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J. [US/US]; 7 Talbot Place, Huntington Station, NY 11746 (US).

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(74) Agent: **BALLARINI, Robert, J.**; Volpe And Koenig, P.c., United Plaza, Suite 1600, 30 S. 17th Street, Philadelphia, PA 19103 (US).

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(71) Applicant (for all designated States except US): **INTER-DIGITAL TECHNOLOGY CORPORATION** [US/US]; 3411 Silverside Road, Concord Plaza, Suite 105, Hagley Building, Wilmington, DE 19810 (US).

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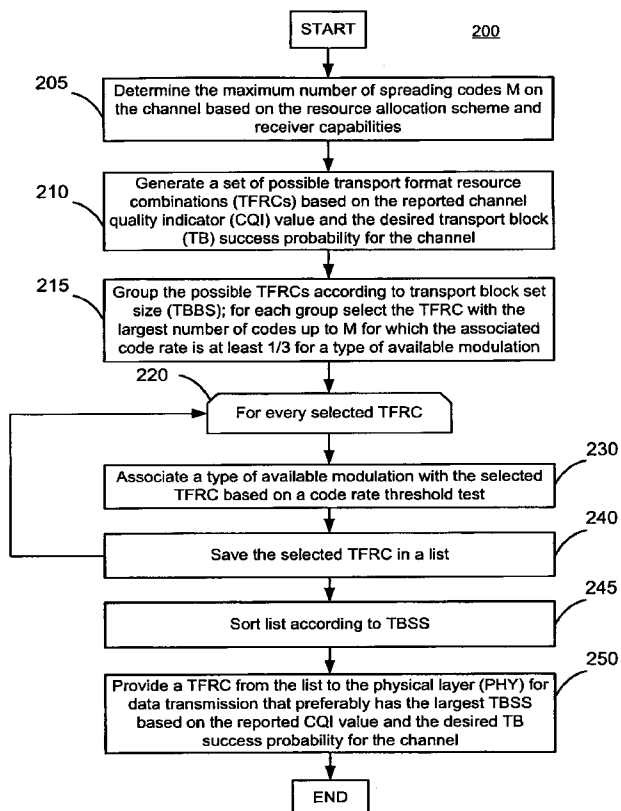
(72) Inventor; and

(75) Inventor/Applicant (for US only): **PIETRASKI, Philip,**

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(54) Title: METHOD AND APPARATUS FOR SELECTING LINK ADAPTATION PARAMETERS FOR CDMA-BASED WIRELESS COMMUNICATION SYSTEMS



(57) Abstract: A method and apparatus enhance the selection of transport block set size (TBSS), number of spreading codes, and modulation type, referred to collectively as transport format resource combination (TFRC), in a medium access control (MAC) layer for transmission of data in a code division multiple access (CDMA) wireless communication system, preferably a Universal Mobile Telecommunications Systems (UMTS) high speed downlink packet access (HSDPA) communication system. The maximum number of spreading codes available for transmission and the set of possible TFRCs are preferably determined based on a channel characteristics provided in part by a channel quality indicator (CQI). For each TBSS value in the set of possible TFRCs, a TFRC is selected with the largest number of spreading codes within the maximum number of spreading codes for which the corresponding coding rate is preferably at least 1/3. The corresponding code rate for each selected TFRCs is compared to a threshold to select a corresponding type of modulation. One of the selected TFRCs is selected to be provided to the PHY layer that best matches the CQI and preferably has a maximum TBSS.



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[0001] **METHOD AND APPARATUS FOR SELECTING
LINK ADAPTATION PARAMETERS FOR CDMA-BASED
WIRELESS COMMUNICATION SYSTEMS**

[0002] **FIELD OF INVENTION**

[0003] The present invention is related to medium access control in wireless communication systems. More particularly, the present invention is a method and apparatus for selecting link adaptation parameters in a medium access control (MAC) layer in code division multiple access (CDMA) wireless communication systems.

[0004] **BACKGROUND**

[0005] Wireless communication systems are well known in the art. Communications standards are developed in order to provide global connectivity for wireless systems and to achieve performance goals in terms of, for example, throughput, latency and coverage. One current standard in widespread use, called Universal Mobile Telecommunications Systems (UMTS), was developed as part of Third Generation (3G) Radio Systems, and is maintained by the Third Generation Partnership Project (3GPP).

[0006] A typical UMTS system architecture in accordance with current 3GPP specifications is depicted in Fig. 1. The UMTS network architecture includes a Core Network (CN) interconnected with a UMTS Terrestrial Radio Access Network (UTRAN) via an Iu interface. The UTRAN is configured to provide wireless telecommunication services to users through wireless transmit receive units (WTRUs), referred to as user equipments (UEs) in the 3GPP standard, via a Uu radio interface. The UTRAN may have one or more radio network controllers (RNCs) and base stations, referred to as Node Bs by 3GPP, which collectively provide for the geographic coverage for wireless communications with UEs. One or more Node Bs may be connected to each RNC via an Iub interface. RNCs within a UTRAN communicate via an Iur interface.

[0007] One type of air interface defined in the UMTS standard is wideband code division multiple access (W-CDMA). In a W-CDMA system baseband signals are spread in the frequency domain using orthogonal spreading codes prior to transmission, and despread at a receiver using the same spreading codes.

[0008] The Uu radio interface of a 3GPP system uses transport channels (TrCHs) for transfer of user data and signaling between UEs and Node Bs. Uplink refers to signaling from a UE to a Node B, and downlink transmissions are from a Node B to a UE. In 3GPP communications, TrCH data is conveyed by one or more physical channels defined by mutually exclusive physical resources, or shared physical resources in the case of shared channels. In a conventional 3GPP system, communications between a UE and a Node B are conducted using a single data stream defined by a combination of TrCHs called a coded composite TrCH (CCTrCH). Typically, a Node B is concurrently communicating with several UEs using respective CCTrCH data streams.

[0009] TrCH data is transferred in sequential groups of transport blocks (TBs) defined as transport block sets (TBSs). Each TBS is transmitted in a given transmission time interval (TTI) which may span a plurality of consecutive system time frames. The number of bits in a TBS is called the transport block set size (TBSS).

[0010] UMTS specification releases 5 and 6 pertain to high speed downlink packet access (HSDPA) and high speed uplink packet access (HSUPA), respectively. HSDPA is a downlink packet access protocol for packet based UMTS wireless communication systems employing a W-CDMA air interface with a spreading factor (SF) of 16. According to HSDPA, up to 15 spreading codes may be allocated to data for transmission in a common TTI. The data may be modulated using either quadrature phase shift keying (QPSK) modulation or 16 quadrature amplitude modulation (16-QAM). In future releases of the HSDPA standard, it is expected that additional types of higher order modulation will also be supported, such as 64 quadrature amplitude modulation (64-QAM). Fast retransmissions are accomplished according to hybrid automatic repeat request

(HARQ) by retransmission combining, which enables operation at relatively high Block Error Rates (BLER).

[0011] Figure 2 is a block diagram of a communication system 100 in which a base station 110 is communicating with a WTRU 120 over a Uu air interface according to the current HSDPA standard. For illustrative purposes, protocol layers are shown in the base station 110 including physical layer (PHY) components 102, medium access control (MAC) layer components 104, and higher layer components 106 which include a radio link control (RLC) layer. Adjacent layers in the protocol stack communicate with each other. The MAC layer components 104 are responsible for mapping data streams 105 (also called logical channels) from the higher layer components 106 to transport channels 107 provided to the PHY layer 102 for physical transmission over the wireless channel.

[0012] The MAC layer also selects the transport format (TF) and link adaptation parameters for data transmission including transport block set size (TBSS), number of spreading codes, and modulation type that are collectively referred to as transport format resource combination (TFRC). As described in accordance with the present invention below, selection of TFRC is preferably performed in the MAC layer by a TFRC selection function component 108 prior to each TTI. The selected TFRC parameters 109 are provided to the PHY layer 102 so that they may be used in the physical transmission of data 114 to the WTRU 120 in a common TTI by way of TBs.

[0013] TFRC selection is based at least in part on characteristics of the physical channel and is not fixed for a given data packet size. Information regarding the physical channel is provided by WTRU 120. WTRU 120 takes channel quality measurements, such as determining the maximum expected data rate, of the downlink channel and transmits a corresponding channel quality indicator (CQI) 122 to the base station 110.

[0014] The CQI is typically represented as an integer value from 1 to 30, where each CQI value has a predetermined mapping to a TFRC including a TBSS, a corresponding number of spreading codes and a corresponding type of

modulation that is known at WTRU 120 and base station 110. This mapping also depends on the physical capabilities of WTRU 120, and a WTRU is typically assigned to a physical layer category based on its receiver capabilities such as the maximum supported number of received bits per TTI and the maximum supported number of spreading codes per TTI. 3GPP Technical Standard (TS) 125.214 provides CQI mapping tables for different WTRU physical layer categories (referred to as UE categories) and UE categories are described in 3GPP TS 125.306. For illustration purposes, an example CQI mapping for UE category 10 is given in Table 1.

[0015] The WTRU selects the CQI value for which the TFRC mapping is determined to most closely match the maximum expected data rate on the downlink channel while satisfying a minimum desired TB success probability, which refers to the desired success rate of decoding received TBs at WTRU 120. The same TB success probability is typically known at WTRU 120 and base station 110, and is preferably equal to 0.9 according to existing HSDPA standards. To compare a TFRC to the maximum expected data rate of the downlink channel, a corresponding expected data rate for the TFRCs in the mapping table can be determined in advance, for example via simulation.

