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- (73) Patenthaver: **Siemens Aktiengesellschaft, Werner-von-Siemens-Straße 1, 80333 München, Tyskland**
- (72) Opfinder: **Kasslatter, Fritz, Semmelweisgasse 10, 3003, Gablitz, Østrig**
Pohl, Alfred, Hochgasse 4, 2130, Mistelbach, Østrig
Karacan, Ömer, Erlaerplatz 5/6, 1230, Wien, Østrig
- (74) Fuldmægtig i Danmark: **Zacco Denmark A/S, Arne Jacobsens Allé 15, 2300 København S, Danmark**
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EP-A- 1 441 321
DE-A1-102006 029 525
MIN-TE SUN ET AL: "GPS-based message broadcast for adaptive inter-vehicle communications" VEHICULAR TECHNOLOGY CONFERENCE, 2000. IEEE VTS FALL VTC 2000. 52ND SEPT. 24-28, 2000, PISCATAWAY, NJ, USA, IEEE, Bd. 6, 24. September 2000 (2000-09-24), Seiten 2685-2692, XP010525075 ISBN: 978-0-7803-6507-0
CHAWLA MOHIT ET AL: "Beaconless Position-based Routing with Guaranteed Delivery for Wireless Ad hoc and Sensor Networks" ZIDONGHUA XUEBAO - ACTA AUTOMATICA SINICA, KEXUE CHUBANSHE, BEIJING, CN, Bd. 32, Nr. 6, 1. November 2006 (2006-11-01), Seiten 846-855, XP002454069 ISSN: 0254-4156
KORKMAZ G ET AL: "Black-Burst-Based Multihop Broadcast Protocols for Vehicular Networks" IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, Bd. 56, Nr. 5, 1. September 2007 (2007-09-01), Seiten 3159-3167, XP011192627 ISSN: 0018-9545

Description**Technical field**

5 The present invention relates to a method for optimally forwarding messages in a space subject to radio limitations, in particular for so-called car-to-X communication. Said forwarding of messages is carried out by stations, wherein the stations are both transmitters and receivers of messages.

10

Prior art

The last decade especially has seen a rapid evolution and proliferation of wireless communication and radio technologies (e.g. wireless LAN, UMTS, etc.). Particularly because of the increasing number of vehicles on the road, wireless communication has also become of interest to automotive manufacturers as a means of providing communication between vehicles and also between vehicles and infrastructure - i.e. so-called car-to-X communication. The possible applications of car-to-X communication range from pure entertainment (e.g. telephoning, chatting, texting, etc.), through improved navigation and driver assistance, to self-organising traffic (e.g. warning messages, information about road conditions, etc.).

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For car-to-X communication, particularly when used in the safety area, data and information is therefore exchanged between vehicles or between vehicles and infrastructure (e.g. traffic lights, road signs, etc.) by means of radio technology such as e.g. wireless LAN or UMTS. Said vehicles and infrastructure elements (e.g. traffic lights, road signs, etc.) are used as transmitting and/or receiving stations.

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Particularly messages such as warnings, information about the road conditions, etc. for e.g. hazard reduction must be forwarded as promptly as possible and should reach all relevant vehicles or road users as comprehensively as possible (e.g. those vehicles that are approaching a hazard situation such as e.g. an accident, poor road conditions, etc.). The aim here is that at least a critical number of vehicles or road users is reached by the messages so that consequential damage (e.g. further accidents, etc.) can be prevented.

For car-to-X communication, radio technologies such as UMTS, GPRS, wireless LAN as defined by the IEEE 802.11 WLAN standard, etc. are used as described, for example, by CAR 2 CAR Communication Consortium in the publication "CAR 2 CAR Communication Consortium Manifesto" of 28.08.2007 at <http://www.car-to-car.org>. However, the stations (vehicles, infrastructure elements, etc.) only have a limited range. When using wireless LAN connections on the basis of the IEEE 802.11 standard, this range is around a few hundred metres. If two or more stations are located within this communications range, they are automatically connected to form a dynamic and temporary mobile network, a so-called ad hoc network. Within the ad hoc network, each station can be a transmitter and receiver of messages, wherein for car-to-X communication the messages are forwarded by means of so-called "multihopping".

