(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 October 2019 (10.10.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/191973 A1

(51) International Patent Classification:
H04W 28/10 (2009.01)

(21) International Application Number:
PCT/CN2018/082015

(22) International Filing Date:
04 April 2018 (04.04.2018)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **ZTE CORPORATION** [CN/CN]; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN).

(72) Inventors: **GUO, Qiujin**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **XU, Jun**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **XU, Jin**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **ZHOU, Wen**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN).

(74) Agent: **BEYOND ATTORNEYS AT LAW**; F6, Xijin Centre, 39 Lianhuachi East Rd., Haidian District, Beijing 100036 (CN).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,

(54) Title: METHODS, APPARATUS AND SYSTEMS FOR DETERMINING TRANSPORT BLOCK SIZE IN WIRELESS COMMUNICATIONS

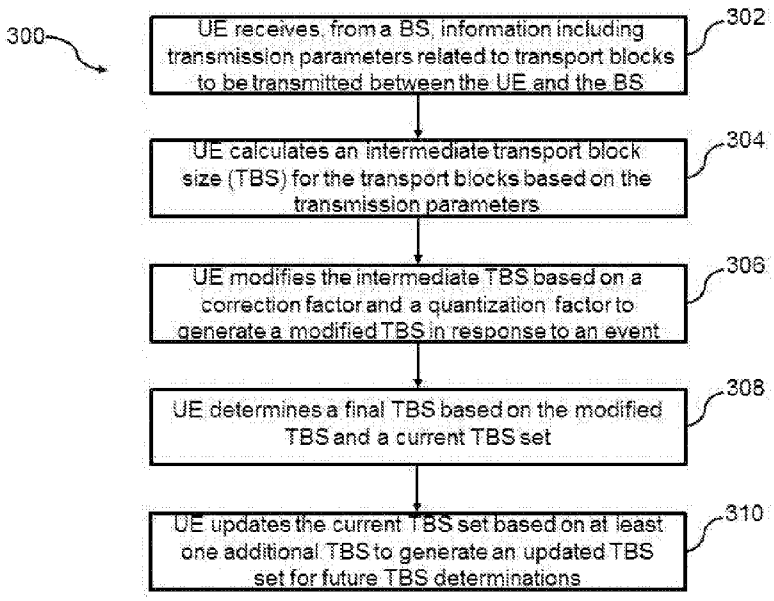


FIG. 3

(57) Abstract: Methods, apparatus and systems for determining a transport block size in wireless communications are disclosed. In one embodiment, a method performed by a wireless communication device is disclosed. The method comprises: receiving information from a wireless communication node, wherein the information includes a plurality of transmission parameters related to transport blocks to be transmitted between the wireless communication device and a wireless communication node; calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters; modifying the intermediate TBS to generate a modified TBS; determining a final TBS for the transport blocks based on the modified TBS and a current set of TBSs; and updating the current set based on at least one new TBS to generate an updated set of TBSs for future TBS determinations.

WO 2019/191973 A1

[Continued on next page]

OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

METHODS, APPARATUS AND SYSTEMS FOR DETERMINING TRANSPORT BLOCK SIZE IN WIRELESS COMMUNICATIONS

TECHNICAL FIELD

The disclosure relates generally to wireless communications and, more particularly, to methods, apparatus and systems for determining a transport block size in wireless communications.

BACKGROUND

Wireless networking systems have become a prevalent means by which a majority of people worldwide has come to communicate. A typical wireless communication network (e.g., employing frequency, time, and/or code division techniques) includes one or more base stations (typically known as a "BS") that each provides a geographical radio coverage, and one or more wireless user equipment devices (typically know as a "UE") that can transmit and receive data within the radio coverage.

In a wireless communication system, e.g. the fifth-generation (5G) new radio (NR) network, a transport block (TB) is usually encoded and then sent. In an NR network, transport block sizes (TBSs) are determined based on a look-up table and/or formula, and N_{info} that is obtained by a product of the total number of resource elements (N_{RE}), the number of mapping layers (v), the modulation order (Q_m) and code rate (R) that is determined by modulation and coding scheme (MCS) index and MCS table for physical downlink shared channel (PDSCH) or physical uplink shared channel (PUSCH).

There are two performances to balance in the TBS determination procedure: effective code rate and scheduling flexibility. An effective code rate is the information bits (including cyclic redundancy check (CRC) bits, i.e., TBS + CRC) divided by the actual information bits (i.e., $N_{RE} * v * Q_m$) on the PDSCH or PUSCH. Scheduling flexibility is the number of different combinations of the number of physical resource blocks (PRBs), the number of resource elements per PRB and MCS index allocated by the control information supported by each TBS. The more different combinations supported by each TBS, the better scheduling flexibility of each TBS is for initial transmission and re-transmission.

Existing TBS determination procedures have an inferior effective code rate performance, especially at the allocated highest MCS index of 64-Quadrature Amplitude Modulation (64-QAM) MCS table and 256-QAM MCS table. In addition, packet sizes for special scenario or service, e.g. Voice over Internet Protocol (VoIP) packet sizes, may be needed to add into the current TBS look-up table. That is, the TBS table may be updated from time to time. There is no existing method to update the TBS table without degrading the scheduling flexibility during TBS determination.

Thus, existing systems and methods for determining a transport block size in wireless communications are not entirely satisfactory.

SUMMARY OF THE INVENTION

The exemplary embodiments disclosed herein are directed to solving the issues relating to one or more of the problems presented in the prior art, as well as providing additional features that will become readily apparent by reference to the following detailed description when taken in conjunction with the accompany drawings. In accordance with various embodiments, exemplary systems, methods, devices and computer program products are disclosed herein. It is understood, however, that these embodiments are presented by way of example and not limitation, and it will be apparent to those of ordinary skill in the art who read the present disclosure that various modifications to the disclosed embodiments can be made while remaining within the scope of the present disclosure.

In one embodiment, a method performed by a wireless communication device is disclosed. The method comprises: receiving information from a wireless communication node, wherein the information includes a plurality of transmission parameters related to transport blocks to be transmitted between the wireless communication device and a wireless communication node; calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters; modifying the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS in response to at least one event; and determining a final TBS for the transport blocks based on the modified TBS and a set of TBSs. The determining comprises: determining a subset of one or more TBSs in the set, wherein each TBS in the subset corresponds to a minimal absolute difference among absolute differences between each TBS in the

TBS set and the modified TBS, in response to the subset including a single TBS, determining the single TBS as the final TBS, and in response to the subset including two TBSs, determining one of the two TBSs as the final TBS, based on one of: a smaller one of the two TBSs, a larger one of the two TBSs, and a random one of the two TBSs.

In another embodiment, a method performed by a wireless communication device is disclosed. The method comprises: receiving information from a wireless communication node, wherein the information includes a plurality of transmission parameters related to transport blocks to be transmitted between the wireless communication device and a wireless communication node; calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters; modifying the intermediate TBS to generate a modified TBS; determining a final TBS for the transport blocks based on the modified TBS and a current set of TBSs; and updating the current set based on at least one new TBS to generate an updated set of TBSs for future TBS determinations.

In a further embodiment, a method performed by a wireless communication node is disclosed. The method comprises: generating a plurality of transmission parameters related to transport blocks to be transmitted between a wireless communication device and the wireless communication node; calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters; modifying the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS in response to at least one event; determining a final TBS for the transport blocks based on the modified TBS and a set of TBSs; and transmitting information that includes the plurality of transmission parameters to the wireless communication device. The determining comprises: determining a subset of one or more TBSs in the set, wherein each TBS in the subset corresponds to a minimal absolute difference among absolute differences between each TBS in the TBS set and the modified TBS, in response to the subset including a single TBS, determining the single TBS as the final TBS, and in response to the subset including two TBSs, determining one of the two TBSs as the final TBS, based on one of: a smaller one of the two TBSs, a larger one of the two TBSs, and a random one of the two TBSs.

In another embodiment, a method performed by a wireless communication node is disclosed. The method comprises: generating a plurality of transmission parameters related to transport blocks to be transmitted between a wireless communication device and the wireless

communication node; calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters; modifying the intermediate TBS to generate a modified TBS; determining a final TBS for the transport blocks based on the modified TBS and a current set of TBSs; and updating the current set based on at least one new TBS to generate an updated set of TBSs for future TBS determinations.

In a different embodiment, a wireless communication device configured to carry out a disclosed method in some embodiment is disclosed.

In yet another embodiment, a wireless communication node configured to carry out a disclosed method in some embodiment is disclosed.

In still another embodiment, a non-transitory computer-readable medium having stored thereon computer-executable instructions for carrying out a disclosed method in some embodiment is disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

Various exemplary embodiments of the present disclosure are described in detail below with reference to the following Figures. The drawings are provided for purposes of illustration only and merely depict exemplary embodiments of the present disclosure to facilitate the reader's understanding of the present disclosure. Therefore, the drawings should not be considered limiting of the breadth, scope, or applicability of the present disclosure. It should be noted that for clarity and ease of illustration these drawings are not necessarily drawn to scale.

FIG. 1A illustrates an exemplary communication network in which techniques disclosed herein may be implemented, in accordance with an embodiment of the present disclosure.

FIG. 1B illustrates an exemplary effective code rate performance for a transport block size (TBS) determination based on 64-Quadrature Amplitude Modulation (64-QAM), in accordance with an embodiment of prior art.

FIG. 1C illustrates an exemplary effective code rate performance for a TBS determination based on 256-Quadrature Amplitude Modulation (256-QAM), in accordance with an embodiment of prior art.

FIG. 2 illustrates a block diagram of a user equipment (UE), in accordance with some embodiments of the present disclosure.

FIG. 3 illustrates a flow chart of a method performed by a UE for determining a TBS and updating a TBS set in a wireless communication, in accordance with some embodiments of the present disclosure.

FIG. 4 illustrates a block diagram of a base station (BS), in accordance with some embodiments of the present disclosure.

FIG. 5 illustrates a flow chart of a method performed by a BS for determining a TBS and updating a TBS set in a wireless communication, in accordance with some embodiments of the present disclosure.

FIG. 6 illustrates a flow chart of a method for determining a TBS, in accordance with an embodiment of the present disclosure.

FIG. 7A illustrates an exemplary effective code rate performance for a TBS determination based on 64-QAM, in accordance with an embodiment of the present disclosure.

FIG. 7B illustrates an exemplary effective code rate performance for a TBS determination based on 256-QAM, in accordance with an embodiment of the present disclosure.

FIG. 8A illustrates another exemplary effective code rate performance for a TBS determination based on 64-QAM, in accordance with an embodiment of the present disclosure.

FIG. 8B illustrates another exemplary effective code rate performance for a TBS determination based on 256-QAM, in accordance with an embodiment of the present disclosure.

FIG. 9A illustrates yet another exemplary effective code rate performance for a TBS determination based on 64-QAM, in accordance with an embodiment of the present disclosure.

FIG. 9B illustrates yet another exemplary effective code rate performance for a TBS determination based on 256-QAM, in accordance with an embodiment of the present disclosure.

FIG. 10A illustrates still another exemplary effective code rate performance for a TBS determination based on 64-QAM, in accordance with an embodiment of the present disclosure.

FIG. 10B illustrates still another exemplary effective code rate performance for a TBS determination based on 256-QAM, in accordance with an embodiment of the present disclosure.

FIG. 11A illustrates a different exemplary effective code rate performance for a TBS determination based on 64-QAM, in accordance with an embodiment of the present disclosure.

FIG. 11B illustrates a different exemplary effective code rate performance for a TBS determination based on 256-QAM, in accordance with an embodiment of the present disclosure.

FIG. 12A illustrates a further exemplary effective code rate performance for a TBS determination based on 64-QAM, in accordance with an embodiment of the present disclosure.

FIG. 12B illustrates a further exemplary effective code rate performance for a TBS determination based on 256-QAM, in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Various exemplary embodiments of the present disclosure are described below with reference to the accompanying figures to enable a person of ordinary skill in the art to make and use the present disclosure. As would be apparent to those of ordinary skill in the art, after reading the present disclosure, various changes or modifications to the examples described herein can be made without departing from the scope of the present disclosure. Thus, the present disclosure is not limited to the exemplary embodiments and applications described and illustrated herein. Additionally, the specific order and/or hierarchy of steps in the methods disclosed herein are merely exemplary approaches. Based upon design preferences, the specific order or hierarchy of steps of the disclosed methods or processes can be re-arranged while remaining within the scope of the present disclosure. Thus, those of ordinary skill in the art will understand that the methods and techniques disclosed herein present various steps or acts in a sample order, and the present disclosure is not limited to the specific order or hierarchy presented unless expressly stated otherwise.

In a wireless communication system, e.g. the fifth-generation (5G) new radio (NR) network, a transport block (TB) is usually encoded and then sent. Existing TBS determination procedures have an inferior effective code rate performance, especially at the allocated highest MCS index of 64-QAM MCS table and 256-QAM MCS table. When an intermediate TBS is smaller than a threshold, the effective code rates of most TBSs determined based on different possible resource configurations are larger than 0.95, which is a poor channel coding such that the receiver will skip decoding and report decoding error. As such, many resource allocations are not available for initial transmission and re-transmission.

In response to this problem, the present disclosure provides a method to determine the size of the transport block. This method modifies the existing TBS calculation by introducing a correction factor and a quantization factor to achieve a modified TBS. The correction factor and

the quantization factor may be applied in either order. In one example, the quantization factor is one such that no quantization is applied when generating the modified TBS. The UE can select a TBS from a TBS table based on the modified TBS. For example, the UE can calculate, corresponding to each TBS in the table, an absolute difference between the TBS and the modified TBS to generate a plurality of absolute differences; and determine a subset of one or more TBSs from the table, such that each TBS in the subset corresponds to an absolute difference that is not larger than any one of the plurality of absolute differences. In one embodiment, the subset includes a single TBS, and the single TBS is selected as the final TBS for data transmission. In another embodiment, the subset includes two TBSs, and the UE selects one of the two TBSs as the final TBS, based on one of: a smaller one of the two TBSs, a larger one of the two TBSs, and a random one of the two TBSs.

In addition, packet sizes for special scenario or service, e.g. Voice over Internet Protocol (VoIP) packet sizes, may be needed to add into the current TBS look-up table. That is, the TBS table may be updated from time to time. Directly adding a TBS into the current TBS table may degrade the scheduling flexibility during TBS determination. In response to this problem, the present disclosure provides a method to update the current TBS table, to ensure the TBSs in the updated table have a good granularity that may be represented by differences between adjacent TBSs in the table. For example, the TBS table may be updated to achieve a granularity that is not too large or too small, an even granularity, and/or an increasing granularity for TBSs less than a threshold in the table.

The methods disclosed in the present teaching can be implemented in a wireless communication network, where a BS and a UE can communicate with each other via a communication link, e.g., via a downlink radio frame from the BS to the UE or via an uplink radio frame from the UE to the BS. In various embodiments, a BS in the present disclosure can include, or be implemented as, a next Generation Node B (gNB), an E-UTRAN Node B (eNB), a Transmission/Reception Point (TRP), an Access Point (AP), etc.; while a UE in the present disclosure can include, or be implemented as, a mobile station (MS), a station (STA), etc. A BS and a UE may be described herein as non-limiting examples of "wireless communication nodes," and "wireless communication devices" respectively, which can practice the methods disclosed herein and may be capable of wireless and/or wired communications, in accordance with various embodiments of the present disclosure.

FIG. 1A illustrates an exemplary communication network 100 in which techniques disclosed herein may be implemented, in accordance with an embodiment of the present disclosure. As shown in FIG. 1A, the exemplary communication network 100 includes a base station (BS) 101 and a plurality of UEs, UE 1 110, UE 2 120 … UE 3 130, where the BS 101 can communicate with the UEs according to some wireless protocols. For example, before a downlink transmission, the BS 101 transmits downlink control information (DCI) to a UE, e.g. UE 1 110, to schedule a transport block (TB) to be transmitted from the BS 101 to the UE 1 110. The DCI may include a plurality of transmission parameters related to the transport blocks to be transmitted. Based on the plurality of transmission parameters, the UE may determine a transport block size (TBS) for transmission of the transport blocks. According to various embodiments, the TBS determination may be performed by the BS and/or the UE, and may be applied to downlink and/or uplink TB transmissions.

In an NR network, a final transport block size (TBS) is determined based on a look-up table and/or formula, and N_{info} that is obtained by a product of the total number of resource elements (N_{RE}), the number of mapping layers (v), the modulation order (Q_m) and code rate (R) that is determined by modulation and coding scheme (MCS) index and MCS table for physical downlink shared channel (PDSCH) or physical uplink shared channel (PUSCH). Effective code rate and scheduling flexibility are two performances to balance during the TBS determination.

The effective code rate would usually not be exactly equal to the target code rate because of the difference between the final TBS and N_{info}. A UE may skip decoding a transport block in an initial transmission if the effective channel code rate is higher than 0.95. Therefore, when the difference between the final TBS and N_{info} is slightly large, the effective code rate is probably larger than 0.95. In addition, the scheduling flexibility will be reduced and the performance of throughput will also be degraded. The effective code rate is an important evaluation parameter for a TBS determination algorithm.

The effective code rate performance for current TBS determination procedures are shown FIG. 1B and FIG. 1C. FIG. 1B shows an effective code rate performance based on the highest MCS index of the 64-QAM MCS Table A and simulation parameters in Table C. FIG. 1C shows an effective code rate performance based on the highest MCS index of the 256-QAM MCS Table B and simulation parameters in Table C.

Table A is shown below.

MCS Index I_{MCS}	Modulation Order Q_m	Target code Rate x [1024] R	Spectral efficiency SE
0	2	120	0.2344
1	2	157	0.3066
2	2	193	0.377
3	2	251	0.4902
4	2	308	0.6016
5	2	379	0.7402
6	2	449	0.877
7	2	526	1.0273
8	2	602	1.1758
9	2	679	1.3262
10	4	340	1.3281
11	4	378	1.4766
12	4	434	1.6953
13	4	490	1.9141
14	4	553	2.1602
15	4	616	2.4063
16	4	658	2.5703
17	6	438	2.5664
18	6	466	2.7305
19	6	517	3.0293
20	6	567	3.3223
21	6	616	3.6094
22	6	666	3.9023
23	6	719	4.2129
24	6	772	4.5234
25	6	822	4.8164
26	6	873	5.1152
27	6	910	5.332
28	6	948	5.5547
29	2	reserved	
30	4	reserved	
31	6	reserved	

Table B is shown below.

