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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 January 2025 (23.01.2025)

WIPO | PCT

(10) International Publication Number
WO 2025/018952 A1

(51) International Patent Classification:
H04B 7/06 (2006.01) *H04W 72/04* (2023.01)

(21) International Application Number:
PCT/TR2023/051472

(22) International Filing Date:
05 December 2023 (05.12.2023)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2023/008274 14 July 2023 (14.07.2023) TR

(71) Applicant: **ULAK HABERLESME ANONIM SIRKETI** [TR/TR]; Mustafa Kemal Mahellesi Sehit Ogretmen Senay Aybuke Yalcin Caddesi No:13 A, 06510 Cankaya/Ankara (TR).

(72) Inventors: **KILINC, Fatih**; Ulak Haberlesme A.S. Teknopark Istanbul Sanayi Mah. Teknopark Bulvari No:1/7 Ic Kapi No:202, 34906 Pendik/Istanbul (TR). **JANJUA, Muhammad Bilal**; Istanbul Medipol Universitesi, Elektrik Elektronik Muhendisligi Bolumu, Istanbul (TR). **ALAYASRA, Musab Mahmoud Abd Alkareem**; Istanbul Medipol Universitesi, Elektrik Elektronik Muhendisligi Bolumu, Istanbul (TR). **ARSLAN, Huseyin**; Istanbul Medipol Universitesi, Elektrik Elektronik Muhendisligi Bolumu, Istanbul (TR).

(74) Agent: **KAYA, Erdem**; Konak Mh. Kudret Sok. Elitpark Park Sit. Ofisler Apt. No:12/27, 16110 Nilufer/Bursa (TR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,

(54) Title: A SMART REPEATER OPERATING IN REFLECTING AND RELAYING MODES

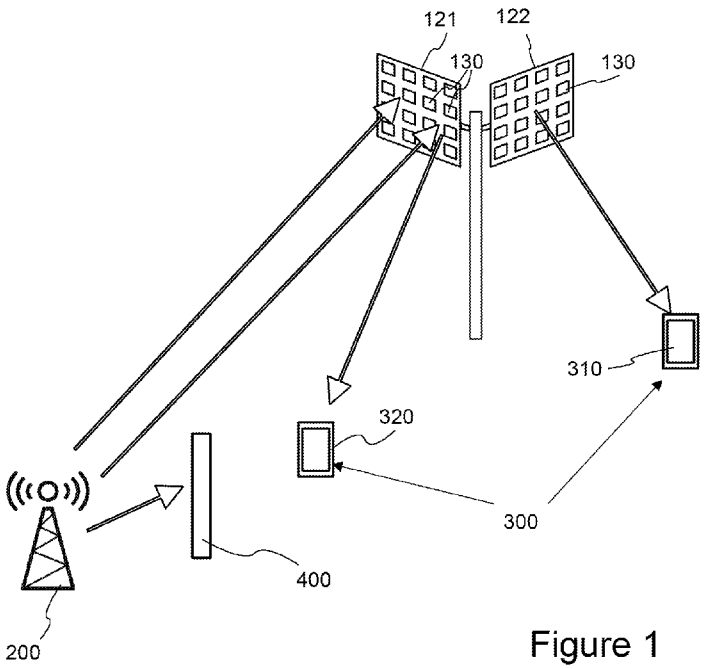

Figure 1

(57) Abstract: Invention is a smart repeater (100) for relaying telecommunication signals. It is characterized by comprising at least a first carrier plate (121) which is facing a base station (200) and at least a second carrier plate (122) which is facing an opposite direction; comprising plurality of antenna elements (130) which are configured to selectively operate between a reflection mode where received communication signal is reflected back to a first direction that carrier plate that is carrying antennas that received the communication signal is facing and a relaying mode where received signal is fed to said uplink line (141) or said downlink line (142) to be transmitted to a second direction by antennas that are on the carrier plates that are on the opposite side of the carrier plates that are carrying antennas that received the communication signal; comprising a controller (110) configured to control antenna elements' (130) operating mode.

WO 2025/018952 A1

[Continued on next page]

HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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

Published:

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

— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

A SMART REPEATER OPERATING IN REFLECTING AND RELAYING MODES

TECHNICAL FIELD

Invention relates to a smart repeater (network controlled repeater) for relaying telecommunication between devices.

