

A SELF-ADAPTIVE VEHICLE MOVEMENT NETWORK SERVICE FOR SMART TRAFFIC DATA COLLECTION

Field of the Invention

The invention generally relates to monitoring of vehicle activity, such as
5 monitoring traffic conditions.

Background to the Invention

The proliferation of GPS-based technology used in devices such as navigation systems is a strong enabler to enhance information collection from motorists. It enables government agencies to have real-time traffic monitoring and
10 management, and also provide more traffic information for the benefits of motorists.

Data such as vehicle location, speed and direction of travel are sent from in-vehicle On-Board Unit (OBU) to a backend server system. After being collected and extracted, useful information (e.g. status of traffic) can be obtained.

15 Having every OBU communicate directly with the backend server system risks situations in which a large amount of data is sent to backend server system, in particular where every vehicle is sending information frequently and where there is a large vehicle population travelling on the road. This is further exacerbated because the vehicle population is increasing over time. Furthermore,
20 this arrangement risks large portions of the communicated information being redundant when used to determine traffic status during a congested situation because vehicles in the same segment of road will travel at the same speed in the same direction, and therefore send substantially the same information.

Summary of the Invention

25 According to an aspect of the present invention, there is provided a communication module for use with a vehicle, comprising: a processor interfaced to a local wireless module configured for communication via a local channel with

one or more other communication modules and a wide-area wireless module configured for communication via a wide-area channel with a traffic monitoring server, wherein the communication module is selectively configurable to operate in at least a first mode corresponding to a master communication module and a
5 second mode corresponding to a slave communication module, and wherein the processor is configured to determine that the communication module is to operate in the first mode or the second mode, wherein when operating in the first mode the communication module is configured to: identify and maintain communication with one or more other slave communication modules located within a
10 predetermined range of the communication module via the local channel; generate vehicle group telemetry data indicative of telemetry data associated with the communication module and telemetry data associated with each other communication module; and communicate said vehicle group telemetry data to the traffic monitoring server via the wide-area channel, and wherein when
15 operating in the second mode the communication module is configured to: identify and maintain communication with another master communication module located within a predetermined range of the communication module via the local channel.

The local channel may implement the 802.11p standard. The wide-area
20 channel may comprise at least one of: GSM, UMTS, CDMA, HSPA+, Mobile WiMAX, LTE, and/or comprises a V2I standard.

In an embodiment, the communication module is configured to operate in the first mode in response to a failure to identify another master communication module. In an embodiment, the communication module is configured to operate in
25 the second mode in response to successfully identifying another master communication module. The communication module may be configured to operate in the first mode after operation in the second mode in response to: either a failure in communication with the other communication module or a change in the conditions; and a failure to identify another communication module
30 configured as a master.

In an embodiment, the vehicle group telemetry data corresponds to vehicle telemetry data of a vehicle associated with the communication module. In another embodiment, the vehicle group telemetry data is generated from vehicle telemetry data of a vehicle associated with the communication module and vehicle telemetry data communicated to the communication module via the local channel from one or more other communication modules. Typically, the vehicle group telemetry data is communicated to the traffic monitoring server periodically.

The communication module may be configured to send and receive heartbeat messages via the local channel. Optionally, the other master communication module is identified due to reception of a heartbeat message sent by the other master communication module.

According to another aspect of the present invention, there is provided a method for configuring and operating a communication module as a master communication module, comprising the steps of: determining, as a result of communication via a local channel, that a predefined local communication criteria has not been satisfied; configuring the communication module to operate in a first mode corresponding to a master communication module; identifying and maintaining communication with one or more slave communication modules located within a predetermined range of the communication module via the local channel; generating vehicle group telemetry data indicative of telemetry data associated with the communication module and telemetry data associated with each other communication module.

According to another aspect of the present invention, there is provided a method for configuring and operating a communication module as a slave communication module, comprising the steps of: determining, as a result of communication via a local channel, that a predefined local communication criteria has been satisfied; configuring the communication module to operate in a second mode corresponding to a slave communication module; identifying and maintaining communication with a master communication module located within a predetermined range of the communication module via the local channel.

According to another aspect of the present invention, there is provided a method for operating a communication module comprising a processor interfaced to a local wireless module configured for communication via a local channel with one or more other communication modules and a wide-area wireless module
5 configured for communication via a wide-area channel with a traffic monitoring server, the method comprising: determining, as a result of communication via a local channel, whether a predefined local communication criteria has or has not been satisfied; in response to determining that the predefined local communication criteria has not been satisfied: operating the communication module in a first
10 mode corresponding to a master communication module; identifying and maintaining communication with one or more slave communication modules located within a predetermined range of the communication module via the local channel; generating vehicle group telemetry data indicative of telemetry data associated with the communication module and telemetry data associated with
15 each other communication module; and communicating said vehicle group telemetry data to the traffic monitoring server via the wide-area channel, and in response to determining that the predefined local communication criteria has been satisfied: identifying and maintaining communication with another master communication module located within a predetermined range of the
20 communication module via the local channel.

The local channel may implement the 802.11p standard. The wide-area channel may comprise at least one of: GSM, UMTS, CDMA, HSPA+, Mobile WiMAX, LTE, and/or comprises a V2I standard.

In an embodiment, the communication module operates in the first mode in
25 response to a failure to identify another master communication module. In an embodiment, the communication module operates in the second mode in response to successfully identifying another master communication module. Optionally, the method further comprises the step of, in response to: either a failure in communication with the other communication module or a change in the
30 conditions; and a failure to identify another communication module configured as

a master, operating the communication module in the first mode after operation in the second mode.

In an embodiment, the vehicle group telemetry data corresponds to vehicle telemetry data of a vehicle associated with the communication module. In another
5 embodiment, the vehicle group telemetry data is generated from vehicle telemetry data of a vehicle associated with the communication module and vehicle telemetry data communicated to the communication module via the local channel from one or more other communication modules. Typically, the method includes the step of periodically communicating the vehicle group telemetry data to the traffic
10 monitoring server.

The method preferably includes the step of periodically communicating heartbeat messages over the local communication module when operating in the first mode. The other master communication module may be identified due to reception of a heartbeat message sent by the other master communication module.

15 According to another aspect of the present invention, there is provided a vehicle communication system comprising one or more vehicle groups, wherein each vehicle group comprises at least one vehicle comprising a communication module, wherein the or each communication module is configured for communication via a local channel with other communication modules, and
20 wherein each communication module is selectively configured for operation in one of a first mode and a second mode, wherein the first mode corresponds to its vehicle configured as a master and the second mode corresponds to its vehicle configured as a slave, wherein each vehicle group comprises one vehicle configured as a master, and wherein for each vehicle group the vehicle configured
25 as a master is configured to generate and communicate vehicle group telemetry data to a traffic monitoring server via a wide area channel.

Preferably at least one vehicle group comprises at least one vehicle configured as a slave. More preferably, each vehicle group comprises at least one vehicle configured as a slave. Each vehicle configured as a slave may be
30 configured to communicate via the local channel with the vehicle configured as a

master for the vehicle group to which it belongs. Optionally, the vehicle group telemetry data generated and communicated by a master of a vehicle group is indicative of at least one of: position, heading direction, and speed of the vehicle(s) of the vehicle group.

5 Typically, the communication module of each vehicle is a communication module according to the first aspect above.

According to another aspect of the present invention, there is provided a method for adding a first vehicle to a vehicle group, said vehicle group comprising a second vehicle configured as a master and optionally one or more
10 additional vehicles each configured as a slave, wherein each vehicle is configured for communication with other vehicles via a local channel, the method comprising the steps of: the first vehicle determining, as a result of communication via the local channel, that a predefined local communication criteria has been satisfied, said predefined local communication criteria indicating that the first vehicle is
15 suitable for joining the vehicle group; in response, configuring the first vehicle to maintain communication with the second vehicle via the local channel; and registering with the second vehicle a slave configuration of the first vehicle, said slave configuration indicating that the first vehicle has been added as a member of the vehicle group and is configured as a slave. Typically, each vehicle comprises a
20 communication module according to the first aspect above.

Optionally, the method further comprises the steps of: in response to registering the first vehicle with the second vehicle, the second vehicle: generating vehicle group telemetry data indicative of telemetry data associated with the first vehicle, the second vehicle, and the optional one or more additional vehicles of
25 the vehicle group; and communicating said vehicle group telemetry data to the traffic monitoring server via the wide-area channel.

According to another aspect of the present invention, there is provided a method for removing a first vehicle configured as a slave from a vehicle group, said vehicle group comprising a second vehicle configured as a master and
30 optionally one or more additional vehicles each configured as a slave, wherein

each vehicle is configured for communication with other vehicles via a local channel, the method comprising the steps of: the second vehicle determining that a leave event has occurred, said leave event indicative that the first vehicle is to be removed from the vehicle group; in response, de-registering with the second vehicle the membership of the first vehicle with thin the vehicle group. Typically, each vehicle comprises a communication module according to the first aspect above.

In an embodiment, the leave event comprises the second vehicle determining that the first vehicle is unable to communicate via the local channel with the second vehicle. Optionally, the second vehicle is configured to wait a predetermined time from a previous communication being received from the first vehicle via the local channel before determining that the leave event has occurred. In another embodiment, the leave event comprises the first vehicle communicating via the local channel to the second vehicle a request for removal from the vehicle group. In another embodiment, the leave event comprises the first vehicle communicating via the local channel to the second vehicle information inconsistent with membership of the vehicle group.

According to yet another aspect of the present invention, there is provided a method for configuring a first vehicle as a master of a vehicle group, wherein said first vehicle is a member of the vehicle group and is originally configured as a slave, said vehicle group comprising the first vehicle configured as a slave, a second vehicle configured as a master, and optionally one or more additional vehicles each configured as a slave, the method comprising the steps of: the first vehicle determining that a master leave event has occurred, said master leave event corresponding to the second vehicle leaving the vehicle group; and in response, configuring the first vehicle as a master of the vehicle group. Typically, each vehicle comprises a communication module according to the first aspect above.

In an embodiment, the master leave event comprises the second vehicle communicating to the first vehicle, via the local channel, a messaging indicating it

is leaving the vehicle group. In another embodiment, the master leave event comprises the first vehicle determining that the second vehicle is unable to communicate via the local channel with the first vehicle. Optionally, the first vehicle is configured to wait a predetermined time from a previous
5 communication being received from the second vehicle via the local channel before determining that the leave event has occurred.

Typically, the vehicle group comprises at least one additional vehicle configured as a slave, and the method further comprises: one or more additional vehicles determining that a master leave event has occurred; the one or more
10 additional vehicles communicating with the first vehicle via the local channel; and thereby determining that the first vehicle is to become the master of the vehicle group and the one or more additional vehicles remaining as slaves of the vehicle group. The first vehicle may be determined to become the master of the vehicle group on account of having an earliest initial membership time when compared to
15 the initial membership times of the one or more additional vehicles, wherein an initial membership time corresponds to a timestamp indicating the time at which the associated vehicle became a member of the vehicle group.

According to still yet another aspect of the present invention, there is provided a method for merging a first vehicle group comprising a first vehicle
20 configured as a master and a second vehicle group comprising a second vehicle configured as a master and at least one additional vehicle configured as a slave, the method comprising the steps of: the first vehicle communicating with the second vehicle via a local channel; determining, as a result of the communication, that a merge condition is satisfied meaning that the second vehicle group is to be
25 merged with the first vehicle group; configuring the second vehicle as a slave of the first vehicle group; configuring each additional vehicle as a slave of the first vehicle group. Typically, each vehicle comprises a communication module according to the first aspect above.

Preferably, the merge condition includes determining that the first vehicle
30 group comprises a larger number of vehicles than the second vehicle group.

As used herein, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

5 Brief description of the drawings

In order that the invention may be more clearly understood, embodiments will now be described, by way of example, with reference to the accompanying drawing, in which:

Figure 1 shows a vehicle communication system;

10 Figure 2 shows a communication module for use in a vehicle according to an embodiment;

Figure 3a shows a process for configuring a vehicle as a master according to an embodiment;

15 Figure 3b shows a process for configuring a vehicle as master according to another embodiment.

Figure 3c shows a first vehicle group associated with and comprising the master;

Figure 4a shows a process for configuring a vehicle as a slave according to an embodiment;

20 Figure 4b shows a process for configuring a vehicle as a slave according to another embodiment;

Figure 4c shows the first vehicle group comprising the master and the slave;

Figure 5a shows a process for configuring a second slave vehicle according to an embodiment;

25 Figure 5b shows a process for configuring a second master vehicle according to an embodiment;

Figure 5c shows a process for configuring a second slave vehicle according

to another embodiment;

Figure 5d shows a process for configuring a second master vehicle according to another embodiment;

Figure 5e shows the first vehicle group comprising the master and two
5 slaves ;

Figure 5f shows the first vehicle group comprising a master and a slave, and a second vehicle group comprising another master;

Figure 6 shows the master in communication with the traffic monitoring server via the wide-area channel and the slaves of the first vehicle group via the
10 local channel;

Figure 7a shows a method for removing a master from a vehicle group;

Figure 7b shows another method for removing a master from a vehicle group; and

Figure 8 shows a method for removing a slave from a vehicle group;

15 Detail description of particular embodiments

In the figures, general features are labelled with a numerical reference. Different instances of the same general feature will include the same number reference and may further be distinguished with a letter suffix. When a feature is referred to in a general sense, the letter suffix is generally omitted. When the
20 description requires distinguishing between different specific instances of a general feature, the letter suffix is included.

Figure 1 shows an exemplary vehicle communication system 10 according to embodiments of the invention. The system 10 comprises a plurality of vehicles 11 (in the drawings, the vehicles 11 are represented as cars), each vehicle
25 comprising a communication module 12. The system 10 is shown schematically, and it is understood that there can be any number of vehicles 11 within the system 10; the three vehicles 11a-11c are shown for illustrative purposes only.

Each communication module 12 is configured for local communication via a local channel 13 with other communication modules 12. Each communication module 12 is also configured for wide-area communication via a wide-area channel 14 with a traffic monitoring server 15.

5 In an embodiment, the wide-area communication involves wireless communication of data between a communication module 12 and a cellular site 16. The data is then communicated between the cellular site 16 and the traffic monitoring server 15 via a packet-switching network 17, typically including the Internet. In an implementation, a communication module 12 communicates with
10 the cellular site 16 using a cellular wireless protocol, such as GSM, UMTS, CDMA, HSPA+, Mobile WiMAX, LTE, etc. In another embodiment, the wide-area communication utilises vehicle-to-infrastructure (V2I) communication.

