets to search, a range of offsets to search, or a specific search algorithm such as searching offsets in increments of 64 chips away from those offsets attempted from those of the
20 base stations listed in the OFNLM.

Following a failed hard handoff attempt, the mobile station will follow the instructions as given, then return to the original system to communicate its findings. Reverse link signals from the mobile station to base station 300 are received through antenna 390, downconverted in
25 receiver 380, and demodulated in demodulator 370 under control of control processor 360.

FIG. 4 depicts an exemplary mobile station 500. Messages arrive at control processor 520 from base station 300 through antenna 610, duplexer 600, receiver 590 and demodulator 570. In the exemplary embodiment,
30 receiver 590 is a CDMA modulator as described in the aforementioned U.S. Patent Nos. 4,901,307 and 5,103,459. Upon receipt of the EHDM message from base station 300, control processor 520 directs receiver 590 and transmitter 560 to tune to the frequency of the destination. At this point, the communication link with the original system has been broken. Control
35 processor 520 directs demodulator 570 to attempt to demodulate pilots at the offsets in the Active Set as given by base station 300 in the EHDM. The energy in the signals demodulated with those offsets is accumulated in pilot energy accumulator 530. Control processor 520 uses the results of the accumulation to compare to MIN_TOT_PILOT. If MIN_TOT_PILOT is

exceeded, the handoff is deemed successful. If MIN_TOT_PILOT is not exceeded, recovery operations begin. Alternatively, a requirement of receiving some number N good frames (no CRC errors) within a specific time T can be used to determine if the handoff attempt is successful.

5 The first step following an unsuccessful hard handoff attempt is to determine if the destination system is available. Received energy accumulator 540 accumulates the total power received in the destination system's frequency band and provides the result to control processor 520. Control processor 520 compares those accumulation results with the
10 threshold MIN_RX_PWR. If MIN_RX_PWR is not exceeded, the handoff attempt is aborted. Receiver 590 and transmitter 560 are retuned to the original frequency and control processor 520 generates a message that notifies base station 300 that the handoff attempt failed and the destination system was not found to be significantly present. The message is provided to
15 modulator 550 which modulates the message and provides the modulated signal through transmitter 560, duplexer 600, and antenna 610 for transmission.

Mobile station 500 contains system preference information stored in system preference table 510. If the destination system is not present, mobile
20 station 500 may send alternate system information to base station 300, so that mobile station 500 may attempt to acquire a different system on the next hard handoff attempt. For example, a neighboring region may be covered by multiple systems, which may include a combination of CDMA systems as well as systems of alternate technologies. System preference table 510 may be
25 programmed such that if a first preferred system is not available, acquisition of a second system is attempted. There may be additional systems upon which to attempt handoff, should the second system be unavailable. Handoff attempts can be made in a prioritized order until acquisition has been attempted on all candidate systems.

30 If MIN_RX_PWR is exceeded, indicating that the destination system is available, mobile station 500 proceeds as previously instructed. In the exemplary embodiment, searcher 580 conducts a search to locate pilot offsets where base stations in the destination system are available. To perform a search, searcher 580 generates the PN sequence with a specific offset.
35 Demodulator 570 correlates the incoming data with the offset PN sequence. Pilot energy accumulator 530 measures the pilot energy for that offset by accumulating samples for a predetermined time interval. Control processor 520 compares that result to a threshold, called T_ADD, to determine whether a pilot is available for that offset. Searcher 580 then moves to the

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next offset candidate. The process repeats until there are no more candidate offsets to measure. The search operation process is described in detail in copending U.S. Patent Application Serial No. 08/509/721 entitled "METHOD AND APPARATUS FOR PERFORMING SEARCH ACQUISITION IN A CDMA COMMUNICATION SYSTEM", filed July 26, 1996, which is assigned to the assignee of the present invention. Alternate search algorithms can be substituted in searcher 580 without modification to the present invention.

without modification to the present invention.

The search subsequent to the hard handoff failure may be performed over all possible offsets or a subset thereof. For example, a range of offsets may be searched. In the exemplary embodiment, the OFNLM contains the subset of offsets to be searched. In the exemplary system, neighboring base stations are separated by integer multiples of 64 chips. If one base station offset in the system is known (even if it is not currently available), only offsets that are integer multiples of 64 from that known offset need to be searched in order to attempt acquisition on the complete set of neighbor base stations. A combination of spaced offsets in a specific range or number of ranges can also be searched.

When the destination system is an alternate technology, there may be different procedures to perform which will yield information that will improve subsequent hard handoff attempts. For example, when the destination system is TDMA, the mobile station may measure the in band energy at a plurality of frequency subbands and report this information to the origination system. Or in the case of a neighboring AMPS system, the base station can send an OFNLM specifying frequencies for the analog control channels. However, it may not be necessary to send the frequencies of the control channels if they are already known. In that case, if the mobile station finds the voice channel to which it was handed off is too weak, the mobile station can proceed to measure the received power on the analog control channels. It may also determine the digital color code (DCC) for the control channel. The DCCs provide better determination of the cell in case the mobile station might be able to receive multiple cells in an area. The frequencies and DCCs of the strongest analog base stations can be returned as information to assist with a subsequent handoff attempt. Further discussion of the use of DCCs can be found in chapter 3 of "Mobile Cellular Telecommunications Systems" by William C.Y. Lee.

After mobile station 500 completes the requisite tasks, receiver 590 and transmitter 560 are retuned to the original frequency and control processor 520 notifies base station 300 through modulator 550, transmitter

560, duplexer 600, and antenna 610 that the handoff attempt failed and delivers any information that has been discovered during subsequent system search procedures.

The flow chart in FIG. 5 illustrates operation of the preferred
5 embodiment of this invention. After determining that a handoff is imminent, the origination system predicts the list of neighbor base stations on the neighboring system's frequency in box 50. Proceed to 52, a base station in the origination system sends to the mobile station the Other Frequency Neighbor List Message (OFNLM) described above. In block 53, the Active Set
10 for the new frequency is determined. In block 54, the destination system sets up the forward link as specified in the Extended Handoff Direction Message (EHDM). In block 56, the base station in the origination system sends the Extended Handoff Direction Message (EHDM) to the mobile station to initiate the inter-frequency hard handoff. Following that message, in 58, the
15 mobile station tunes to the new frequency and attempts to acquire the destination system according to the Active Set information in the EHDM message.