The ad hoc network formed by the stations for car-to-X communication thus constitutes a distributed, dynamic and self-organising temporary mobile network for forwarding messages - albeit in a space subject to radio limitations. The radio limitations are caused, for example, by a large number of stations, a short range of the individual stations, a

narrow bandwidth and/or a limited number of radio channels. To enable messages to be forwarded efficiently and effectively, so-called "flooding" of the radio channel e.g. due to redundant messages being transmitted must be prevented, as otherwise no space will be available for transmitting other messages. In contrast to other communication networks (e.g. mobile phone network, etc.), in the case of car-to-X communication the creation of a dynamic and temporary ad hoc network between the stations means that when flooding occurs there is no known network topology in place as a basis for scheduling alternative forwarding of messages. A message forwarding method is therefore not only dependent on the positions of the stations, but must also be capable of rapidly responding to topology changes in the ad hoc network.

In order to prevent flooding of the radio channel and find optimum paths for message forwarding, information technology (IT) approaches, for example, can be combined with position-dependent additional information. For this purpose e.g. known routing and graph theories from so-called mesh networking theory can be used and applied to dynamic stations (e.g. vehicles) and static stations (e.g. infrastructure elements such as e.g. traffic lights, road signs, etc.), wherein the forwarding of messages in the ad hoc network of car-to-X communication is seen from an IT networking standpoint using the methods employed in the Internet.

Thus maximally flooding-free forwarding of messages for car-to-X communication can be based on methods such as e.g. Dynamic Source Routing (DSR), Ad-Hoc On-demand Distance Vector Routing (AODV), Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) or Greedy Perimeter Stateless Routing (GPSR). Dynamic Source Routing (DSR) which is described, for example, in Roth, Jörg: Mobile Computing, 1st

edition 2002, dpunkt.verlag is a routing protocol which is used in mobile mesh networks. Ad-Hoc On-demand Distance Vector Routing (AODV) which is described e.g. in Tanenbaum Andrew S.: Computernetzwerke (Computer Networks), 4th revised edition 2003, Pearson Studium, Chapter 5.2 represents a topology-based, reactive method for forwarding messages, i.e. forwarding destinations are only determined as required. Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) which is known from Perkins, C. E. and Bhagwat, P., In proceedings of ACM SIGCOMM '94, pp. 234-244, August 1994, and Greedy Perimeter Stateless Routing (GPSR) which is described, for example, in Karp, B., Geographic Routing for Wireless Networks, Ph.D. Dissertation, Harvard University, Cambridge, MA, October 2000 likewise represent methods for forwarding messages in mobile ad hoc networks, wherein GPSR, for example, is a method whereby data packets are to be piloted to their intended destination in a spontaneously created computer network.

Other possible methods for channelling messages through an ad hoc network include e.g. GeoGRID - geocasting protocol for mobile ad hoc networks from the publication "W.-H. Liao, Y.-C. Tseng, K.-L. Lo, and J.-P. Sheu. Journal of Internet Technology, 1(2): 23.32, 2000." and in the publication "GeoTORA: A Protocol for Geocasting in Mobile Ad Hoc Networks, Young-Bae Ko, Dept. of Computer Science Texas A&M University College station, TX 77843,3112, USA".

However, the methods cited have been developed primarily for computer networks or the Internet. The disadvantage of using them for car-to-X communication has therefore proved to be, for example, that important radio channel parameters resulting in particular from the highly dynamic environment are not taken into account by these methods for car-to-X

communication. Particularly in the case of approaches derived from graph theory, a prior interlinking of the stations (e.g. vehicles, infrastructure elements, etc.) is premised, to the detriment of a rapid and reliable forwarding of messages, as adaptations to changes in the network created would have to be continuously performed due to the mobility of the stations (e.g. vehicles).

A method for forwarding messages in car-to-X communication is also described by the CAR 2 CAR Communication Consortium in the publication "CAR 2 CAR Communication Consortium Manifesto" of 28.08.2007, which is available at <http://www.car-to-car.org>. In the case of the message forwarding methods disclosed in this publication, a distinction is drawn between four types of message forwarding depending on the application of car-to-X communication (e.g. warnings, safety messages, entertainment, navigation, etc.): geographical unicast or point-to-point communication, topologically-scoped broadcast or multipoint communication, geographically-scoped broadcast or multipoint communication, and geographical anycast communication, wherein wireless LAN as per the IEEE 802.11 standard is used for communication between the stations. Each of these four types of message forwarding is based on different algorithms for message transmission - thus, for example, so-called greedy forwarding is used for geographical unicast communication, whereas e.g. geographically-scoped broadcast communication is based on a so-called simple flooding algorithm with detection of duplicated messages.