The local channel 13 is configured to enable local communication between communication modules 12 over a limited physical range. The local channel 13
15 comprises wireless data communication. In an implementation, the local channel 13 corresponds to the 802.11p protocol. Wireless data communication between vehicles 11 can be referred to as Wireless Access in Vehicular Environments (WAVE) or Vehicle-to-Vehicle (V2V) communication. In an implementation, the local channel 13 operates within the 5.9 GHz radio band with allocated 70 MHz
20 wireless spectrum.

The “limited physical range” of the local channel 13 is characterised by a maximum range over which communications can occur between different communication modules 12. The maximum range is not necessarily a specific range value, as it may be influenced by environmental considerations etc. The
25 maximum range can also be extended when several communication modules 12 are in communication via the local channel 13, as each communication module 12 can act as a relay for each other communication module 12.

Figure 2 shows a communication module 12 according to an embodiment. The communication module 12 includes a processor 90 interfaced with a memory
30 91 configured for storing transient data and program instructions. The processor

90 executes instructions stored within the memory 91, and can read and write data to the memory 91. The memory 91 typically comprises volatile and non-volatile memories.

The communication module 12 also includes, and is interfaced to, a sensor module 92. The communication module 12 includes a power supply input 93 which can be interfaced with an external power supply (not shown) and/or a battery (not shown). The sensor module 92 comprises or is interfaced to one or more sensors. According to an embodiment, the sensors include a position sensor (also referred to as a location sensor), direction sensor, and optionally a speed/velocity sensor. The position sensor can be configured to identify the current latitude and longitude of the communication module 12 (and therefore, the latitude and longitude of the associated vehicle 11). The sensor module 92 is configured for providing data acquired by the one or more sensors to the processor 90.

The communication module 12 is configured to generate vehicle telemetry data based on received sensor inputs. Typically, this vehicle telemetry data comprises at least one of: position, heading direction, and speed. The vehicle telemetry data is suitable for recording travel undertaken by the vehicle, and may be accumulated in real-time or periodically.

The communication module 12 further includes local wireless module 94 configured for facilitating the local communication via the local channel 13 between different communication modules 12. The local wireless module 94 is interfaced with the processor 90 and enables data to be communicated between the communication module 12 and other communication modules 12. The communication module 12 is also interfaced with a wide-area wireless module 95 configured for facilitating the wide-area communication via the wide-area channel 14 between the communication module 12 and the traffic monitoring server 15. The wide-area wireless module 95 can comprise the same or different physical hardware as the local wireless module 94. In a general sense, the communication module 12 is configured for communicating the generated vehicle telemetry data

to the traffic monitoring server 15 via the wide-area channel 14.

The communication module 12 can be permanently located on (or within) its vehicle 11, or can be a removable device. The communication module 12 can be a dedicated device, or alternatively, the communication module 12 can be implemented as a feature of a general computing device such as a smartphone. Each communication module 12 is selectively configurable to operate in a first mode as a “master” or in a second mode as a “slave”. The communication modules 12 can also be in an initial state before being configured as a master or slave.

For convenience, the description herein refers to vehicles 11 as being master, slave, or in an initial state. Furthermore, the description refers to the vehicles 11 communicating via the local channel 13 and the wide-area channel 14. It is understood that it is the communication modules 12 associated with the vehicles 11 which are configured as master, slave, or in an initial state, and undertake the communication via the local 13 and wide-area channels 14.

Figures 3a to 3c show a first vehicle 11a being configured as a master (M), the vehicle 11a being a part of a collection of three vehicles 11a-11c each being in an initial state (I). Generally, the first vehicle 11a determines that a predetermined local communication criteria has not been satisfied, and as a result, configures itself as a master (M).

In an embodiment, as shown in Figure 3a, a first vehicle 11a attempts to identify another vehicle 11 already configured as a master by determining if such a vehicle 11 exists within the maximum range of the local channel 13 (i.e. if such a vehicle 11 is close enough to communicate via the local channel 13). The first vehicle 11a sends a master identification request via the local channel 13. Seeing as there is no vehicle 11 currently configured as a master, the first vehicle 11a will either receive no reply to the master identification request, or will receive negative replies from the second and third vehicles 11b, 11c (i.e. the predetermined local communication criteria, being reception of a response to the master identification request, is not satisfied). The first vehicle 11a may implement a “timeout”, being a

specified time within which a positive response must be received. The first vehicle 11a may also implement a minimum number of attempts, in which it sends a minimum number of master identification requests via the local channel 13, with a preconfigured time delay between subsequent requests.

5 In response to determining that the predefined local communication criteria is not satisfied (i.e. in response to not identifying another vehicle 11b, 11c configured as a master), the first vehicle 11a then configures itself as a master. Typically, it is the vehicle 11 which first sends a master identification request via the local channel 13 which becomes a master (when considering a collection of
10 vehicles 11 within the physical range of the local channel 13).

 In another embodiment, as shown in Figure 3b, the first vehicle 11a listens for a heartbeat message within the local channel 13. The heartbeat message corresponds to periodic communication from another vehicle 11 configured as a master. The heartbeat message corresponds, in this embodiment, to the predefined
15 local communication criteria. Seeing as there is no vehicle 11 currently configured as a master, the first vehicle 11a will receive no heartbeat message. The first vehicle 11a may implement a “timeout”, being a specified time within which a heartbeat message is to be received to satisfy the predefined local communication criteria.

20 In response to not receiving a heartbeat message (i.e. in response to determining that the predefined local communication criteria is not satisfied), the first vehicle 11a then configures itself as a master.

 Referring to Figure 3c, the first vehicle 11a is also associated with a first vehicle group 19a, and is the master of this vehicle group 19a. The system 10 can
25 comprise one or more vehicle groups 19, each of which is associated with a vehicle 11 configured as a master. Typically, there is one vehicle 11 configured as a master for each vehicle group 19. The number of vehicle groups 19 present within the system 10 can vary with time, as different vehicles 11 are configured as masters, and as existing vehicles 11 configured as masters leave the system 10 (or
30 otherwise revert to an initial state or being a slave).

Generally, a vehicle 11 configured as a master and associated with a vehicle group 19 will generate vehicle group telemetry data, being telemetry data representative of the entire vehicle group 19. The vehicle 11 configured as a master then proceeds to periodically (or in real-time) communicate the generated
5 vehicle group telemetry data to the traffic monitoring server 15.

Figures 4a to 4c show a second vehicle 11b being configured as a slave (S) within a vehicle group 19a. The figures refer to the same three vehicles 11a-11c from Figures 3a to 3c. However, due to the actions described in reference to Figures 3a to 3c, the first vehicle 11a is now configured as a master (M) and is
10 associated with the first vehicle group 19a. Generally, the second vehicle 11b determines that a predetermined local communication criteria has been satisfied, and as a result, configures itself as a slave (S) and becomes part of the first vehicle group 19a.

In an embodiment, shown in Figure 4a, the second vehicle 11b attempts to
15 identify another vehicle 11 configured as a master by sending a master identification request via the local channel 13, in the same manner as undertaken by the first vehicle 11a as shown in Figure 3a. The first vehicle 11a receives the master identification request from the second vehicle 11b, and generates a master identification response and communicates it, via the local channel 13, to the
20 second vehicle 11b. The master identification response typically contains information such as the master OBU ID and direction of travel. Optionally, the second vehicle 11b analyses the received master identification response in order to determine that the first vehicle group 19a is suitable for the second vehicle 11b to belong. Furthermore, the first vehicle 11a generates an identification token (ID
25 token) associated with the second vehicle 11b for storing within the memory 91 of its communication module 12a. Typically, the ID token will comprise unique identifying data associated with the second vehicle 11b and a timestamp corresponding to the time at which the ID token was generated.

The master identification response corresponds to the predefined local
30 communication criteria being satisfied; that is, it is a positive response to the

master identification request communicated by the second vehicle 11b. The master identification response typically comprises at least an identifier of the first vehicle 11a. The second vehicle 11b is then able to communicate via the local channel 13 directly with the first vehicle 11a. The first vehicle 11a optionally
5 communicates to the traffic monitoring server 15 information indicating the membership of the second vehicle 11b to the first vehicle group 19a.

In another embodiment, shown in Figure 4b, the second vehicle 11b attempts to identify another vehicle 11 configured as a master by listening for a heartbeat message over the local channel 13, in the same manner as undertaken by
10 the first vehicle 11a in Figure 3b. Unlike with Figure 3b, there is a master present (the first vehicle 11a) which is periodically communicating heartbeat messages over the local channel 13. Thus, the second vehicle 11b receives a heartbeat message over the local channel 13, thereby satisfying the predetermined local communication criteria. The heartbeat message typically contains information
15 such as the master OBU ID and direction of travel. Optionally, the second vehicle 11b analyses the received heartbeat message in order to determine that the first vehicle group 19a is suitable for the second vehicle 11b to belong. For example, that the direction of travel within the heartbeat message is broadly consistent with the direction of travel of the second vehicle 11b.

20 In response to receiving the heartbeat message from the first vehicle 11a, the second vehicle communicates a heartbeat response via the local channel 13 to the first vehicle 11a. The first vehicle 11a receives the heartbeat response from the second vehicle 11b, and optionally generates a heartbeat response acknowledgement and communicates it, via the local channel 13, to the second
25 vehicle 11b. The heartbeat response acknowledgement corresponds to a positive response to the heartbeat response communicated by the second vehicle 11b. The heartbeat response acknowledgement typically comprises at least an identifier of the first vehicle 11a. The second vehicle 11b is then able to communicate via the local channel 13 directly with the first vehicle 11a. The first vehicle 11a
30 optionally communicates to the traffic monitoring server 15 information

indicating the membership of the second vehicle 11b to the first vehicle group 19a.

As a result of the predetermined local communication criteria being satisfied, referring to Figure 4c, the second vehicle 11b is now registered with the first vehicle group 19a, and is configured as a slave. The second vehicle 11b is in
5 communication with the first vehicle 11a via the local channel 13.

Referring now to Figures 5a, 5b, 5c and 5d, a process is shown whereby the third vehicle 11c joins the first vehicle group 19a (see Figure 5a or Figure 5c) or creates its own vehicle group 19b and is configured as a master (see Figure 5b or Figure 5d). In these figures, as a result of the actions described with reference to
10 both Figures 3 and 4, the first vehicle 11a is shown initially configured as a master (M) with associated first vehicle group 19a, and the second vehicle 11b is shown initially configured as a slave (S) also associated with the first vehicle group 19a. The third vehicle 11c is in its initial state (I). Figure 5a and 5c shows a situation where the third vehicle 11c is able to communicate via the local channel 13 with
15 the first vehicle 11a (i.e. the third vehicle 11c is within the limited physical range of the local channel 13). Figure 5b and 5d shows a situation where the third vehicle 11c is not able to communicate via the local channel 13 with the first vehicle 11a (i.e. the third vehicle 11c is not within the limited physical range of the local channel 13).

20 Considering first the situation whereby communication between the third vehicle 11c and the first vehicle 11a via local channel 13 is possible, Figure 5a shows one embodiment, whereby the third vehicle 11c attempts to identify another vehicle 11 configured as a master by sending a master identification request via the local channel 13 (similar to the process described with respect to
25 the second vehicle 11b in relation to Figure 4a) Seeing as the third vehicle 11c is able to communicate with the first vehicle 11a, the first vehicle 11a receives the master identification request from the third vehicle 11c. The process then proceeds as described with reference to the second vehicle 11b and Figure 4a; the result is that the predefined local communication criteria is satisfied and the third
30 vehicle 11c joins the first vehicle group 19a as a slave (S) and is then able to

communicate directly with the first vehicle 11a using an identifier of the first vehicle 11a.

In another embodiment of the above process, Figure 5c shows the third vehicle 11c attempting to identify another vehicle 11 configured as a master by listening for a heartbeat message via the local channel 13 (similar to the process described with respect to the second vehicle 11b in relation to Figure 4b). Seeing as the third vehicle 11c is able to communicate with the first vehicle 11a, the third vehicle 11c receives a heartbeat message from the first vehicle 11a and sends a heartbeat response to the first vehicle 11a, and the first vehicle 11a receives the heartbeat response from the third vehicle 11c and sends a heartbeat response acknowledgement to third vehicle 11c. The process then proceeds as described with reference to the second vehicle 11b and Figure 4b; the result is that the predefined local communication criteria is satisfied and the third vehicle 11c joins the first vehicle group 19a as a slave (S) and is then able to communicate directly with the first vehicle 11a using the network address of the first vehicle 11a.

Now considering the situation whereby communication between the third vehicle 11c and the first vehicle 11a via local channel 13 is not possible, Figure 5b shows one embodiment, whereby the third vehicle 11c attempts to identify another vehicle 11 configured as a master by sending a master identification request via the local channel 13 (again, similar to the process described with respect to the first vehicle 11a in relation to Figure 3a). Seeing as the third vehicle 11c is not able to communicate with the first vehicle 11a, the first vehicle 11a does not receive the master identification request from the third vehicle 11c. The predefined local communication criteria is therefore not satisfied and the third vehicle 11c is unable to join the first vehicle group 19a, and is unable to enter into a direct communication via the local channel 13 with the first vehicle 11a.

In another embodiment of the above process, Figure 5d shows the third vehicle 11c attempting to identify another vehicle 11 configured as a master by waiting for a heartbeat message via the local channel 13 (again, similar to the process described with respect to the first vehicle 11a in relation to Figure 3b).

Seeing as the third vehicle 11c is not able to communicate with the first vehicle 11a, the third vehicle 11c does not receive a heartbeat message, and the first vehicle 11a will not receive a heartbeat response from the third vehicle 11c. The predefined local communication criteria is therefore not satisfied and the third vehicle 11c will not join the first vehicle group 19a, and is unable to enter into a direct communication via the local channel 13 with the first vehicle 11a.

Having failed to identify a vehicle 11 configured as a master (such as the first vehicle 11a), the third vehicle 11c can undertake the actions described with reference to Figures 3a to 3c, thereby configuring itself as a master (M). In this case, the traffic monitoring server 15 can receive telemetry data from both the first vehicle 11a and the third vehicle 11b, which are both configured as masters. Furthermore, the third vehicle 11c in this case is associated with a second vehicle group 19b, different to the first vehicle group 19a.

Figure 5e shows the first, second, and third vehicles 11a, 11b, 11c within the same vehicle group 19a, as a result of the process described with reference to Figures 5a and 5c. In this case, the first vehicle 11a is configured as a master and the second and third vehicles 11b, 11c are each configured as slaves. Both the second and the third vehicles 11b, 11c are registered with the first vehicle group 19a and in communication with the first vehicle 11a via the local channel 13. Figure 5f shows the first and second vehicles 11a, 11b within a first vehicle group 19a (i.e. the second vehicle 11b is registered with the first vehicle group 19a), and the third vehicle 11c within a second vehicle group 19b, different to the first vehicle group 19a. The first and second vehicles 11a, 11b are in communication with one another via the local channel 13, whereas the third vehicle 11c is not.