In block 60, the mobile station measures the pilot energy, the sum of the energy of all pilots in the Active Set, and if the received total pilot energy
20 exceeds that of parameter MIN_TOT_PILOT, proceed to 62, a successful hard handoff has occurred. The exemplary embodiment envisions that a mobile station is capable of being handed off directly into a soft handoff condition in the destination system, although that is not a requirement. A single pilot in the new Active Set whose received pilot energy exceeds that of parameter
25 MIN_TOT_PILOT is sufficient for a successful handoff.

From 60, if MIN_TOT_PILOT is not exceeded, proceed to 68. In 68, if total received power in the frequency band exceeds parameter MIN_RX_PWR indicating the general presence of the destination system, proceed to 66, otherwise go to 69.

30 An alternative embodiment would be to check total received power before pilot energy. If the MIN_RX_PWR threshold is not exceeded, the handoff is aborted. This may be faster in some implementations.

In 66, search the possible offsets for available pilot signals. Any alternate search strategy can be performed here as well. When search is
35 complete, proceed to 65. The mobile station returns to the original system in 65, then proceeds to 64. In 64, make necessary changes to OFNLM and return to 52, where the operation proceeds as described above.

In 69, the mobile station returns to the original system, then proceeds to 72. From 72, the decision can be made to continue attempting handoff by

proceeding to 70, or the handoff procedure can be aborted by proceeding to 74. An optional delay is introduced in 70, then proceed to 64.

In an alternative embodiment of the present invention, the base station sends the mobile station an extended list of base stations which may be available at the point in which the mobile station is entering the destination system. In this alternative embodiment, no forward links are immediately set up in the destination system. Rather the mobile station simply determines whether the strength of any of the signals provided by any of the extended list of candidate systems are adequate to support a communication link. The mobile station monitors the forward link signals of each of the base stations in the extended list of candidate base stations.

After monitoring the signal strength of each of base stations in the extended list of candidate base stations, the mobile station necessarily returns to the original system and sends a message indicating the signal strength of the forward links of the candidate base stations. In the exemplary embodiment, the mobile station compares the strength of the signals received by each of the base stations in the extended list to a predetermined threshold T_ADD and reports only whether the measured signal power is above or below the threshold.

The base station of the original system receives the information regarding the signal strength of each of the base stations in the destination system and from this information the base station of the original system generates an Active Set list. This list is provided to the destination system which sets up forward links for the mobile station in accordance with the Active Set list provided by the original system. The base station of the original system transmits the active list to the mobile station which attempts to acquire the base stations in the active list and, if acquisition is successful, transmission to the mobile station is available without interruption.

Referring to FIG. 2, the alternative embodiment will be described in terms of acquisition of mobile M3. When original system S1 determines that mobile M3 should begin hard hand off operations to destination system S2, the base station in original system S1 which is currently in communication with mobile station M3 generates an extended list of base stations in S2 which the mobile station may be able to acquire. In the exemplary embodiment, the extended candidate list would likely consists of the parameters necessary to perform a search on all of base stations B1, B2, B3, B4 and B5, as well as additional base stations in destination system S2 (not shown). Note in the alternative embodiment, no information regarding M3 has, as of yet, been provided to the destination system S2.

Mobile station M3 tunes to the frequency of destination system S2 and measures the energy on each of the pilot channels of the base stations in the extended candidate list. In the example of mobile station M3, the mobile station would transmit back a message to the base station on the original system S1 a message indicating that acquisition upon base station B5 was possible. In response to this message, the base station in the original system would generate an Active Set list consisting solely of base station B5.

The base station in the original system would send a message to the destination system S2, indicating that a forward link for the mobile station M3 should be provide on base station B5. In response to this message, the destination system S2 sets up a forward link for mobile station M3 on base station B5. The Active Set list is sent to mobile station M3. In response to the Active Set message, mobile station M3 attempts acquisition of base station B5.

Referring to FIG. 3, base station 300 of the original system generates an extended candidate list in message generator 320 and provides the message to modulator 330. The message is modulated by modulator 330 and provided to transmitter 340 which upconverts and amplifies the signal and transmits the resulting signal through antenna 350.

Referring to FIG. 4, the transmitted signal is received by mobile station 500 by antenna 610 and is downconverted, filtered and amplified by receiver 590. The received signal is then demodulated by demodulator 570 and provided to control processor 520. Control processor 520 then generates a set of commands directing a search to be performed by searcher 580. Searcher 580 provides a set of search demodulation parameters to demodulator 570. The demodulated signals are provided to pilot energy accumulator 530 which measures the strength of the pilots of the base stations of the extended candidate list. The energy of each of these candidates is provided to control processor 520 which compares the measured energy with a threshold T_ADD. Control processor 520 generates a message which signifies which, if any, of the candidate base station's signals exceed the threshold.

The message is provided to modulator 550 where it is modulated. The modulated signal is then provided to transmitter 560 where it is upconverted, amplified, and transmitted through antenna 610.

Referring back to FIG. 3, the message indicating the strengths of the candidate base stations is received by antenna 390 of base station 300 of the original system. The signal is downconverted and amplified by receiver 380 and provided to demodulator 370. Demodulator 370 demodulates the signal

and provides the result to control processor 360. Control processor 360 generates an Active Set list for the destination system in accordance with the information in the message transmitted by mobile station 500 indicating the results of its search. In the exemplary embodiment, the Active Set list will
5 consist of all base stations whose signals, when monitored by mobile station 500, exceeded the energy threshold T_ADD.

Control processor 360 sends the Active Set list to system interface 310 which sends a message indicating the Active Set list to the destination system S2. Capacity issues allowing, destination system S2 provides forward
10 link channels on each of the systems in the Active Set list.

Control processor 360 also provides the Active Set list to message generator 320. The resulting message is modulated by modulator 330 and transmitted as described above.