[0016] The CQI value 122 reported by WTRU 120 to base station 110 is provided to the MAC layer 104 via the PHY layer 102, and the TFRC selection function 108 selects a TFRC 109 that best achieves the maximum expected data rate of the channel as determined by the CQI value and its mapping. While the CQI mapping table, as in Table 1 for example, indicates a preferred TFRC for a given CQI according to conventional TFRC selection approaches for HSDPA, the TFRC parameters of TBSS, number of spreading codes, and modulation are mutually dependent. Therefore, multiple different TFRCs may be able to match the desired channel characteristics corresponding to a given CQI level, including maximum expected data rate and TB success probability.

CQI	TBSS	Number of spreading codes	Modulation
0	N/A	Out of range	
1	137	1	QPSK
2	173	1	QPSK
3	233	1	QPSK
4	317	1	QPSK
5	377	1	QPSK
6	461	1	QPSK
7	650	1	QPSK
8	792	2	QPSK
9	931	2	QPSK
10	1262	2	QPSK
11	1483	3	QPSK
12	1742	3	QPSK
13	2279	3	QPSK
14	2583	4	QPSK
15	3319	4	QPSK
16	3565	5	16-QAM
17	4189	5	16-QAM
18	4664	5	16-QAM
19	5287	5	16-QAM
20	5887	5	16-QAM
21	6554	5	16-QAM
22	7168	5	16-QAM
23	9719	7	16-QAM
24	11418	8	16-QAM
25	14411	10	16-QAM
26	17237	12	16-QAM
27	21754	15	16-QAM
28	23370	15	16-QAM
29	24222	15	16-QAM
30	25558	15	16-QAM

TABLE 1: CQI mapping table for UE category 10 according to 3GPP TS 125.214.

[0017] Conventional strategies for selecting a TFRC 109 include choosing a fewer number of spreading codes N than the maximum number of available spreading codes M because the total allocated power P_t is divided among the N

used spreading codes. Therefore it is believed that received signal quality is better when more power is allocated per spreading code.

[0018] The inventor has recognized, however, that higher power for each spreading code increases interference with the other spreading codes in the channel, and employing fewer spreading codes does not necessarily provide better performance results, particularly in receivers employing advanced decoding techniques. Existing TFRC selection procedures do not take into account the interference effects of simultaneous transmissions using different spreading codes or the capabilities of advanced receivers. Therefore, a procedure for TFRC selection that improves upon the existing techniques is desired.

[0019]

SUMMARY

[0020] The present invention provides a method and apparatus for transport format resource combination (TFRC) selection in a medium access control (MAC) layer that enhances channel capacity. TFRC selection includes selection of transport block set size (TBSS), number of spreading codes, and modulation type for data transmission. The maximum number of spreading codes available for transmission and the set of possible TFRCs are determined based on channel characteristics of the downlink channel provided by the physical (PHY) layer. For each TBSS value in the set of possible TFRCs, a TFRC is selected with the largest number of spreading codes within the maximum number of spreading codes for which the corresponding coding rate is preferably at least 1/3. The corresponding code rates for the selected TFRCs are compared to thresholds to select a type of modulation. Finally, one of the selected TFRCs is selected to be provided to the PHY layer that best matches downlink channel quality and preferably with the largest TBSS in order to maximize the throughput. The present invention is preferably used in Universal Mobile Telecommunications Systems (UMTS) high speed downlink packet access (HSDPA) communication systems, or in a wireless communication system employing code division multiple access (CDMA).

[0021] Other objects and advantages will be apparent to those of ordinary

skill in the art based upon the following description of presently preferred embodiments of the invention.

[0022] **BRIEF DESCRIPTION OF THE DRAWINGS**

[0023] Figure 1 shows an overview of the system architecture of a conventional Universal Mobile Telecommunications Systems (UMTS) network.

[0024] Figure 2 is a block diagram of an example communication system 100 in which a base station 110 is communicating with a WTRU 120 in accordance with the present invention.

[0025] Figure 3 illustrates a graph of measured channel throughput versus signal-to-noise ratio (SNR) at a receiver for various modulation techniques, which may be used to select a preferred type of modulation for a transport format resource combination (TFRC) in accordance with the present invention.

[0026] Figure 4A is a flow diagram of a method for generating and selecting TFRCs in accordance with the present invention.

[0027] Figure 4B is a flow diagram of a method for selecting a type of modulation from among quadrature phase shift keying (QPSK), 16 quadrature amplitude modulation (16-QAM) and 64 quadrature amplitude modulation (64-QAM) to be associated with a TFRC in accordance with the present invention.

[0028] Figure 5 shows the measured throughput on a downlink CDMA channel using the existing 3GPP CQI mapping as given in Table 1 compared to the measured throughput for the optimized CQI mapping generated according to the present invention in Table 2 for a category 10 UE for a range of average SNR values and for a TB success probability of 0.9.

[0029] **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

[0030] As used herein, a wireless transmit/receive unit (WTRU) includes but is not limited to a user equipment, mobile station, fixed or mobile subscriber unit, pager, cellular telephone, personal digital assistant (PDA), computer, or any other type of device capable of operating in a wireless environment. A base station is a type of WTRU generally designed to provide network services to

multiple WTRUs and includes, but is not limited to, a Node B, site controller, access point or any other type of interfacing device in a wireless environment.

[0031] The present invention provides an information theoretic approach to selecting a more optimal transport format resource combination (TFRC) in a wireless communication system, where TFRC includes transport block set size (TBSS), number of spreading codes, and modulation type for data transmission over a wireless code division multiple access (CDMA) channel on a common transmission time interval (TTI) boundary. Although the present invention is described herein with reference to high speed downlink packet access (HSDPA) for downlink communications in UMTS systems, the disclosed TFRC selection procedure has broader applicability and is applicable to general CDMA wireless communication systems including Third Generation Partnership Project (3GPP) CDMA2000 and high speed packet access evolution (HSPA+) systems. The present invention may be used in both uplink (UL) and downlink (DL) communications, and therefore may be readily be implemented in WTRUs configured as user equipments (UEs) or base stations, such as Node Bs.

[0032] Preferably, an optimum number of spreading codes N is selected for TFRC according to the number of spreading codes that maximize the information theoretic channel capacity. To derive this capacity, the communication channel can be assumed to be an additive white Gaussian noise (AWGN) channel with bandwidth B such that the power P_t of the transmitter is fixed. Data is transmitted over bandwidth B using N different orthogonal spreading codes such that N is less than or equal to the maximum number of available spreading codes M . In HSDPA, the maximum number of available spreading codes M is at most 15.

[0033] A signal transmitted over the communication channel using N orthogonal spreading codes can be modeled by N separate corresponding propagation channels, each with bandwidth B/M . Because the spreading codes are orthogonal, the noise on each of the propagation channels after the despreading of the signal is uncorrelated and has equal power. If A represents the total signal-to-noise ratio (SNR) of the communication channel, the SNR of

each individual propagation channel is proportional to A/N because the total allocated power P_t is shared equally over the N spreading codes. Adaptive modulation and coding (AMC) can be applied individually to each propagation channel along with advanced receiver and coding techniques to achieve a channel capacity close to the theoretical upper limit of $B/M * \log(1 + A/N)$ (known as Shannon's capacity formula). It then follows that the capacities of each of the propagation channels $C_1, \dots, C_N$ are the same and proportional to $(1/M) * \log(1 + A/N)$. According to this result, propagation channel capacities $C_1, \dots, C_N$ slowly decrease as N increases. The total capacity C , however, is proportional to $N * (1/M) * \log(1 + A/N)$, which is an increasing function of N in all practical cases. Therefore, in accordance with the present invention, the number of spreading codes N is preferably maximized in order to maximize the total capacity of the channel. This is different from typical HSDPA TFRC selection approaches that do not attempt to maximize the number of spreading codes N used for communication with a particular WTRU.

[0034] The number of spreading codes N is limited by the total number of available spreading codes M such that $N \leq M$. In accordance with a preferred embodiment of the present invention, the number of spreading codes N may also be limited by the code rate used for error correction on the physical channel. Coding techniques, such as convolutional codes and turbo codes, are used to add redundancy to transmitted information to correct bit errors that occur in the channel and at the receiver, and the code rate (also called coding rate) is the fraction of non-redundant data bits in a transmitted packet. For example, if for each data bit, one redundant bit is added by the encoder, the resulting code rate is $1/2$. According to HSDPA, all error correcting codes are derived from a rate $1/3$ turbo code, although the actual coding rate may be adjusted based on the channel quality indicator (CQI) information using puncturing or repetition techniques that involve deleting or adding bits, respectively, at the encoder output. The selection of coding rate and modulation based on channel quality information is referred to as adaptive modulation and coding (AMC).

[0035] If, as a result of AMC, the code rate is less than $1/3$, then the

effective coding gain is reduced because bit repetition, which is known to be a weak coding scheme, is required to fill the coded transport block (TB). Therefore, in accordance with a preferred embodiment of the present invention, the number of spreading codes N is preferably selected to be as large as possible while maintaining a 1/3 or greater channel coding rate and without exceeding the total number of available spreading codes M . The unused spreading codes may preferably be used by other WTRUs communicating over the same channel to make full use of the physical resources. Alternatively, a greater number of spreading codes may be used with a corresponding code rate less than 1/3 and with a lower coding gain, however, this results in fewer spreading codes being available for use by other WTRUs.

[0036] Referring back to the theoretical channel capacity model above, each of the N propagation channels may experience multipath fading and inter-code interference that is present at the output of a despreader in the receiver. By modeling the inter-code interference as additive noise, the inter-code interference has the effect of decreasing the received SNR at the despreader output. The multipath experienced on each of the N propagation channels is identical (because the propagation channels are spread over the same bandwidth), the equalizer used to receive each propagation channel is identical and the power transmitted on each propagation channel is identical. Thus, the effective noise increase as a result of inter-code interference is the same in each propagation channel and proportional to $(N-1)/N$, such that the actual value of the proportionality constant depends on the effectiveness of the equalizer in restoring the orthogonality of the spreading codes.