BACKGROUND

The coverage enhancement for 5G systems is a challenge in 3GPP standards. Radio frequency repeaters are known in the art to widen the coverage area, but they work independently and create interference. Therefore, a network-controlled repeater (NCR), also known as a smart repeater (SR), is developed in order to enhance the coverage. Additional functions in NCR make it superior and smarter than traditional repeaters, including time division duplex (TDD) information access, RU on/off, and multi-beam operation. To incorporate these features, a control unit is added to NCR that performs simple baseband processing to retrieve the side information from the control signals sent by the base station. The side information helps to improve its performance. For instance, it can exploit TDD information for efficient amplification and forward relaying or beamforming the signals toward the users and base station. Besides, with on/off information, it can turn off to save power and avoid the unnecessary amplification of noise signals.

The current network-controlled repeater operation is only works in amplify and forward configuration. The NCR device can be controlled by the base station and turned off when the NCR operation is not necessary to save energy. NCR by its design has two antenna units separated by each other and physically separated to overcome self-interference problem. However, this type design limits the coverage region of the NCR device.

WO2021022241 discloses a control method for smart repeaters to receive the RF signal and control information over a bandwidth part. Then extract the information to select the beams and use those beams to receive or transmit information from or to one or more devices based on the control information.

WO2022228786A1 discloses a reconfigurable intelligent beamforming system comprising a passive fixed array panel configured to receive signals and focus the signals to provide focused signals towards at least one fixed location, and at least one intelligent surface at the at least one fixed location, the at least one intelligent surface configured to receive the focused signals and to control beamforming of the focused signals to provide beamformed signals.

US2017069967 discloses an antenna is including an electromagnetic metasurface. The electromagnetic characteristics of the antenna are dynamically tunable thus allowing reflection of signals.

Tierui Gong et al. "Holographic MIMO Communications: Theoretical Foundations, Enabling Technologies, and Future Directions" and Jiancheng An. Et al. "A Tutorial on Holographic MIMO Communications—Part II: Performance Analysis and Holographic Beamforming" discloses holographic antennas and meta-surfaces that are able to reflect or receive radio frequency signals.

All the problems mentioned above have made it necessary to make an innovation in the relevant technical field as a result.

BRIEF DESCRIPTION OF THE INVENTION

The present invention relates to a smart repeater to eliminate the above-mentioned disadvantages and bring new advantages to the relevant technical field.

An object of the invention is to increase coverage area and quality of a cell.

Another object of the invention is to provide a smart repeater that contributes to cell reception in power saving mode.

To achieve all the objects mentioned above and that will emerge from the following detailed description, the present invention relates to a smart repeater for relaying telecommunication signals. Accordingly, it is characterized in that comprising at least a first carrier plate which is facing a base station and at least a second carrier plate which is facing an opposite direction; plurality of antenna elements are provided on said first carrier plate and said second carrier plate; at least an uplink line and at least a downlink line are provided between antenna elements of first carrier plate and second carrier plate; antenna elements are configured to

selectively operate between a reflection mode where received communication signal is reflected back to a first direction that carrier plate that is carrying antennas that received the communication signal is facing and a relaying mode where received signal is fed to said uplink line or said downlink line to be transmitted to a second direction by antennas that are on the carrier plates that are on the opposite side of the carrier plates that are carrying antennas that received the communication signal; comprising a controller configured to control antenna elements' operating mode. Thus, coverage area and quality of a cell reception is increased. Enables user equipment that are obstructed from base station's direct communication signal to receive reflected communication signals. In other words, this allows coverage of blind spots.

A possible embodiment of the invention is characterized in that at least some of the antenna elements are holographic antennas.

Another possible embodiment of the invention is characterized in that at least some of antenna elements are meta-surface antennas.

Another possible embodiment of the invention is characterized in that control unit is configured to operate at least some of the antennas in the reflecting mode and some of the antennas in relaying mode.