MCS Index I_{MCS}	Modulation Order Q_m	Target code Rate x [1024] R	Spectral efficiency SE
0	2	120	0.2344
1	2	193	0.377
2	2	308	0.6016
3	2	449	0.877
4	2	602	1.1758
5	4	378	1.4766
6	4	434	1.6953
7	4	490	1.9141
8	4	553	2.1602
9	4	616	2.4063
10	4	658	2.5703
11	6	466	2.7305
12	6	517	3.0293
13	6	567	3.3223
14	6	616	3.6094
15	6	666	3.9023
16	6	719	4.2129
17	6	772	4.5234
18	6	822	4.8164
19	6	873	5.1152
20	8	682.5	5.332
21	8	711	5.5547
22	8	754	5.8906
23	8	797	6.2266
24	8	841	6.5703
25	8	885	6.9141
26	8	916.5	7.1602
27	8	948	7.4063
28	2	reserved	
29	4	reserved	
30	6	reserved	
31	8	reserved	

Table C is shown below.

Parameters	Values
The number of PRB(n_{PRB})	1~273 in NR.
The number of mapping layers(v)	1~4
The number of symbols within a slot(N_{symb}^{sh})	3~14
The overhead configured by Xoh-PDSCH(N_{oh}^{PRB})	{0,6,12,18}
The number of REs within a PRB(N'_{RE})	{6,8,12,16,18,20,24,28,30,32,36,40,42,44,48,52,54,56,60,64,66,68,70,72,76,78,80,82,84,88,90,92,94,96,100,102,104,106,108,112,114,116,118,120,124,126,128,130,132,136,138,140,144,148,150,152,156} in NR;
MCS Tables	Table A: MCS index table A for PDSCH; Table B: MCS index table A for PDSCH.

As shown in FIG. 1B, the effective code rates 140 based on the highest MCS index of 64-QAM MCS table as shown in Table A are about 30% higher than 0.95. As shown in FIG. 1C, the effective code rates 140 based on the highest MCS index of 256-QAM MCS table as shown in Table B are about 23% higher than 0.95. Moreover, there is also a serious dispersal of effective code rate leading to a large number of unavailable scheduling parameters.

Table D is shown below.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	336	61	1288	91	3624
2	32	32	352	62	1320	92	3752
3	40	33	368	63	1352	93	3824
4	48	34	384	64	1416		
5	56	35	408	65	1480		
6	64	36	432	66	1544		
7	72	37	456	67	1608		
8	80	38	480	68	1672		
9	88	39	504	69	1736		
10	96	40	528	70	1800		
11	104	41	552	71	1864		
12	112	42	576	72	1928		
13	120	43	608	73	2024		
14	128	44	640	74	2088		
15	136	45	672	75	2152		
16	144	46	704	76	2216		
17	152	47	736	77	2280		
18	160	48	768	78	2408		
19	168	49	808	79	2472		
20	176	50	848	80	2536		
21	184	51	888	81	2600		
22	192	52	928	82	2664		
23	208	53	984	83	2728		
24	224	54	1032	84	2792		
25	240	55	1064	85	2856		
26	256	56	1128	86	2976		
27	272	57	1160	87	3104		
28	288	58	1192	88	3240		
29	304	59	1224	89	3368		
30	320	60	1256	90	3496		

When N_{info} ≤ the maximum TBS among TBSs in the look-up table as shown in Table D, there are some packet sizes for special scenario or service, e.g. VoIP packet sizes, that are not included in the current TBS table. One may add these packet sizes in the TBS table directly, for example, special TBSs such as 328, 344, 688, 720, 752 are inserted in the look-up table directly and placed at a position between two TBSs. One of the two TBSs is a TBS, in the look-up table, that is closest to and larger than the special TBS among the look-up table; while the other one of the two TBSs is a TBS, in the look-up table, that is closest to and smaller than the special TBS.

If one inserts all the special TBSs directly, the original {…304, 320, 336, 352, 368…} with a fixed granularity 16 (namely 320-304 =16) becomes {…304, 320, 328,336, 344, 352, 368…} with an uneven granularity {…16, 8, 8, 8, 8, 16…}, where the first step and the last step are larger than the four intermediate steps. This will degrade the scheduling flexibility.

Table 1 below shows a new look-up table updated based on the above method.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	328	61	1128	91	2976
2	32	32	336	62	1160	92	3104
3	40	33	344	63	1192	93	3240
:	:	:	:	:	:	:	:
18	160	48	688	78	2024		
19	168	49	704	79	2088		
20	176	50	720	80	2152		
21	184	51	736	81	2216		
22	192	52	752	82	2280		
:	:	:	:	:	:		
30	320	60	1064	90	2856		

FIG. 2 illustrates a block diagram of a user equipment (UE) 200, in accordance with some embodiments of the present disclosure. The UE 200 is an example of a device that can be configured to implement the various methods described herein. As shown in FIG. 2, the UE 200 includes a housing 240 containing a system clock 202, a processor 204, a memory 206, a transceiver 210 comprising a transmitter 212 and receiver 214, a power module 208, a control information

analyzer 220, an intermediate transport block size calculator 222, a transport block size modifier 224, a final transport block size determiner 226, and a transport block size set updater 228. In this embodiment, the system clock 202 provides the timing signals to the processor 204 for controlling the timing of all operations of the UE 200. The processor 204 controls the general operation of the UE 200 and can include one or more processing circuits or modules such as a central processing unit (CPU) and/or any combination of general-purpose microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate array (FPGAs), programmable logic devices (PLDs), controllers, state machines, gated logic, discrete hardware components, dedicated hardware finite state machines, or any other suitable circuits, devices and/or structures that can perform calculations or other manipulations of data.

The memory 206, which can include both read-only memory (ROM) and random access memory (RAM), can provide instructions and data to the processor 204. A portion of the memory 206 can also include non-volatile random access memory (NVRAM). The processor 204 typically performs logical and arithmetic operations based on program instructions stored within the memory 206. The instructions (a.k.a., software) stored in the memory 206 can be executed by the processor 204 to perform the methods described herein. The processor 204 and memory 206 together form a processing system that stores and executes software. As used herein, "software" means any type of instructions, whether referred to as software, firmware, middleware, microcode, etc. which can configure a machine or device to perform one or more desired functions or processes. Instructions can include code (e.g., in source code format, binary code format, executable code format, or any other suitable format of code). The instructions, when executed by the one or more processors, cause the processing system to perform the various functions described herein.

The transceiver 210, which includes the transmitter 212 and receiver 214, allows the UE 200 to transmit and receive data to and from a remote device (e.g., the BS or another UE). An antenna 250 is typically attached to the housing 240 and electrically coupled to the transceiver 210. In various embodiments, the UE 200 includes (not shown) multiple transmitters, multiple receivers, and multiple transceivers. In one embodiment, the antenna 250 is replaced with a multi-antenna array 250 that can form a plurality of beams each of which points in a distinct direction. The transmitter 212 can be configured to wirelessly transmit packets having different packet types or functions, such packets being generated by the processor 204. Similarly, the receiver 214 is

configured to receive packets having different packet types or functions, and the processor 204 is configured to process packets of a plurality of different packet types. For example, the processor 204 can be configured to determine the type of packet and to process the packet and/or fields of the packet accordingly.

In a wireless communication, the UE 200 may receive information from a BS. The information may be downlink control information (DCI) in this embodiment. For example, the control information analyzer 220 may receive, via the receiver 214, DCI including a plurality of transmission parameters related to transport blocks to be transmitted between the UE 200 and the BS, e.g. from the BS to the UE 200. The control information analyzer 220 may analyze the DCI to identify the plurality of transmission parameters, which may include at least one of: a quantity of layers configured for transmission of the transport blocks; a modulation order configured for transmission of the transport blocks; a code rate configured for transmission of the transport blocks; a quantity of physical resource blocks configured for transmission of the transport blocks; a quantity of resource elements per each physical resource block; a total quantity of resource elements for transmission of the transport blocks, which is a product of the quantity of physical resource blocks and the quantity of resource elements per physical resource block; and a spectral efficiency configured for transmission of the transport blocks, which is equal to a product of the modulation order and the code rate. The control information analyzer 220 may send the analyzed DCI including the plurality of transmission parameters to the intermediate transport block size calculator 222 for calculating an intermediate transport block size (TBS), and to the transport block size modifier 224 for modifying the intermediate TBS to generate a modified TBS.

The intermediate transport block size calculator 222 in this example receives the analyzed DCI including the plurality of transmission parameters from the control information analyzer 220. Based on the plurality of transmission parameters, the intermediate transport block size calculator 222 calculates an intermediate TBS for the transport blocks to be transmitted from the BS to the UE 200. In one embodiment, the intermediate transport block size calculator 222 can calculate the intermediate TBS based on the plurality of transmission parameters. The intermediate transport block size calculator 222 transmits the intermediate TBS to the transport block size modifier 224 for modifying the intermediate TBS to generate a modified TBS.

The transport block size modifier 224 in this example can receive the plurality of transmission parameters from the control information analyzer 220 and receive the intermediate TBS from the intermediate transport block size calculator 222. The transport block size modifier 224 first determines whether a condition is met based on at least one of the plurality of transmission parameters and at least one threshold. In one embodiment, the condition is met when at least one of the following happens: the quantity of physical resource blocks is smaller than or equal to a first threshold, e.g. 2; the modulation order is smaller than or equal to a second threshold, e.g. 4; the total quantity of resource elements is smaller than a third threshold; and the intermediate transport block size is smaller than a fourth threshold, e.g. 4000.

When the condition is met, the transport block size modifier 224 modifies the intermediate transport block size to generate a modified transport block size. In one embodiment, when the condition is met, the transport block size modifier 224 modifies the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS. In one example, the transport block size modifier 224 first generates a corrected TBS based on the intermediate TBS and a correction factor; and then quantizes the corrected TBS based on a quantization factor to generate the modified TBS. In another example, the transport block size modifier 224 first quantizes the intermediate TBS based on a quantization factor to generate a quantized TBS; and then generates the modified TBS based on the quantized TBS and a correction factor.

In one embodiment, the transport block size modifier 224 determines the correction factor based on a coefficient and a correction order. The coefficient may be an integer not smaller than zero and not larger than three. The correction order may be an integer not smaller than zero and not larger than four.

In yet another embodiment, the transport block size modifier 224 determines the quantization factor based on a coefficient and a quantization order, wherein the quantization order is an integer. In one example, the quantization order is not smaller than zero and not larger than five. In another example, the coefficient is not smaller than one. In another example, the quantization order is zero, the coefficient is one, and the quantization factor is one, where no quantization is applied when generating the modified TBS.

The final transport block size determiner 226 in this example may receive the plurality of transmission parameters from the control information analyzer 220, and receive the modified TBS

from the transport block size modifier 224. The final transport block size determiner 226 can determine a final transport block size based on the modified transport block size for transmission of the transport blocks.

The final transport block size determiner 226 generates a final TBS for the transport blocks based on the modified TBS and a set of TBSs. In one embodiment, the final transport block size determiner 226 calculates, corresponding to each TBS in the set, an absolute difference between the TBS and the modified TBS to generate a plurality of absolute differences, and determines a subset of one or more TBSs in the set. Each TBS in the subset corresponds to an absolute difference that is not larger than any one of the plurality of absolute differences. Then in response to the subset including a single TBS, the final transport block size determiner 226 selects the single TBS as the final TBS. In response to the subset including two TBSs, the final transport block size determiner 226 selects one of the two TBSs as the final TBS, based on one of: a smaller one of the two TBSs, a larger one of the two TBSs, and a random one of the two TBSs.

In another embodiment, the final transport block size determiner 226 rounds up the modified transport block size to a closest larger integer to generate an integer transport block size; determines a quantity of code blocks in each of the transport blocks based on the integer transport block size and a block segmentation rule related to channel coding; and calculates the final transport block size based on the integer transport block size and the quantity of code blocks to ensure the multiple of 8 and equal code block size after block segmentation of the transport blocks. For example, the final transport block size determiner 226 can determine a least common multiple of eight and the quantity of code blocks; and determine the final transport block size based on an integer that is closest to the integer transport block size, among integers that are divisible by the least common multiple and not smaller than the integer transport block size. Because one byte includes eight bits, being divisible by the least common multiple of eight and the quantity of code blocks ensures both the multiple of 8 and equal code block size after block segmentation of the transport blocks.

In the present disclosure, the expressions “X is divisible by Y” and “X is evenly divisible by Y” can be used interchangeably to mean that X is a (positive integer) multiple of Y and there is no remainder.

In yet another embodiment, the final transport block size determiner 226 generates a quantized set of transport block sizes, where the quantization step, from a transport block to next transport block in the quantized set, increases as the transport block size increases. The final transport block size determiner 226 then determines the final transport block size based on a transport block size that is closest to the modified transport block size, among transport block sizes that are in the quantized set and not smaller than the modified transport block size.

In still another embodiment, the final transport block size determiner 226 generates a quantized set of transport block sizes, where the quantization step, from a transport block to next transport block in the quantized set, is determined to ensure granularity of the quantized set is larger than a threshold; and determines the final transport block size based on a transport block size that is closest to the modified transport block size, among transport block sizes that are in the quantized set and not smaller than the modified transport block size. In this embodiment, the quantization step is determined to ensure that the final transport block size is the same for both an initial transmission and a re-transmission of a transport block.

The transport block size set updater 228 in this example updates a current set of TBSs based on at least one new TBS to generate an updated set of TBSs for future TBS determinations. The updated set may include at least one TBS that is not in the current set and is generated based on at least part of the at least one new TBS. The current and updated TBS sets may be TBS tables. In one embodiment, the TBSs in the current set are arranged in an increasing order. For each of the at least one new TBS, the transport block size set updater 228 determines, in the current set, a TBS that is closest to and larger than the new TBS, and replaces the TBS in the current set with the new TBS to generate a replaced TBS in the updated set.

In one embodiment, for at least one replaced TBS in the updated set, the transport block size set updater 228 performs: identifying a first original TBS that is in the current set, and is adjacent to and smaller than the replaced TBS in the updated set; determining a first distance between the first original TBS and the replaced TBS; determining a second distance between the first original TBS and a TBS that is adjacent to and smaller than the first original TBS in the updated set; and deleting the first original TBS from the updated set in response to the first distance being smaller than the second distance.

In another embodiment, for the at least one replaced TBS in the updated set, the transport block size set updater 228 performs: identifying a second original TBS that is in the current set, and is adjacent to and smaller than the replaced TBS in the updated set, in response to the first original TBS deleted from the updated set; determining a third distance between the second original TBS and the replaced TBS; determining a fourth distance between the second original TBS and a TBS that is adjacent to and smaller than the second original TBS in the updated set; in response to the third distance being smaller than the fourth distance and not larger than a threshold, deleting the replaced TBS from the updated set; and in response to the third distance being smaller than the fourth distance and larger than the threshold, replacing the second original TBS in the updated set with a corrected TBS that is adjacent to and smaller than the replaced TBS in the updated set. An absolute difference between a fifth distance and a sixth distance is not greater than a predetermined value, e.g. 8, where the fifth distance is a distance between the corrected TBS and the replaced TBS, where the sixth distance is a distance between the corrected TBS and a TBS that is adjacent to and smaller than the corrected TBS in the updated set.

In yet another embodiment, the TBSs in the updated set are arranged in a first increasing order such that, for a subset of TBSs in the updated set that are smaller than a threshold, distances between adjacent TBSs in the subset are in a second increasing order. The threshold may be an integer that is not smaller than 320 and not larger than a maximum TBS among the TBSs in the updated set.

In still another embodiment, the TBSs in the updated set are arranged in an increasing order such that distances between adjacent TBSs in the updated set form a distance sequence; and the updated set is generated based on the at least one new TBS in a manner such that, for each distance in the distance set that is not larger than a first threshold, an absolute difference between the distance and a preceding adjacent distance in the distance sequence is not larger than a second threshold.

The power module 208 can include a power source such as one or more batteries, and a power regulator, to provide regulated power to each of the above-described modules in FIG. 2. In some embodiments, if the UE 200 is coupled to a dedicated external power source (e.g., a wall electrical outlet), the power module 208 can include a transformer and a power regulator.

The various modules discussed above are coupled together by a bus system 230. The bus system 230 can include a data bus and, for example, a power bus, a control signal bus, and/or a status

signal bus in addition to the data bus. It is understood that the modules of the UE 200 can be operatively coupled to one another using any suitable techniques and mediums.

Although a number of separate modules or components are illustrated in FIG. 2, persons of ordinary skill in the art will understand that one or more of the modules can be combined or commonly implemented. For example, the processor 204 can implement not only the functionality described above with respect to the processor 204, but also implement the functionality described above with respect to the intermediate transport block size calculator 222. Conversely, each of the modules illustrated in FIG. 2 can be implemented using a plurality of separate components or elements.

FIG. 3 illustrates a flow chart for a method 300 performed by a UE, e.g. the UE 200 in FIG. 2, for determining a TBS and updating a TBS set in a wireless communication, in accordance with some embodiments of the present disclosure. At operation 302, the UE receives, from a BS, information including transmission parameters related to transport blocks to be transmitted between the UE and the BS. At operation 304, the UE calculates an intermediate transport block size for the transport blocks based on the transmission parameters. The UE modifies at operation 306 the intermediate transport block size based on a correction factor and a quantization factor to generate a modified TBS in response to at least one event. At operation 308, the UE determines a final TBS based on the modified TBS and a current TBS set. At operation 310, the UE updates the current TBS set based on at least one new TBS to generate an updated TBS set for future TBS determinations.

