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(54) **COMMUNICATION SUPPORT FOR LOW CAPABILITY DEVICES**

(71) Applicant: **Samsung Electronics Co., Ltd.**, Gyeonggi-do (KR)

(72) Inventors: **Aris Papasakellariou**, Houston, TX (US); **Hyoung-Ju Ji**, Seoul (KR); **Young-Bum Kim**, Seoul (KR)

(73) Assignee: **Samsung Electronics Co., Ltd** (KR)

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(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,144,065	B2	9/2015	Papasakellariou
9,538,521	B2	1/2017	Papasakellariou

(Continued)

FOREIGN PATENT DOCUMENTS

KR	10-2011-0088452	8/2011
WO	WO 2009/128677	10/2009
WO	WO 2010/107604	9/2010

Primary Examiner — Anh Vu H Ly

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

Methods for performing communication by a user equipment (UE) and a base station (BS) in a wireless communication system, a UE, and a BS are provided. The method for performing communication by the UE includes identifying a starting orthogonal frequency division multiplexing (OFDM) symbol for a downlink (DL) channel in a subframe based on higher layer signaling; identifying a bandwidth of the DL channel based on a modulo operation using a cell identity and a predetermined number; and receiving the DL channel in the subframe based on the starting OFDM symbol and the bandwidth.

20 Claims, 17 Drawing Sheets