Another possible embodiment of the invention is characterized by comprising at least a first amplification element provided on uplink line and at least a second amplification element provided on downlink line; comprising a first reflection switch element and a second reflection switch element, controlled by said controller, connecting uplink line to downlink line in such way that received uplink communication signal is fed to downlink line in order to be transmitted back from the antenna elements that are provided on the carrier plate that received the communication signal; and received downlink communication signal is fed to uplink line in order to be transmitted back from the antenna elements that are provided on the carrier plate that received the communication signal.

Another possible embodiment of the invention is characterized in that smart repeater is configured to operate in a power saving mode where antenna elements operate in reflection mode and rest of the antenna elements are in off state. Thus, power consumption is greatly reduced while providing coverage using reflection.

Another possible embodiment of the invention is characterized in that controller is configured to receive instruction signals from a base station in order to control operation mode of smart repeater or antenna elements.

Another possible embodiment of the invention is characterized in that controller is configured to control antenna elements' operating channels; controller is configured to operate at least some of the antenna elements that is dedicated to receive communication signals in a first channel in reflection mode; and operate at least some of the antenna elements that is dedicated to receive a communication signal in a second channel in relaying mode.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a drawing illustrating schematic view of the smart repeater.

Figure 2 is a drawing illustrating schematic view of the system.

Figure 3 is a drawing illustrating representative an operating scenario of the system.

Figure 4 is a drawing illustrating representative an operating scenario of the system.

Figure 5 is a drawing illustrating representative an operating scenario of the system.

REFERENCE NUMBERS GIVEN IN THE FIGURE

100 Smart repeater
110 Controller
121 First carrier plate
122 Second carrier plate
130 Antenna elements
141 Uplink line
142 Downlink line
151 First reflection switch element
152 Second reflection switch element
153 Connection line
160 Amplification element
200 Base station

300 User equipment
310 First user equipment
320 Second user equipment
400 Obstacle
510 First device
520 Second device

DETAILED DESCRIPTION OF THE INVENTION

In this detailed description, the subject matter is explained with references to examples without forming any restrictive effect only in order to make the subject more understandable.

Referring to figure 1, present invention is a smart repeater (100) for relaying communication signals between a base station (200) and user equipment (300) or between other devices that realize radio frequency communication. Smart repeater (100), selectively reflects and/or relays communication signals in hybrid manner. Smart repeater (100) comprises a controller (110) in order to control operation functions thereof. Smart repeaters (100) are known in the art as smart repeater device (SRD) or network controlled repeaters (NCR).

Smart repeater (100) comprises a first carrier plate (121) facing a base station (200) and a second carrier plate (122) facing an opposite side. Carrier plates comprise antenna elements in order to receive and transmit communication signals in radio frequency. Antenna elements may comprise beamforming circuitry and other well-known components in the art. Thus, further details are not disclosed herein.

Referring to figure 2, an uplink line (141) and a downlink line (142) and an uplink line (141) is provided between antenna elements that are on first carrier plate (121) and antenna elements that are on second carrier plate (122). Uplink line (141) is provided to receive, amplify and transmit uplink communication signals. Downlink line (142) is provided in order to receive, amplify and transmit downlink communication signals. Uplink line (141) and downlink line (142) comprises amplification element (160). Uplink line (141) and downlink line (142) may comprise frequency shifting elements (not shown in the drawings) controlled by controller (110) in order the shift the frequencies of signals before they are transmitted. Base station (200) is well-known in the art. Base station (200) may comprise RF transceivers, antennas, baseband processing components, controllers (110) and software in order to provide telecommunication

between user equipment (300) in its cell and a wider network. Base station (200) may be a g-Node-B (gNB) base station (200).

Antenna elements (130) are configured to selectively operate in a reflection mode and a relaying mode. Said controller (110) is configured to control operating mode of antenna elements. Antenna elements (130) may be integrated into carrier plates (122).

In said reflective mode, antenna elements (130) reflects received communications signals towards the side that signal was received. In relaying mode, antenna elements (130) is fed to uplink line (141) or downlink line (142) to be transmitted by antenna elements (130) that are on the opposite side of the antenna elements that received the communication signal.

Referring to figure 3, invention is also a system that comprises at least a base station (200) and at least above mentioned smart repeater (100). Base station (200) is configured to command smart repeater (100) relating to communication channels to be used and operation mode to be operated in.