FIG. 4 illustrates a block diagram of a BS 400, in accordance with some embodiments of the present disclosure. The BS 400 is an example of a device that can be configured to implement the various methods described herein. As shown in FIG. 4, the BS 400 includes a housing 440 containing a system clock 402, a processor 404, a memory 406, a transceiver 410 comprising a transmitter 412 and a receiver 414, a power module 408, a control information generator 420, an intermediate transport block size calculator 422, a transport block size modifier 424, a final transport block size determiner 426 and a transport block size set updater 428.

In this embodiment, the system clock 402, the processor 404, the memory 406, the transceiver 410 and the power module 408 work similarly to the system clock 202, the processor 204, the memory 206, the transceiver 210 and the power module 208 in the UE 200. An antenna 450 or a

multi-antenna array 450 is typically attached to the housing 440 and electrically coupled to the transceiver 410.

The control information generator 420 may generate a plurality of transmission parameters related to transport blocks to be transmitted between the BS 400 and a UE, e.g. from the BS 400 to the UE 200. The plurality of transmission parameters may include at least one of: a quantity of layers configured for transmission of the transport blocks; a modulation order configured for transmission of the transport blocks; a code rate configured for transmission of the transport blocks; a quantity of physical resource blocks configured for transmission of the transport blocks; a quantity of resource elements per each physical resource block; a total quantity of resource elements for transmission of the transport blocks, which is a product of the quantity of physical resource blocks and the quantity of resource elements per physical resource block; and a spectral efficiency configured for transmission of the transport blocks, which is equal to a product of the modulation order and the code rate. The control information generator 420 may send the generated transmission parameters to the intermediate transport block size calculator 422 for calculating an intermediate transport block size (TBS), and to the transport block size modifier 424 for modifying the intermediate TBS to generate a modified TBS. The control information generator 420 also generates and transmits, via the transmitter 412, information that includes the plurality of transmission parameters and/or a transport block size, e.g. a final transport block size as discussed later, to the UE. The information may also include an updated set of TBSs or an updated TBS table for future TBS determinations.

In one embodiment, the information is downlink control information (DCI). In one example, the final transport block size and/or the updated TBS table is determined by the BS 400, such that the BS informs the UE 200 about the final transport block size and/or the updated TBS table via the DCI. In another example, the final transport block size and/or the updated TBS table is determined by the UE 200, such that the DCI transmitted by the BS 400 does not include the final transport block size and/or the updated TBS table. In yet another example, the final transport block size and/or the updated TBS table is determined by both the BS 400 and the UE 200 according to the same rule, such that the DCI transmitted by the BS 400 does not include the final transport block size and/or the updated TBS table.

The intermediate transport block size calculator 422 in this example receives the plurality of transmission parameters from the control information generator 420. Based on the plurality of transmission parameters, the intermediate transport block size calculator 422 calculates an intermediate TBS for the transport blocks to be transmitted from the BS 400 to the UE 200. In one embodiment, the intermediate transport block size calculator 422 can calculate the intermediate TBS based on the transmission parameters. The intermediate transport block size calculator 422 transmits the intermediate TBS to the transport block size modifier 424 for modifying the intermediate TBS to generate a modified TBS.

The transport block size modifier 424 in this example can receive the plurality of transmission parameters from the control information generator 420 and receive the intermediate TBS from the intermediate transport block size calculator 422. The transport block size modifier 424 first determines whether a condition is met based on at least one of the plurality of transmission parameters and at least one threshold. In one embodiment, the condition is met when at least one of the following happens: the quantity of physical resource blocks is smaller than or equal to a first threshold, e.g. 2; the modulation order is smaller than or equal to a second threshold, e.g. 4; the total quantity of resource elements is smaller than a third threshold; and the intermediate transport block size is smaller than a fourth threshold, e.g. 4000.

When the condition is met, the transport block size modifier 424 modifies the intermediate transport block size to generate a modified transport block size. In one embodiment, when the condition is met, the transport block size modifier 424 modifies the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS. In one example, the transport block size modifier 424 first generates a corrected TBS based on the intermediate TBS and a correction factor; and then quantizes the corrected TBS based on a quantization factor to generate the modified TBS. In another example, the transport block size modifier 424 first quantizes the intermediate TBS based on a quantization factor to generate a quantized TBS; and then generates the modified TBS based on the quantized TBS and a correction factor.

In one embodiment, the transport block size modifier 424 determines the correction factor based on a coefficient and a correction order. The coefficient may be an integer not smaller than zero and not larger than three. The correction order may be an integer not smaller than zero and not larger than four.

In yet another embodiment, the transport block size modifier 424 determines the quantization factor based on a coefficient and a quantization order, wherein the quantization order is an integer. In one example, the quantization order is not smaller than zero and not larger than five. In another example, the coefficient is not smaller than one. In another example, the quantization order is zero, the coefficient is one, and the quantization factor is one, where no quantization is applied when generating the modified TBS.

The final transport block size determiner 426 in this example may receive the plurality of transmission parameters from the control information generator 420, and receive the modified TBS from the transport block size modifier 424. The final transport block size determiner 426 can determine a final transport block size based on the modified transport block size for transmission of the transport blocks.

The final transport block size determiner 426 generates a final TBS for the transport blocks based on the modified TBS and a set of TBSs. In one embodiment, the final transport block size determiner 426 calculates, corresponding to each TBS in the set, an absolute difference between the TBS and the modified TBS to generate a plurality of absolute differences, and determines a subset of one or more TBSs in the set. Each TBS in the subset corresponds to an absolute difference that is not larger than any one of the plurality of absolute differences. Then in response to the subset including a single TBS, the final transport block size determiner 426 selects the single TBS as the final TBS. In response to the subset including two TBSs, the final transport block size determiner 426 selects one of the two TBSs as the final TBS, based on one of: a smaller one of the two TBSs, a larger one of the two TBSs, and a random one of the two TBSs.

In another embodiment, the final transport block size determiner 426 rounds up the modified transport block size to a closest larger integer to generate an integer transport block size; determines a quantity of code blocks in each of the transport blocks based on the integer transport block size and a block segmentation rule related to channel coding; and calculates the final transport block size based on the integer transport block size and the quantity of code blocks to ensure the multiple of 8 and equal code block size after block segmentation of the transport blocks. For example, the final transport block size determiner 426 can determine a least common multiple of eight and the quantity of code blocks; and determine the final transport block size based on an integer that is closest to the integer transport block size, among integers that are divisible by the least

common multiple and not smaller than the integer transport block size. Because one byte includes eight bits, being divisible by the least common multiple of eight and the quantity of code blocks ensures both the multiple of 8 and equal code block size after block segmentation of the transport blocks.

In yet another embodiment, the final transport block size determiner 426 generates a quantized set of transport block sizes, where the quantization step, from a transport block to next transport block in the quantized set, increases as the transport block size increases. The final transport block size determiner 426 then determines the final transport block size based on a transport block size that is closest to the modified transport block size, among transport block sizes that are in the quantized set and not smaller than the modified transport block size.

In still another embodiment, the final transport block size determiner 426 generates a quantized set of transport block sizes, where the quantization step, from a transport block to next transport block in the quantized set, is determined to ensure granularity of the quantized set is larger than a threshold; and determines the final transport block size based on a transport block size that is closest to the modified transport block size, among transport block sizes that are in the quantized set and not smaller than the modified transport block size. In this embodiment, the quantization step is determined to ensure that the final transport block size is the same for both an initial transmission and a re-transmission of a transport block.

The transport block size set updater 428 in this example updates a current set of TBSs based on at least one new TBS to generate an updated set of TBSs for future TBS determinations. The updated set may include at least one TBS that is not in the current set and is generated based on at least part of the at least one new TBS. The current and updated TBS sets may be TBS tables. In one embodiment, the TBSs in the current set are arranged in an increasing order. For each of the at least one new TBS, the transport block size set updater 428 determines, in the current set, a TBS that is closest to and larger than the new TBS, and replaces the TBS in the current set with the new TBS to generate a replaced TBS in the updated set. The transport block size set updater 428 may transmit the updated TBS set to the UE, or instruct the control information generator 420 to transmit the updated TBS set to the UE.

In one embodiment, for at least one replaced TBS in the updated set, the transport block size set updater 428 performs: identifying a first original TBS that is in the current set, and is adjacent

to and smaller than the replaced TBS in the updated set; determining a first distance between the first original TBS and the replaced TBS; determining a second distance between the first original TBS and a TBS that is adjacent to and smaller than the first original TBS in the updated set; and deleting the first original TBS from the updated set in response to the first distance being smaller than the second distance.

In another embodiment, for the at least one replaced TBS in the updated set, the transport block size set updater 428 performs: identifying a second original TBS that is in the current set, and is adjacent to and smaller than the replaced TBS in the updated set, in response to the first original TBS deleted from the updated set; determining a third distance between the second original TBS and the replaced TBS; determining a fourth distance between the second original TBS and a TBS that is adjacent to and smaller than the second original TBS in the updated set; in response to the third distance being smaller than the fourth distance and not larger than a threshold, deleting the replaced TBS from the updated set; and in response to the third distance being smaller than the fourth distance and larger than the threshold, replacing the second original TBS in the updated set with a corrected TBS that is adjacent to and smaller than the replaced TBS in the updated set. An absolute difference between a fifth distance and a sixth distance is not greater than a predetermined value, e.g. 8, where the fifth distance is a distance between the corrected TBS and the replaced TBS, where the sixth distance is a distance between the corrected TBS and a TBS that is adjacent to and smaller than the corrected TBS in the updated set.

In yet another embodiment, the TBSs in the updated set are arranged in a first increasing order such that, for a subset of TBSs in the updated set that are smaller than a threshold, distances between adjacent TBSs in the subset are in a second increasing order. The threshold may be an integer that is not smaller than 320 and not larger than a maximum TBS among the TBSs in the updated set.

In still another embodiment, the TBSs in the updated set are arranged in an increasing order such that distances between adjacent TBSs in the updated set form a distance sequence; and the updated set is generated based on the at least one new TBS in a manner such that, for each distance in the distance set that is not larger than a first threshold, an absolute difference between the distance and a preceding adjacent distance in the distance sequence is not larger than a second threshold.

The various modules discussed above are coupled together by a bus system 430. The bus system 430 can include a data bus and, for example, a power bus, a control signal bus, and/or a status signal bus in addition to the data bus. It is understood that the modules of the BS 400 can be operatively coupled to one another using any suitable techniques and mediums.

Although a number of separate modules or components are illustrated in FIG. 4, persons of ordinary skill in the art will understand that one or more of the modules can be combined or commonly implemented. For example, the processor 404 can implement not only the functionality described above with respect to the processor 404, but also implement the functionality described above with respect to the intermediate transport block size calculator 422. Conversely, each of the modules illustrated in FIG. 4 can be implemented using a plurality of separate components or elements.

FIG. 5 illustrates a flow chart for a method 500 performed by a BS, e.g. the BS 400 in FIG. 4, for determining a TBS and updating a TBS set in a wireless communication, in accordance with some embodiments of the present disclosure. At operation 502, the BS generates a plurality of transmission parameters related to transport blocks to be transmitted between the BS and a UE. At operation 504, the BS calculates an intermediate transport block size for the transport blocks based on the plurality of transmission parameters. The BS modifies at operation 506 the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS in response to an event. The BS determines at operation 508 a final TBS based on the modified TBS and a current TBS set. At operation 510, the BS updates the current TBS set based on at least one new TBS to generate an updated TBS set for future TBS determinations. At operation 512, the BS transmits information that includes the plurality of transmission parameters and/or the updated TBS set to the UE.

In one embodiment, the roles of the BS 400 and the UE 200 in FIGs. 2-5 are exchanged, where the UE 200 generates and transmits uplink information to the BS 400. The TBS is calculated and determined for transport blocks to be transmitted from the UE 200 to the BS 400 for uplink transmissions, in a similar manner to the manner discussed above for downlink transmissions.

Different embodiments of the present disclosure will now be described in detail hereinafter. It is noted that the features of the embodiments and examples in the present disclosure may be combined with each other in any manner without conflict.

According to various embodiments of the present disclosure, methods for determining TBS and updating TBS table are provided and can be applied to a new radio (NR) access technology communication system. The methods proposed in the present disclosure may be applied to a fifth generation (5G) mobile communication system or other wireless or wired communication system. The data transmission direction is that a base station sends data (downlink transmission service data) to a mobile user or a mobile user sends data (uplink transmission service data) to the base station. Mobile users include: mobile devices, access terminals, user terminals, subscriber stations, subscriber units, mobile stations, remote stations, remote terminals, user agents, user equipment, user devices, or some other terminology. The base station includes: an access point (AP), a node B, a radio network controller (RNC), an evolved Node B (eNB), a base station controller (BSC), Base Transceiver Station (BTS), a Base Station (BS), a Transceiver Function (TF), a radio router, a radio transceiver, a basic service unit, an extension service unit, a Radio Base Station (RBS), or some other terminology. The methods provided in the present disclosure may be applied to an enhanced Mobile Broadband (eMBB) scenario, an ultra-reliable low-latency communications (URLLC) scenario or a massive Machine Type Communications (mMTC) scenario, in the NR access technology.

In one embodiment, the functional model for TBS calculation is: $TBS = F(\beta)$, with a specific form shown as follows:

$$TBS = function\left(\frac{function\left(\beta \times function\left(Q_m \times R \times v \times Y \times N_{PRB}^{XL}\right)\right)}{\delta}\right) \times \delta .$$

In the above formula, the correction factor β is a function of (a) the number of PRBs allocated for uplink or downlink, and/or (b) the order of the modulation and coding Q_m, and/or (c) the code rate R (or spectrum efficiency); $function(\bullet)$ indicates rounding, rounding up, rounding down, or retaining the original value; Y is the quantized value of X that is the number of REs per PRB; δ is the quantization step of the TBS. Since the correction factor is mainly added to improve the link stability when the PRB is small and when the order of the MCS is low, the value of β can be determined by Q_m and N_{PRB}^{XL}.

In a first situation, when the PRB is small and/or the MCS order is low, the correction factor is set to be a fraction close to 1, e.g. 0.9. For the sake of simple hardware implementation, the value of the correction factor can be taken as $\frac{2^{n1}-1}{2^{n1}}$. In a second situation, when the MCS order is high and the allocated spectrum efficiency (SE) is the same as the SE at the modulation order hopping (where the modulation order changes from an MCS index to an adjacent MCS index in the MCS table) in the MCS table, the correction factor is also set to be a fraction close to 1, e.g. 0.94. For the sake of simple hardware implementation, the value of the correction factor can be taken as $\frac{2^{n2}-1}{2^{n2}}$. In general, the correction factor in the second situation is larger than that in the first situation. When the RE value in each PRB changes, the correspondingly obtained link stability will also change. Therefore, the values of the correction factors may be different for different RE values. For example, when the RE value in each PRB is 120, the correction factor can be set to be 1.

When the PRB is larger and/or the order of the MCS is higher, the value of the correction factor is set to be 1. Because when the PRB is larger and the MCS is higher, the TBS is larger, and the interval of actually available TBSs is also larger. Therefore, the calculated TBS does not need to be modified to obtain good link stability.

In the following description, intermediate TBS is denoted as TBS_temp; modified TBS is denoted as TBS_prime; TBS table is denoted as look-up table with an increasing order. The intermediate TBS is equal to Q_m*R*N_{RE}*v. The maximum TBS in TBS table is denoted as TBS_max.

When TBS_temp < $TBS_{threshold}$, the function model for modifying TBS_temp is shown as below.

Step 1: TBS_prime1 = $function(Q_m \times R \times N_{RE} \times v) - offset$.

Step 2: TBS_prime= $function\left(\frac{function(TBS_prime1)}{\delta}\right) \times \delta$. In one example, offset = $\alpha*2^m$. The offset is a correction factor and determined by the value of modulation order (Qm), target code rate in MCS table (R), the total number of allocated resource elements (N_{RE}), the number of mapping layers (v) and/or the number of $\delta=C*2^n$, where C is the number of code block; α is an integer that is not larger than 3 and not less than 0; m is an integer that is not larger than 4 and not less than 0; where $TBS_{threshold} \geq$ TBS_max. The function(x) means rounding down x to

the closest smaller integer, or rounding up x to the closest larger integer, or rounding x to the closest integer or keeping original values. Additionally, the two modifying steps can be exchanged with each other, such as Step 1: TBS_prime1 = $function\left(\frac{function(Q_m \times R \times N_{RE} \times v)}{\delta}\right) \times \delta$; Step 2: TBS_prime= $TBS_prime1 - offset$. The values of modifying factors are the same as the above mentioned example.

Step 3: after modifying TBS_temp into TBS_prime, the final TBS is selected from TBSs in the look-up table and corresponding to a minimum difference among absolute differences between TBS_prime and each TBS in the look-up table. The final TBS is selected from TBSs in look-up table with the method shown below.

(1) $T = \arg\min_{e_i} |X - e_i|$, where $e_i \in S$;

(2) if only one element in *T*, then TBS = *T*; otherwise there are two options as follows:

option (a): the final TBS is always equal to the larger one between elements in *T*;

option (b): the final TBS is always equal to the smaller one between elements in *T*;

option (c): the final TBS is equal to a random one between elements in *T*.

where *X* represents TBS_prime; *S* represents the look-up table; e_i represents TBS in look-up table; $\arg_{e_i}(\cdot)$ represents that choose an element among all elements e_i; *T* represents element(s) in *S* and that is(are) satisfied with the condition of the equality. That is, calculate the absolute values of differences between TBS_prime and every element in *S*, and then find the minimum absolute value(s) and the corresponding element(s) e_i is determined. There are two situations that the number of corresponding element(s) may be only one or two, the final TBS must be the sole element. Thus, there are two options that the smaller one shall be always selected as the final TBS, or the larger one shall be always selected as the final TBS for two elements satisfied with the searching condition.

FIG. 6 illustrates a flow chart of a method 600 for determining a TBS, in accordance with an embodiment of the present disclosure. The method 600 begins at 601 and proceeds to operation 610, where the TBS_temp is calculated based on parameters Q_m, R, N_{RE}, and v 605. At operation 615, it is determined whether the TBS_temp is smaller than or equal to the $TBS_{threshold}$. If so, the process goes to operation 620, where the TBS_temp is modified into TBS_prime1 based on an offset 619. Then at operation 630, the TBS_prime1 is quantized into TBS_prime based on the

quantization factor δ 629. Then at operation 640, the final TBS is calculated based on the look-up table or TBS table 639. Then the process ends at operation 690.