Additional vehicles 11 are able to undertake any of the above actions, thereby resulting in each additional vehicle 11 becoming a master associated with a new vehicle group 19, or becoming registering with and becoming a slave of an existing vehicle group 19.

Figure 6 shows a vehicle group 19a of one or more vehicles 11 (in this case, three vehicles 11a-11c). The first vehicle 11a is configured as a master, and the

second and third vehicles 11b, 11c are each configured as slaves, each in communication via the local channel 13 with the first vehicle 11a. The vehicles 11a-11c are travelling in close proximity in substantially the same direction and at approximately the same speed (the vehicles 11 are "travelling together"). The vehicle communication system 10 enables the vehicles 11a-11c of the vehicle group 19a to communicate vehicle travelling information as a single entity via the first vehicle 11a (being the master of the vehicle group 19a). In this way, only the first vehicle 11a is required to communicate vehicle telemetry data (in the form of vehicle group telemetry data) to the traffic monitoring server 15 via the wide-area channel 14. This means that less overall vehicle telemetry data is required to be received by the traffic monitoring server 15 while still maintaining an accurate representation of traffic conditions. The first vehicle 11a optionally also communicates the number of vehicles 11a-11c within its vehicle group 19a to the traffic monitoring server 15 in addition to the vehicle group telemetry data.

In a variation, the vehicle group telemetry data is calculated from the vehicle telemetry data of each vehicle 11 within a particular vehicle group 19. For example, an averaging algorithm may be applied. In this case, each vehicle 11 configured as a slave communicates (periodically or in real-time) its vehicle telemetry data to the vehicle 11 configured as a master, which then utilises the received vehicle telemetry data and its own vehicle telemetry data to calculate the vehicle group telemetry data.

Figure 7a and 7b show two processes whereby a vehicle 11 configured as a master leaves its associated vehicle group 19. For example, it may be that the communication module 12 of the vehicle configured as a master utilises other input information in order to determine that the vehicle 11 should no longer be considered the master of the vehicle group 19. For example, the communication module 12 may determine that a destination has been reached.

Referring to Figure 7a, the first vehicle 11a identifies that it should leave the vehicle group 19a (thus, no longer be the master for the vehicle group 19a) at check step 100, the cause of which is a master leave event. The first vehicle 11a transmits via the local channel 13 a master leave command to each of the other

vehicles 11 within the vehicle group 19a at intention to leave step 101. The first vehicle 11a optionally also informs the traffic monitoring server 15 via the wide-area channel 14 that it is no longer the master for the vehicle group 19a, at optional inform step 102.

5 The remaining vehicles 11b, 11c, within the vehicle group 19a then determine a new master, whereby one of these vehicles 11b, 11c configures itself as a master instead of a slave, at determine new master step 103. The communication modules 12 of the vehicles 11 comprise rule-based decision making functionally in order to determine which vehicle 11b, 11c should be the new master.
10 In one implementation, the new master corresponds to the remaining vehicle 11b, 11c which joined the vehicle group 19a earliest, and is therefore determined from its associated timestamp. In this case, the appropriate vehicle 11b configures itself as a master and communicates its status to each other vehicle 11c still within the vehicle group via the local channel 13. In another implementation, the new master
15 corresponds to the vehicle 11b, 11c having best satisfied one or more rules, which can include consideration of, for example, the vehicle 11b, 11c having the highest bandwidth connection to the traffic monitoring server 15. The new master then optionally communicates its status as such as the traffic monitoring server 15 at inform step 104.

20 Referring to Figure 7b, communication between the first vehicle 11a and at least one other vehicle 11b, 11c (here we assume both other vehicles 11b, 11c) via the local channel 13 ceases, at communication end step 200. This may happen for several reasons, including the first vehicle 11a leaving vehicle group 19a or a failure of the controller module 12a of the first vehicle 11a. In any event, the at least one
25 other vehicle 11b, 11c will be required to determine a new master and possibly a new vehicle group 19b. In this embodiment, the communication end step 200 corresponds to the master leave event.

 The remaining vehicles 11b, 11c can determine the new master in a similar manner to that described with reference to Figure 7a. As in that case, one of these

30

vehicles 11b, 11c configures itself as a master instead of a slave, at determine new master step 201. The communication modules 12 of the vehicles 11 comprise rule-based decision making functionality in order to determine which vehicle 11b, 11c should be the new master. In one implementation, the new master corresponds to the remaining vehicle 11b, 11c which joined the vehicle group 19a earliest because it has the shortest “timeout”, and is therefore determined from its associated timestamp. In this case, the appropriate vehicle 11b configures itself as a master and communicates its status to each other vehicle 11c still within the vehicle group via the local channel 13 and to the traffic monitoring server 15 via the wide-area channel 14. In another implementation, the new master corresponds to the vehicle 11b, 11c having best satisfying one or more rules, which can include consideration of, for example, the vehicle 11b, 11c having the highest bandwidth connection to the traffic monitoring server 15.

Optionally, the new master will communicate its status as such to the traffic monitoring server 15 via the wide-area channel 14 at inform step 202.

If two vehicle groups 19a, 19b come within the maximum range of the local channel 13, the vehicles 11 of the two vehicle groups 19 can communicate with one another via the local channel 13. When this occurs, the masters of each vehicle group 19a, 19b can elect to combine the vehicle groups 19a, 19b into a single vehicle group 19c comprising the vehicles 11 from both original vehicle groups 19a, 19b and one master. Typically, this will occur when a merge condition is satisfied, which can simply correspond to the master of the first vehicle group 19a and the master of the second vehicle group 19b communicating with one another via the local channel 13.

The merge condition also includes the master of the first vehicle group 19a and the master of the second vehicle group 19b undertaking a decision making process in order to determine which will be the master of the new vehicle group 19c. For example, the decision making process can include: comparing the size of the first vehicle group 19a and the size of the second vehicle group 19b and selecting, for example, the master of the larger of the two vehicle groups 19a, 19b

to be the new master; selection based on a property of the controllers 10 of the masters (for example, a larger or smaller identification number of the controllers 10); or combinations thereof.

Referring now to Figures 8, a process is shown according to an embodiment wherein a vehicle 11b configured as a slave leaves an existing vehicle group 19a due to a slave leave event. The master of this vehicle group 19a (in this case, first vehicle 11a) regularly (for example, periodically) communicates with the other vehicles 11 of the vehicle group 19a. In an implementation, this communication is instigated by the master vehicle 11a periodically broadcasting a heartbeat message to the slave vehicles 11 within the vehicle group 19a. In another implementation, this communication is instigated by the master vehicle 11a actively requesting updates from the slave vehicles 11 within the vehicle group 19a. In response, the slave vehicles 11 provide an update via the local channel 13 which can include telemetry data.

In the example of Figure 8, the second vehicle 11b undertakes an action that is inconsistent with the telemetry data of the entire vehicle group 19a (which, as described, may simply correspond to the telemetry data of the first vehicle 11a, being the master of the vehicle group 19a), causing the slave leave event at communication fail step 300. Such inconsistencies may be due to a sudden and abrupt change in speed and/or direction of the second vehicle 11b, or the second vehicle 11b determines that a condition has been met, such as a destination reached, which means it should no longer be considered part of the first vehicle group 19a. As a result of this slave leave event, the second vehicle 11b is no longer able to communicate with the first vehicle 11a via the local channel 13

As a result, the first vehicle 11a (being the master of the vehicle group 19a) will determine that the second vehicle 11b is no longer part of the first vehicle group 19a at determination step 302, and will de-register it (e.g. remove its record from within the memory 91 of its communication module 12, or at least record a data entry associated with the second vehicle 11b indicating that it is no longer part of the first vehicle group 19a), at de-register step 303. In an implementation, a

vehicle 11a configured as a master is configured to wait a predetermined time after first failing to receive an update from the second vehicle 11b before determining that the second vehicle is no longer part of the first vehicle group 19a.

In an embodiment, an existing vehicle 11 configured as a master of a vehicle group 19 includes rule-based decision functionality to determine whether another vehicle 11 should be added to the vehicle group 19, when said other vehicle 11 initiates communication with the existing vehicle 11 via the local channel 13. For example, the new vehicle 11 may be required to communicate additional information, such as destination, current speed, current direction, etc., and the master vehicle 11 utilises this information in order to determine whether to include the new vehicle 11 within the existing vehicle group 19. If the new vehicle 11 does not satisfy the conditions, then it may proceed to join another vehicle group or create its own vehicle group.

In another embodiment, an existing vehicle 11 includes rule-based decision functionality to determine if it will join in the vehicle group 19, when it receives a broadcast heartbeat message from said another vehicle via the local channel 13. For example, the said another vehicle 11 may be required to communicate additional information, such as destination, current speed, current direction, etc., and the existing vehicle 11 utilises this information in order to determine whether to join the existing vehicle group 19. If a broadcasted heartbeat message from another vehicle 11 does not satisfy the conditions, then it may proceed to join another vehicle group or create its own vehicle group.

The vehicle group telemetry data is utilised by the traffic monitoring server 15 for maintaining a record of traffic conditions associated with the time and place from which the vehicle group telemetry data was received. This can be used for future data analysis or real-time actions. An advantage of the present invention is that a reduction in the quantity of data communicated to the traffic monitoring server 15 can be achieved when compared to situations in which every vehicle 11 communicates telemetry data to the traffic monitoring server 15, with no or at least minimal reduction in the quality of the record of traffic conditions.

It will be understood to persons skilled in the art of the invention that many modifications may be made without departing from the spirit and scope of the invention.

The claims defining the invention are as follows:

1. A communication module for use with a vehicle, comprising:
 - a processor interfaced to a local wireless module configured for communication via a local channel with one or more other communication modules and a wide-area
 - 5 wireless module configured for communication via a wide-area channel with a traffic monitoring server,
 - wherein the communication module is selectively configurable to operate in at least a first mode corresponding to a master communication module and a second mode corresponding to a slave communication module, and wherein the processor is
 - 10 configured to determine that the communication module is to operate in the first mode or the second mode,
 - wherein when operating in the first mode the communication module is configured to:
 - identify and maintain communication with one or more other slave
 - 15 communication modules located within a predetermined range of the communication module via the local channel;
 - generate, via an interfaced sensor module, vehicle group telemetry data corresponding to telemetry data of the vehicle associated with the communication module; and
 - 20 communicate said vehicle group telemetry data to the traffic monitoring server via the wide-area channel,
 - and wherein when operating in the second mode the communication module is configured to:
 - identify and maintain communication with another master communication
 - 25 module located within a predetermined range of the communication module via the local channel.
2. A communication module as claimed in claim 1, wherein the local channel implements the 802.11p standard.
3. A communication module as claimed in any one of claims 1 to 2, wherein the
- 30 wide-area channel comprises at least one of: GSM, UMTS, CDMA, HSPA+, Mobile

WiMAX, LTE, and/or comprises a V2I standard.

4. A communication module as claimed in any one of claims 1 to 3, wherein the communication module is configured to operate in the first mode in response to a failure to identify another master communication module.
- 5 5. A communication module as claimed in any one of claims 1 to 4, wherein the communication module is configured to operate in the second mode in response to successfully identifying another master communication module.
6. A communication module as claimed in any one of claims 1 to 5, wherein the communication module is configured to operate in the first mode after operation in the
10 second mode in response to:
 - either a failure in communication with the other communication module or a change in the conditions; and
 - a failure to identify another communication module configured as a master.
7. A communication module as claimed in any one of claims 1 to 6, wherein the
15 vehicle group telemetry data is communicated to the traffic monitoring server periodically.
8. A communication module as claimed in any one of claims 1 to 7, configured to send and receive heartbeat messages via the local channel.
9. A communication module as claimed in claim 8, wherein the other master
20 communication module is identified due to reception of a heartbeat message sent by the other master communication module.
10. A method for configuring and operating a communication module as a master communication module, comprising the steps of:
 - determining, as a result of communication via a local channel, that a predefined
25 local communication criteria has not been satisfied;
 - configuring the communication module to operate in a first mode corresponding to a master communication module;
 - identifying and maintaining communication with one or more slave

communication modules located within a predetermined range of the communication module via the local channel;

generating, via a sensor module interfaced with the communication module, vehicle group telemetry data corresponding to telemetry data associated with the communication module.

11. A method for operating a communication module comprising a processor interfaced to a local wireless module configured for communication via a local channel with one or more other communication modules and a wide-area wireless module configured for communication via a wide-area channel with a traffic monitoring server, the method comprising:

determining, as a result of communication via a local channel, whether a predefined local communication criteria has or has not been satisfied;

in response to determining that the predefined local communication criteria has not been satisfied:

operating the communication module in a first mode corresponding to a master communication module;

identifying and maintaining communication with one or more slave communication modules located within a predetermined range of the communication module via the local channel;

generating, via a sensor module interfaced with the communication module, vehicle group telemetry data corresponding to telemetry data associated with the communication module; and

communicating said vehicle group telemetry data to the traffic monitoring server via the wide-area channel,

and in response to determining that the predefined local communication criteria has been satisfied:

identifying and maintaining communication with another master communication module located within a predetermined range of the communication module via the local channel.

12. A method as claimed in claim 11, wherein the local channel implements the 802.11p standard.

13. A method as claimed in any one of claims 11 to 12, wherein the wide-area channel comprises at least one of: GSM, UMTS, CDMA, HSPA+, Mobile WiMAX, LTE, and/or comprises a V2I standard.
14. A method as claimed in any one of claims 11 to 13, wherein the communication
5 module operates in the first mode in response to a failure to identify another master communication module.
15. A method as claimed in any one of claims 11 to 14, wherein the communication module operates in the second mode in response to successfully identifying another master communication module.
16. A method as claimed in any one of claims 11 to 15, including the step of, in
10 response to: either a failure in communication with the other communication module or a change in the conditions; and a failure to identify another communication module configured as a master, operating the communication module in the first mode after operation in the second mode.
17. A method as claimed in any one of claims 11 to 16, wherein the vehicle group
15 telemetry data corresponds to vehicle telemetry data of a vehicle associated with the communication module.
18. A method as claimed in any one of claims 11 to 17, including the step of
20 periodically communicating the vehicle group telemetry data to the traffic monitoring server.
19. A method as claimed in any one of claims 11 to 18, including the step of periodically communicating heartbeat messages over the local communication module when operating in the first mode.
20. A method as claimed in claim 19, wherein the other master communication
25 module is identified due to reception of a heartbeat message sent by the other master communication module.
21. A vehicle communication system comprising one or more vehicle groups, wherein each vehicle group comprises at least one vehicle comprising a

communication module, wherein the or each communication module is configured for communication via a local channel with other communication modules, and wherein each communication module is selectively configured for operation in one of a first mode and a second mode, wherein the first mode corresponds to its vehicle configured
 5 as a master and the second mode corresponds to its vehicle configured as a slave,
 wherein each vehicle group comprises one vehicle configured as a master,
 and wherein for each vehicle group the vehicle configured as a master is configured to generate, via a sensor module interfaced with its communication module, vehicle group telemetry data and communicate the generated vehicle group telemetry
 10 data to a traffic monitoring server via a wide area channel, wherein the vehicle group telemetry data corresponds to vehicle telemetry data of the vehicle associated with the communication module configured as a master.

