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(54) METHOD AND SYSTEM FOR PROVIDING MAP AND SPAT MESSAGES FOR A NEWLY ESTABLISHED SET OF AT LEAST ONE TRAFFIC LIGHT

(57) The invention relates to a method for providing MAP and SPaT messages (15,16) for a newly established set (2) of at least one traffic light (3), wherein a position (13) of each of the at least one traffic light (3) within the set (2) is determined by a global positioning system (7), wherein the determined positions (13) are assigned to corresponding traffic lanes of at least one street in a digital street map by a processing device (5), wherein a MAP message (15) is generated based on the digital street map, wherein the generated MAP message (15) comprises the assignments, wherein at least one SPaT message (16) is generated based on a traffic light phase plan (20) of the at least one traffic light (3) or at least one SPaT message (16) is generated based on the information of the current phase of the at least one traffic light (3), and wherein the generated MAP and SPaT messages (15,16) are broadcasted by the set (2) of the at least one traffic light (3). Further, the invention relates to a corresponding system (1), a traffic light (3), and a back-end server (4).

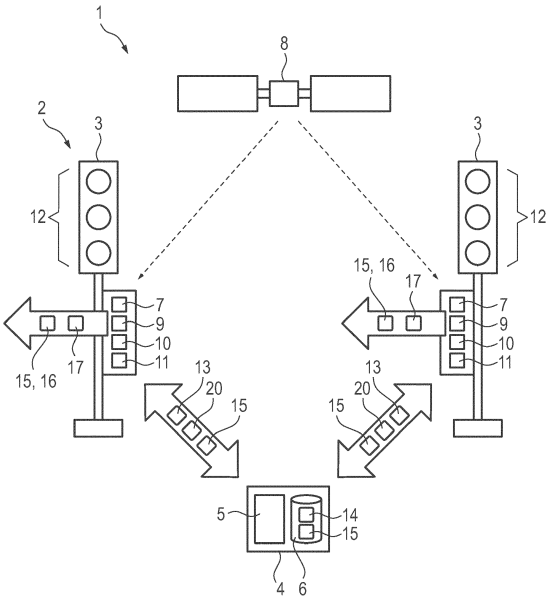

Fig. 1

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Description

[0001] The invention relates to a method and a system for providing MAP and SPaT messages for a newly established set of at least one traffic light. The invention further relates to a traffic light and a backend server.

[0002] Autonomous driving requires highly reliable detection of traffic lights. Sometimes there are situations in which this is difficult to achieve with current camera systems. For example, rear lights of other vehicles can be confused with traffic lights when driving at night. Besides detecting of the optical signaling devices one of the main problems is detecting the traffic light itself. This problem particularly occurs when a traffic light is not recorded in a digital map the vehicle is using. For example, this is often the case for traffic lights that are only temporarily established at construction sites.

[0003] Usually, the positions of the traffic lights and their optical signaling devices are recorded in the digital maps the vehicles are using when driving autonomously. However, only permanently established traffic lights are incorporated into the maps.

[0004] It is known to equip traffic lights with V2X technology, so that they can transmit information regarding their status using standardized messages to vehicles in their environment. For example, SPaT (Signal Phase and Timing) messages and/or MAP messages (topological information regarding traffic lanes for vehicles and pedestrian crossings as well as information regarding which traffic lane and/or pedestrian crossing is controlled by which optical signaling device etc.) can be transmitted to the vehicles.

[0005] The invention is based on the technical problem of providing MAP and SPaT messages for a newly established set of at least one traffic light.

[0006] According to the invention, the technical problem is solved by a method having the features of claim 1, a system having the features of claim 8, a traffic light having the features of claim 9, and a backend server having the features of claim 10. Advantageous embodiments of the invention emerge from the dependent claims.

