

Exhibit C

'383 Patent Infringement Contentions

T-Mobile directly infringes the '383 patent—either literally or under the doctrine of equivalents—by making, using, selling, offering for sale, and/or importing into the United States T-Mobile's Infringing Instrumentalities, which are covered by claims 1-17 of the '383 patent. General Access contends that each limitation of the Asserted Claims is literally present in T-Mobile's Infringing Instrumentalities. To the extent that any limitation is not literally present, General Access contends that it is present under the doctrine of equivalents.

T-Mobile's Infringing Instrumentalities that General Access has identified to date are listed in these infringement contentions. General Access contends that any other T-Mobile products made, used, sold, offered for sale, and/or imported into the United States during the relevant period, and that operated similarly to the accused 4G and 5G Products, also infringe the '383 patent. General Access reserves the right to update these contentions, and its list of Infringing Instrumentalities, as discovery progresses.

T-Mobile has aggressively touted its use of 5G technology and leadership in the 5G arena:

T-Mobile Rules the World for 5G Availability and 5G Reach. In a new global report, leading research firm Opensignal today confirmed that T-Mobile (NASDAQ: TMUS) customers get a 5G signal more often and in more places than anyone else on the planet. [S]aid Neville Ray, President of Technology at T-Mobile[,] “[w]e’re out in front of the competition, and we’re not looking back.”

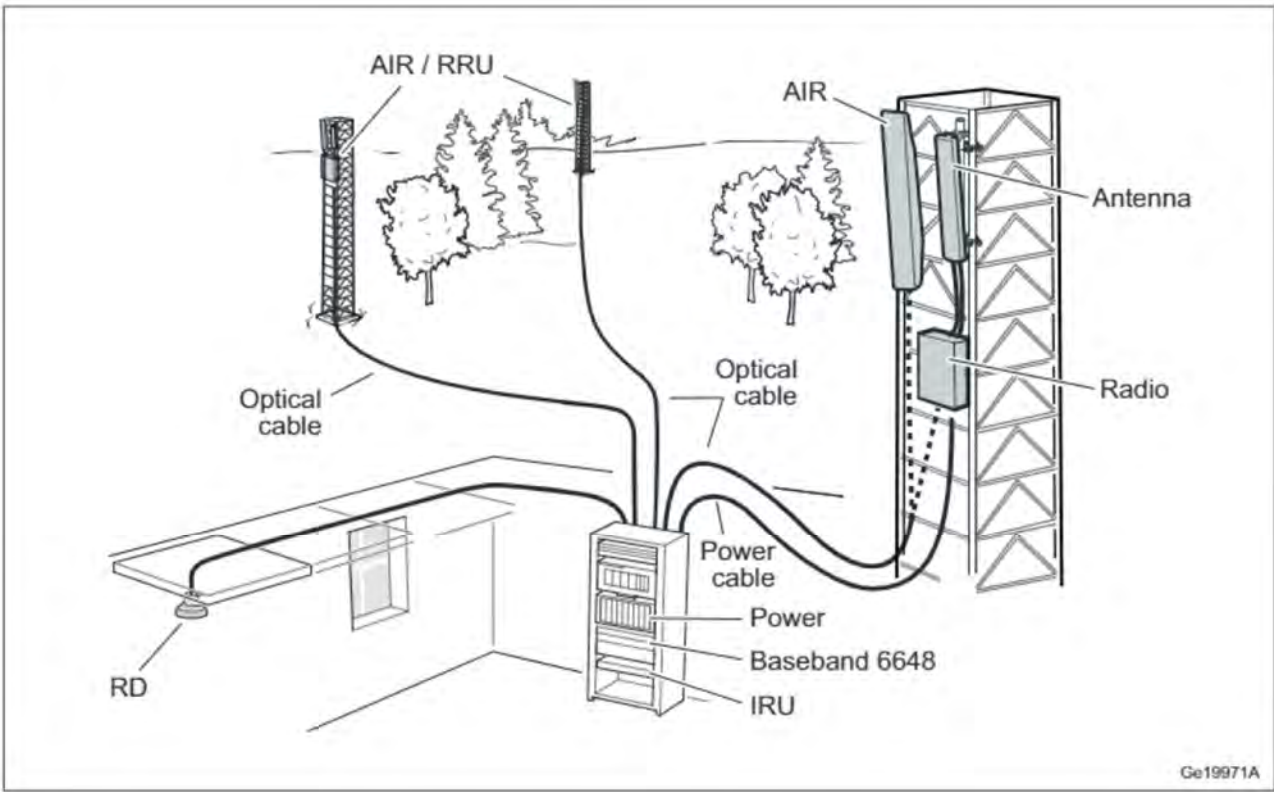
<https://www.t-mobile.com/news/network/t-mobile-rules-the-world-for-5g-availability-and-reach> (Sep. 20, 2022).

5G is the next generation of wireless technology, designed to expand the scope of mobile technology beyond the capabilities of LTE. It will fuel innovation across every industry and transform every aspect of our lives. Over time, 5G technology will change the way we live, work, and play—for the better.

<https://www.t-mobile.com/5g#:~:text=What%20does%205G%20UC%20mean,5G%20and%20Ultra%20Capacity%205G>. (“What is 5G Technology”)

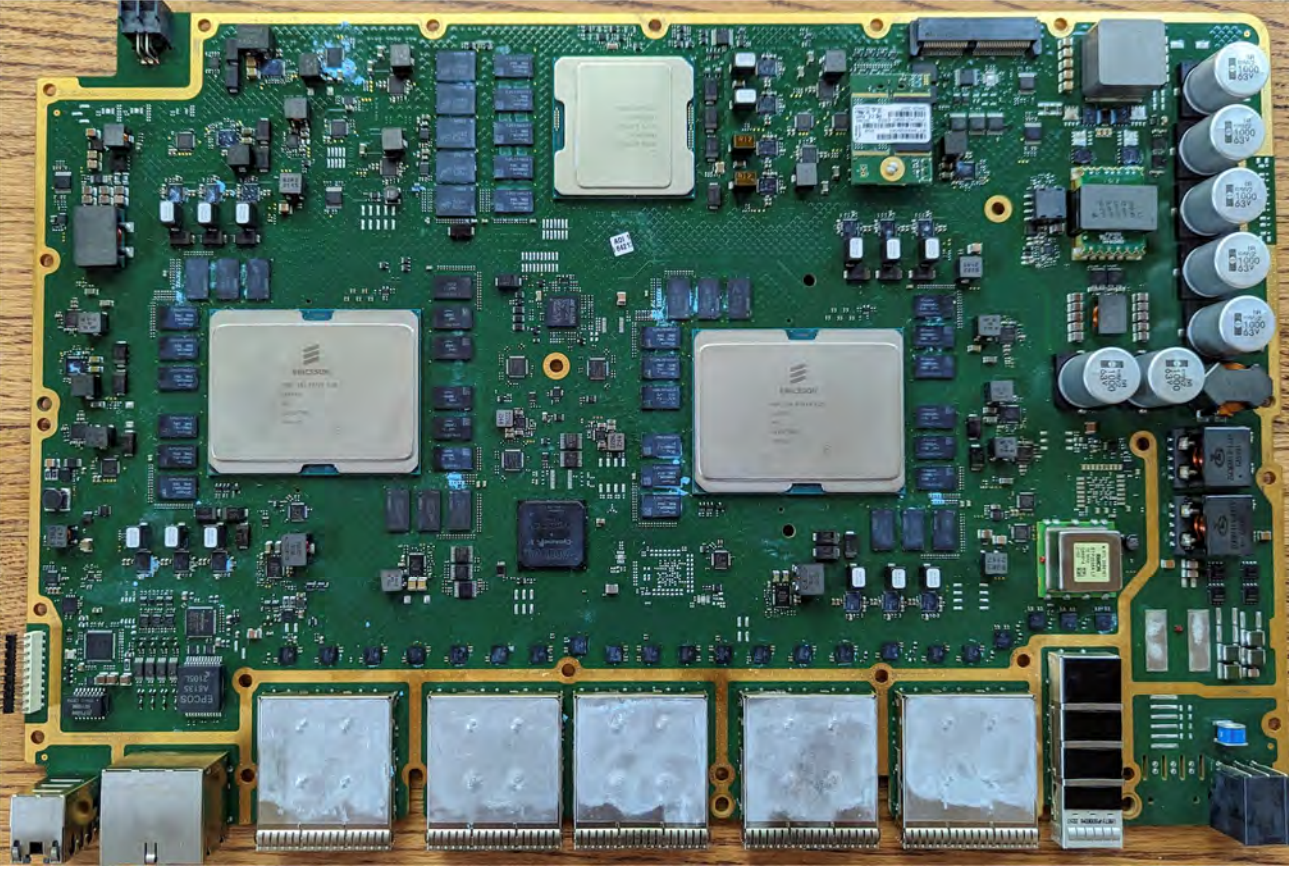
T-Mobile has also aggressively touted its leadership in 4G LTE. *See, e.g.* <https://www.t-mobile.com/resources/what-is-lte> ; <https://www.t-mobile.com/coverage/extended-range-compatible-devices>.

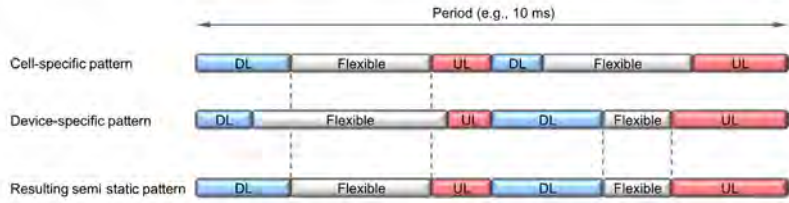
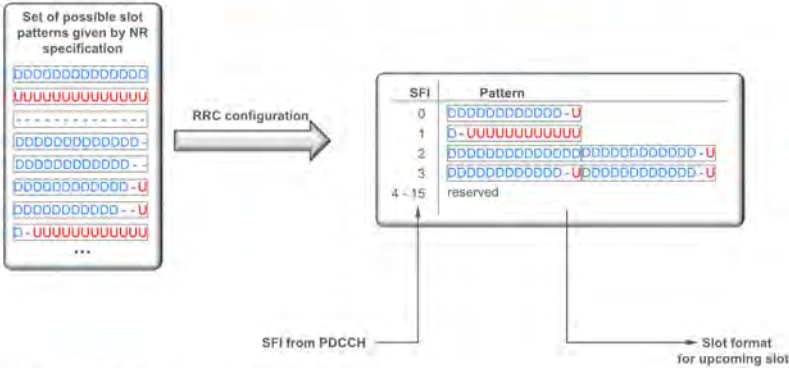
	Claim Language	Infringement Contentions
Claim 1 Preamble	An apparatus for a communication station operable in a wireless communication system at least to receive first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, respectively, within a plurality of subscriber stations, the apparatus comprising:	To the extent that the preamble is limiting, T-Mobile's Infringing Instrumentalities are apparatuses for a communication station operable in a wireless communication system at least to receive first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, respectively, within a plurality of subscriber stations, as described in Claim 1. For example, and without limitation, T-Mobile's 4G and 5G base stations are apparatuses for a communication station operable in a wireless communication system. <i>See, e.g.</i>, https://www.t-mobile.com/coverage/4g-lte-5g-networks (touting the benefits of T-Mobile's network, including that it "covers 325 million Americans nationwide"). <i>See also</i> https://www.t-mobile.com/news/network/americas-leading-wireless-network-tops-competitors-in-new-report (touting the same 325 million figure, and noting T-Mobile's network speed); https://www.t-mobile.com/news/network/tmobile-5g-claims-more-third-party-report-wins (T-Mobile news release regarding "umlaut" report finding that T-Mobile had the fastest uplink speeds in 5G). T-Mobile's 4G and 5G base station equipment is operable to receive first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, respectively, within a plurality of subscriber stations. For example, and without limitation, T-Mobile's Accused 4G and 5G base stations include antennas, baseband units, air interface units, radios, and additional hardware and software. For example, and without limitation, the following image depicts some of the hardware that may be included in a base station utilizing an Ericsson BBU:

	Claim Language	Infringement Contentions
		 The diagram illustrates a base station architecture. On the left, a rack contains a Baseband 6648 and an IRU (Integrated Radio Unit). A Power cable connects this rack to a separate Power supply unit. Optical cables connect the Baseband 6648 to two remote antenna units. One unit, labeled 'AIR / RRU', is a vertical antenna structure. The other unit, labeled 'AIR', is a more complex structure featuring an Antenna and a Radio. A Remote Drive (RD) is also shown connected via an optical cable to the Baseband 6648. The diagram is labeled 'Ge19971A' in the bottom right corner. See Ericsson Baseband Description, Baseband 6648, 6641 (retrieved from https://studylib.net/doc/25912867/baseband-6641-6648-description). See also https://www.coursehero.com/file/142380780/ts-t-mobile-025-211006-dcltr-CheshireStdoc/ (Transcend Wireless application for T-Mobile station including Ericsson 6648 BBU). T-Mobile's 4G and 5G base stations can alternatively utilize equipment from other manufacturers, including but not limited to Samsung, Nokia, Commscope, and others. See, e.g., https://www.nokia.com/about-us/news/releases/2023/02/28/nokia-qualcomm-and-t-mobile-achieve-industry-first-5g-carrier-aggregation-combining-5-component-carriers-mwc23/ (discussing T-Mobile's use of Nokia base station equipment); https://www.nokia.com/networks/radio-access-networks/ (more detailed descriptions of Nokia base stations). Regardless of the specific equipment that is deployed, all T-Mobile 4G and 5G base stations are operable to receive first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, within a plurality of subscriber stations.

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		<i>See, e.g.</i>, 3GPP TR 38.913 version 16.0.0 Release 16 (antenna arrays): 3.1 Definitions For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1]. Transmission Reception Point (TRxP): Antenna array with one or more antenna elements available to the network located at a specific geographical location for a specific area. For 5G NR, document “ETSI TR 138 913 V16.0.0” describes requirements for 5G deployment, including §6.1.2, which describes requirements for dense urban deployment, where a large number of UEs will be located in a relatively small geographic area: 6.1.2 Dense urban The dense urban microcellular deployment scenario focuses on macro TRxPs with or without micro TRxPs and high user densities and traffic loads in city centres and dense urban areas. The key characteristics of this deployment scenario are high traffic loads, outdoor and outdoor-to-indoor coverage. This scenario will be interference-limited, using macro TRxPs with or without micro TRxPs. A continuous cellular layout and the associated interference shall be assumed. <i>See</i> 3GPP TR 38.913 version 16.0.0 Release 16 “ETSI TR 138 913 V16.0.0” also defines requirements for rural deployments in §6.1.3, where a base station will cover a large geographic area with numerous UEs: 6.1.3 Rural The rural deployment scenario focuses on larger and continuous coverage. The key characteristics of this scenario are continuous wide area coverage supporting high speed vehicles. This scenario will be noise-limited and/or interference-limited, using macro TRxPs. When a base station antenna receives an uplink signal from a UE, that signal is processed by the antennas, radios, and associated hardware/software, and then sent to the BBU. For example and without limitation, it could be sent to an Ericsson Baseband 6648, like the one depicted below:

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		 The following image depicts the bottom side of the PCB in an Ericsson 6648:

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		 The silver-colored squares near the bottom of the above image depict the ports through which the BBU receives uplink signals processed by the base stations' antennas, radios, and air units. The uplink signals received by T-Mobile's 4G and 5G base stations include first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, within a plurality of subscriber stations. For example, and without limitation, a 5G base station will typically receive uplink transmissions from multiple UEs, both within a single frame and across multiple frames. <i>See, e.g.,</i> Dahlman 5G NR at 141 (depicting one example of how slots are structured in a 5G frame):

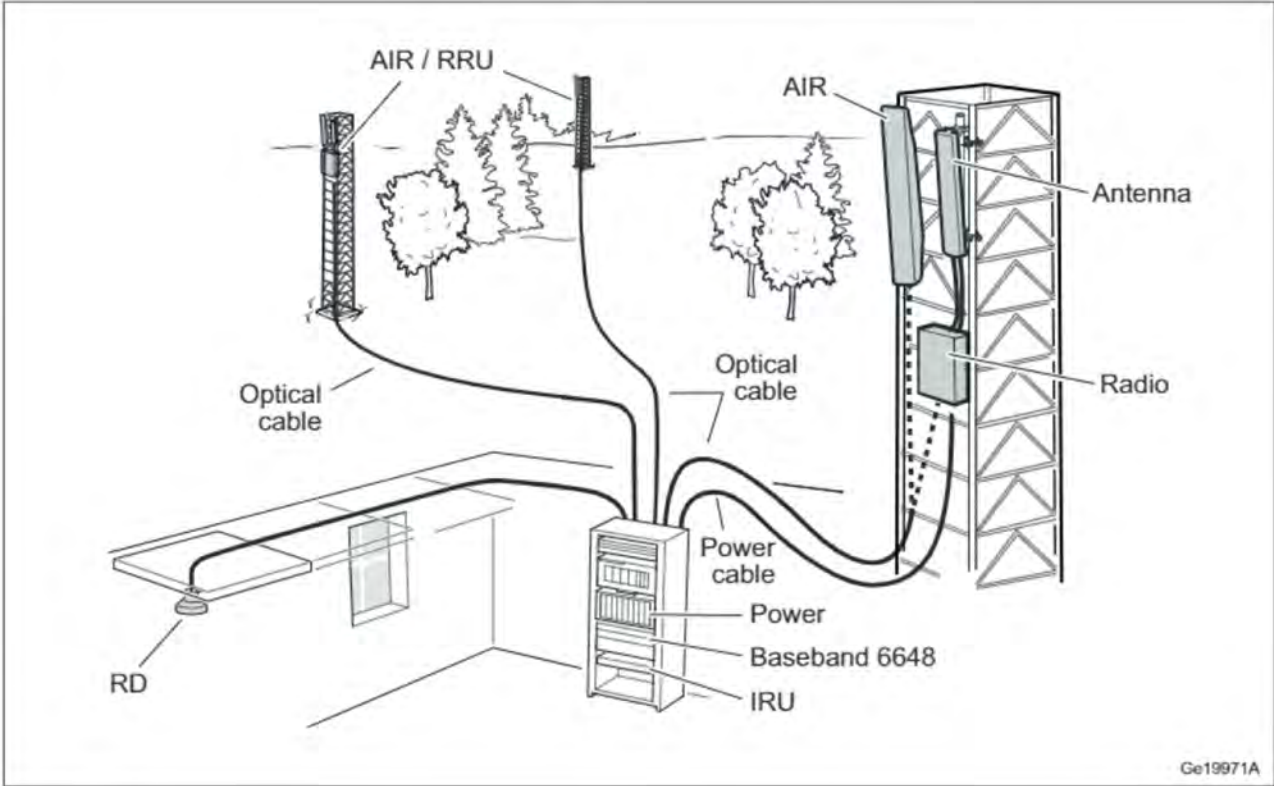
	Claim Language	Infringement Contentions
		 Fig. 7.18 Example of cell-specific and device-specific uplink-downlink patterns.  Fig. 7.19 Example of configuring the SFI table. <i>See also id.</i> at Section 14.2 (discussing uplink scheduling in NR, including scheduling for multiple devices). <i>See also,</i> Ahmadi at 211 (discussing uplink scheduling of multiple UEs across the time domain): The uplink scheduler serves a similar purpose, that is, dynamically controlling the transmission opportunities of the active UEs and efficiently sharing of UL-SCH. The scheduling strategy of a gNB is vendor-dependent and implementation specific and is not specified by 3GPP. In general, the ultimate goal of all schedulers is to take advantage of the channel variations experienced by various devices and to schedule the transmissions/receptions to/from each device on the radio resources with advantageous channel conditions in time and frequency domains, that is, channel-dependent scheduling. <i>See also</i> 3GPP TS 38.213v16.11.00 pg 136 – Table 11.1.1-1 (depicting 5G frame formats including one or more uplink symbols allowing a base station to receive successive transmissions from multiple UEs in a single frame and across multiple frames):

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	3GPP TS 38.213 version 16.11.0 Release 16136ETSI TS 138 213 V16.11.0 (2022-09) Table 11.1.1-1: Slot formats for normal cyclic prefix <table><tr><th rowspan="2">Format</th><th colspan="13">Symbol number in a slot</th></tr><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th></tr><tr><td>0</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr><tr><td>1</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>2</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>3</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>4</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>5</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td></tr><tr><td>6</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>7</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>8</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>9</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>10</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>11</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>12</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>13</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>14</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>15</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>16</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>17</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>18</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>19</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>20</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>21</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>22</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>23</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>24</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>25</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>26</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>27</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>28</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td></tr><tr><td>29</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td></tr><tr><td>30</td><td>D</td><td>D</td><td>D</t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– 254</td><td colspan="13">Reserved</td></tr><tr><td>255</td><td colspan="13">UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats</td></tr></table> ETSI LTE base stations similarly receive multiple uplink transmissions from multiple UEs. <i>See, e.g.,</i> Keysight LTE Physical Layer Overview (https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm) (showing how the physical uplink shared channel (PUSCH) is divided into resource blocks allocated to multiple UEs):	Format	Symbol number in a slot													0	1	2	3	4	5	6	7	8	9	10	11	12	13	0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	2	F	F	F	F	F	F	F	F	F	F	F	F	F	F	3	D	D	D	D	D	D	D	D	D	D	D	D	D	F	4	D	D	D	D	D	D	D	D	D	D	D	D	D	F	5	D	D	D	D	D	D	D	D	D	D	D	F	F	F	6	D	D	D	D	D	D	D	D	D	D	F	F	F	F	7	D	D	D	D	D	D	D	D	D	F	F	F	F	F	8	F	F	F	F	F	F	F	F	F	F	F	F	F	U	9	F	F	F	F	F	F	F	F	F	F	F	F	F	U	10	F	U	U	U	U	U	U	U	U	U	U	U	U	U	11	F	F	U	U	U	U	U	U	U	U	U	U	U	U	12	F	F	F	U	U	U	U	U	U	U	U	U	U	U	13	F	F	F	F	U	U	U	U	U	U	U	U	U	U	14	F	F	F	F	F	U	U	U	U	U	U	U	U	U	15	F	F	F	F	F	F	U	U	U	U	U	U	U	U	16	D	F	F	F	F	F	F	F	F	F	F	F	F	F	17	D	D	F	F	F	F	F	F	F	F	F	F	F	F	18	D	D	D	F	F	F	F	F	F	F	F	F	F	F	19	D	F	F	F	F	F	F	F	F	F	F	F	F	F	20	D	D	F	F	F	F	F	F	F	F	F	F	F	U	21	D	D	D	F	F	F	F	F	F	F	F	F	F	U	22	D	F	F	F	F	F	F	F	F	F	F	F	F	U	23	D	D	F	F	F	F	F	F	F	F	F	F	F	U	24	D	D	D	F	F	F	F	F	F	F	F	F	F	U	25	D	F	F	F	F	F	F	F	F	F	F	U	U	U	26	D	D	F	F	F	F	F	F	F	F	F	U	U	U	27	D	D	D	F	F	F	F	F	F	F	F	U	U	U	28	D	D	D	D	D	D	D	D	D	D	D	D	F	U	29	D	D	D	D	D	D	D	D	D	D	D	D	F	U	30	D	D	D	D	D	D	D	D	D	D	F	F	F	U	31	D	D	D	D	D	D	D	D	D	D	D	F	F	U	32	D	D	D	D	D	D	D	D	D	D	F	F	F	U	33	D	D	D	D	D	D	D	D	D	D	F	F	F	U	34	D	F	U	U	U	U	U	U	U	U	U	U	U	U	35	D	D	F	U	U	U	U	U	U	U	U	U	U	U	36	D	D	D	F	U	U	U	U	U	U	U	U	U	U	37	D	F	F	U	U	U	U	U	U	U	U	U	U	U	38	D	D	F	F	U	U	U	U	U	U	U	U	U	U	39	D	D	D	F	F	U	U	U	U	U	U	U	U	U	40	D	F	F	F	U	U	U	U	U	U	U	U	U	U	41	D	D	F	F	F	U	U	U	U	U	U	U	U	U	42	D	D	D	F	F	F	U	U	U	U	U	U	U	U	43	D	D	D	D	D	D	D	D	D	F	F	F	F	U	44	D	D	D	D	D	D	F	F	F	F	F	F	F	U	45	D	D	D	D	D	D	F	F	U	U	U	U	U	U	46	D	D	D	D	D	F	U	D	D	D	D	D	F	U	47	D	D	F	U	U	U	U	D	D	F	U	U	U	U	48	D	F	U	U	U	U	U	D	F	U	U	U	U	U	49	D	D	D	D	F	F	U	D	D	D	D	F	F	U	50	D	D	F	F	U	U	U	D	D	F	F	U	U	U	51	D	F	F	U	U	U	U	D	F	F	U	U	U	U	52	D	F	F	F	F	F	U	D	F	F	F	F	F	U	53	D	D	F	F	F	F	U	D	D	F	F	F	F	U	54	F	F	F	F	F	F	F	D	D	D	D	D	D	D	55	D	D	F	F	F	U	U	U	D	D	D	D	D	D	56 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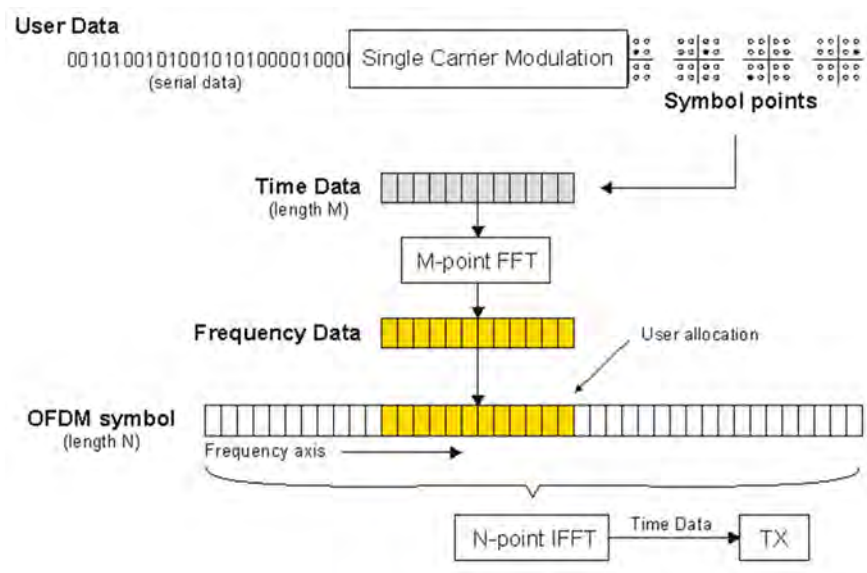
	Claim Language	Infringement Contentions
		LTE uplink subframes 2-3 Bandwidth: 5 MHz = 300 subcarriers = 25 RB Normal CP, PUCCH Type 2, 15 kHz subcarrier spacing Subcarrier 149, RB 24 RB 20 ... Subcarrier -150, RB 0 Slot 4 Slot 5 Slot 6 Slot 7 Subframe 2 Subframe 3 Legend: - PUSCH allocation (User 1) - PUCCH allocation (User 2) - PUSCH or PUCCH DMRS - PUSCH allocation (Other users) - S-RS allocation (User 3) - PRACH allocation (User 4) <i>See also, Dahlman LTE/LTE-Advanced for Mobile Broadband, page 136 (showing the basic structure of LTE frames, including multiple uplink subframes in both TDD and FDD):</i> One radio frame, $T_{\text{frame}} = 10 \text{ ms}$ One subframe, $T_{\text{subframe}} = 1 \text{ ms}$ FDD UL DL f_{UL} f_{DL} TDD Subframe #0 #1 #2 #3 #4 #5 #6 #7 #8 #9 (special subframe) (special subframe) UL DL DwPTS GP UpPTS $f_{\text{DL/UL}}$ FIGURE 9.9 Uplink/downlink time-frequency structure for FDD and TDD.