In a possible embodiment, at least some of the antenna elements (130) are holographic antennas. Holographic antennas are known in the art. Therefore specific operating principle is not disclosed herein. Holographic antennas are controlled by a controller (110) and they transmit received signals in desired directions.

In another possible embodiment, at least some of the antenna elements (130) are meta-surface antennas. Meta surface antennas are also know in the art. Meta surface antennas reflect received transmission signals and may be used to receive transmission signals as well.

Referring to figure 2, in another possible embodiment, smart repeater (100) comprises at least a first amplification element (160) provided on uplink line (141) and at least a second amplification element (160) provided on downlink line (142). First (510) reflection switch (151) element and a second reflection switch element (152), are provided which are controlled by said controller (110). First reflection switch element (151) and second reflection switch element (152) connects uplink line (141) to downlink line (142) in such way that received uplink communication signal is fed to downlink line (142) in order to be transmitted back from the reflective antennas that are provided on the carrier plate that received the communication signal; and received downlink communication signal is fed to uplink line (141) in order to be transmitted back from the reflective antennas that are provided on the carrier plate that

received the communication signal. First reflection switch (151) element and second reflection switch elements (152) are connected by connection lines (153) In a scenario when a downlink communication is received from reflective antenna elements (130) on the first carrier plate (121), if antenna elements (130) are operating in a reflection mode, first reflection switch element (151) connects to second reflection switch element (152). This enables feeding communication signal back to antennas that are on the first carrier plate (121). Antenna elements that are on the carrier plate transmits fed back communication signal, thus causing a reflection of communication signal. When relaying mode is activated, reflection switch elements separates inputs of amplification elements (160) on uplink line (141) and downlink line (142). This enables generic transmission of received signal from the antennas that are on second carrier plate (122). This embodiment gives example of an active reflection mode. In another embodiment, antenna elements (130) may operate in passive reflection mode where received signal is directly reflected back without going through reflection switches.

Amplification element (160) may be an RF amplifier. In a possible embodiment (160) amplification element (160) may be reflection type amplifier.

In a possible embodiment, controller (110) may operate some of the antenna elements (130) in reflecting and some of the antenna elements (130) in relaying mode. For instance, reflective antenna elements (130) that are dedicated to a first channel may operate in reflecting mode and antenna elements (130) that are dedicated to a second channel may operate in relaying mode.

Referring to figure 1, base station (200) transmits a downlink communication signal in a first channel to a first user equipment (310). Base station (200) also transmits a downlink communication signal in a second channel to a second user equipment (320). Since, second user equipment (320) is between base station (200) and smart repeater (100) and first user equipment (310) is located facing second carrying plate of base station (200), base station (200) sends command signal to smart repeater (100) device so that smart repeater (100) device operates at least some of antenna elements dedicated to second channel on first carrier plate (121) in reflecting mode and operates antenna elements (130) dedicated to first channel on first carrier plate (121) in relaying mode. Thus, if communication signals transmitted from base station (200) to second user equipment (320) is blocked by an obstacle (400), signals reflected from smart repeater (100) may reach to second user equipment (320).

Referring to figure 4, in an exemplary base station (200) transmits communication signal to user equipment (300) on first channel. A first device (510) transmits RF signal to a second device (520) on a second channel. Smart repeater (100) operates antenna elements (130) on first carrier plate (121) and second carrier plate (122). Smart repeater (100) operates some of the antenna elements (130) in relaying mode on first carrier plate (122) and some of the antenna elements (130) on second carrier plate (122) in reflective mode. Thus, first device (510) may send RF signal to second device (520) with help of smart repeater (100).

Referring to figure 5, in an exemplary scenario base station (200) transmits downlink communication signal to user equipment (300). In this scenario link between base station (200) and user equipment (300) may be weak. Smart repeater (100) operates reflective antenna elements (130) in passive reflection mode, and rest of the antennas in off state. Thus, smart repeater (100) provides reflection of communication signals consuming reduced power. In this embodiment meta surface antennas may be utilized in order to operate in passive reflection mode.

The scope of protection of the invention is specified in the attached claims and cannot be limited to those explained for sampling purposes in this detailed description. It is evident that a person skilled in the art may exhibit similar embodiments in light of the above-mentioned facts without drifting apart from the main theme of the invention.