If it is determined that the TBS_temp is greater than the $TBS_{threshold}$ at operation 615, the process goes to operation 650, where the TBS_temp is quantized into the TBS_prime. Then at operation 660, the TBS_prime is quantized into the final TBS based on a formula. Then the process ends at operation 690.

In Embodiment 1, when TBS_temp ≤ TBS_max, TBS is determined based on the above steps and the value of the parameters are as follows: δ is a positive integer and equal to 2^n, n is an integer and is up to TBS_temp; function(x) means to round up to the closest larger integer or round down to the closest smaller integer or round or keep the original value.

Then the final TBS is determined to be the TBS that is closest to TBS_prime in the look-up table and that is not less than modified TBS. Here, α=3, m=n, offset =$3*2^n$, and the first function(x) means rounding down x to the closest smaller integer, the others are keeping original values; δ = $C*2^n$, C=1, n is a positive integer and related to TBS_temp, if TBS_temp<1024, n=3; else n = floor ($\log_2$ (TBS_temp/64)); where floor (x) means rounding down x to the closest smaller integer.

FIG. 7A illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 64-QAM MCS table as shown in Table A, in accordance with the Embodiment 1. FIG. 7B illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 256-QAM MCS table as shown in Table B, in accordance with the Embodiment 1. As shown in FIG. 7A and FIG. 7B, the effective code rates 710 based on the highest MCS index of 64-QAM MCS table and the effective code rates 720 based on the highest MCS index of 256-QAM MCS table are almost all smaller than 0.95, even with the target code rate of 0.9258.

In Embodiment 2, when TBS_temp ≤ TBS_max, TBS is determined based on above steps and the value of the parameters are as follows: where δ is a positive integer and equal to 2^n, n is an integer and not less than 0; function(x) means to round up to the closest larger integer or round down to the closest smaller integer or round or keep the original value.

The final TBS is determined from the look-up table based on option (a) of Step 3 discussed above. Here, α=1, m=4, offset = 16; δ = C*2^n, C=1, n=0; the function(x) means to keep the original value.

FIG. 8A illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 64-QAM MCS table as shown in Table A, in accordance with the Embodiment 2. FIG. 8B illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 256-QAM MCS table as shown in Table B, in accordance with the Embodiment 2. As shown in FIG. 8A and FIG. 8B, the effective code rates 810 based on the highest MCS index of 64-QAM MCS table and the effective code rates 820 based on the highest MCS index of 256-QAM MCS table are almost all smaller than 0.95, even with the target code rate of 0.9258.

In Embodiment 3, when TBS_temp ≤ TBS_max, TBS is determined based on the above steps and the value of the parameters are as follows: where δ is a positive integer and equal to 2^n, n is an integer and related to TBS_temp; function(x) means to round up to the closest larger integer or round down to the closest smaller integer or round or keep the original value.

The final TBS is determined from the look-up table based on option (a) of Step 3 discussed above. Here, α=0, offset =0; δ = C*2^n, C=1, and the first function(x) means rounding down x to the closest smaller integer, the others are keeping original values; n is a positive integer and related to TBS_temp, if TBS_temp<1024, n=3; else n = floor ($\log_2$ (TBS_temp/64)); where floor (x) means rounding down x to the closest smaller integer.

FIG. 9A illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 64-QAM MCS table as shown in Table A, in accordance with the Embodiment 3. FIG. 9B illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 256-QAM MCS table as shown in Table B, in accordance with the Embodiment 3. As shown in FIG. 9A and FIG. 9B, most of the effective code rates 910 based on the highest MCS index of 64-QAM MCS table and most of the effective code rates 920 based on the highest MCS index of 256-QAM MCS table are smaller than 0.95, even with the target code rate of 0.9258.

In Embodiment 4, when TBS_temp ≤ TBS_max, TBS is determined based on the above steps and the value of the parameters are as follows: modify TBS_temp by an offset, the function model is shown as below:

$$\text{TBS_prime}= function\left(\frac{function\left(function\left(Q_m \times R \times N_{RE} \times v\right)-offset\right)}{\delta}\right)\times\delta,$$

where δ is a positive integer and equal to 2^n, n is an integer and related to TBS_temp; function(x) means to round up to the closest larger integer or round down to the closest smaller integer or round or keep the original value.

The final TBS is determined from the look-up table based on option (a) of Step 3 discussed above. Here, α=1, m=4, Offset =16; $\delta = C*2^n$, C=1, and the first function(x) means rounding down x to the closest smaller integer, the others are keeping original values; n is a positive integer and related to TBS_temp, if TBS_temp<1024, n=3; else n = floor ($\log_2$ (TBS_temp/64)); where floor (x) means rounding down x to the closest smaller integer.

FIG. 10A illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 64-QAM MCS table as shown in Table A, in accordance with the Embodiment 4. FIG. 10B illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 256-QAM MCS table as shown in Table B, in accordance with the Embodiment 4. As shown in FIG. 10A and FIG. 10B, the effective code rates 1010 based on the highest MCS index of 64-QAM MCS table and the effective code rates 1020 based on the highest MCS index of 256-QAM MCS table are almost all smaller than 0.95, even with the target code rate of 0.9258.

In Embodiment 5, when TBS_temp ≤ TBS_max, TBS is determined based on the above steps and the value of the parameters are as follows: δ is a positive integer and equal to 2^n, n is an integer and related to TBS_temp; function(x) means to round up to the closest larger integer or round down to the closest smaller integer or round or keep the original value.

The final TBS is determined from the look-up table based on option (a) of Step 3 discussed above. Here, offset is an integer and not less than 0, if TBS_temp< 1500, α=3, m=n, offset =$3*2^n$; else α=0, offset =0. The first function(x) means rounding down x to the closest smaller integer, the others are keeping original values; $\delta = C*2^n$, C=1, n is a positive integer and

related to TBS_temp, if TBS_temp<1024, n=3; else n = floor ($\log_2$ (TBS_temp/64)); where floor (x) means rounding down x to the closest smaller integer.

FIG. 11A illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 64-QAM MCS table as shown in Table A, in accordance with the Embodiment 5. FIG. 11B illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 256-QAM MCS table as shown in Table B, in accordance with the Embodiment 5. As shown in FIG. 11A and FIG. 11B, the effective code rates 1110 based on the highest MCS index of 64-QAM MCS table and the effective code rates 1120 based on the highest MCS index of 256-QAM MCS table are almost all smaller than 0.95, even with the target code rate of 0.9258.

In Embodiment 6, when TBS_temp ≤ TBS_max, TBS is determined based on the above steps and the value of the parameters are as follows: modify TBS_temp by a offset, the function model is shown as below:

①TBS_prime1= $function\left(\frac{function(function(Q_m \times R \times N_{RE} \times v))}{\delta}\right) \times \delta$,

②TBS_prime = TBS_prime1-offset,

where δ is a positive integer and equal to 2^n, n is an integer and related to TBS_temp; function(x) means to round up to the closest larger integer or round down to the closest smaller integer or round or keep the original value.

The final TBS is determined from the look-up table based on option (a) of Step 3 discussed above. Here, α=1, m=4, Offset =16; δ = C*2^n, C=1, and the first function(x) means rounding down x to the closest smaller integer, the others are keeping original values; n is a positive integer and related to TBS_temp, if TBS_temp<1024, n=3; else n = floor ($\log_2$ (TBS_temp/64)); where floor (x) means rounding down x to the closest smaller integer.

FIG. 12A illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 64-QAM MCS table as shown in Table A, in accordance with the Embodiment 6. FIG. 12B illustrates an exemplary effective code rate performance for a TBS determination based on the highest MCS index of 256-QAM MCS table as shown in Table B, in accordance with the Embodiment 6. As shown in FIG. 12A and FIG. 12B, the effective code rates 1210 based on the highest MCS index of 64-QAM MCS table and the effective

code rates 1220 based on the highest MCS index of 256-QAM MCS table are almost all smaller than 0.95, even with the target code rate of 0.9258.

Special TBSs such as VoIP packet sizes, denoted as $TBS^{special}$, that are not included in current TBS table may be inserted in the original look-up table under the conditions as below:

Condition 1: $(TBS_{j+1} - TBS_j) / 2 / TBS_{j+1} \leq threshold_A$, where $threshold_A$ is not smaller than 0 and not larger than 0.2; and TBS_j is the element in common look-up table, and elements in look-up table with an increasing order; and/or

Condition 2: $TBS_{j+1}^{new} - TBS_j^{new} \geq TBS_{j+1}^{original} - TBS_j^{original} - 8$, where TBS_j^{new} is the special TBS inserted in new look-up table and $TBS_j^{original}$ is the original TBS replaced by the special TBS_j^{new} in original look-up table; and/or

Condition 3: After the special packet sizes are inserted in the original look-up table: if $TBS_{j+1}^{new} - TBS_j^{new} \leq$ Threshold2, then $|(TBS_{j+1}^{new} - TBS_j^{new}) - (TBS_j^{new} - TBS_{j-1}^{new})| \leq 8$, where Threshold2 is larger than 2^{n1} and smaller than 2^{n2} , and n1 is a positive integer and not smaller than 4, and n2 is a positive integer and not smaller than 6, and TBS_j^{new} is the element value in new look-up table; and /or

Condition 4: Differences between adjacent TBSs form an increasing order in the new look-up table when $TBS < threshold_B$, and the $threshold_B$ is an integer between 320 and the maximum TBS among TBSs in the look-up table;

Condition 5: Three different methods of inserting the special TBSs or packet sizes that are not included in the original look-up table are shown below:

(1) insert the special TBS in original look-up table by replacing the TBS among TBSs in original look-up table and that is closest to and larger than the special TBS.

(2) insert the special TBS in original look-up table by replacing the original TBS among TBSs in original look-up table and that is larger than the special TBS, and delete the TBS among TBSs in original look-up table and that is smaller than the special TBS.

(3) insert the special TBS in original look-up table by replacing the original TBS among TBSs in original look-up table and that is larger than the special TBS, denote this new quantized set as look-up table A; and then calculate the steps of look-up table A, and if the step of the inserted position is larger than both the two adjacent steps, then this element should be changed by a

temporary TBS or add a new TBS that is between the former and latter TBSs of the TBS at the position and could be satisfied with the above conditions.

Condition 6: In order to ensure a proper granularity of TBSs in look-up table, special TBSs should be inserted partly or entirely in the original look-up table.

In Embodiment 7, the special TBS is used to replace the original TBS that is closest to and larger than the special TBS, among TBSs in original look-up table. For example, the original {…304, 320, 336, 352, 368…} with a fixed granularity 16 (namely 320-304 =16) becomes {…304,320, 328, 344,368…} with a granularity {…16, 8, 16, 24…}. Thus, the original {… 640, 672, 704, 736, 768, 808, 848…} with an increasing granularity {… 32, 32, 32, 32, 40, 40…} becomes {…640, 672, 688, 720, 752, 808, 848…} with a granularity {…32, 16, 32, 32, 56, 40…}. The granularity is sparser than that in original look-up table so that the scheduling can be degraded.

Table 2 below shows a new look-up table updated based on the above method.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	328	61	1288	91	3624
2	32	32	344	62	1320	92	3752
3	40	33	368	63	1352	93	3824
:	:	:	:	:	:		
15	136	45	672	75	2152		
16	144	46	688	76	2216		
17	152	47	720	77	2280		
18	160	48	752	78	2408		
19	168	49	808	79	2472		
:	:	:	:	:	:		
30	320	60	1256	90	3496		

The new look-up table should satisfy some of the above six conditions so that all the special TBSs may not be inclusively inserted in the original look-up table. The TBS quantization steps can be based on any existing method.

Additional Embodiment based on Embodiment 7, the absolute difference between the new TBS and the TBS replaced by the new TBS is the multiple of eight such as the absolute difference between the new TBS 328 and the TBS 336 replaced by 328 is equal to 8 that is the multiple of 8 with multiple=1.

In Embodiment 8, the special TBS is used to replace the original TBS, among TBSs in original look-up table, that is closest to and larger than special TBS, and delete the TBS, among TBSs in original look-up table, that is closest to and smaller than special TBS. For example, the original {…304, 320, 336, 352, 368…} with a fixed granularity 16 (namely 320-304 =16) becomes {…304, 328, 344, 368…} with a granularity {…24, 16, 24…}. Thus, the original {… 640, 672, 704, 736, 768, 808, 848…} with an increasing granularity {… 32, 32, 32, 32, 40, 40…} becomes {…640, 688, 720, 752, 808, 848…} with a granularity {…48, 32, 32, 56, 40…}. The granularity is sparser than that in original look-up table so that the scheduling can be degraded.

Table 3 below shows a new look-up table updated based on the above method.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	344	61	1352	91	3824
2	32	32	368	62	1416		
:	:	:	:	:	:		
13	120	43	640	73	2152		
14	128	44	688	74	2216		
15	136	45	720	75	2280		
16	144	46	752	76	2408		
17	152	47	808	77	2472		
:	:	:	:	:	:		
29	304	59	1288	89	3624		
30	328	60	1320	90	3752		

The new look-up table should satisfy some of the above six conditions so that all the special TBSs may not be inclusively inserted in the original look-up table. The TBS quantization steps can be based on any existing method.

In Embodiment 9, first, the special TBSs are inserted in the original look-up table directly, for example, the original {…304, 320, 336, 352, 368…} with a fixed granularity 16 (namely 320-304 =16) becomes {…304, 320, 328, 336, 344, 352, 368…} with a granularity {…16, 8, 8, 8, 8, 16…}. The granularity that is downward from 16 to 8 is too densely to ensure a better scheduling flexibility. So the two special TBSs will not be inserted. For another example, the original {…608, 640, 672, 704, 736, 768, 808…} with an increasing granularity {…32, 32, 32, 32, 32, 40…} becomes {…608, 640,672, 688, 704,720, 736, 752, 768, 808…} with a granularity {…32, 32, 16, 16, 16, 16, 16, 16,

40…}. The granularity that is downward from 32 to 16 is too densely to ensure a better scheduling flexibility.

Table 4 below shows a new look-up table updated based on the above method.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	336	61	1192	91	3240
:	:	:	:	:	:		
15	136	45	672	75	1928		
16	144	46	688	76	2024		
17	152	47	704	77	2088		
18	160	48	720	78	2152		
19	168	49	736	79	2216		
20	176	50	752	80	2280		
21	184	51	768	81	2408		
:	:	:	:	:	:		
30	320	60	1160	90	3104		

The new look-up table should satisfy some of the above six conditions so that all the special TBSs may not be inclusively inserted in the original look-up table. The TBS quantization steps can be based on any existing method.

In an additional embodiment based on Embodiment 9, an absolute difference between the new TBS and a half of the sum of the two adjacent TBSs among TBSs in the current set is a multiple of eight, wherein the smaller one of the two adjacent TBSs is closest to and smaller than the new TBS; and the multiple is not smaller than zero. For example, the absolute difference between the new TBS 688 and the half of the two adjacent TBSs 672 and 704 (namely, 688-(672+704)/2 = 0) is equal to zero and is the multiple of 8 with multiple=0.

Embodiment 10: based on the conclusion of Embodiment 9, the special TBSs 328 and 344 will not be inserted. For the special TBSs 688, 720 and 752, the steps of inserting special TBSs are as follows: first, use the special TBS to replace the original TBS, among TBSs in original look-up table, that is closest to and larger than special TBS, and delete the TBS, among TBSs in original look-up table, that is closest to and smaller than special TBS. For example, the original {…608, 640, 672, 704, 736, 768, 808, 848…} with an increasing granularity {…32, 32, 32, 32, 32, 40, 40…} becomes {…608, 640, 672, 688, 720, 752, 808, 848…} with a granularity {…32, 32, 16, 32, 32, 56,

40…}. Second, modify some original TBSs or add some temporary TBSs to correct the difference between adjacent TBSs in temporary look-up table. For example, change TBSs in temporary look-up table into {…608, 640, 664, 688, 720, 752, 784, 816, 848…} with an increasing granularity {…32, 24, 24, 32, 32, 32, 32, 32…}.

Table 5 below shows a new look-up table updated based on the above method.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	336	61	1256	91	3496
:	:	:	:	:	:		
14	128	44	640	74	2024		
15	136	45	664	75	2088		
16	144	46	688	76	2152		
17	152	47	720	77	2216		
18	160	48	752	78	2280		
19	168	49	784	79	2408		
20	176	50	816	80	2472		
21	184	51	848	81	2536		
:	:	:	:	:	:		
30	320	60	1224	90	3368		

The new look-up table should satisfy some of the above six conditions so that all the special TBSs may not be inclusively inserted in the original look-up table. The TBS quantization steps can be based on any existing method.

In Embodiment 11, first, the special TBS is used to replace the original TBS, among TBSs in original look-up table, that is closest to and larger than special TBS, and delete the TBS, among TBSs in original look-up table, that is closest to and smaller than special TBS. For example, the original {…304, 320, 336, 352, 368…} with a fixed granularity 16 (namely 320-304 =16) becomes {…304, 328, 344, 368…} with a granularity {…24, 16, 24…}. Second, these special TBSs should not be inserted in TBS set because the steps of them are so small that there are not temporary TBSs to modify the step and the effective code rate value is sensitive to the step when TBS is small. In another example, when TBS is a little larger, first, the original {… 608, 640, 672, 704, 736, 768, 808, 848…} with an increasing granularity {…32, 32, 32, 32, 32, 40, 40…} becomes {…608, 640, 688, 720, 752, 808, 848…} with a granularity {…32, 48,

32, 32, 56, 40...}. Second, modify some TBS values to obtain a, for example, modify into {...608, 640, 680, 720, 760, 800...} with an increasing granularity {...32, 40, 40, 40, 40...}. The new look-up table should be satisfied with some of the above six conditions so that all the special TBSs may not be inclusively inserted in the original look-up table. Simulation results are shown as follows and the.