[0007] In particular a method is proposed for providing MAP and SPaT messages for a newly established set of at least one traffic light, wherein a position of each of the at least one traffic light within the set is determined by a global positioning system, wherein the determined positions are assigned to corresponding traffic lanes of at least one street in a digital street map by a processing device, wherein a MAP message is generated based on the digital street map, wherein the generated MAP message comprises the assignments, wherein at least one SPaT message is generated based on a traffic light phase plan of the at least one traffic light or at least one SPaT message is generated based on the information of the current phase of the at least one traffic light, and wherein the generated MAP and SPaT messages are broadcasted by the set of the at least one traffic light.

[0008] Further, a system for providing MAP and SPaT messages for a newly established set of at least one traffic light is proposed, comprising a set of at least one traffic light, a processing device, at least one global positioning system, configured to determine a position for each of the at least one traffic light within the set, wherein the at least one traffic light within the set is configured to generate a SPaT message based on a traffic light phase plan of the at least one traffic light or to generate a SPaT message based on the information of the current phase of the at least one traffic light, and wherein the processing device is configured to assign the determined positions to corresponding traffic lanes of at least one street in a digital street map, and to generate a MAP message based on the digital street map, wherein the generated MAP message comprises the assignments, and wherein the at least one traffic light within the set is configured to broadcast the generated MAP and SPaT messages.

[0009] In addition, a traffic light for a system for providing MAP and SPaT messages for a newly established set of at least one traffic light is proposed, comprising a global positioning system, configured to determine a position of the traffic light after establishment at a site of operation, at least one communication device, configured to communicate at least with other traffic lights within the set of traffic lights and/or with a backend server, and configured to communicate via a V2X interface, and a control device, configured to control the traffic light according to a traffic light phase plan, wherein the control device is further configured to generate a SPaT message based on the traffic light phase plan or to generate a SPaT message based on the information of the current phase of the at least one traffic light, to transmit the determined position to the backend server and to receive a MAP message from the backend server via the at least one communication device, and to broadcast the received MAP message and the generated SPaT message via the at least one communication device.

[0010] Also, a backend server for a system for providing MAP and SPaT messages for a newly established set of at least one traffic light is proposed, comprising a processing device, and a communication device, configured to communicate with at least one traffic light within a set of traffic lights, wherein the processing device is configured to receive a position of the at least one traffic light via the communication device and to assign the determined position(s) to corresponding traffic lanes of at least one street in a digital street map, and to generate a MAP message based on the digital street map, wherein the generated MAP message comprises the assignments, and to transmit the generated MAP message via the communication device to the at least one traffic light for broadcasting.

[0011] The method and the system allow to generate SPaT and MAP messages for newly established traffic lights. In particular, traffic lights established at construction sites, i.e. only temporarily established traffic lights, can be furnished with SPaT and MAP messages. Thus

valuable information that can be broadcasted to vehicles able to process SPaT and MAP messages can be provided also for these temporarily established traffic lights. Besides capturing a current status of the traffic light by a sensor of the vehicle, e.g. by a camera, in particular the status of the optical signaling devices of the traffic light, the current status can be directly extracted from the distributed SPaT and MAP messages. This offers an additional channel of information to evaluate the plausibility of sensor data captured by the sensors of the autonomous vehicle. This is achieved by determining a position of each of the at least one traffic light within the set by a global positioning system (e.g. GPS, GLONASS, Beidou etc.) after the traffic lights are setup at the site of operation. In addition, confidence data regarding the confidence of the determined position can be used to check the plausibility of the position. In case such a check fails, for example, an error message can be generated prompting personnel to verify the position of the traffic light(s). The determined positions are then assigned to corresponding traffic lanes of at least one street in a digital street map by using a processing device. In particular, the processing device assigns the determined positions to inflow and outflow lanes of the site at which the set of traffic lights has been established. In particular, the assigning comprises a map matching, and if applicable a correction of the determined positions and/or plausibilization of the determined positions with the infrastructure in the digital map. Based on the digital street map and the assignments, a MAP message is created, which comprises the assignments, i.e. the assignments to traffic lanes of inflowing and outflowing traffic. In particular the MAP message comprises a definition of at least one stop line for each of the traffic lights within the set and corresponding outflow lanes. In principle, it is also possible that more than one MAP message is created. Based on traffic light phase plans, which describe the sequence and duration of the optical signaling for each of the optical signaling devices of each of the traffic lights within the set, a SPaT message is generated for each traffic light within the set. Alternatively, the SPaT message(s) can also be generated based on the information of the current phase of the at least one traffic light within the set. In particular, a SPaT message is created in each of the at least one traffic light within the set. The SPaT message is in particular generated according to the actual optical signaling performed by the respective traffic light. The MAP and SPaT messages are linked to each other. Therefore, the traffic light phase plan(s) and/or the generated SPaT message(s) can, for example, be transmitted to the processing device by each of the traffic lights within the set, and the processing device establishes the link, in particular by linking the generated MAP message and the generated SPaT messages using the SignalGroupID which indicates the traffic lane that is corresponding to a certain optical signaling device of a traffic light. The generated MAP and SPaT messages are then broadcasted by the set of the at least one traffic light, such that they can be received by vehicles approaching the set of the at least one traffic light.