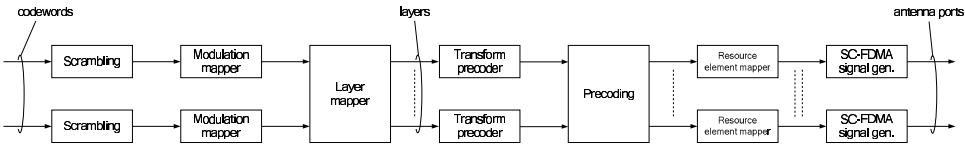
	Claim Language	Infringement Contentions
		In addition, T-Mobile's 4G and 5G base stations receive at least first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, respectively, across multiple frames. For example, and without limitation, T-Mobile operates a cell tower on or about East Houston Street in Marshall Texas. <i>See</i> https://www.cellmapper.net/map?MCC=310&MNC=260&type=NR&latitude=32.5431861083393&longitude=-94.34003503355731&zoom=15.270350353792669&showTowers=true&showIcons=true&showTowerLabels=true&clusterEnabled=true&tilesEnabled=true&showOrphans=false&showNoFrequencyOnly=false&showFrequencyOnly=false&showBandwidthOnly=false&DateFilterType=Last&showHex=false&showVerifiedOnly=false&showUnverifiedOnly=false&showLTECAOnly=false&showENDCOnly=false&showBand=0&showSectorColours=true&mapType=roadmap&darkMode=false&imperialUnits=false. This cell tower receives successive uplink data signals from a large number of subscriber stations, both within a single frame and across multiple frames. T-Mobile's 4G and 5G base stations also include the remaining limitations of Claim 1, as discussed below.
1.1	a first demodulator selectably coupled to receive the first data signals transmitted to the communication station; at least a second demodulator also selectably coupled to receive the second data signals transmitted to the communication station; and	T-Mobile's 4G and 5G base stations include a first demodulator selectably coupled to receive the first data signals transmitted to the communication station. For example, and without limitation, T-Mobile's base stations include BBUs that contain the claimed demodulators. One example of the type of BBU used in T-Mobile's base stations is an Ericsson Baseband 6648 (see above). The following image depicts the bottom side of the PCB in an Ericsson 6648:

	Claim Language	Infringement Contentions
		 The above image includes 5 processing components: an Intel Atom processor, an STMicro Arm processor, two Ericsson SoCs, and an Altera Cyclone V FPGA. The claimed demodulators are located within one or more of those processing components. As shown in the following image, a BBU is connected to the base station antenna and radio via cables to transmit and receive data signals transmitted to and from the communication station:

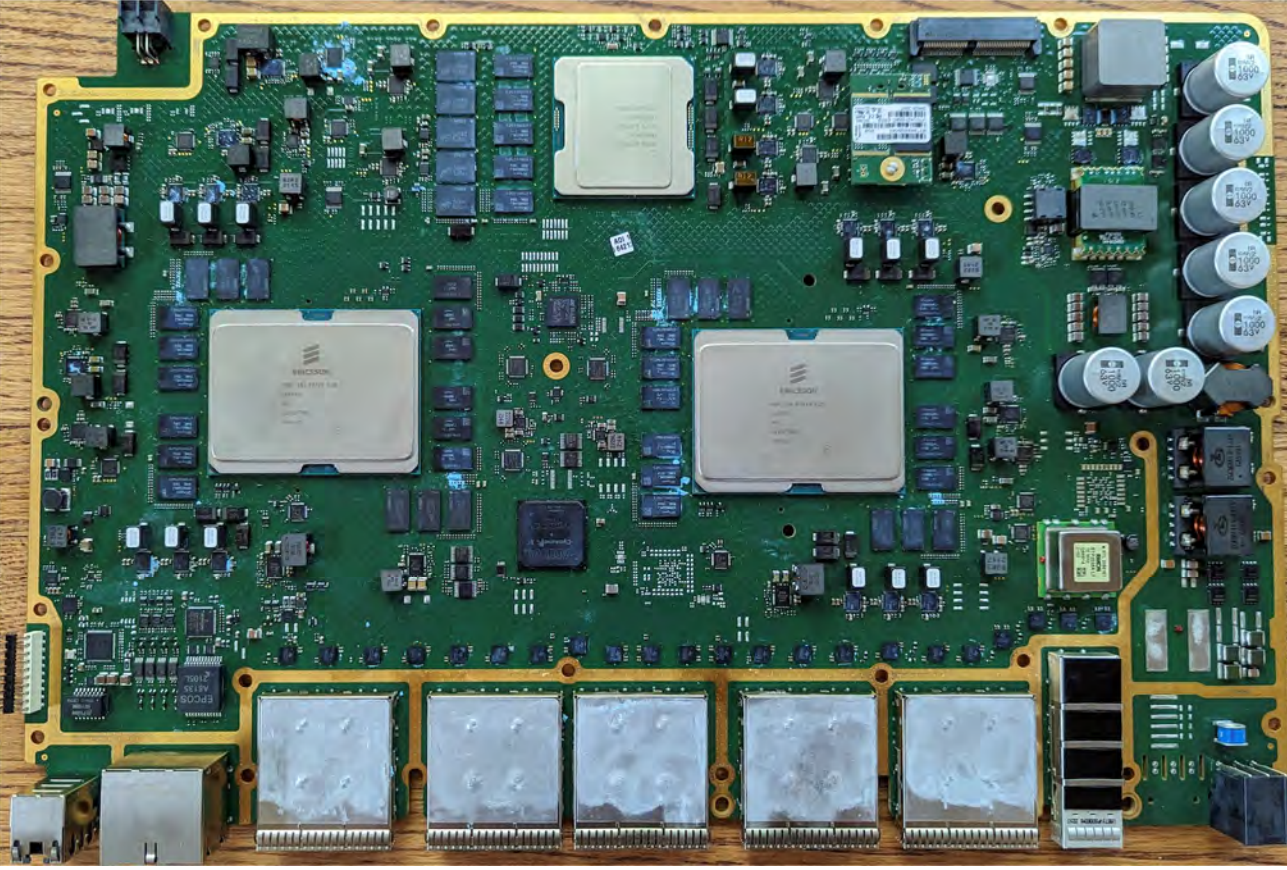
	Claim Language	Infringement Contentions
		 Ericsson Baseband Description, Baseband 6648, 6641. T-Mobile's 4G and 5G base stations can alternatively utilize equipment from other manufacturers, including but not limited to Samsung, Nokia, Commscope, and others. Regardless of the specific equipment that is deployed, all T-Mobile 4G and 5G base stations include the claimed demodulators. The baseband units used in Verizon's 4G and 5G base stations include a first demodulator selectably coupled to receive the first data signals transmitted to the communication station. Figure 4.72 in Ahmadi depicts some of the "uplink physical layer processing" in 5G. The right side of the figure shows the steps performed by the base station, including layer demapping, demodulation, de-scrambling, de-interleaving, channel decoding, and HARQ buffering of data signals transmitted to the communication station:

	Claim Language	Infringement Contentions
		New Radio Access Physical Layer Aspects (Part 2) 591 Figure 4.72 Overall uplink physical layer processing [5]. T-Mobile’s 5G base stations also include at least a second demodulator also selectably coupled to receive the second data signals transmitted to the communication station. As shown in the above figure, the base station performs “resource de-mapping.” After resource de-mapping, the controller will send data from one UE to a first demodulator, and data from a second UE will be sent to a different demodulator. <i>See, e.g.</i>, Dahlman 5G at 63 (“NR does not include cell-specific reference signals but solely relies on user-specific demodulation reference signals for channel estimation”); <i>id.</i> at 349 (“spatial separation is typically enabled by using different demodulation reference signals (DM-RS) for the different transmissions, allowing the network to estimate the channel from each device separately...”). <i>See also</i> Ahmadi at 415 (NR “exclusively relies on user-specific demodulation reference signals (DM-RSs) for channel estimation”); <i>id.</i> at 719 (“The baseband modems utilize digital signal processing to perform

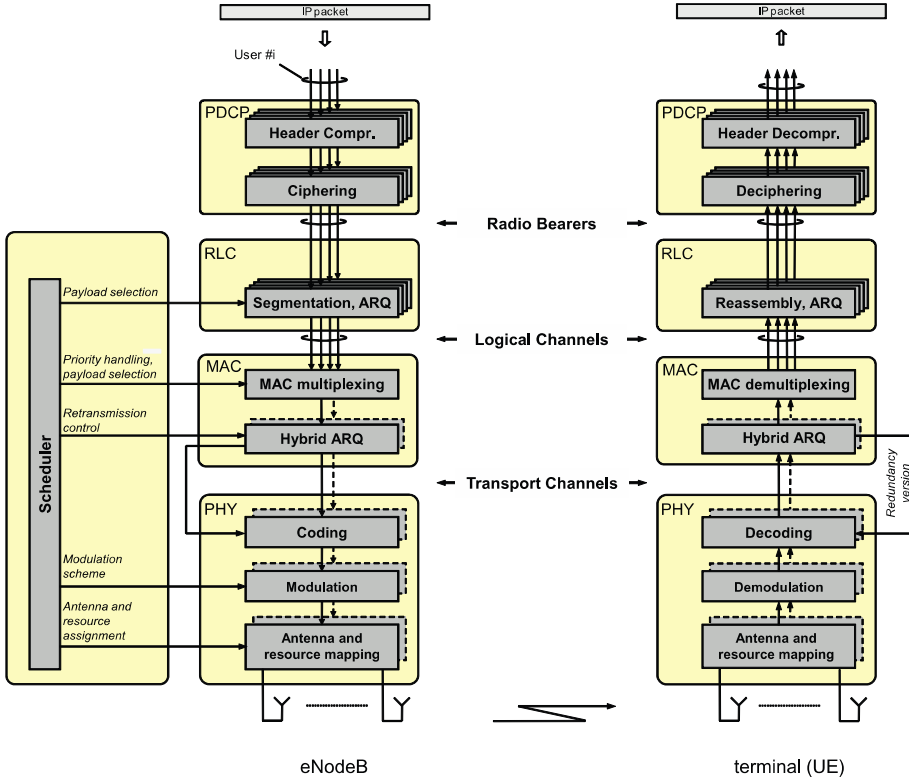
	Claim Language	Infringement Contentions
		channel coding and complex-valued modulation and demodulation in order to transmit extremely high data rate streams over RF carriers in mmWave band. . . . The baseband modulation schemes, generating complex-valued symbols, range from BPSK, QPSK, 16QAM and up to 256QAM (or higher) for high-performance systems.”); <i>id.</i> at Introduction, page xc (noting that 5G communications will utilize “multiple transmit/receive chains to accomplish transceiver functionality”). T-Mobile’s 4G base stations similarly include a first demodulator selectably coupled to receive the first data signals transmitted to the communication station; at least a second demodulator also selectably coupled to receive the second data signals transmitted to the communication station. <i>See, e.g.,</i> https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (depicting a simplified view of some of the steps involved in modulating an uplink LTE signal for a single UE; demodulation would involve the same basic steps in reverse order):  The diagram illustrates the LTE uplink transmission process. It begins with 'User Data' represented as a sequence of bits: 0010100101001010100001000. This data is processed by 'Single Carrier Modulation' to produce 'Symbol points', shown as a grid of points. These symbol points are then mapped to 'Time Data (length M)', represented as a horizontal bar. An 'M-point FFT' is applied to the time data, resulting in 'Frequency Data', shown as a yellow bar. This frequency data is then mapped to an 'OFDM symbol (length N)' on a 'Frequency axis'. A portion of the OFDM symbol is highlighted in yellow and labeled 'User allocation'. Finally, an 'N-point IFFT' is applied to the OFDM symbol, resulting in 'Time Data', which is then transmitted ('TX'). <i>See also</i> 3GPP TS 36.211v14.15.0 (2020-09) (depicting some of the steps involved in uplink transmissions in LTE; these steps are performed in reverse by the base station when decoding and demodulating the received transmission):

	Claim Language	Infringement Contentions
		3GPP TS 36.211 version 14.15.0 Release 14 23 ETSI TS 136 211 V14.15.0 (2020-09) 5.3 Physical uplink shared channel The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - mapping of the complex-valued modulation symbols onto one or several transmission layers - transform precoding to generate complex-valued symbols - precoding of the complex-valued symbols - mapping of precoded complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  Figure 5.3-1: Overview of uplink physical channel processing See also Ericsson Baseband Description, Baseband 6648, 6641, at 4 (listing “Uplink (UL) baseband processing” and other functions of an Ericsson BBU). See also https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (showing how the physical uplink shared channel (PUSCH) is divided into resource blocks allocated to multiple UEs, requiring multiple receive chains to demodulate the received transmissions):

	Claim Language	Infringement Contentions
		LTE uplink subframes 2-3 Bandwidth: 5 MHz = 300 subcarriers = 25 RB Normal CP, PUCCH Type 2, 15 kHz subcarrier spacing Subcarrier 149, RB 24 RB 20 ... Subcarrier -150, RB 0 Slot 4 Slot 5 Slot 6 Slot 7 Subframe 2 Subframe 3 - PUSCH allocation (User 1) - PUCCH allocation (User 2) - PUSCH or PUCCH DMRS - PUSCH allocation (Other users) - S-RS allocation (User 3) - PRACH allocation (User 4) To the extent that T-Mobile's 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
1.2	a controller, coupled to the first demodulator and to the at least second demodulator in a feedback arrangement, the controller alternately selecting the first data signals for application to the first demodulator and the second data signals for application to the second demodulator,	T-Mobile's 4G and 5G base stations include a controller, coupled to the first demodulator and to the at least second demodulator in a feedback arrangement, the controller alternately selecting the first data signals for application to the first demodulator and the second data signals for application to the second demodulator. For example, and without limitation, T-Mobile's 4G and 5G base stations include processors, ASICs, and/or FPGAs that comprise the claimed controllers and are coupled to the first demodulator and to the at least second demodulator in a feedback arrangement. For example, the following image of the PCB in an Ericsson Baseband 6648 shows five processors, all of which are communicatively coupled with each other and the demodulators:

	Claim Language	Infringement Contentions
		 The controller included in T-Mobile's 4G and 5G base stations alternately selects the first data signal for application to the first demodulator and the second data signal for application to the second demodulator. For example, and without limitation, the below figure depicts the receive chain of a gNodeB, including multiple configuration parameters dynamically set and/or determined by the controller in communication with the demodulators:

	Claim Language	Infringement Contentions
		New Radio Access Physical Layer Aspects (Part 2) 591 Figure 4.72 Overall uplink physical layer processing [5]. Ahmadi, 5G NR page 591. <i>See also id.</i> at Chapter 4 (discussing downlink and uplink physical layer signal processing in 5G); Dahlman 4G LTE/LTE Advanced for Mobile Broadband at Figure 8.4 (showing the MAC and PHY layers in an eNodeB, including a “scheduler” that dynamically determines and/or sets multiple MAC and PHY configuration parameters in communication with the demodulators):

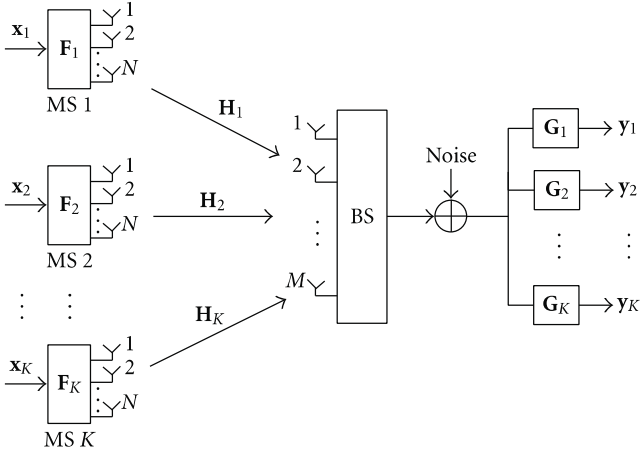
	Claim Language	Infringement Contentions
		 FIGURE 8.4 LTE protocol architecture (downlink). <i>See also</i> Dahlman 5G at 256 (“[i]n the case of codebook-based precoding, the scheduling grant includes information about a precoder,” and “the device is assumed to use the precoder provided by the matrix”). The receive chain used for demodulation (and other processing) of transmissions from each of multiple UEs in a cell is dynamically determined by the controller. The controller alternately selects the demodulators to which different UE’s data are transmitted to enable efficient processing of received signals. As explained in Dahlman 5G, “the gNB is in complete control of the UL-SCH transmissions and the device always follows the scheduling grants received from the network, including the UL-SCH transport format specified in those grants. Thus, the network knows the transport format used for the UL-SCH transmission in advance.” <i>Id.</i> at 229. <i>See also id.</i> at 229-241 (discussing the uplink control signaling used in 5G); <i>id.</i> at 256 (discussing the base station’s role in determining the precoding that UEs

Claim Language	Infringement Contentions
	apply to uplink transmissions); <i>id.</i> at Section 11.3.1 (discussing codebook-based transmission); <i>id.</i> at Section 11.3.2 (discussing non-codebook based precoding). <i>See also</i> Dahlman 5G at 63 (“NR does not include cell-specific reference signals but solely relies on user-specific demodulation reference signals for channel estimation”); <i>id.</i> at 349 (“spatial separation is typically enabled by using different demodulation reference signals (DM-RS) for the different transmissions, allowing the network to estimate the channel from each device separately...”). These processes control successive transmissions, and their demodulation, both within a single frame and across multiple frames. In a given 4G or 5G frame, the base station receives uplink transmissions from multiple UEs. <i>See, e.g.</i>, Dahlman 5G NR at 141 (depicting one example of a 5G frame): Fig. 7.18 Example of cell-specific and device-specific uplink-downlink patterns. Fig. 7.19 Example of configuring the SFI table. <i>See also id.</i> at Section 14.2 (discussing uplink scheduling in NR, including scheduling for multiple devices). <i>See also</i>, Ahmadi at 211 (discussing uplink scheduling of multiple UEs across the time domain): The uplink scheduler serves a similar purpose, that is, dynamically controlling the transmission opportunities of the active UEs and efficiently sharing of UL-SCH. The scheduling strategy of a gNB is vendor-dependent and implementation specific and is

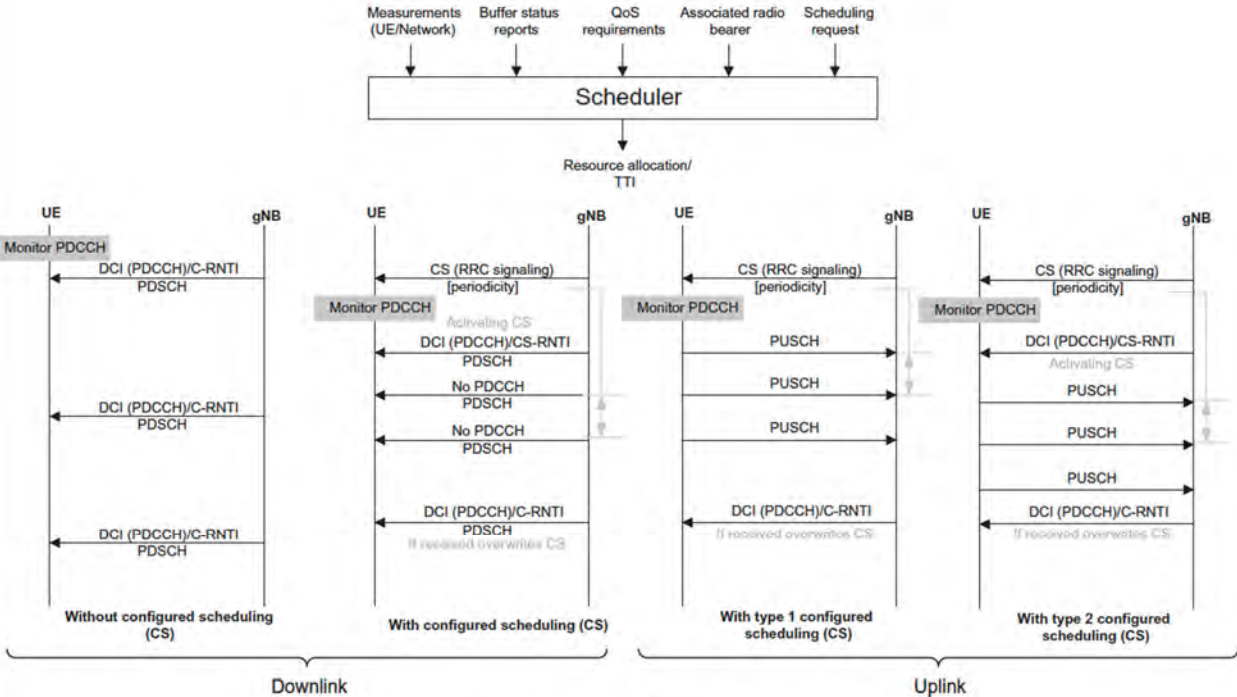
	Claim Language	Infringement Contentions
		not specified by 3GPP. In general, the ultimate goal of all schedulers is to take advantage of the channel variations experienced by various devices and to schedule the transmissions/receptions to/from each device on the radio resources with advantageous channel conditions in time and frequency domains, that is, channel-dependent scheduling. <i>See also</i> 3GPP TS 38.213v16.11.00 pg 136 – Table 11.1.1-1 (depicting 5G frame formats including one or more uplink symbols allowing a base station to receive successive transmissions from multiple UEs in a single frame and across multiple frames):

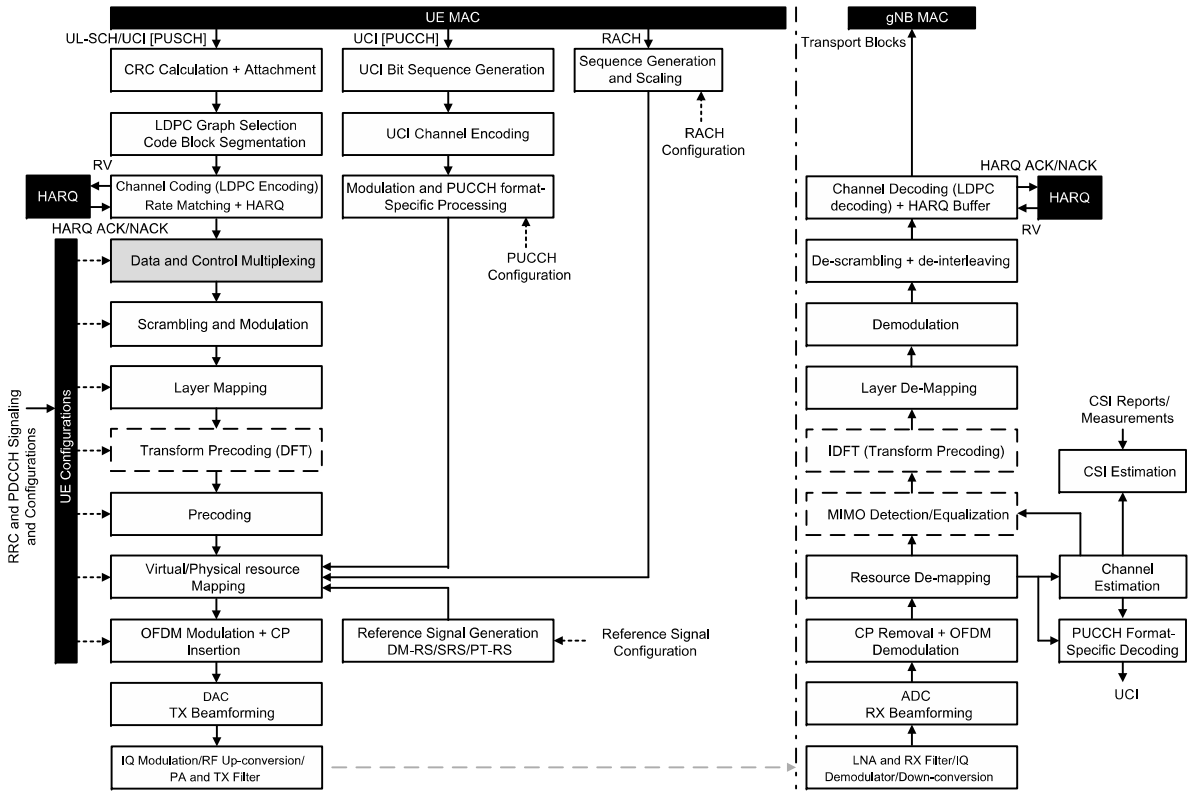
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	3GPP TS 38.213 version 16.11.0 Release 16136ETSI TS 138 213 V16.11.0 (2022-09) Table 11.1.1-1: Slot formats for normal cyclic prefix <table><tr><th rowspan="2">Format</th><th colspan="14">Symbol number in a slot</th></tr><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th></tr><tr><td>0</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr><tr><td>1</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>2</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>3</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>4</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>5</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td></tr><tr><td>6</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>7</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>8</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>9</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>10</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>11</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>12</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>13</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>14</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>15</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>16</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>17</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>18</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>19</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>20</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>21</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>22</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>23</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>24</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>25</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>26</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>27</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>28</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td></tr><tr><td>29</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td></tr><tr><td>30</td><td>D</td><td>D</td><td>D</t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– 254</td><td colspan="14">Reserved</td></tr><tr><td>255</td><td colspan="14">UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats</td></tr></table> ETSI LTE frames similarly include multiple uplink transmissions from multiple UEs. <i>See, e.g.,</i> Keysight LTE Physical Layer Overview (https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm) (showing how the physical uplink shared channel (PUSCH) is divided into resource blocks allocated to multiple UEs):	Format	Symbol number in a slot														0	1	2	3	4	5	6	7	8	9	10	11	12	13	0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	2	F	F	F	F	F	F	F	F	F	F	F	F	F	F	3	D	D	D	D	D	D	D	D	D	D	D	D	D	F	4	D	D	D	D	D	D	D	D	D	D	D	D	D	F	5	D	D	D	D	D	D	D	D	D	D	D	F	F	F	6	D	D	D	D	D	D	D	D	D	D	F	F	F	F	7	D	D	D	D	D	D	D	D	D	F	F	F	F	F	8	F	F	F	F	F	F	F	F	F	F	F	F	F	U	9	F	F	F	F	F	F	F	F	F	F	F	F	U	U	10	F	U	U	U	U	U	U	U	U	U	U	U	U	U	11	F	F	U	U	U	U	U	U	U	U	U	U	U	U	12	F	F	F	U	U	U	U	U	U	U	U	U	U	U	13	F	F	F	F	U	U	U	U	U	U	U	U	U	U	14	F	F	F	F	F	U	U	U	U	U	U	U	U	U	15	F	F	F	F	F	F	U	U	U	U	U	U	U	U	16	D	F	F	F	F	F	F	F	F	F	F	F	F	F	17	D	D	F	F	F	F	F	F	F	F	F	F	F	F	18	D	D	D	F	F	F	F	F	F	F	F	F	F	F	19	D	F	F	F	F	F	F	F	F	F	F	F	F	U	20	D	D	F	F	F	F	F	F	F	F	F	F	F	U	21	D	D	D	F	F	F	F	F	F	F	F	F	F	U	22	D	F	F	F	F	F	F	F	F	F	F	F	U	U	23	D	D	F	F	F	F	F	F	F	F	F	F	U	U	24	D	D	D	F	F	F	F	F	F	F	F	F	U	U	25	D	F	F	F	F	F	F	F	F	F	F	U	U	U	26	D	D	F	F	F	F	F	F	F	F	F	U	U	U	27	D	D	D	F	F	F	F	F	F	F	F	U	U	U	28	D	D	D	D	D	D	D	D	D	D	D	D	F	U	29	D	D	D	D	D	D	D	D	D	D	D	D	F	U	30	D	D	D	D	D	D	D	D	D	D	F	F	F	U	31	D	D	D	D	D	D	D	D	D	D	D	F	U	U	32	D	D	D	D	D	D	D	D	D	D	F	F	U	U	33	D	D	D	D	D	D	D	D	D	F	F	F	U	U	34	D	F	U	U	U	U	U	U	U	U	U	U	U	U	35	D	D	F	U	U	U	U	U	U	U	U	U	U	U	36	D	D	D	F	U	U	U	U	U	U	U	U	U	U	37	D	F	F	U	U	U	U	U	U	U	U	U	U	U	38	D	D	F	F	U	U	U	U	U	U	U	U	U	U	39	D	D	D	F	F	U	U	U	U	U	U	U	U	U	40	D	F	F	F	U	U	U	U	U	U	U	U	U	U	41	D	D	F	F	F	U	U	U	U	U	U	U	U	U	42	D	D	D	F	F	F	U	U	U	U	U	U	U	U	43	D	D	D	D	D	D	D	D	F	F	F	F	U	U	44	D	D	D	D	D	D	F	F	F	F	F	F	U	U	45	D	D	D	D	D	D	F	F	U	U	U	U	U	U	46	D	D	D	D	D	F	U	D	D	D	D	D	F	U	47	D	D	F	U	U	U	U	D	D	F	U	U	U	U	48	D	F	U	U	U	U	U	D	F	U	U	U	U	U	49	D	D	D	D	F	F	U	D	D	D	D	F	F	U	50	D	D	F	F	U	U	U	D	D	F	F	U	U	U	51	D	F	F	U	U	U	U	D	F	F	U	U	U	U	52	D	F	F	F	F	F	U	D	F	F	F	F	U	U	53	D	D	F	F	F	F	U	D	D	F	F	F	U	U	54	F	F	F	F	F	F	F	D	D	D	D	D	D	D	55	D	D	F	F	F	U	U	U	D	D	D	D	D	D	56 – 254	Reserved														255	UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats													
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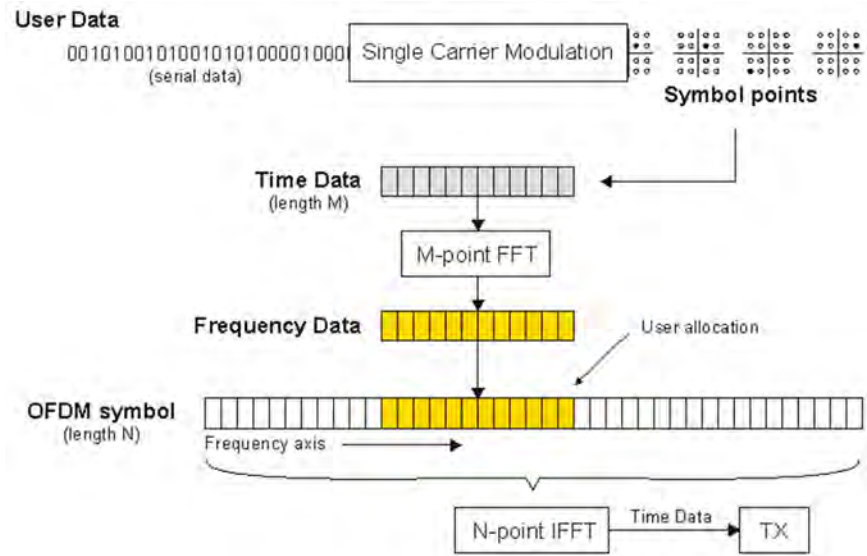
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		LTE uplink subframes 2-3 Bandwidth: 5 MHz = 300 subcarriers = 25 RB Normal CP, PUCCH Type 2, 15 kHz subcarrier spacing Subcarrier 149, RB 24 RB 20 ... Subcarrier -150, RB 0 Slot 4 Slot 5 Slot 6 Slot 7 Subframe 2 Subframe 3 Legend: - PUSCH allocation (User 1) - PUCCH allocation (User 2) - PUSCH or PUCCH DMRS - PUSCH allocation (Other users) - S-RS allocation (User 3) - PRACH allocation (User 4) <i>See also, Dahlman LTE/LTE-Advanced for Mobile Broadband, page 136 (showing the basic structure of LTE frames, including multiple uplink subframes in both TDD and FDD):</i> One radio frame, $T_{\text{frame}} = 10 \text{ ms}$ One subframe, $T_{\text{subframe}} = 1 \text{ ms}$ FDD UL DL f_{UL} f_{DL} TDD Subframe #0 #1 #2 #3 #4 #5 #6 #7 #8 #9 (special subframe) (special subframe) DwPTS GP UpPTS $f_{\text{DL/UL}}$ FIGURE 9.9 Uplink/downlink time-frequency structure for FDD and TDD.