Table 6 below shows a new look-up table updated based on the above method.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	336	61	1320	91	3752
:	:	:	:	:	:		
14	128	44	640	74	2152		
15	136	45	680	75	2216		
16	144	46	720	76	2280		
17	152	47	760	77	2408		
18	160	48	800	78	2472		
19	168	49	848	79	2536		
:	:	:	:	:	:		
30	320	60	1288	90	3624		

The new look-up table should satisfy some of the above six conditions so that all the special TBSs may not be inclusively inserted in the original look-up table. The TBS quantization steps can be based on any existing method. The TBS quantization steps in Embodiment 11 may be based on any existing method.

In Embodiment 12, the special TBS is used to replace the original TBS that is closest to and smaller than the special TBS, among TBSs in original look-up table. For example, the original {...304, 320, 336, 352, 368...} with a fixed granularity 16 (namely 320-304 =16) becomes {...304, 328, 344, 352, 368...} with a granularity {...24, 16, 8, 16...}. Thus, the original {... 640, 672, 704, 736, 768, 808, 848...} with an increasing granularity {... 32, 32, 32, 32, 40, 40...} becomes {...640, 688, 720, 752, 768, 808, 848...} with a granularity {...48, 32, 32, 16, 40, 40...}. The granularity is sparser than that in original look-up table so that the scheduling can be degraded.

Table 7 below shows a new look-up table updated based on the above method.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	344	61	1288	91	3624
2	32	32	352	62	1320	92	3752
3	40	33	368	63	1352	93	3824
:	:	:	:	:	:		
15	136	45	688	75	2152		
16	144	46	720	76	2216		
17	152	47	752	77	2280		
18	160	48	768	78	2408		
19	168	49	808	79	2472		
:	:	:	:	:	:		
30	328	60	1256	90	3496		

The new look-up table should satisfy some of the above six conditions so that all the special TBSs may not be inclusively inserted in the original look-up table. The TBS quantization steps can be based on any existing method.

In an additional embodiment based on Embodiment 12, an absolute difference between the new TBS and the TBS replaced by the new TBS is a multiple of eight. For example, the difference between the new TBS 328 and the TBS 320 replaced by 328 is equal to 8 that is a multiple of 8 with multiple=1.

In Embodiment 13, the special TBS is used to replace the original TBS that is closest to and smaller than the special TBS, or replace the original TBS that is closest to and larger than the special TBS, or insert between the two original TBSs, where one is closest to and smaller than the special TBS and the other one is closest to and larger than the special TBS, among TBSs in original look-up table. For example, the original {…304, 320, 336, 352, 368…} with a fixed granularity 16 (namely 320-304 =16) becomes {…304, 320, 328, 344, 352, 368…} with a granularity {…16, 8, 16, 8, 16…}. Thus, the original {… 640, 672, 704, 736, 768, 808, 848…} with an increasing granularity {… 32, 32, 32, 32, 40, 40…} becomes {…640, 672, 688, 720, 752, 808, 848…} with a granularity {…32, 16, 32, 32, 56, 40…}. The granularity is sparser than that in original look-up table so that the scheduling can be degraded.

Table 8 below shows a new look-up table updated based on the above method.

Index	TBS	Index	TBS	Index	TBS	Index	TBS
1	24	31	328	61	1256	91	3496
2	32	32	344	62	1288	92	3624
3	40	33	352	63	1320	93	3752
4	48	34	368	64	1352	94	3824
:	:	:	:	:	:	:	:
16	144	46	672	76	2152		
17	152	47	688	77	2216		
18	160	48	720	78	2280		
19	168	49	752	79	2408		
20	176	50	808	80	2472		
:	:	:	:	:	:		
30	320	60	1224	90	3368		

The new look-up table should satisfy some of the above six conditions so that all the special TBSs may not be inclusively inserted in the original look-up table. The TBS quantization steps can be based on any existing method.

While various embodiments of the present disclosure have been described above, it should be understood that they have been presented by way of example only, and not by way of limitation. Likewise, the various diagrams may depict an example architectural or configuration, which are provided to enable persons of ordinary skill in the art to understand exemplary features and functions of the present disclosure. Such persons would understand, however, that the present disclosure is not restricted to the illustrated example architectures or configurations, but can be implemented using a variety of alternative architectures and configurations. Additionally, as would be understood by persons of ordinary skill in the art, one or more features of one embodiment can be combined with one or more features of another embodiment described herein. Thus, the breadth and scope of the present disclosure should not be limited by any of the above-described exemplary embodiments.

It is also understood that any reference to an element herein using a designation such as "first," "second," and so forth does not generally limit the quantity or order of those elements. Rather, these designations can be used herein as a convenient means of distinguishing between two or more elements or instances of an element. Thus, a reference to first and second elements does not mean that only two elements can be employed, or that the first element must precede the second element in some manner.

Additionally, a person having ordinary skill in the art would understand that information and signals can be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits and symbols, for example, which may be referenced in the above description can be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

A person of ordinary skill in the art would further appreciate that any of the various illustrative logical blocks, modules, processors, means, circuits, methods and functions described in connection with the aspects disclosed herein can be implemented by electronic hardware (e.g., a digital implementation, an analog implementation, or a combination of the two), firmware, various forms of program or design code incorporating instructions (which can be referred to herein, for convenience, as "software" or a "software module"), or any combination of these techniques.

To clearly illustrate this interchangeability of hardware, firmware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware, firmware or software, or a combination of these techniques, depends upon the particular application and design constraints imposed on the overall system. Skilled artisans can implement the described functionality in various ways for each particular application, but such implementation decisions do not cause a departure from the scope of the present disclosure. In accordance with various embodiments, a processor, device, component, circuit, structure, machine, module, etc. can be configured to perform one or more of the functions described herein. The term "configured to" or "configured for" as used herein with respect to a specified operation or function refers to a processor, device, component, circuit, structure, machine, module, etc. that is physically constructed, programmed and/or arranged to perform the specified operation or function.

Furthermore, a person of ordinary skill in the art would understand that various illustrative logical blocks, modules, devices, components and circuits described herein can be implemented within or performed by an integrated circuit (IC) that can include a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, or any combination thereof. The logical blocks, modules, and circuits can further include antennas and/or transceivers to communicate with various components within the network or within the device. A general purpose processor can be a microprocessor, but in the alternative, the processor can be any conventional processor, controller, or state machine. A processor can also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of

microprocessors, one or more microprocessors in conjunction with a DSP core, or any other suitable configuration to perform the functions described herein.

If implemented in software, the functions can be stored as one or more instructions or code on a computer-readable medium. Thus, the steps of a method or algorithm disclosed herein can be implemented as software stored on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that can be enabled to transfer a computer program or code from one place to another. A storage media can be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can include RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to store desired program code in the form of instructions or data structures and that can be accessed by a computer.

In this document, the term "module" as used herein, refers to software, firmware, hardware, and any combination of these elements for performing the associated functions described herein. Additionally, for purpose of discussion, the various modules are described as discrete modules; however, as would be apparent to one of ordinary skill in the art, two or more modules may be combined to form a single module that performs the associated functions according embodiments of the present disclosure.

Additionally, memory or other storage, as well as communication components, may be employed in embodiments of the present disclosure. It will be appreciated that, for clarity purposes, the above description has described embodiments of the present disclosure with reference to different functional units and processors. However, it will be apparent that any suitable distribution of functionality between different functional units, processing logic elements or domains may be used without detracting from the present disclosure. For example, functionality illustrated to be performed by separate processing logic elements, or controllers, may be performed by the same processing logic element, or controller. Hence, references to specific functional units are only references to a suitable means for providing the described functionality, rather than indicative of a strict logical or physical structure or organization.

Various modifications to the implementations described in this disclosure will be readily apparent to those skilled in the art, and the general principles defined herein can be applied to other implementations without departing from the scope of this disclosure. Thus, the disclosure is not intended to be limited to the implementations shown herein, but is to be accorded the widest scope consistent with the novel features and principles disclosed herein, as recited in the claims below.

CLAIMS

1. A method performed by a wireless communication device, the method comprising:

receiving information from a wireless communication node, wherein the information includes a plurality of transmission parameters related to transport blocks to be transmitted between the wireless communication device and a wireless communication node;

calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters;

modifying the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS in response to at least one event; and

determining a final TBS for the transport blocks based on the modified TBS and a set of TBSs, wherein the determining comprises:

determining a subset of one or more TBSs in the set, wherein each TBS in the subset corresponds to a minimal absolute difference among absolute differences between each TBS in the TBS set and the modified TBS,

in response to the subset including a single TBS, determining the single TBS as the final TBS, and

in response to the subset including two TBSs, determining one of the two TBSs as the final TBS, based on one of: a smaller one of the two TBSs, a larger one of the two TBSs, and a random one of the two TBSs.

2. The method of claim 1, wherein modifying the intermediate TBS comprises:

generating a corrected TBS based on the intermediate TBS and a correction factor; and

quantizing the corrected TBS based on a quantization factor to generate the modified TBS.

3. The method of claim 1, wherein modifying the intermediate TBS comprises:

quantizing the intermediate TBS based on a quantization factor to generate a quantized TBS; and

generating the modified TBS based on the quantized TBS and a correction factor.

4. The method of claim 1, further comprising determining the correction factor based on a coefficient and a correction order.

5. The method of claim 4, wherein the coefficient is an integer not smaller than zero and not larger than three; and

6. The method of claim 4, wherein the correction order is an integer not smaller than zero and not larger than four.

7. The method of claim 1, further comprising determining the quantization factor based on a coefficient and a quantization order, wherein the quantization order is an integer.

8. The method of claim 7, wherein:

the quantization order is not smaller than zero and not larger than five; and

the coefficient is not smaller than one.

9. The method of claim 1, wherein the plurality of transmission parameters comprises at least one of:

a quantity of layers configured for transmission of the transport blocks;

a modulation order configured for transmission of the transport blocks;

a code rate configured for transmission of the transport blocks;

a quantity of physical resource blocks configured for transmission of the transport blocks;

a quantity of resource elements per each physical resource block;

a total quantity of resource elements for transmission of the transport blocks, which is a product of the quantity of physical resource blocks and the quantity of resource elements per physical resource block; and

a spectral efficiency configured for transmission of the transport blocks, which is equal to a product of the modulation order and the code rate.

10. The method of claim 9, wherein the at least one event includes at least one of the

following:

the quantity of physical resource blocks is smaller than a first threshold;

the modulation order is smaller than a second threshold;

the total quantity of resource elements is smaller than a third threshold; and

the intermediate TBS is smaller than a fourth threshold.

11. A method performed by a wireless communication device, the method comprising:

receiving information from a wireless communication node, wherein the information includes a plurality of transmission parameters related to transport blocks to be transmitted between the wireless communication device and a wireless communication node;

calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters;

modifying the intermediate TBS to generate a modified TBS;

determining a final TBS for the transport blocks based on the modified TBS and a current set of TBSs; and

updating the current set based on at least one new TBS to generate an updated set of TBSs for future TBS determinations.

12. The method of claim 11, wherein:

the at least one new TBS is not included in the current set and includes at least one of: {328,344,688,720,752}.

13. The method of claim 11, wherein:

the TBSs in the current set are arranged in an increasing order; and

a new TBS in the at least one new TBS is inserted in the updated set by replacing a TBS that is among TBSs in the current set and is closest to and larger than the new TBS.

14. The method of claim 11, wherein:

the TBSs in the current set are arranged in an increasing order; and

a new TBS in the at least one new TBS is inserted in the updated set by replacing a TBS

that is among TBSs in the current set and is closest to and smaller than the new TBS.

15. The method of claim 11, wherein:

the TBSs in the current set are arranged in an increasing order; and

a new TBS in the at least one new TBS is inserted in the updated set between two adjacent TBSs in the current set, wherein the smaller one of the two adjacent TBSs is closest to and smaller than the new TBS among TBSs in the current set.

16. The method of claim 13, wherein:

an absolute difference between the new TBS and the TBS replaced by the new TBS is a multiple of eight; and

the multiple is an integer and not smaller than one.

17. The method of claim 14, wherein:

an absolute difference between the new TBS and the TBS replaced by the new TBS is a multiple of eight; and

the multiple is an integer and not smaller than one.

18. The method of claim 15, wherein:

an absolute difference between the new TBS and a half of a sum of the two adjacent TBSs is a multiple of eight; and

the multiple is an integer and not smaller than zero.

19. A method performed by a wireless communication node, the method comprising:

generating a plurality of transmission parameters related to transport blocks to be transmitted between a wireless communication device and the wireless communication node;

calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters;

modifying the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS in response to at least one event;

determining a final TBS for the transport blocks based on the modified TBS and a set of TBSs, wherein the determining comprises:

determining a subset of one or more TBSs in the set, wherein each TBS in the subset corresponds to a minimal absolute difference among absolute differences between each TBS in the TBS set and the modified TBS;

in response to the subset including a single TBS, determining the single TBS as the final TBS, and

in response to the subset including two TBSs, determining one of the two TBSs as the final TBS, based on one of: a smaller one of the two TBSs, a larger one of the two TBSs, and a random one of the two TBSs; and

transmitting information that includes the plurality of transmission parameters to the wireless communication device.

20. The method of claim 19, wherein modifying the intermediate TBS comprises:

generating a corrected TBS based on the intermediate TBS and a correction factor; and

quantizing the corrected TBS based on a quantization factor to generate the modified TBS.

21. The method of claim 19, wherein modifying the intermediate TBS comprises:

quantizing the intermediate TBS based on a quantization factor to generate a quantized TBS; and

generating the modified TBS based on the quantized TBS and a correction factor.

22. The method of claim 19, further comprising determining the correction factor based on a coefficient and a correction order.

23. The method of claim 22, wherein the coefficient is an integer not smaller than zero and not larger than three; and

24. The method of claim 22, wherein the correction order is an integer not smaller than zero

and not larger than four.

25. The method of claim 19, further comprising determining the quantization factor based on a coefficient and a quantization order, wherein the quantization order is an integer.

26. The method of claim 25, wherein:

the quantization order is not smaller than zero and not larger than five; and

the coefficient is not smaller than one.

27. A method performed by a wireless communication node, the method comprising:

generating a plurality of transmission parameters related to transport blocks to be transmitted between a wireless communication device and the wireless communication node;

calculating an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters;

modifying the intermediate TBS to generate a modified TBS;

determining a final TBS for the transport blocks based on the modified TBS and a current set of TBSs; and

updating the current set based on at least one new TBS to generate an updated set of TBSs for future TBS determinations.

28. The method of claim 27, wherein:

the at least one new TBS is not included in the current set and includes at least one of: {328,344,688,720,752}.

29. The method of claim 27, wherein:

the TBSs in the current set are arranged in an increasing order; and

a new TBS in the at least one new TBS is inserted in the updated set by replacing a TBS that is among TBSs in the current set and is closest to and larger than the new TBS.

30. The method of claim 27, wherein:

the TBSs in the current set are arranged in an increasing order; and

a new TBS in the at least one new TBS is inserted in the updated set by replacing a TBS that is among TBSs in the current set and is closest to and smaller than the new TBS.

31. The method of claim 27, wherein:

the TBSs in the current set are arranged in an increasing order; and

a new TBS in the at least one new TBS is inserted in the updated set between two adjacent TBSs in the current set, wherein the smaller one of the two adjacent TBSs is closest to and smaller than the new TBS among TBSs in the current set.

32. The method of claim 29, wherein:

an absolute difference between the new TBS and the TBS replaced by the new TBS is a multiple of eight; and

the multiple is an integer and not smaller than one.

33. The method of claim 30, wherein:

an absolute difference between the new TBS and the TBS replaced by the new TBS is a multiple of eight; and

the multiple is an integer and not smaller than one.

34. The method of claim 31, wherein:

an absolute difference between the new TBS and a half of a sum of the two adjacent TBSs is a multiple of eight; and

the multiple is an integer and not smaller than zero.

35. A wireless communication device configured to carry out the method of any one of claims 1 through 18.

36. A wireless communication node configured to carry out the method of any one of claims 19 through 34.

37. A non-transitory computer-readable medium having stored thereon computer-executable instructions for carrying out the method of any one of claims 1 through 34.