22. A system as claimed in claim 21, wherein at least one vehicle group comprises at least one vehicle configured as a slave.

15 23. A system as claimed in claim 22, wherein vehicles configured as a slave are configured to communicate via the local channel with the vehicle configured as a master for the vehicle group to which it belongs.

24. A system as claimed in either one of claims 22 and 23, wherein the vehicle group telemetry data generated and communicated by a master of a vehicle group is
 20 indicative of at least one of: position, heading direction, and speed of the vehicle(s) configured as a master of the, or each, vehicle group.

25. A system as claimed in any one of claims 21 to 24, wherein the communication module of each vehicle is a communication module according to any one of claims 1 to 9.

25 26. A method for adding a first vehicle to a vehicle group,
 said vehicle group comprising a second vehicle configured as a master and at least one or more additional vehicles each configured as a slave, wherein each vehicle is configured for communication with other vehicles via a local channel, the method comprising the steps of:

the first vehicle determining, as a result of communication via the local channel, that a predefined local communication criteria has been satisfied, said predefined local communication criteria indicating that the first vehicle is suitable for joining the vehicle group;

5 in response, configuring the first vehicle to maintain communication with the second vehicle via the local channel; and

 registering with the second vehicle a slave configuration of the first vehicle, said slave configuration indicating that the first vehicle has been added as a member of the vehicle group and is configured as a slave,

10 wherein the second vehicle is configured to generate, via an onboard sensor, vehicle group telemetry data corresponding to telemetry data of the second vehicle and to communicate said vehicle group telemetry data to a traffic monitoring server via a wide-area channel.

27. A method as claimed in claim 26, wherein each vehicle comprises a
15 communication module according to any one of claims 1 to 9.

28. A method for removing a first vehicle configured as a slave from a vehicle group,

 said vehicle group comprising a second vehicle configured as a master and optionally one or more additional vehicles each configured as a slave, wherein each
20 vehicle is configured for communication with other vehicles via a local channel, the method comprising the steps of:

 the second vehicle determining that a leave event has occurred, said leave event indicative that the first vehicle is to be removed from the vehicle group;

 in response, de-registering with the second vehicle the membership of the first
25 vehicle from the vehicle group,

 wherein the second vehicle is configured to generate, via an onboard sensor, vehicle group telemetry data corresponding to telemetry data of the second vehicle and to communicate said vehicle group telemetry data to a traffic monitoring server via a wide-area channel.

30 29. A method as claimed in claim 28, wherein each vehicle comprises a

communication module according to any one of claims 1 to 19.

30. A method as claimed in any one of claims 28 to 29, wherein the leave event comprises the second vehicle determining that the first vehicle is unable to communicate via the local channel with the second vehicle.

5 31. A method as claimed in claim 30, wherein the second vehicle is configured to wait a predetermined time from a previous communication being received from the first vehicle via the local channel before determining that the leave event has occurred.

32. A method as claimed in any one of claims 28 to 29, wherein the leave event comprises the first vehicle communicating via the local channel to the second vehicle a
10 request for removal from the vehicle group.

33. A method as claimed in any one of claims 28 to 29, wherein the leave event comprises the first vehicle communicating via the local channel to the second vehicle information inconsistent with membership of the vehicle group.

34. A method for configuring a first vehicle as a master of a vehicle group, wherein
15 said first vehicle is a member of the vehicle group and is originally configured as a slave,

said vehicle group comprising the first vehicle configured as a slave, a second vehicle configured as a master, and optionally one or more additional vehicles each configured as a slave, the method comprising the steps of:

20 the first vehicle determining that a master leave event has occurred, said master leave event corresponding to the second vehicle leaving the vehicle group; and
in response, configuring the first vehicle as a master of the vehicle group,
wherein, when configured as a master, the first vehicle is configured to generate,
via an onboard sensor, vehicle group telemetry data corresponding to telemetry data of
25 the first vehicle and to communicate said vehicle group telemetry data to a traffic monitoring server via a wide-area channel.

35. A method as claimed in claim 34, wherein each vehicle comprises a communication module according to any one of claims 1 to 9.

36. A method as claimed in any one of claims 34 to 35, wherein the master leave event comprises the second vehicle communicating to the first vehicle, via the local channel, a messaging indicating it is leaving the vehicle group.

37. A method as claimed in any one of claims 34 to 35, wherein the master leave event comprises the first vehicle determining that the second vehicle is unable to communicate via the local channel with the first vehicle.

38. A method as claimed in claim 37, wherein the first vehicle is configured to wait a predetermined time from a previous communication being received from the second vehicle via the local channel before determining that the leave event has occurred.

39. A method as claimed in any one of claims 34 to 38, wherein the vehicle group comprises at least one additional vehicle configured as a slave, the method further comprising:

one or more additional vehicles determining that a master leave event has occurred;

the one or more additional vehicles communicating with the first vehicle via the local channel; and

thereby determining that the first vehicle is to become the master of the vehicle group and the one or more additional vehicles remaining as slaves of the vehicle group.

40. A method as claimed in claim 39, wherein the first vehicle is determined to become the master of the vehicle group on account of having an earliest initial membership time when compared to the initial membership times of the one or more additional vehicles,

wherein an initial membership time corresponds to a timestamp indicating the time at which the associated vehicle became a member of the vehicle group.

41. A method for merging a first vehicle group comprising a first vehicle configured as a master and a second vehicle group comprising a second vehicle configured as a master and at least one additional vehicle configured as a slave, the method comprising the steps of:

the first vehicle communicating with the second vehicle via a local channel;

determining, as a result of the communication, that a merge condition is satisfied meaning that the second vehicle group is to be merged with the first vehicle group;

configuring the second vehicle as a slave of the first vehicle group;

configuring each additional vehicle as a slave of the first vehicle group,

5 wherein , when configured as a master, the first vehicle is configured to generate, via an onboard sensor, vehicle group telemetry data corresponding to telemetry data of the first vehicle and to communicate said vehicle group telemetry data to a traffic monitoring server via a wide-area channel.

42. A method as claimed in claim 41, wherein each vehicle comprises a
10 communication module according to any one of claims 1 to 19.

43. A method as claimed in any one of claims 41 to 42, wherein the merge condition includes determining that the first vehicle group comprises a larger number of vehicles than the second vehicle group.