Mobile station 500 receives the message by antenna 610, demodulates
15 the signal as described above, and provides the message to control processor 520. Control processor 520 then provides information regarding the Active Set list to demodulator 570 and receiver 590 and a hard handoff to the destination system S2 is attempted using the parameters of the base stations in the Active Set list. It should be noted that because, in this example, the
20 active list was determined by mobile station 500, the mobile station need not receive the Active Set list, since it knows the station on the list apriori. Thus, in an alternative, embodiment, the mobile station may delay a predetermined time period and perform handoff to the base stations who's signals exceeded the threshold. If, on the other hand, the Active Set is not
25 simply a copy of the base stations which exceeded the threshold but rather also takes into account parameters unknown to the mobile station, such as capacity parameters of S2, then transmission of the message would prove of value.

In a variation on the above described alternative embodiment, the
30 mobile station periodically tunes to the new frequency and measures the offsets supplied in the OFNLM without direction from the base station. The period may be specified in the OFNLM. After the search is complete, the mobile station returns to the origination system and reports its findings. This information gained by polling the neighboring system can be used to
35 determine the Active Set for a subsequent handoff attempt, as well as to assist in determining whether to initiate a handoff to that system.

The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to

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those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent
5 with the principles and novel features disclosed herein.

WE CLAIM:

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CLAIMS:

1. In a wireless communication system wherein a mobile station is moving from an area covered by an origination system into an area covered by a first destination system and wherein said mobile station has attempted to acquire said first destination system has failed, a method for avoiding a loss of communication with said mobile station, comprising the steps of:

attempting to acquire said first destination system by said mobile station;

if said attempting to acquire said first destination system failed, then transmitting parameter data from said mobile station to said origination system;

receiving at said origination system said parameter data;

generating at said origination system a search list of alternative destination systems in accordance with said parameter data; and

attempting to acquire one of said alternative destination systems in accordance with said search list of alternative destination systems.

2. The method of claim 1 further comprising the step of measuring said parameter data at said mobile station.

3. The method of claim 2 wherein said step of measuring said parameter data comprises measuring signal energy from pilot signals of said destination system.

4. The method of claim 2 wherein said step of measuring said parameter data is performed in accordance with a predetermined set of search parameters.

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5. The method of claim 4 wherein said predetermined set of search parameters is transmitted to said mobile station by said origination system.

6. The method of claim 2 wherein said step of measuring said parameter data comprises measuring whether a minimum power threshold has been exceeded in the area covered by a first destination system.

7. The method of claim 1 further comprising transmitting said search list from said origination system to said mobile station.

8. A method of providing handoff for wireless communication wherein a mobile station is moving from an area covered by an origination system to an area covered by at least one destination system, comprising:

15 predicting first destination systems at the origination system;

attempting by the mobile station to connect to said first destination systems;

20 searching for alternate destination systems based on a failure to connect to said first destination systems;

attempting to connect the mobile station to said alternate destination systems located by said searching; and

25 reconnecting to the origination system based on a failure to connect to the alternate destination systems located by said searching.

9. The method of claim 8, further comprising measuring by the mobile station of a minimum primary signal from said first destination systems.

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10. The method of claim 9, wherein said attempting to connect to said first destination systems is based on locating said minimum primary signal.

11. The method of claim 9, wherein said minimum
5 primary signal is a pilot signal.

12. The method of claim 8, wherein said searching for alternate destination systems comprises measuring by the mobile station of a minimum secondary signal.

13. The method of claim 12, wherein said attempting to
10 connect the mobile station to said alternate destination systems is based on locating said minimum secondary signal.

14. The method of claim 12, wherein said reconnecting to the origination system is based on a failure to locate said minimum secondary signal.

15 15. The method of claim 12, wherein said minimum secondary signal is a power signal.

16. The method of claim 8, further comprising receiving by the mobile station of a search list of first destination systems based on said predicting of first
20 destination systems by the origination system.

17. The method of claim 8, further comprising receiving by the mobile station of a search list of second destination systems based on said predicting of second destination systems by the origination system.

25 18. A mobile station for avoiding a loss of communication in a wireless communication system when said mobile station moves from an area covered by an origination system into an area covered by a first destination system, said mobile station comprising:

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means for attempting to acquire said first destination system;

means for transmitting to said origination system parameter data if means for attempting to acquire said first destination system fails to acquire said first destination system;

means for receiving from said origination system a search list of alternative destination systems generated by said origination system in accordance with said parameter data; and

means for attempting to acquire one of said alternative destination systems in accordance with said search list of alternative destination systems.

19. The mobile station of claim 18 further comprising means for measuring said parameter data.

20. The mobile station of claim 19 wherein said means for measuring said parameter data measures said parameter data by measuring signal energy from pilot signals of said destination system.

20 21. The mobile station of claim 19 wherein said means for measuring said parameter data measures said parameter data in accordance with a predetermined set of search parameters.

22. The mobile station of claim 21 further comprising means for receiving said predetermined set of search parameters from said origination system.

23. The mobile station of claim 19 wherein said means for measuring said parameter data measures said parameter

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data by measuring whether a minimum power threshold has been exceeded in the area covered by a first destination system.

24. A system for avoiding a loss of communication in a wireless communication system when a mobile station moves
5 from an area covered by said system into an area covered by a first destination system, said system comprising:

means for providing coverage to said mobile station within said area covered by said system;

means for receiving parameter data from said
10 mobile station if an attempt by said mobile station to acquire said first destination system failed; and

means for generating a search list of alternative destination systems in accordance with said parameter data for said mobile station to use in attempting to acquire one
15 of said alternative destination systems.

25. The system of claim 24 further comprising means for transmitting to said mobile station a predetermined set of search parameters for measuring said parameter data at said mobile station.

20 26. The system of claim 24 further comprising means for transmitting said search list to said mobile station.

27. A mobile station for providing handoff for wireless communication when said mobile station moves from an area covered by an origination system to an area covered
25 by at least one destination system, said mobile station comprising:

means for attempting to connect to first destination systems predicted by said origination system;

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means for searching for alternate destination systems based on a failure to connect to said first destination systems;

means for attempting to connect to said alternate destination systems located by said means for searching for alternate destination systems; and

means for reconnecting to the origination system based on a failure to connect to the alternate destination systems located by said means for searching for alternate destination systems.

28. The mobile station of claim 27, further comprising means for measuring a minimum primary signal from said first destination systems.