[0012] One of the advantages of the method and the system is that SPaT and MAP messages can be provided in a flexible way for arbitrary configurations of traffic lights. Hence, even temporarily established traffic lights, in particular at construction sites, can be furnished with custom-made MAP and SPaT messages. This is in particular valuable for autonomously driving vehicles.

[0013] A MAP message comprises topological information regarding, for example, the traffic lanes, the pedestrian crossings and which optical signaling devices of the traffic light controls these traffic lanes and pedestrian crossings.

[0014] A SPaT (Signal Phase and Timing) message comprises, in particular, traffic control information, e.g. the signal phases of the traffic lights and timing of the the traffic lights.

[0015] A set of traffic lights comprises at least one traffic light. The set can also comprise a plurality of traffic lights. A traffic light comprises optical signaling devices (e.g. "red", "yellow", "green"). A status and a duration of the status of the optical signaling devices of the traffic lights within the set are controlled according to traffic light phase plans.

[0016] A global positioning system is in particular one of the following: a Global Positioning System (GPS), GLONASS and/or Beidou. Further the global positioning system can use augmentation techniques, for example in the form of Differential Global Positioning System.

[0017] Part of the processing device can be provided separately or jointly with other devices as a combination of hardware and software, e.g. as program code that is executed on a microcontroller or microprocessor.

[0018] In one embodiment, determining the positions is executed in each case by global positioning systems of each of the at least one traffic light, wherein the determined positions are each transmitted from the traffic lights to the processing device by a respective communication link. For this purpose each traffic light is equipped with its own global positioning system and a communication device. Each traffic light within the set can then be established at its respective site and the position for each traffic light can be determined with the respective global positioning system. The positions determined by each of the global positioning systems are then transmitted to the processing device and the method is carried out in the way described above.

[0019] In one embodiment, the processing device is part of a backend server, wherein the processing device also generates the MAP message. The backend server can be a server of a traffic infrastructure system or it can be part of the set of traffic lights. For example, the backend server can be part of a particular traffic light within the set.

[0020] In one embodiment, the measures are executed automatically after the set of the at least one traffic light is established at a site of operation. This way MAP and

SPaT messages can be generated automatically without much effort or manual assistance. In a particular embodiment, the method is started after a start or reset command is given to the set of traffic lights such that the set of the at least one traffic light is triggered to execute the measures of the method.

[0021] In one embodiment, an approval of the MAP and SPaT messages is requested before the MAP and SPaT messages are broadcasted. In particular, this approval can be a manual approval, for example by an operational engineer or road worker that sets up the traffic lights at a newly established construction site. This way the information provided in the MAP and SPaT messages can be verified and confirmed after being generated.