[0037] This proportionality constant is commonly referred to as the non-orthogonality factor (NOF), and can range from 0.0 to 1.0 but is typically much less than 1.0 in advanced receivers. The overall noise power in the channel resulting from inter-code interference is equal to $NOF \cdot S(N-1)$, where S is the received signal power on a propagation channel. The resulting overall channel capacity is given by

$$C = \frac{N}{M} \log_2 \left(1 + \frac{S}{N \cdot I + NOF \cdot S(N-1)} \right). \quad \text{Equation (1)}$$

where I is the total interference on the received signal.

[0038] The capacity in Equation 1 is not necessarily monotone increasing depending on the values of S , I , and NOF . Nonetheless, for practical scenarios Equation 1 is maximized by maximizing the number of codes N because the slowly decreasing logarithmic function of N is outweighed by the linearly increasing factor of N outside of the logarithmic function. In scenarios where the values of S , I , and NOF are such that the logarithmic function of N dominates the outside factor of N , choosing $N=1$ maximizes the channel capacity. However, the latter scenario is likely only to occur under very poor channel conditions in which a WTRU may have already handed-off to another base station.

[0039] Based on the above, and in accordance with a preferred embodiment of the present invention, the number spreading codes N selected as part of TFRC selection is preferably maximized, as permitted by the coding rate and the total number of available codes M , except under very poor channel conditions in which case only one spreading code $N=1$ is preferably used.

[0040] Also in accordance with the present invention, the modulation type associated with a TFRC is preferably selected to maximize channel capacity. In the case of 3GPP systems and in particular HSDPA, the available modulation types are limited to, for example, quadrature phase shift keying (QPSK) modulation, 16 quadrature amplitude modulation (16-QAM) and possibly higher order modulation such as 64 quadrature amplitude modulation (64-QAM). In accordance with a preferred embodiment of the present invention, a threshold test on the code rate is preferably used to select a type of modulation from among the available modulation types to maximize the channel throughput, as described further below.

[0041] For any particular type of modulation, the code rate must be proportionally increased with the desired signal-to-noise ratio (SNR) at the receiver to maintain a channel throughput as close as possible to the maximum throughput. Therefore, the code rate threshold values are preferably determined

by comparing the measured throughput for a desired SNR for each of the available modulation techniques, and a modulation scheme is selected that achieves the highest throughput for its associated coding rate. By way of example, consider an HSDPA downlink channel that supports QPSK, 16-QAM and 64-QAM modulations. Figure 3 illustrates an example of the empirically measured channel throughput for different SNR values at the receiver for each of the available modulation techniques. The code rate CR_{QPSK} where the QPSK and 16-QAM throughput curves cross, and code rate CR_{16-QAM} where the 16-QAM and 64-QAM throughput curves cross are determined and used as the code rate threshold values. Given a TFRC, for each type of available modulation a corresponding code rate is determined according to the reported CQI information.

If the corresponding code rate for QPSK is below the CR_{QPSK} threshold, then QPSK modulation is selected because it achieves the highest throughput for that coding rate compared to 16-QAM and 64-QAM as shown in Figure 3. If the code rate associated with QPSK modulation is greater than the threshold CR_{QPSK} , and the code rate associated with 16-QAM modulation is less than CR_{16-QAM} , then 16-QAM is selected to maximize throughput. If the code rate for 16-QAM is greater than CR_{16-QAM} , then 64-QAM is selected to maximize throughput. An example of a possible code rate threshold for QPSK is $CR_{QPSK} \approx 0.74$, which is greater than $1/3$. Although choosing a modulation type for TFRC selection has been described for QPSK, 16-QAM and 64-QAM, the present invention may be extended to select a modulation type from among any number of modulation techniques, including, but not limited to, additional higher order modulations, or between QPSK and 16-QAM only when 64-QAM is not available.

[0042] Figures 4A and 4B illustrate the steps of a preferred method 200 for generating and selecting TFRCs in accordance with the present invention that includes the various embodiments discussed above for selecting a number of spreading codes and modulation type. The TFRC selection presented in Figures 4A and 4B is preferably performed by a TFRC selection function component 108 in Figure 2 prior to a TTI.

[0043] Referring to Figure 4A, in step 205 the maximum number of

spreading codes M available for use on the physical channel is determined based on the resource allocation scheme and the receiver capabilities of the receiving WTRU. Recall that for HSDPA, the transmitting base station may use up to 15 spreading codes, and the number of spreading codes supported by the receiving WTRU is given by its UE physical layer category. In step 210, a set of possible TFRCs are generated that match the channel characteristics implied by the reported CQI value and that meet a minimum desired TB success probability. The channel characteristics are preferably a maximum expected data rate for the downlink channel, which may be known at the base station for a given CQI level or explicitly provided by the WTRU. Generating a possible TFRC includes generating a transport block set size (TBSS), a number of spreading codes and a modulation type which, when applied to a transmitted TB, have an expected data rate close to the maximum expected data rate of the downlink channel and meet the desired TB success probability following decoding at the receiving WTRU. The expected data rate for a given TFRC may be determined, for example, by simulation. As discussed above, the desired TB success probability for the downlink channel is preferably a predetermined value that is known to both the transmitting base station and the receiving WTRU.

[0044] In step 215, the set of possible TFRCs are grouped according to common TBSS. In each group a TFRC is preferably selected that has a largest number of spreading codes, up to the determined maximum number of spreading codes M , for which the associated code rate is at least 1/3 for at least one type of available modulation scheme. Types of modulation may include QPSK modulation, 16-QAM modulation and any other higher order modulations. The TFRCs that are not selected are preferably discarded.

[0045] For every selected TFRC, beginning at step 220, a modulation type is associated with the selected TFRC based on a code rate threshold test in step 230. Determining code rate threshold values is described above with respect to Figure 3. Figure 4B gives a particular example of a code rate threshold test for selecting a modulation type when QPSK, 16-QAM and 64-QAM modulations are available. The code rate associated with QPSK modulation is compared to a

predetermined threshold in step 232. If that code rate is below CR_{QPSK} , QPSK modulation is associated with the selected TFRC in step 233. If the code rate is above CR_{QPSK} , then the code rate associated with 16-QAM modulation is compared to threshold CR_{16-QAM} in step 235. If that code rate is below CR_{16-QAM} , then 16-QAM is associated with the selected TFRC in step 236. Otherwise, 64-QAM is associated with the selected TFRC in step 238. Referring to Figure 4A, each selected TFRC is thereafter preferably saved in a list in step 240.

[0046] When the listing of the selected TFRCs is completed, the list of selected TFRCs is preferably sorted in order of TBSS in step 245. The list represents all of the possible TFRCs for use when sending data to the WTRU in accordance with the present invention. In step 250, one TFRC from among the list of selected TFRCs is provided to the PHY layer for data transmission that preferably has the largest TBSS while maintaining the desired TB success probability for the channel characteristics defined by the reported CQI value.

[0047] In accordance with a preferred embodiment of the present invention as described with respect to Figures 4A and 4B, a new mapping of CQI values to preferred TFRCs can be created, an example of which is illustrated in Table 2 for a HSDPA downlink channel that supports a maximum number of 15 spreading codes, QPSK and 16-QAM modulation and a TB success probability of 0.9. A CQI of 0 is used when the receiving WTRU is out of range to receive signals on the downlink channel.

CQI	Code rate	TBSS	Number of spreading codes	Modulation
0	N/A	N/A	Out of range	
1	0.14271	137	1	QPSK
2	0.18021	173	1	QPSK
3	0.21771	209	1	QPSK
4	0.26771	257	1	QPSK
5	0.33021	317	1	QPSK
6	0.40521	389	1	QPSK
7	0.56771	545	1	QPSK
8	0.39115	751	2	QPSK
9	0.35972	1036	3	QPSK
10	0.35313	1356	4	QPSK
11	0.3191	1838	6	QPSK
12	0.35149	2362	7	QPSK
13	0.34502	2981	9	QPSK
14	0.32656	3762	12	QPSK
15	0.32389	4664	15	QPSK
16	0.38056	5480	15	QPSK
17	0.45514	6554	15	QPSK
18	0.52528	7564	15	QPSK
19	0.59542	8574	15	QPSK
20	0.67493	9719	15	QPSK
21	0.75146	10821	15	QPSK
22	0.43361	12488	15	16-QAM
23	0.48278	13904	15	16-QAM
24	0.53753	15481	15	16-QAM
25	0.58788	16931	15	16-QAM
26	0.62031	17865	15	16-QAM
27	0.66639	19192	15	16-QAM
28	0.70316	20251	15	16-QAM
29	0.76899	22147	15	16-QAM
30	0.88743	25558	15	16-QAM

TABLE 2: CQI mapping for TFRC selection according to the present invention for a HSDPA downlink channel with a category 10 UE supporting a maximum of 15 spreading codes and QPSK or 16-QAM modulation

[0048] Table 2 includes the preferred TBSS, number of spreading codes and modulation type as derived according to the present invention described above, and the associated coding rate, for each possible CQI value for a category 10 WTRU. When Table 2 is compared to the CQI mapping table for a category 10 UE in 3GPP TS 125.214 as reproduced in Table 1, it is observed that TFRC selection according to the present invention generally selects a greater number of spreading codes and a larger TBSS, whenever possible and in particular for intermediate CQI values, in order to improve overall channel throughput.