However, the methods presented in the publication "CAR 2 CAR Communication Consortium Manifesto" of 28.08.2007 also do not take into account all the important parameters for a radio channel due to the highly dynamic environment. Although possible control mechanisms such as e.g. monitoring of the

bandwidth of the radio channel, overload control, forwarding or transmission according to message priority, etc. are described as means of reducing the probability of flooding of the radio channel, this adversely affects the speed and
5 reliability of message forwarding via a plurality of stations. In addition, the methods described do not prevent redundant transmission of messages.

The publication DE 10 2006 029 525 A1 likewise discloses a
10 method for forwarding information in a wireless ad hoc network such as e.g. for car-to-X communication. In this method, the retransmission, i.e. onward transmission, of received information is scheduled such that a schedule time for the retransmission of the information is proportional to
15 a signal strength with which the information was received by a recipient node. Each range of signal strength corresponds to a unique schedule time - i.e. the higher the signal strength, the longer the schedule time for the forwarding of the information. In this way, although the number of
20 (onwardly) transmitting stations and therefore the possibility of flooding of the radio channel is reduced, redundant dispatching of information is only prevented to a limited extent, as the schedule time is allocated in a fixed manner. In addition, the method disclosed in the publication
25 DE 10 2006 029 525 A1 provides only limited means of determining an optimum or optimally positioned station for forwarding a message.

The publication MIN-TE SUN et al.: "GP-Based Message
30 Broadcast for Adaptive Inter-vehicle Communications" and the publication EP 1 441 321 A1 also disclose methods for transmitting information between mobile stations, i.e. by means of so-called car-to-car dissemination. Here position data (e.g. determined by GPS) is used for the forwarding of

information by a transmitting station or by receiving stations. This position data is either used by the transmitting station in order to include, in said information, identification for a potential candidate for forwarding, or position data of the transmitting station is inserted in the information for use by the receiving station. However, the disadvantage of both of these methods is therefore that they only provide limited means of determining an optimum or optimally positioned station for forwarding a message.

Summary of the invention

The object of the invention is therefore to specify a method whereby messages are forwarded rapidly and reliably via a plurality of stations in a space subject to radio limitations, dispatching of redundant messages is prevented, and optimally positioned stations for dispatching are determined.

This object is achieved by a method of the kind mentioned in the introduction, wherein a respective position within the range of the transmitting station is automatically determined by each receiving station located within range of a transmitting station from a signal strength of the received messages in combination with a periodic update of environmental information based on so-called beacon information. At least position data, direction of travel, speed and signal strength are exchanged between adjacent stations by means of the beacon information. A forwarding behaviour of the adjacent stations is monitored by each station. If a received message is forwarded by none of the adjacent stations within a predetermined time period, forwarding of the received message is carried out only by the

receiving station by which it is established, based on the signal strength and the environmental information exchanged with the adjacent stations, that it is located at the edge of the range of the transmitting station. Said time period until
5 the forwarding of the received message is determined as a function of the signal strength of the received message.

The main aspect of the inventive solution is that messages are forwarded promptly and reliably in a simple and
10 efficient manner, and dispatching of redundant messages is prevented, as a received message is only retransmitted by the station located at the edge of the range of the transmitting station. This means that the station which is farthest from the transmitting station within that range,
15 and by which a message has still been received in an error-free manner, becomes a new transmitting station. This new transmitting station is determined on the one hand on the basis of the signal strength of the received messages and, on the other, using the environmental information - e.g. on
20 the basis of the so-called beacon information by means of which data such as, for example, position indications, direction of travel, speed, signal strength, etc. can be exchanged between adjacent stations.

