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(71) Applicant: **SATIXFY ISRAEL LTD.** [IL/IL]; 12 HaMada Strret, 7670314 Rehovot (IL).

(72) Inventor: **RAINISH, Doron**; 4 Kish Street, 5231282 Ramat Gan (IL).

(74) Agent: **INGEL, Gil**; Alef. Gimel. - Intellectual Property Consulting Ltd., P.O. Box 2079, 7612002 Rehovot (IL).

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(54) Title: A SYSTEM THAT INTEGRATES A COMMUNICATION SATELLITE NETWORK WITH A CELLULAR NETWORK

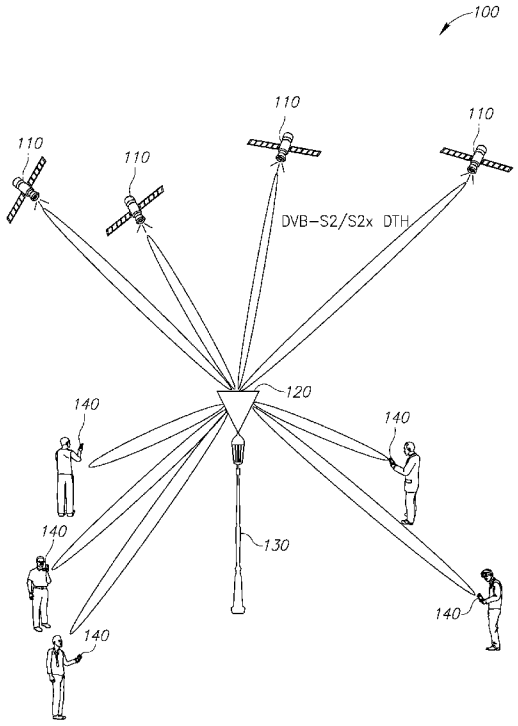

FIG.1

(57) Abstract: The present invention provides a communication unit that is configured to receive traffic from a plurality of satellites over respective satellite links and to re-distribute the received traffic over a terrestrial cellular network to a plurality of mobile devices located at the vicinity of the communication unit, wherein the communication unit is adapted to be mounted on an object having unobstructed sky view, such as a lamp post.

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[Continued on next page]

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A SYSTEM THAT INTEGRATES A COMMUNICATION SATELLITE NETWORK WITH A CELLULAR NETWORK

Field of the Disclosure

The present disclosure relates to the field of communications and in particularly to communications exchanged in satellite and terrestrial cellular communications systems.

Background of the Disclosure

A communications satellite is an artificial satellite that relays and amplifies radio telecommunications signals via a transponder; it creates a communication channel between a source transmitter and receivers at different locations on Earth. Communications satellites are used for television, radio, internet and military applications.

Wireless communication uses electromagnetic waves to carry signals. The purpose of communications satellites is to relay the signal around the curve of the earth allowing communication between widely separated points. Communications satellites use a wide range of radio and microwave frequencies.

The term "satellite system(s)" referred to hereinbelow, should be understood to encompass any one or more members of the group that consists of geo-stationary satellite systems, Low Earth Orbit ("LEO") satellite systems and Medium Earth Orbit ("MEO") satellite systems and other types of platforms such as High-Altitude Platforms ("HAP") which are quasi-stationary aircrafts that provide means of delivering a service to a large area while remaining in the air for long periods of time, High-altitude, long-endurance unmanned aerial vehicles ("HALE UAV"), and the like.

The term "phased array antenna" referred to hereinbelow, should be understood to encompass any one or more members of a group that consists of electrically steering antennas, including antennas that controlls, on top of the phase of each antenna element, the gain of each element and the delay of each element (which may be referred to as "true time delay"), and the like.

The term "base station" as used herein throughout the specification and claims, should be understood to encompass any one or more members of a group that consists of a cellular base station, a cellular mini base station, a cellular micro base station, a cellular nano base station, a cellular base station that is optimized to support only broadcast services, and the like.