[0049] Figure 5 shows the measured throughput on a downlink CDMA channel using the existing 3GPP CQI mapping as given in Table 1 compared to the measured throughput for the optimized CQI mapping generated according to the present invention in Table 2 for a category 10 UE for a range of average SNR values and for a TB success probability of 0.9. The throughput is given versus an average SNR because of variations in the instantaneous SNR as a result of fading in the channel. Figure 5 illustrates the improvement in throughput achieved by the present invention over existing TFRC selection techniques.

[0050] Embodiments.

[0051] Embodiment 1. A method for generating and selecting transport format resource combinations (TFRCs) in a medium access control layer of a wireless transmit receive unit (WTRU) to be used for transmission of data over a code division multiple access (CDMA) channel in a wireless communication system, wherein a TFRC includes a transport block set size (TBSS) value, a number of spreading codes, and a type of modulation.

[0052] Embodiment 2. The method of embodiment 1 further comprising determining a maximum number of spreading codes for transmission.

[0053] Embodiment 3. The method as in any of embodiments 1-2 further comprising generating a set of possible TFRCs.

[0054] Embodiment 4. The method of embodiment 3 further comprising grouping the possible TFRCs according to common TBSS value.

[0055] Embodiment 5. The method of embodiment 4 further comprising from each group of possible TFRCs, selecting a TFRC that has the largest

number of spreading codes not greater than the determined maximum number of spreading codes and that has a corresponding code rate at least equal to a minimum code rate.

[0056] Embodiment 6. The method of embodiment 5 further comprising selecting a type of modulation for each selected TFRC by comparing at least one corresponding code rate to at least one predetermined threshold.

[0057] Embodiment 7. The method of embodiment 6 further comprising providing one of the selected TFRCs to a physical (PHY) layer to be used for data transmission over the CDMA channel.

[0058] Embodiment 8. The method as in any of embodiments 2-7 wherein the determining a maximum number of spreading codes is based on a resource allocation scheme associated with the CDMA channel.

[0059] Embodiment 9. The method of embodiment 7 further comprising receiving from the PHY layer a channel quality indicator (CQI) value corresponding to the CDMA channel.

[0060] Embodiment 10. The method of embodiment 9 wherein the generating a set of possible TFRCs is based at least in part on the received CQI value and a predetermined transport block (TB) success probability associated with the CDMA channel.

[0061] Embodiment 11. The method as in any of embodiments 9-10 wherein the providing one of the selected TFRCs to the PHY layer is based at least in part on the received CQI value and a predetermined transport block (TB) success probability associated with the CDMA channel.

[0062] Embodiment 12. The method as in any of embodiments 10-11 wherein a predetermined TB success probability of approximately 0.9 is utilized.

[0063] Embodiment 13. The method as in any of embodiments 9-12 wherein the CQI value that is received is an integer value from 1 to 30 having a known corresponding mapping to a TBSS value, a number of spreading codes and a modulation type that correspond to characteristics of the CDMA channel.

[0064] Embodiment 14. The method of embodiment 13 wherein the CQI value that is received is an integer value from 1 to 30 having a known

corresponding mapping to a TBSS value, a number of spreading codes and a modulation type that corresponds to at least a maximum expected data rate characteristic of the CDMA channel.

[0065] Embodiment 15. The method of embodiment 14 wherein the generating a set of possible TFRCs is based on matching a data rate corresponding to a TFRC to the maximum expected data rate characteristic of the CDMA channel and the predetermined TB success probability.

[0066] Embodiment 16. The method as in any of embodiments 14-15 wherein providing one of the selected TFRCs to the PHY layer is based on matching a data rate corresponding to a TFRC to the maximum expected data rate of the CDMA channel and the predetermined TB success probability.

[0067] Embodiment 17. The method of embodiment 16 wherein the providing one of the selected TFRCs to the PHY layer is further based on choosing one of the selected TFRCs with a largest corresponding TBSS value.

[0068] Embodiment 18. The method as in any of the previous embodiments performed in a base station wherein the CDMA channel is a downlink channel.

[0069] Embodiment 19. The method of embodiment 18 further comprising receiving the CQI value in the base station PHY layer via an uplink channel.

[0070] Embodiment 20. The method of embodiment 19 wherein CQI value has been determined by measuring a maximum expected data rate of the downlink channel.

[0071] Embodiment 21. The method of embodiment 20 wherein the CQI value is determined as proportional to the measured maximum expected data rate.

[0072] Embodiment 22. The method of embodiment 21 wherein selecting a TFRC from each group of possible TFRCs is according to a TFRC that has exactly 1 spreading code for low CQI values for which 1 spreading code maximizes a theoretical CDMA channel capacity.

[0073] Embodiment 23. The method of embodiment 22 wherein the low CQI values include CQI values no greater than 7.

[0074] Embodiment 24. The method as in any of embodiments 5-23 further comprising maintaining selected TFRCs in a list and sorting the list according to TBSS value.

[0075] Embodiment 25. The method as in any of embodiments 5-24 wherein a turbo code rate equal to 1/3 is used as the minimum code rate.

[0076] Embodiment 26. The method as in any of embodiments 6-25 wherein a type of modulation part of a TFRC is one of quadrature phase shift keying (QPSK) modulation and 16 quadrature amplitude modulation (16-QAM).

[0077] Embodiment 27. The method of embodiment 26 wherein the selecting a type of modulation for each selected TFRC includes determining the at least one corresponding code rate for each selected TFRC when the type of modulation is assumed to be QPSK.

[0078] Embodiment 28. The method of embodiment 27 wherein if the at least one corresponding code rate is below the at least one predetermined threshold QPSK modulation is selected and otherwise 16-QAM is selected.

[0079] Embodiment 29. The method of embodiment 28 wherein the type of modulation part of a TFRC may also be 64 quadrature amplitude modulation (64-QAM).

[0080] Embodiment 30. The method of embodiment 29 further comprising determining a second corresponding code rate for each selected TFRC when the type of modulation is assumed to be 16-QAM.

[0081] Embodiment 31. The method of embodiment 30 further comprising comparing the second corresponding code rate for each selected TFRC to a second predetermined threshold.

[0082] Embodiment 32. The method of embodiment 31 wherein if the at least one corresponding code rate is above the at least one predetermined threshold and the second corresponding code rate is below the second predetermined threshold 16-QAM is selected, and if the second corresponding code rate is above the second predetermined threshold 64-QAM is selected.

[0083] Embodiment 33. The method as in any of embodiments 31-32 wherein the second predetermined threshold is in between 0 and 1.

[0084] Embodiment 34. The method as in any of embodiments 6-33 wherein the at least one predetermined is in between 0 and 1.

[0085] Embodiment 35. The method of embodiment 34 wherein the at least one predetermined threshold is 0.74.

[0086] Embodiment 36. The method as in any of embodiments 6-35 further comprising determining the pre-determined thresholds by measuring empirically and comparing throughput versus received signal-to-noise ratio (SNR) for each modulation type.

[0087] Embodiment 37. The method as in any of the previous embodiments performed in a WTRU configured for use in a Third Generation Partnership Project (3GPP) compliant wireless communication system.

[0088] Embodiment 38. The method of embodiment 37 performed in a WTRU configured for use in a Third Generation Partnership Project (3GPP) compliant wireless communication system with high speed downlink packet access (HSDPA).

[0089] Embodiment 39. The method of embodiment 28 wherein a maximum number of codes is no more than 15.

[0090] Embodiment 40. The method of embodiment 39 wherein the maximum number of codes is also according to receiver capabilities of a receiving WTRU of the CDMA channel.

[0091] Embodiment 41. The method of embodiment 40 wherein the receiver capabilities are according to a physical layer category associated with the receiving WTRU.

[0092] Embodiment 42. The method as in any of embodiments 1-37 performed in a WTRU configured for use in a Third Generation Partnership Project (3GPP) compliant wireless communication system with high speed packet access evolution (HSPA+).

[0093] Embodiment 43. A wireless transmit receive unit (WTRU) configured with a hierarchy of processing layers including physical (PHY) layer, medium access control (MAC) layer and higher layers.

[0094] Embodiment 44. The WTRU of embodiment 43 further comprising a MAC layer transport format resource combination (TFRC) selection function component configured to generate and select transport format resource combinations (TFRCs) to be used for transmission of data over a CDMA channel, wherein a TFRC includes a transport block set size (TBSS) value, a number of spreading codes, and a type of modulation.

[0095] Embodiment 45. The WTRU of embodiment 44 wherein the TFRC selection function component is further configured to determine a maximum number of codes available for transmission.

[0096] Embodiment 46. The WTRU of embodiment 45 wherein the TFRC selection function component is further configured generate a set of possible TFRCs.

[0097] Embodiment 47. The WTRU of embodiment 46 wherein the TFRC selection function component is further configured to group the possible TFRCs according to common TBSS value.

[0098] Embodiment 48. The WTRU of embodiment 47 wherein the TFRC selection function component is further configured to select a TFRC from each group of possible TFRCs that has the largest number of spreading codes not greater than the determined maximum number of codes and that has a corresponding code rate at least equal to a minimum code rate.

[0099] Embodiment 49. The WTRU of embodiment 48 wherein the TFRC selection function component is further configured to select a type of modulation for each selected TFRC by comparing at least one corresponding code rate to at least one predetermined threshold.

[00100] Embodiment 50. The WTRU of embodiment 49 wherein the TFRC selection function component is further configured to provide one of the selected TFRCs to the PHY layer to be used for data transmission over the CDMA channel.

[00101] Embodiment 51. The WTRU of embodiment 27 wherein the TFRC selection function component is configured to determine a maximum number of

spreading codes based on a resource allocation scheme associated with the CDMA channel.