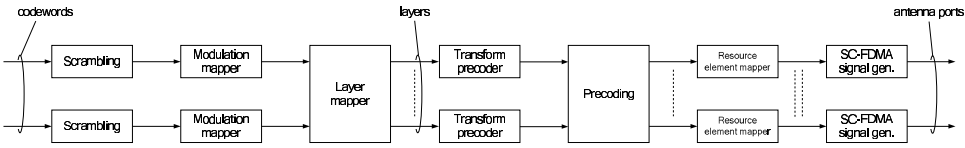
	Claim Language	Infringement Contentions
		As illustrated in the following figure, the receive streams from multiple UEs are separated into separate receive chains, each of which is separately demodulated:  FIGURE 1: Block diagram of an uplink multiuser MIMO wireless system with an M-antenna BS and K mobile users each with N antennas. See Hu , Yang: “<i>Combined Transceiver Optimization for Uplink Multiuser MIMO with Limited CSI</i>”, ISRN Signal Processing Volume 2011, Article ID 735695. <i>See also</i> Ahmadi, 5G NR (“For the 5G mmWave fixed wireless applications, requirements for massive MIMO and beamforming mean that transmit and receive functions will most likely be in distributed array formats. As a result, there will be multiple transmit/receive chains to accomplish transceiver functionality for fixed/mobile wireless devices.”). As discussed further below in the context of Claim 5, element 5.3, and the claims that depend on Claim 5, controllers in T-Mobile’s 4G and 5G base stations utilize information received from the demodulators to determine, among other things, resources and settings to allocate to UEs. The controllers then communicate information regarding those resources and settings to the demodulators. To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
1.3	wherein the at least the second subscriber station comprises a plurality of	T-Mobile’s 4G and 5G base stations receive data signals from at least first and second subscriber stations, wherein the at least the second subscriber station comprises a plurality of subscriber stations. For example and without limitation, each T-Mobile 4G and 5G base station will receive uplink

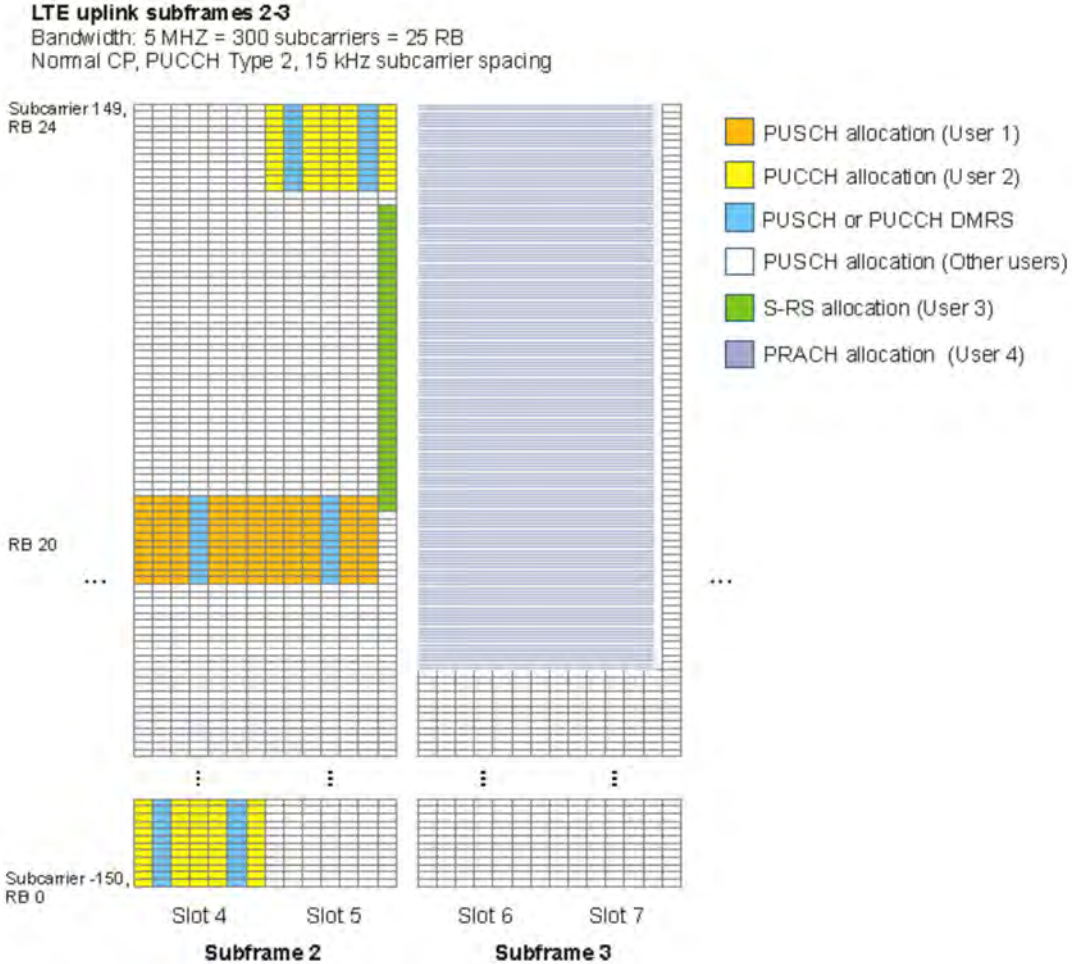
	Claim Language	Infringement Contentions
	subscriber stations and	transmissions from a large number of UEs. <i>See</i> Preamble Contentions, above. Subscriber stations in T-Mobile’s 4G and 5G networks also include fixed wireless access points that connect multiple subscriber stations to a base station. <i>See, e.g.,</i> https://www.t-mobile.com/home-internet (discussing T-Mobile’s fixed wireless offerings); https://www.cnet.com/home/internet/t-mobiles-60-home-internet-service-powered-by-5g-expands-nationwide/ (discussing T-Mobile’s fixed wireless offerings, which utilize both 5G and 4G technology). Subscriber stations in T-Mobile’s 4G and 5G networks also include WiFi hotspots that connect multiple subscriber stations to a base station. <i>See, e.g.,</i> https://www.t-mobile.com/devices/iot/hotspots (listing WiFi hotspot devices available for use on T-Mobile’s network).
1.4	wherein the controller selectively applies the first and second data signals to the first and second demodulators according to a selected pattern by alternately coupling the first demodulator and the second demodulator to receive, selectably, the first and at least second data signals communicated by alternating ones of the plurality of subscriber stations.	T-Mobile’s 4G and 5G base stations include controllers, wherein the controller selectively applies the first and second data signals to the first and second demodulators according to a selected pattern by alternately coupling the first demodulator and the second demodulator to receive, selectably, the first and at least second data signals communicated by alternating ones of the plurality of subscriber stations. For example and without limitation, controllers in T-Mobile’s 4G and 5G base include schedulers responsible for managing and dynamically allocating “radio resources to active users in the downlink and uplink.” Ahmadi 5G NR at 475. <i>See also id.</i> at Section 4.1.3.2.5 (discussing scheduling in 5G); <i>see also id.</i> at Figure 4.26 (illustrating scheduling operations performed by the controller):

	Claim Language	Infringement Contentions
		 Figure 4.26 Illustration of downlink and uplink dynamic and configured scheduling [11]. <i>See also id.</i> at 210 (“The uplink scheduler serves a similar purpose, that is, dynamically controlling the transmission opportunities of the active UEs and efficient sharing of UL-SCH. . . . In general, the ultimate goal of all schedulers is to take advantage of the channel variations experienced by various devices and to schedule the transmissions/receptions to/from each device on the radio resources with advantageous channel conditions in time and frequency domains, that is, channel-dependent scheduling.”). <i>See also</i> Dahlman 4G at Section 6.2.2 (discussing uplink scheduling in 4G LTE); <i>id.</i> at 133 (“The uplink scheduler serves a similar purpose, namely to (dynamically) control which terminals are to transmit on their respective UL-SCH and on which uplink time–frequency resources (including component carrier).”); <i>id.</i> “[T]he overall goal of most schedulers is to take advantage of the channel variations between terminals and preferably schedule transmissions to a terminal on resources with advantageous channel conditions. A benefit of the use of OFDM in LTE is the possibility to exploit channel variations in both time and frequency domains through channel-dependent scheduling.”); <i>id.</i> at Section 10.4.3 (discussing the role of the PDCCH/DCI in uplink scheduling); <i>id.</i> at Section 10.4.7 (discussing uplink scheduling grants); <i>id.</i> at Section 13.2 (discussing uplink scheduling in LTE).

	Claim Language	Infringement Contentions
		Controllers in T-Mobile’s 4G and 5G base stations utilize uplink scheduling to determine the selected pattern with which the controller selectively applies the first and second data signals to the first and second demodulators. For example, and without limitation, after resource de-mapping, 5G base stations dynamically apply the first data signals to a first demodulator and second data signals to a second demodulator for additional processing, as shown on the right side of the following figure in Ahmadi: New Radio Access Physical Layer Aspects (Part 2) 591  Figure 4.72 Overall uplink physical layer processing [5]. See also Dahlman 5G at 63 (“NR does not include cell-specific reference signals but solely relies on user-specific demodulation reference signals for channel estimation”); <i>id.</i> at 349 (“spatial separation is typically enabled by using different demodulation reference signals (DM-RS) for the different transmissions, allowing the network to estimate the channel from each device separately...”). See also

	Claim Language	Infringement Contentions
		Ahmadi at 415 (NR “exclusively relies on user-specific demodulation reference signals (DM-RSs) for channel estimation”); <i>id.</i> at 719 (“The baseband modems utilize digital signal processing to perform channel coding and complex-valued modulation and demodulation in order to transmit extremely high data rate streams over RF carriers in mmWave band. . . . The baseband modulation schemes, generating complex-valued symbols, range from BPSK, QPSK, 16QAM and up to 256QAM (or higher) for high-performance systems.”); <i>id.</i> at Introduction, page xc (noting that 5G communications will utilize “multiple transmit/receive chains to accomplish transceiver functionality”); <i>id.</i> at 365-66 (“In orthogonal MA schemes, the same MCS is selected over all subbands allocated to a single user. Therefore, the average signal-to-interference plus noise power ratio over all allocated subbands is used for MCS selection.”). <i>See also</i> https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (depicting a simplified view of some of the steps involved in modulating an uplink LTE signal for a single UE; demodulation would involve the same basic steps in reverse order):  The diagram illustrates the LTE uplink modulation process. It begins with 'User Data' represented as a sequence of bits: 0010100101001010100001000. This data is processed by 'Single Carrier Modulation' to produce 'Symbol points', shown as a grid of points. The 'Symbol points' are then converted into 'Time Data (length M)', represented as a horizontal bar. This 'Time Data' undergoes an 'M-point FFT' to become 'Frequency Data', shown as a horizontal bar. The 'Frequency Data' is then mapped to an 'OFDM symbol (length N)' on a 'Frequency axis'. A portion of the OFDM symbol is highlighted in yellow and labeled 'User allocation'. Finally, the OFDM symbol is processed by an 'N-point IFFT' to produce 'Time Data', which is then transmitted ('TX'). <i>See also</i> 3GPP TS 36.211v14.15.0 (2020-09) (depicting some of the steps involved in uplink transmissions in LTE; these steps are performed in reverse by the base station when decoding and demodulating the received transmission):

	Claim Language	Infringement Contentions
		3GPP TS 36.211 version 14.15.0 Release 14 23 ETSI TS 136 211 V14.15.0 (2020-09) 5.3 Physical uplink shared channel The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - mapping of the complex-valued modulation symbols onto one or several transmission layers - transform precoding to generate complex-valued symbols - precoding of the complex-valued symbols - mapping of precoded complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  Figure 5.3-1: Overview of uplink physical channel processing Controllers in T-Mobile's 4G and 5G base stations alternately couple the first demodulator and the second demodulator to receive, selectably, the first and at least second data signals communicated by alternating ones of the plurality of subscriber stations. For example and without limitation, the following figure depicts an example of LTE uplink schedule for multiple UEs. When processing uplink signals, controllers in T-Mobile's 4G and 5G base stations alternately couple the first demodulator to receive the first data signals communicated by a first subscriber station and the second demodulator to receive second data signals communicated by a second subscriber station.:

	Claim Language	Infringement Contentions
		LTE uplink subframes 2-3 Bandwidth: 5 MHz = 300 subcarriers = 25 RB Normal CP, PUCCH Type 2, 15 kHz subcarrier spacing  Subcarrier 149, RB 24 RB 20 ... Subcarrier -150, RB 0 Slot 4 Slot 5 Slot 6 Slot 7 Subframe 2 Subframe 3 Legend: - PUSCH allocation (User 1) - PUCCH allocation (User 2) - PUSCH or PUCCH DMRS - PUSCH allocation (Other users) - S-RS allocation (User 3) - PRACH allocation (User 4) https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm Uplink scheduling in 5G is structured similarly.

	Claim Language	Infringement Contentions																												
		One Subframe The diagram illustrates the 5G Resource Grid structure. It shows a grid of Resource Elements (REs) organized into Resource Blocks (RBs). The total number of subcarriers is $N_{RB}^{\mu} \cdot N_{SC}^{RB}$, and the number of subcarriers per RB is $N_{SC}^{RB} = 12$. The grid is indexed by k (horizontal) and ℓ (vertical). A specific Resource Block is highlighted in red, and a Resource Element within it is highlighted in blue. The diagram also shows the mapping of the Resource Grid to the Slot configuration table. $k = N_{RB}^{\mu} \cdot N_{SC}^{RB} - 1$ Resource Block Resource Element (k, ℓ) in Resource Grid (k, ℓ) in Resource Block $N_{RB}^{\mu} \cdot N_{SC}^{RB}$ subcarriers $N_{SC}^{RB} = 12$ subcarriers $k = 0$ $\ell = 0$ $\ell = 14 \cdot 2^{\mu} - 1$ < 38.211-Table 4.2.2-1 > <table><thead><tr><th>μ</th><th colspan="2">Slot configuration 0</th><th></th></tr><tr><th></th><th>N_{symb}^{μ}</th><th>$N_{\text{slots,frame}}^{\mu}$</th><th>$\ell = 14 \cdot 2^{\mu} - 1$</th></tr></thead><tbody><tr><td>0</td><td>14</td><td>10</td><td>13</td></tr><tr><td>1</td><td>14</td><td>20</td><td>27</td></tr><tr><td>2</td><td>14</td><td>40</td><td>55</td></tr><tr><td>3</td><td>14</td><td>80</td><td>111</td></tr><tr><td>4</td><td>14</td><td>160</td><td>223</td></tr></tbody></table>	μ	Slot configuration 0				N_{symb}^{μ}	$N_{\text{slots,frame}}^{\mu}$	$\ell = 14 \cdot 2^{\mu} - 1$	0	14	10	13	1	14	20	27	2	14	40	55	3	14	80	111	4	14	160	223
μ	Slot configuration 0																													
	N_{symb}^{μ}	$N_{\text{slots,frame}}^{\mu}$	$\ell = 14 \cdot 2^{\mu} - 1$																											
0	14	10	13																											
1	14	20	27																											
2	14	40	55																											
3	14	80	111																											
4	14	160	223																											
		See: https://www.sharetechnote.com/html/5G/5G_FrameStructure.html. See also 3GPP TS 38.213v16.11.00 pg 136 – Table 11.1.1-1 (depicting 5G frame formats including one or more uplink symbols allowing a base station to receive successive transmissions from multiple UEs in a single frame and across multiple frames, and selectively apply the transmissions to multiple demodulators according to a selected pattern):																												

See: https://www.sharetechnote.com/html/5G/5G_FrameStructure.html.

See also 3GPP TS 38.213v16.11.00 pg 136 – Table 11.1.1-1 (depicting 5G frame formats including one or more uplink symbols allowing a base station to receive successive transmissions from multiple UEs in a single frame and across multiple frames, and selectively apply the transmissions to multiple demodulators according to a selected pattern):

Claim Language	Infringement Contentions																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
	3GPP TS 38.213 version 16.11.0 Release 16136ETSI TS 138 213 V16.11.0 (2022-09) Table 11.1.1-1: Slot formats for normal cyclic prefix <table><tr><th>Format</th><th colspan="14">Symbol number in a slot</th></tr><tr><th></th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th></tr><tr><td>0</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr><tr><td>1</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>2</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>3</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>4</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td></tr><tr><td>5</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td></tr><tr><td>6</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>7</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>8</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>9</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>10</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>11</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>12</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>13</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>14</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>15</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>16</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>17</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>18</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>19</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>20</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>21</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>22</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>23</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>24</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>25</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>26</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>27</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>28</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td><td>U</td></tr><tr><td>29</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>U</td></tr><tr><td>30</td><td>D</td><td>D</td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– 254</td><td colspan="14">Reserved</td></tr><tr><td>255</td><td colspan="14">UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats</td></tr></table> ETSI Uplink scheduling, including the identification of uplink resources and parameters, is assigned by the base station controller for each UE, using the PDCCH. See, e.g., 3GPP TS 38.300v16.12.0 pg 29:	Format	Symbol number in a slot															0	1	2	3	4	5	6	7	8	9	10	11	12	13	0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	2	F	F	F	F	F	F	F	F	F	F	F	F	F	F	3	D	D	D	D	D	D	D	D	D	D	D	D	D	F	4	D	D	D	D	D	D	D	D	D	D	D	D	F	F	5	D	D	D	D	D	D	D	D	D	D	D	F	F	F	6	D	D	D	D	D	D	D	D	D	D	F	F	F	F	7	D	D	D	D	D	D	D	D	D	F	F	F	F	F	8	F	F	F	F	F	F	F	F	F	F	F	F	F	U	9	F	F	F	F	F	F	F	F	F	F	F	F	U	U	10	F	U	U	U	U	U	U	U	U	U	U	U	U	U	11	F	F	U	U	U	U	U	U	U	U	U	U	U	U	12	F	F	F	U	U	U	U	U	U	U	U	U	U	U	13	F	F	F	F	U	U	U	U	U	U	U	U	U	U	14	F	F	F	F	F	U	U	U	U	U	U	U	U	U	15	F	F	F	F	F	U	U	U	U	U	U	U	U	U	16	D	F	F	F	F	F	F	F	F	F	F	F	F	F	17	D	D	F	F	F	F	F	F	F	F	F	F	F	F	18	D	D	D	F	F	F	F	F	F	F	F	F	F	F	19	D	F	F	F	F	F	F	F	F	F	F	F	F	U	20	D	D	F	F	F	F	F	F	F	F	F	F	F	U	21	D	D	D	F	F	F	F	F	F	F	F	F	F	U	22	D	F	F	F	F	F	F	F	F	F	F	F	U	U	23	D	D	F	F	F	F	F	F	F	F	F	F	U	U	24	D	D	D	F	F	F	F	F	F	F	F	F	U	U	25	D	F	F	F	F	F	F	F	F	F	F	U	U	U	26	D	D	F	F	F	F	F	F	F	F	F	U	U	U	27	D	D	D	F	F	F	F	F	F	F	F	U	U	U	28	D	D	D	D	D	D	D	D	D	D	D	F	U	U	29	D	D	D	D	D	D	D	D	D	D	D	F	F	U	30	D	D	D	D	D	D	D	D	D	D	F	F	F	U	31	D	D	D	D	D	D	D	D	D	D	D	F	U	U	32	D	D	D	D	D	D	D	D	D	D	F	F	U	U	33	D	D	D	D	D	D	D	D	D	D	F	F	U	U	34	D	F	U	U	U	U	U	U	U	U	U	U	U	U	35	D	D	F	U	U	U	U	U	U	U	U	U	U	U	36	D	D	D	F	U	U	U	U	U	U	U	U	U	U	37	D	F	F	U	U	U	U	U	U	U	U	U	U	U	38	D	D	F	F	U	U	U	U	U	U	U	U	U	U	39	D	D	D	F	F	U	U	U	U	U	U	U	U	U	40	D	F	F	F	U	U	U	U	U	U	U	U	U	U	41	D	D	F	F	F	U	U	U	U	U	U	U	U	U	42	D	D	D	F	F	F	U	U	U	U	U	U	U	U	43	D	D	D	D	D	D	D	D	D	F	F	F	F	U	44	D	D	D	D	D	D	F	F	F	F	F	F	U	U	45	D	D	D	D	D	D	F	F	U	U	U	U	U	U	46	D	D	D	D	D	F	U	D	D	D	D	D	F	U	47	D	D	F	U	U	U	U	D	D	F	U	U	U	U	48	D	F	U	U	U	U	U	D	F	U	U	U	U	U	49	D	D	D	D	F	F	U	D	D	D	D	F	F	U	50	D	D	F	F	U	U	U	D	D	F	F	U	U	U	51	D	F	F	U	U	U	U	D	F	F	U	U	U	U	52	D	F	F	F	F	F	U	D	F	F	F	F	F	U	53	D	D	F	F	F	F	U	D	D	F	F	F	F	U	54	F	F	F	F	F	F	F	D	D	D	D	D	D	D	55	D	D	F	F	F	F	U	U	D	D	D	D	D	D	56 – 254	Reserved														255	UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats													
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255	UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				

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		5.2.3 Physical downlink control channels The Physical Downlink Control Channel (PDCCH) can be used to schedule DL transmissions on PDSCH and UL transmissions on PUSCH, where the Downlink Control Information (DCI) on PDCCH includes: - Downlink assignments containing at least modulation and coding format, resource allocation, and hybrid-ARQ information related to DL-SCH; - Uplink scheduling grants containing at least modulation and coding format, resource allocation, and hybrid-ARQ information related to UL-SCH. In addition to scheduling, PDCCH can be used to for - Activation and deactivation of configured PUSCH transmission with configured grant; - Activation and deactivation of PDSCH semi-persistent transmission; - Notifying one or more UEs of the slot format; - Notifying one or more UEs of the PRB(s) and OFDM symbol(s) where the UE may assume no transmission is intended for the UE; - Transmission of TPC commands for PUCCH and PUSCH; - Transmission of one or more TPC commands for SRS transmissions by one or more UEs; - Switching a UE's active bandwidth part; - Initiating a random access procedure; - Indicating the UE(s) to monitor the PDCCH during the next occurrence of the DRX on-duration; - In IAB context, indicating the availability for soft symbols of an IAB-DU; - Triggering one shot HARQ-ACK codebook feedback; - For operation with shared spectrum channel access: - Triggering search space set group switching; - Indicating one or more UEs about the available RB sets and channel occupancy time duration; - Indicating downlink feedback information for configured grant PUSCH (CG-DFI). A UE monitors a set of PDCCH candidates in the configured monitoring occasions in one or more configured Control Resource SETs (CORESETs) according to the corresponding search space configurations. The base station controller “may assign resources taking into account the radio conditions at the UE identified through measurements made at the gNB and/or reported by the UE. <i>See, e.g. id.</i> at page 96:

	Claim Language	Infringement Contentions
		10 Scheduling 10.1 Basic Scheduler Operation In order to utilise radio resources efficiently, MAC in gNB includes dynamic resource schedulers that allocate physical layer resources for the downlink and the uplink. In this clause, an overview of the scheduler is given in terms of scheduler operation, signalling of scheduler decisions, and measurements. Scheduler Operation: - Taking into account the UE buffer status and the QoS requirements of each UE and associated radio bearers, schedulers assign resources between UEs; - Schedulers may assign resources taking account the radio conditions at the UE identified through measurements made at the gNB and/or reported by the UE; - Resource assignment consists of radio resources (resource blocks). Signalling of Scheduler Decisions: - UEs identify the resources by receiving a scheduling (resource assignment) channel. Measurements to Support Scheduler Operation: - Uplink buffer status reports (measuring the data that is buffered in the logical channel queues in the UE) are used to provide support for QoS-aware packet scheduling; - Power headroom reports (measuring the difference between the nominal UE maximum transmit power and the estimated power for uplink transmission) are used to provide support for power aware packet scheduling. <i>See also</i>, Ahmadi 5G NR at 210 (discussing the dynamic scheduling of groups of UEs in 5G): In order to efficiently utilize the radio resources, the MAC sublayer in gNB includes schedulers that allocate radio resources in the downlink/uplink to the active users in the cell. The default mode of operation of a gNB scheduler is dynamic scheduling, in which the gNB makes scheduling decisions, typically once per slot, and sends the scheduling information to a group of devices. While slot-based scheduling is a common practice, neither the scheduling decisions, nor the actual data transmission are required to start or end at the slot boundaries, which is important for low-latency applications and unlicensed spectrum operation. The downlink/uplink scheduling are independent and scheduling decisions can be independently made. <i>See also id.</i> at 212 (discussing dynamic scheduling of multiple UEs' uplink transmissions and retransmissions):

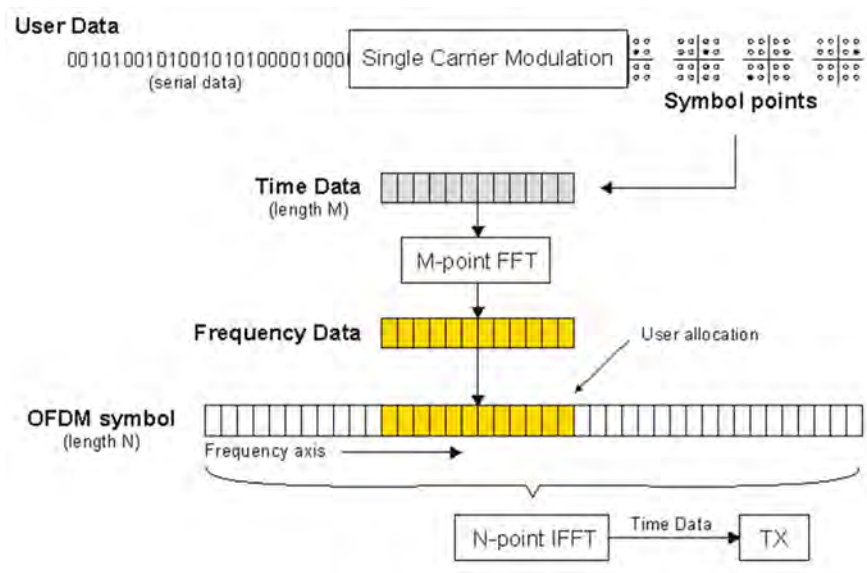
	Claim Language	Infringement Contentions
		In the uplink, the gNB can dynamically allocate resources to the active UEs and identify them by their C-RNTI on PDCCH(s). A UE always monitors the PDCCH(s) in order to find possible grants for uplink transmission according to its configured DRX cycles. When carrier aggregation is configured, the same C-RNTI applies to all serving cells. In addition, the gNB can allocate uplink resources for the initial HARQ transmissions to the UEs with the configured grants (alternatively known as semi-persistent scheduling). Two types of configured uplink grants are specified in NR. In Type 1 configured grant the RRC signaling directly provides the configured uplink grant (including the periodicity), whereas in Type 2 configured grant, the RRC signaling defines the periodicity of the configured uplink grant, while PDCCH addressed to CS-RNTI can either signal and activate the configured uplink grant or deactivate it. Therefore, a PDCCH addressed to CS-RNTI indicates that the uplink grant can be implicitly reused according to the periodicity defined through RRC signaling until it is deactivated. The dynamically allocated uplink transmission overrides the configured uplink grant in the same serving cell, if they overlap in time. The retransmissions other than repetitions are required to be explicitly allocated via PDCCH(s) [8]. If carrier aggregation or bandwidth adaptation is configured, one configured uplink grant can be signaled per serving cell or per BWP, respectively. In each serving cell, there is only one active configured uplink grant at a time. A configured grant for a serving cell in the uplink can either be Type 1 or Type 2. The activation and deactivation of configured grants for the uplink are independent among the serving cells for Type 2. In the case of supplemental uplink (SUL), a configured grant can only be signaled for one of the two uplink carriers of the cell [8]. <i>See also id.</i> at 397 (discussing dynamic allocation of resources in 5G): The resource allocation in NR is defined both in time domain and frequency domain. Unlike LTE where the resource allocation in time domain was determined based on a fixed/ predefined rule, in NR the resource allocation in time domain is more flexible, whereas the resource allocation in frequency domain is relatively similar to that of LTE [30]. Resource allocation type specifies the way in which the scheduler allocates physical resource blocks in frequency domain to each user for transmission in the downlink or uplink. <i>See also id.</i> at Introduction, page xc (noting that 5G communications will utilize “multiple transmit/receive chains to accomplish transceiver functionality”); <i>id.</i> at 365-66 (“In orthogonal MA schemes, the same MCS is selected over all subbands allocated to a single user. Therefore, the average signal-to-interference plus noise power ratio over all allocated subbands is used for MCS selection.”). Base stations utilize a variety of methods for dynamically determining the modulation, coding, resource allocation, beamforming, MIMO, and other settings used for each UE. For example, and without limitation, <i>see</i> Ahmadi 5G NR at 416 (discussing use of UE-specific CSI):

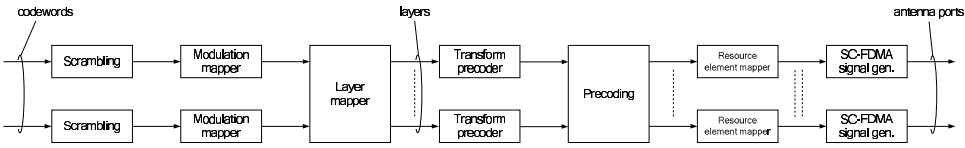
	Claim Language	Infringement Contentions
		UE-specific CSI-RS can be used for estimation of CSI to allow CSI measurement and reporting which assists the gNB in modulation coding scheme (MCS) selection, resource allocation, beamforming, and MIMO rank selection. The CSI-RS can be configured for periodic, aperiodic, or semi-persistent transmission with a configurable density by the gNB. The CSI-RS also can be used for interference measurement (IM) and fine frequency/time tracking purposes. Specific instances of CSI-RS can be configured for time/frequency tracking and mobility measurements. In the absence of the cell-specific reference signals in NR the CSI-RS can be used for radio resource management, measurements and mobility management purposes in connected mode. <i>See also id.</i> at 4.1.7.5 (discussing modulation schemes and MCS determination); Dahlman 5G at Section 10.2 (discussing uplink scheduling and MCS, as it relates to both the PUCCH and PUSCH, which is controlled in advance by the base station, and noting that PUCCH and PUSCH are typically transmitted successively). To the extent that T-Mobile's 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
2	The apparatus of claim 1 wherein the wireless communication system comprises a fixed wireless access system, wherein the communication station comprises a base station of the fixed wireless access system in which the data signals transmitted thereto by the first subscriber station comprise first uplink burst data signals and the data signals transmitted thereto by the second subscriber station comprise second uplink burst data signals, the first demodulator embodied at a first modem.	As discussed above, T-Mobile's 4G and 5G base stations are the apparatuses of Claim 1. In addition, T-Mobile's 4G and 5G base stations are apparatuses for a communication station operable in a wireless communication system wherein the wireless communication system comprises a fixed wireless access system, wherein the communication station comprises a base station of the fixed wireless access system in which the data signals transmitted thereto by the first subscriber station comprise first uplink burst data signals and the data signals transmitted thereto by the second subscriber station comprise second uplink burst data signals, the first demodulator embodied at a first modem. For example, and without limitation, T-Mobile's 4G and 5G base stations are part of a wireless communication system that comprises a fixed wireless access system, wherein the communication station comprises a base station of the fixed wireless access system. In addition to serving mobile subscriber's, T-Mobile's base stations serve fixed wireless subscribers. <i>See, e.g.</i>, https://www.t-mobile.com/home-internet (discussing T-Mobile's fixed wireless offerings); https://www.cnet.com/home/internet/t-mobiles-60-home-internet-service-powered-by-5g-expands-nationwide/ (discussing T-Mobile's fixed wireless offerings, which utilize both 5G and 4G technology). In addition, the data signals transmitted thereto by the first subscriber station comprise first uplink burst data signals and the data signals transmitted thereto by the second subscriber station comprise second uplink burst data signals. For example, and without limitation, UEs sending uplink signals to T-Mobile's 4G and 5G base stations utilize burst data signaling. <i>See, e.g.</i>, Ahmadi 5G at 256 (discussing the "bursty" nature of 5G transmissions); <i>id.</i> at 728 (noting that 5G's "effective doubling of the uplink data rate

	Claim Language	Infringement Contentions
		enables shorter uplink bursts”); Dahlman 5G at 72 (“[g]iven the bursty nature of most data traffic...”); <i>id.</i> at 137 (noting that “it is beneficial to avoid placing interference-sensitive signals at the start of an uplink burst”); <i>id.</i> at Section 19.5 (discussing uplink data transmission in 5G, including scheduling of slots and mini-slot for various bursts of uplink data transmission). Subscriber stations transmit data to T-Mobile’s 4G and 5G base stations in “packets.” <i>Id.</i> at Introduction, liv – lv (discussing packet transmissions in 3GPP). Packet data traffic is transmitted in bursts. <i>See, e.g.</i>, Dahlman 4G at 335 (noting that “[p]acket-data traffic is often highly bursty”); <i>see also</i> Ahmadi, 5G NR at Introduction, liv – lv (discussing the “transmission time intervals” in 3GPP, and noting that “data on a transport channel is organized into transport blocks”). In addition, the first demodulator in T-Mobile’s 4G and 5G base stations is embodied at a first modem. <i>See, e.g.</i>, Ahmadi 5G NR at 719 (“baseband modems utilize digital signal processing to perform channel coding and complex-valued modulation and demodulation”); https://www.eetimes.com/practical-implications-of-lte-on-mobile-baseband-architecture-implementations/ (discussing LTE baseband modems, which perform demodulation on uplink data burst transmissions). The modem in T-Mobile’s 4G and 5G baseband units performs demodulation on uplink data bursts. For example and without limitation, the modems in the Ericsson Baseband 6648 are located within one or more of 5 processing components shown below (including an Intel Atom processor, an STMicro Arm processor, two Ericsson SoCs, and an Altera Cyclone V FPGA):

	Claim Language	Infringement Contentions
		 Similar modems are included in all of T-Mobile's 4G and 5G base stations.
3	The apparatus of claim 2 wherein the second demodulator is embodied at a second modem.	As discussed above, T-Mobile's 4G and 5G base stations comprise the apparatus of Claim 2. In addition, T-Mobile's 4G and 5G base stations comprise a second demodulator embodied at a second modem. For example and without limitation, Figure 4.72 in Ahmadi depicts some of the “uplink physical layer processing” in 5G. The right side of the figure shows the steps performed by the station, including layer demapping, demodulation, de-scrambling, de-interleaving, channel decoding, and HARQ buffering of data signals transmitted to the communication station:

	Claim Language	Infringement Contentions
		New Radio Access Physical Layer Aspects (Part 2) 591 Figure 4.72 Overall uplink physical layer processing [5]. As discussed above, T-Mobile’s 5G base stations utilize a modem to perform the demodulation shown above. After resource de-mapping, data from one UE will be sent to a first modem and data from a second UE will be sent to a different modem. <i>See, e.g.,</i> Dahlman 5G at 63 (“NR does not include cell-specific reference signals but solely relies on user-specific demodulation reference signals for channel estimation”); <i>id.</i> at 349 (“spatial separation is typically enabled by using different demodulation reference signals (DM-RS) for the different transmissions, allowing the network to estimate the channel from each device separately...”). <i>See also</i> Ahmadi at 415 (NR “exclusively relies on user-specific demodulation reference signals (DM-RSs) for channel estimation”); <i>id.</i> at 719 (“The baseband modems utilize digital signal processing to perform channel coding and complex-valued modulation and demodulation in order to transmit extremely high data rate streams over RF carriers in mmWave band. . . . The baseband modulation schemes, generating