[0022] In one embodiment, a Decentralized Environmental Notification Message (DEMN) is broadcasted in case one or more of the measures cannot be executed properly. This way a fallback level of operation can be provided.

[0023] In one embodiment, a plausibility of the SPaT message is evaluated in consideration of passage and clearing times required at a site of operation. This way, additional security can be provided when broadcasting and using the SPaT messages. For example, the passage and clearing times are checked against the timing information of the phases within the SPaT message. If they do not conform with each other, the SPaT message can be adapted to conform with the passage and clearing times. Also, further information regarding the positions and a distance between the traffic lights, which can in particular be derived from the determined positions, can be taken into account when evaluating the plausibility. It is also possible, that an approval of the MAP and/or SPaT messages is provided based on the outcome of the plausibility evaluation.

[0024] The individual embodiments of the system, the traffic light, and the backend server in each case correspond to the embodiments of the method. The advantages of the system, the traffic light, and the backend server are in each case the same as for the embodiments of the method.

[0025] In principle, the method can be executed fully automatically, semi-automatically or manually.

[0026] Manually executing the measures comprises in particular determining the positions of the traffic lights within the set by using, for example, a handheld global positioning system. The measures of assigning the street lanes, generating the MAP message(s) and/or linking of MAP and SPaT messages can be performed on a portable processing device, for example on a laptop computer. An up-to-date digital street map is downloaded on the laptop computer and the measures are then performed on the laptop computer. The generated MAP message(s) is/are then transmitted to the traffic lights. The traffic lights can then broadcast the respective MAP message(s) and the corresponding SPaT messages, in particular via the V2X interface.

[0027] The invention is explained in greater detail below on the basis of preferred exemplary embodiments with reference to the drawing. In the drawing:

Fig. 1 shows an embodiment of the system for providing MAP and SPaT messages for a newly established set of at least one traffic light.

[0028] In Fig. 1 an embodiment of the system 1 for providing MAP and SPaT messages 15, 16 for a newly established set 2 of traffic lights 3 is shown. The system 1 comprises a set 2 of two traffic lights 3 and a backend server 4 with a processing device 5 and a memory 6. The processing device 5 can access data stored in the memory 6 and can process the data within the memory 6.

[0029] The traffic lights 3 and the backend server 4 can be remotely connected, for example, by an internet connection. Also, in a particular embodiment, the backend server 4 can be part of one of the traffic lights 3.

[0030] Each traffic light 3 comprises a global positioning system 7, configured to determine a position of the respective traffic light 3 by receiving positioning signals from a navigation satellite system 8. Further, the traffic lights 3 each comprise a (vehicle-to-x) V2X transmitter 9, configured to broadcast MAP and SPaT messages to vehicles in the environment of the traffic lights 3, and a communication device 10, which is configured to communicate with the other traffic light 3 within the set 2, for example to avoid opposing "green" signals, and to communicate with the backend server 4. The communication device 10 can use, among others, for example, WiFi, mobile communication (3G, 4G, 5G,...) etc. The traffic lights 3 also comprise a control device 11, configured to control the traffic light 3, in particular to control optical signaling devices 12 of the traffic lights 3.

[0031] The system 1 is configured to execute the method described in this disclosure. In particular, the measures of the method are executed automatically after the set 2 of traffic lights 3 is established at a site of operation, for example at a construction site.

[0032] In principle, the measures can also be executed manually. In an alternative embodiment the traffic lights 3 do not comprise a proper global positioning system 7, but, for example, a handheld positioning system is used to determine the positions of the traffic lights 3 one by one.

[0033] After establishing the traffic lights 3 at their respective positions 13, for example at opposing ends of a constructions site, a position 13 of each of the traffic lights 3 is determined by the respective global positioning systems 7.

[0034] The determined positions 13 are transmitted by the communication devices 10 to the backend server 4.