25 Each station monitors a forwarding behaviour of the adjacent stations, thereby automatically establishing whether it is itself the most suitable or optimum candidate for forwarding a message. For example, in the case of car-to-X communication another dissemination direction for the message to be
30 forwarded can be taken into account, as e.g. not all the stations that are within the range of the transmitting station and by which the message has therefore been received are affected by the message. Thus, for example, a message about a hazard or accident site is only of interest to those stations

or vehicles that are travelling in a direction of the hazard or accident site on a same traffic lane. The message can therefore be forwarded, for example, in a so-called upstream oriented direction in terms of the respective traffic lane, wherein upstream is regarded as a direction counter to a direction of movement of the vehicles on the respective traffic lane. The station most suitable for forwarding the message is then e.g. the station that is farthest upstream within the range of the transmitting station and therefore has the greatest distance from the transmitting station within the range.

Thus, particularly for car-to-X communication, a message (e.g. warning, safety message relating to a traffic or hazard situation) is forwarded promptly, reliably and in a resource-saving manner. Flooding of a radio channel due to the dispatching of a plurality of redundant messages is likewise prevented in this simple manner. In addition, the method according to the invention advantageously requires no prior interlinking of the stations, which means that it can be very easily used in highly dynamic environments such as e.g. for car-to-X communication. The method only requires periodic updating of environmental information as provided in the case of car-to-X communication by means of a so-called beacon signal, for example.

In addition, each station monitors a forwarding behaviour of the adjacent stations. If the received messages is forwarded by none of the adjacent stations within a predefined period of time, forwarding of the received message is carried out by the station itself. This ensures that a message is forwarded by a station within the range of the transmitting station, wherein the time period up to forwarding of the received message is

determined as a function of the signal strength of the received message.

5 The signal strength constitutes a measure of the distance from the transmitting station within the range. This ensures that preferably stations at the edge of the range undertake forwarding of the message. Mutual monitoring means that only the most suitable station dispatches the message. If the message is not sent within the time period, forwarding is
10 undertaken by the second most suitable station, and so on. This provides a simple means of preventing redundant message dispatching and flooding of the radio channel.

For forwarding of the message in a particular dissemination
15 direction (e.g. upstream, etc.), the mutual monitoring of adjacent stations can be limited, for example, to the adjacent stations within range that are located in the direction of this dissemination direction, as these stations are deemed to be more suitable for forwarding. Thus, for
20 example, in particular adjacent stations that are farther upstream (e.g. other stations or vehicles, etc. travelling behind the respective station or the respective vehicle), can be monitored by a station for car-to-X communication. The message is only forwarded by the station if the message has
25 not been dispatched by any of the stations monitored and deemed to be more suitable within range after the time period has elapsed.

For determining the respective position of the receiving
30 station within the range of the transmitting station, it is advantageous for a difference between the received signal strength of the message and a known minimum required reception power of the receiving station to be used. This is because a position of a station within the range of a

transmitting station can easily be derived from this difference. Thus, for example, it can be assumed that a station is located close to the transmitting station if said difference between measured signal strength of the message and the necessary reception power of the receiving station is relatively large. The smaller this difference, the farther the station will be from the transmitting station, for example. Even if in the urban area, for example, an attenuation of the signal strength of a message may vary markedly over time, an average over time of this attenuation is a good measure of the distance of the receiving station from the transmitting station. Adjustment of estimation methods to suit the respective environment for the average over time can be very easily carried out e.g. on passing infrastructure elements (e.g. road signs, traffic lights, mobile elements, etc.).

It is advantageous if a distance of the receiving station from the transmitting station is additionally determined using a so-called Global Navigation Satellite System or GNSS. In this advantageous manner, position determination of a station within the range of a transmitting station can be carried out more accurately. The position of a station is e.g. initially derived automatically by the station from the signal strength of the received message and can then be assisted and/or refined by the GNSS so that forwarding is carried out by the most suitable station - i.e. the station at the edge of the range that is farthest from the transmitting station. However, the GNSS can also be used to further optimise forwarding.

Thus, for example, by determining the position of a respective station by means of GNSS and by e.g. position indications of adjacent stations obtained by means of beacon

information, distances between the adjacent stations can be determined by the station itself. As the received signal strength decreases with distance from the transmitting station, e.g. more suitable stations for forwarding can
5 therefore be identified. Thus, for example, a station can easily identify the adjacent stations which are farther from the transmitting station in a particular dissemination direction for the message (e.g. upstream, etc.) and by which the message can nevertheless be received with a still
10 adequate signal strength.