A cellular network or mobile network is a communication network where the last link is wireless. The network is distributed over land areas referred to as "cells", each served by at least one fixed-location transceiver referred to as a base station which provides the associated cells with the network coverage which can be used for transmission of voice, data, etc.

When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones, tablets and laptops) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via the base stations, even if some of the transceivers are moving through more than one cell during transmission.

Terrestrial networks can enhance satellite communications system availability, efficiency and/or economic viability. In particular, it is known that it may be difficult for satellite systems to reliably serve densely

populated areas, because satellite signals may be blocked by high-rise structures and/or may not penetrate into buildings. As a result, satellite spectrum may be underutilized or unutilized in such areas. A terrestrial relaying can reduce or eliminate this potential problem.

Moreover, the capacity of an overall hybrid system, comprising space-based (i.e., satellite) and terrestrial communications capability, may be increased by the introduction of terrestrial relaying. In fact, capacity may be enhanced where it may be mostly needed, i.e., in densely populated urban/industrial/commercial areas. As a result, the overall system may become more effectively.

One example of terrestrial relay is described in US 5,937,332. It describes satellite telecommunications repeaters which receive, amplify, and locally retransmit the downlink/uplink signal received from a satellite, thereby increasing an effective downlink/uplink margin in the vicinity of the satellite telecommunications repeater and allowing an increase in the penetration of uplink and downlink signals into buildings, foliage, transportation vehicles, and other objects which can reduce link margin.

Summary of the Disclosure

Therefore, it is an object of the present invention to provide a communication unit that enables integrating part of a communication satellite network with part of a cellular network.

It is another object of the present invention to provide a communication unit that enables integrating part of a communication satellite network with part of a cellular network that can be mounted on an object having a

substantially unobstructed sky view, such as for example a lamp post.

It is another object of the present invention to provide a system that comprises a communication unit that enables integrating part of a communication satellite network with part of a cellular network, and wherein at least one communication satellite of the communication satellite network may be used as a system configured for providing control and data channels for use in the cellular network.

Other objects of the present invention will become apparent as the description of the invention proceeds.

According to a first embodiment of the disclosure, a method is provided a communication unit configured to be wirelessly connected with a plurality of satellites and a plurality of mobile devices, and wherein the communication unit is adapted to be mounted on an object having unobstructed sky view.

The term "mobile devices" as used herein through the specification and claims, is used to denote a mobile terminal such as a mobile telephone, a laptop, a tablet, a PDA, and the like.

According to another embodiment, the object having unobstructed sky view is a lamp post.

By yet another embodiment, the communication unit is configured to receive traffic from the plurality of satellites over respective satellite links and re-distributes the received traffic over a terrestrial wireless network (e.g. a cellular network) to the plurality of mobile devices, preferably wherein the mobile devices are physically located at the vicinity of the communication unit.

In accordance with another embodiment, the communication unit comprises a multi-beam antenna for transmitting and receiving communications from a plurality of satellites, a multi-satellite transceiver, equipped with a multi-beam phased array, where each beam points to a different satellite, a manager unit for managing traffic being exchanged between the satellites and the mobile devices, at least one cellular base station module. Preferably, the at least one cellular base station module is compatible with the 4G/5G cellular standard or higher.

According to still another embodiment, the at least one cellular base station module is configured to communicate with a plurality of mobile devices associated therewith that are located at its vicinity using MIMO/ Massive MIMO/ or high frequency multi-beamforming.

According to another aspect of the present invention, there is provided a communication system comprising at least one communication unit described hereinabove, and at least one communication satellite, and wherein the at least one communication satellite is configured for providing the at least one cellular base station module of the communication unit with control and data channels for conveying communications to and from the cellular network to the communication satellite network.

In accordance with another embodiment of the disclosure, the communication system is further configured to enable re-distribution of broadcast traffic along existing broadcast satellite channels to mobile devices, by obtaining direct access to a plurality of communication channels without being required to convey the broadcasted traffic via a central cellular network entity that is connected to cellular base stations of the cellular network.