	Claim Language	Infringement Contentions
		complex-valued symbols, range from BPSK, QPSK, 16QAM and up to 256QAM (or higher) for high-performance systems.”); <i>id.</i> at Introduction, page xc (noting that 5G communications will utilize “multiple transmit/receive chains to accomplish transceiver functionality”); <i>id.</i> at 365-66 (“In orthogonal MA schemes, the same MCS is selected over all subbands allocated to a single user. Therefore, the average signal-to-interference plus noise power ratio over all allocated subbands is used for MCS selection.”). T-Mobile’s 4G base stations similarly include multiple demodulators embodied in multiple modems. <i>See, e.g.,</i> https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (depicting a simplified view of some of the steps involved in modulating an LTE signal for a single UE; demodulation would involve the same basic steps in reverse order):  The diagram illustrates the LTE uplink transmission process. It begins with 'User Data' represented as a sequence of bits: 0010100101001010100001000. This data is processed by 'Single Carrier Modulation' to produce 'Symbol points', shown as a grid of points. These symbol points are then mapped to 'Time Data (length M)', represented as a horizontal bar. An 'M-point FFT' is applied to the time data to produce 'Frequency Data', shown as a horizontal bar with yellow segments. A 'User allocation' is indicated by a bracket over a portion of the frequency data. This frequency data is then mapped to an 'OFDM symbol (length N)', shown as a horizontal bar with a 'Frequency axis' indicated by an arrow. Finally, an 'N-point IFFT' is applied to the OFDM symbol to produce 'Time Data', which is then transmitted via 'TX'. <i>See also</i> 3GPP TS 36.211v14.15.0 (2020-09) (depicting some of the steps involved in uplink transmissions in LTE; these steps are performed in reverse by the base station when decoding and demodulating the received transmission):

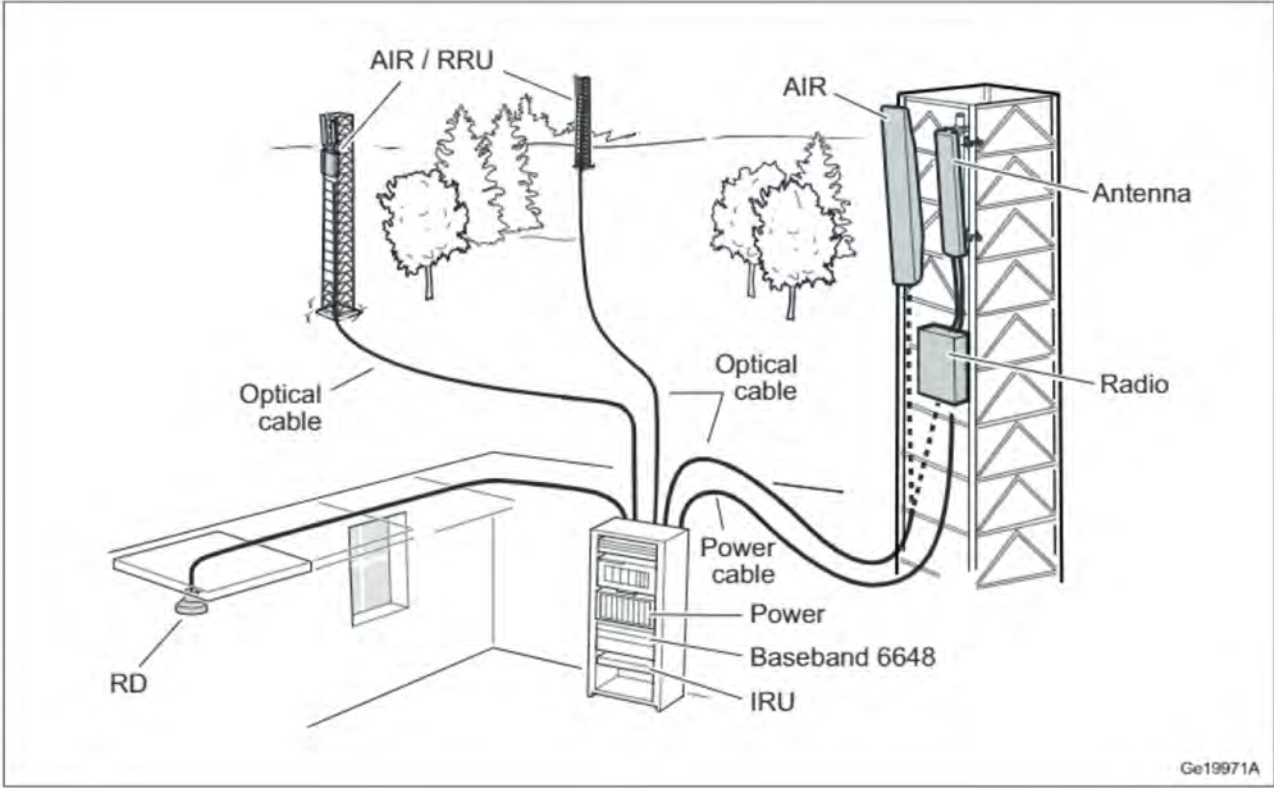
	Claim Language	Infringement Contentions
		3GPP TS 36.211 version 14.15.0 Release 14 23 ETSI TS 136 211 V14.15.0 (2020-09) 5.3 Physical uplink shared channel The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - mapping of the complex-valued modulation symbols onto one or several transmission layers - transform precoding to generate complex-valued symbols - precoding of the complex-valued symbols - mapping of precoded complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  Figure 5.3-1: Overview of uplink physical channel processing <i>See also</i> Ericsson Baseband Description, Baseband 6648, 6641, at 4 (listing “Uplink (UL) baseband processing” and other functions of an Ericsson BBU). <i>See also</i> https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (showing how the physical uplink shared channel (PUSCH) is divided into resource blocks allocated to multiple UEs, requiring multiple receive changes to demodulate the received transmissions):

	Claim Language	Infringement Contentions
		LTE uplink subframes 2-3 Bandwidth: 5 MHz = 300 subcarriers = 25 RB Normal CP, PUCCH Type 2, 15 kHz subcarrier spacing Subcarrier 149, RB 24 RB 20 ... Subcarrier -150, RB 0 Slot 4 Slot 5 Slot 6 Slot 7 Subframe 2 Subframe 3 ■ PUSCH allocation (User 1) ■ PUCCH allocation (User 2) ■ PUSCH or PUCCH DMRS ■ PUSCH allocation (Other users) ■ S-RS allocation (User 3) ■ PRACH allocation (User 4)
4	An apparatus for a communication station operable in a wireless communication system at least to receive first and second data signals successively transmitted thereto by a first subscriber station a second subscriber station, respectively, within a plurality of subscriber stations, the apparatus comprising:	See Contentions for Claim 1, Preamble, above.

	Claim Language	Infringement Contentions
4.1	a first demodulator selectably coupled to receive the first data signals transmitted to the communication station; at least a second demodulator also selectably coupled to receive the second data signals transmitted to the communication station; and	<i>See</i> Contentions for Claim 1, Element 1.1, above.
4.2	a controller, coupled to the first demodulator and to the at least second demodulator in a feedback arrangement, the controller alternately selecting the first data signals for application to the first demodulator and the second data signals for application to the second demodulator,	<i>See</i> Contentions for Claim 1, Element 1.2, above.
4.3	wherein the first and at least second data signals transmitted to the communication station by the first and at least second subscriber stations are transmitted in bursts of selected time durations and wherein the controller further determines times of arrival and time directions of the bursts which form the data signals,	T-Mobile's 4G and 5G base stations receive first and second data signals, wherein the first and at least second data signals transmitted to the communication station by the first and at least second subscriber stations are transmitted in bursts of selected time durations and wherein the controller further determines times of arrival and time directions of the bursts which form the data signals. For example, and without limitation, subscriber stations transmit data signals to the base station in bursts of selected time durations. <i>See, e.g.</i>, Ahmadi 5G at 256 (discussing the “bursty” nature of 5G transmissions); <i>id.</i> at 728 (noting that 5G’s “effective doubling of the uplink data rate enables shorter uplink bursts”); Dahlman 5G at 72 (“[g]iven the bursty nature of most data traffic...”); <i>id.</i> at 137 (noting that “it is beneficial to avoid placing interference-sensitive signals at the start of an uplink burst”); <i>id.</i> at Section 19.5 (discussing uplink data transmission in 5G, including scheduling of slots and mini-slot for various bursts of uplink data transmission); Dahlman 4G at 335 (noting that “[p]acket-data traffic is often highly bursty”). The duration and timing of burst data signals are determined by the base station controller. <i>See, e.g.</i>, Ahmadi, 5G NR, Introduction, liv – lv (discussing packet transmissions in 3GPP); Ahmadi, 5G NR at

	Claim Language	Infringement Contentions
		Introduction, liv – lv (discussing the “transmission time intervals” in 3GPP, and noting that “data on a transport channel is organized into transport blocks”); <i>id.</i> at 93-94 (discussing the organization of data transmissions into “transport blocks” of “dynamic size”); <i>id.</i> at 103 (discussing how transport blocks are organized on both the uplink and downlink). In addition, controllers in T-Mobile’s 4G and 5G base stations determine timing-advance values for each UE as described in Dahlman: The timing-advance value for each device is determined by the network based on measurements on the respective uplink transmissions. Hence, as long as a device carries out uplink data transmission, this can be used by the receiving base station to estimate the uplink receive timing and thus be a source for the timing-advance commands. Sounding reference signals can be used as a regular signal to measure upon, but in principle the base station can use any signal transmitted from the devices. Based on the uplink measurements, the network determines the required timing correction for each device. If the timing of a specific device needs correction, the network issues a timing-advance command for this specific device, instructing it to retard or advance its timing relative to the current uplink timing. The user-specific timing-advance command is transmitted as a MAC control element on the DL-SCH. Typically, Dahlmand 5G at 332. <i>See also</i>, Dahlman 4G at 296-97. In addition, directions of the bursts of the data signals can be detected using reference signals, including SRS and/or DM-RS. Those direction measurements can be used to determine the settings for transmitting in the direction of a subscriber and/or to focus reception of an uplink burst from a subscriber. These measurements can also be updated over time to account, for example, for changes in the location of the subscriber station. <i>See, e.g.</i>, Dahlman 5G at Chapter 11 (discussing multi-antenna transmission, including receiver beamforming). For additional information on beamforming, see the Contentions for Claim 13, below. To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
4.4	wherein the at least the second subscriber station comprises a plurality of subscriber stations and	<i>See</i> Contentions for Claim 1, Element 1.3, above.
4.5	wherein said controller selectively applies the first	<i>See</i> Contentions for Claim 1, Element 1.4, above.

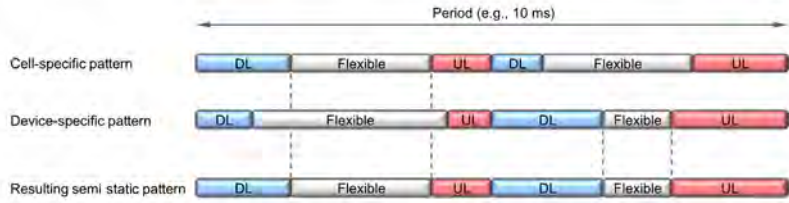
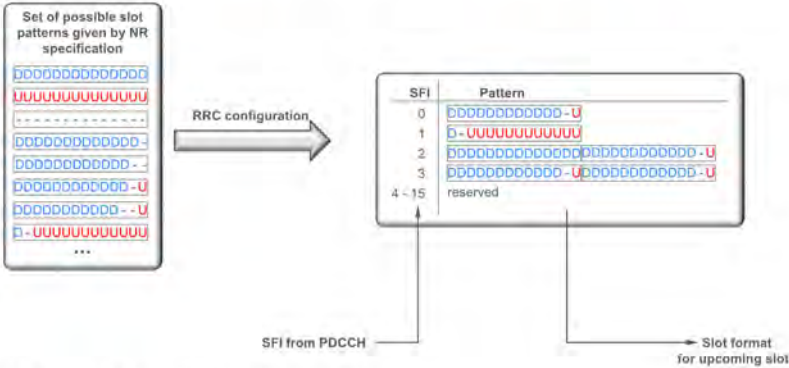
	Claim Language	Infringement Contentions
	and second data signals to the first and second demodulators according to a selected pattern by alternately coupling the first demodulator and the second demodulator to receive, selectably, the first and at least second data signals communicated by alternating ones of the plurality of subscriber stations.	
5	Apparatus for a communication station operable in a wireless communication system at least to receive first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, respectively, within a plurality of subscriber stations, the apparatus comprising:	To the extent that the preamble is limiting, T-Mobile's Accused Products are apparatuses for a communication station operable in a wireless communication system at least to receive first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, respectively, within a plurality of subscriber stations, as described in Claim 5. For example, T-Mobile's 4G and 5G base stations are apparatuses for a communication station operable in a wireless communication system. <i>See, e.g.</i>, https://www.t-mobile.com/coverage/4g-lte-5g-networks (touting the benefits of T-Mobile's 5G network, including that it “covers 325 million Americans nationwide”). <i>See also</i> https://www.t-mobile.com/news/network/americas-leading-wireless-network-tops-competitors-in-new-report (touting the same 325 million figure, and noting T-Mobile's network speed); https://www.t-mobile.com/news/network/tmobile-5g-claims-more-third-party-report-wins (T-Mobile news release regarding “umlaut” report finding that T-Mobile had the fastest uplink speeds in 5G). T-Mobile's 4G and 5G base station equipment is operable to receive first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, respectively, within a plurality of subscriber stations. For example and without limitation, T-Mobile's Accused 4G and 5G base stations include antennas, baseband units, air interface units, radios, and additional hardware and software. For example and without limitation, the following image depicts some of the hardware that may be included in a base station utilizing an Ericsson BBU:

	Claim Language	Infringement Contentions
		 The diagram illustrates a base station architecture. On the left, a Remote Drive (RD) is shown inside a building. It is connected via an optical cable to an Air Interface Radio (AIR) / Remote Radio Unit (RRU) located outdoors. This RRU is further connected via another optical cable to a second AIR, which is also outdoors. The second AIR is connected via a power cable to a Radio Unit (RU) located inside a building. The RU contains a Baseband 6648 and an Integrated Radio Unit (IRU). The RU is also connected to an Antenna. The diagram is labeled with 'Ge19971A' in the bottom right corner. See Ericsson Baseband Description, Baseband 6648, 6641. T-Mobile's 4G and 5G base stations can alternatively utilize equipment from other manufacturers, including but not limited to Samsung, Nokia, Commscope, and others. Regardless of the specific equipment that is deployed, all T-Mobile 4G and 5G base stations are operable to receive first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, within a plurality of subscriber stations. See, e.g., 3GPP TR 38.913 version 16.0.0 Release 16 (antenna arrays):

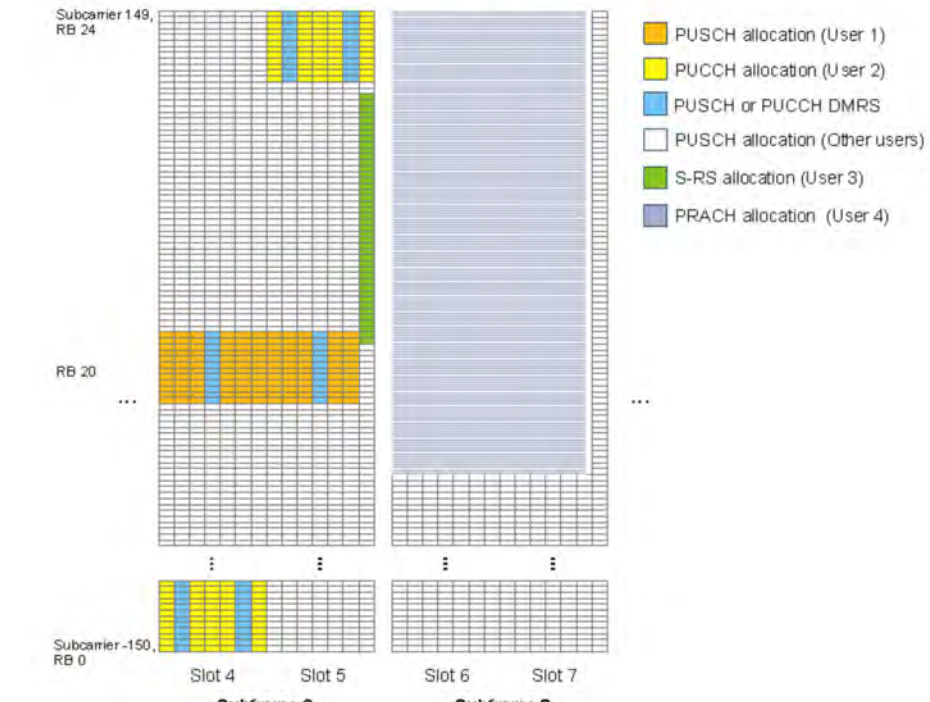
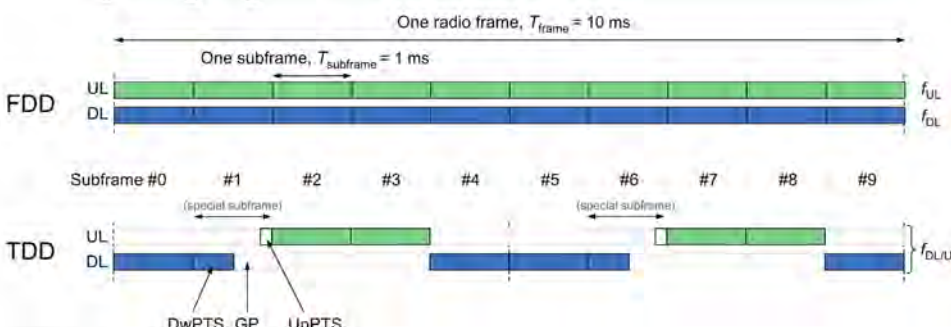
	Claim Language	Infringement Contentions
		3.1 Definitions For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1]. Transmission Reception Point (TRxP): Antenna array with one or more antenna elements available to the network located at a specific geographical location for a specific area. For 5G NR, document “ETSI TR 138 913 V16.0.0” describes requirements for 5G deployment, including §6.1.2, which describes requirements for dense urban deployment, where a large number of UEs will be located in a relatively small geographic area: 6.1.2 Dense urban The dense urban microcellular deployment scenario focuses on macro TRxPs with or without micro TRxPs and high user densities and traffic loads in city centres and dense urban areas. The key characteristics of this deployment scenario are high traffic loads, outdoor and outdoor-to-indoor coverage. This scenario will be interference-limited, using macro TRxPs with or without micro TRxPs. A continuous cellular layout and the associated interference shall be assumed. See 3GPP TR 38.913 version 16.0.0 Release 16 “ETSI TR 138 913 V16.0.0” also defines requirements for rural deployments in §6.1.3, where a base station will cover a large geographic area with numerous UEs: 6.1.3 Rural The rural deployment scenario focuses on larger and continuous coverage. The key characteristics of this scenario are continuous wide area coverage supporting high speed vehicles. This scenario will be noise-limited and/or interference-limited, using macro TRxPs. When a base station antenna receives an uplink signal from a UE, that signal is processed by the antennas, radios, and associated hardware/software, and then sent to the BBU. For example and without limitation, it could be sent to an Ericsson Baseband 6648, like the one depicted below:

	Claim Language	Infringement Contentions
		 The following image depicts the bottom side of the PCB in an Ericsson 6648:

	Claim Language	Infringement Contentions
		 The silver-colored squares near the bottom of the above image depict the ports through which the BBU receives uplink signals processed by the base stations' antennas, radios, and air units. The uplink signals received by T-Mobile's 4G and 5G base stations include first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, within a plurality of subscriber stations. For example and without limitation, a 5G base station will typically receive uplink transmissions from multiple UEs, both within a single frame and across multiple frames. <i>See, e.g.,</i> Dahlman 5G NR at 141 (depicting one example of how slots are structured in a 5G frame):

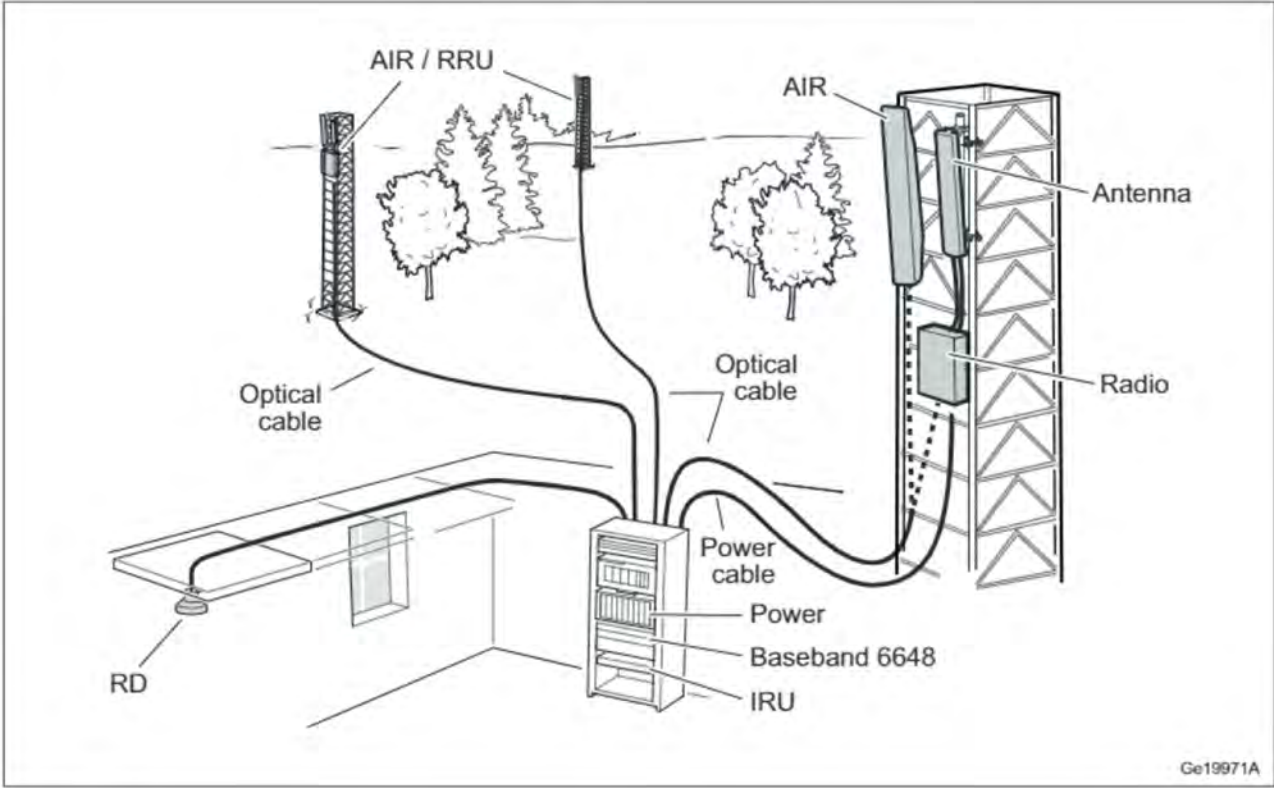
	Claim Language	Infringement Contentions
		 Fig. 7.18 Example of cell-specific and device-specific uplink-downlink patterns.  Fig. 7.19 Example of configuring the SFI table. <i>See also id.</i> at Section 14.2 (discussing uplink scheduling in NR, including scheduling for multiple devices). <i>See also,</i> Ahmadi at 211 (discussing uplink scheduling of multiple UEs across the time domain): The uplink scheduler serves a similar purpose, that is, dynamically controlling the transmission opportunities of the active UEs and efficiently sharing of UL-SCH. The scheduling strategy of a gNB is vendor-dependent and implementation specific and is not specified by 3GPP. In general, the ultimate goal of all schedulers is to take advantage of the channel variations experienced by various devices and to schedule the transmissions/receptions to/from each device on the radio resources with advantageous channel conditions in time and frequency domains, that is, channel-dependent scheduling. <i>See also</i> 3GPP TS 38.213v16.11.00 pg 136 – Table 11.1.1-1 (depicting 5G frame formats including one or more uplink symbols allowing a base station to receive successive transmissions from multiple UEs in a single frame and across multiple frames):

Claim Language	Infringement Contentions																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	3GPP TS 38.213 version 16.11.0 Release 16136ETSI TS 138 213 V16.11.0 (2022-09) Table 11.1.1-1: Slot formats for normal cyclic prefix <table><tr><th>Format</th><th colspan="13">Symbol number in a slot</th></tr><tr><th></th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th></tr><tr><td>0</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr><tr><td>1</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>2</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>3</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>4</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>5</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td></tr><tr><td>6</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>7</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>8</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>9</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>10</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>11</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>12</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>13</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>14</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>15</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>16</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>17</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>18</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>19</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>20</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>21</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>22</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>23</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>24</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>25</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>26</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>27</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>28</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td></tr><tr><td>29</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td></tr><tr><td>30</td><td>D</td><td>D</td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– 254</td><td colspan="13">Reserved</td></tr><tr><td>255</td><td colspan="13">UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats</td></tr></table> ETSI LTE base stations similarly receive uplink transmissions from multiple UEs. <i>See, e.g.,</i> Keysight LTE Physical Layer Overview (https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm) (showing how the physical uplink shared channel (PUSCH) is divided into resource blocks allocated to multiple UEs):	Format	Symbol number in a slot														0	1	2	3	4	5	6	7	8	9	10	11	12	13	0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	2	F	F	F	F	F	F	F	F	F	F	F	F	F	F	3	D	D	D	D	D	D	D	D	D	D	D	D	D	F	4	D	D	D	D	D	D	D	D	D	D	D	D	D	F	5	D	D	D	D	D	D	D	D	D	D	D	F	F	F	6	D	D	D	D	D	D	D	D	D	D	F	F	F	F	7	D	D	D	D	D	D	D	D	D	F	F	F	F	F	8	F	F	F	F	F	F	F	F	F	F	F	F	F	U	9	F	F	F	F	F	F	F	F	F	F	F	F	F	U	10	F	U	U	U	U	U	U	U	U	U	U	U	U	U	11	F	F	U	U	U	U	U	U	U	U	U	U	U	U	12	F	F	F	U	U	U	U	U	U	U	U	U	U	U	13	F	F	F	F	U	U	U	U	U	U	U	U	U	U	14	F	F	F	F	F	U	U	U	U	U	U	U	U	U	15	F	F	F	F	F	F	U	U	U	U	U	U	U	U	16	D	F	F	F	F	F	F	F	F	F	F	F	F	F	17	D	D	F	F	F	F	F	F	F	F	F	F	F	F	18	D	D	D	F	F	F	F	F	F	F	F	F	F	F	19	D	F	F	F	F	F	F	F	F	F	F	F	F	F	20	D	D	F	F	F	F	F	F	F	F	F	F	F	U	21	D	D	D	F	F	F	F	F	F	F	F	F	F	U	22	D	F	F	F	F	F	F	F	F	F	F	F	F	U	23	D	D	F	F	F	F	F	F	F	F	F	F	F	U	24	D	D	D	F	F	F	F	F	F	F	F	F	F	U	25	D	F	F	F	F	F	F	F	F	F	F	U	U	U	26	D	D	F	F	F	F	F	F	F	F	F	U	U	U	27	D	D	D	F	F	F	F	F	F	F	F	U	U	U	28	D	D	D	D	D	D	D	D	D	D	D	D	F	U	29	D	D	D	D	D	D	D	D	D	D	D	D	F	U	30	D	D	D	D	D	D	D	D	D	D	F	F	F	U	31	D	D	D	D	D	D	D	D	D	D	D	F	F	U	32	D	D	D	D	D	D	D	D	D	D	F	F	F	U	33	D	D	D	D	D	D	D	D	D	D	F	F	F	U	34	D	F	U	U	U	U	U	U	U	U	U	U	U	U	35	D	D	F	U	U	U	U	U	U	U	U	U	U	U	36	D	D	D	F	U	U	U	U	U	U	U	U	U	U	37	D	F	F	U	U	U	U	U	U	U	U	U	U	U	38	D	D	F	F	U	U	U	U	U	U	U	U	U	U	39	D	D	D	F	F	U	U	U	U	U	U	U	U	U	40	D	F	F	F	U	U	U	U	U	U	U	U	U	U	41	D	D	F	F	F	U	U	U	U	U	U	U	U	U	42	D	D	D	F	F	F	U	U	U	U	U	U	U	U	43	D	D	D	D	D	D	D	D	D	F	F	F	F	U	44	D	D	D	D	D	D	F	F	F	F	F	F	F	U	45	D	D	D	D	D	D	F	F	U	U	U	U	U	U	46	D	D	D	D	D	F	U	D	D	D	D	D	F	U	47	D	D	F	U	U	U	U	D	D	F	U	U	U	U	48	D	F	U	U	U	U	U	D	F	U	U	U	U	U	49	D	D	D	D	F	F	U	D	D	D	D	F	F	U	50	D	D	F	F	U	U	U	D	D	F	F	U	U	U	51	D	F	F	U	U	U	U	D	F	F	U	U	U	U	52	D	F	F	F	F	F	U	D	F	F	F	F	F	U	53	D	D	F	F	F	F	U	D	D	F	F	F	F	U	54	F	F	F	F	F	F	F	D	D	D	D	D	D	D	55	D	D	F	F	F	U	U	U	D	D	D	D	D	D	56 – 254	Reserved													255	UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats												
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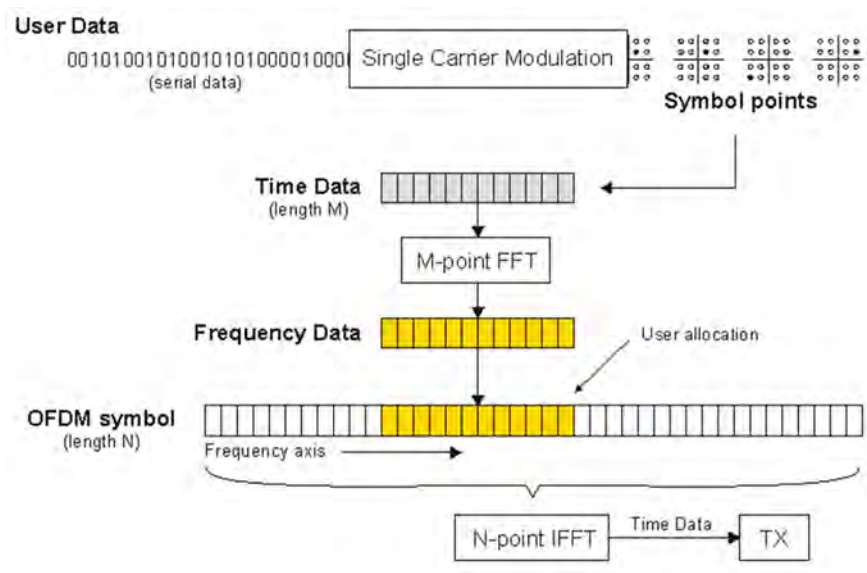
	Claim Language	Infringement Contentions
		LTE uplink subframes 2-3 Bandwidth: 5 MHz = 300 subcarriers = 25 RB Normal CP, PUCCH Type 2, 15 kHz subcarrier spacing  Subcarrier 149, RB 24 RB 20 Subcarrier -150, RB 0 Slot 4 Slot 5 Slot 6 Slot 7 Subframe 2 Subframe 3 Legend: - PUSCH allocation (User 1) - PUCCH allocation (User 2) - PUSCH or PUCCH DMRS - PUSCH allocation (Other users) - S-RS allocation (User 3) - PRACH allocation (User 4) <i>See also, Dahlman LTE/LTE-Advanced for Mobile Broadband, page 136 (showing the basic structure of LTE frames, including multiple uplink subframes in both TDD and FDD):</i>  One radio frame, $T_{\text{frame}} = 10 \text{ ms}$ One subframe, $T_{\text{subframe}} = 1 \text{ ms}$ FDD UL DL f_{UL} f_{DL} Subframe #0 #1 #2 #3 #4 #5 #6 #7 #8 #9 (special subframe) UL DL $f_{\text{DL/UL}}$ DwPTS GP UpPTS FIGURE 9.9 Uplink/downlink time-frequency structure for FDD and TDD.