[0035] The backend server 4 receives the determined positions 13. The determined positions 13 are assigned to corresponding traffic lanes of at least one street in a digital street map 14 by the processing device 5. In particular, the determined positions 13 are assigned to inflow and outflow lanes within the digital street map. Before and/or during the assignment corrections to the positions

13 can be made based on the digital street map 14 by the processing device 5. For example, the positions 13 can be shifted to conform with the street infrastructure that is recorded in the digital street map 14.

[0036] A MAP message 15 is generated by the processing device 5 based on the positions 13 in the digital street map 14 and the assignments. The generated MAP message 15 comprises the respective assignments. In particular, the MAP message 15 is generated in accordance with standard SAE J2735 2016-03.

[0037] SPaT messages 16 are generated by the control devices 11 of each of the traffic lights 3 based on the traffic light phase plan 20 of the respective traffic light 3 or the SPaT messages 16 are generated based on the information of the current phase of the respective traffic light 3. In particular, the SPaT messages 16 are generated in accordance with standard SAE J2735 2016-03.

[0038] The processing device 5 links the generated MAP message 15 and the SPaT messages 16 to each other by the SignalGroupID which indicates the traffic lane that is corresponding to a certain optical signaling device 12 of a traffic light 3. For this purpose the traffic light phase plan(s) 20 can be transmitted to the backend server 4.

[0039] The generated MAP message 15 is transmitted to the traffic lights 3. The traffic lights 3 receive the MAP message 15 by the communication devices 10.

[0040] The received MAP message 15 and the generated SPaT messages 16 are then broadcasted by each traffic light 3 using the V2X transmitters 9. Vehicles equipped to receive and process MAP/SPaT can then use the MAP messages 15 and SPaT messages 16 as additional information when approaching the traffic lights 3 of the set 2.

[0041] In one embodiment, an approval of the MAP and SPaT messages 15, 16 is requested before the MAP and SPaT messages 15, 16 are broadcasted. For example, a traffic engineer or road worker can approve the MAP and SPaT messages 15, 16 after generation. This allows to manually or automatically control and verify the generated MAP and SPaT messages 15, 16.

[0042] In one embodiment, a Decentralized Environmental Notification Message 17 (DEMN) is broadcasted in case one or more of the measures cannot be executed properly.

[0043] In one embodiment, a plausibility of the SPaT message 16 is evaluated in consideration of passage and clearing times required at a site of operation. For this purpose, further information can be provided and/or transmitted to the control devices 11, for example topology data of the site of operation of the set 2 of traffic lights 3. If the plausibility evaluation of the SPaT message results in detection of conflicting timing information, the timing information in the SPaT message can be adapted to conform with the passage and clearing times. Also, the plausibility can be evaluated by the processing device 4 if the generated SPaT messages 16 and the further information are transmitted to the processing device 5.

[0044] In particular, it is also possible that the traffic lights 3 and/or the processing device 5 determines the passage and clearing times based on the determined positions 13 of the traffic lights 3, which allow to determine, for example the distance between the traffic lights 3.

List of reference numerals

[0045]

1	system
2	set
3	traffic light
4	backend server
5	processing device
6	memory
7	global positioning system
8	navigation satellite system
9	V2X transmitter
10	communication device
11	control device
12	optical signaling device
13	position
14	digital street map
15	MAP message
16	SPaT message
17	DEMN message
20	traffic light phase plan

Claims

1. Method for providing MAP and SPaT messages (15,16) for a newly established set (2) of at least one traffic light (3),
wherein a position (13) of each of the at least one traffic light (3) within the set (2) is determined by a global positioning system (7),
wherein the determined positions (13) are assigned to corresponding traffic lanes of at least one street in a digital street map by a processing device (5),
wherein a MAP message (15) is generated based on the digital street map, wherein the generated MAP message (15) comprises the assignments,
wherein at least one SPaT message (16) is generated based on a traffic light phase plan (20) of the at least one traffic light (3) or at least one SPaT message (16) is generated based on the information of the current phase of the at least one traffic light (3), and
wherein the generated MAP and SPaT messages (15,16) are broadcasted by the set (2) of the at least one traffic light (3).