29. The mobile station of claim 28, wherein said means for attempting to connect to said alternate destination systems attempts to connect to said first destination systems based on locating said minimum primary signal.

30. The mobile station of claim 28, wherein said minimum primary signal is a pilot signal.

31. The mobile station of claim 27, wherein said means for searching for alternate destination systems searches for alternate destination systems by measuring a minimum secondary signal.

32. The mobile station of claim 31, wherein said means for attempting to connect to said alternate destination systems attempts to connect to said alternate destination systems based on locating said minimum secondary signal.

33. The mobile station of claim 31, wherein said reconnecting to the origination system reconnects to the

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origination system based on a failure to locate said minimum secondary signal.

34. The mobile station of claim 31, wherein said minimum secondary signal is a power signal.

5 35. The mobile station of claim 27, further comprising means for receiving a search list of first destination systems based on said first destination systems predicted by the origination system.

36. The mobile station of claim 27, further comprising
10 means for receiving a search list of second destination systems based on second destination systems predicted by the origination system.

37. A system for providing handoff for wireless communication when a mobile station moves from an area
15 covered by said system to an area covered by at least one destination system, said system comprising:

means for providing coverage to said mobile station within said area covered by said system;

means for predicting first destination systems;

20 and

means for reconnecting the mobile station to the system based on a failure to connect the mobile station to alternate destination systems located by searching, after the mobile system attempted to connect to said first
25 destination systems and searched for said alternate destination systems based on a failure to connect the mobile station to said first destination systems.

38. The system of claim 37, wherein said means for reconnecting to the mobile station reconnects the mobile

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station to the system based on a failure to locate a minimum secondary signal measured by said mobile station when said mobile station searched for said alternative destination systems.

5 39. The system of claim 38, wherein said minimum secondary signal is a power signal.

40. The system of claim 37, further comprising means for transmitting to the mobile station a search list of first destination systems based on said first destination
10 systems.

41. The system of claim 37, further comprising means for transmitting to the mobile station a search list of second destination systems based on second destination systems predicted by the system.

15 42. In a wireless communication system wherein a mobile station is moving from the coverage area of an origination system operating at a first frequency into the coverage area of a destination system operating at a second frequency, a method for providing handoff from said
20 origination system to said destination system, the method comprising:

predicting at least one PN offset associated with the destination system;

transmitting, at the first frequency, from said
25 origination system to said mobile station a set of search parameter data associated with the at least one PN offset;

determining at said mobile station the availability of said destination system in accordance with said set of search parameter data;

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transmitting from said mobile station to said origination system a message indicative of the received strength of signals associated with the at least one PN offset measured at the mobile station;

5 generating at said origination system a set of acquisition parameters in accordance with said message from said mobile station; and

 attempting at said mobile station to acquire said destination system in accordance with said set of
10 acquisition parameters.

43. The method of claim 42, wherein said generating further comprises electing at said origination system a new set of at least one PN offset associated with the destination system.

15 44. The method of claim 42, wherein said attempting further comprises electing at said mobile station a new set of at least one PN offset associated with the destination system.

45. A method of providing handoff of a mobile station
20 from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising:

 receiving from the origination system at least one PN offset associated with the destination system and a
25 minimum total received pilot value;

 tuning, at the mobile station, to the second frequency;

 determining a pilot energy associated with the at least one PN offset received at the mobile station;

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comparing the determined pilot energy with the minimum total received pilot value; and

sending, from the mobile station to the origination system, a message based on said comparing.

5 46. The method of claim 45 wherein said message comprises said determined pilot energy.

47. The method of claim 45 wherein said receiving further comprises receiving from the origination system a set of additional parameters comprising instructions to the
10 mobile station following a failed hard handoff attempt.

48. The method of claim 47 wherein said sending is based on said instructions.

49. The method of claim 45 further comprising performing a search at the second frequency based on said
15 comparing.

50. The method of claim 49 wherein said performing a search is based on said instructions.

51. A method of providing handoff of a mobile station from an origination system operating at a first frequency to
20 a destination system operating at a second frequency, comprising:

receiving from the origination system at least one PN offset associated with the destination system and a received power threshold;

25 tuning, at the mobile station, to the second frequency;

determining a pilot energy associated with the at least one PN offset received at the mobile station;

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measuring in-band energy received by the mobile station at the second frequency;

comparing the measured in-band energy with the received power threshold; and

5 sending, from the mobile station to the origination system, a message based on said comparing.

52. The method of claim 51 wherein said message comprises said measured in-band energy.

53. The method of claim 51 wherein said receiving
10 further comprises receiving from the origination system a set of additional parameters comprising instructions to the mobile station following a failed hard handoff attempt.

54. The method of claim 53 wherein said sending is based on said instructions.

15 55. The method of claim 51 further comprising performing a search at the second frequency based on said comparing.

56. The method of claim 55 wherein said performing a search is based on said instructions.

20 57. A method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising:

25 sending from the origination system to the mobile station at least one PN offset associated with the destination system and a minimum total received pilot value;

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sending from the origination system to the mobile station a message directing the mobile station to perform a hard handoff to the destination system;

receiving at the origination system from the
5 mobile station a message based on a total received pilot value measured by the mobile station at the second frequency; and

sending to the mobile station at least one adjusted PN offset having a different value than said at
10 least one PN offset based on said message.

58. The method of claim 57 wherein said sending to the mobile station further comprises sending to the mobile station a set of additional parameters comprising instructions to the mobile station following a failed hard
15 handoff attempt.

59. The method of claim 57 wherein said message further comprises measurements from a search performed at the second frequency.

60. A method of providing handoff of a mobile station
20 from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising:

sending from the origination system to the mobile station at least one PN offset associated with the
25 destination system and a received power threshold;

sending from the origination system to the mobile station a message directing the mobile station to perform a hard handoff to the destination system;

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receiving at the origination system from the mobile station a message based on a received power measured by the mobile station at the second frequency; and

5 sending to the mobile station at least one adjusted PN offset having a different value than said at least one PN offset based on said message.

61. The method of claim 60 wherein said sending to the mobile station further comprises sending to the mobile station a set of additional parameters comprising
10 instructions to the mobile station following a failed hard handoff attempt.