CLAIMS

1. A smart repeater (100) for relaying telecommunication signals ***characterized in that*** comprising at least a first carrier plate (121) which is facing a base station (200) and at least a second carrier plate (122) which is facing an opposite direction; plurality of antenna elements are provided on said first carrier plate (121) and said second carrier plate (122); at least an uplink line (141) and at least a downlink line (142) are provided between antenna elements of first carrier plate (121) and second carrier plate (122); antenna elements are configured to selectively operate between a reflection mode where received communication signal is reflected back to a first direction that carrier plate that is carrying antennas that received the communication signal is facing and a relaying mode where received signal is fed to said uplink line (141) or said downlink line (142) to be transmitted to a second direction by antennas that are on the carrier plates that are on the opposite side of the carrier plates that are carrying antennas that received the communication signal; comprising a controller (110) configured to control antenna elements' (130) operating mode.

2. The smart repeater (100) according to claim 1, ***characterized in that*** at least some of the antenna elements (130) are holographic antennas.

3. The smart repeater (100) according to claim 1, ***characterized in that*** at least some of antenna elements (130) are meta-surface antennas.

4. The smart repeater (100) according to claim 1, ***characterized in that*** control unit (210) is configured to operate at least some of the antenna elements (130) in the reflecting mode and some of the antenna elements (130) in relaying mode.

5. The smart repeater (100) according to claim 1, ***characterized in that*** comprising at least a first amplification element (160) provided on uplink line (141) and at least a second amplification element (160) provided on downlink line (142); comprising a first reflection switch element (151) and a second reflection switch element (152), controlled by said controller (110), connecting uplink line (141) to downlink line (142) in such way that received uplink communication signal is fed to downlink line (142) in order to be transmitted back from the reflective antennas that are provided on the carrier plate that received the communication signal; and received downlink communication signal is fed to uplink line (141) in order to be transmitted back from the antenna elements (130) that are provided on the carrier plate that received the communication signal.

6. The smart repeater (100) according to claim 3, ***characterized in that*** smart repeater (100) is configured to operate in a power saving mode where antenna elements (130) operate in reflection mode.

7. The smart repeater (100) according to claim 1, ***characterized in that*** controller (110) is configured to receive instruction signals from a base station (200) in order to control operation mode of smart repeater (100) or antenna elements (130).

8. The smart repeater (100) according to claim 1, ***characterized in that*** controller (110) is configured to control antenna elements' (130) operating channels; controller (110) is configured to operate at least some of the antenna elements (130) that is dedicated to receive communication signals in a first channel in reflection mode; and operate at least some of the antenna elements (130) that is dedicated to receive a communication signal in a second channel in relaying mode.

9. A system comprising a smart repeater (100) of one of the claims 1-8 and a base station (200) which is configured to control said smart repeater (100).