2. Method according to claim 1, wherein determining the positions (13) is executed in each case by global positioning systems (7) of each of the at least one

traffic light (3), wherein the determined positions (13) are each transmitted from the traffic lights (3) to the processing device (5) by a respective communication link.

3. Method according to claim 1 or 2, wherein the processing device (5) is part of a backend server (4), and wherein the processing device (5) also generates the MAP message (15).

4. Method according to any one of the preceding claims, wherein the measures are executed automatically after the set (2) of the at least one traffic light (3) is established at a site of operation.

5. Method according to any one of the preceding claims, wherein an approval of the MAP and SPaT messages (15,16) is requested before the MAP and SPaT messages (15,16) are broadcasted.

6. Method according to any one of the preceding claims, wherein a Decentralized Environmental Notification Message (DEMN) (17) is broadcasted in case one or more of the measures cannot be executed properly.

7. Method according to any one of the preceding claims, wherein a plausibility of the SPaT message (16) is evaluated in consideration of passage and clearing times required at a site of operation.

8. System (1) for providing MAP and SPaT messages (15,16) for a newly established set (2) of at least one traffic light (3), comprising:

a set (2) of at least one traffic light (3),
a processing device (5),
at least one global positioning system (7), configured to determine a position (13) for each of the at least one traffic light (3) within the set (2),
wherein the at least one traffic light (3) within the set (2) is configured to generate a SPaT message (16) based on a traffic light phase plan (20) of the at least one traffic light (3) or
to generate a SPaT message (16) based on the information of the current phase of the at least one traffic light (3), and
wherein the processing device (5) is configured to assign the determined positions (13) to corresponding traffic lanes of at least one street in a digital street map, to generate a MAP message (15) based on the digital street map, wherein the generated MAP message (15) comprises the assignments, and
wherein the at least one traffic light (3) within the set (2) is configured to broadcast the generated MAP and SPaT messages (15,16).

9. Traffic light (3) for a system (1) for providing MAP and SPaT messages (15,16) for a newly established set (2) of at least one traffic light (3), comprising:

a global positioning system (7), configured to determine a position (13) of the traffic light (3) after establishment at a site of operation,
at least one communication device (10), configured to communicate at least with other traffic lights (3) within the set (2) of traffic lights (3) and/or with a backend server (4), and
configured to communicate via a V2X interface, and
a control device (11), configured to control the traffic light (3) according to a traffic light phase plan (20), wherein the control device (11) is further configured to generate a SPaT message (16) based on the traffic light phase plan (20) or to generate a SPaT message (16) based on the information of the current phase of the at least one traffic light (3), to transmit the determined position (13) to the backend server (4) and to receive a MAP message (15) from the backend server (4) via the at least one communication device (10), and to broadcast the received MAP message (15) and the generated SPaT message (16) via the at least one communication device (10).

10. Backend server (4) for a system (1) for providing MAP and SPaT messages (15,16) for a newly established set of at least one traffic light (3), comprising:

a processing device (5), and
a communication device (10), configured to communicate with at least one traffic light (3) within a set (2) of traffic lights (3),
wherein the processing device (5) is configured to receive a position (13) of the at least one traffic light (3) via the communication device (10) and to assign the determined position(s) (13) to corresponding traffic lanes of at least one street in a digital street map,
and to generate a MAP message (15) based on the digital street map, wherein the generated MAP message (15) comprises the assignments, and to transmit the generated MAP message (15) via the communication device (10) to the at least one traffic light (3) for broadcasting.