62. The method of claim 60 wherein said message further comprises measurements from a search performed at the second frequency.

15 63. A mobile station apparatus comprising:

a receiver configured to tune to one of at least two system frequencies based on a frequency control signal; and

a control processor configured to generate the
20 frequency control signal directing said receiver to tune to a first frequency associated with an origination system, to receive from the origination system at a first frequency at least one PN offset associated with a destination system and a minimum total received pilot value, to direct said
25 receiver to tune to a second frequency associated with the destination system, to compare a pilot energy measured at the second frequency with the minimum total received pilot value to generate a comparison, to direct said receiver to tune back to the first frequency based on the comparison,

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and to generate a message for the origination system based on the comparison.

64. The mobile station apparatus of claim 63 wherein said message comprises the pilot energy measured at the
5 second frequency.

65. The mobile station apparatus of claim 63 wherein said control processor is further configured to receive from the origination system a set of additional parameters comprising instructions to the mobile station following a
10 failed hard handoff attempt.

66. The mobile station apparatus of claim 65 further comprising a searcher configured to perform a search at the second frequency based on commands from said control processor, and wherein said control processor directs said
15 searcher to perform the search based on the instructions.

67. A mobile station apparatus comprising:

a receiver configured to tune to one of at least two system frequencies based on a frequency control signal; and

20 a control processor configured to generate the frequency control signal directing said receiver to tune to a first frequency associated with an origination system, to receive from the origination system at a first frequency at least one PN offset associated with a destination system and
25 a received power threshold, to direct said receiver to tune to a second frequency associated with the destination system, to compare a received power measured at the second frequency with the received power threshold to generate a comparison, to direct said receiver to tune back to the

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first frequency based on the comparison, and to generate a message for the origination system based on the comparison.

68. The mobile station apparatus of claim 67 wherein said message comprises the received power measured at the
5 second frequency.

69. The mobile station apparatus of claim 67 wherein said control processor is further configured to receive from the origination system a set of additional parameters comprising instructions to the mobile station following a
10 failed hard handoff attempt.

70. The mobile station apparatus of claim 69 further comprising a searcher configured to perform a search at the second frequency based on commands from said control processor, and wherein said control processor directs said
15 searcher to perform the search based on the instructions.

71. A method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, the method comprising: receiving from the origination system a
20 first message directing the mobile station to perform a hard handoff to the destination system; tuning, at the mobile station, to the second frequency; measuring, at the mobile station, a total received pilot energy received at said second frequency; and sending at said first frequency from
25 the mobile station to the origination system a second message based on the total received pilot energy.

72. The method of claim 71 further comprising receiving from the origination system a set of parameters comprising instructions to the mobile station in the event
30 of a failed hard handoff attempt.

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73. The method of claim 71 wherein said second message further comprises measurements from a search performed at the second frequency.

74. A method of providing handoff of a mobile station
5 from an origination system operating at a first frequency to a destination system operating at a second frequency, the method comprising:

receiving from the origination system a first
message directing the mobile station to perform a hard
10 handoff to the destination system;

tuning, at the mobile station, to the second
frequency;

measuring, at the mobile station, a total received
power received at said second frequency; and

15 sending at said first frequency from the mobile
station to the origination system a second message based on
the total received power.

75. The method of claim 74 further comprising
receiving from the origination system a set of additional
20 parameters comprising instructions to the mobile station in
the event of a failed hard handoff attempt.

76. The method of claim 74 wherein said second message further comprises measurements from a search performed at the second frequency.

25 77. A computer readable medium containing computer-executable instructions embodying a method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising:

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receiving from the origination system at least one PN offset associated with the destination system and a minimum total received pilot value;

5 tuning, at the mobile station, to the second frequency;

determining a pilot energy associated with the at least one PN offset received at the mobile station;

comparing the determined pilot energy with the minimum total received pilot value; and

10 sending, from the mobile station to the origination system, a message based on said comparing.

78. The computer readable medium of claim 77 wherein said message comprises said determined pilot energy.

79. The computer readable medium of claim 77 wherein
15 said receiving further comprises receiving from the origination system a set of parameters comprising instructions to the mobile station following a failed handoff attempt.

80. The computer readable medium of claim 79 wherein
20 said sending is based on said instructions.

81. The computer readable medium of claim 77 further comprising performing a search at the second frequency based on said comparing.

82. The computer readable medium of claim 81 wherein
25 said performing a search is based on said instructions.

83. A computer readable medium containing computer-executable instructions embodying a method of providing handoff of a mobile station from an origination system

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operating at a first frequency to a destination system
operating at a second frequency, comprising:

receiving from the origination system at least one
PN offset associated with the destination system and a
5 received power threshold;

tuning, at the mobile station, to the second
frequency;

determining a pilot energy associated with the at
least one PN offset received at the mobile station;

10 measuring in-band energy received by the mobile
station at the second frequency;

comparing the measured in-band energy with the
received power threshold; and

sending, from the mobile station to the
15 origination system, a message based on said comparing.

84. The computer readable medium of claim 83 wherein
said message comprises said measured in-band energy.

85. The computer readable medium of claim 83 wherein
said receiving further comprises receiving from the
20 origination system a set of additional parameters comprising
instructions to the mobile station following a failed hard
handoff attempt.

86. The computer readable medium of claim 85 wherein
said sending is based on said instructions.

25 87. The computer readable medium of claim 83 further
comprising performing a search at the second frequency based
on said comparing.

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88. The computer readable medium of claim 87 wherein said performing a search is based on said instructions.

89. A computer readable medium containing computer-executable instructions embodying a method of providing
5 handoff of a mobile station from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising:

sending from the origination system to the mobile station at least one PN offset associated with the
10 destination system and a minimum total received pilot value;

sending from the origination system to the mobile station a message directing the mobile station to perform a hard handoff to the destination system;

receiving at the origination system from the
15 mobile station a message based on a total received pilot value measured by the mobile station at the second frequency; and

sending to the mobile station at least one adjusted PN offset having a different value than said at
20 least one PN offset based on said message.

90. The computer readable medium of claim 89 wherein said sending to the mobile station further comprises sending to the mobile station a set of additional parameters comprising instructions to the mobile station following a
25 failed hard handoff attempt.