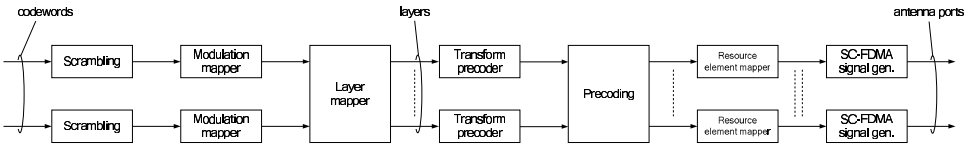
	Claim Language	Infringement Contentions
		In addition, T-Mobile's 4G and 5G base stations receive at least first and second data signals successively transmitted thereto by a first subscriber station and a second subscriber station, respectively, across multiple frames. For example and without limitation, T-Mobile operates a cell tower on or about East Houston Street in Marshall Texas. This cell tower receives successive uplink data signals from a large number of subscriber stations, both within a single frame and across multiple frames. T-Mobile's 4G and 5G base stations also include the remaining limitations of Claim 5, as discussed below.
5.1	a first demodulator selectably coupled to receive the first data signals transmitted to the communication station; at least a second demodulator also selectably coupled to receive the second data signals transmitted to the communication station; and	T-Mobile's 4G and 5G base stations include a first demodulator selectably coupled to receive the first data signals transmitted to the communication station. For example and without limitation, T-Mobile's base stations include BBUs that contain the claimed demodulators. One example of the type of BBU used in T-Mobile's base stations is an Ericsson Baseband 6648 (see above). The following image depicts the bottom side of the PCB in an Ericsson 6648:

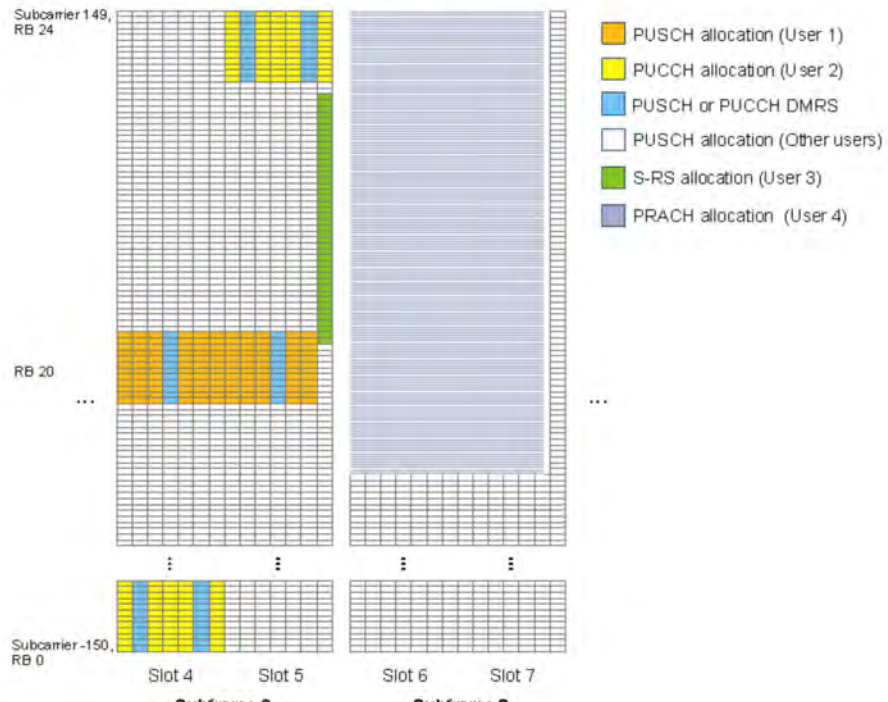
	Claim Language	Infringement Contentions
		 The above image includes 5 processing components: an Intel Atom processor, an STMicro Arm processor, two Ericsson SoCs, and an Altera Cyclone V FPGA. The claimed demodulators are located within one or more of those processing components. As shown in the following image, a BBU is connected to the base station antenna and radio via cables to transmit and receive data signals transmitted to and from the communication station:

	Claim Language	Infringement Contentions
		 Ericsson Baseband Description, Baseband 6648, 6641. T-Mobile's 4G and 5G base stations can alternatively utilize equipment from other manufacturers, including but not limited to Samsung, Nokia, Commscope, and others. Regardless of the specific equipment that is deployed, all T-Mobile 4G and 5G base stations include the claimed demodulators. The baseband units used in Verizon's 4G and 5G base stations include a first demodulator selectably coupled to receive the first data signals transmitted to the communication station. Figure 4.72 in Ahmadi depicts some of the "uplink physical layer processing" in 5G. The right side of the figure shows the steps performed by the station, including layer demapping, demodulation, de-scrambling, de-interleaving, channel decoding, and HARQ buffering of data signals transmitted to the communication station:

	Claim Language	Infringement Contentions
		New Radio Access Physical Layer Aspects (Part 2) 591 Figure 4.72 Overall uplink physical layer processing [5]. T-Mobile’s 5G base stations also include at least a second demodulator also selectably coupled to receive the second data signals transmitted to the communication station. As shown in the above figure, the base station performs “resource de-mapping.” After resource de-mapping, the controller sends data from one UE to a first demodulator, and sends data from a second UE to a different demodulator. <i>See, e.g.,</i> Dahlman 5G at 63 (“NR does not include cell-specific reference signals but solely relies on user-specific demodulation reference signals for channel estimation”); <i>id.</i> at 349 (“spatial separation is typically enabled by using different demodulation reference signals (DM-RS) for the different transmissions, allowing the network to estimate the channel from each device separately...”). <i>See also</i> Ahmadi at 415 (NR “exclusively relies on user-specific demodulation reference signals (DM-RSs) for channel estimation”); <i>id.</i> at 719 (“The baseband modems utilize digital signal processing to perform

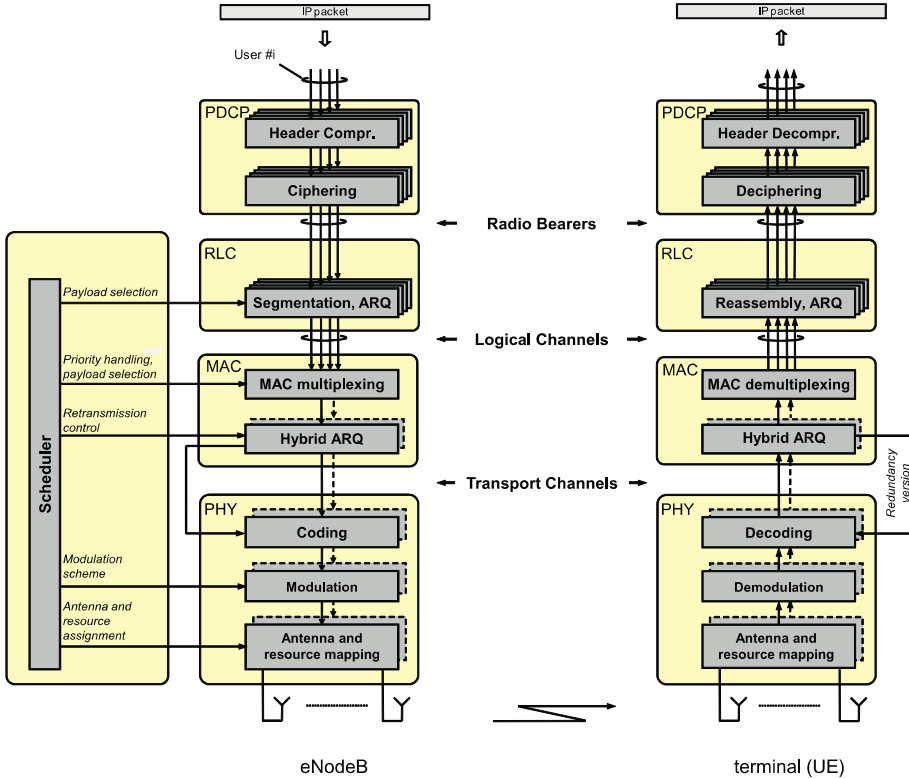
	Claim Language	Infringement Contentions
		channel coding and complex-valued modulation and demodulation in order to transmit extremely high data rate streams over RF carriers in mmWave band. . . . The baseband modulation schemes, generating complex-valued symbols, range from BPSK, QPSK, 16QAM and up to 256QAM (or higher) for high-performance systems.”); <i>id.</i> at Introduction, page xc (noting that 5G communications will utilize “multiple transmit/receive chains to accomplish transceiver functionality”). T-Mobile’s 4G base stations similarly include a first demodulator selectably coupled to receive the first data signals transmitted to the communication station; at least a second demodulator also selectably coupled to receive the second data signals transmitted to the communication station. <i>See, e.g.,</i> https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (depicting a simplified view of some of the steps involved in modulating an uplink LTE signal for a single UE; demodulation would involve the same basic steps in reverse order):  The diagram illustrates the LTE uplink transmission process. It begins with 'User Data' represented as a binary sequence '0010100101001010100001000'. This data is processed by 'Single Carrier Modulation' to produce 'Symbol points', shown as a grid of points. These points are then mapped to 'Time Data (length M)', represented as a horizontal bar. An 'M-point FFT' is applied to the time data, resulting in 'Frequency Data', shown as a yellow bar. A 'User allocation' is indicated by an arrow pointing to a specific segment of the frequency data. This segment is then mapped to an 'OFDM symbol (length N)', shown as a long horizontal bar with a 'Frequency axis' indicated. Finally, an 'N-point IFFT' is applied to the OFDM symbol, resulting in 'Time Data' which is then transmitted via 'TX'. <i>See also</i> 3GPP TS 36.211v14.15.0 (2020-09) (depicting some of the steps involved in uplink transmissions in LTE; these steps are performed in reverse by the base station when decoding and demodulating the received transmission):

	Claim Language	Infringement Contentions
		3GPP TS 36.211 version 14.15.0 Release 14 23 ETSI TS 136 211 V14.15.0 (2020-09) 5.3 Physical uplink shared channel The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - mapping of the complex-valued modulation symbols onto one or several transmission layers - transform precoding to generate complex-valued symbols - precoding of the complex-valued symbols - mapping of precoded complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  Figure 5.3-1: Overview of uplink physical channel processing See also Ericsson Baseband Description, Baseband 6648, 6641, at 4 (listing “Uplink (UL) baseband processing” and other functions of an Ericsson BBU). See also https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm (showing how the physical uplink shared channel (PUSCH) is divided into resource blocks allocated to multiple UEs, requiring multiple receive chains to demodulate the received transmissions):

	Claim Language	Infringement Contentions
		LTE uplink subframes 2-3 Bandwidth: 5 MHz = 300 subcarriers = 25 RB Normal CP, PUCCH Type 2, 15 kHz subcarrier spacing  To the extent that T-Mobile's 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
5.2	a controller, coupled to the first demodulator and to the at least second demodulator in a feedback arrangement, the controller alternately selecting the first data signal for application to the first demodulator and the second data signal for application to the second demodulator,	T-Mobile's 4G and 5G base stations include a controller, coupled to the first demodulator and to the at least second demodulator in a feedback arrangement, the controller alternately selecting the first data signal for application to the first demodulator and the second data signal for application to the second demodulator. For example and without limitation, T-Mobile's 4G and 5G base stations include processors, ASICs, and/or FPGAs that comprise the claimed controllers and are coupled to the first demodulator and to the at least second demodulator in a feedback arrangement. For example, the following image of the PCB in an Ericsson Baseband 6648 shows five processors, all of which are communicatively coupled with each other and the demodulators:

	Claim Language	Infringement Contentions
		 The controller included in T-Mobile's 4G and 5G base stations alternately selects the first data signal for application to the first demodulator and the second data signal for application to the second demodulator. For example and without limitation, the below figure depicts the receive chain of a gNodeB, including multiple configuration parameters dynamically set and/or determined by the controller in communication with the demodulators:

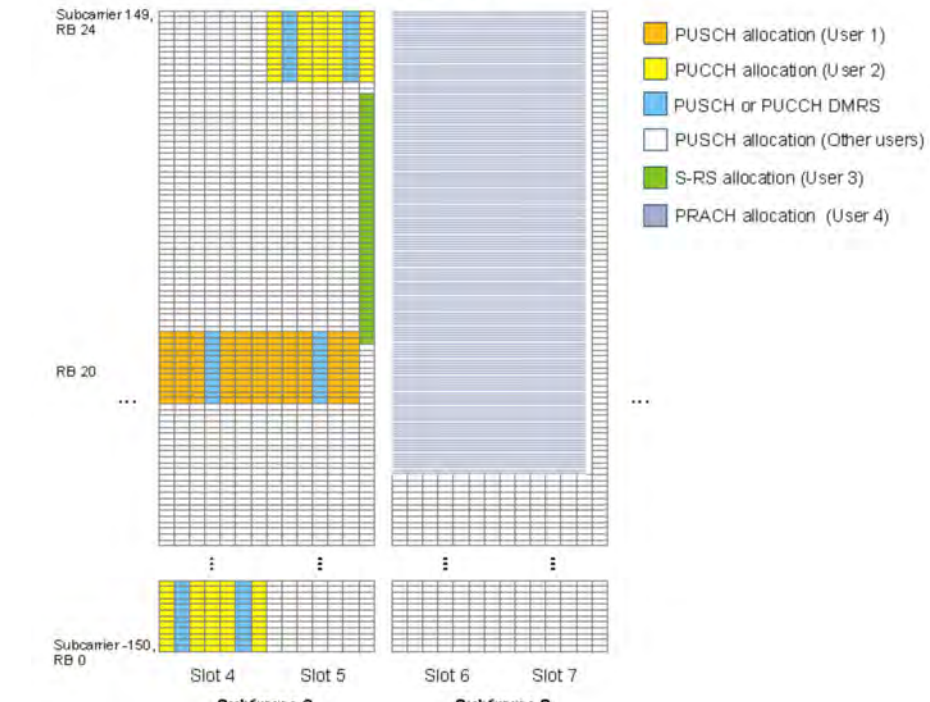
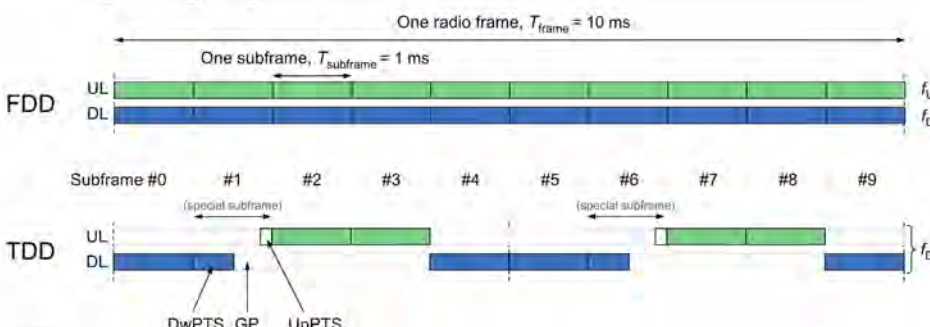
	Claim Language	Infringement Contentions
		New Radio Access Physical Layer Aspects (Part 2) 591 Figure 4.72 Overall uplink physical layer processing [5]. Ahmadi, 5G NR page 591. <i>See also id.</i> at Chapter 4 (discussing downlink and uplink physical layer signal processing in 5G); Dahlman 4G LTE/LTE Advanced for Mobile Broadband at Figure 8.4 (showing the MAC and PHY layers in an eNodeB, including a “scheduler” that dynamically determines and/or sets multiple MAC and PHY configuration parameters in communication with the demodulators):

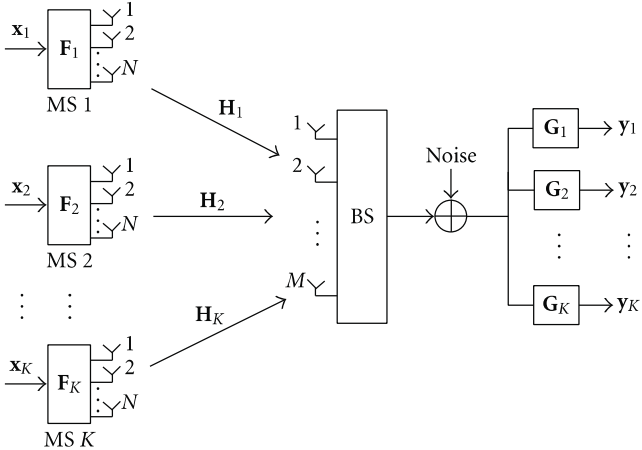
	Claim Language	Infringement Contentions
		 FIGURE 8.4 LTE protocol architecture (downlink). <i>See also</i> Dahlman 5G at 256 (“[i]n the case of codebook-based precoding, the scheduling grant includes information about a precoder,” and “the device is assumed to use the precoder provided by the matrix”). The receive chain used for demodulation (and other processing) of transmissions from each of multiple UEs in a cell is dynamically determined by the controller. The controller alternately selects the demodulators to which different UE’s data are transmitted to enable efficient processing of received signals. As explained in Dahlman 5G, “the gNB is in complete control of the UL-SCH transmissions and the device always follows the scheduling grants received from the network, including the UL-SCH transport format specified in those grants. Thus, the network knows the transport format used for the UL-SCH transmission in advance.” <i>Id.</i> at 229. <i>See also id.</i> at 229-241 (discussing the uplink control signalling used in 5G); <i>id.</i> at 256 (discussing the base station’s role in determining the precoding that

	Claim Language	Infringement Contentions
		UEs apply to uplink transmissions); <i>id.</i> at Section 11.3.1 (discussing codebook-based transmission); <i>id.</i> at Section 11.3.2 (discussing non-codebook based precoding). <i>See also</i> Dahlman 5G at 63 (“NR does not include cell-specific reference signals but solely relies on user-specific demodulation reference signals for channel estimation”); <i>id.</i> at 349 (“spatial separation is typically enabled by using different demodulation reference signals (DM-RS) for the different transmissions, allowing the network to estimate the channel from each device separately...”). These processes control successive transmissions, and their demodulation, both within a single frame and across multiple frames. In a given 4G or 5G frame, the base station receives uplink transmissions from multiple UEs. <i>See, e.g.,</i> Dahlman 5G NR at 141 (depicting one example of a 5G frame): The diagram illustrates three patterns over a period of 10 ms. The top pattern, labeled 'Cell-specific pattern', consists of segments: DL (blue), Flexible (grey), UL (red), DL (blue), Flexible (grey), and UL (red). The middle pattern, labeled 'Device-specific pattern', consists of segments: DL (blue), Flexible (grey), UL (red), DL (blue), Flexible (grey), and UL (red). The bottom pattern, labeled 'Resulting semi static pattern', consists of segments: DL (blue), Flexible (grey), UL (red), DL (blue), Flexible (grey), and UL (red). Vertical dashed lines connect the corresponding segments across the three patterns. Fig. 7.18 Example of cell-specific and device-specific uplink-downlink patterns. The diagram shows the configuration of the SFI table. On the left, a box labeled 'Set of possible slot patterns given by NR specification' contains various patterns of DL (blue) and UL (red) segments. An arrow labeled 'RRC configuration' points to a box on the right labeled 'SFI table'. The SFI table has two columns: 'SFI' and 'Pattern'. The SFI values are 0, 1, 2, 3, and 4-15 (reserved). The corresponding patterns are: 0: DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL; 1: DL-UL-UL-UL-UL-UL-UL-UL-UL-UL-UL-UL-UL-UL-UL-UL; 2: DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-UL; 3: DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-DL-UL-UL; 4-15: reserved. An arrow labeled 'SFI from PDCCH' points to the SFI column, and an arrow labeled 'Slot format for upcoming slots' points to the Pattern column. Fig. 7.19 Example of configuring the SFI table. <i>See also id.</i> at Section 14.2 (discussing uplink scheduling in NR, including scheduling for multiple devices). <i>See also,</i> Ahmadi at 211 (discussing uplink scheduling of multiple UEs across the time domain):

	Claim Language	Infringement Contentions
		The uplink scheduler serves a similar purpose, that is, dynamically controlling the transmission opportunities of the active UEs and efficiently sharing of UL-SCH. The scheduling strategy of a gNB is vendor-dependent and implementation specific and is not specified by 3GPP. In general, the ultimate goal of all schedulers is to take advantage of the channel variations experienced by various devices and to schedule the transmissions/receptions to/from each device on the radio resources with advantageous channel conditions in time and frequency domains, that is, channel-dependent scheduling. <i>See also</i> 3GPP TS 38.213v16.11.00 pg 136 – Table 11.1.1-1 (depicting 5G frame formats including one or more uplink symbols allowing a base station to receive successive transmissions from multiple UEs in a single frame and across multiple frames):

Claim Language	Infringement Contentions																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
	3GPP TS 38.213 version 16.11.0 Release 16136ETSI TS 138 213 V16.11.0 (2022-09) Table 11.1.1-1: Slot formats for normal cyclic prefix <table><tr><th rowspan="2">Format</th><th colspan="14">Symbol number in a slot</th></tr><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th></tr><tr><td>0</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr><tr><td>1</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>2</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>3</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>4</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td></tr><tr><td>5</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td></tr><tr><td>6</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>7</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>8</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>9</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>10</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>11</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>12</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>13</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>14</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>15</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td></tr><tr><td>16</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>17</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>18</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td></tr><tr><td>19</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>20</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>21</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td></tr><tr><td>22</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>23</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>24</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td></tr><tr><td>25</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>26</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>27</td><td>D</td><td>D</td><td>D</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>F</td><td>U</td><td>U</td><td>U</td></tr><tr><td>28</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td></tr><tr><td>29</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>F</td><td>U</td></tr><tr><td>30</td><td>D</td><td>D</td><td>D</t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– 254</td><td colspan="14">Reserved</td></tr><tr><td>255</td><td colspan="14">UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats</td></tr></table> ETSI LTE frames similarly include multiple uplink transmissions from multiple UEs. <i>See, e.g.,</i> Keysight LTE Physical Layer Overview (https://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_overview.htm) (showing how the physical uplink shared channel (PUSCH) is divided into resource blocks allocated to multiple UEs):	Format	Symbol number in a slot														0	1	2	3	4	5	6	7	8	9	10	11	12	13	0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	2	F	F	F	F	F	F	F	F	F	F	F	F	F	F	3	D	D	D	D	D	D	D	D	D	D	D	D	D	F	4	D	D	D	D	D	D	D	D	D	D	D	D	D	F	5	D	D	D	D	D	D	D	D	D	D	D	F	F	F	6	D	D	D	D	D	D	D	D	D	D	F	F	F	F	7	D	D	D	D	D	D	D	D	D	F	F	F	F	F	8	F	F	F	F	F	F	F	F	F	F	F	F	F	U	9	F	F	F	F	F	F	F	F	F	F	F	F	U	U	10	F	U	U	U	U	U	U	U	U	U	U	U	U	U	11	F	F	U	U	U	U	U	U	U	U	U	U	U	U	12	F	F	F	U	U	U	U	U	U	U	U	U	U	U	13	F	F	F	F	U	U	U	U	U	U	U	U	U	U	14	F	F	F	F	F	U	U	U	U	U	U	U	U	U	15	F	F	F	F	F	F	U	U	U	U	U	U	U	U	16	D	F	F	F	F	F	F	F	F	F	F	F	F	F	17	D	D	F	F	F	F	F	F	F	F	F	F	F	F	18	D	D	D	F	F	F	F	F	F	F	F	F	F	F	19	D	F	F	F	F	F	F	F	F	F	F	F	F	U	20	D	D	F	F	F	F	F	F	F	F	F	F	F	U	21	D	D	D	F	F	F	F	F	F	F	F	F	F	U	22	D	F	F	F	F	F	F	F	F	F	F	F	U	U	23	D	D	F	F	F	F	F	F	F	F	F	F	U	U	24	D	D	D	F	F	F	F	F	F	F	F	F	U	U	25	D	F	F	F	F	F	F	F	F	F	F	U	U	U	26	D	D	F	F	F	F	F	F	F	F	F	U	U	U	27	D	D	D	F	F	F	F	F	F	F	F	U	U	U	28	D	D	D	D	D	D	D	D	D	D	D	D	F	U	29	D	D	D	D	D	D	D	D	D	D	D	D	F	U	30	D	D	D	D	D	D	D	D	D	D	F	F	F	U	31	D	D	D	D	D	D	D	D	D	D	D	F	U	U	32	D	D	D	D	D	D	D	D	D	D	F	F	U	U	33	D	D	D	D	D	D	D	D	D	F	F	F	U	U	34	D	F	U	U	U	U	U	U	U	U	U	U	U	U	35	D	D	F	U	U	U	U	U	U	U	U	U	U	U	36	D	D	D	F	U	U	U	U	U	U	U	U	U	U	37	D	F	F	U	U	U	U	U	U	U	U	U	U	U	38	D	D	F	F	U	U	U	U	U	U	U	U	U	U	39	D	D	D	F	F	U	U	U	U	U	U	U	U	U	40	D	F	F	F	U	U	U	U	U	U	U	U	U	U	41	D	D	F	F	F	U	U	U	U	U	U	U	U	U	42	D	D	D	F	F	F	U	U	U	U	U	U	U	U	43	D	D	D	D	D	D	D	D	D	F	F	F	F	U	44	D	D	D	D	D	D	F	F	F	F	F	F	U	U	45	D	D	D	D	D	D	F	F	U	U	U	U	U	U	46	D	D	D	D	D	F	U	D	D	D	D	D	F	U	47	D	D	F	U	U	U	U	D	D	F	U	U	U	U	48	D	F	U	U	U	U	U	D	F	U	U	U	U	U	49	D	D	D	D	F	F	U	D	D	D	D	F	F	U	50	D	D	F	F	U	U	U	D	D	F	F	U	U	U	51	D	F	F	U	U	U	U	D	F	F	U	U	U	U	52	D	F	F	F	F	F	U	D	F	F	F	F	F	U	53	D	D	F	F	F	F	U	D	D	F	F	F	F	U	54	F	F	F	F	F	F	F	D	D	D	D	D	D	D	55	D	D	F	F	F	U	U	U	D	D	D	D	D	D	56 – 254	Reserved														255	UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats													
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255	UE determines the slot format for the slot based on tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated and, if any, on detected DCI formats																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

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		LTE uplink subframes 2-3 Bandwidth: 5 MHz = 300 subcarriers = 25 RB Normal CP, PUCCH Type 2, 15 kHz subcarrier spacing  See also, Dahlman LTE/LTE-Advanced for Mobile Broadband, page 136 (showing the basic structure of LTE frames, including multiple uplink subframes in both TDD and FDD):  FIGURE 9.9 Uplink/downlink time-frequency structure for FDD and TDD.