By yet another embodiment, the system provided comprises a plurality of communication satellites, and wherein broadcast transmissions available from several communication satellites are transferable upon demand to the plurality of mobile devices.

Brief Description of the Drawings

The present invention will be more fully understood from the following detailed description of the embodiments thereof, taken together with the drawings in which:

FIG. 1 – illustrates an embodiment of the present invention, wherein an integrated system which encompasses both a communication satellite part and a cellular part is depicted; and

FIG. 2 – demonstrates an embodiment showing a communication unit block diagram, which enables exchanging communications between the communication satellite part and the cellular part of the integrated system of FIG. 1.

Detailed Description of the Disclosure

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a better understanding of the present invention by way of examples. It should be apparent, however, that the present invention may be practiced without these specific details.

The underlying concept of the solution provided by the present invention relates to a network that integrates operation of a communication satellite component with that of small cells that provide local coverage, so that the latter may be used for offering cellular services (especially 4G and newer) by cellular service providers.

The solution provided by the present invention allows re-distribution of broadcast traffic (e.g. video) from existing broadcast satellite channels to mobile devices such as cellular phones and alike. This in turn enables saving cellular infrastructure as well as bandwidth of the cellular network, by obtaining for example direct access to hundreds or thousands of high resolution video channels, without the need to connect the cellular base stations of the cellular network to a central cellular network entity (e.g. a central network station).

FIG. 1 illustrates a schematic view of that concept. System 100 presents a number of communication satellites 110, each of which is configured to communicate with a communication unit 120 mounted in this example on a lamp post 130 (or possibly on any other object having unobstructed sky view as much as possible). Communication unit 120 is configured to receives traffic from communication satellites 110 over respective satellite links and re-distributes it over the terrestrial network to multiple users 140 that are physically located at the vicinity of communication unit 120.

The communications may be exchanged between communication satellites 110 and communication unit 120 for example by using DVB-S2/ DVB-S2X standard (EN 302 307, part I and part II).

FIG. 2 exemplifies an embodiment showing a detailed block diagram of a communication unit which enables exchanging communications between the communication satellite part and the cellular part of the integrated system illustrated in FIG. 1.

The exemplified communication unit 200 comprises a multi-beam antenna 210 which operates at any applicable band

such as for example Ku/Ka, for transmitting and receiving communications from different communication satellites. Such an antenna that employs for example a Ku and/or a Ka Band for communicating with geostationary satellite, is capable of working at these frequency ranges without the need of any manual change or handling of the system.

Communication unit 200 further comprises a multi-satellite transceiver 220, equipped with a multi-beam phased array, where each beam points to a different communication satellite. The transceiver is connected in this example, via a manager unit 230, to cellular (4G/5G) base stations 240 and 240' (preferably of the fifth generation, 5G) serving the users that are located in their vicinity using MIMO/ Massive MIMO/ or high frequency multi-beamforming.

For the 4G/5G base stations 240 and 240', the respective communication satellite serves for providing control and data channels, whereas broadcast transmissions, available from several communication satellites could be transferred to the users (the mobile devices), upon demand, e.g. via 5G EMBS (Enhanced Multimedia Broadcast Service), or by other applicable means such as a broadcast transmitter operative according to a terrestrial video broadcast standard (e.g. DVB-T, DVB-T2, ASTC, ISDB-3, DVB-H etc.)

As can be appreciated by those skilled in the art, the solution provided by the present invention may also apply to Verticals such as multimedia and entertainment, transportation, public safety verticals, IoT in underserved area, by providing services to remotely located base stations, and like, and they should all be understood to be encompassed by within the scope of the present invention.

The present invention has been described using detailed descriptions of embodiments thereof that are provided by way

of example and are not intended to limit the scope of the invention in any way. The described embodiments comprise different features, not all of which are required in all embodiments of the invention. Some embodiments of the present invention utilize only some of the features or possible combinations of the features.