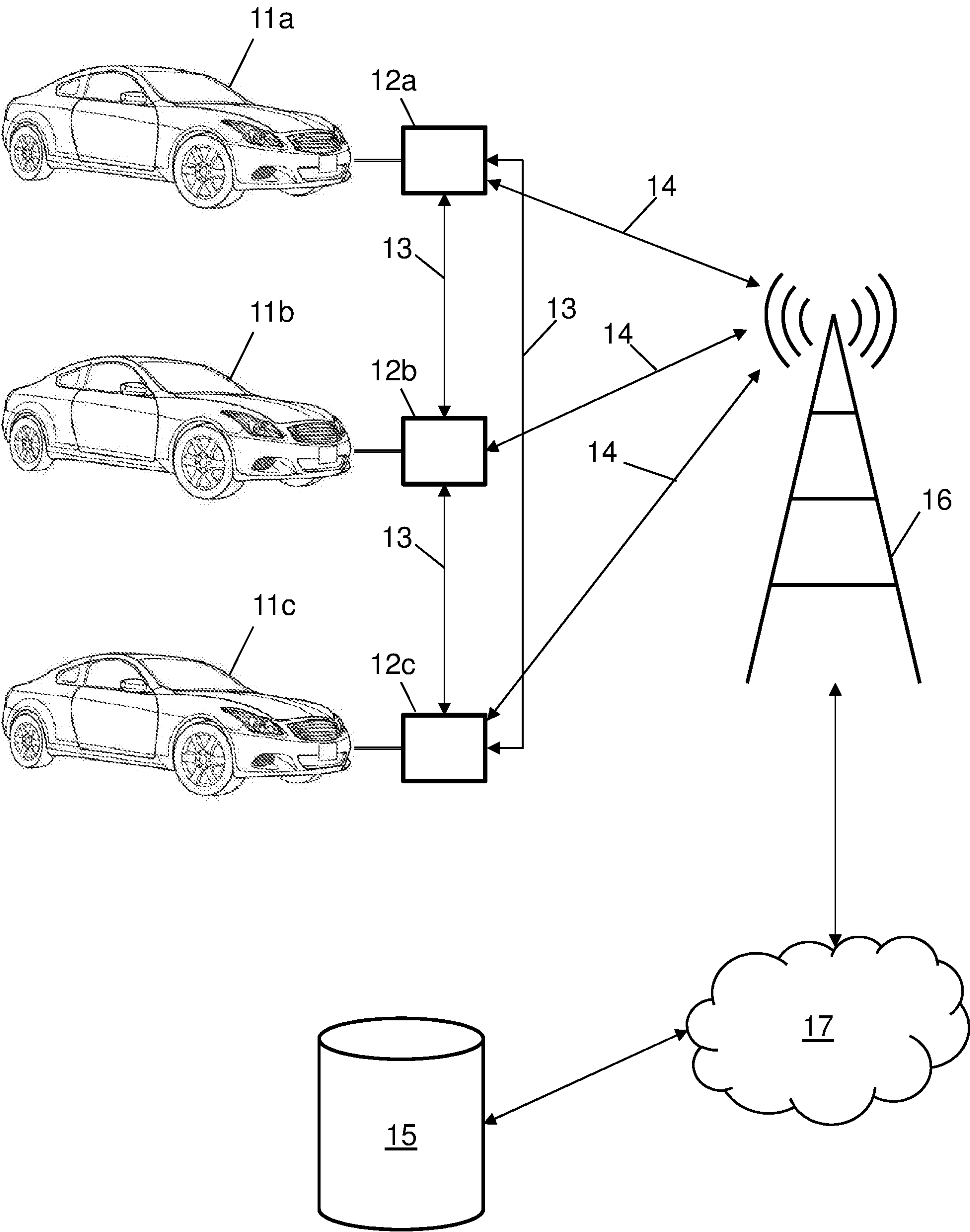


Figure 1

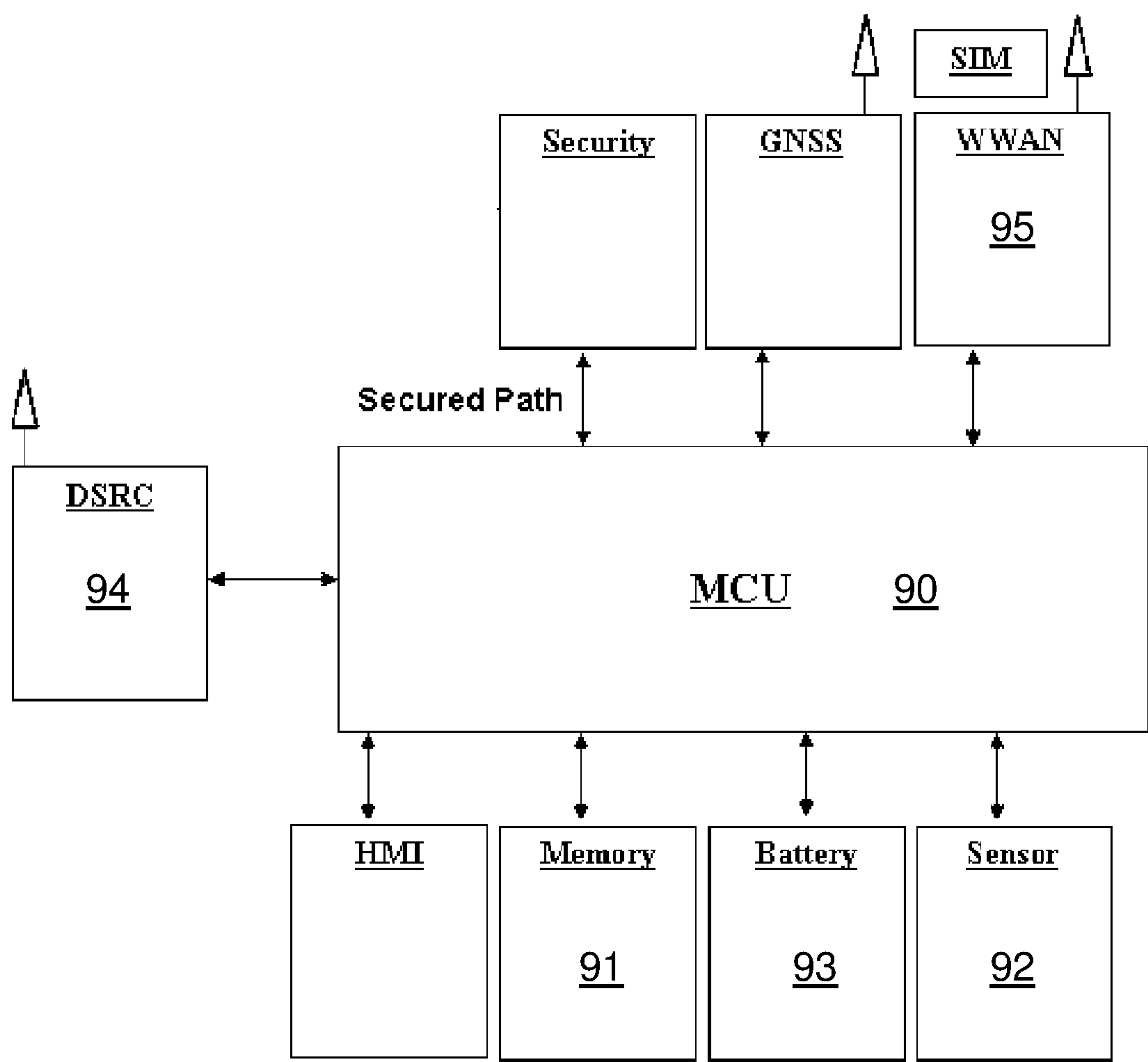


Figure 2

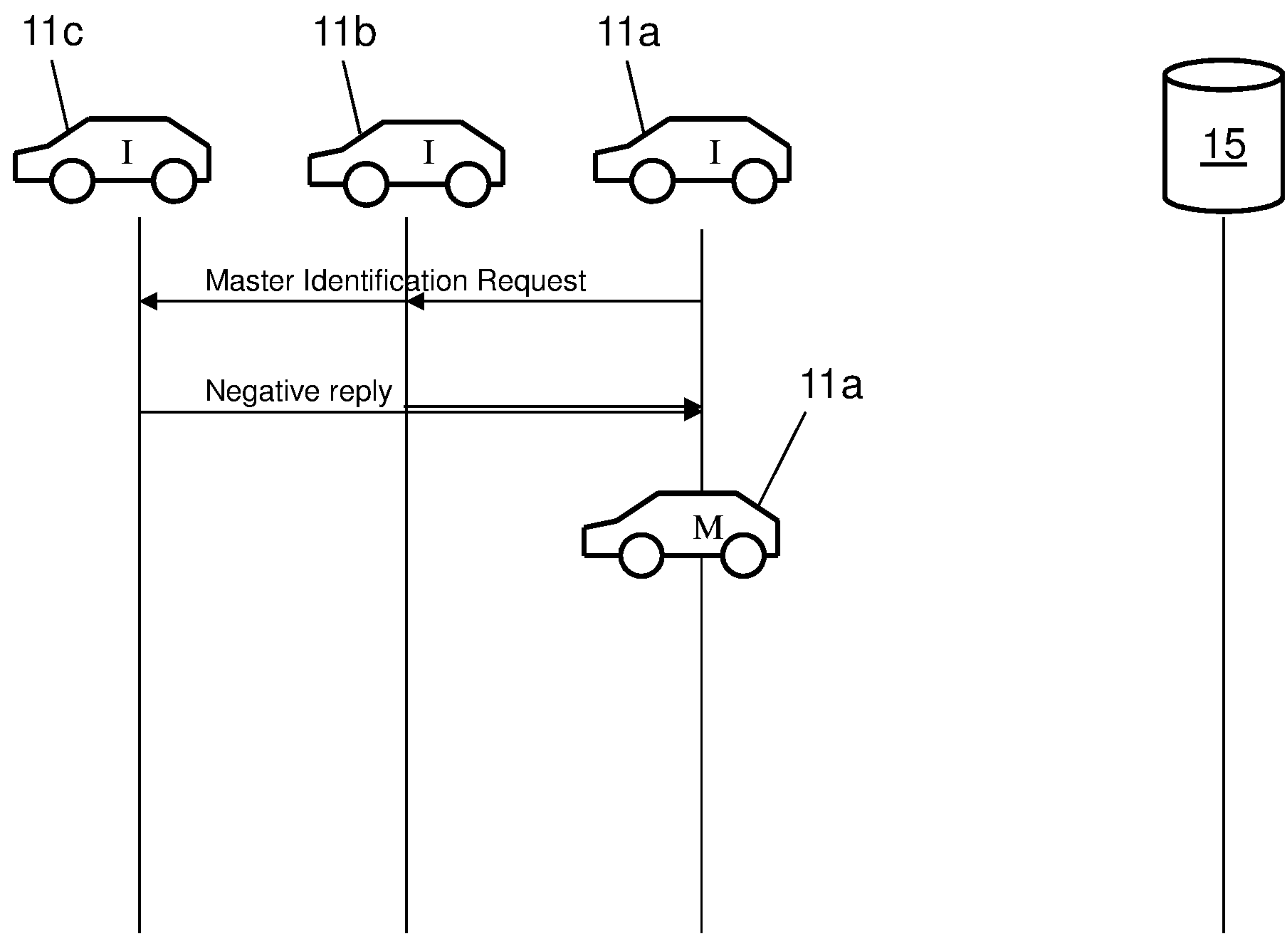


Figure 3a

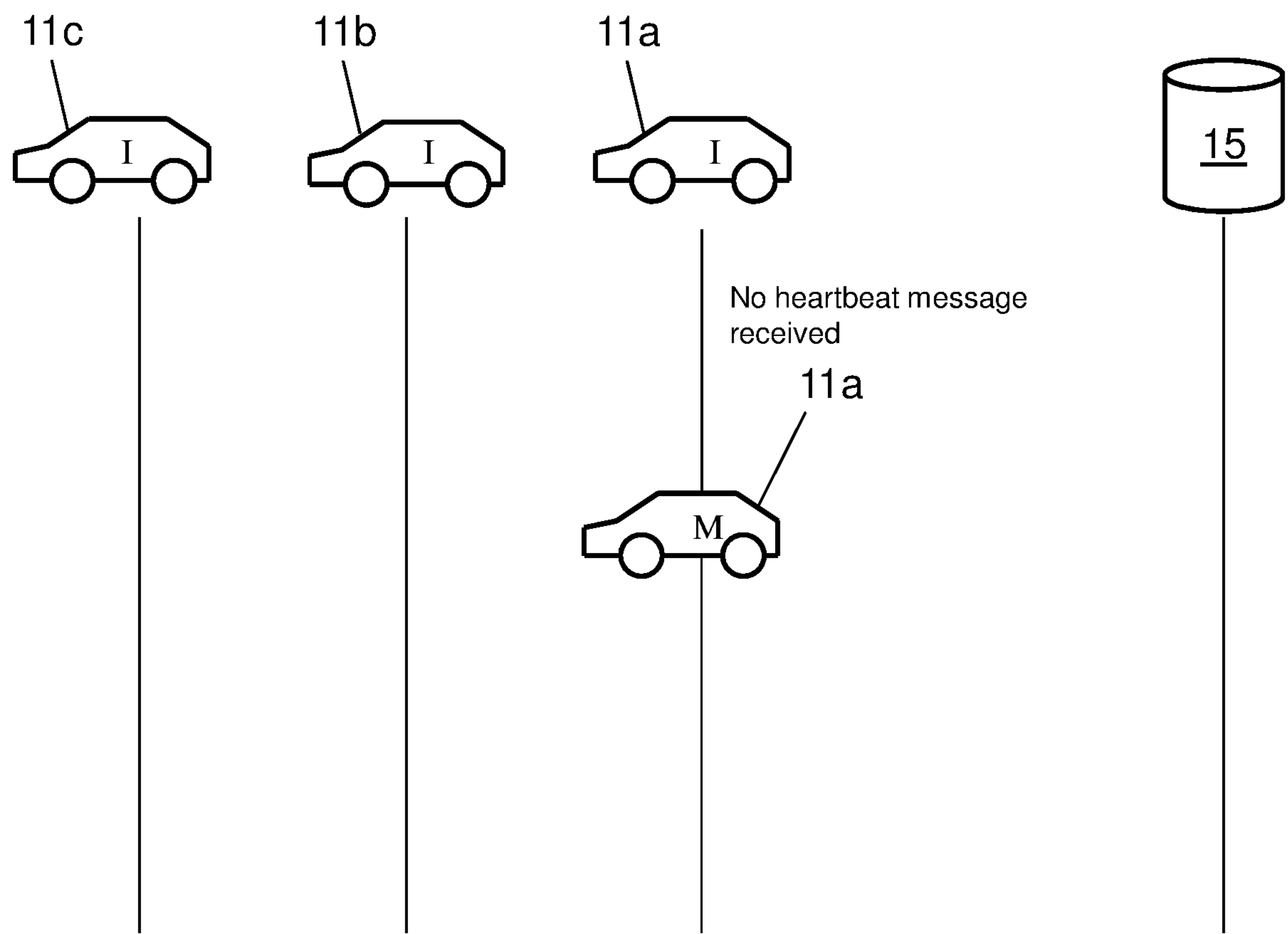


Figure 3b

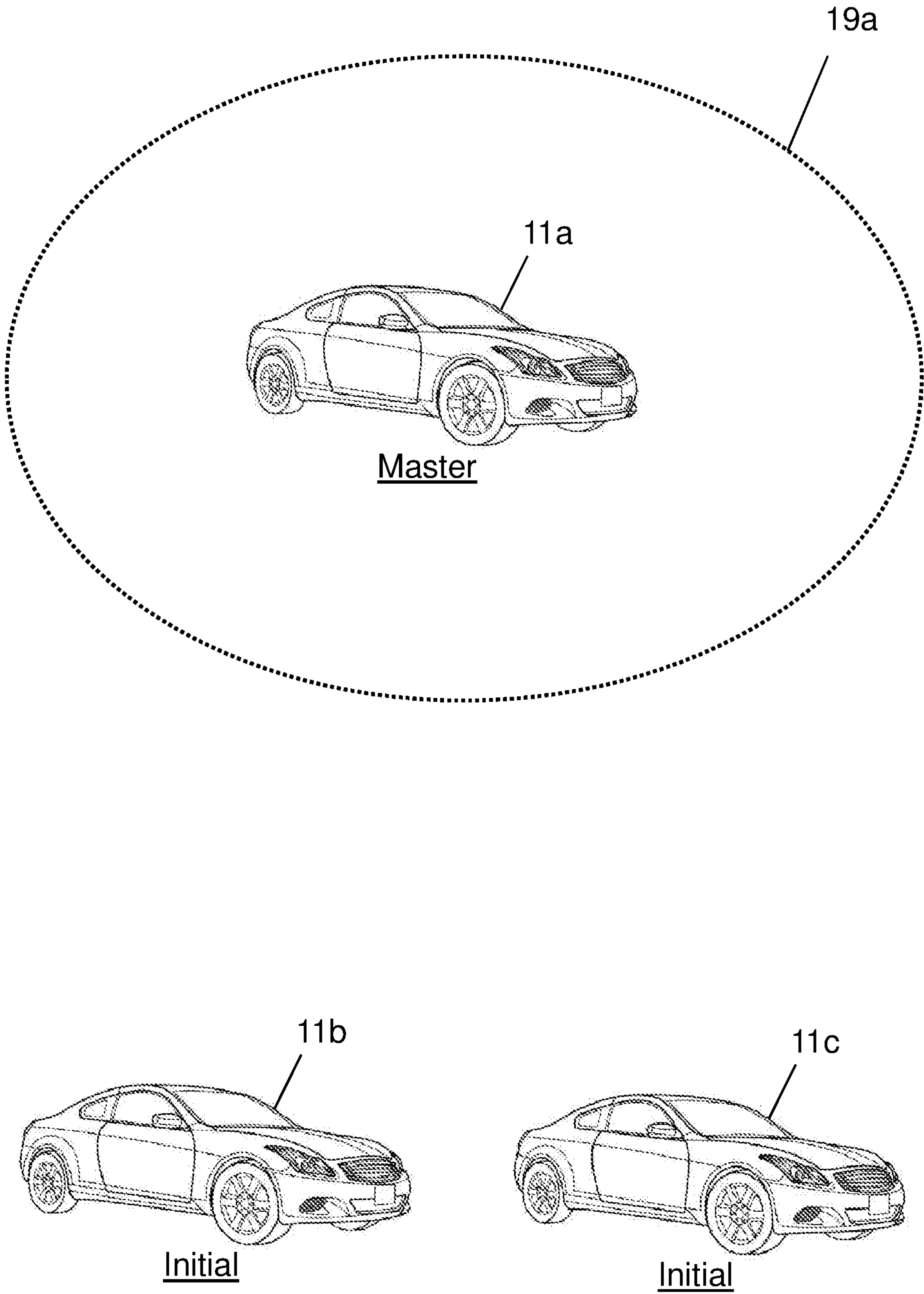