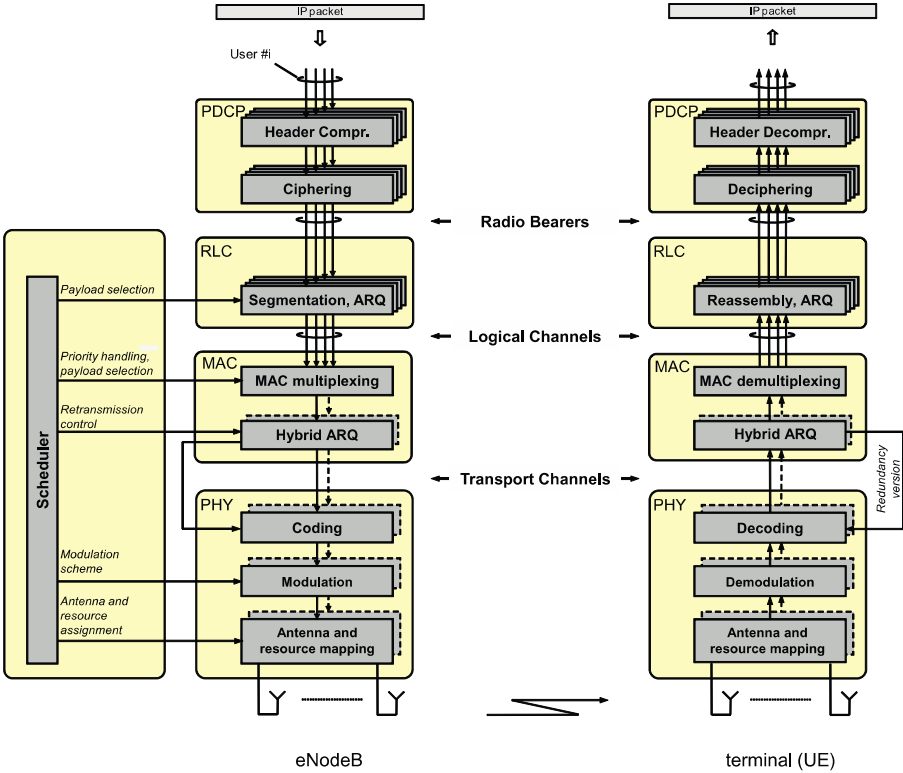
	Claim Language	Infringement Contentions
		As illustrated in the following figure, the receive streams from multiple UEs are separated into separate receive chains, each of which is separately demodulated:  FIGURE 1: Block diagram of an uplink multiuser MIMO wireless system with an M-antenna BS and K mobile users each with N antennas. See Hu , Yang: “<i>Combined Transceiver Optimization for Uplink Multiuser MIMO with Limited CSI</i>”, ISRN Signal Processing Volume 2011, Article ID 735695. <i>See also</i> Ahmadi, 5G NR (“For the 5G mmWave fixed wireless applications, requirements for massive MIMO and beamforming mean that transmit and receive functions will most likely be in distributed array formats. As a result, there will be multiple transmit/receive chains to accomplish transceiver functionality for fixed/mobile wireless devices.”). As discussed further below, in the context of element 5.3, and the claims that depend on this claim, controllers in T-Mobile’s 4G and 5G base stations utilize information received from the demodulators to determine, among other things, resources and settings to allocate to UEs. The controllers then communicate information regarding those resources and settings to the demodulators. To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
5.3	wherein the controller further comprises a memory portion, the controller	The controllers in T-Mobile’s 4G and 5G base stations comprise a memory portion, the controller further for maintaining profiles associated with each of the first and at least second data signals transmitted upon first and at least second channels, respectively, the profiles stored at the memory

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	further for maintaining profiles associated with each of the first and at least second data signals transmitted upon first and at least second channels, respectively, the profiles stored at the memory portion of the controller.	portion of the controller. For example and without limitation, the processors in T-Mobile's 4G and 5G base stations include associated memory portions. These memory portions may be included within the processors and/or may be located externally, as shown in the following image that highlights, in purple, some of the memory portions associated with the processing components in an Ericsson Baseband 6648:  The memory portions of the controllers in T-Mobile's 4G and 5G base stations maintain profiles associated with each of the first and at least second data signals transmitted upon first and at least second channels, respectively, the profiles stored at the memory portion of the controller. For example and without limitation, the eNodeB calculates and stores time/frequency resource blocks, modulation and coding schemes, antenna mapping, precoding schemes, and other signal-related and channel-related parameters for each UE as shown in the block labeled "Scheduler" in Dahlman Figure 8.4. When allocating the next uplink for each UE, the base station retrieves these parameters and includes them in the uplink allocation. When the UE transmits uplink transmissions using the parameters prescribed by

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		the eNodeB, the stored parameters are fed to the various signal processing blocks as shown in Dahlman Figure 8.4: FIGURE 8.4 LTE protocol architecture (downlink). See Dahlman 4G LTE/LTE Advanced for Mobile Broadband. See also 3GPP TS 36.211v14.15.0 (2020-09) at Figure 5.3-1 (showing some of the uplink physical channel processing used in LTE; the process shown here is applied in reverse at the eNodeB when receiving and decoding uplink transmissions from UEs, and includes parameters that are stored by the eNodeB for the first and second data signals):

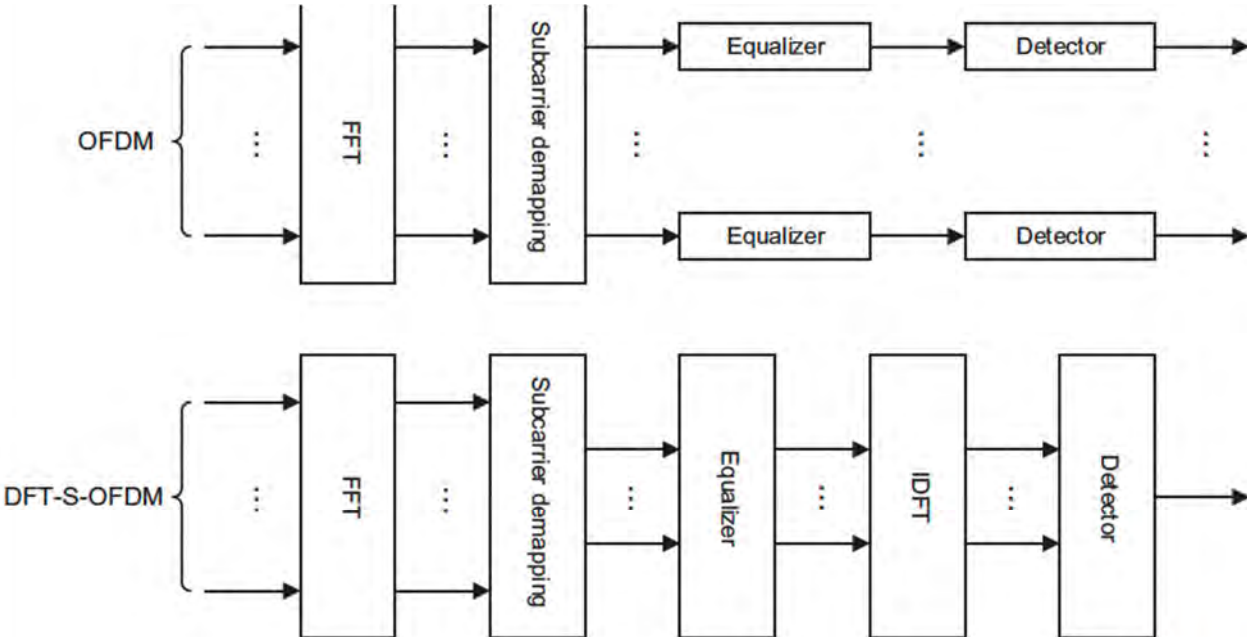
	Claim Language	Infringement Contentions
		3GPP TS 36.211 version 14.15.0 Release 14 23 ETSI TS 136 211 V14.15.0 (2020-09) 5.3 Physical uplink shared channel The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - mapping of the complex-valued modulation symbols onto one or several transmission layers - transform precoding to generate complex-valued symbols - precoding of the complex-valued symbols - mapping of precoded complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port <pre> graph LR CW[codewords] --> S1[Scrambling] CW --> S2[Scrambling] S1 --> M1[Modulation mapper] S2 --> M2[Modulation mapper] M1 --> LM[Layer mapper] M2 --> LM LM --> TP1[Transform precoder] LM --> TP2[Transform precoder] TP1 --> P[Precoding] TP2 --> P P --> REM1[Resource element mapper] P --> REM2[Resource element mapper] REM1 --> SC1[SC-FDMA signal gen.] REM2 --> SC2[SC-FDMA signal gen.] SC1 --> AP[antenna ports] SC2 --> AP </pre> Figure 5.3-1: Overview of uplink physical channel processing <i>See also</i> 3GPP 36.211 and 36.213 (discussing LTE reference signals, including CRS, DM-RS, CSI-RS, CQI, PMI, PTI, and RI all of which may comprise and/or be used to determine portions of the profiles maintained by the controller); Similarly, for 5G/NR, the gNodeB calculates and stores time/frequency resource blocks, modulation and coding schemes, antenna mapping, precoding schemes, and other parameters, including those associated with the block labelled “UE Configuration” in Ahmadi. When allocating the next uplink for each UE, the gNodeB retrieves these parameters and includes them in the uplink allocation. When the UE transmits the uplink burst using the parameters prescribed by the gNodeB, the stored parameters are fed to the various signal processing blocks as shown in Ahmadi Figure 4.72. <i>See</i> Ahmadi 5G NR Figure 4.72 pg. 591. <i>See also</i> Dahlman 5G NR at Chapter 12 (discussing “beam management” in 5G, and profile information that is stored by the controller for purposes of beam management); <i>id.</i> at Chapter 13 (discussing “retransmission protocols” in 5G, and profile information that is stored by the controller for purposes of retransmission); <i>id.</i> at 304 (for uplink transmissions, “[e]ach scheduled device is provided with a scheduling grant indicating the set of time/frequency/spatial resources to use for the UL-SCH as well as the associated transport format. Uplink data transmissions can only take place in the case that the device

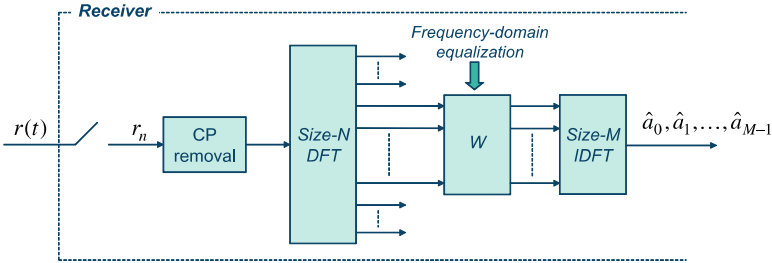
	Claim Language	Infringement Contentions
		has a valid grant. Without a grant, no data can be transmitted.”); <i>id.</i> at Section 8.3 (discussing reference signalling in 5G). To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers and/or cloud-based memory portions that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
6	The apparatus of claim 5 wherein the profiles maintained at the memory portion of the controller comprise at least one channel-related parameter associated with the first and at least second channels upon which the first and at least second data signals are communicated, respectively.	As discussed above, T-Mobile’s 4G and 5G base stations comprise the apparatus of Claim 5. In addition, T-Mobile’s 4G and 5G base stations include profiles stored at the memory portion of the controller wherein the profiles maintained at the memory portion of the controller comprise at least one channel-related parameter associated with the first and at least second channels upon which the first and at least second data signals are communicated, respectively. For example and without limitation, the eNodeB calculates and stores parameters related to equalization weighting, antenna parameters (including but not limited to beamforming), etc. As discussed above, these and other channel-related parameters are generated and stored for each UE as shown in the block labeled “Scheduler” in Dahlman Figure 8.4. When allocating the next uplink for each UE, the eNodeB retrieves these parameters from the memory portions of the controller and includes them in the uplink allocation. When the UE transmits the uplink burst using the parameters prescribed by the eNodeB, the stored parameters are fed to the various signal processing blocks as shown in Dahlman Figure 8.4:

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		 FIGURE 8.4 LTE protocol architecture (downlink). See Dahlman 4G LTE/LTE Advanced for Mobile Broadband. See also 3GPP TS 36.211v14.15.0 (2020-09) at Figure 5.3-1 (showing some of the uplink physical channel processing used in LTE; the process shown here is applied in reverse at the eNodeB when receiving and decoding uplink transmissions from UEs, and includes parameters that are stored by the eNodeB for the first and second data signals):

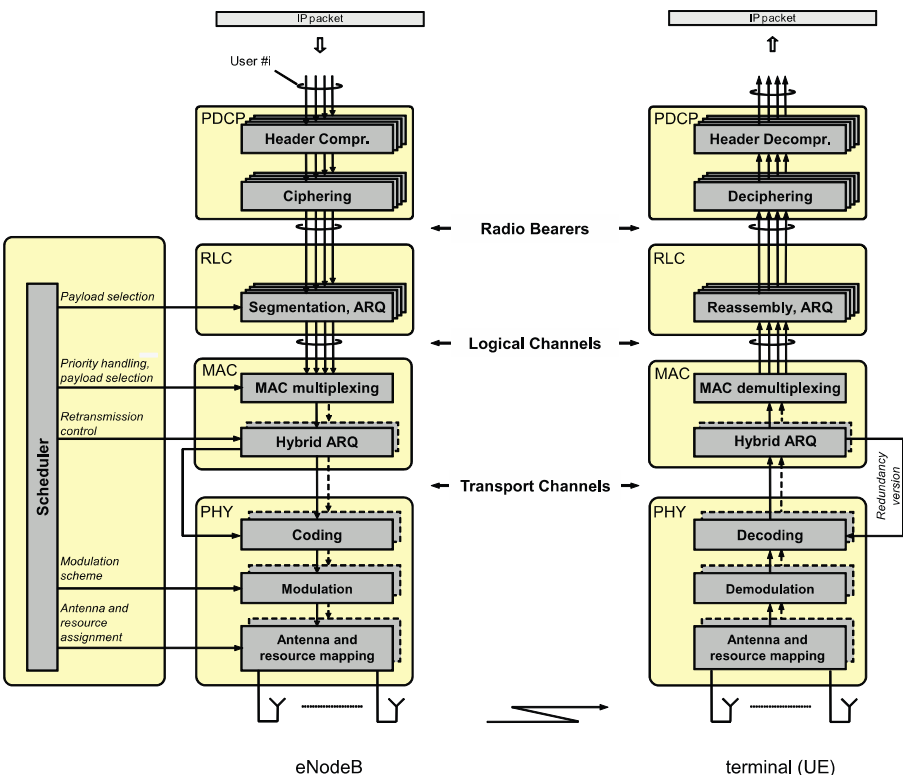
	Claim Language	Infringement Contentions
		3GPP TS 36.211 version 14.15.0 Release 14 23 ETSI TS 136 211 V14.15.0 (2020-09) 5.3 Physical uplink shared channel The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - mapping of the complex-valued modulation symbols onto one or several transmission layers - transform precoding to generate complex-valued symbols - precoding of the complex-valued symbols - mapping of precoded complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port <pre> graph LR CW[codewords] --> S1[Scrambling] CW --> S2[Scrambling] S1 --> M1[Modulation mapper] S2 --> M2[Modulation mapper] M1 --> LM[Layer mapper] M2 --> LM LM --> TP1[Transform precoder] LM --> TP2[Transform precoder] TP1 --> P[Precoding] TP2 --> P P --> REM1[Resource element mapper] P --> REM2[Resource element mapper] REM1 --> SC1[SC-FDMA signal gen.] REM2 --> SC2[SC-FDMA signal gen.] SC1 --> AP[antenna ports] SC2 --> AP </pre> Figure 5.3-1: Overview of uplink physical channel processing Similarly, for 5G/NR, the gNodeB calculates and stores parameters related to equalization weighting, antenna parameters (including but not limited to beamforming), etc., including those associated with the block labelled “UE Configuration” in Ahmadi. When allocating the next uplink for each UE, the gNodeB retrieves these parameters and includes them in the uplink allocation. When the UE transmits the uplink burst using the parameters prescribed by the gNodeB, the stored parameters are fed to the various signal processing blocks as shown in Ahmadi Figure 4.72. <i>See</i> Ahmadi 5G NR Figure 4.72 pg. 591. <i>See also</i> Dahlman 5G NR at 304 (for uplink transmissions, “[e]ach scheduled device is provided with a scheduling grant indicating the set of time/frequency/spatial resources to use for the UL-SCH as well as the associated transport format. Uplink data transmissions can only take place in the case that the device has a valid grant. Without a grant, no data can be transmitted.”); <i>id.</i> at Section 8.3 (discussing reference signalling in 5G). To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.

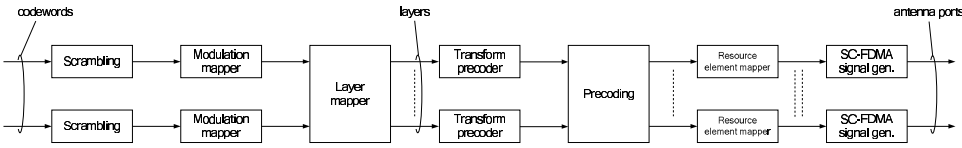
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7	The apparatus of claim 6 wherein the first demodulator and the second demodulator each include equalizer portions for equalizing the at least one of the first and second data signals selectably applied to the first demodulator and the second demodulator, respectively.	As discussed above, T-Mobile's 4G and 5G base stations comprise the apparatus of Claim 6. In addition, T-Mobile's 4G and 5G base stations include first and second demodulators wherein the first demodulator and the second demodulator each include equalizer portions for equalizing the at least one of the first and second data signals selectably applied to the first demodulator and the second demodulator, respectively. For example and without limitation, each of the demodulators in T-Mobile's 4G and 5G base stations include an equalizer for equalizing data signals applied to that demodulator. The figure below depicts a 5G receive chain with an equalization step performed by the demodulator: New Radio Access Physical Layer Aspects (Part 2) 591 Figure 4.72 Overall uplink physical layer processing [5]. Ahmadi 5G NR, Figure 4.72. As shown in the above figure, a channel estimator receives the resource de-mapped signals, performs channel estimation, and passes the channel estimate on to the equalization

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		block for equalization before layer de-mapping, demodulation, channel decoding, and other processing. <i>See also id.</i> at Chapter 3 (discussing the equalization applied by the receiver's demodulators). <i>See also id.</i> at Figure 3.15 (showing different aspects of equalization in 5G):  Figure 3.15 Illustration of different equalization/detection aspects of DFT-S-OFDM and OFDM [30]. T-Mobile's 4G base stations require an equalizer for each incoming transmission. For example, and without limitation, in the case DFTS-OFDM, Dahlman explains the need for equalization: Thus, in the case of DFTS-OFDM, an equalizer is needed to compensate for the radio-channel frequency selectivity. Assuming the basic DFTS-OFDM demodulator structure according to Figure 4.10, frequency-domain equalization as discussed in Section 4.1.2 is especially applicable to DFTS-OFDM transmission (see Figure 4.11).

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		 FIGURE 4.11 DFTS-OFDM demodulator with frequency-domain equalization. Dahlman 4G LTE/LTE Advanced for Mobile Broadband, at 54-55. <i>See also id.</i> at 52: 4.3 DFT-SPREAD OFDM DFT-spread OFDM (DFTS-OFDM) is a transmission scheme that can combine the desired properties discussed in the previous sections, that is: • Small variations in the instantaneous power of the transmitted signal (“single-carrier” property). • Possibility for low-complexity high-quality equalization in the frequency domain. • Possibility for FDMA with flexible bandwidth assignment. Due to these properties, DFTS-OFDM is, for example, used for uplink data transmission in LTE. <i>See also id.</i> at 26, 49-55 (discussing various scenarios in which equalization is utilized in 4G). As shown in the above figures and discussed by Dahlman and Ahmadi, equalization is performed on uplink transmissions as part of the demodulation process in 4G LTE as well as 5G. To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
8	The apparatus of claim 7 wherein filter weight values form portions of the profiles maintained by the controller and stored at the memory portion thereof.	As discussed above, T-Mobile’s 4G and 5G base stations comprise the apparatus of Claim 7. In addition, T-Mobile’s 4G and 5G base stations include profiles stored at the memory portion of the controller wherein filter weight values form portions of the profiles maintained by the controller and stored at the memory portion thereof. For example and without limitation, T-Mobile’s 4G and 5G base stations maintain filter weight profiles associated with equalization and/or antenna weights for each UE. <i>See, e.g.,</i> Dahlman 4G at Chapter 4 (discussing the equalization filter weight values maintained and stored for each UE utilizing 4G LTE); <i>id.</i> at Chapter 5 (discussing multi-antenna techniques utilized in 4G, and the antenna filter weight values maintained and stored for each UE). <i>See also</i> Ahmadi, 5G NR at Chapter 3 (discussing the equalization filter weight values maintained and stored for each UE utilizing 5G); <i>id.</i> at Chapter 4 (discussing the extensive use of multi-antenna technologies in 5G, and the antenna filter weight values maintained and

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		stored for each UE). <i>See also id.</i> at 411 (“Massive MIMO is one of the main enabling technologies in 5G wireless communications.”); <i>id.</i> at 515 (discussing some of the ways that beamforming weights are determined); <i>id.</i> at Section 4.1.9 (discussing Downlink MIMO options in 5G, including the various forms of beamforming used in 5G and the associated beamforming antenna filter weight values maintained and stored for each UE). <i>See also</i>, Dahlman 5G at 247, 256-57 (discussing antenna weights and noting that “in contrast to the downlink, where the network may or may not use the precoder matrix indicated by the PMI, in the uplink direction the device is assumed to use the precoder provided by the network”); <i>id.</i> at Section 8.1.8 discussing “spatial filters” which comprise filter weight portions as described in this claim). For more information about equalization in T-Mobile’s 4G and 5G base stations, see the contentions for Claim 7, above. For more information about beamforming and antenna weighting, see the contentions for Claim 13, below. To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
9	The apparatus in claim 5 wherein the profiles maintained at the memory portion of the controller comprise at least one signal-related parameter associated with the first and at least second data signals, respectively.	As discussed above, T-Mobile’s 4G and 5G base stations comprise the apparatus of Claim 5. In addition, T-Mobile’s 4G and 5G base stations include profiles stored at the memory portion of the controller wherein the profiles maintained at the memory portion of the controller comprise at least one signal-related parameter associated with the first and at least second data signals, respectively. For example and without limitation, the eNodeB calculates and stores parameters related to forward error correction, change in frequency, time, power level, modulation, modulation indexes, modulation orthogonalizations, etc., including but not limited to those associated with the “Scheduler” block in Dahlman Figure 8.4. When allocating the next uplink for each UE, the eNodeB retrieves these parameters from the memory portions of the controller and includes them in the uplink allocation. When the UE transmits the uplink burst using the parameters prescribed by the eNodeB, the stored parameters are fed to the various signal processing blocks as shown in Dahlman Figure 8.4:

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		 FIGURE 8.4 LTE protocol architecture (downlink). See Dahlman 4G LTE/LTE Advanced for Mobile Broadband. See also 3GPP TS 36.211v14.15.0 (2020-09) at Figure 5.3-1 (showing some of the uplink physical channel processing used in LTE; the process shown here is applied in reverse at the eNodeB when receiving and decoding uplink transmissions from UEs, and includes parameters that are stored by the eNodeB for the first and second data signals):

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		3GPP TS 36.211 version 14.15.0 Release 14 23 ETSI TS 136 211 V14.15.0 (2020-09) 5.3 Physical uplink shared channel The baseband signal representing the physical uplink shared channel is defined in terms of the following steps: - scrambling - modulation of scrambled bits to generate complex-valued symbols - mapping of the complex-valued modulation symbols onto one or several transmission layers - transform precoding to generate complex-valued symbols - precoding of the complex-valued symbols - mapping of precoded complex-valued symbols to resource elements - generation of complex-valued time-domain SC-FDMA signal for each antenna port  Figure 5.3-1: Overview of uplink physical channel processing Similarly, for 5G/NR, the gNodeB calculates and stores parameters related to forward error correction, change in frequency, time, power level, modulation, modulation indexes, modulation orthogonalizations, etc., including those associated with the block labelled “UE Configuration” in Ahmadi. When allocating the next uplink for each UE, the gNodeB retrieves these parameters and includes them in the uplink allocation. When the UE transmits the uplink burst using the parameters prescribed by the gNodeB, the stored parameters are fed to the various signal processing blocks as shown in Ahmadi Figure 4.72. <i>See</i> Ahmadi 5G NR Figure 4.72 pg. 591. <i>See also</i> Dahlman 5G NR at 304 (for uplink transmissions, “[e]ach scheduled device is provided with a scheduling grant indicating the set of time/frequency/spatial resources to use for the UL-SCH as well as the associated transport format. Uplink data transmissions can only take place in the case that the device has a valid grant. Without a grant, no data can be transmitted.”). To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.

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10	The apparatus of claim 9 wherein the first and at least second data signals are characterized by modulation indexes, and wherein values of the modulation indexes form portions of the profiles maintained by the controller and stored at the memory portion of the controller.	As discussed above, T-Mobile's 4G and 5G base stations comprise the apparatus of Claim 9. In addition, T-Mobile's 4G and 5G base stations include first and second data signals wherein the first and at least second data signals are characterized by modulation indexes, and wherein values of the modulation indexes form portions of the profiles maintained by the controller and stored at the memory portion of the controller. For example and without limitation, 4G and 5G base stations dynamically determine the modulation and coding scheme ("MCS") for each UE, including modulation indexes which form portions of the profiles maintained by the controller and stored at the memory portion of the controller. <i>See, e.g.</i>, Ahmadi 5G NR at 536 (discussing MCS and explaining that, in 5G, "the DL-SCH and UL-SCH MCS and code rate for transmission are determined by predefined tables"); <i>id.</i> at Section 4.1.7 (discussing channel coding and modulation schemes in 5G). <i>See also</i> 3GPP TS 38.214, NR, Physical Layer Procedures for Data (Release 15), December 2018. <i>See also</i> Ahmadi 5G NR at 416: UE-specific CSI-RS can be used for estimation of CSI to allow CSI measurement and reporting which assists the gNB in modulation coding scheme (MCS) selection, resource allocation, beamforming, and MIMO rank selection. The CSI-RS can be configured for periodic, aperiodic, or semi-persistent transmission with a configurable density by the gNB. The CSI-RS also can be used for interference measurement (IM) and fine frequency/time tracking purposes. Specific instances of CSI-RS can be configured for time/frequency tracking and mobility measurements. In the absence of the cell-specific reference signals in NR the CSI-RS can be used for radio resource management, measurements and mobility management purposes in connected mode. <i>Id.</i> at 536-37 (noting, among other things, the similarities between MCS in 5G and 4G LTE):

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		The concepts of MCS, code rate, TB, and TBS in 3GPP NR are similar to those of 3GPP LTE. In NR, the DL-SCH and UL-SCH MCS and code rate for transmission are determined by predefined tables given in [9]. However, TBS determination in NR is more complicated than that of LTE. Unlike LTE where all possible TBSs were precalculated and listed in the MCS table, in NR, the TBS determination process is described as a procedure that has been illustrated in Fig. 4.53. As shown in the flow chart, the initial input to this algorithm is N_{info}; however, to determine this value, the following calculations are necessary [9]: $ \begin{aligned} \underbrace{N'_{RE}}_{\substack{\text{The number of REs allocated for} \\ \text{PDSCH within a PRB}}} &= 12 \underbrace{N_{slot}^{symb}}_{\substack{\text{The number of symbols of the PDSCH} \\ \text{allocation within the slot}}} - \underbrace{N_{DM-RS}^{PRB}}_{\substack{\text{The number of REs for DM-RS per PRB} \\ \text{in the scheduled duration including the overhead} \\ \text{of the DM-RS CDM groups without data}}} - \underbrace{N_{overhead}^{PRB}}_{\substack{\text{The overhead configured by higher-layer} \\ \text{parameter } \alpha \text{ Overhead in PDSCH - ServingCellConfig}}} \\ \underbrace{N_{RE}}_{\substack{\text{The total number of REs allocated for PDSCH}}} &= \min(156, N'_{RE}) \underbrace{n_{PRB}}_{\substack{\text{The total number of allocated PRBs for the UE}}} \\ \underbrace{N_{info}}_{\substack{\text{Intermediate number of information bits}}} &= N_{RE} \underbrace{R}_{\substack{\text{Target code rate}}} \underbrace{Q_m}_{\substack{\text{Modulation order}}} \underbrace{V}_{\substack{\text{Number of layers}}} \end{aligned} $ For downlink shared channel, the supported modulation schemes include QPSK, 16QAM, 64QAM, and 256QAM. After detecting the CSI-RS and estimating the channel quality, UE

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		Figure 4.53 TBS determination procedure in NR [30]. reports the CQI to the gNB, which includes the information such as modulation scheme and coding rate. To balance the overhead and the granularity of CQI indication, two CQI/MCS tables are defined for eMBB, where the maximum order of modulation in one CQI/MCS table is 64QAM and in another table is 256QAM (see MCS Tables I and II in Table 4.16). The network will instruct the UE to select CQI/MCS table through RRC signaling. The third MCS table is meant for URLLC use cases where the target BLER is 10^{-5}, which is signaled to UE when the CRC of the PDCCH is scrambled with MCS-C-RNTI. This MCS table was designed to allow single transmissions to the UEs with delay sensitive applications to ensure maximum likelihood of correct reception. <i>See also id.</i> at 365-66 (discussing the persistence of MCS across multiple subbands allocated to a single user). <i>See also id.</i> at 870 (describing one way that a base station may inform a UE of its MCS):

	Claim Language	Infringement Contentions																																																																																																																																				
		in the uplink buffers. The PRB allocation and MCS as well as DMRS cyclic shift and orthogonal cover code are indicated to the UE via AUL activation DCI. The UE informs the eNB along with each AUL transmission of the selected HARQ-process ID, new data indicator, redundancy version, UE ID, PUSCH starting and ending points, as well as whether the UE-acquired channel occupancy time can be shared with the eNB. The eNB may provide the UE with HARQ feedback for AUL-enabled HARQ processes, transmit power command, and transmit PMI [5,6]. <i>See generally</i> Dahlman 4G at Chapter 11 (discussing uplink scheduling and MCS in 4G). <i>See also</i> 3GPP, TS 38.214 (showing an example of an MCS table that includes “MCS index” entries associated with the “modulation order,” which form portions of the profiles maintained by the controller and stored at the memory portion of the controller): 3GPP TS 38.214 version 16.11.0 Release 16 27 ETSI TS 138 214 V16.11.0 (2022-09) Table 5.1.3.1-1: MCS index table 1 for PDSCH <table><tr><th>MCS index i_{MCS}</th><th>Modulation Order Q_m</th><th>Target code Rate $R \times [1024]$</th><th>Spectral efficiency</th></tr><tr><td>0</td><td>2</td><td>120</td><td>0.2344</td></tr><tr><td>1</td><td>2</td><td>157</td><td>0.3066</td></tr><tr><td>2</td><td>2</td><td>193</td><td>0.3770</td></tr><tr><td>3</td><td>2</td><td>251</td><td>0.4902</td></tr><tr><td>4</td><td>2</td><td>308</td><td>0.6016</td></tr><tr><td>5</td><td>2</td><td>379</td><td>0.7402</td></tr><tr><td>6</td><td>2</td><td>449</td><td>0.8770</td></tr><tr><td>7</td><td>2</td><td>526</td><td>1.0273</td></tr><tr><td>8</td><td>2</td><td>602</td><td>1.1758</td></tr><tr><td>9</td><td>2</td><td>679</td><td>1.3262</td></tr><tr><td>10</td><td>4</td><td>340</td><td>1.3281</td></tr><tr><td>11</td><td>4</td><td>378</td><td>1.4766</td></tr><tr><td>12</td><td>4</td><td>434</td><td>1.6953</td></tr><tr><td>13</td><td>4</td><td>490</td><td>1.9141</td></tr><tr><td>14</td><td>4</td><td>553</td><td>2.1602</td></tr><tr><td>15</td><td>4</td><td>616</td><td>2.4063</td></tr><tr><td>16</td><td>4</td><td>658</td><td>2.5703</td></tr><tr><td>17</td><td>6</td><td>438</td><td>2.5664</td></tr><tr><td>18</td><td>6</td><td>466</td><td>2.7305</td></tr><tr><td>19</td><td>6</td><td>517</td><td>3.0293</td></tr><tr><td>20</td><td>6</td><td>567</td><td>3.3223</td></tr><tr><td>21</td><td>6</td><td>616</td><td>3.6094</td></tr><tr><td>22</td><td>6</td><td>666</td><td>3.9023</td></tr><tr><td>23</td><td>6</td><td>719</td><td>4.2129</td></tr><tr><td>24</td><td>6</td><td>772</td><td>4.5234</td></tr><tr><td>25</td><td>6</td><td>822</td><td>4.8164</td></tr><tr><td>26</td><td>6</td><td>873</td><td>5.1152</td></tr><tr><td>27</td><td>6</td><td>910</td><td>5.3320</td></tr><tr><td>28</td><td>6</td><td>948</td><td>5.5547</td></tr><tr><td>29</td><td>2</td><td>reserved</td><td></td></tr><tr><td>30</td><td>4</td><td>reserved</td><td></td></tr><tr><td>31</td><td>6</td><td>reserved</td><td></td></tr></table> To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one	MCS index i_{MCS}	Modulation Order Q_m	Target code Rate $R \times [1024]$	Spectral efficiency	0	2	120	0.2344	1	2	157	0.3066	2	2	193	0.3770	3	2	251	0.4902	4	2	308	0.6016	5	2	379	0.7402	6	2	449	0.8770	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	5.3320	28	6	948	5.5547	29	2	reserved		30	4	reserved		31	6	reserved	
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	Claim Language	Infringement Contentions
		or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
11	The apparatus of claim 9 wherein the first and at least second data signals are characterized by modulation orthogonalizations and wherein values of the modulation orthogonalizations form portions of the profiles maintained by the controller and stored at the memory portion of the controller.	As discussed above, T-Mobile's 4G and 5G base stations comprise the apparatus of Claim 9. In addition, T-Mobile's 4G and 5G base stations include first and second data signals wherein the first and at least second data signals are characterized by modulation orthogonalizations and wherein values of the modulation orthogonalizations form portions of the profiles maintained by the controller and stored at the memory portion of the controller. For example and without limitation, uplink transmissions in 4G and 5G use OFDM, and the particular OFDM values are part of the profiles maintained by the controller and stored at the memory portion of the controller. <i>See, e.g.</i>, Dahlman 4G at 14 ("it was decided that the LTE radio access should be based on OFDM in the downlink and DFT-precoded OFDM in the uplink"); <i>id.</i> at Section 3.2 (discussing OFDM demodulation, and the "orthogonality between subcarriers"); <i>id.</i> at 105 ("The LTE uplink is also based on OFDM transmission."); <i>id.</i> at 106-07 (discussing the base station's scheduling of multiple terminals, including the OFDM parameters assigned to each UE, which are maintained by the controller and stored at the memory portion of the controller); <i>id.</i> at 133 (noting that "the overall goal of most schedulers is to take advantage of the channel variations between terminals and preferably schedule transmissions to a terminal with advantageous channel conditions," of course the same basic principle applies to uplink scheduling as well); <i>see also id.</i> at Figure 8.4 (depicting the "scheduler" responsible for assigning parameters to each UE, including but not limited to OFDM parameters, which parameters are maintained by the controller and stored at the memory portion of the controller); <i>id.</i> at 49-55 (discussing DFTS-OFDM). The following figure depicts uplink physical layer processing in 5G, including OFDM modulation and demodulation:

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		New Radio Access Physical Layer Aspects (Part 2) 591 Figure 4.72 Overall uplink physical layer processing [5]. Ahmadi, 5G NR at Figure 4.72. As shown above, OFDM modulation is one of the “UE Configurations” determined by the base station, and which are maintained by the controller and stored at the memory portion of the controller. <i>See also id.</i> at 316-17 (discussing OFDM orthogonality and associated settings):

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		In a conventional serial data transmission system the information bearing symbols are transmitted sequentially, with the frequency spectrum of each symbol occupying the entire available bandwidth. An unfiltered QAM signal spectrum can be described in the form of $\sin(\pi f T_u)/\pi f T_u$ with zero-crossing points at integer multiples of $1/T_u$, where T_u is the QAM symbol period. The concept of OFDM is to transmit the data bits in parallel QAM-modulated subcarriers using frequency division multiplexing. The carrier spacing is carefully selected so that each subcarrier is located on other subcarriers' zero-crossing points in the frequency domain. Although there are spectral overlaps among subcarriers, they do not interfere with each other, if they are sampled at the subcarrier frequencies. In other words, they maintain spectral orthogonality. The OFDM signal in frequency domain is generated through aggregation of N_{FFT} parallel QAM-modulated subcarriers where adjacent subcarriers are separated by subcarrier spacing $1/T_u$. Since an OFDM signal consists of many parallel QAM subcarriers, the mathematical expression of the signal in time domain can be expressed as follows: $x(t) = \text{Re} \left\{ e^{j\omega_c t} \sum_{k=-(N_{FFT}-1)/2}^{(N_{FFT}-1)/2} s_k e^{j2\pi k(t-t_g)/T_u} \right\}, \quad nT_u \leq t \leq (n+1)T_u$ where $x(t)$ denotes the OFDM signal in time domain, s_k is the complex-valued data that is QAM-modulated and transmitted over subcarrier k, N_{FFT} is the number of subcarriers in frequency domain, ω_c is the RF carrier frequency, and T_g is the guard interval or the CP length. For a large number of subcarriers, direct generation and demodulation of the OFDM signal would require arrays of coherent sinusoidal generators which can become excessively complex and expensive. However, one can notice that the OFDM signal is actually the real part of the inverse discrete Fourier transform (IDFT) of the original complex-valued data symbols $\{s_k k = -(N_{FFT}-1)/2, \dots, (N_{FFT}-1)/2\}$. It can be observed that there are $N < N_{FFT}$ subcarriers each carrying the corresponding data α_k. The inverse of the subcarrier spacing $\Delta f = 1/T_u$ is defined as the OFDM useful symbol duration T_u, which is N_{FFT} times longer than that of the original input data symbol duration.