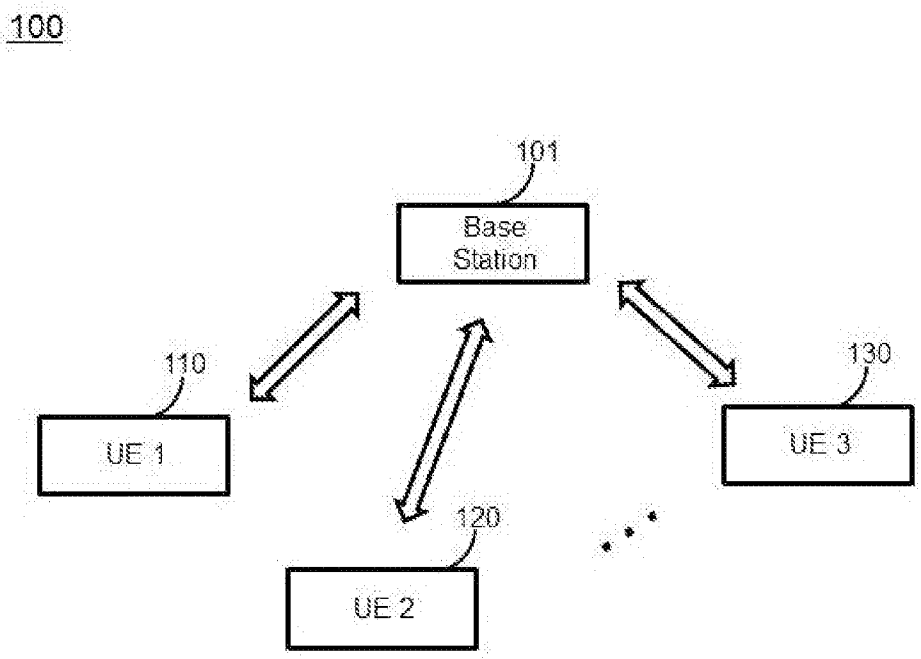

100
101
Base Station
110
UE 1
120
UE 2
130
UE 3

FIG. 1A

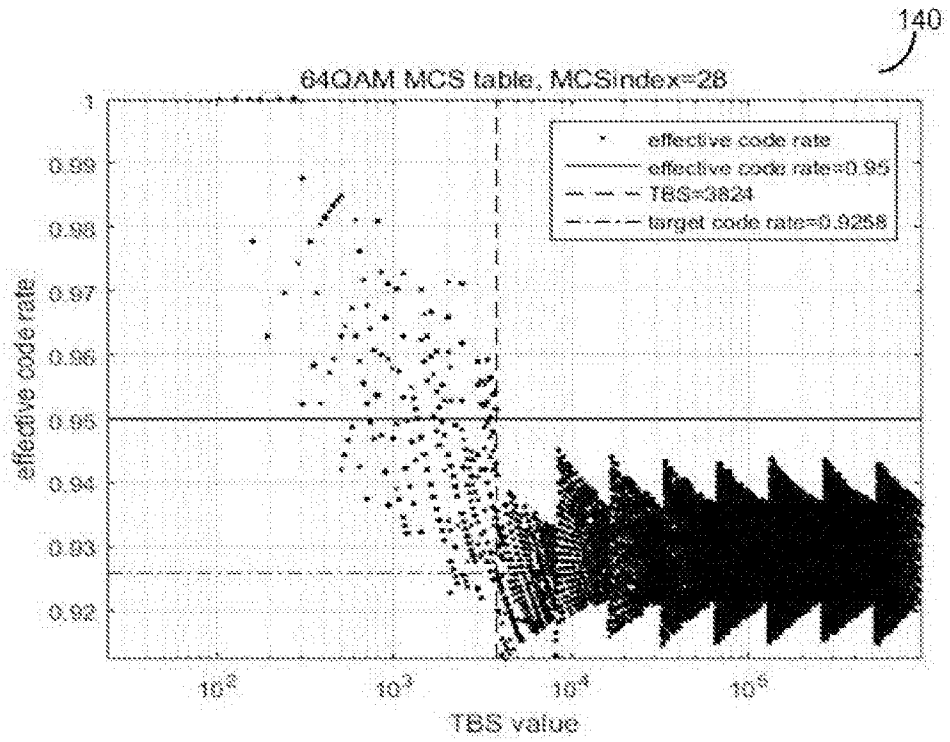

140
64QAM MCS table, MCSindex=28
effective code rate
effective code rate=0.95
TBS=3824
target code rate=0.9258
effective code rate
TBS value
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
10^2
10^3
10^4
10^5

FIG. 1B

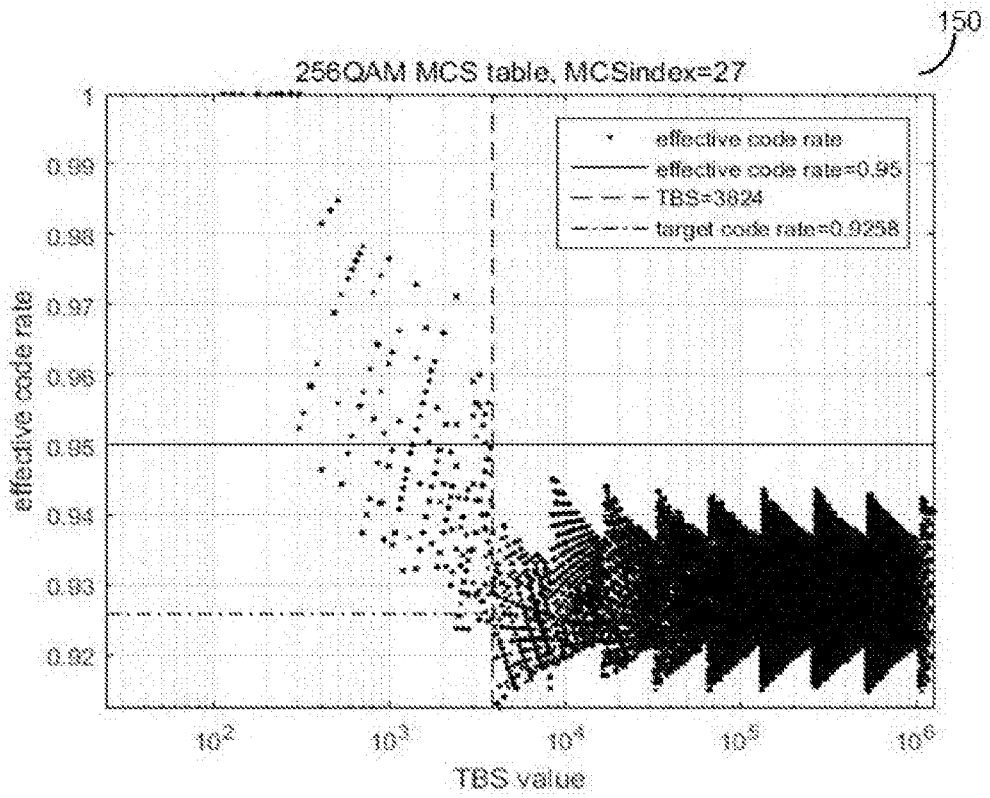

150
256QAM MCS table, MCSindex=27
effective code rate
effective code rate=0.95
TBS=3624
target code rate=0.9258
effective code rate
TBS value
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
10^2
10^3
10^4
10^5
10^6

FIG. 1C

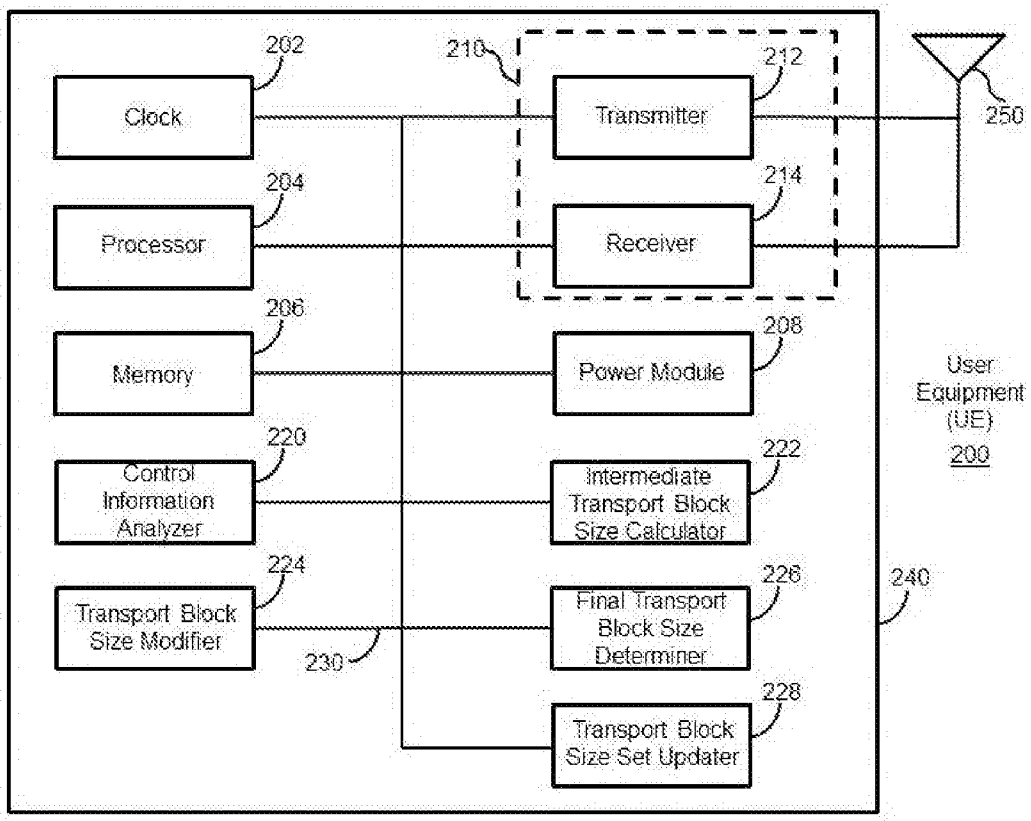

202
Clock
204
Processor
206
Memory
220
Control Information Analyzer
224
Transport Block Size Modifier
230
210
212
Transmitter
214
Receiver
208
Power Module
222
Intermediate Transport Block Size Calculator
226
Final Transport Block Size Determiner
228
Transport Block Size Set Updater
240
250
User Equipment (UE)
200

FIG. 2

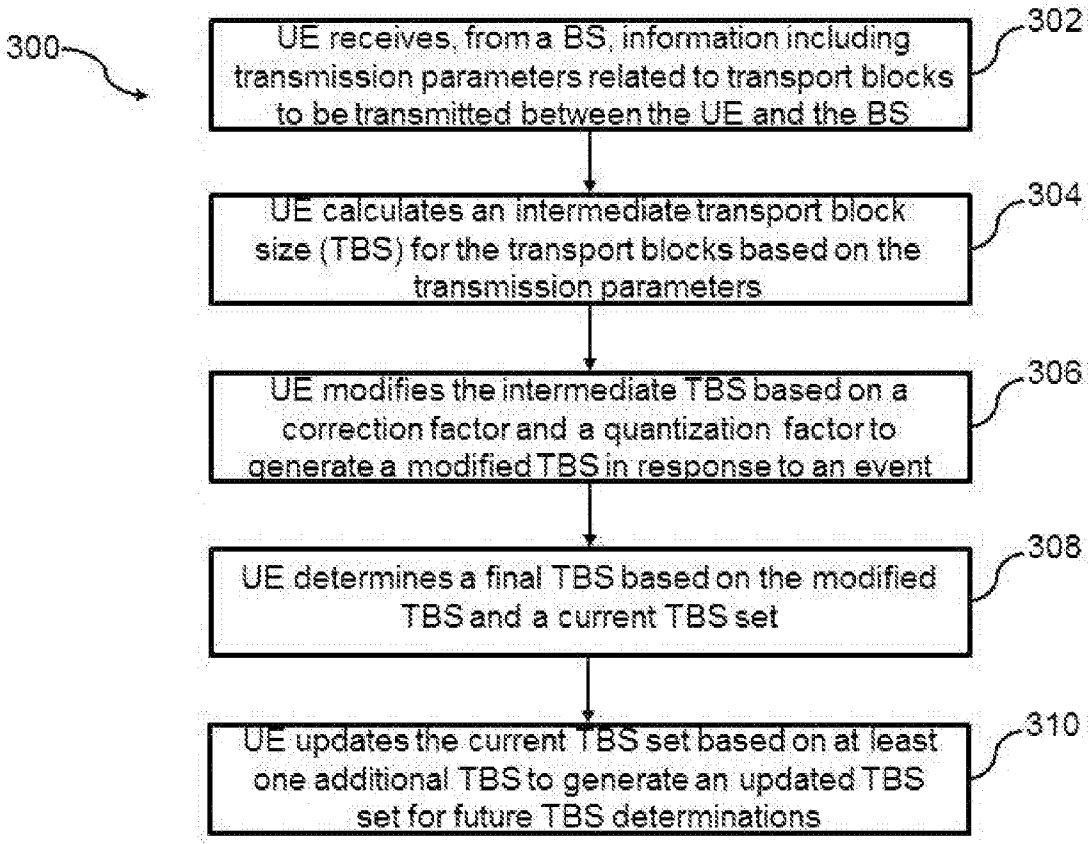

300
UE receives, from a BS, information including transmission parameters related to transport blocks to be transmitted between the UE and the BS
302
UE calculates an intermediate transport block size (TBS) for the transport blocks based on the transmission parameters
304
UE modifies the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS in response to an event
306
UE determines a final TBS based on the modified TBS and a current TBS set
308
UE updates the current TBS set based on at least one additional TBS to generate an updated TBS set for future TBS determinations
310

FIG. 3

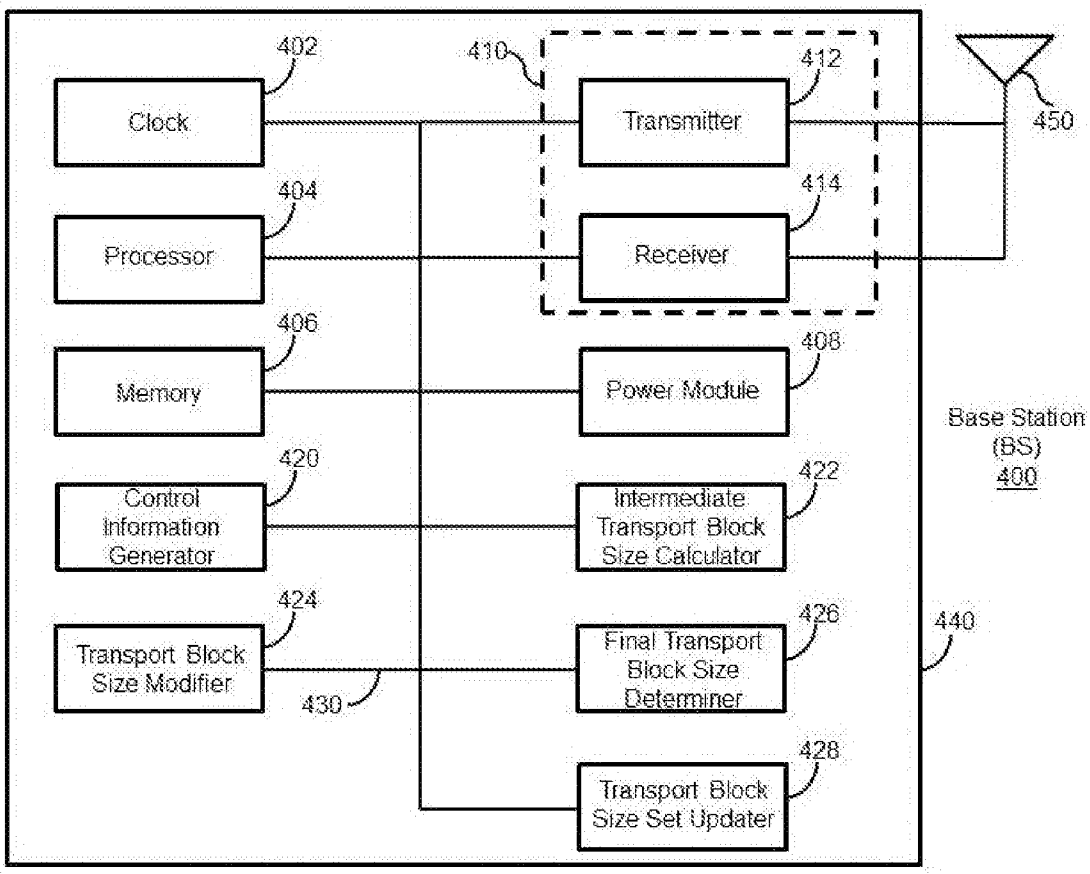

402
Clock
404
Processor
406
Memory
420
Control Information Generator
424
Transport Block Size Modifier
430
410
412
Transmitter
414
Receiver
408
Power Module
422
Intermediate Transport Block Size Calculator
426
Final Transport Block Size Determiner
428
Transport Block Size Set Updater
440
450
Base Station (BS)
400

FIG. 4

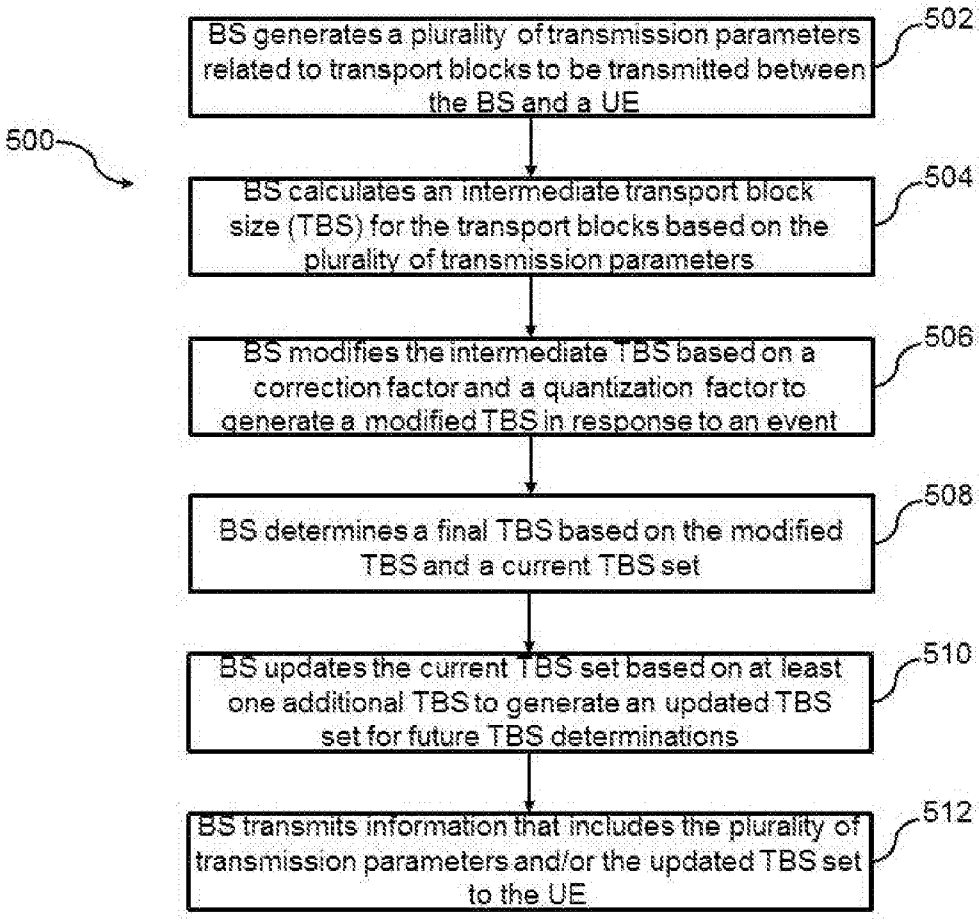

500
BS generates a plurality of transmission parameters related to transport blocks to be transmitted between the BS and a UE
502
BS calculates an intermediate transport block size (TBS) for the transport blocks based on the plurality of transmission parameters
504
BS modifies the intermediate TBS based on a correction factor and a quantization factor to generate a modified TBS in response to an event
506
BS determines a final TBS based on the modified TBS and a current TBS set
508
BS updates the current TBS set based on at least one additional TBS to generate an updated TBS set for future TBS determinations
510
BS transmits information that includes the plurality of transmission parameters and/or the updated TBS set to the UE
512