[00102] Embodiment 52. The WTRU of embodiment 50 wherein the TFRC selection function component is further configured to receive from the PHY layer a channel quality indicator (CQI) value corresponding to the CDMA channel.

[00103] Embodiment 53. The WTRU of embodiment 52 wherein the TFRC selection function component is further configured to generate a set of possible TFRCs according to the CQI value and a predetermined transport block (TB) success probability associated with the CDMA channel.

[00104] Embodiment 54. The WTRU as in any of embodiments 52-53 wherein the TFRC selection function component is further configured provide one of the selected TFRCs to the PHY layer according to the CQI value and a predetermined transport block (TB) success probability associated with the CDMA channel.

[00105] Embodiment 55. The WTRU as in any of embodiments 53-54 wherein the TFRC selection function component is configured to use a TB success probability of approximately 0.9 as the predetermined TB success probability.

[00106] Embodiment 56. The WTRU as in any of embodiments 52-55 the TFRC selection function component is configured to receive as a CQI value an integer value from 1 to 30 with a known corresponding mapping to a TBSS value, a number of spreading codes and a modulation type that correspond to characteristics of the CDMA channel.

[00107] Embodiment 57. The WTRU of embodiment 56 wherein the TFRC selection function component is configured to receive as a CQI value an integer value from 1 to 30 with a known corresponding mapping to a TBSS value, a number of spreading codes and a modulation type that correspond to a maximum expected data rate characteristic of the CDMA channel.

[00108] Embodiment 58. The WTRU of embodiment 57 wherein the TFRC selection function component is further configured to generate a set of possible TFRCs by matching a data rate corresponding to a TFRC to the maximum

expected data rate characteristic of the CDMA channel and the predetermined TB success probability.

[00109] Embodiment 59. The WTRU as in any of embodiments 57-58 wherein the TFRC selection function component is further configured to provide one of the selected TFRCs to the PHY layer by matching a data rate corresponding to a TFRC to the maximum expected data rate of the CDMA channel and the predetermined TB success probability.

[00110] Embodiment 60. The WTRU of embodiment 59 wherein the TFRC selection function component is configured to provide one of the selected TFRCs to the PHY layer is further based on choosing one of the selected TFRCs with a largest corresponding TBSS value.

[00111] Embodiment 61. The WTRU as in any of embodiments 53-60 configured as a base station wherein the CDMA channel is a downlink channel.

[00112] Embodiment 62. The base station of embodiment 61 configured to receive the CQI value by the base station PHY layer via an uplink channel.

[00113] Embodiment 63. The base station of embodiment 62 wherein the CQI value is determined by measuring a maximum expected data rate of the downlink channel transmitted by the base station.

[00114] Embodiment 64. The WTRU of embodiment 63 wherein the CQI value is proportional to the measured maximum expected data rate.

[00115] Embodiment 65. The WTRU of embodiment 64 wherein the TFRC selection function component is configured to select a TFRC from each group of possible TFRCs according to the TFRC that has exactly 1 spreading code for low CQI values for which 1 spreading code maximizes a theoretical CDMA channel capacity.

[00116] Embodiment 66. The WTRU of embodiment 65 wherein the TFRC selection function component is configured to use as the low CQI values a value no greater than 7.

[00117] Embodiment 67. The WTRU as in any of embodiment 48-66 wherein the TFRC selection function component is further configured to maintain the selected TFRCs in a list and sort the list according to TBSS.

[00118] Embodiment 68. The WTRU as in any of embodiments 48-67 wherein the TFRC selection function component is configured to use as the code rate a turbo code rate that has a minimum code rate equal to $1/3$.

[00119] Embodiment 69. The WTRU as in any of embodiments 49-68 configured to use as the type of modulation part of a TFRC, one of quadrature phase shift keying (QPSK) modulation and 16 quadrature amplitude modulation (16-QAM).

[00120] Embodiment 70. The WTRU of embodiment 69 wherein the TFRC selection function component is configured select a type of modulation for each selected TFRC by determining the at least one corresponding code rate for each selected TFRC when the type of modulation is assumed to be QPSK.

[00121] Embodiment 71. The WTRU of embodiment 70 wherein if the at least one corresponding code rate is below the at least one predetermined threshold QPSK modulation is selected and otherwise 16-QAM is selected.

[00122] Embodiment 72. The WTRU of embodiment 71 wherein the type of modulation part of a TFRC may also be 64 quadrature amplitude modulation (64-QAM).

[00123] Embodiment 73. The WTRU of embodiment 72 wherein the TFRC selection function component is further configured to determine a second corresponding code rate for each selected TFRC when the type of modulation is assumed to be 16-QAM.

[00124] Embodiment 74. The WTRU of embodiment 73 wherein the TFRC selection function component is further configured to compare the second corresponding code rate for each selected TFRC to a second predetermined threshold, wherein if the at least one corresponding code rate is above the at least one predetermine threshold and the second corresponding code rate is below the second predetermined threshold 16-QAM is selected, and if the second corresponding code rate is above the second predetermined threshold 64-QAM is selected.

[00125] Embodiment 75. The WTRU as in any of embodiment 74 wherein the TFRC selection function component is configured to use as the second predetermined threshold a value that is between 0 and 1.

[00126] Embodiment 76. The WTRU as in any of embodiment 49-75 wherein the TFRC selection function component is configured to use as the at least one predetermined threshold a value that is between 0 and 1.

[00127] Embodiment 77. The WTRU of embodiment 76 wherein the TFRC selection function component is configured to use as the at least one predetermined threshold a value of 0.74.

[00128] Embodiment 78. The WTRU as in any of embodiments 43-77 configured to operate in a Third Generation Partnership Project (3GPP) compliant wireless communication system.

[00129] Embodiment 79. The WTRU of embodiment 78 configured to conduct wireless communication according to high speed downlink packet access (HSDPA).

[00130] Embodiment 80. The WTRU of embodiment 79 configured to use no more than 15 codes as the maximum number of codes.

[00131] Embodiment 81. The WTRU of embodiment 80 configured to determine the maximum number of codes according to capabilities of a WTRU that receives the CDMA channel.

[00132] Embodiment 82. The WTRU of embodiment 78 configured to conduct wireless communication according to high speed downlink packet access evolution (HSDPA+).

[00133] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the preferred embodiments or in various combinations with or without other features and elements of the present invention. The methods or flow charts provided in the present invention may be implemented in a computer program, software, or firmware tangibly embodied in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-

readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

[00134] The components for implementing the invention referenced above may be implemented as separate physical devices or combined such as in a processor that implements the functions of multiple components. Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any integrated circuit, and/or a state machine.

[00135] A processor in association with software may be used to implement a radio frequency transceiver for in use in a wireless transmit receive unit (WTRU), user equipment, terminal, base station, radio network controller, or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) module.

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CLAIMS

What is claimed is:

1. A method for generating and selecting transport format resource combinations (TFRCs) in a medium access control layer of a wireless transmit receive unit (WTRU) to be used for transmission of data over a code division multiple access (CDMA) channel in a wireless communication system, wherein a TFRC includes a transport block set size (TBSS) value, a number of spreading codes, and a type of modulation, the method comprising:

determining a maximum number of spreading codes for transmission;

generating a set of possible TFRCs and grouping the possible TFRCs according to common TBSS value;

from each group of possible TFRCs, selecting a TFRC that has the largest number of spreading codes not greater than the determined maximum number of spreading codes and that has a corresponding code rate at least equal to a minimum code rate;

selecting a type of modulation for each selected TFRC by comparing at least one corresponding code rate to at least one predetermined threshold; and

providing one of the selected TFRCs to a physical (PHY) layer to be used for data transmission over the CDMA channel.

2. The method of claim 1 wherein the determining a maximum number of spreading codes is based on a resource allocation scheme associated with the CDMA channel.

3. The method of claim 1 further comprising receiving from the PHY layer a channel quality indicator (CQI) value corresponding to the CDMA channel, wherein:

the generating a set of possible TFRCs and the providing one of the selected TFRCs to the PHY layer is based at least in part on the received CQI value and a predetermined transport block (TB) success probability associated with the CDMA channel.

4. The method of claim 3 wherein a predetermined TB success probability of approximately 0.9 is utilized.

5. The method of claim 3 wherein the CQI value that is received is an integer value from 1 to 30 having a known corresponding mapping to a TBSS value, a number of spreading codes and a modulation type that correspond to characteristics of the CDMA channel.

6. The method of claim 3 wherein the CQI value that is received is an integer value from 1 to 30 having a known corresponding mapping to a TBSS value, a number of spreading codes and a modulation type that corresponds to at least a maximum expected data rate characteristic of the CDMA channel.

7. The method of claim 6 wherein the generating a set of possible TFRCs and providing one of the selected TFRCs to the PHY layer is based on matching a data rate corresponding to a TFRC to the maximum expected data rate characteristic of the CDMA channel and the predetermined TB success probability.

8. The method of claim 7 wherein the providing one of the selected TFRCs to the PHY layer is further based on choosing one of the selected TFRCs with a largest corresponding TBSS value.

9. The method of claim 3 performed in a base station wherein the CDMA channel is a downlink channel.

10. The method of claim 9 further comprising:
receiving the CQI value in the base station PHY layer via an uplink channel that has been determined by measuring a maximum expected data rate of the downlink channel.

11. The method of claim 10, wherein the CQI value is determined as proportional to the measured maximum expected data rate, and wherein selecting a TFRC from each group of possible TFRCs is according to the TFRC that has exactly 1 spreading code for low CQI values for which 1 spreading code maximizes a theoretical CDMA channel capacity.

12. The method of claim 11 wherein the low CQI values include CQI values no greater than 7.

13. The method of claim 1 further comprising maintaining the selected TFRCs in a list and sorting the list according to TBSS value.