91. The computer readable medium of claim 89 wherein said message further comprises measurements from a search performed at the second frequency.

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92. A computer readable medium containing computer-executable instructions embodying a method of providing handoff of a mobile station from an origination system operating at a first frequency to a destination system
5 operating at a second frequency, comprising:

sending from the origination system to the mobile station at least one PN offset associated with the destination system and a received power threshold;

10 sending from the origination system to the mobile station a message directing the mobile station to perform a hard handoff to the destination system;

receiving at the origination system from the mobile station a message based on a received power measured by the mobile station at the second frequency; and

15 sending to the mobile station at least one adjusted PN offset having a different value than said at least one PN offset based on said message.

93. The computer readable medium of claim 92 wherein said sending to the mobile station further comprises sending
20 to the mobile station a set of additional parameters comprising instructions to the mobile station following a failed hard handoff attempt.

94. The computer readable medium of claim 92 wherein said message further comprises measurements from a search
25 performed at the second frequency.

95. A digital signal processing apparatus for performing handoff from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising:

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memory; and

a digital signal processing unit communicatively coupled to said memory, the digital signal processor capable of executing instructions and data to perform the handoff

5 by:

receiving from the origination system a first message directing the mobile station to perform a hard handoff to the destination system;

10 tuning, at the mobile station, to the second frequency;

measuring, at the mobile station, a total received power received at said second frequency; and

15 sending at said first frequency from the mobile station to the origination system a second message based on the total received power.

96. A digital signal processing apparatus for performing handoff from an origination system operating at a first frequency to a destination system operating at a second frequency, comprising:

20 memory; and

a digital signal processing unit communicatively coupled to said memory, the digital signal processor capable of executing instructions and data to perform the handoff by:

25 receiving from the origination system at least one PN offset associated with the destination system and a minimum total received pilot value;

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tuning, at the mobile station, to the second frequency;

determining a pilot energy associated with the at least one PN offset received at the mobile station;

5 comparing the determined pilot energy with the minimum total received pilot value; and

sending, from the mobile station to the origination system, a message based on said comparing.

97. A mobile station apparatus for performing handoff
10 from an origination system operating at a first frequency to a destination system operating at a second frequency, the mobile station apparatus comprising:

means for receiving from the origination system at least one PN offset associated with the destination system
15 and a minimum total received pilot value;

means for tuning, at the mobile station, to the second frequency;

means for determining a pilot energy associated with the at least one PN offset received at the mobile
20 station;

means for comparing the determined pilot energy with the minimum total received pilot value; and

means for sending a message to the origination system based on said comparing.

25 98. A mobile station apparatus for performing handoff from an origination system operating at a first frequency to a destination system operating at a second frequency, the mobile station apparatus comprising:

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means for receiving from the origination system at least one PN offset associated with the destination system and a received power threshold;

means for tuning, at the mobile station, to the
5 second frequency;

means for determining a pilot energy associated with the at least one PN offset received at the mobile station;

means for measuring in-band energy received by the
10 mobile station at the second frequency;

means for comparing the measured in-band energy with the received power threshold; and

means for sending a message based on said comparing to the origination system at the first frequency.

15 99. A communication system apparatus comprising:

means for sending at a first frequency to a mobile station a minimum total received pilot value and at least one PN offset associated with a destination system operating at a second frequency;

20 means for receiving from the mobile station a message based on a total received pilot value measured by the mobile station at the second frequency; and

means for sending to the mobile station at least one adjusted PN offset having a different value than said at
25 least one PN offset based on said message.

100. A communication system apparatus comprising:

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means for sending at a first frequency to a mobile station a received power threshold and at least one PN offset associated with a destination system operating at a second frequency;

5 means for receiving from the mobile station a message based on a received power measured by the mobile station at the second frequency; and

means for sending to the mobile station at least one adjusted PN offset having a different value than said at
10 least one PN offset based on said message.