FIG. 5

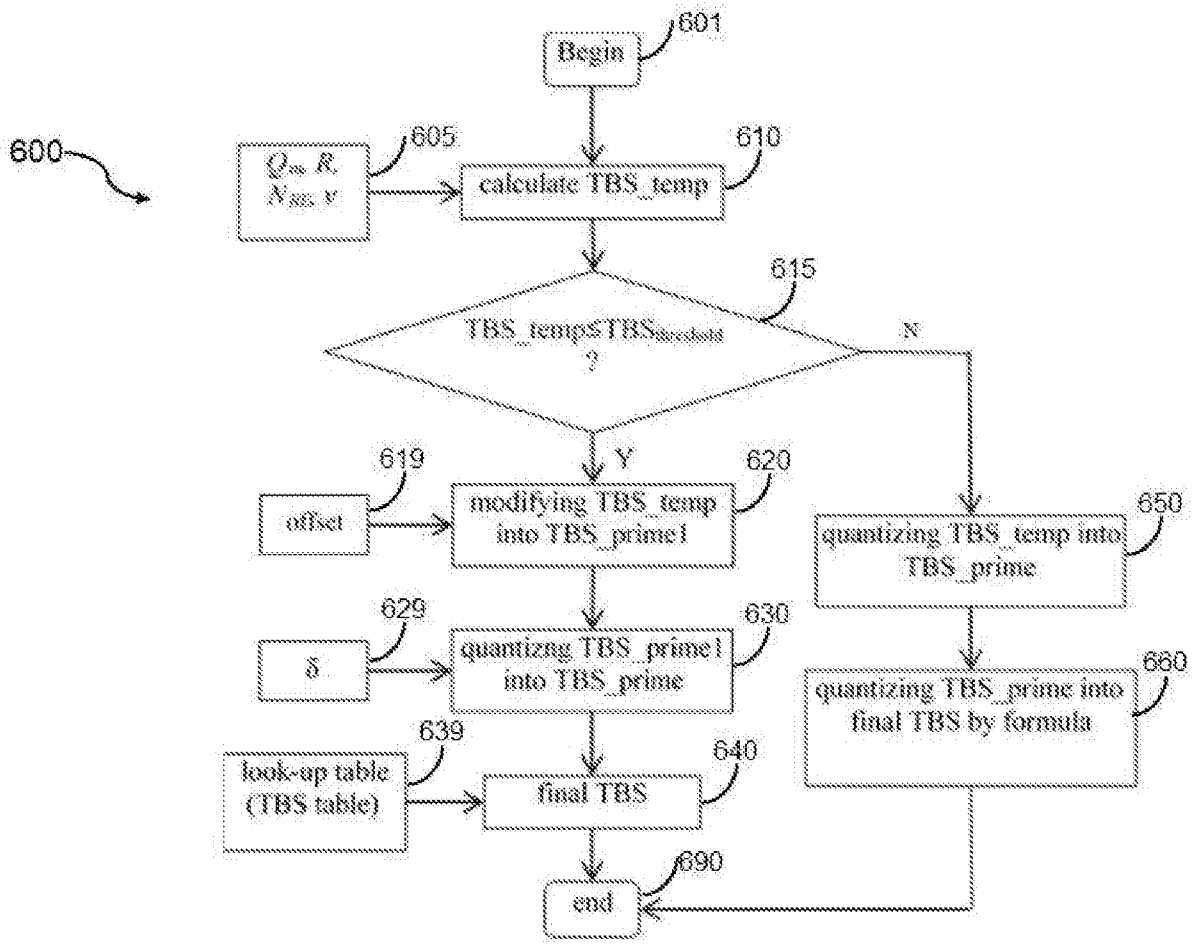

600
Begin
601
Q_m, R, N_{sc}, v
605
calculate TBS_temp
610
TBS_temp≤TBS_threshold ?
615
N
Y
offset
619
modifying TBS_temp into TBS_prime1
620
quantizing TBS_temp into TBS_prime
650
δ
629
quantizing TBS_prime1 into TBS_prime
630
quantizing TBS_prime into final TBS by formula
660
look-up table (TBS table)
639
final TBS
640
end
690

FIG. 6

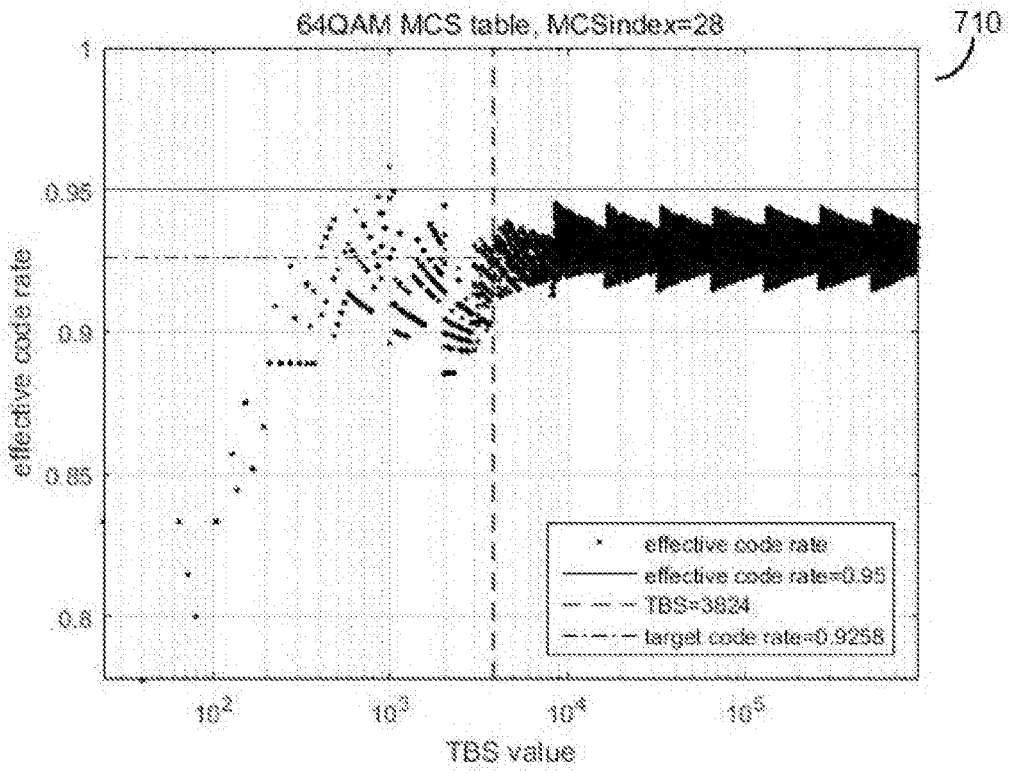

64QAM MCS table, MCSindex=28
710
effective code rate
TBS value
1
0.95
0.9
0.85
0.8
10^2
10^3
10^4
10^5
effective code rate
effective code rate=0.95
TBS=3824
target code rate=0.9258

FIG. 7A

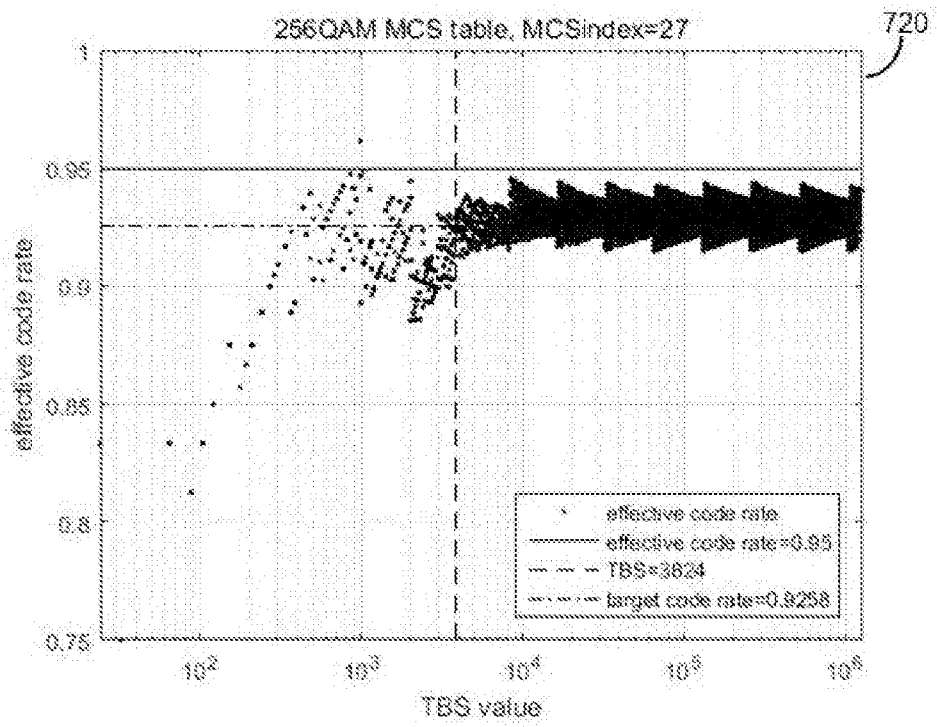

256QAM MCS table, MCSindex=27
720
effective code rate
TBS value
1
0.95
0.9
0.85
0.8
0.75
10^2
10^3
10^4
10^5
10^6
effective code rate
effective code rate=0.95
TBS=3824
target code rate=0.9258

FIG. 7B

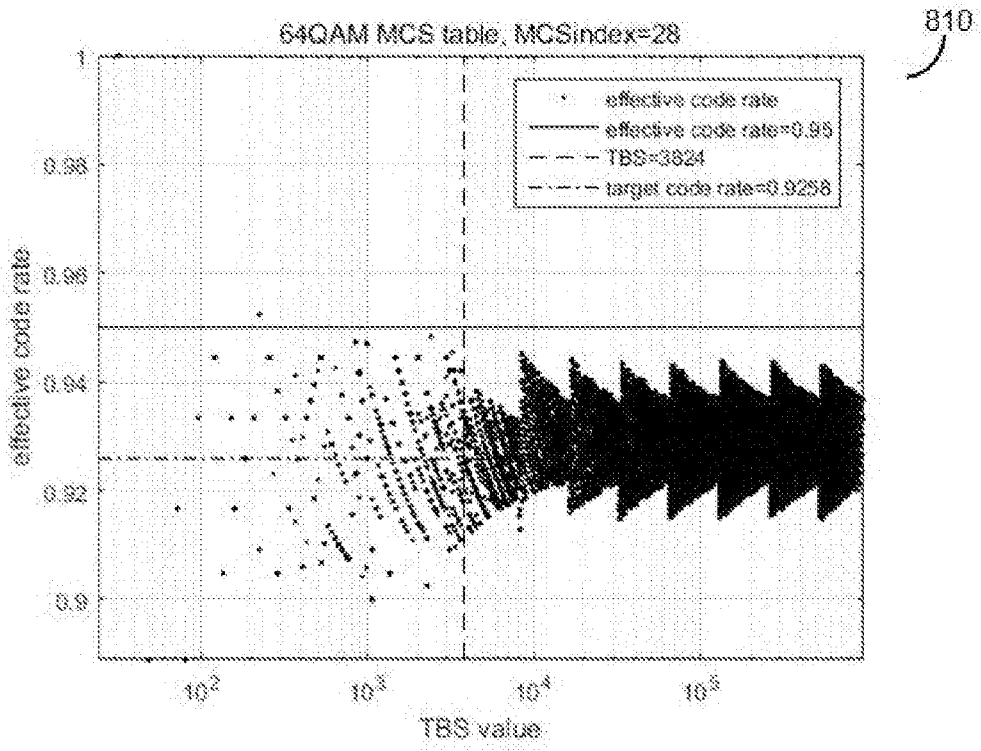

64QAM MCS table, MCSindex=28
810
effective code rate
effective code rate=0.95
TBS=3824
target code rate=0.9258
effective code rate
1
0.98
0.96
0.94
0.92
0.9
10^2
10^3
10^4
10^5
TBS value

FIG. 8A

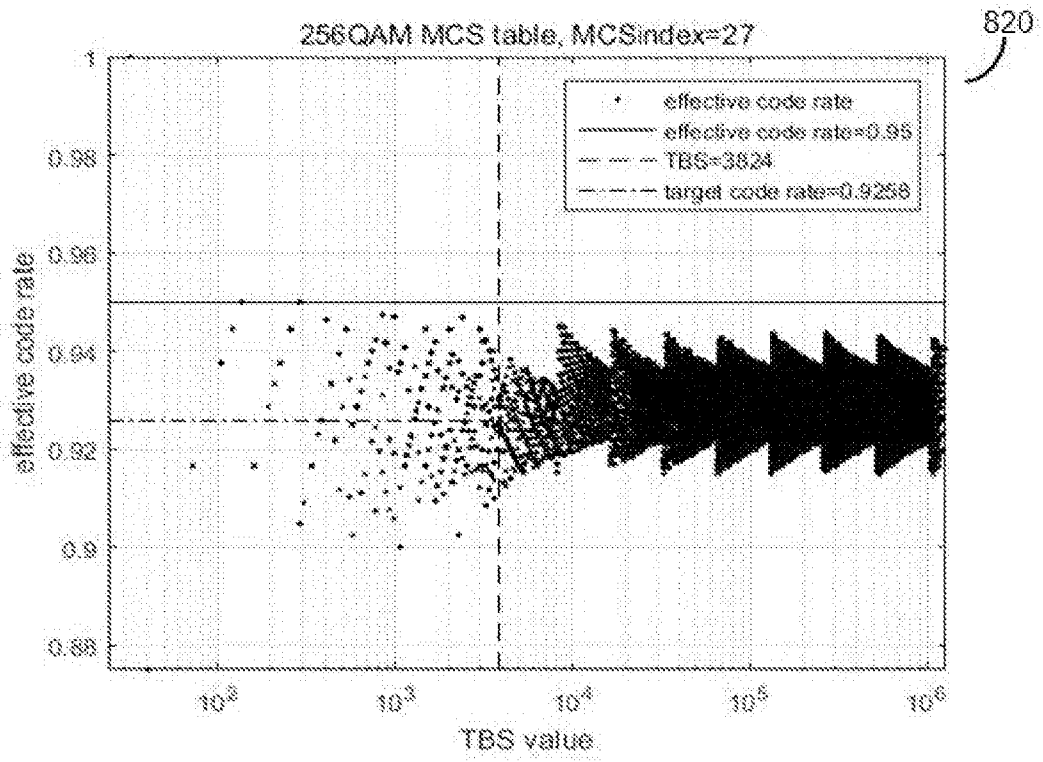

256QAM MCS table, MCSindex=27
820
effective code rate
effective code rate=0.95
TBS=3824
target code rate=0.9258
effective code rate
1
0.98
0.96
0.94
0.92
0.9
0.88
10^2
10^3
10^4
10^5
10^6
TBS value

FIG. 8B

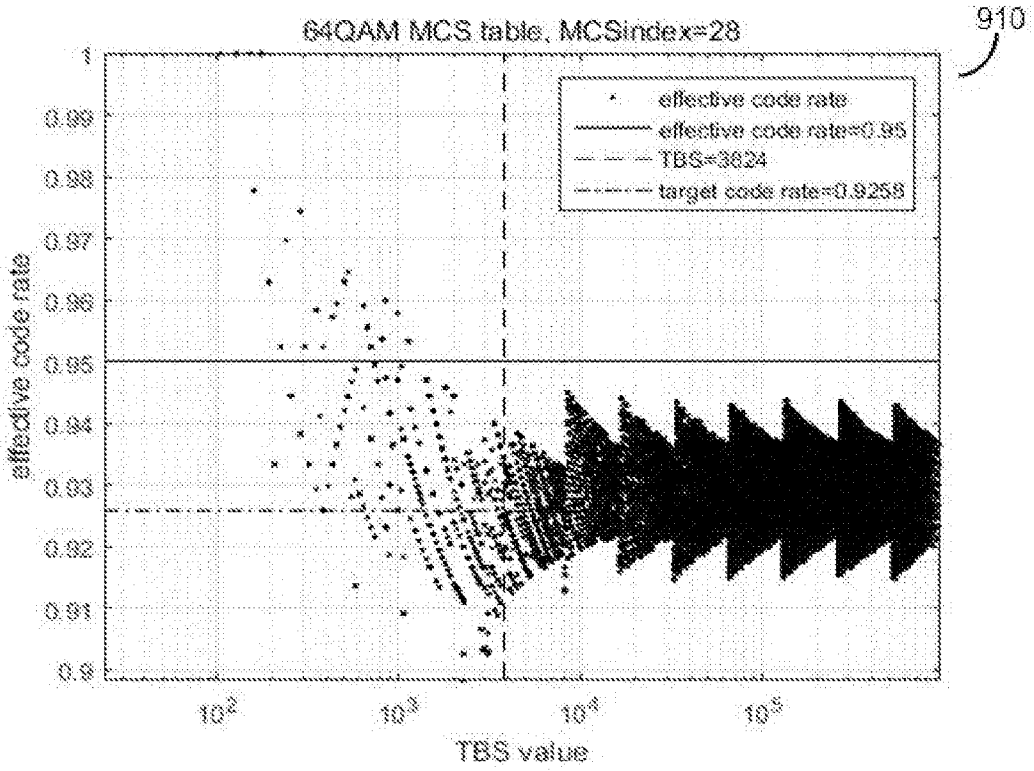

64QAM MCS table, MCSindex=28
910
effective code rate
effective code rate=0.95
TBS=3824
target code rate=0.9258
effective code rate
TBS value
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.9
10^2
10^3
10^4
10^5