	Claim Language	Infringement Contentions
		Since IDFT is used in the OFDM modulator, the original data are defined in the frequency domain, while the OFDM signal $s(t)$ is defined in the time domain. The IDFT can be implemented via a computationally efficient FFT algorithm. The orthogonality of subcarriers in OFDM can be maintained and individual subcarriers can be completely separated and demodulated by an FFT at the receiver when there is no ISI introduced by communication channel. In practice, linear distortions such as multipath delay cause ISI between OFDM symbols, resulting in loss of orthogonality and an effect that is similar to cochannel interference. However, when delay spread is small, that is, within a fraction of the OFDM useful symbol length, the impact of ISI is negligible, although it depends on the order of modulation implemented by the subcarriers (see Fig. 3.10). A simple solution to mitigate multipath delay is to increase the OFDM effective symbol duration such that it is much larger than the delay spread; however, when the delay spread is large, it requires a large number of subcarriers and a large FFT size. Meanwhile, the system might become sensitive to Doppler shift and carrier frequency offset. An alternative approach to mitigate multipath distortion is to generate a cyclically extended guard interval, where each OFDM symbol is prefixed with a periodic extension of the signal itself, as shown in Fig. 3.10 where the tail of the symbol is copied to the beginning of the symbol. The OFDM symbol duration then is defined as $T_s = T_u + T_g$, where T_g is the guard interval or CP. When the guard interval is longer than the channel impulse response or the multipath delay, the ISI can be effectively eliminated. The ratio of the guard interval to useful OFDM symbol duration depends on the deployment scenario and the frequency band. Since the insertion of the guard intervals will reduce the system throughput, T_g is usually selected less than $T_u/4$. The CP should absorb most of the signal energy dispersed by the multipath channel. The entire the ISI energy is contained within the CP, if its length is greater than that of the channel RMS delay spread ($T_g > \tau_{RMS}$). In general it is sufficient to have most of the delay spread energy absorbed by the guard interval, considering the inherent robustness of large OFDM symbols to time dispersion. Fig. 3.11 illustrate the OFDM modulation and demodulation process in the transmitter and the receiver, respectively. In practice, a windowing or filtering scheme is utilized in the OFDM transmitter side to reduce the OOB emissions of the OFDM signal (see Fig. 3.10). In addition, T-Mobile's 4G and 5G base stations utilize OFDMA sub-channelization. <i>See, e.g.,</i> Ahmadi 5G NR at 351-52:

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		OFDMA is the multi-user variant of the OFDM scheme where multiple access is achieved by assigning subsets of time-frequency resources to different users, allowing simultaneous data transmission from several users. In OFDMA, the radio resources are 2D regions over time (an integer number of OFDM symbols) and frequency (a number of contiguous or non-contiguous subcarriers). Similar to OFDM, OFDMA employs multiple closely spaced subcarriers that are divided into groups of subcarriers where each group is called a resource block. The grouping of subcarriers into groups of resource blocks is referred to as sub-channelization. The subcarriers that form a resource block do not need to be physically adjacent. In the downlink, a resource block may be allocated to different users. In the uplink, a user may be assigned to one or more resource blocks. Sub-channelization defines subchannels that can be allocated to mobile stations depending on their channel conditions and service requirements. Using sub-channelization, within the same time slot (i.e., an integer number of OFDM symbols) an OFDMA system can allocate more transmit power to user devices with lower SNR and less power to user devices with higher SNR. Sub-channelization also enables the base station to allocate higher power to sub-channels assigned to indoor mobile terminals resulting in better indoor coverage. In OFDMA, an OFDM symbol is constructed of subcarriers, the number of which is determined by the FFT size. There are several subcarrier types: (1) data subcarriers are used for data transmission, (2) pilot or reference-signal subcarriers are utilized for channel estimation and coherent detection, and (3) null subcarriers that are not used for pilot/data transmission. The null subcarriers including the DC subcarrier (if it exists) are used for guard bands. The number of used (or occupied) subcarriers is always less than the FFT size. The guard bands are used to allow spectrum sharing and to reduce the adjacent channel interference and OOB emissions. The sampling frequency is selected to be greater than or equal the channel bandwidth. The number of time samples in a radio frame is always an integer and to further simplify the design of analog transmit filter, the sampling frequency is scaled by a factor greater than one (e.g., in LTE, the sampling frequency for 20 MHz bandwidth is 30.72 MHz). ... By assigning different groups of subcarriers to different users, each user's transmit power can be concentrated in a restricted part of the channel bandwidth, resulting in significant coverage enhancement. Different user signals remain orthogonal only if time/frequency synchronization is maintained and an appropriate CP is appended to compensate for timing misalignments at the receiver. In order to maintain good performance in frequency-selective fading channels, robust forward error correction schemes must be employed. To the extent that T-Mobile's 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.

	Claim Language	Infringement Contentions
12	The apparatus of claim 9 wherein the first and at least second data signals include FEC (forward error correction), the FEC characterized by FEC parameters and wherein values of the FEC parameters form portions of the profiles maintained by the controller and stored at the memory portion of the controller.	As discussed above, T-Mobile's 4G and 5G base stations comprise the apparatus of Claim 9. In addition, T-Mobile's 4G and 5G base stations include first and second data signals wherein the first and at least second data signals include FEC (forward error correction), the FEC characterized by FEC parameters and wherein values of the FEC parameters form portions of the profiles maintained by the controller and stored at the memory portion of the controller. For example and without limitation, the following figure from Ahmadi identifies forward error correction utilizing an LDPC code: New Radio Access Physical Layer Aspects (Part 2) 591 Figure 4.72 Overall uplink physical layer processing [5]. Ahmadi 5G NR, Figure 4.72. <i>See also</i> Dahlman 5G at 165 (noting that, in 5G transmissions, including uplink transmissions on the UL-SCH, “[a] CRC for error-detecting purposes is added to each transport

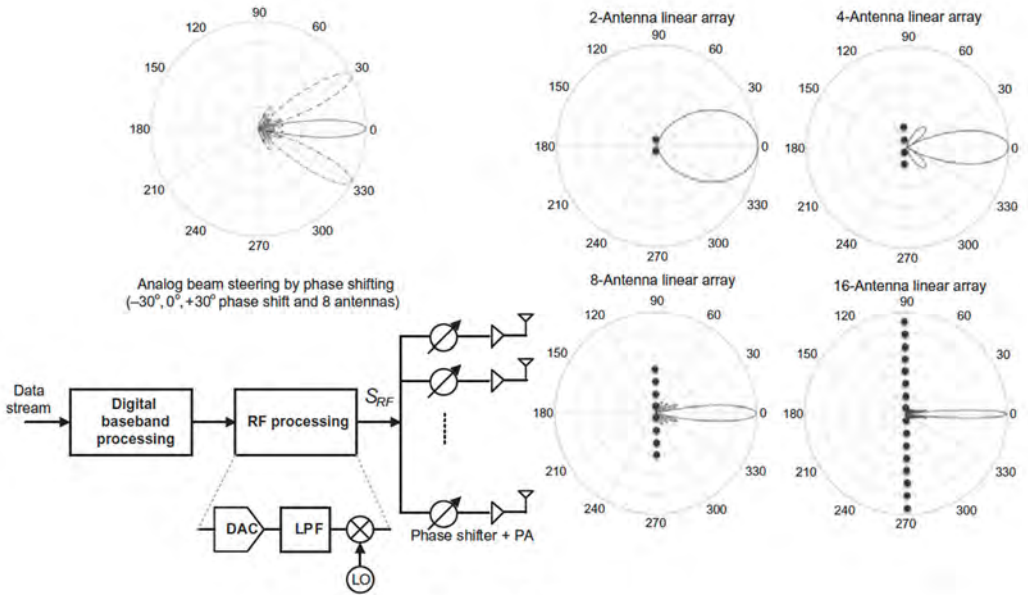
	Claim Language	Infringement Contentions
		block, followed by error-correcting codes using LDPC codes”); <i>id.</i> at Section 9.2.3 (discussing the LDPC codes used in 5G). <i>See also</i> https://ieeexplore.ieee.org/abstract/document/8477009 (discussing the LDPC codes used in 5G). While these sources indicate that CRC and LDPC codes are used with 5G, other forward error correction codes would similarly meet the limitations. Parameters related to FEC, including but not limited to parameters related to code rate, puncturing, and shortening are stored by the controller, where they form portions of the profiles maintained by the controller and stored at the memory portion of the controller. <i>See also</i> Harri Holma, Antti Toskala, and Takehiro Nakamura, 5G Technology, Wiley, Kindle Edition at 134-35 (discussing the importance of FEC in 5G, and the importance of selecting flexible FEC capable of operating with a variable code length, code rate, and HARQ): Channel coding is one of the main hardware critical components in 5G, and codes used in 5G are capable of providing good performance gains with a lower implementation complexity and processing delays compared to its predecessors. In 3GPP Rel-15, different service scenarios were considered in the initial phase of the channel coding discussion; however, the final selection of the channel coding scheme was mainly decided based on the eMBB requirements, which were identified as performance of the coding scheme, implementation complexity, the latency of encoding and decoding, and the flexibility (e.g. variable code length, code rate, HARQ) of the coding scheme. <i>Id.</i> at 135: LDPC is a very mature coding scheme which has been considered by many other standards. The flexibility that the coding scheme provided in implementations together with competitive performance can be identified as one of the key advantages that LDPC possesses when compared to all other coding schemes. In addition, 5G NR utilizes Hybrid ARQ forward error correction techniques. <i>See, e.g.</i>, Ahmadi 5G at Section 4.1.8 (discussing HARQ, which combines “ARQ error-control mechanism[s] and FEC coding”). When utilizing HARQ, the transmissions from the UEs are encoded with FEC. The FEC (and related data) are then stored by the controller, where they form portions of the profiles maintained by the controller and stored at the memory portion of the controller. <i>See id.</i> at 540:

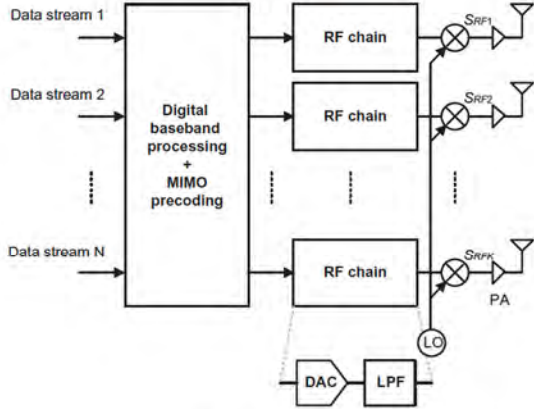
	Claim Language	Infringement Contentions
		The drawbacks of ARQ and FEC can be overcome, if the two error control schemes are properly combined. In order to achieve increased throughput and lower latency in packet transmission, hybrid ARQ (HARQ) scheme was designed to combine ARQ error-control mechanism and FEC coding. A HARQ system consists of a FEC subsystem contained in an ARQ system. In this approach, the average number of retransmissions is reduced by using FEC through correction of the error patterns that occur more frequently; however, when the less frequent error patterns are detected, the receiver requests a retransmission where each retransmission carries the same or some redundant information to help the packet detection. The HARQ uses FEC to correct a subset of errors at the receiver and rely on error detection to detect the remaining errors. Most practical HARQ schemes utilize CRC codes for error detection and some form of FEC for correcting the transmission errors. The HARQ schemes <i>Id.</i> at 542: 3GPP NR uses an asynchronous HARQ-IR scheme in the downlink and uplink. The gNB provides the UE with the HARQ-ACK feedback timing either dynamically in the DCI or semi-statically through RRC configuration messages. The gNB schedules each uplink transmission and retransmission using the uplink grant on DCI. In LTE, the basic mode of operation for uplink HARQ is synchronous retransmission, which can be used to reduce the scheduling overhead for retransmissions. In this case, HARQ ACK/NACK is carried on PHICH as a short and efficient message. In NR, asynchronous HARQ is supported. In order to support asynchronous HARQ, a straightforward solution for the gNB is to send an explicit uplink grant through PDCCH for the retransmission in the same way that is done for transmissions in LTE. In some sense, the explicit grant can imply an implicit ACK/NACK. For example, an explicit scheduling grant of a retransmission may imply a NACK for the initial transmission. The maximum number of HARQ processes in the downlink and uplink per cell is 16. The number of HARQ processes is separately configured for the UE for each cell by RRC parameter <i>nrofHARQ-processesForPDSCH</i>. In the absence of any configuration, the UE may assume a default number of 8 HARQ processes. <i>Id.</i> at 542:

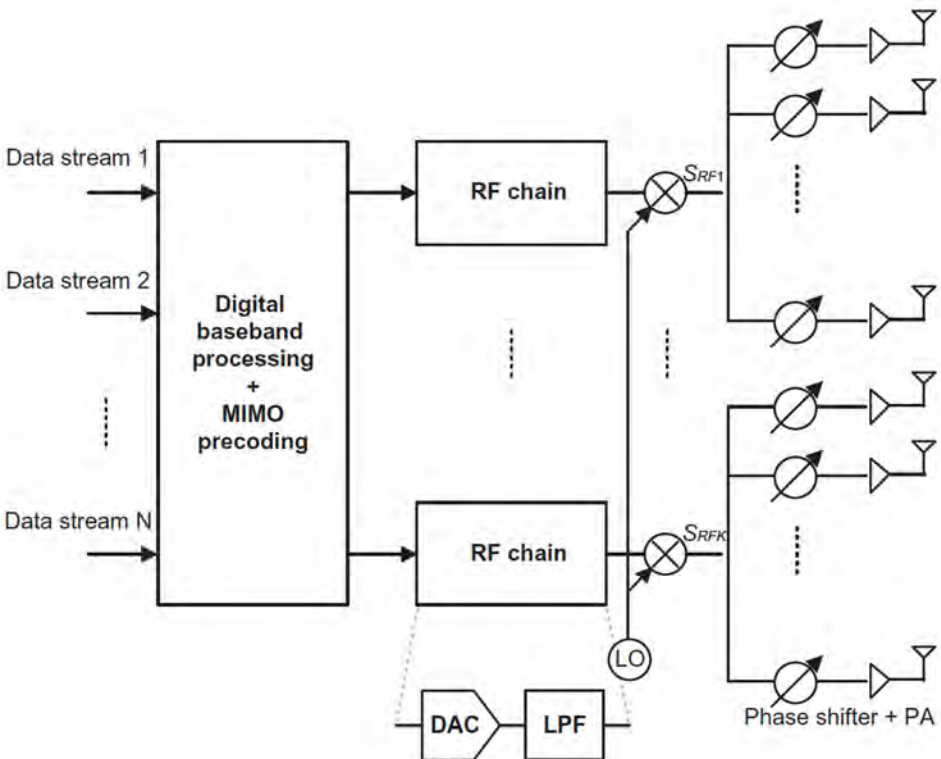
	Claim Language	Infringement Contentions
		The UE must provide a valid HARQ-ACK message, if the first uplink symbol of PUCCH conveying the HARQ-ACK information, as identified by HARQ-ACK timing parameter K_1 and the assigned PUCCH resource including the effect of the timing advance, starts on or after symbol L_1, that is, the next uplink symbol with its cyclic prefix starting after $T_{proc} = 2192(N_1 + d_x) \kappa 2^{-\mu} T_c$ (processing time) following the end of the last symbol of the PDSCH carrying the transport block being acknowledged. As shown in Fig. 4.55, parameter N_1 is based on the numerology and corresponds to $(\mu_{PDCCH}, \mu_{PDSCH}, \mu_{UL})$ where μ_{PDCCH}, μ_{PDSCH}, and μ_{UL} correspond to the subcarrier spacing of the PDCCH scheduling, PDSCH transmission, and the uplink channel on which the HARQ-ACK is transmitted, respectively. As shown in Table 4.18, the value of parameter N_1 further depends on the PDSCH DM-RS pattern and whether additional DM-RS is used as well as UE PDSCH processing capability. The value of parameter d_x is dependent on the PDSCH mapping type (A or B), UE PDSCH processing capability, and the number of PDSCH symbols [9]. The timing relationship between HARQ-ACK and PDSCH data transmission depends on the value of the above parameters and is depicted in Fig. 4.55. <i>Id.</i> at 544: In the NR downlink, retransmissions are scheduled in the same way as new data, that is, they may occur at any time and at an arbitrary frequency location within the downlink cell bandwidth. The scheduling assignment contains the necessary HARQ-related control signaling such as process number, new-data indicator, CBGTI, and CBGFI in case of CBG-based retransmission as well as information to handle the transmission of the acknowledgment in the uplink such as timing and resource indication. Upon receiving a scheduling assignment ... The NR uplink uses asynchronous HARQ protocol in the same way as downlink. The HARQ-related information including process number, new-data indicator, CBG-based retransmission (if configured), and the CBGTI are included in the scheduling grant. The uplink CBGTI is used in the same way as in the downlink, that is, to indicate the CBGs that need to be retransmitted in the case of CBG-based retransmission. Note that no CBGFI is needed in the uplink as the soft buffer is located in the gNB which can decide whether to flush the buffer or not based on the scheduling decisions. Similarly, uplink transmissions in 4G LTE utilize FEC. <i>See, e.g.</i>, Dahlman 4G at Sections 10.1.1.2 and 10.1.1.3 (discussing “channel coding” in LTE that utilizes turbo FEC codes, as well as CRC encoding for error detection, both of which entail parameters that would be maintained and stored by the controller); <i>see also id.</i> at 11.1 (discussing uplink transmissions in LTE, including the use of FEC turbo and CRC codes). Uplink transmissions in 4G LTE also utilize Hybrid ARQ. <i>See, e.g.</i>, Dahlman 4G at 97

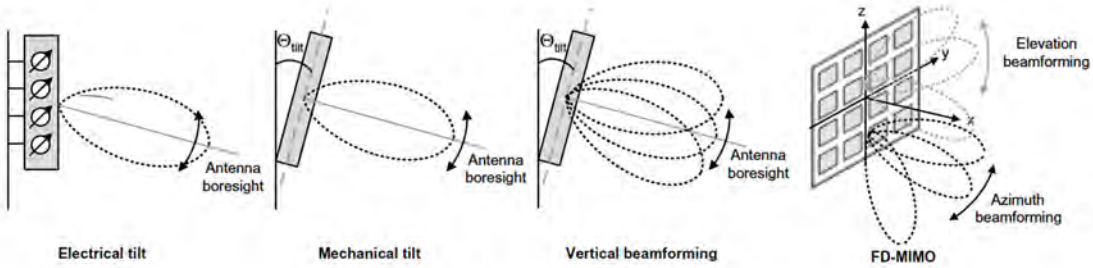
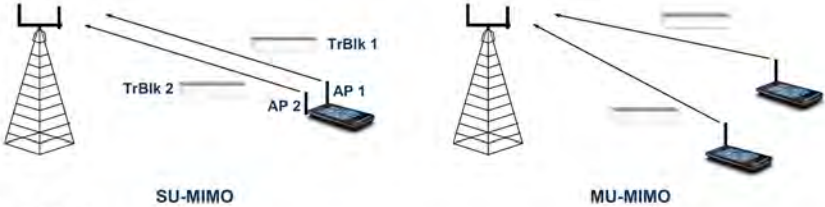
Claim Language	Infringement Contentions																																																																																																																																				
	“Virtually all modern communication systems, including LTE, employ a combination of forward error-correction coding and ARQ, known as hybrid ARQ.”; <i>id.</i> at 98 (“In hybrid ARQ with soft combining, the erroneously received packet is stored in a buffer memory and later combined with the retransmission to obtain a single, combined packet that is more reliable than its constituents. Decoding of the error-correction code operates on the combined signal. If the decoding fails (typically a CRC code is used to detect this event), a retransmission is requested.”); <i>id.</i> at Section 11.4.2.3 (discussing uplink HARQ). <i>See also</i> Contentions for Claim 10, above, discussing MCS, which includes FEC parameters that form portions of the profiles maintained by the controller and stored at the memory portion of the controller. <i>See also</i> 3GPP, TS 38.214 (showing an example of an MCS table that includes “target code rate” as one of the parameters included with the MCS): 3GPP TS 38.214 version 16.11.0 Release 16 27 ETSI TS 138 214 V16.11.0 (2022-09) Table 5.1.3.1-1: MCS index table 1 for PDSCH <table><tr><th>MCS index I_{MCS}</th><th>Modulation Order Q_m</th><th>Target code Rate $R \times [1024]$</th><th>Spectral efficiency</th></tr><tr><td>0</td><td>2</td><td>120</td><td>0.2344</td></tr><tr><td>1</td><td>2</td><td>157</td><td>0.3066</td></tr><tr><td>2</td><td>2</td><td>193</td><td>0.3770</td></tr><tr><td>3</td><td>2</td><td>251</td><td>0.4902</td></tr><tr><td>4</td><td>2</td><td>308</td><td>0.6016</td></tr><tr><td>5</td><td>2</td><td>379</td><td>0.7402</td></tr><tr><td>6</td><td>2</td><td>449</td><td>0.8770</td></tr><tr><td>7</td><td>2</td><td>526</td><td>1.0273</td></tr><tr><td>8</td><td>2</td><td>602</td><td>1.1756</td></tr><tr><td>9</td><td>2</td><td>679</td><td>1.3262</td></tr><tr><td>10</td><td>4</td><td>340</td><td>1.3281</td></tr><tr><td>11</td><td>4</td><td>378</td><td>1.4766</td></tr><tr><td>12</td><td>4</td><td>434</td><td>1.6953</td></tr><tr><td>13</td><td>4</td><td>490</td><td>1.9141</td></tr><tr><td>14</td><td>4</td><td>553</td><td>2.1602</td></tr><tr><td>15</td><td>4</td><td>616</td><td>2.4063</td></tr><tr><td>16</td><td>4</td><td>658</td><td>2.5703</td></tr><tr><td>17</td><td>6</td><td>438</td><td>2.5664</td></tr><tr><td>18</td><td>6</td><td>466</td><td>2.7305</td></tr><tr><td>19</td><td>6</td><td>517</td><td>3.0293</td></tr><tr><td>20</td><td>6</td><td>567</td><td>3.3223</td></tr><tr><td>21</td><td>6</td><td>616</td><td>3.6094</td></tr><tr><td>22</td><td>6</td><td>666</td><td>3.9023</td></tr><tr><td>23</td><td>6</td><td>719</td><td>4.2129</td></tr><tr><td>24</td><td>6</td><td>772</td><td>4.5234</td></tr><tr><td>25</td><td>6</td><td>822</td><td>4.8164</td></tr><tr><td>26</td><td>6</td><td>873</td><td>5.1152</td></tr><tr><td>27</td><td>6</td><td>910</td><td>5.3320</td></tr><tr><td>28</td><td>6</td><td>948</td><td>5.5547</td></tr><tr><td>29</td><td>2</td><td>reserved</td><td></td></tr><tr><td>30</td><td>4</td><td>reserved</td><td></td></tr><tr><td>31</td><td>6</td><td>reserved</td><td></td></tr></table>	MCS index I_{MCS}	Modulation Order Q_m	Target code Rate $R \times [1024]$	Spectral efficiency	0	2	120	0.2344	1	2	157	0.3066	2	2	193	0.3770	3	2	251	0.4902	4	2	308	0.6016	5	2	379	0.7402	6	2	449	0.8770	7	2	526	1.0273	8	2	602	1.1756	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	5.3320	28	6	948	5.5547	29	2	reserved		30	4	reserved		31	6	reserved	
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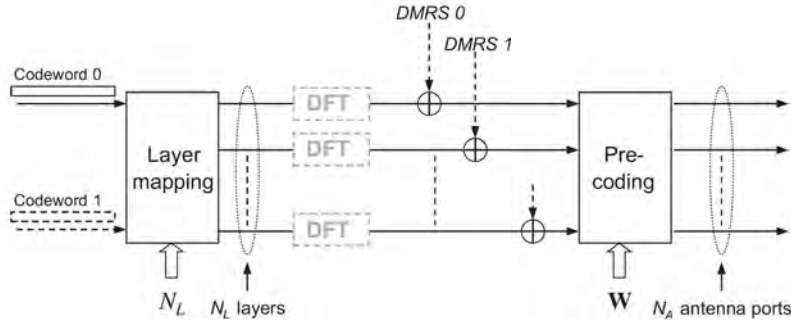
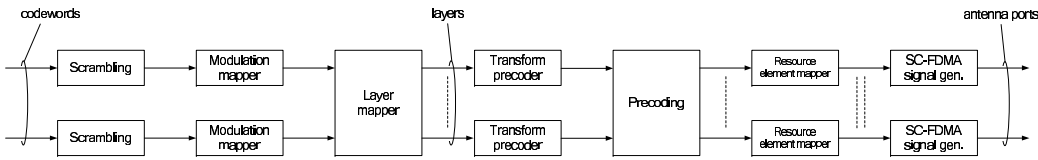
	Claim Language	Infringement Contentions
		To the extent that T-Mobile's 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
13	The apparatus of claim 5 wherein the communication station to which the first and at least second data signals are transmitted by the first and at least second subscriber stations, respectively, exhibits antenna diversity provided by a first antenna transducer and at least a second antenna transducer, the first and at least second data signals transduced by the first and at least second antenna transducer, respectively, combined utilizing antenna combining parameters, and	As discussed above, T-Mobile's 4G and 5G base stations comprise the apparatus of Claim 5. In addition, T-Mobile's 4G and 5G base stations comprise a communication station wherein the communication station to which the first and at least second data signals are transmitted by the first and at least second subscriber stations, respectively, exhibits antenna diversity provided by a first antenna transducer and at least a second antenna transducer, the first and at least second data signals transduced by the first and at least second antenna transducer, respectively, combined utilizing antenna combining parameters. For example, and without limitation, T-Mobile's 4G and 5G base stations include a plurality of antenna transducers which are used in antenna combining techniques such as beamforming (including both transmit and receive beamforming) and MIMO. <i>See, e.g.,</i> Dahlman 5G NR at Section 5.1.9 (discussing the “beam-centric design” of 5G, and noting that “[s]upport for (a large number of) steerable antenna elements for both transmission and reception is a key feature of NR”). <i>See also,</i> Ahmadi 5G NR at Section 4.1.9.3 (Discussing Analog, Digital, and Hybrid Beamforming in 5G). <i>Id.</i> at 564: Large antenna arrays and beamforming play an important role in 5G implementations since both base stations and devices can accommodate a larger number of antenna elements at mmWave frequencies. Aside from a higher directional gain, these antenna types offer complex beamforming capabilities. This allows increasing the capacity of cellular networks by improving the signal-to-interference ratio through direct targeting of user groups. The narrow transmit-beams simultaneously lower the amount of interference in the radio propagation environment and make it possible to maintain sufficient signal power at the receiver terminal at larger distances in rural areas. An important prerequisite for any beamforming architecture is a phase coherent signal, which means that there is a defined and stable phase relationship between all RF carriers. A fixed phase offset between the carriers can be used to steer the main antenna lobe to a desired direction. A major difference between NR and LTE is the support for beamformed control channels, which resulted in different reference signal design for each control channel. The NR physical channels and signals, including those used for control and synchronization, have all been designed to support beamforming. The CSI for operation with a large number of antennas can be obtained via CSI reports from the devices based on transmission of CSI-RSs in the downlink, as well as using uplink measurements exploiting channel reciprocity.