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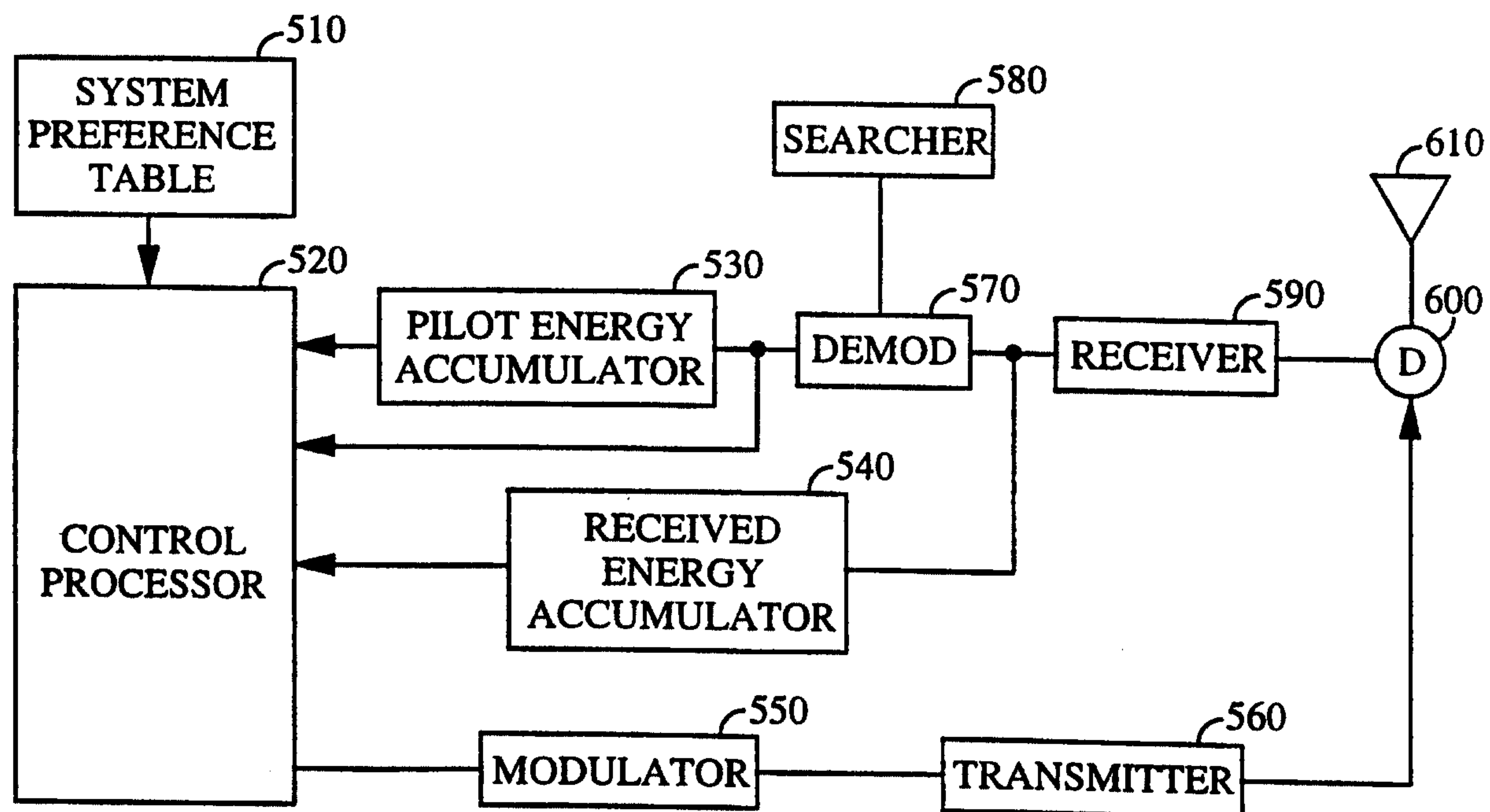
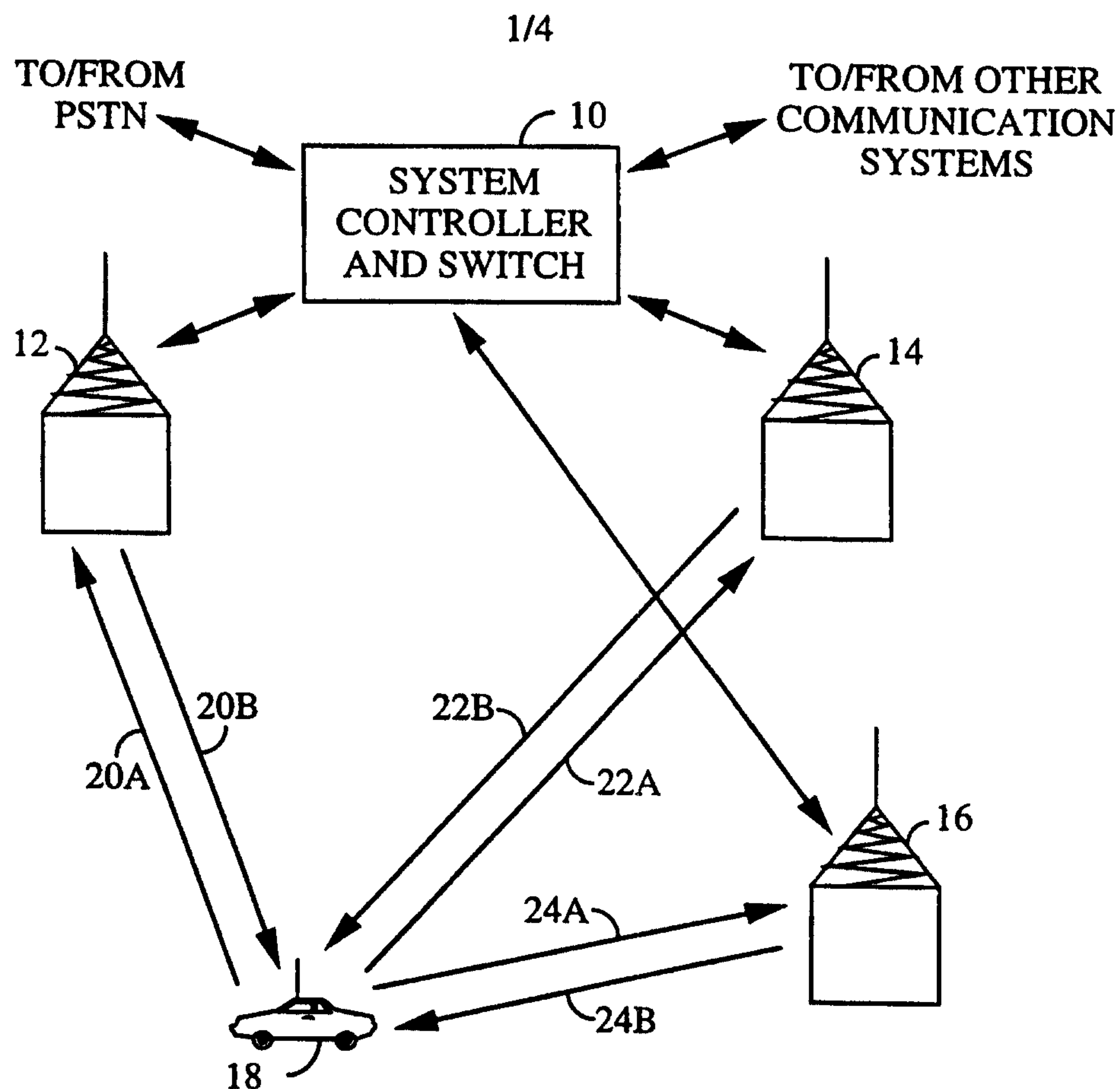