Variations of embodiments of the present invention that are described and embodiments of the present invention comprising different combinations of features noted in the described embodiments will occur to persons of the art. The scope of the invention is limited only by the following claims.

Claims

1. A communication unit configured to be wirelessly connected with a plurality of communication satellites and a plurality of mobile devices, and wherein said communication unit is adapted to be mounted on an object having unobstructed sky view.

2. The communication unit of claim 1, wherein the object having unobstructed sky view is a lamp post.

3. The communication unit of claim 1, configured to receive traffic from the plurality of communication satellites over respective satellite links and to re-distribute the received traffic over a terrestrial wireless network to the plurality of mobile devices, wherein said mobile devices are physically located at the vicinity of said communication unit.

4. The communication unit of claim 1, comprising a multi-beam antenna for transmitting and receiving communications from a plurality of communication satellites, a multi-satellite transceiver, equipped with a multi-beam phased array, where each beam points to a different communication satellite, a manager unit, at least one cellular base station module.

5. The communication unit of claim 4, wherein said at least one cellular base station module is compatible with 4G cellular standard or higher.

6. The communication unit of claim 4, wherein said at least one cellular base station module is configured to

communicate with a plurality of mobile devices associated therewith that are located at its vicinity using MIMO/ Massive MIMO/ or high frequency multi-beamforming.

7. A communication system comprising the communication unit of claim 1, and at least one communication satellite, and wherein said at least one communication satellite is configured for providing the at least one cellular base station module with control and data channels for conveying communications between the cellular network and the communication satellite network.

8. The communication system of claim 7, further configured to enable re-distribution of broadcast traffic along existing broadcast satellite channels to mobile devices, by obtaining a direct access to a plurality of communication channels without being required to convey the broadcasted traffic via a central cellular network entity that is connected to cellular base stations of the cellular network.

9. The communication system of claim 7, comprising a plurality of communication satellites, and wherein broadcast transmissions available from several communication satellites are transferable upon demand to the plurality of mobile devices.