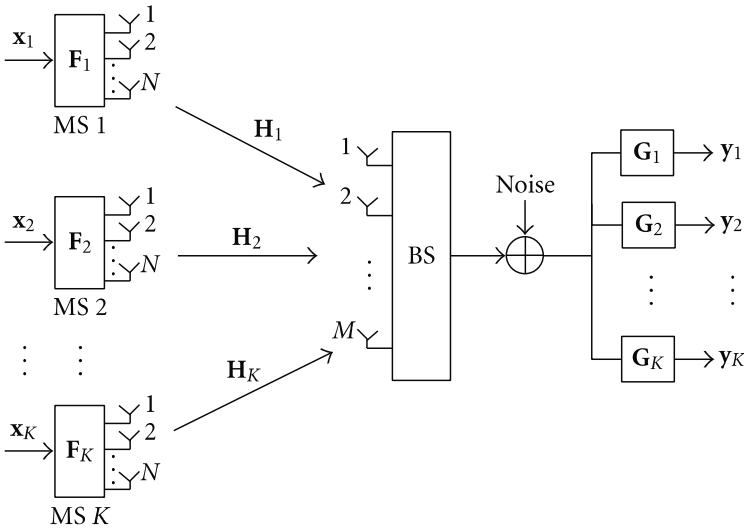
	Claim Language	Infringement Contentions
		<i>Id.</i> at 565 (depicting some basic analog beamforming techniques):  The figure illustrates an analog beamforming transmitter architecture. The block diagram shows a 'Data stream' input to a 'Digital baseband processing' block, which outputs to an 'RF processing' block. The 'RF processing' block is connected to a 'DAC' (Digital-to-Analog Converter) and a 'LPF' (Low-Pass Filter). The output of the LPF is multiplied by a 'LO' (Local Oscillator) signal. The resulting signal is then processed by a 'Phase shifter + PA' (Power Amplifier) block. The output of the PA is connected to an antenna array. The antenna array is shown with four different configurations: 2-Antenna linear array, 4-Antenna linear array, 8-Antenna linear array, and 16-Antenna linear array. Each configuration is accompanied by a radiation pattern plot showing the beam steering capabilities. The plots are polar plots with angles from 0 to 330 degrees. The 2-Antenna array shows a single beam at 0 degrees. The 4-Antenna array shows a beam at 0 degrees and a smaller beam at 180 degrees. The 8-Antenna array shows a beam at 0 degrees and a smaller beam at 180 degrees. The 16-Antenna array shows a beam at 0 degrees and a smaller beam at 180 degrees. The text 'Analog beam steering by phase shifting (-30°, 0°, +30° phase shift and 8 antennas)' is also present. Figure 4.63 Analog beamforming transmitter architecture. <i>Id.</i> at 566 (discussing digital beamforming techniques):

	Claim Language	Infringement Contentions
		While analog beamforming is generally restricted to one RF chain even when using large number of antenna arrays, digital beamforming in theory supports as many RF chains as there are antenna elements. If suitable precoding is performed in the digital-domain baseband, this would yield higher flexibility regarding the transmission and reception. The additional degree of freedom can be leveraged to perform advanced techniques such as multi-beam MIMO. These advantages result in the highest theoretical performance possible compared to other beamforming architectures. Fig. 4.64 illustrates the high-level digital beamforming transmitter architecture with multiple RF chains. Uneven beam is a problem  Figure 4.64 Digital beamforming transmitter architecture. <i>Id.</i> at 567 (noting the use of beamforming in both transmit and receive processing in 5G): Multiple antennas at the transmitter and receiver can be used to achieve array and diversity gain instead of capacity gain. In this case, the same symbol weighted by a complex-valued scale factor is sent from each transmit antenna, so that the input covariance matrix has unit rank. This scheme is referred to as beamforming. It must be noted that there are two conceptually and practically different classes of beamforming: (1) direction-of-arrival beamforming (i.e., adjustment of transmit or receive antenna directivity) and (2) eigen-beamforming (i.e., a mathematical approach to maximize signal power at the receive antenna based on certain criterion). In this section, we only consider eigen-beamforming schemes. <i>Id.</i> at 572 (depicting hybrid beamforming):

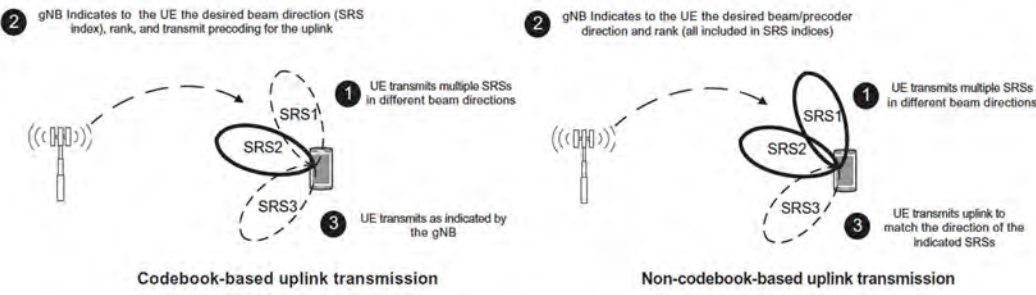
	Claim Language	Infringement Contentions
		 Figure 4.66 Hybrid beamforming architecture. <i>See also id.</i> at Section 4.1.9.4 (Discussing “full-dimension MIMO”). <i>Id.</i> at 574 (depicting various types of beamforming):

	Claim Language	Infringement Contentions
		 Electrical tilt Mechanical tilt Vertical beamforming FD-MIMO Figure 4.67 Illustration of mechanical/electrical tilting, vertical, and 3D beamforming [23]. <i>See also</i> Dahlman 4G at Section 5.5.3 (discussing nonlinear receiver processing in 4G); <i>id.</i> at Section 11.3 (discussing “uplink multi-antenna transmission” including SU-MIMO, MU-MIMO, and beamforming uplink transmissions in 4G). <i>Id.</i> at Figure 11.21 (showing uplink SU-MIMO and MU-MIMO in LTE):  SU-MIMO MU-MIMO FIGURE 11.21 SU-MIMO and MU-MIMO <i>Id.</i> at Figure 11.18 (depicting UE processing for precoder-based multi-antenna uplink transmissions in LTE):

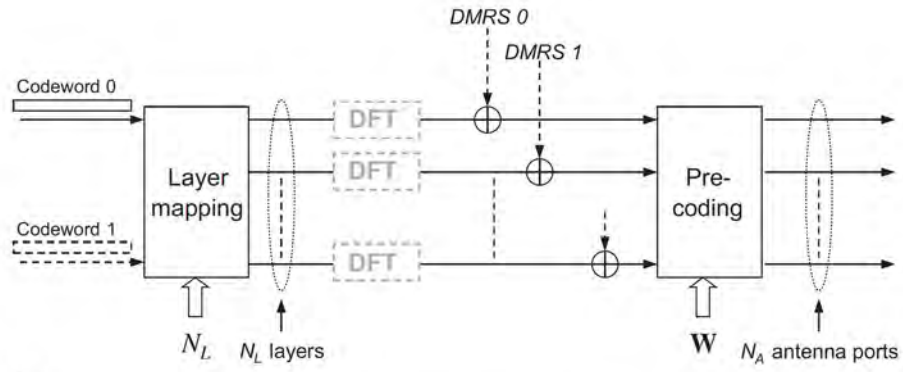
	Claim Language	Infringement Contentions
		 FIGURE 11.18 Precoder-based multi-antenna transmission for LTE uplink A similar example of the transmission processing for a UE transmitting two layers is shown in 3GPP 36.211 Figure 5.3-1:  Figure 5.3-1: Overview of uplink physical channel processing An example of a block diagram of a multi-antenna base station receiver with applied weights to isolate individual transmissions is shown below:

	Claim Language	Infringement Contentions
		 FIGURE 1: Block diagram of an uplink multiuser MIMO wireless system with an M-antenna BS and K mobile users each with N antennas. Hu, Yang: “<i>Combined Transceiver Optimization for Uplink Multiuser MIMO with Limited CSI</i>”, ISRN Signal Processing Volume 2011, Article ID 735695. To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
	wherein the antenna combining parameters form portions of the profiles maintained by the controller and stored at the memory portion of the controller.	The antenna combining parameters in T-Mobile’s 4G and 5G base stations form portions of the profiles maintained by the controller and stored at the memory portion of the controller. For example, and without limitation, T-Mobile’s 4G and 5G base stations utilize pre-coding of antenna combining parameters to maximize the signal from a particular UE while minimizing interference from other sources. <i>See, e.g.</i>, Ahmadi 5G NR at 569 (discussing the “precoding matrices (MIMO codebooks)” in 5G, and some design considerations for them); <i>see also id.</i> (noting that “[b]eamforming relies on long-term statistics of the radio channel,” highlighting the importance of storing antenna combining parameters in the controller); <i>id.</i> at Section 4.2.2.3 (discussing the SRS transmitted from the UE “to enable the gNB to estimate the uplink channel,” including beamforming and MIMO parameters which form portions of

	Claim Language	Infringement Contentions
		the profiles maintained by the controller and stored at the memory portion of the controller); <i>Id.</i> at Section 4.2.4 and 4.2.5 (discussing beamforming and MIMO in the PUSCH); <i>id.</i> at 631: The physical uplink shared channel is used to transmit the user traffic and control information in the uplink. It supports two transmission modes namely codebook-based and non-codebook-based multi-antenna transmission. For codebook-based transmission, the gNB provides the UE with a transmit precoding matrix indication in DCI. The UE uses the indicator to select the PUSCH transmit precoder from a set of codebooks. For non-codebook-based transmission, the UE determines its PUSCH precoder based on (wideband) SRS resource indication (SRI) field from DCI. A closed-loop DM-RS-based spatial multiplexing is supported for PUSCH with up to four transmission layers for SU-MIMO with CP-OFDM waveform. Uplink SU-MIMO uses one codeword. Support of DFT-S-OFDM in the uplink is optional, and when transform precoding is used, only a single MIMO transmission layer is supported. <i>Id.</i> at 638: The NR supports multi-antenna precoding with up to four layers for PUSCH transmission. However, when uplink DFT-based transform precoding is enabled, only single-layer (rank 1) transmission is supported. The UE can be configured in either codebook-based or non-codebook-based modes for PUSCH transmission. The selection between these two modes depends on the extent to which the uplink channel conditions can be estimated by the UE based on downlink measurements. PUSCH DM-RSs are precoded in the same way that PUSCH data subcarriers are precoded to allow coherent demodulation, making uplink precoding transparent to the gNB receiver. When codebook-based precoding is used in the uplink, the scheduling grant includes information about the precoder in the same way that the UE provides the network with PMI to assist downlink multi-antenna precoding. However, in contrast to the downlink, where the network may or may not use the precoder matrix indicated by the PMI, in the uplink direction, the UE is expected to use the precoder suggested by the network. In case of non-codebook-based transmission, the network can influence the selection of the uplink precoder. Another aspect that may impose constraints <i>Id.</i> at 640 (simplified depiction of codebook and non-codebook based uplink transmission in 5G):

	Claim Language	Infringement Contentions
		 Figure 4.89 Codebook-based uplink transmission versus non-codebook-based uplink transmission [69]. <i>Id.</i> at 640: As we mentioned earlier, codebook-based and non-codebook-based transmission modes are supported for PUSCH transmission. The UE will be configured with codebook-based transmission, when the RRC parameter <i>txConfig</i> in <i>pusch-Config</i> is set to “codebook”, and it will be configured with non-codebook-based transmission, when the RRC parameter <i>txConfig</i> is set to “nonCodebook”. If the RRC parameter <i>txConfig</i> is not provided, the <i>See also</i>, Dahlman 5G at Section 4.4 (discussing some of the “multi-antenna enhancements” in 5G, including some related to beamforming and MIMO); <i>Id.</i> at 47 (noting the control exercised by the base station in beamforming): In release 10, downlink spatial multiplexing was expanded to support up to eight transmission layers. This can be seen as an extension of the release-9 dual-layer beamforming to support up to eight antenna ports and eight corresponding layers. Together with the support for carrier aggregation, this enables downlink data rates up to 3 Gbit/s in 100 MHz of spectrum in release 10, increased to 25 Gbit/s in release 13 using 32 carriers, eight layers spatial multiplexing, and 256QAM. Uplink spatial multiplexing of up to four layers was also introduced as part of LTE release 10. Together with the possibility for uplink carrier aggregations this allows for uplink data rates up to 1.5 Gbit/s in 100 MHz of spectrum. Uplink spatial multiplexing consists of a codebook-based scheme under the control of the base station, which means that the structure can also be used for uplink transmitter-side beamforming. <i>Id.</i> at 163:

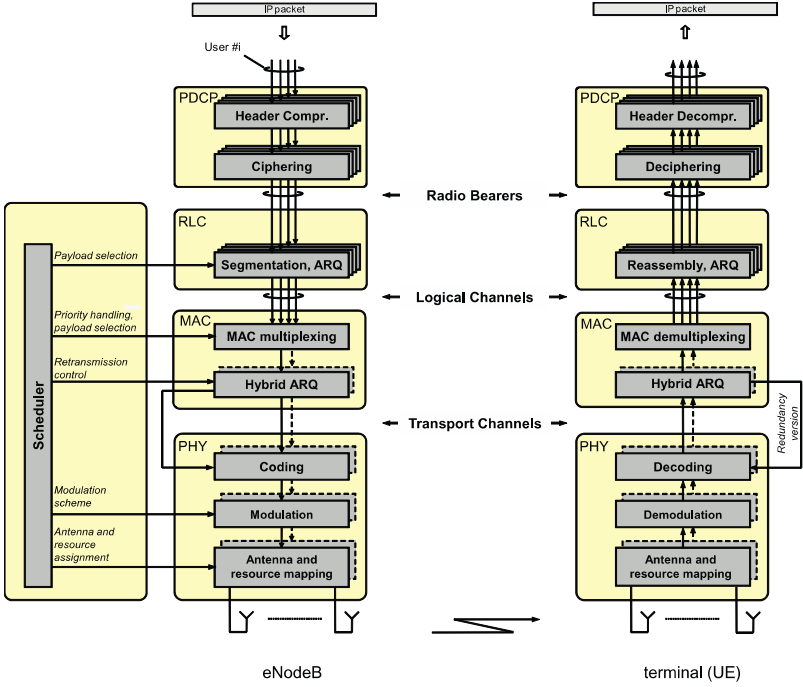
	Claim Language	Infringement Contentions
		A device can be configured with multiple SRS resource sets that can be used for different purposes, including both downlink and uplink multi-antenna precoding and downlink and uplink beam management. <i>Id.</i> at Sections 11.3.1 and 11.3.2 (discussing codebook and non-codebook based precoding for uplink transmissions in 5G; regardless of whether codebook or non-codebook precoding is used, the precoding forms portions of the profiles maintained by the controller and stored at the memory portion of the controller); <i>Id.</i> at 12.2.3 (discussing some of the ways that uplink beamforming parameters are adjusted over time; these parameters form portions of the profiles maintained by the controller and stored at the memory portion of the controller): Uplink beam adjustment serves the same purpose as downlink beam adjustment, that is, to retain a suitable beam pair, which, in the case of uplink beam adjustment, implies a suitable transmitter beam at the device side and a corresponding suitable receiver beam at the network side. As discussed earlier, if sufficient beam correspondence can be assumed and if a suitable downlink beam pair has been established and retained, explicit uplink beam management is not needed. Rather, a suitable beam pair for the downlink transmission direction can be assumed to be suitable also for the uplink direction. Note that the opposite would also be true, that is, if a suitable beam pair is established and retained for the uplink direction, the same beam pair could also be used in the downlink direction without the need for explicit downlink beam management. If explicit uplink beam adjustment is needed it can be done in essentially the same way as for downlink beam adjustment with the main difference being that measurements are done by the network based on configured SRS, rather than CSI-RS or SS block. Similarly, in 4G, base stations maintain and store antenna combining parameters related to beamforming and MIMO for UEs in the cell. <i>See, e.g.</i>, Dahlman 4G at 11.3 (discussing uplink multi-antenna transmission, including both beamforming and MIMO); <i>Id.</i> at Figure 11.18:

	Claim Language	Infringement Contentions
		 FIGURE 11.18 Precoder-based multi-antenna transmission for LTE uplink <i>Id.</i> at 263: place at the transmitter side. However, for LTE the uplink precoder matrix is selected by the network and conveyed to the terminal as part of the scheduling grant. The terminal should then follow the precoder matrix selected by the network. Thus, in the uplink, the precoder is visible in the specification and, in order to limit the downlink signaling, there is a limited set of precoder matrices specified for each transmission rank.

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		More specifically, for each combination of transmission rank N_L and number of antennas ports N_A, a set of precoder matrices of size $N_A \times N_L$ is defined, as illustrated in Tables 11.1 and 11.2 for two and four antenna ports respectively. For full-rank transmission—that is, when the transmission rank or number of layers equals the number of transmit antennas—only a single precoder matrix is defined, namely the identity matrix of size $N_A \times N_A$ (not shown in the tables). Note that, for the case of four antenna ports, only a subset of the defined matrices is shown. In total there are 24 rank-1 matrices, 16 rank-2 matrices, and 12 rank-3 matrices defined for four antenna ports, in addition to the single rank-4 matrix. As can be seen, all the precoder matrices in Table 11.1 contain one and only one non-zero element in each row, and this is generally true for all precoder matrices defined for the uplink. As a consequence, the signal transmitted on a certain antenna port (corresponding to a certain row of the precoder matrix) always depends on one and only one specific layer (corresponding to a specific column of the precoder matrix). Expressed alternatively, the precoder matrix maps the layers to the antenna ports <i>with at most one layer being mapped to each antenna port</i>. Due to this, the good cubic-metric properties of the transmitted signal are also preserved for each antenna port when antenna precoding is applied. The precoder matrices of Tables 11.1 and 11.2 are therefore also referred to as <i>cubic-metric-preserving precoder matrices</i>. In order to select a suitable precoder, the network needs information about the uplink channel. Such information can, for example, be based on measurements on the uplink sounding reference signals (Section 11.2.2). As indicated in Figure 11.20, sounding reference signals (SRS) are transmitted non-precoded—that is, directly on the different antenna ports. The received SRS thus reflect the channel of each antenna port, not including any precoding. <table><tr><th colspan="7">Table 11.1 Uplink Precoder Matrices for two Antenna Ports</th></tr><tr><th rowspan="2">Transmission Rank</th><th colspan="6">Codebook Index</th></tr><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr><tr><td>1</td><td>$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$</td><td>$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -1 \end{bmatrix}$</td><td>$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ j \end{bmatrix}$</td><td>$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -j \end{bmatrix}$</td><td>$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 0 \end{bmatrix}$</td><td>$\frac{1}{\sqrt{2}} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$</td></tr><tr><td>2</td><td>$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr></table>	Table 11.1 Uplink Precoder Matrices for two Antenna Ports							Transmission Rank	Codebook Index						0	1	2	3	4	5	1	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -1 \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ j \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -j \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 0 \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$	2	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$	-	-	-	-	-
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Transmission Rank	Codebook Index																																			
	0	1	2	3	4	5																														
1	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -1 \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ j \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -j \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 0 \end{bmatrix}$	$\frac{1}{\sqrt{2}} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$																														
2	$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$	-	-	-	-	-																														

	Claim Language	Infringement Contentions																																			
		Table 11.2 Subset of Uplink Precoder Matrices for Four Antenna Ports and Different Transmission Ranks <table><tr><th rowspan="2">Transmission Rank</th><th colspan="5">Codebook Index</th></tr><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>...</th></tr><tr><td>1</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ -1 & 1 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ j & 1 \\ j & 1 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ -1 & 1 \\ 1 & 1 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ -j & 1 \\ -j & 1 \end{bmatrix}$</td><td>...</td></tr><tr><td>2</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & -j & 1 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & j & 1 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ -j & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ -j & 0 & 0 \\ 0 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$</td><td>...</td></tr><tr><td>3</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix}$</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix}$</td><td>...</td></tr><tr><td>4</td><td>$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$</td><td>-</td><td>-</td><td>-</td><td>...</td></tr></table> FIGURE 11.20 Illustration of SRS transmitted <i>after</i> uplink antenna precoding Regardless of whether codebook or non-codebook precoding is used, the precoding forms portions of the profiles maintained by the controller and stored at the memory portion of the controller. To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one	Transmission Rank	Codebook Index					0	1	2	3	...	1	$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ -1 & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ j & 1 \\ j & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ -1 & 1 \\ 1 & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ -j & 1 \\ -j & 1 \end{bmatrix}$	...	2	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & -j & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & j & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ -j & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ -j & 0 & 0 \\ 0 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$	...	3	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix}$	...	4	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$	-	-	-	...
Transmission Rank	Codebook Index																																				
	0	1	2	3	...																																
1	$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ -1 & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ j & 1 \\ j & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ -1 & 1 \\ 1 & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ -j & 1 \\ -j & 1 \end{bmatrix}$	...																																
2	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & -j & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & j & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ -j & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 \\ -j & 0 & 0 \\ 0 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$	...																																
3	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix}$	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix}$	...																																
4	$\frac{1}{2} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$	-	-	-	...																																

	Claim Language	Infringement Contentions
		or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
14	The apparatus of claim 5 wherein profiles maintained by the controller and stored at the memory portion thereof comprise values of Band timing adjustments by which to adjust the first and at least second data signals.	As discussed above, T-Mobile's 4G and 5G base stations comprise the apparatus of Claim 5. In addition, T-Mobile's 4G and 5G base stations include profiles wherein profiles maintained by the controller and stored at the memory portion thereof comprise values of Band timing adjustments by which to adjust the first and at least second data signals. For example and without limitation, controllers in T-Mobile's 4G and 5G base stations set and store frequency and time adjustment parameters for each UE. In 4G base stations, controllers in the eNodeB calculate and stores time/frequency resource blocks, modulation and coding schemes, antenna mapping, precoding schemes, and other signal-related and channel-related parameters in the block labeled "Scheduler" in Dahlman. When allocating the next uplink for each UE, the eNodeB retrieves these parameters and includes them in the uplink allocation. The eNodeB's controller also maintains and stores these parameters to aid in decoding uplink transmissions as shown in Dahlman Figure 8.4:

	Claim Language	Infringement Contentions
		 FIGURE 8.4 LTE protocol architecture (downlink). See Dahlman 4G LTE/LTE Advanced for Mobile Broadband. The process of setting, maintaining, and storing Band timing adjustments for UEs in the cell also includes, but is not limited to, the parameters that are established on the “Random Access Channel” or “RACH.” <i>See</i> 3GPP TS 36.331 14.16.0 pg. 427 for the RACH-ConfigCommon information element and pg. 428 for the RACH-ConfigCommon field descriptions. The Random Access procedure is described in 3GPP TS 36.321 version 14.13.0 §5.1. Processing (by the UE) of a Random Access Response is described in 3GPP TS 36.321 version 14.13.0 §5.1.4, including the following clause describing the determined parameters sent by the controller, including Band timing adjustments:

	Claim Language	Infringement Contentions
		- if the Random Access Response contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble (see clause 5.1.3), the MAC entity shall: - consider this Random Access Response reception successful and apply the following actions for the serving cell where the Random Access Preamble was transmitted: - process the received Timing Advance Command (see clause 5.2); - indicate the <i>preambleInitialReceivedTargetPower</i> and the amount of power ramping applied to the latest preamble transmission to lower layers (i.e., (PREAMBLE_TRANSMISSION_COUNTER – 1) * <i>powerRampingStep</i>); - if the SCell is configured with <i>ul-Configuration-r14</i>, ignore the received UL grant otherwise process the received UL grant value and indicate it to the lower layers; - if, except for NB-IoT, <i>ra-PreambleIndex</i> was explicitly signalled and it was not 000000 (i.e., not selected by MAC): - consider the Random Access procedure successfully completed. - else if, the UE is an NB-IoT UE, <i>ra-PreambleIndex</i> was explicitly signalled and it was not 000000 (i.e., not selected by MAC) and <i>ra-CFRA-Config</i> is configured: - consider the Random Access procedure successfully completed. - the UL grant provided in the Random Access Response message is valid only for the configured carrier (i.e. UL carrier used prior to this Random Access procedure). Following the initial access, the base station controller will adjust the Band timing adjustment parameters in response to changes in signal and/or channel characteristics. Similarly, for 5G/NR, the gNodeB calculates and stores time/frequency resource blocks, modulation and coding schemes, antenna mapping, precoding schemes, and other signal-related and channel-related parameters in the block labelled “UE Configuration” in Ahmadi. When allocating the next uplink for each UE, the gNodeB retrieves these parameters and includes them in the uplink allocation. The gNodeB’s controller also maintains and stores these parameters to aid in decoding uplink transmissions as shown Ahmadi 5G NR Figure 4.72 pg. 591. Like in 4G, Band timing adjustments in 5G NR base stations may be set during initial access, subsequent transmissions, and/or further adjusted over time. To the extent that T-Mobile’s 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
15	The apparatus of claim 5 wherein profiles maintained by the controller and stored at the memory portion	As discussed above, T-Mobile’s 4G and 5G base stations comprise the apparatus of Claim 5. In addition, T-Mobile’s 4G and 5G base stations include profiles wherein profiles maintained by the controller and stored at the memory portion thereof comprise values of residual carrier adjustments by

	Claim Language	Infringement Contentions
	thereof comprise values of residual carrier adjustments by which to adjust the first and at least second data signals.	which to adjust the first and at least second data signals. For example and without limitation, T-Mobile's 4G and 5G base stations utilize residual carrier adjustments to minimize the effects of the carrier frequency and timing offsets that can occur between base stations and UEs. These residual carrier adjustments are determined and maintained by the base station controller, and stored at the memory portion thereof. These adjustments are periodically updated based on measurements of the communications between the base station and the UE. <i>See, e.g.</i>, Ahmadi 5G NR at Section 3.2.1.5 (discussing carrier frequency offset in 5G); Dahlman 4G at Chapter 3 (discussing OFDM transmission in 4G, and the frequency inaccuracies that can arise); <i>id.</i> at Section 4.1.9.6 ("In NR, the DM-RS and the TRS are used to estimate the timing offset and frequency errors."). To the extent that T-Mobile's 4G or 5G base stations include cloud-based controllers that perform one or more of the limitations described here, those base stations also infringe, at least under the doctrine of equivalents.
16	A method for acting upon first and second successive data signals transmitted to a communication station operable in a wireless communication system by a first subscriber station and at least a second subscriber station, the method comprising:	To the extent the preamble is limiting, T-Mobile's 4G and 5G base stations perform a method for acting upon first and second successive data signals transmitted to a communication station operable in a wireless communication system by a first subscriber station and at least a second subscriber station. <i>See</i> Contentions for Claim 1 Preamble, above.

	Claim Language	Infringement Contentions
16.1	selecting at which of a first demodulator and at least a second demodulator to apply at least one of the first data signals and the second data signals, wherein the first and second successive data signals and any subsequent data signals are alternately applied to the first and second demodulators; demodulating the at least one of the first and at least second data signals at the first demodulator when the first demodulator is selected during the operation of selecting; and demodulating the at least one of the first and at least second data signals at the second demodulator when the second demodulator is selected during the operation of selecting; and	<i>See</i> Contentions for Claim 1, Elements 1.1, 1.2, and 1.4 above.
16.2	maintaining profiles associated with each of the first and at least second data signals transmitted upon the first and at least second channels, respectively, and wherein the operations of demodulating further comprise accessing the profiles.	<i>See</i> Contentions for Claim 5, Element 5.3, above.

	Claim Language	Infringement Contentions
17	The method of claim 16 wherein selections made during the operation of selecting are made according to a selected pattern.	<i>See</i> Contentions for Claim 1, Element 1.4, above.

Exhibit D

PRODBEG	PRODEND
GA0001936	GA0001937
GA0001939	GA0001939
GA0001942	GA0001980
GA0002025	GA0002076
GA0002247	GA0002258
GA0002261	GA0002277
GA0002294	GA0002300
GA0002302	GA0002302
GA0002306	GA0002318
GA0002322	GA0002330
GA0002462	GA0002479
GA0002509	GA0002528
GA0002609	GA0002609
GA0002662	GA0002662
GA0002690	GA0002690
GA0002849	GA0002849
GA0002957	GA0002976
GA0002978	GA0002984
GA0002987	GA0002993
GA0002999	GA0003009
GA0003012	GA0003019
GA0003121	GA0003121
GA0003164	GA0003164
GA0003175	GA0003175
GA0003374	GA0003374
GA0003377	GA0003377
GA0003394	GA0003394
GA0003404	GA0003404
GA0003425	GA0003426
GA0003478	GA0003478
GA0003525	GA0003526
GA0003535	GA0003535
GA0003560	GA0003561
GA0003600	GA0003600
GA0003626	GA0003626
GA0003722	GA0003722
GA0003819	GA0003819
GA0003858	GA0003859
GA0003899	GA0003899
GA0003926	GA0003927
GA0003934	GA0003935
GA0003998	GA0003998

PRODBEG	PRODEND
GA0004012	GA0004013
GA0004017	GA0004018
GA0004050	GA0004051
GA0004079	GA0004079
GA0004081	GA0004082
GA0004089	GA0004089
GA0004111	GA0004111
GA0004114	GA0004116
GA0004123	GA0004124
GA0004149	GA0004149
GA0004161	GA0004162
GA0004168	GA0004169
GA0004204	GA0004205
GA0004227	GA0004227
GA0004240	GA0004241
GA0004249	GA0004250
GA0004271	GA0004271
GA0004618	GA0004638
GA0004736	GA0004739
GA0004868	GA0005029
GA0005277	GA0005323
GA0006244	GA0006397
GA0009493	GA0009583
GA0011034	GA0011105
GA0011472	GA0011477
GA0011479	GA0011522
GA0011524	GA0011947
GA0011974	GA0012087
GA0012114	GA0012114
GA0012116	GA0012118
GA0012120	GA0012124
GA0012126	GA0012151
GA0012153	GA0012153
GA0012155	GA0012166
GA0012168	GA0012169
GA0012171	GA0012172
GA0012174	GA0012174
GA0012176	GA0012177
GA0012179	GA0012180
GA0012182	GA0012183
GA0012185	GA0012185
GA0012191	GA0012191

PRODBEG	PRODEND
GA0012193	GA0012193
GA0012843	GA0012861
GA0012947	GA0012956
GA0012973	GA0013022
GA0013312	GA0013358
GA0013396	GA0013491
GA0013494	GA0013494
GA0013518	GA0013519
GA0013529	GA0013532
GA0013540	GA0013540
GA0013551	GA0013583
GA0013621	GA0013670
GA0013683	GA0013697
GA0013775	GA0013779
GA0013792	GA0013804
GA0013884	GA0013888
GA0013891	GA0013896
GA0014128	GA0014130
GA0014157	GA0014167
GA0014180	GA0014201
GA0014204	GA0014228
GA0014244	GA0014244
GA0014255	GA0014255
GA0014261	GA0014263
GA0014275	GA0014285
GA0014287	GA0014342
GA0014352	GA0014371
GA0014376	GA0014381
GA0014776	GA0014777
GA0014779	GA0014806
GA0014808	GA0014812
GA0014820	GA0014820
GA0014937	GA0014938
GA0014940	GA0014966
GA0014968	GA0014971
GA0014973	GA0014977
GA0014979	GA0014979
GA0028211	GA0028283
GA0029012	GA0029035
GA0062403	GA0062525
GA0076949	GA0076954

Exhibit E

PRODBEG	PRODEND
GA0000010	GA0001917
GA0001936	GA0001937
GA0001943	GA0001948
GA0001976	GA0001980
GA0002075	GA0002076
GA0002306	GA0002307
GA0002319	GA0002365
GA0002404	GA0002460
GA0002464	GA0002479
GA0002489	GA0002528
GA0002537	GA0002564
GA0002566	GA0002593
GA0002595	GA0003139
GA0003142	GA0003146
GA0003150	GA0003159
GA0003164	GA0004242
GA0004245	GA0004250
GA0004252	GA0004255
GA0004257	GA0004266
GA0004268	GA0004273
GA0004475	GA0004476
GA0004618	GA0004638
GA0004736	GA0004739
GA0004868	GA0005029
GA0005225	GA0005233
GA0005240	GA0005276
GA0005322	GA0005323
GA0005411	GA0006620
GA0006976	GA0009403
GA0009493	GA0009652
GA0009713	GA0009716
GA0009729	GA0009729
GA0009736	GA0010559
GA0010610	GA0010988
GA0011034	GA0011105
GA0011121	GA0011132
GA0011166	GA0011171
GA0011320	GA0011329
GA0011448	GA0011473
GA0011480	GA0011522
GA0011554	GA0011947
GA0011974	GA0012087

PRODBEG	PRODEND
GA0012123	GA0012123
GA0012156	GA0012166
GA0012185	GA0012185
GA0012191	GA0012191
GA0012193	GA0012193
GA0012843	GA0012861
GA0012884	GA0012911
GA0013279	GA0013288
GA0013312	GA0013358
GA0013396	GA0013491
GA0013494	GA0013494
GA0013518	GA0013519
GA0013529	GA0013779
GA0013809	GA0013809
GA0013884	GA0013888
GA0013891	GA0013896
GA0014069	GA0014098
GA0014131	GA0014134
GA0014157	GA0014173
GA0014180	GA0014236
GA0014244	GA0014244
GA0014246	GA0014247
GA0014249	GA0014250
GA0014254	GA0014255
GA0014257	GA0014259
GA0014261	GA0014263
GA0014269	GA0014269
GA0014286	GA0014342
GA0014347	GA0014347
GA0014352	GA0014372
GA0014376	GA0014381
GA0014383	GA0014493
GA0014776	GA0014777
GA0014779	GA0014806
GA0014808	GA0014812
GA0014820	GA0014820
GA0014940	GA0014953
GA0014964	GA0014965
GA0014973	GA0014977
GA0014979	GA0014979