14. The method of claim 1 wherein a turbo code rate equal to 1/3 is used as the minimum code rate.

15. The method of claim 1 wherein the type of modulation part of a TFRC is one of quadrature phase shift keying (QPSK) modulation and 16 quadrature amplitude modulation (16-QAM).

16. The method of claim 15 wherein the selecting a type of modulation for each selected TFRC includes determining the at least one corresponding code rate for each selected TFRC when the type of modulation is assumed to be QPSK, wherein if the at least one corresponding code rate is below the at least one predetermined threshold QPSK modulation is selected and otherwise 16-QAM is selected.

17. The method of claim 16 wherein the type of modulation part of a TFRC may also be 64 quadrature amplitude modulation (64-QAM), further comprising:

determining a second corresponding code rate for each selected TFRC when the type of modulation is assumed to be 16-QAM; and

comparing the second corresponding code rate for each selected TFRC to a second predetermined threshold, wherein if the at least one corresponding code rate is above the at least one predetermine threshold and the second corresponding code rate is below the second predetermined threshold 16-QAM is selected, and if the second corresponding code rate is above the second predetermined threshold 64-QAM is selected.

18. The method of claim 17 wherein the at least one predetermined threshold and the second predetermined threshold are each in between 0 and 1.

19. The method of claim 18 wherein the at least one predetermined threshold is 0.74.

20. The method of claim 17 further comprising:

determining the pre-determined thresholds by measuring empirically and comparing throughput versus received signal-to-noise ratio (SNR) for each modulation type.

21. The method of claim 1 performed in a WTRU configured for use in a Third Generation Partnership Project (3GPP) compliant wireless communication system.

22. The method of claim 21 performed in a WTRU configured for use in a Third Generation Partnership Project (3GPP) compliant wireless communication system with high speed downlink packet access (HSDPA).

23. The method of claim 22 wherein the maximum number of codes is no more than 15.

24. The method of claim 23 wherein the maximum number of codes is also according to receiver capabilities of a receiving WTRU of the CDMA channel.

25. The method of claim 24 wherein the receiver capabilities are according to a physical layer category associated with the receiving WTRU.

26. The method of claim 21 performed in a WTRU configured for use in a Third Generation Partnership Project (3GPP) compliant wireless communication system with high speed packet access evolution (HSPA+).

27. A wireless transmit receive unit (WTRU) configured with a hierarchy of processing layers including physical (PHY) layer, medium access control (MAC) layer and higher layers, the WTRU comprising:

a MAC layer transport format resource combination (TFRC) selection function component configured to generate and select transport format resource combinations (TFRCs) to be used for transmission of data over a CDMA channel, wherein a TFRC includes a transport block set size (TBSS) value, a number of spreading codes, and a type of modulation, the TFRC selection function component further configured to:

determine a maximum number of codes available for transmission;
generate a set of possible TFRCs and group the possible TFRCs according to common TBSS value;

select a TFRC from each group of possible TFRCs that has the largest number of spreading codes not greater than the determined maximum number of codes and that has a corresponding code rate at least equal to a minimum code rate;

select a type of modulation for each selected TFRC by comparing at least one corresponding code rate to at least one predetermined threshold;
and

provide one of the selected TFRCs to the PHY layer to be used for data transmission over the CDMA channel.

28. The WTRU of claim 27 wherein the TFRC selection function component is configured to determine a maximum number of spreading codes based on a resource allocation scheme associated with the CDMA channel.

29. The WTRU of claim 27 wherein the TFRC selection function component is further configured to receive from the PHY layer a channel quality indicator (CQI) value corresponding to the CDMA channel, wherein:

the TFRC selection function component is configured to generate a set of possible TFRCs, and provide one of the selected TFRCs to the PHY layer according to the CQI value and a predetermined transport block (TB) success probability associated with the CDMA channel.

30. The WTRU of claim 29 wherein the TFRC selection function component is configured to use a TB success probability of approximately 0.9 as the predetermined TB success probability.

31. The WTRU of claim 29 wherein the TFRC selection function component is configured to receive as a CQI value an integer value from 1 to 30 with a known corresponding mapping to a TBSS value, a number of spreading codes and a modulation type that correspond to characteristics of the CDMA channel.

32. The WTRU of claim 29 wherein the TFRC selection function component is configured to receive as a CQI value an integer value from 1 to 30 with a known corresponding mapping to a TBSS value, a number of spreading codes and a modulation type that correspond to a maximum expected data rate characteristic of the CDMA channel.

33. The WTRU of claim 32 wherein the TFRC selection function component is configured to generate a set of possible TFRCs and provide one of

the selected TFRCs to the PHY layer by matching a data rate corresponding to a TFRC to the maximum expected data rate characteristic of the CDMA channel and the predetermined TB success probability.

34. The WTRU of claim 33 wherein the TFRC selection function component is configured to provide one of the selected TFRCs to the PHY layer based on choosing one of the selected TFRCs with a largest corresponding TBSS value.

35. The WTRU of claim 27 configured as a base station wherein the CDMA channel is a downlink channel.

36. The base station of claim 35 configured to receive the CQI value by the base station PHY layer via an uplink channel that is determined by measuring a maximum expected data rate of the downlink channel transmitted by the base station.

37. The WTRU of claim 36 wherein the CQI value is proportional to the measured maximum expected data rate, and wherein the TFRC selection function component is configured to select a TFRC from each group of possible TFRCs according to the TFRC that has exactly 1 spreading code for low CQI values for which 1 spreading code maximizes a theoretical CDMA channel capacity.

38. The WTRU of claim 37 wherein the TFRC selection function component is configured to use as the low CQI values a value no greater than 7.

39. The WTRU of claim 27 wherein the TFRC selection function component is further configured to maintain the selected TFRCs in a list and sort the list according to TBSS.

40. The WTRU of claim 27 wherein the TFRC selection function component is configured to use as the code rate a turbo code rate that has a minimum code rate equal to $1/3$.

41. The WTRU of claim 27 configured to use as the type of modulation part of a TFRC, one of quadrature phase shift keying (QPSK) modulation and 16 quadrature amplitude modulation (16-QAM).

42. The WTRU of claim 41 wherein the TFRC selection function component is configured select a type of modulation for each selected TFRC by determining the at least one corresponding code rate for each selected TFRC when the type of modulation is assumed to be QPSK, wherein if the at least one corresponding code rate is below the at least one predetermined threshold QPSK modulation is selected and otherwise 16-QAM is selected.

43. The WTRU of claim 42 wherein the type of modulation part of a TFRC may also be 64 quadrature amplitude modulation (64-QAM), wherein the TFRC selection function component is further configured to:

determine a second corresponding code rate for each selected TFRC when the type of modulation is assumed to be 16-QAM; and

compare the second corresponding code rate for each selected TFRC to a second predetermined threshold, wherein if the at least one corresponding code rate is above the at least one predetermine threshold and the second corresponding code rate is below the second predetermined threshold 16-QAM is selected, and if the second corresponding code rate is above the second predetermined threshold 64-QAM is selected.

44. The WTRU of claim 27 wherein the TFRC selection function component is configured to use as the at least one predetermined threshold and as the second predetermined threshold values that are between 0 and 1.

45. The WTRU of claim 27 wherein the TFRC selection function component is configured to use as the at least one predetermined threshold a value of 0.74.

46. The WTRU of claim 27 configured to operate in a Third Generation Partnership Project (3GPP) compliant wireless communication system.

47. The WTRU of claim 27 configured to conduct wireless communication according to high speed downlink packet access (HSDPA).

48. The WTRU of claim 47 configured to use no more than 15 codes as the maximum number of codes.

49. The WTRU of claim 48 configured to determine the maximum number of codes according to capabilities of a WTRU that receives the CDMA channel.

50. The WTRU of claim 27 configured to conduct wireless communication according to high speed downlink packet access evolution (HSDPA+).