In addition, by means of position information compared against map data for a station, for example, the forwarding of a warning or hazard message can be organised such that
15 this message is only received by stations (e.g. vehicles) which are heading towards a hazard area. This provides a simple means of preventing the message from being transported in a direction or rather to stations (e.g. vehicles) unaffected by the hazardous situation.

20

A preferred further development of the invention provides that the transmission power of a message is determined by the transmitting station on the basis of message priority. The transmission power of a message is matched to its importance
25 or urgency. Thus, for example, life-saving messages such as e.g. warnings, hazard messages, etc. that are conducive to safety are dispatched with high priority and therefore with a higher transmission power than other messages such as e.g. navigation information, etc. Life-saving messages are
30 therefore transmitted preferentially and forwarded more promptly. In addition, other lower priority messages queued for forwarding can be overtaken by these messages.

It is also advantageous if a decision about the forwarding of the message is governed by the type of the station itself or by the type of the adjacent station. Types of station used e.g. for car-to-X communication are vehicles (e.g. lorries, cars) and/or so-called Road side Units (RSUs).

Road side Units (RSUs) are infrastructure elements which are installed at fixed positions along roads and motorways or at particular locations such as e.g. petrol stations, car parks, motorway service areas, etc. RSUs are equipped with at least one device (e.g. antenna, etc.) for wireless mobile communication over short distances (e.g. wireless LAN). In addition, RSUs can also be provided with access to other communication networks (e.g. infrastructure networks, etc.).

The transmission of a message can be additionally optimised by deciding which type of station - i.e. vehicle or RSU - is more suitable for forwarding, as an RSU, for example, has, for example, a better and more selective range e.g. by having a higher-mounted antenna, directional characteristic, etc. Also taking into account the type of the adjacent station can further accelerate and optimise message transmission. Precedence in dispatching is given to the adjacent station - e.g. a RSU, having a greater range or transmission characteristics matched to the road, etc.; a lorry with high-mounted antenna; an emergency vehicle having an antenna aligned away from the hazardous situation, etc. In other words, it is detected by the receiving station that has been ascertained to be located at the edge of the range of the transmitting station that an adjacent station is a better forwarder of the message. The receiving station therefore waits for a short period of time (e.g. a few milliseconds) to see if the message is dispatched by a better forwarder.

For dispatching messages, antennas with directional characteristic, in particular so-called smart antennas by which messages are dispatched in at least one preferred direction, are advantageously used. The directional characteristic is set for the messages according to a desired target region (e.g. direction of travel of the vehicles, one or more lanes of a road, etc.) which makes it possible to prevent stations from receiving messages by which they are unaffected or only slightly affected. Aligning the directional characteristic of the antennas to a target region can be assisted, for example, by digital maps and possibly using a so-called electronic horizon, so that e.g. the transmission power can cater for cornering.

Summary of the drawings

The invention will now be explained in a schematic and exemplary manner with reference to the accompanying drawings in which:

Fig. 1 shows an example of the method according to the invention for optimum message forwarding with reference to car-to-X communication

Fig. 2 schematically illustrates a typical sequence of the method according to the invention for optimum message forwarding

Description of preferred embodiments

Figure 1 explains in a schematic and exemplary manner the method according to the invention for optimum message forwarding in a space subject to radio limitations with reference to car-to-X communication.

Figure 1 shows a road S having two traffic lanes and a side road S1 likewise with two traffic lanes. Vehicles 10 to 19, which are at the same time transmitting and receiving stations for car-to-X communication, are travelling on the road S and the side road S1. Where the side road S1 joins the road S there is an infrastructure component RSU or a so-called Road side Unit such as e.g. traffic lights, a road sign, etc., which is equipped for car-to-X communication.

For car-to-X communication, data is e.g. regularly exchanged by the vehicles 10 to 19 by transmission of so-called beacon information. As a result, a distance from their respective adjacent vehicles 10 to 19, for example, is known to the vehicles 10 to 19, as a vehicle position determined e.g. by GPS (Global Positioning System) is sent along with the beacon information. The transmitted beacon information can also contain e.g. a speed of a respective adjacent vehicle 10 to 19 for determining a speed relative to the respective adjacent vehicle 10 to 19, a direction of travel of a respective adjacent vehicle 10 to 19 from which it can be established whether the respective vehicle is moving towards or away from a position, and/or the current transmission power of a transmitting vehicle 10 to 19. A signal attenuation to the respective adjacent vehicle 10 to 19 and therefore a range and a distance of all the respective adjacent vehicles 10 to 19 can be determined, for example, by a receiver (e.g. vehicle 10 to 19, infrastructure component RSU) from the current transmission power of the respective adjacent vehicle 10 to 19 which is sent along with the beacon information, and from the distance of the respective adjacent vehicle 10 to 19 determined from the beacon information.