Figure 3c

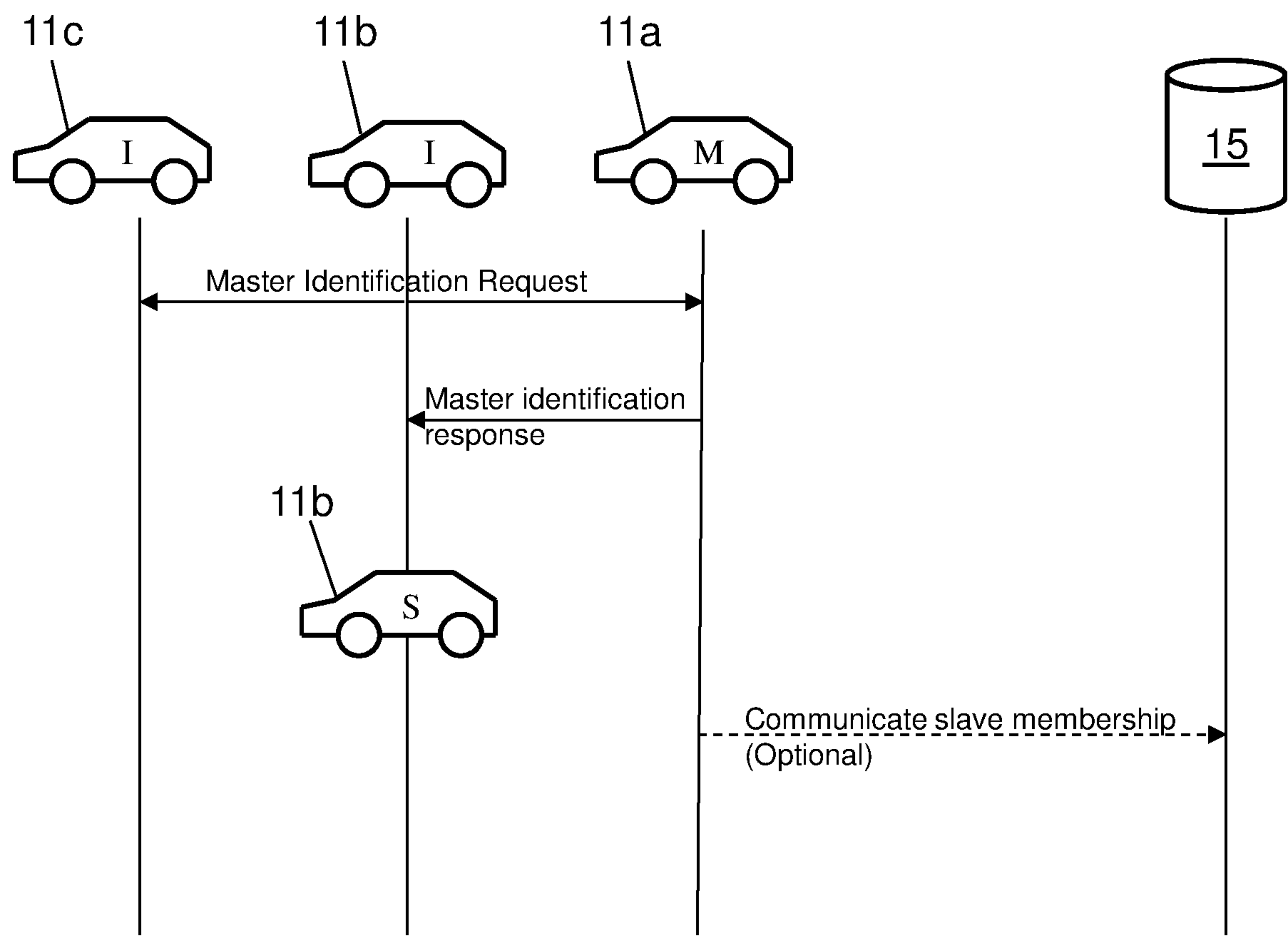


Figure 4a

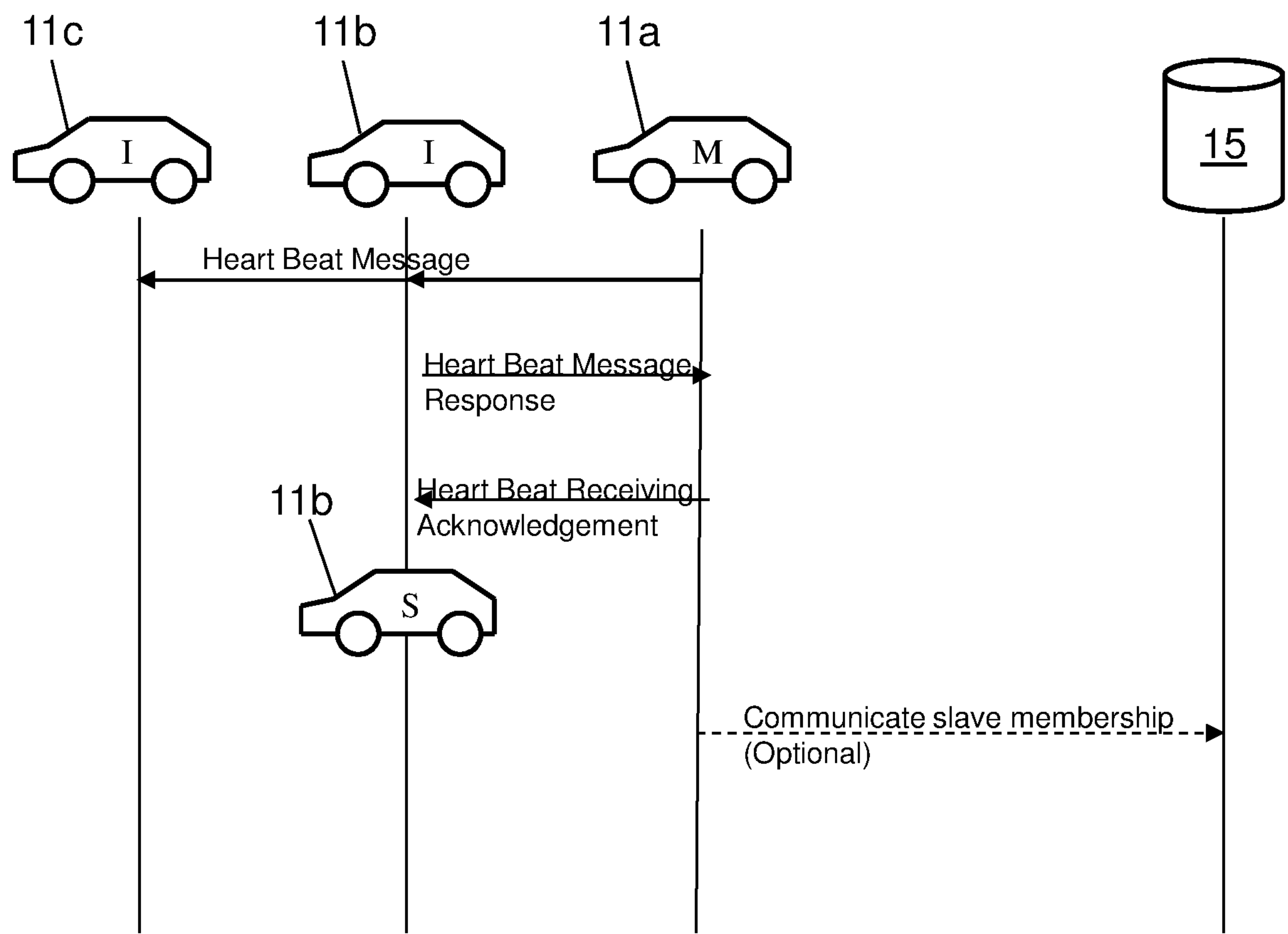


Figure 4b

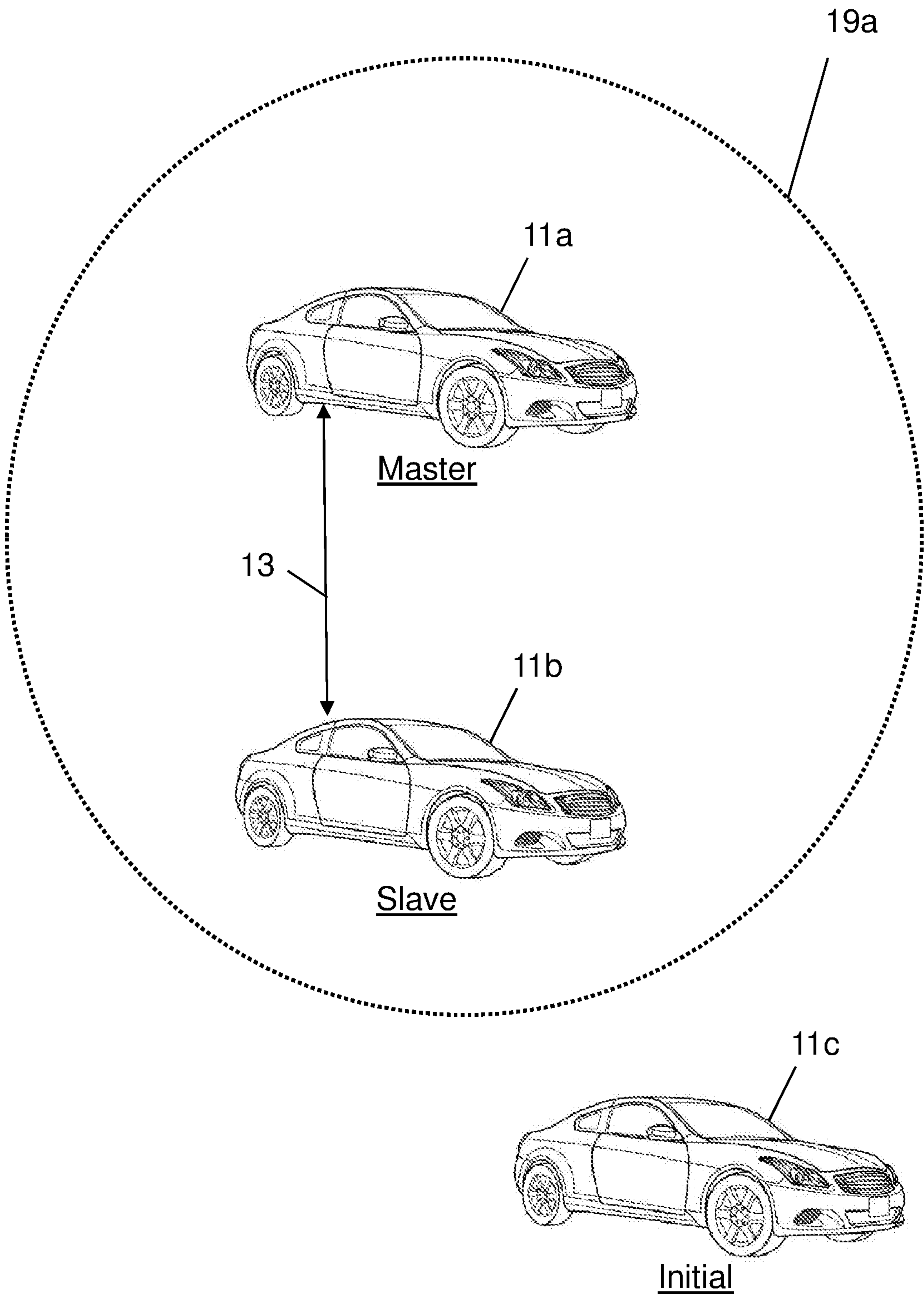


Figure 4c

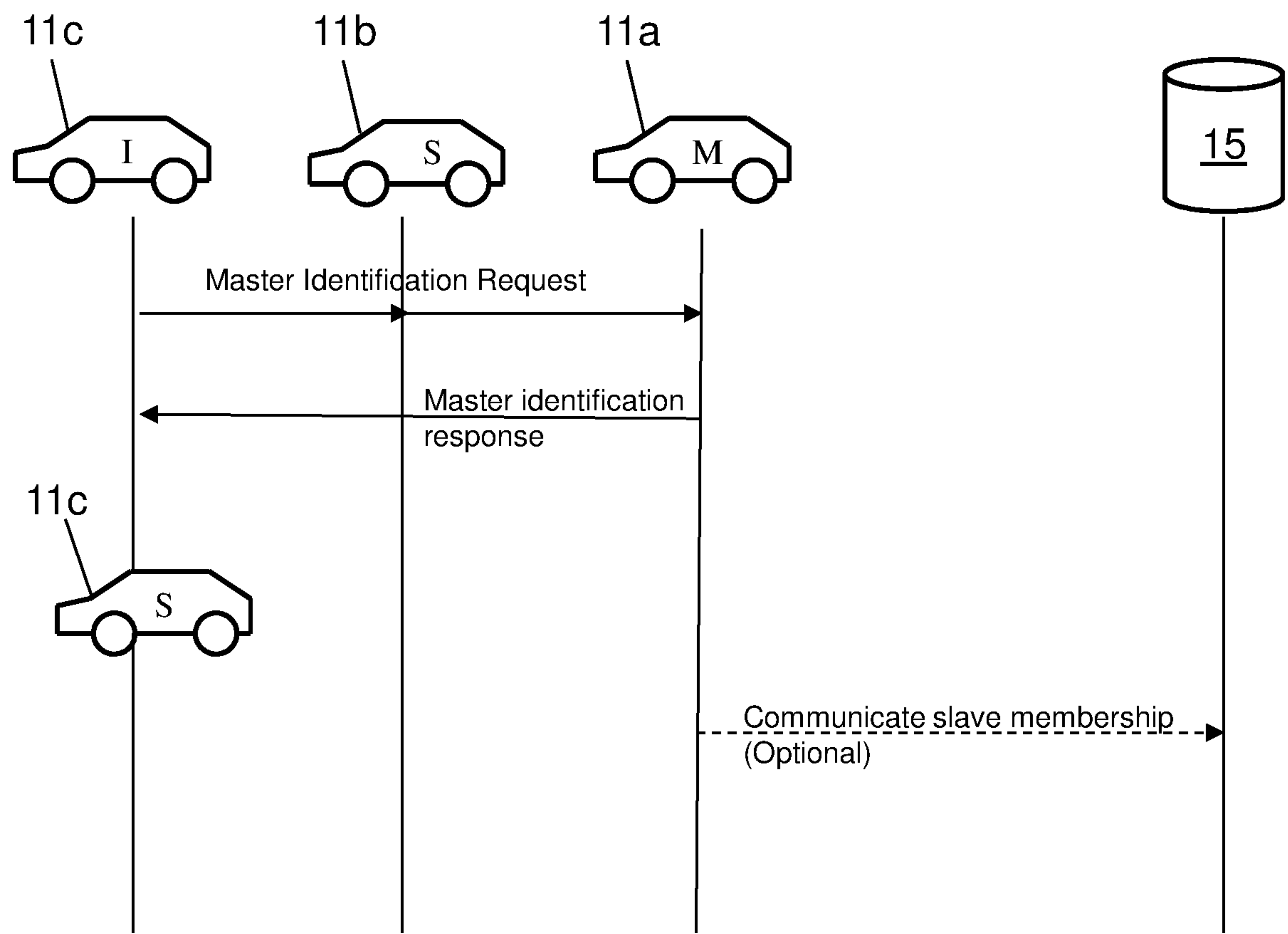


Figure 5a