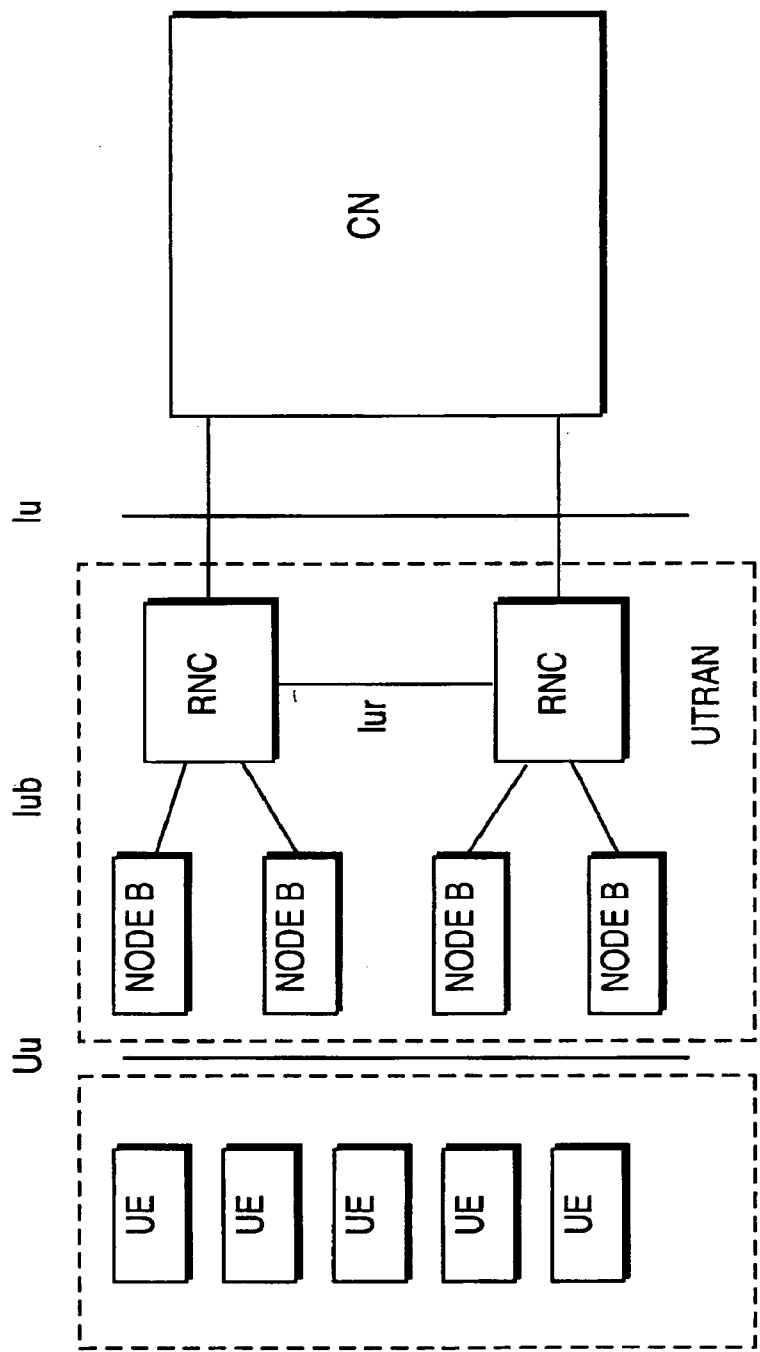


FIG. 1
PRIOR ART

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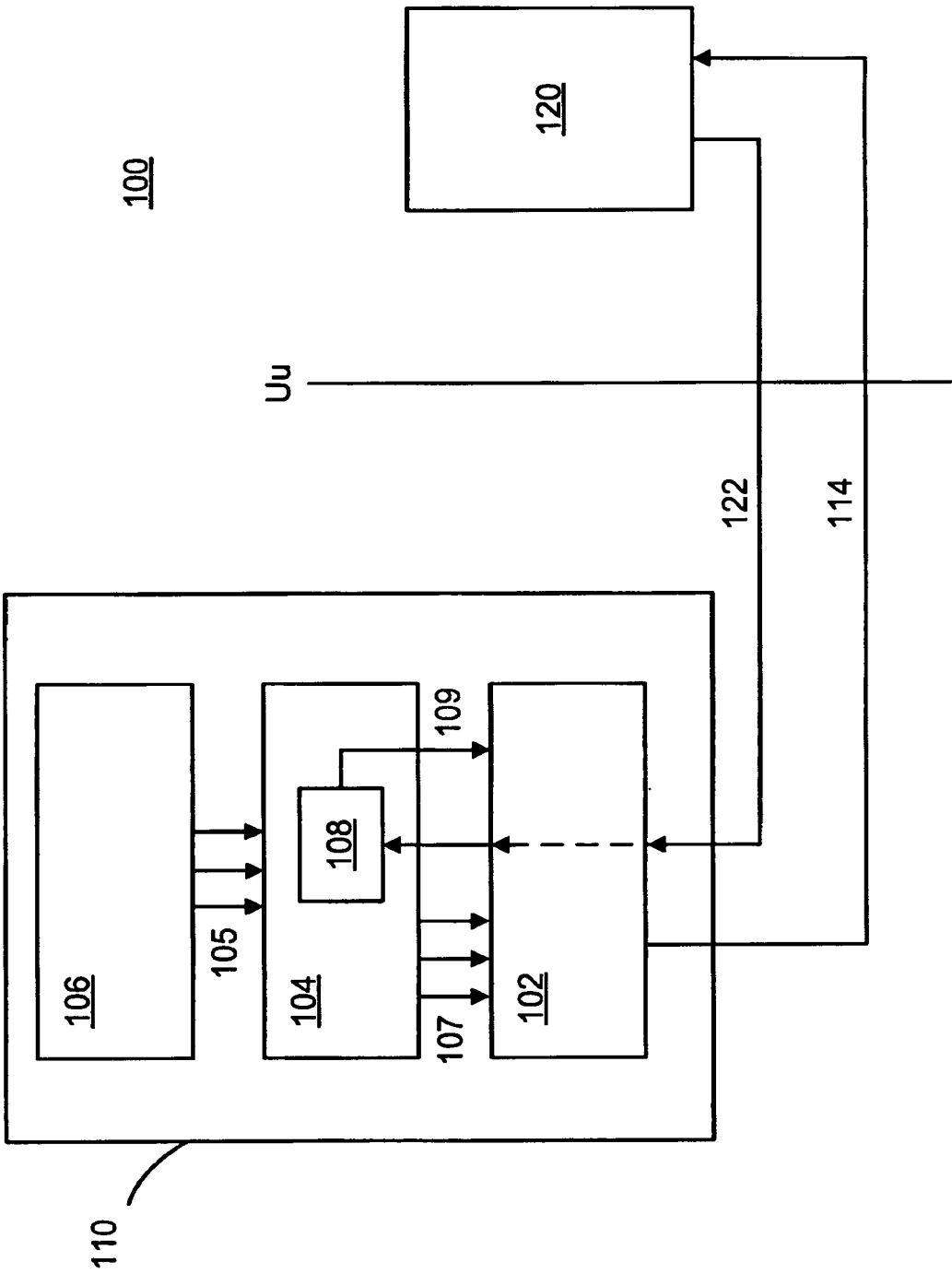