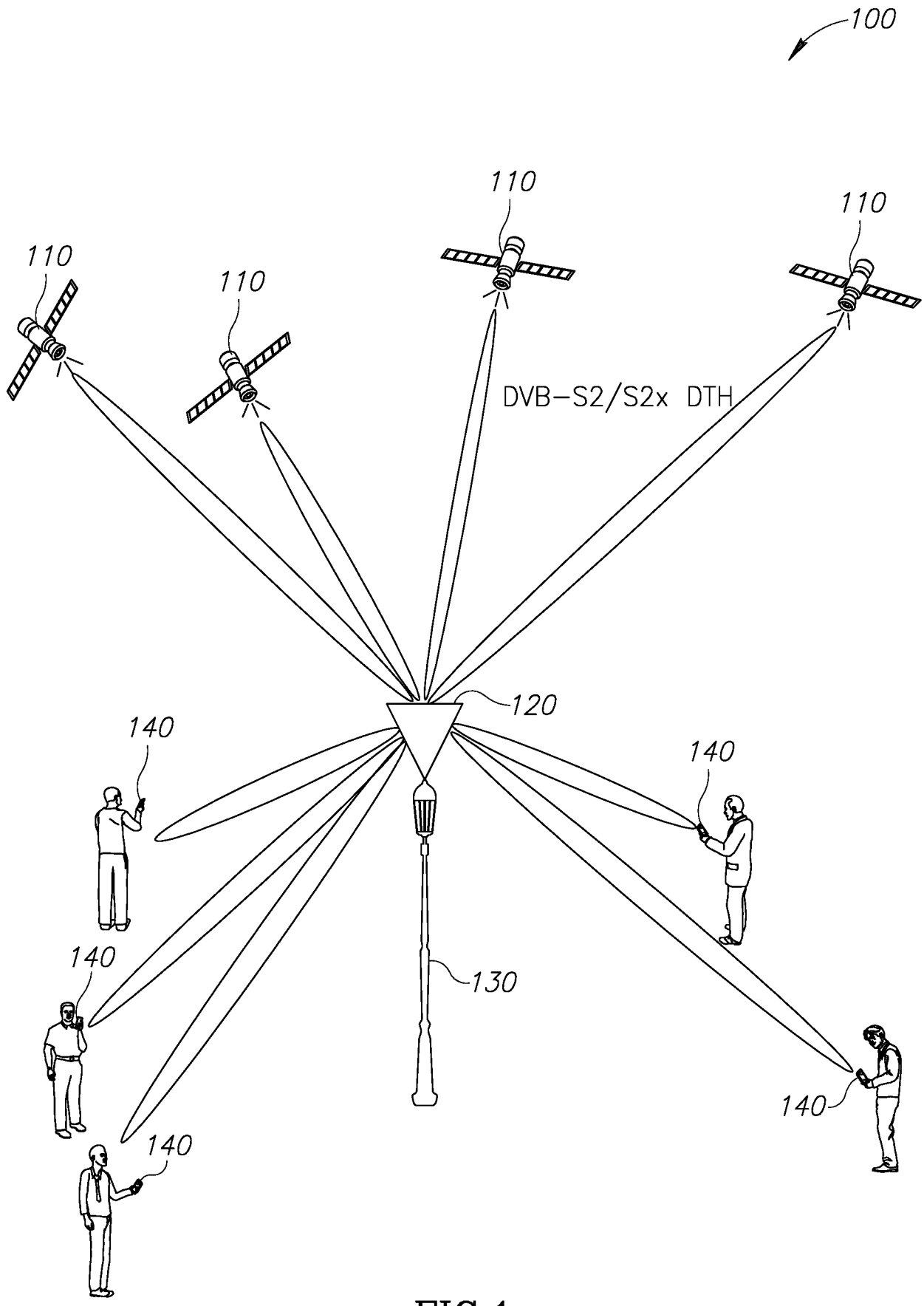

FIG.1

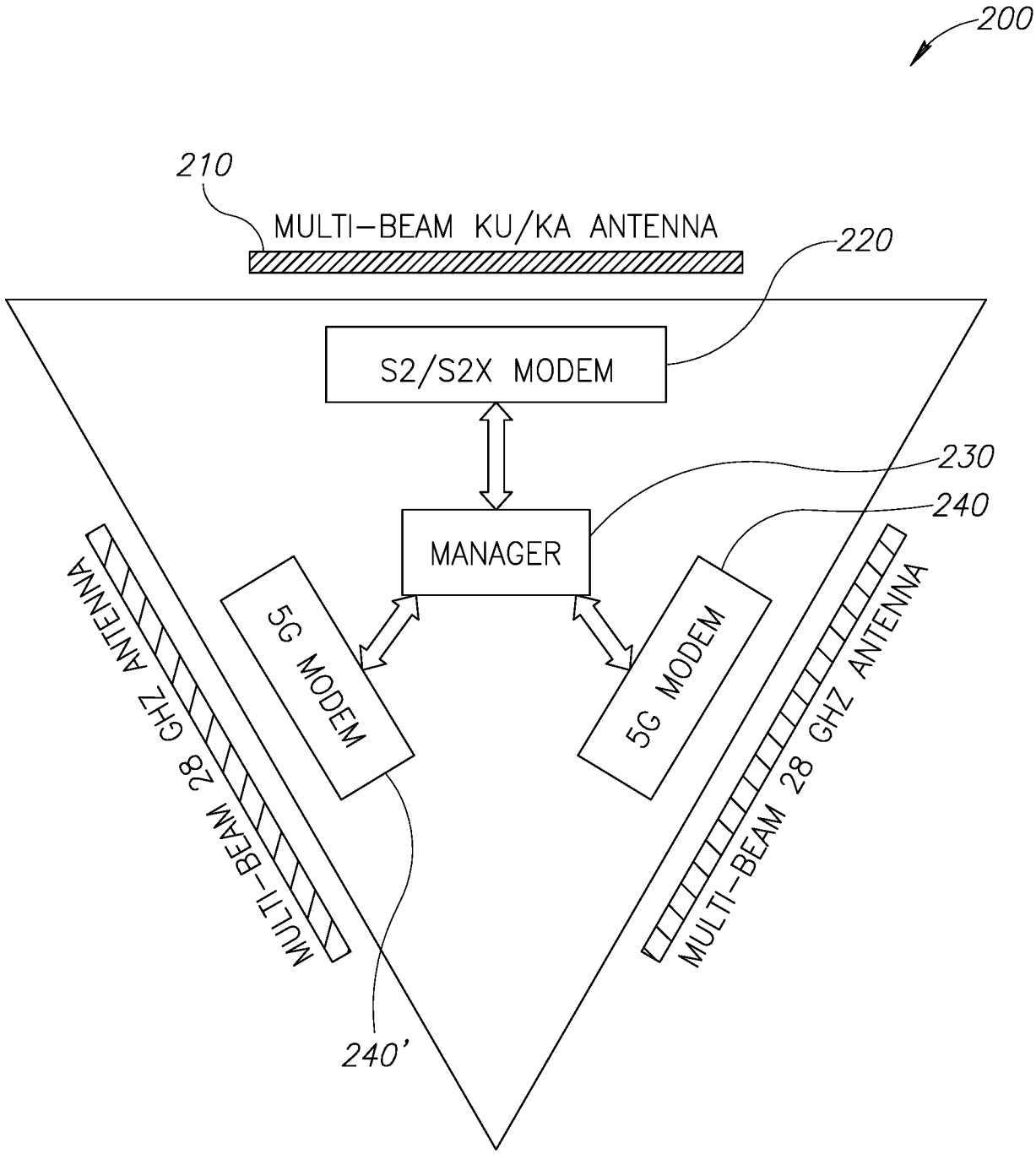
200
210
MULTI-BEAM KU/KA ANTENNA
220
S2/S2X MODEM
230
240
MANAGER
5G MODEM
5G MODEM
MULTI-BEAM 28 GHZ ANTENNA
MULTI-BEAM 28 GHZ ANTENNA
240'

FIG.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2018/050255

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC (2018.01) H04B 7/185, H04W 84/06, H04W 4/00, H04H 20/53, H04H 40/90, H04H 40/00, H04H 20/00, H04H 20/20, H04H 20/06, H04B 1/38, H04N 7/20, H04N 21/00

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

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

Databases consulted: Esp@cenet, Google Patents, Google Scholar, Orbit
Search terms used: integrating redistribution transceiver communication satellite cellular base station modem multi beam antenna video broadcasting

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2017085003 A1 JOHNSON et al. 23 Mar 2013 (2013/03/23) The whole document	1,2,4-7
A	US 2014375492 A1 PLOSCHNITZNG JOHN E. [US] 25 Dec 2014 (2014/12/25) The whole document	1-9
A	US 2013053095 A1 BUCKLE ROBERT [US] 28 Feb 2013 (2013/02/28) The whole document	1-9
A	"Integration of satellite and terrestrial systems in future multimedia communications"; EEE Wireless Communications; 12.5: pp. 72-80; 2005, Retrieved from the Internet: <URL: http://epubs.surrey.ac.uk/1850/1/fulltext.pdf> EVANS, Barry, et al. 24 Oct 2005 (2005/10/24) The whole document	1-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA:	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL2018/050255

A. CLASSIFICATION OF SUBJECT MATTER:

IPC (2018.01) H04B 7/185, H04W 84/06, H04W 4/00, H04H 20/53, H04H 40/90, H04H 40/00, H04H 20/00, H04H 20/20, H04H 20/06, H04B 1/38, H04N 7/20, H04N 21/00