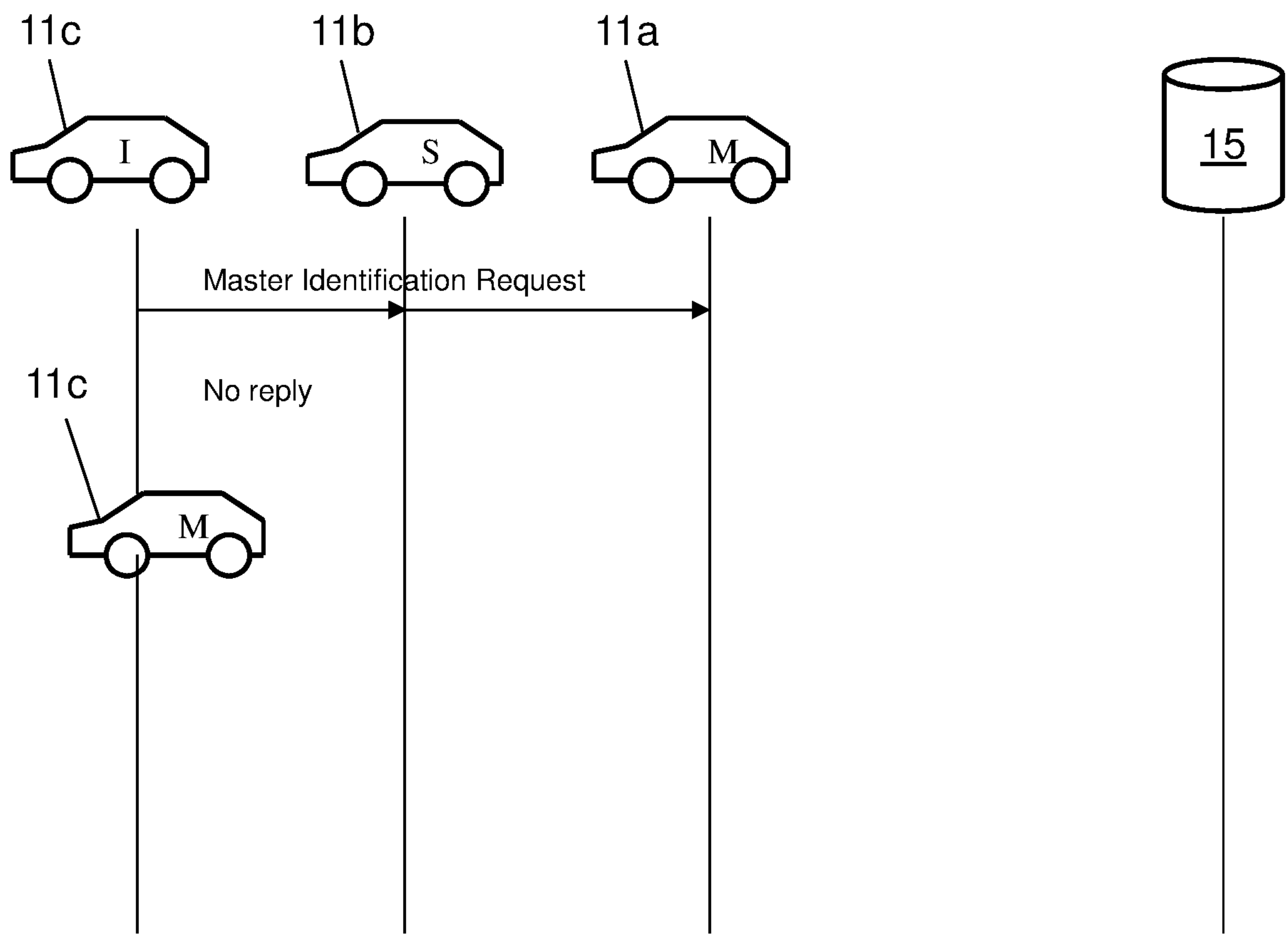


Figure 5b

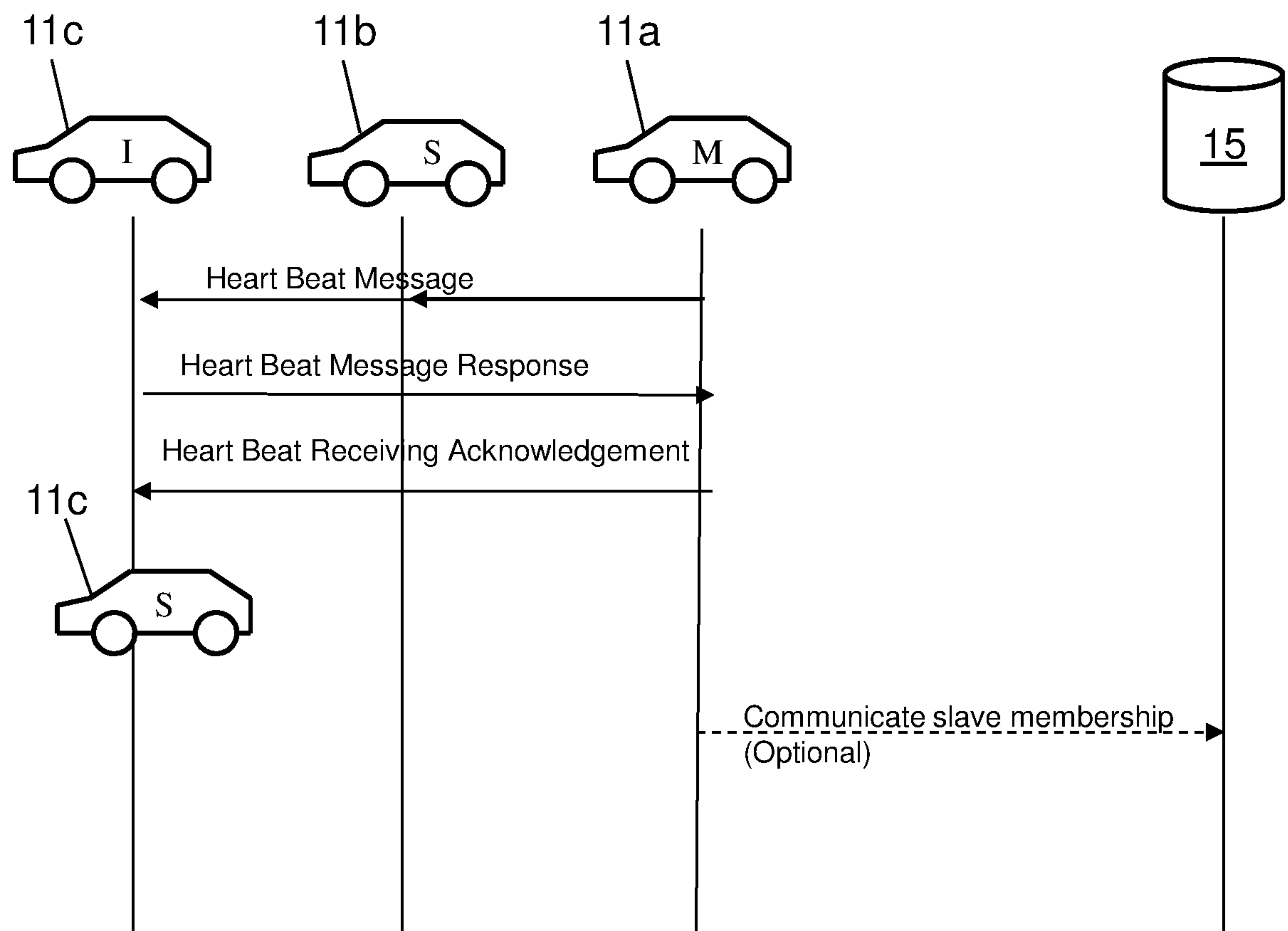


Figure 5c

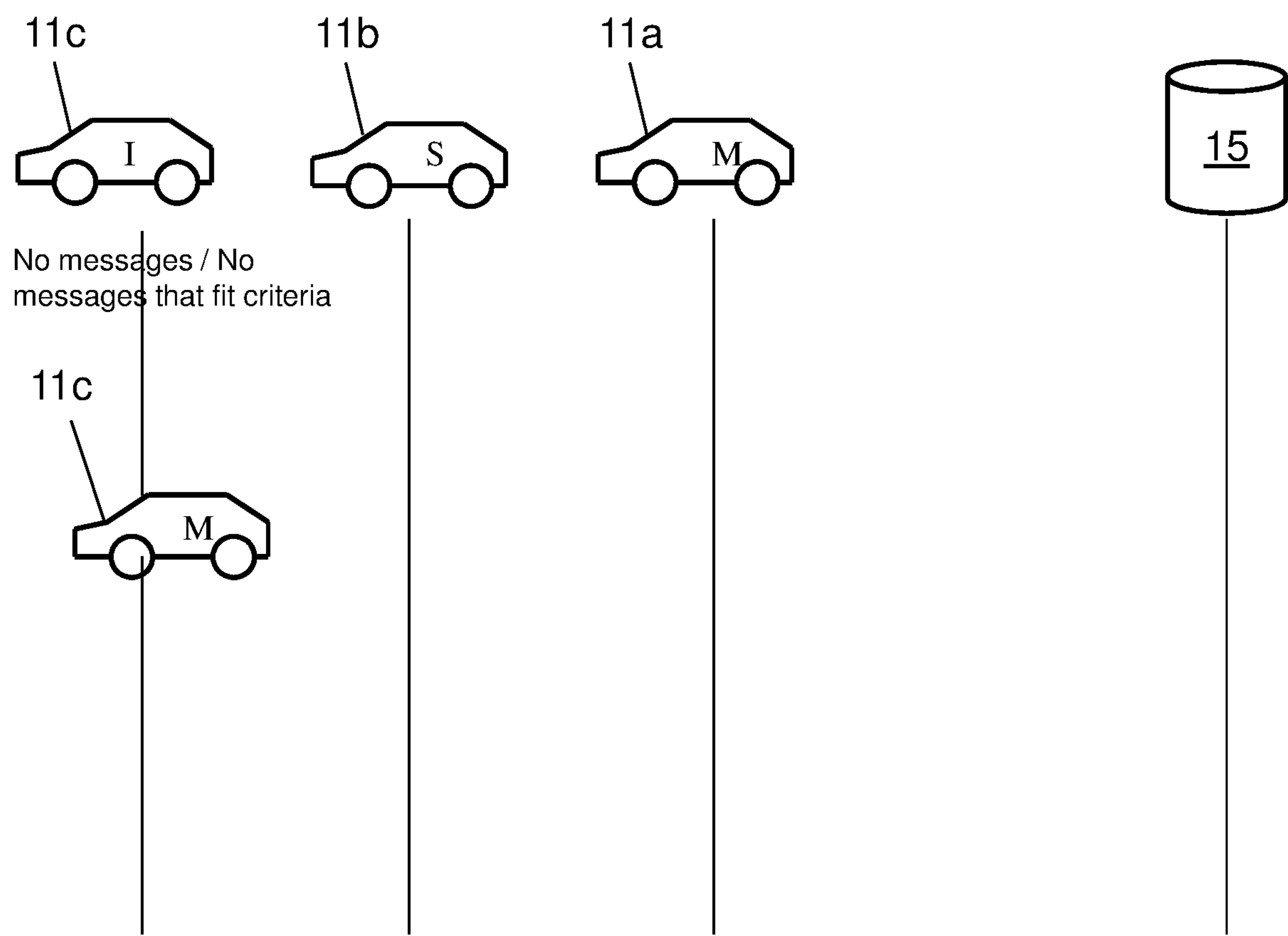


Figure 5d

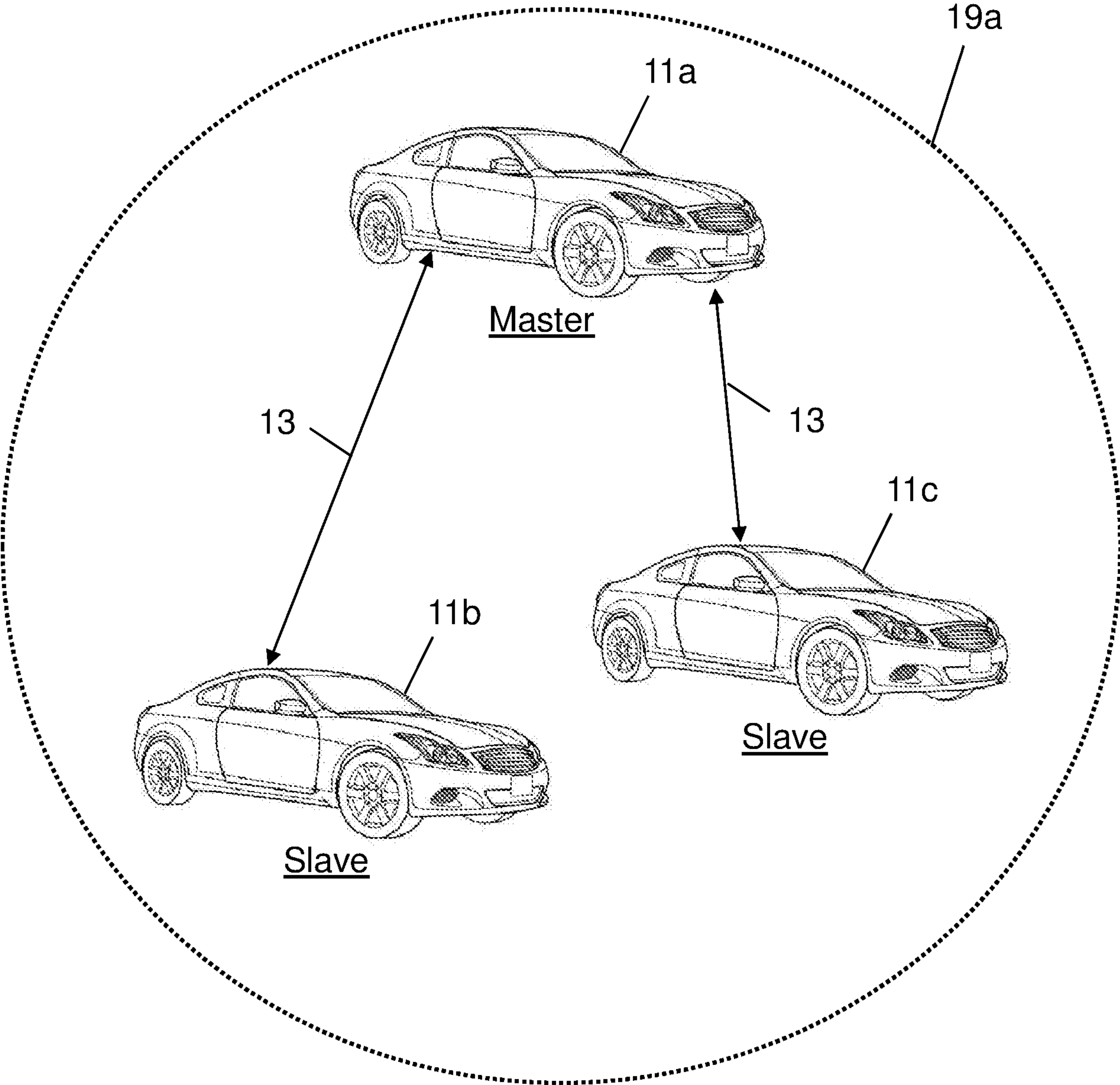


Figure 5e

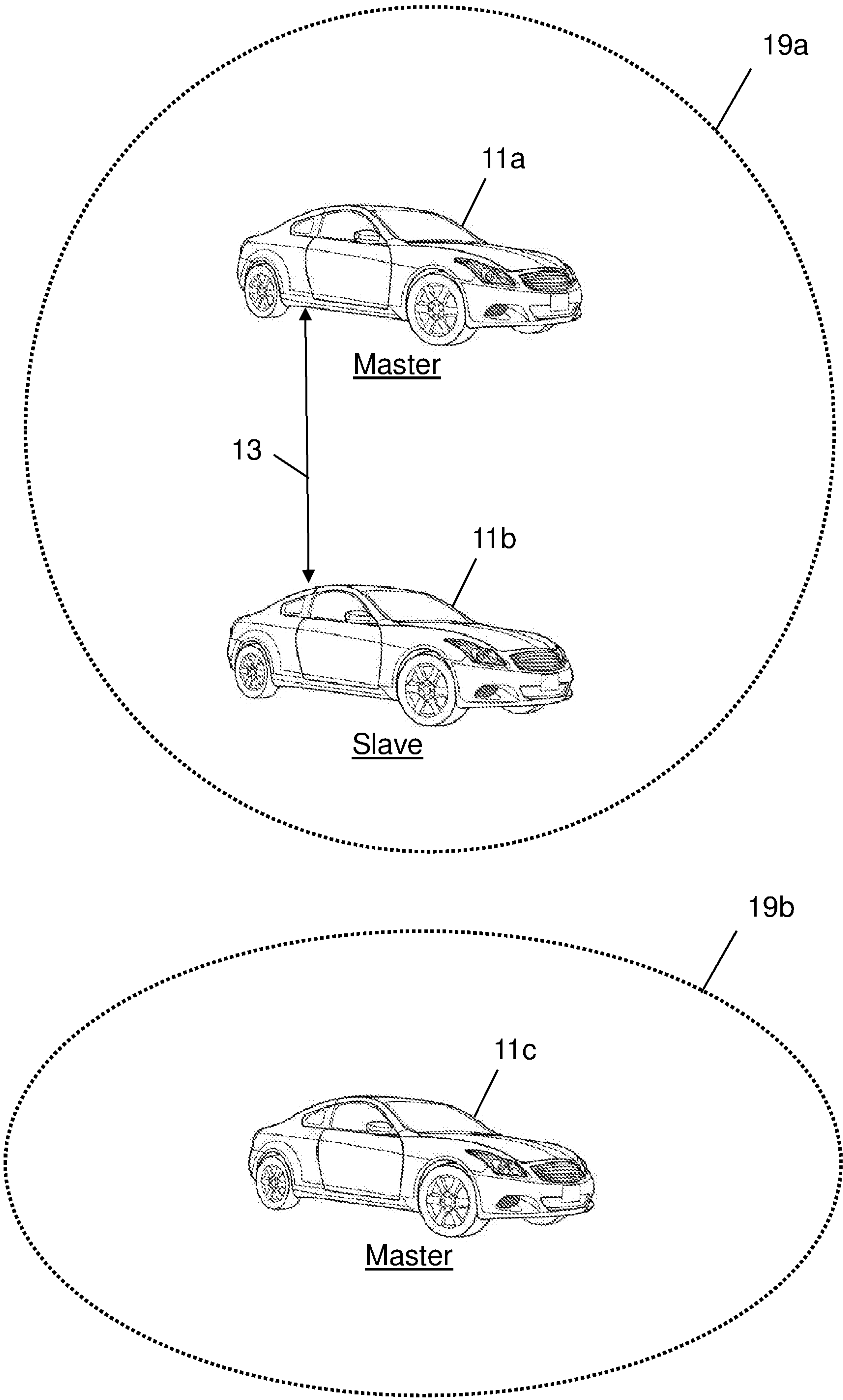