FIG. 9A

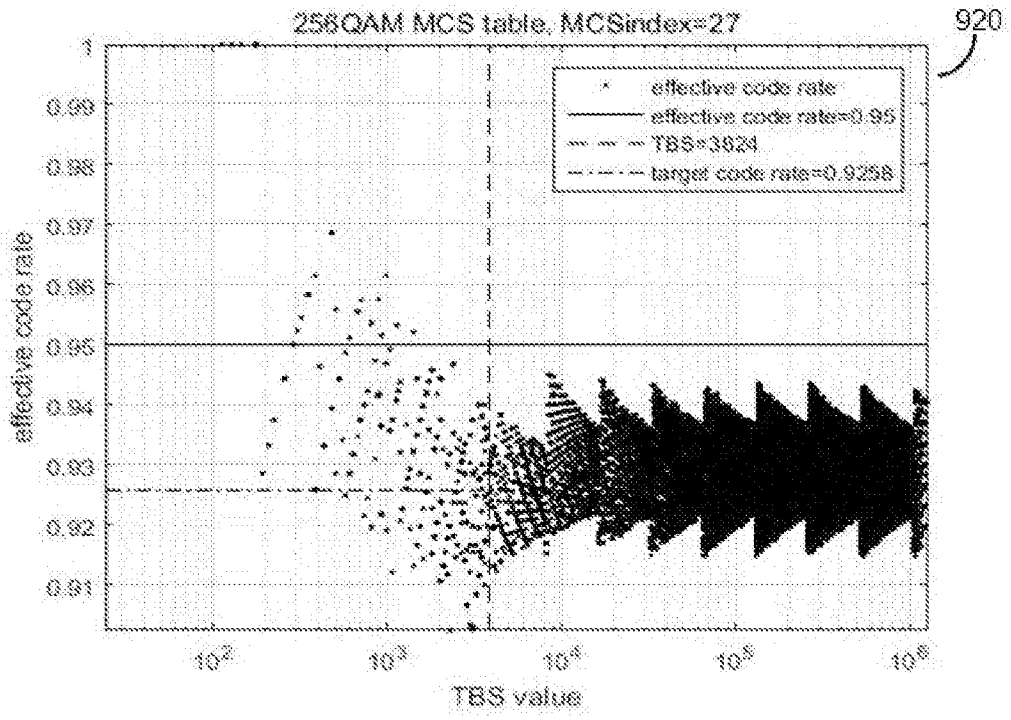

256QAM MCS table, MCSindex=27
920
effective code rate
effective code rate=0.95
TBS=3824
target code rate=0.9258
effective code rate
TBS value
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
10^2
10^3
10^4
10^5
10^6

FIG. 9B

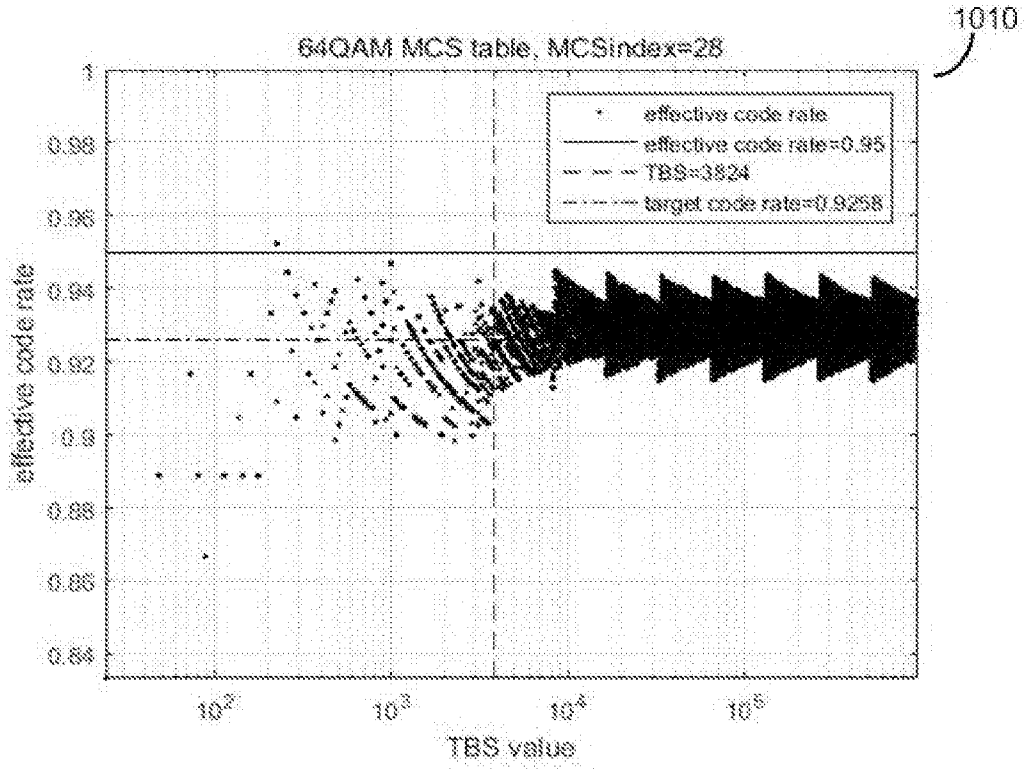


FIG. 10A

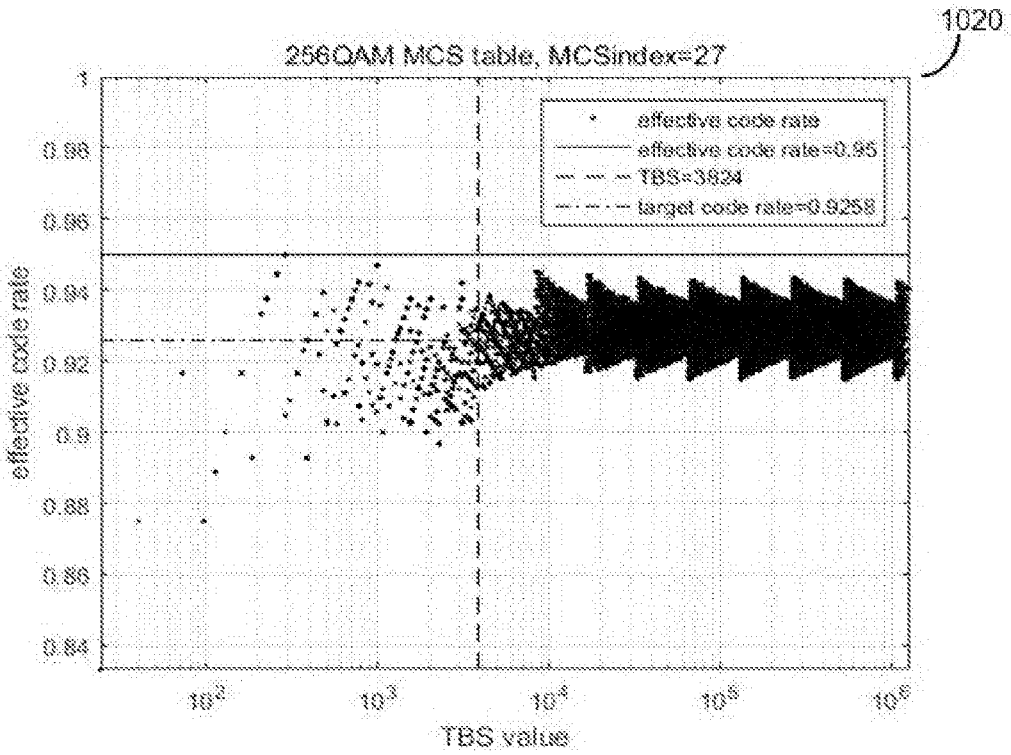


FIG. 10B

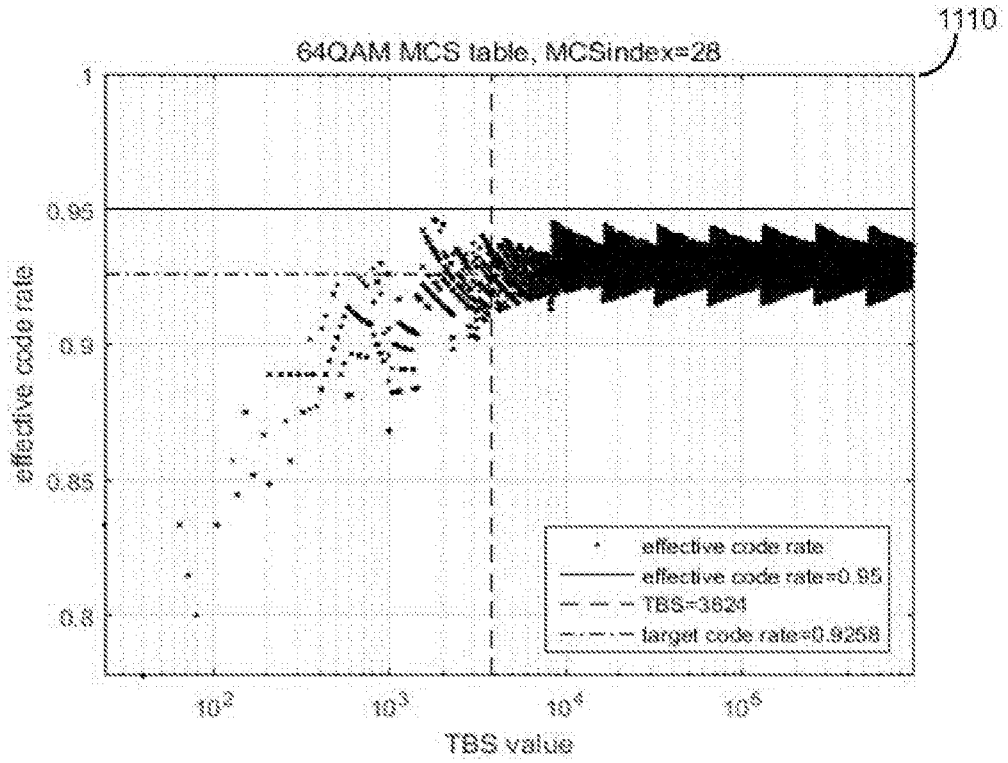


FIG. 11A

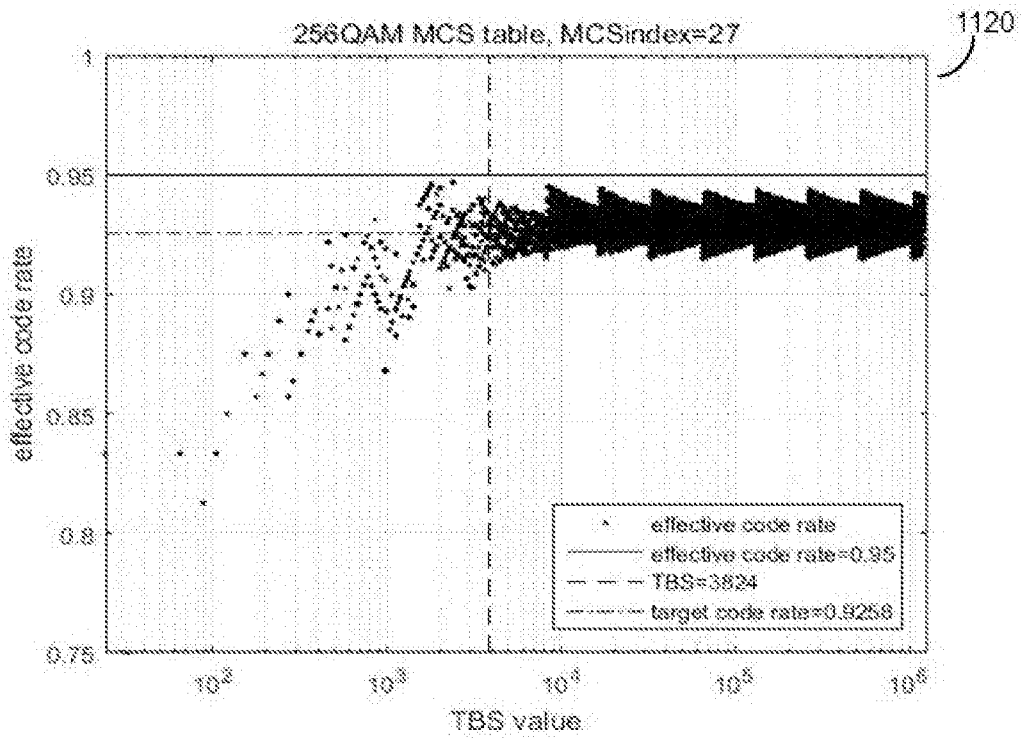


FIG. 11B

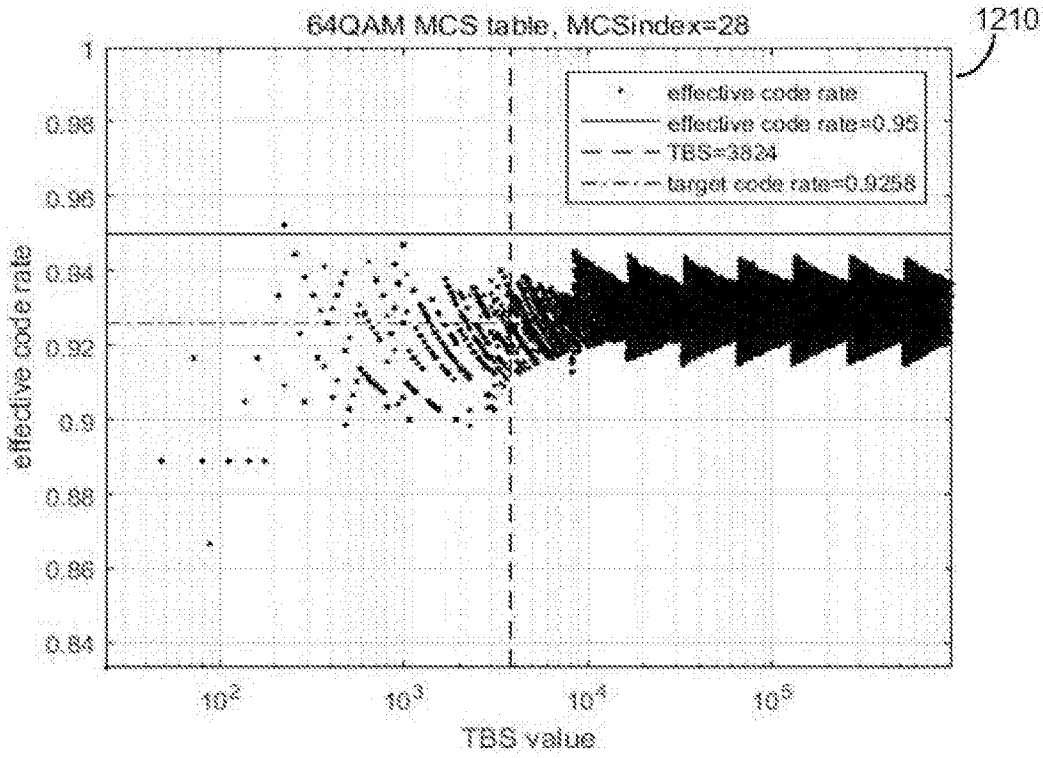


FIG. 12A

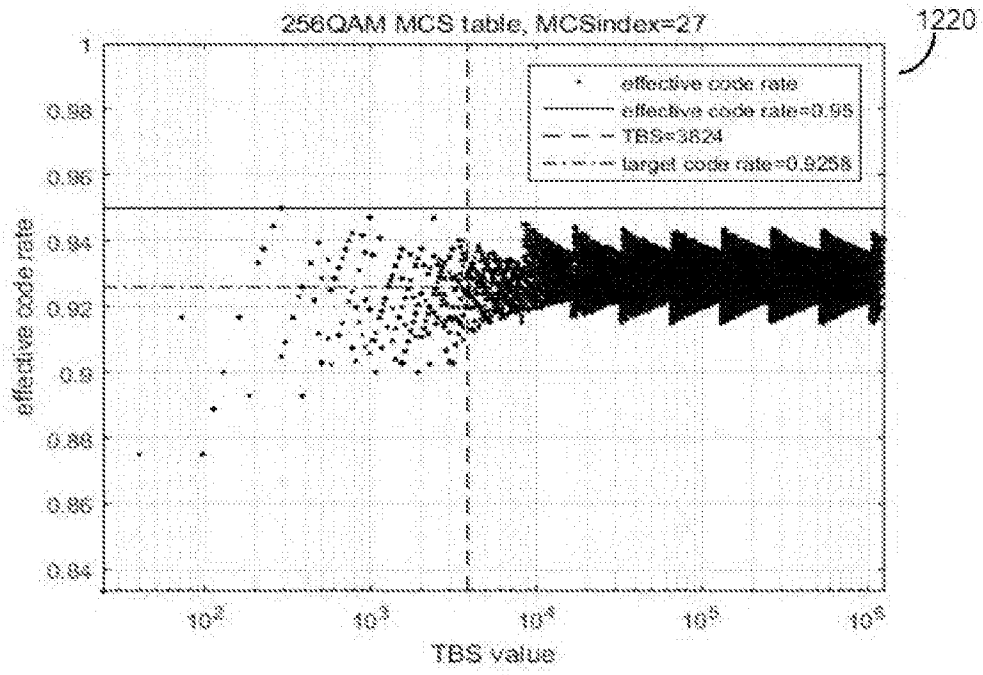


FIG. 12B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/082015

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/10(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT;WPI;EPODOC;3GPP:correct+, TBS, modif+, trans+ block? size?, TB, size,updat+, quantiz+, VoIP

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HUAWEI et al. "Resource allocation and TBS, " *3GPP TSG RAN WG1 Meeting #91 R1-1719381*, , 01 December 2017 (2017-12-01), section 5	1-37
A	CN 102378253 A (CHINA MOBILE COMMUNICATION CORP.) 14 March 2012 (2012-03-14) the whole document	1-37
A	CN 103580776 A (CHINA ACADEMY OF TELECOMMUNICATIONS TECHNOLOGY) 12 February 2014 (2014-02-12) the whole document	1-37
A	CN 102088732 A (ERICSSON CHINA COMMUNICATIONS CO., LTD.) 08 June 2011 (2011-06-08) the whole document	1-37

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 November 2018	**04 January 2019**

Name and mailing address of the ISA/CN	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**XU,Hongyan**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(10)-53961670**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/082015

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 102378253 A	14 March 2012	None	
CN 103580776 A	12 February 2014	WO 2014012423 A1	23 January 2014
CN 102088732 A	08 June 2011	None	