FIG. 4

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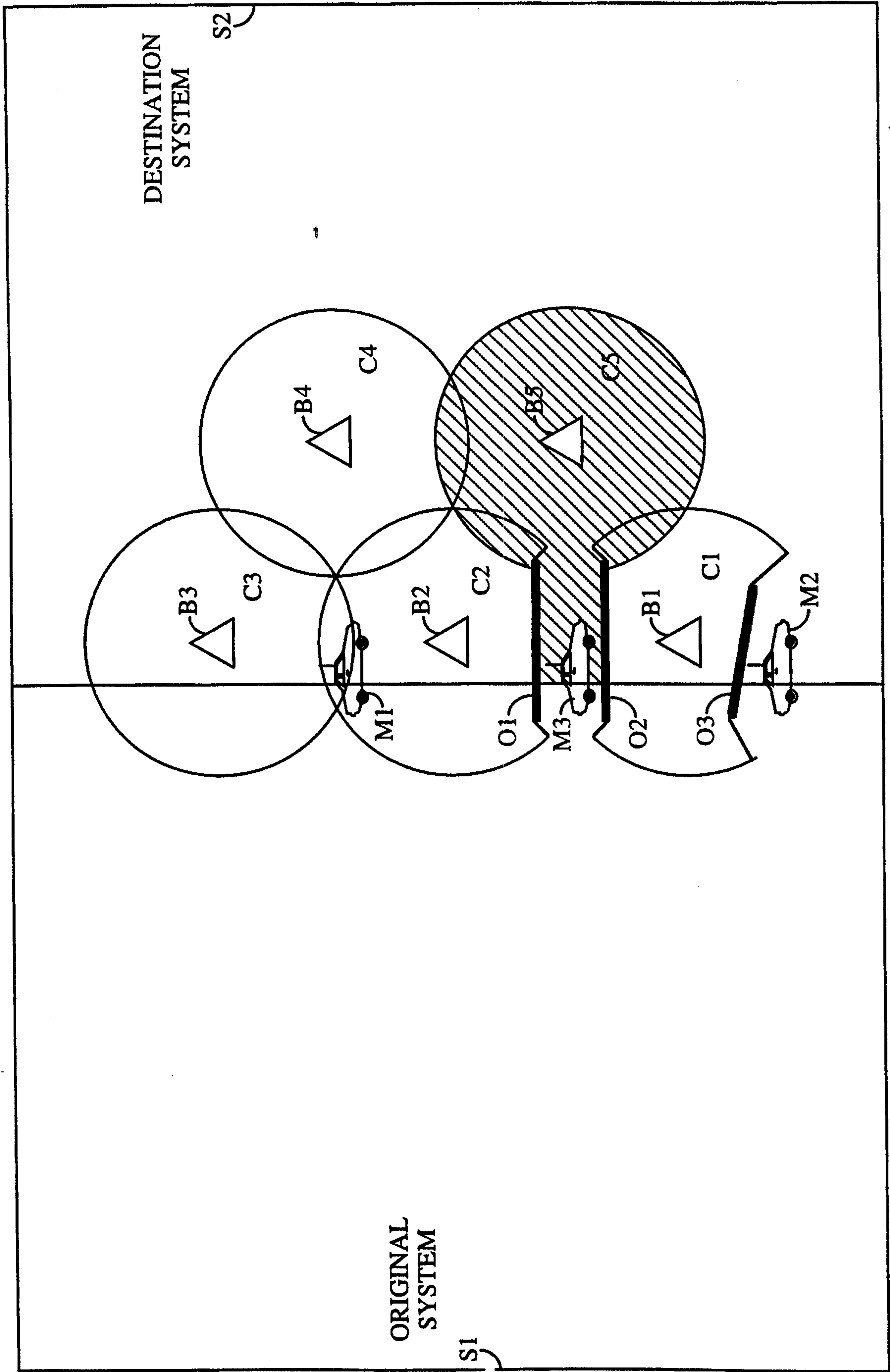
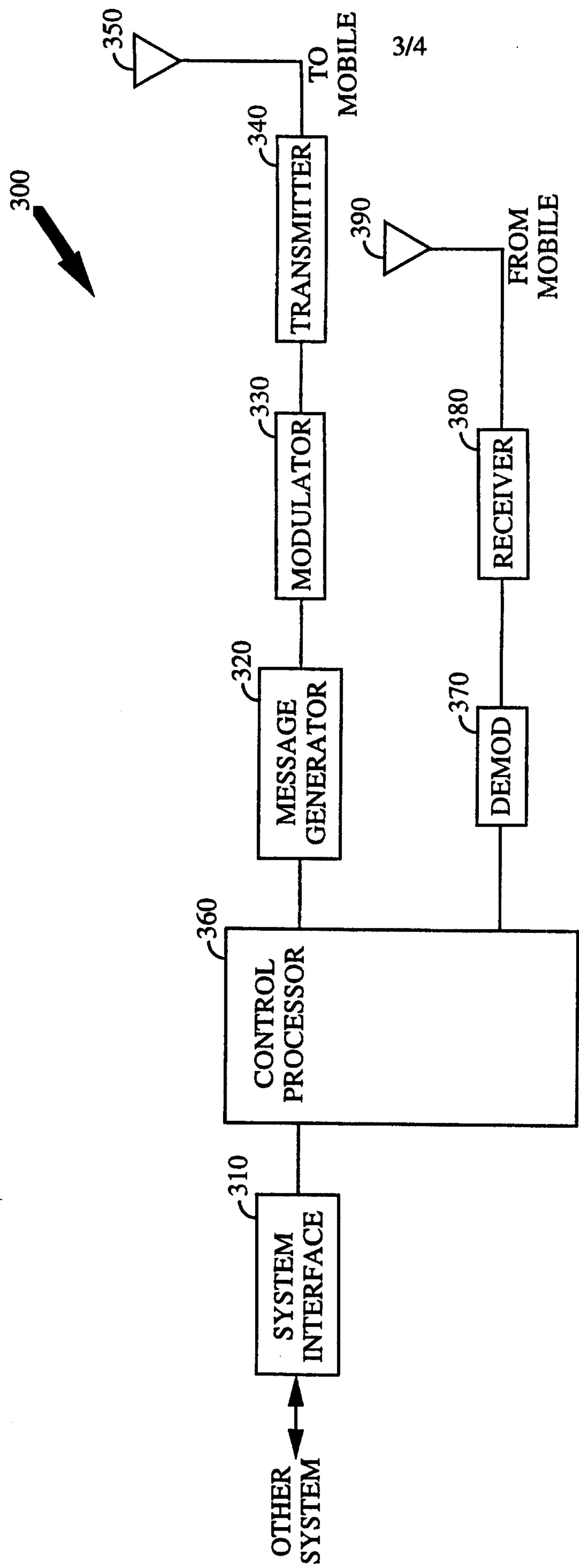


FIG. 2



BASE STATION

FIG. 3