Figure 5f

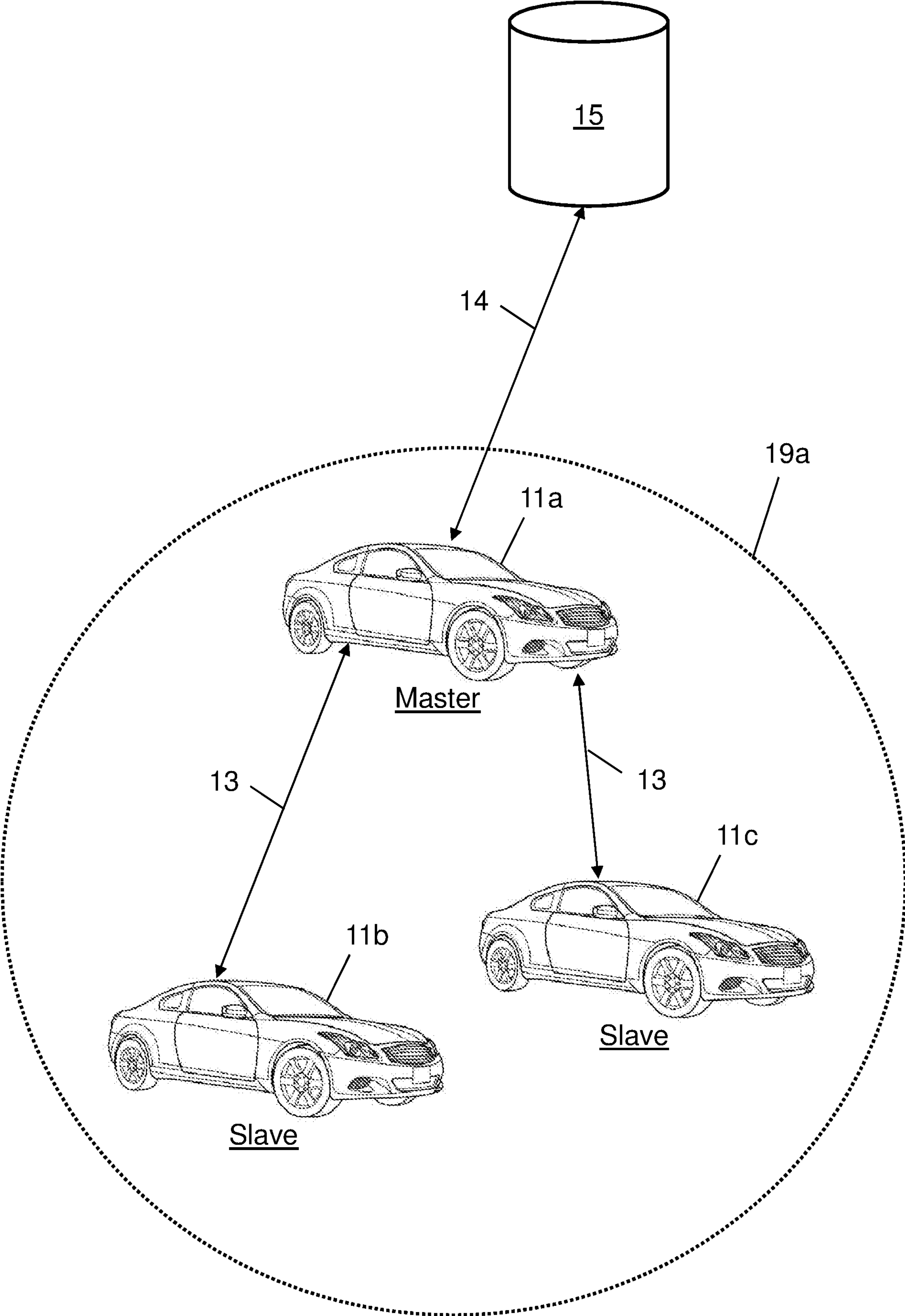


Figure 6

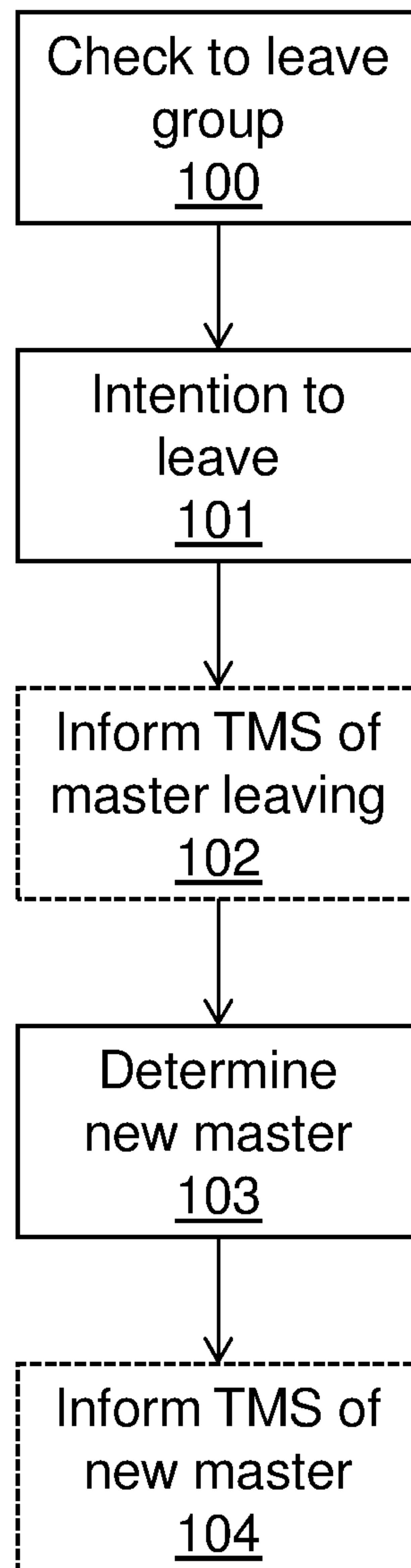


Figure 7a

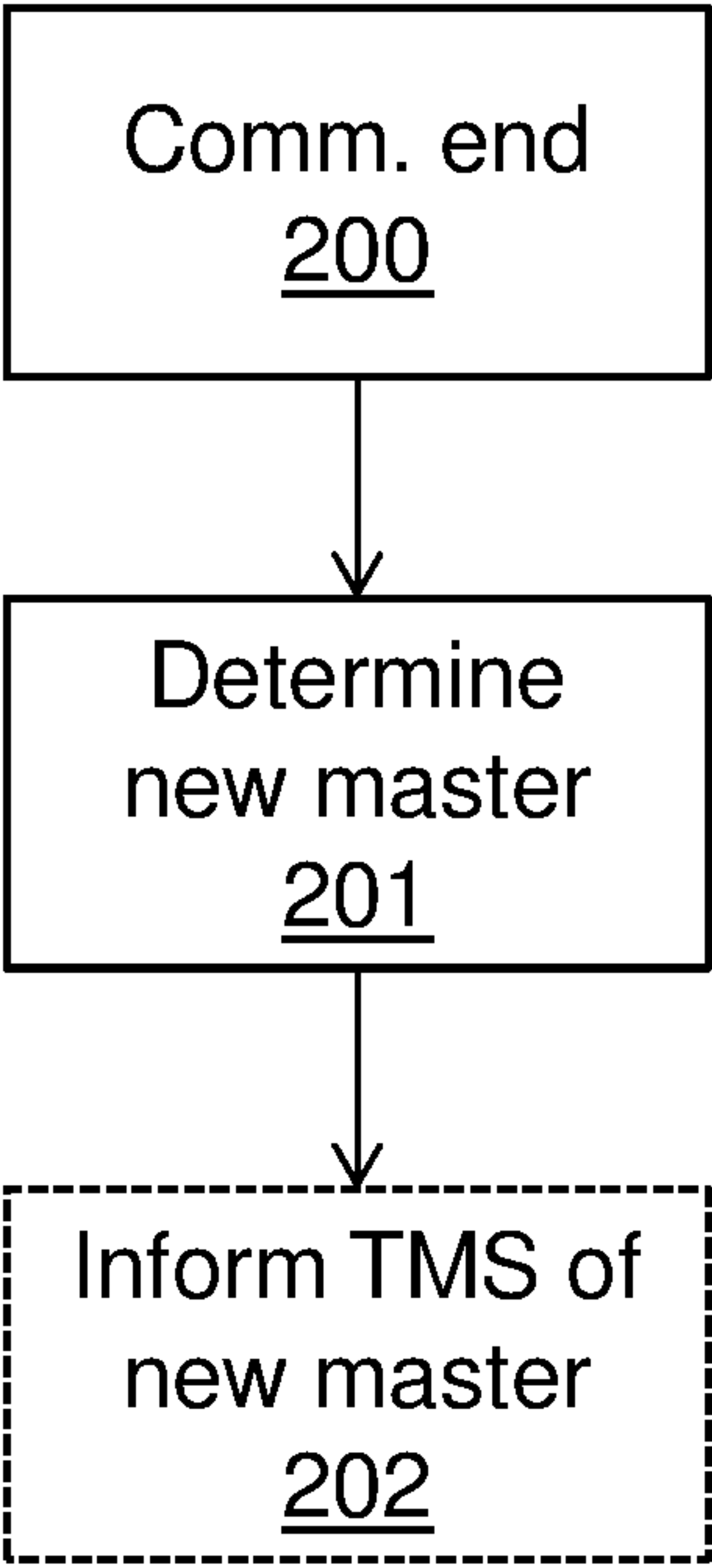


Figure 7b

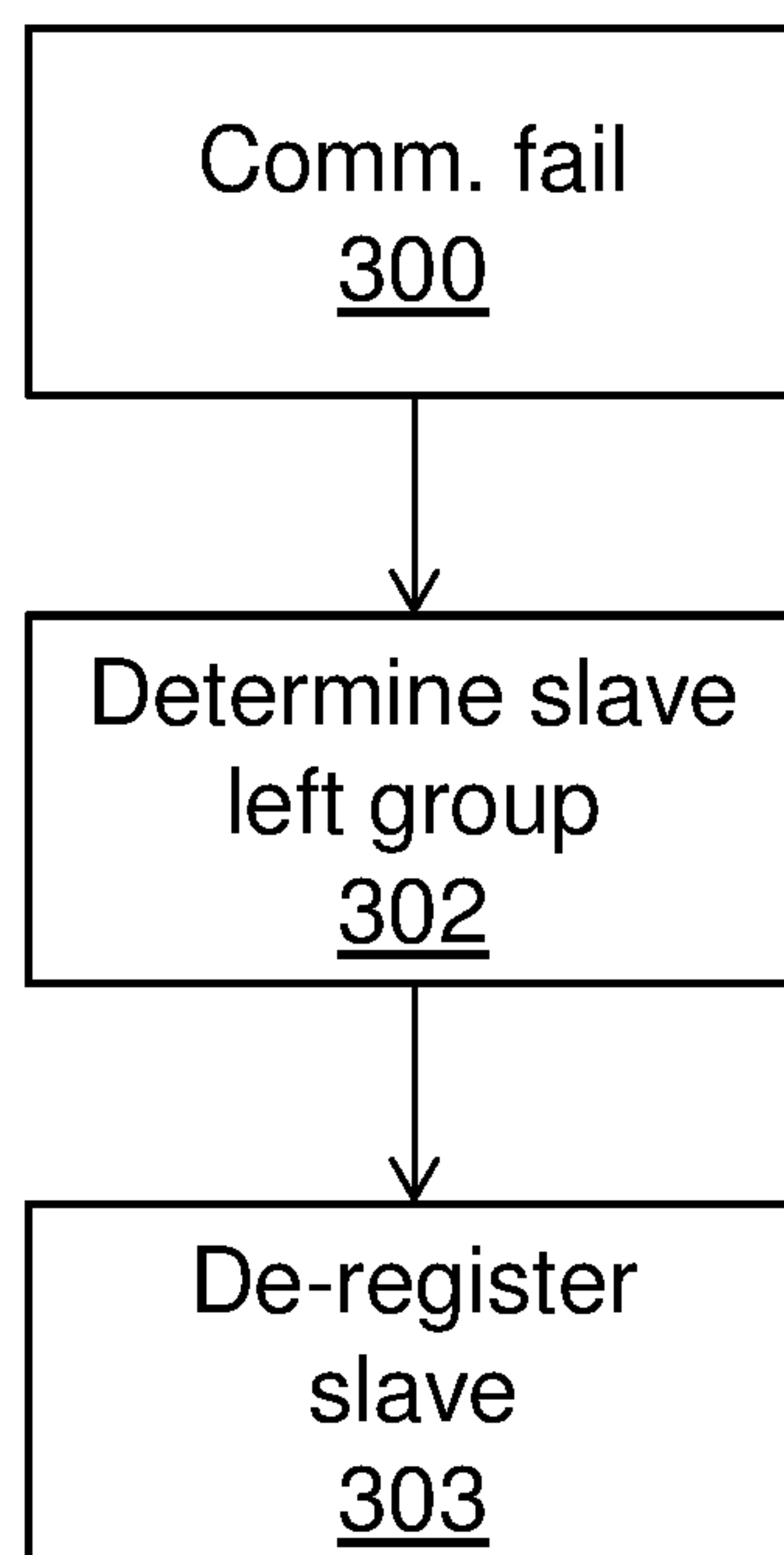


Figure 8