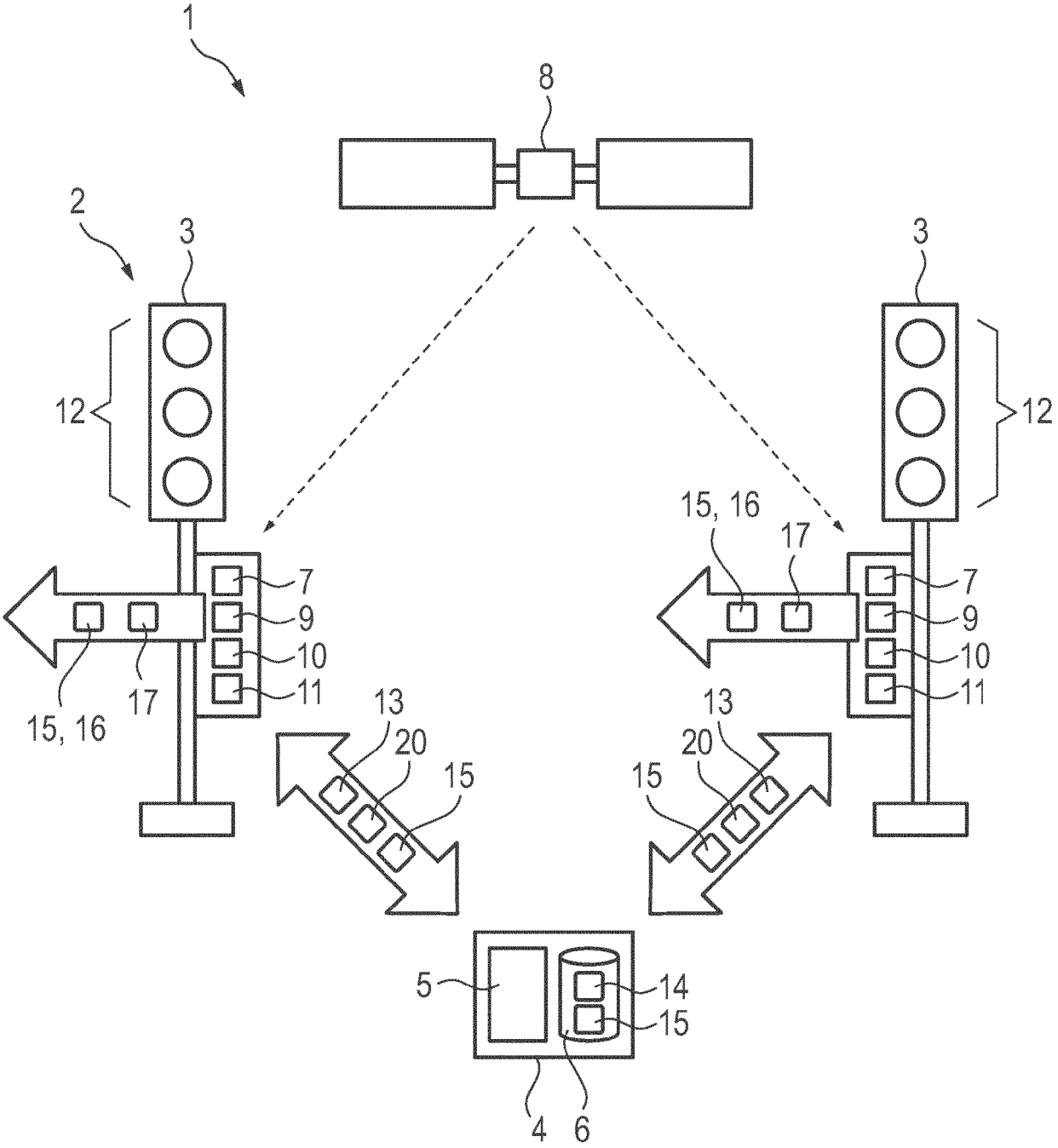

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 20 17 1678

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A	* page 3, left-hand column, paragraph 1 - right-hand column, paragraph 1 * * figure 1a *	2-9	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 October 2020	de la Cruz Valera, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

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D : document cited in the application
L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 17 1678

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