FIG. 2

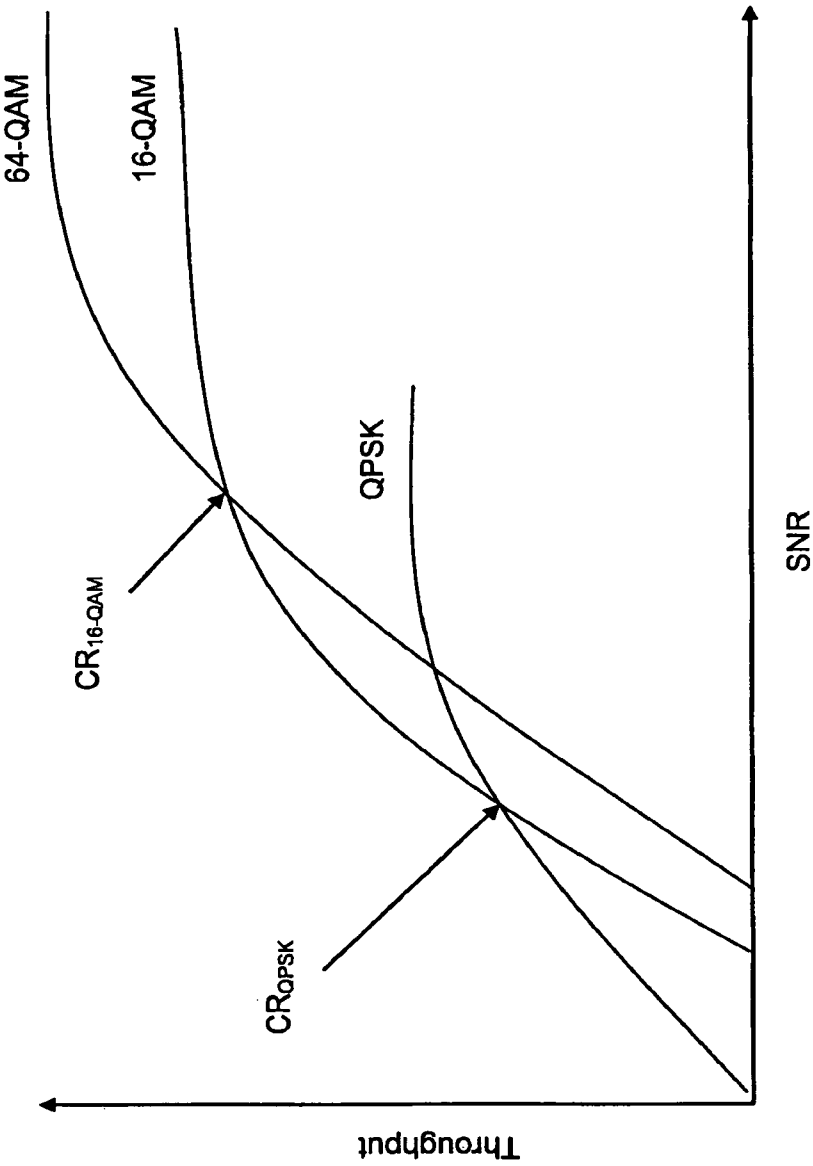
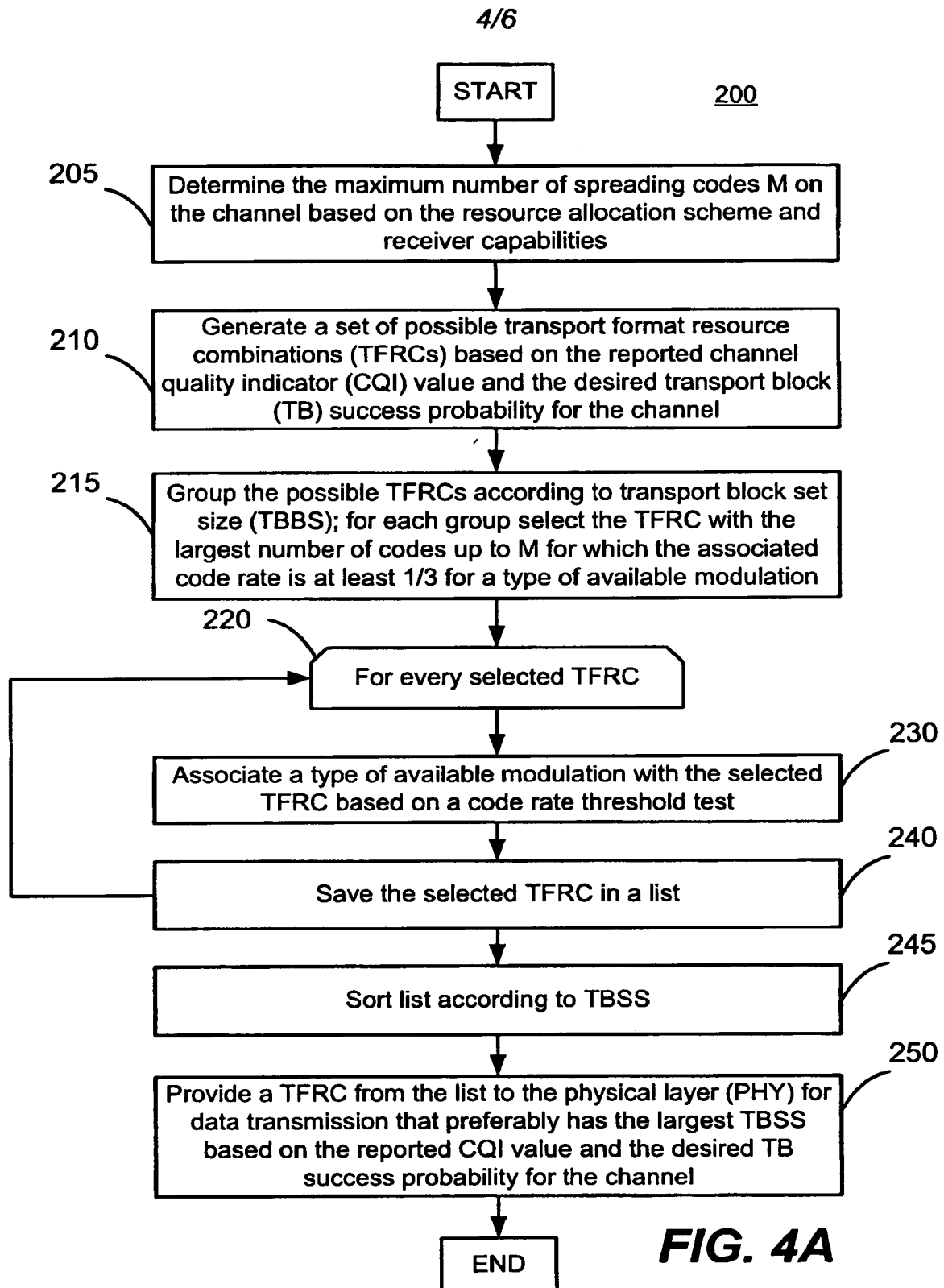
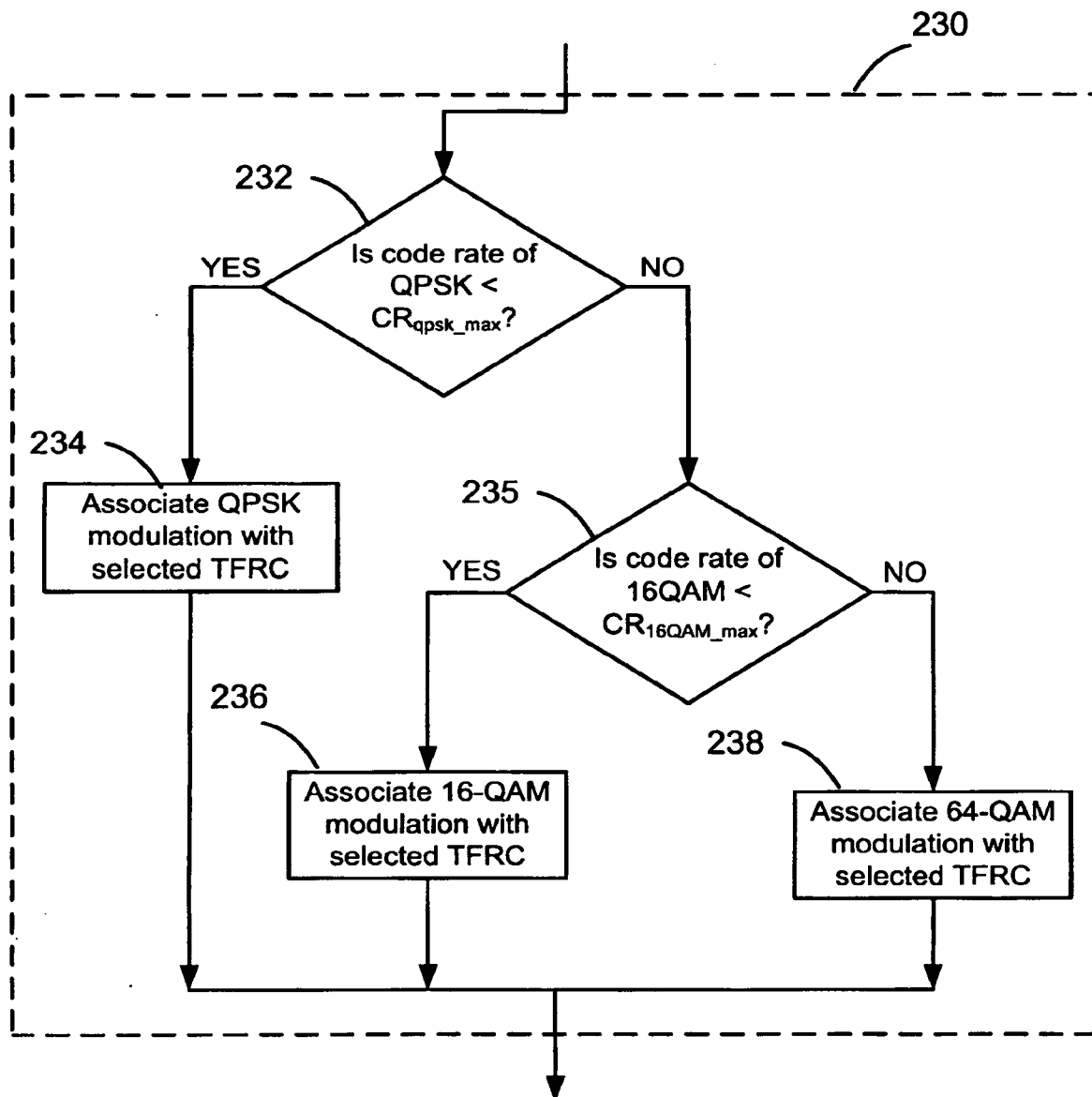


FIG. 3



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**FIG. 4B**

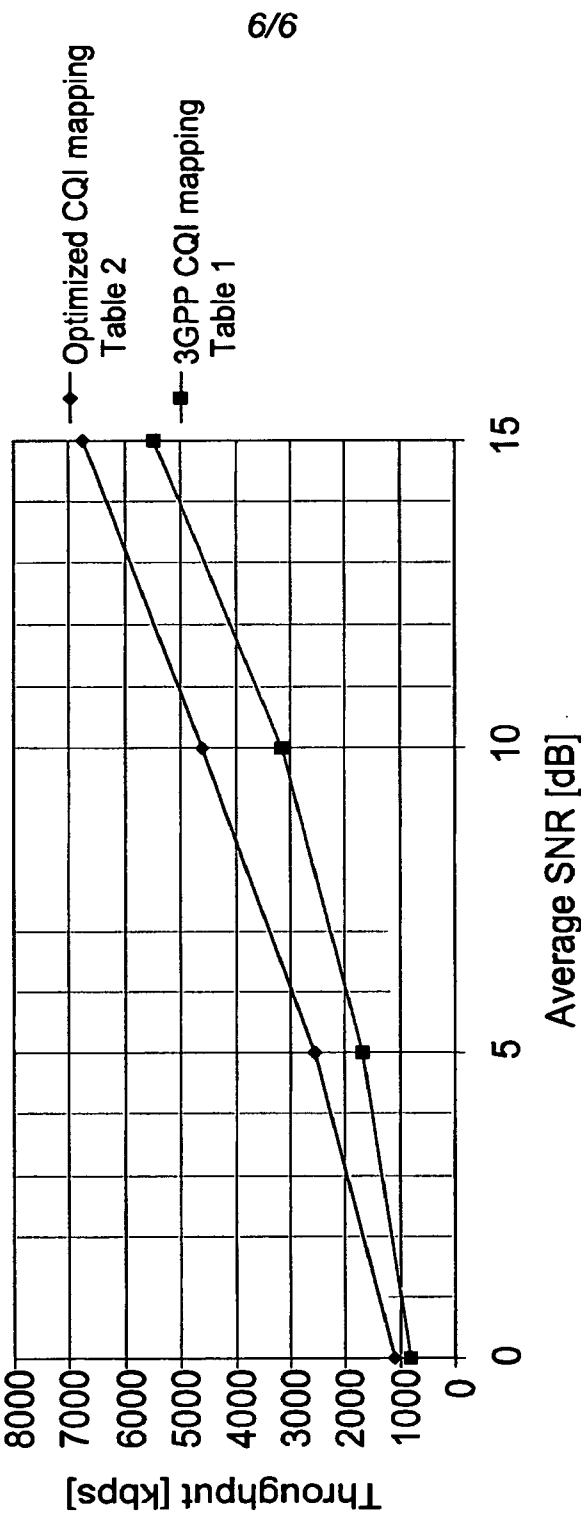


FIG. 5