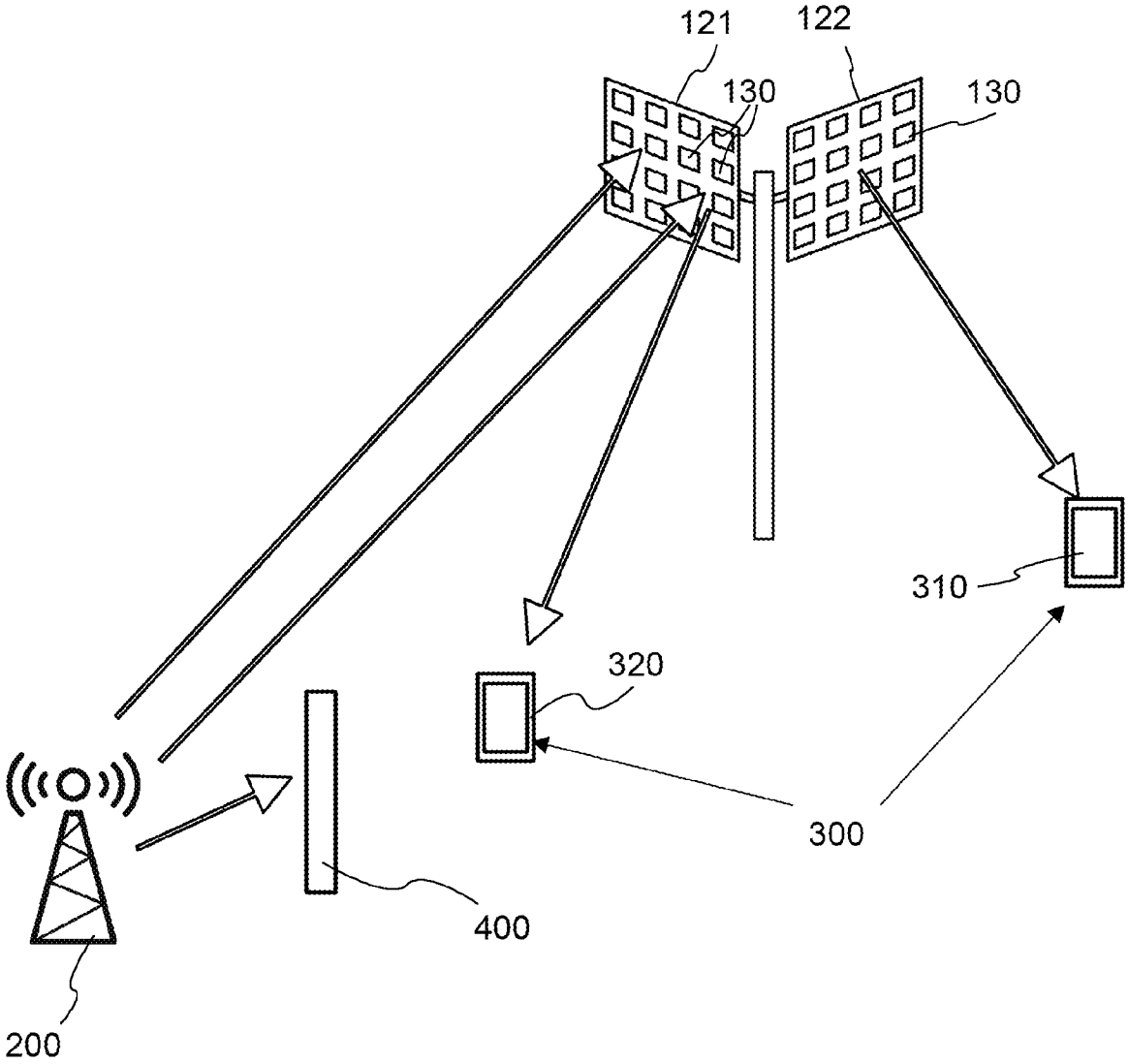

Figure 1

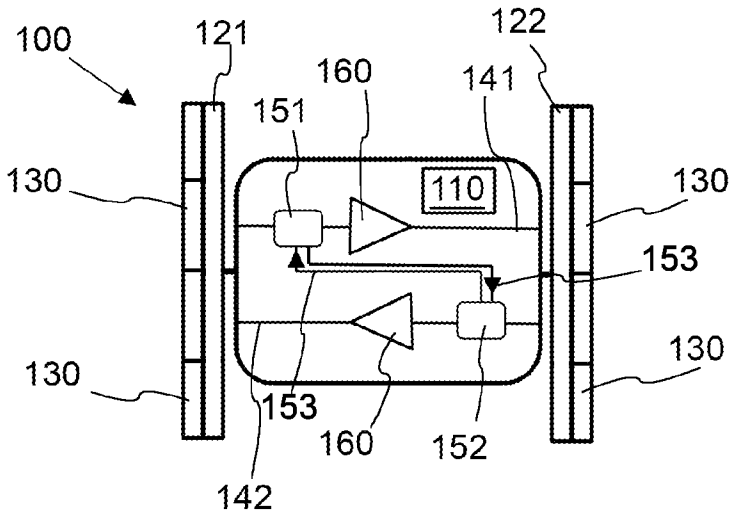

Figure 2

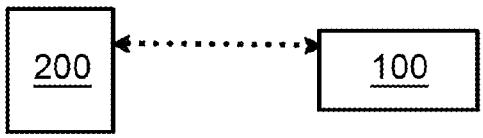

Figure 3

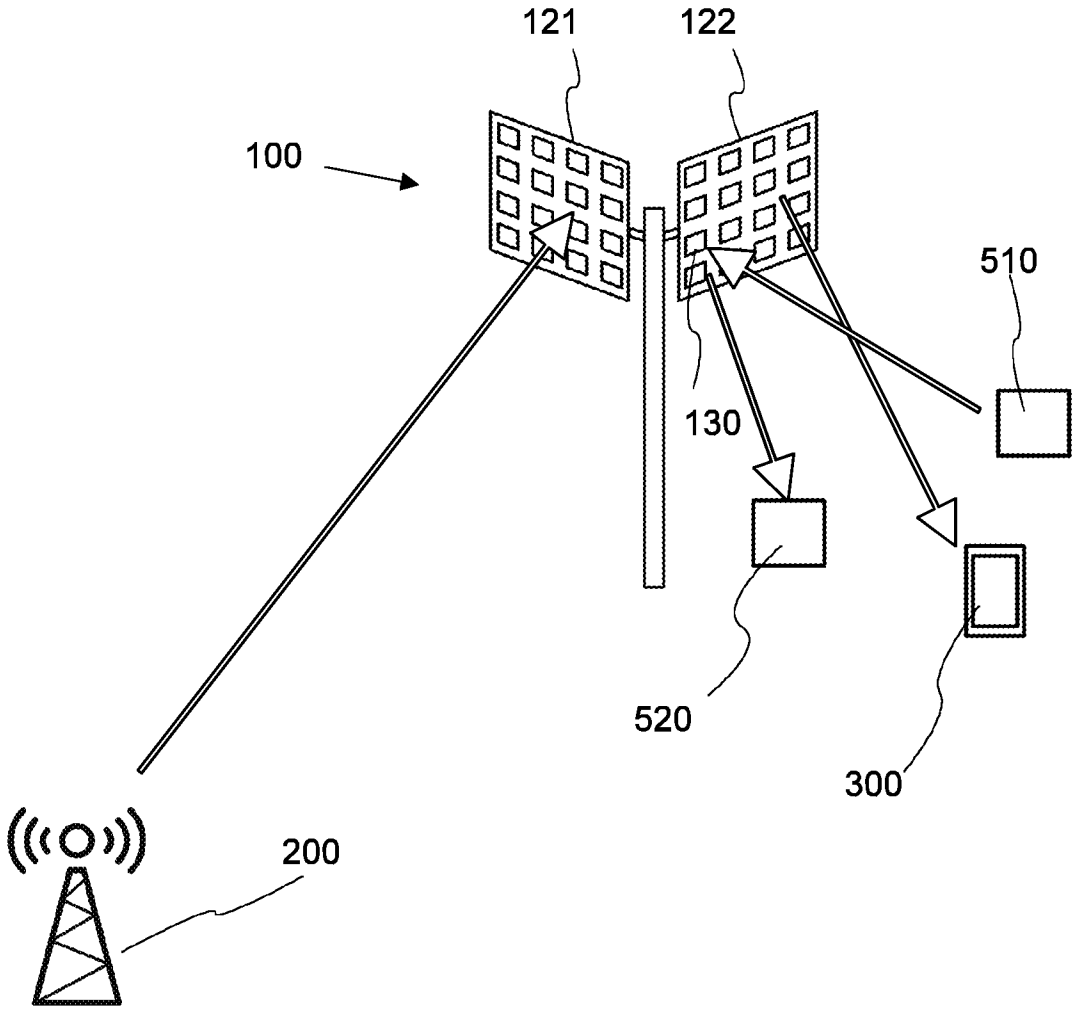

Figure 4

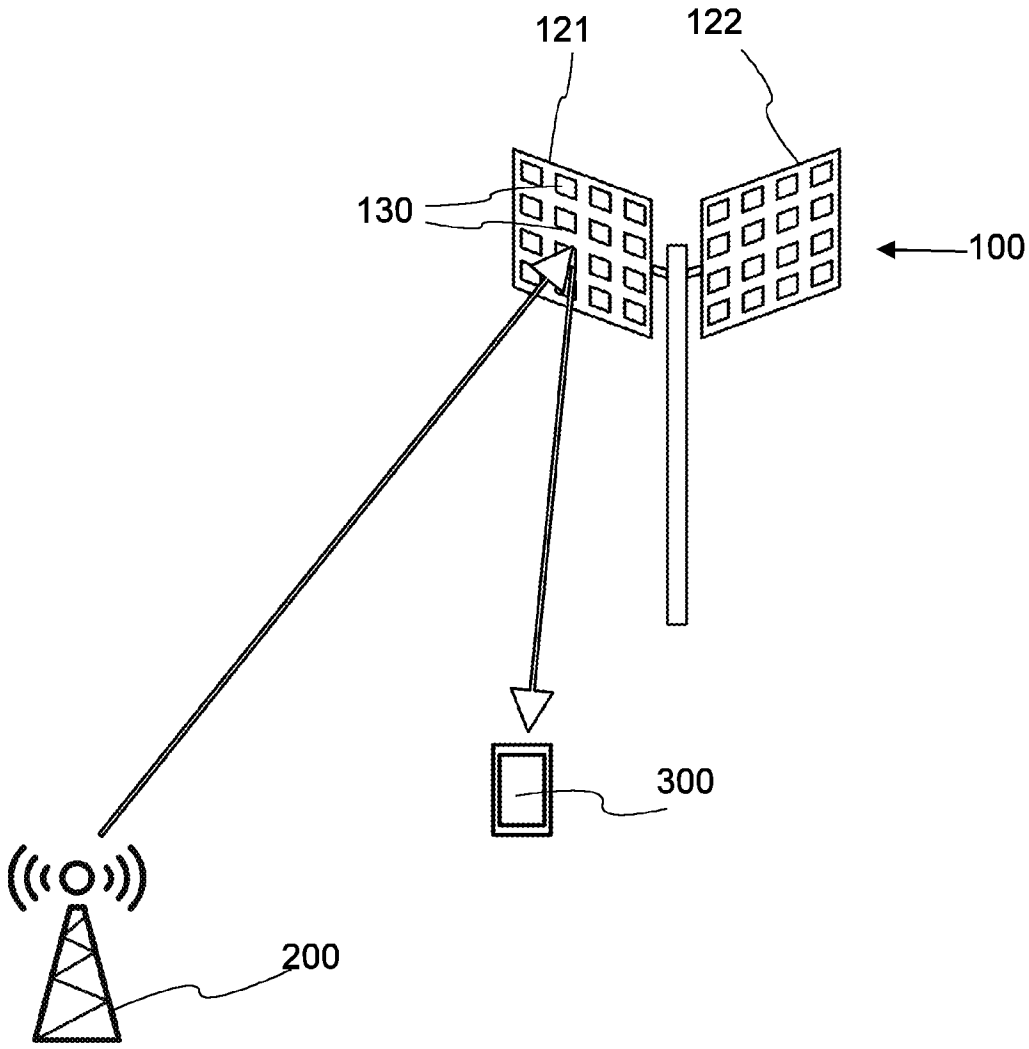

Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR2023/051472

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/06(2006.01)i; ***H04W 72/04***(2023.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B 7/06; H04W 72/04

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)

EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2023105802 A1 (NTT DOCOMO INC [JP]) 15 June 2023 (2023-06-15) Whole document	1-9
A	WO 2022133957 A1 (HUAWEI TECH CO LTD [CN]) 30 June 2022 (2022-06-30) Whole document	1-9
A	CN 111245492 A (UNIV BEIJING POSTS & TELECOMM) 05 June 2020 (2020-06-05) 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

"D" document cited by the applicant in the international application

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 July 2024	**31 July 2024**

Name and mailing address of the ISA/TR

Turkish Patent and Trademark Office (Turkpatent)
Hipodrom Caddesi No. 13
06560 Yenimahalle
Ankara
Türkiye

Telephone No. **+903123031000**
Facsimile No. **+903123031220**

Authorized officer

Batuhan ERTÜRK

Telephone No. **+903123031649**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/TR2023/051472

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2023105802 A1	15 June 2023	CN 118355616 A	16 July 2024
WO 2022133957 A1	30 June 2022	CN 116648864 A	25 August 2023
		JP 2024501298 A	11 January 2024
		US 2023327714 A1	12 October 2023
CN 111245492 A	05 June 2020	CN 111245492 B	21 January 2022