If, for example, traffic flow on the first lane of the road S is disturbed e.g. by an accident-damaged or defective vehicle 11, an emergency message shall be sent by the accident-damaged or defective vehicle 11 to all the vehicles 12, 14, 15, 17 and 19 travelling behind it. Said accident-damaged or defective vehicle 11 has a range R11 as the transmitting station.

The emergency message shall be transmitted in a dissemination direction MW, i.e. in the direction of the vehicles 12, 14, 15, 17 and 19 travelling towards the position of the accident-damaged or defective vehicle 11, wherein a first direction of travel of the vehicles 12, 14, 15 and 17 travelling on the first lane of the road S towards the accident-damaged or defective vehicle 11 will hereinafter also be termed downstream. The vehicles 13, 16 and 18 are travelling on the second traffic lane of the road S in a second direction of travel leading away from the position of the accident-damaged or defective vehicle 11 and hereinafter termed upstream. This second direction of travel also corresponds to the dissemination direction MW of the emergency message.

An emergency message e.g. relating to the accident or obstruction is sent out by the accident-damaged or defective vehicle 11, wherein it is known to the accident-damaged or defective vehicle 11 e.g. on the basis of the beacon information that other vehicles 10, 12, 13, 14 are within its range R11 and that the message can therefore be radio-relayed, i.e. forwarded by them. If the message is not passed on by any adjacent vehicle 10, 12, 13, 14 within a predefined time period of the order of milliseconds, the message is repeated by the accident-damaged or defective vehicle 11.

The vehicles 10, 12, 13, 14 that are located within radio range R11 of the accident-damaged or defective vehicle 11 are

reached by the emergency message. According to the inventive method, it is now decided automatically by each of these vehicles 10, 12, 13, 14 whether the respective vehicle 10, 12, 13, 14 is itself in the best position to forward the message -
5 i.e. is located at the edge of the range R11 of the accident-damaged or defective vehicle 11.

A first vehicle 10 within the range R11, for example, establishes with the aid of the beacon information and on the
10 basis of the signal strength of the emergency message itself that it is ahead of the accident-damaged or defective vehicle 11 and is moving away from the position thereof. The first vehicle 10 within the range R11 therefore recognises that it is rather unsuitable for forwarding the emergency message.

15 The emergency message is likewise received by a second vehicle 12 and a third vehicle 13. Said second vehicle 12 can detect on the basis of the signal strength of the received emergency message, e.g. in combination with the beacon information, that
20 the third vehicle 13 and a fourth vehicle 14 is also reached by the emergency message. The vehicle 12 therefore establishes that both the third vehicle 13 and the fourth vehicle 14 are farther upstream - i.e. at a position more suitable for forwarding the message. The second vehicle 12 therefore waits
25 for a predefined period of time (e.g. 2 to 5 milliseconds) to see if the emergency message is forwarded.

Like the second vehicle 12, the third vehicle 13 establishes that the fourth vehicle 14 is in a more favourable position
30 within the range R11 of the accident-damaged or defective vehicle 11 for forwarding the message. The third vehicle 13 therefore likewise waits for a predefined time period (e.g. 2 to 5 milliseconds), which can be reduced e.g. as a function of the signal strength of the received emergency message, to see

if the emergency message is forwarded by a station (e.g. vehicle 14, etc.) more favourably positioned within the range R11.

5 The fourth vehicle 14 now establishes on the basis of the signal strength of the emergency message likewise in combination with the beacon information that its position is at the edge of the range R11 of the accident-damaged or defective vehicle 11. In other words, the fourth vehicle 14
10 recognises that the emergency message has not been received by vehicles 15, 16 located farther upstream, as these are travelling outside the range R11 of the accident-damaged or defective vehicle 11. The fourth vehicle 14 therefore forwards the emergency message, as it is the most favourably
15 located to do so. The second and third vehicles 12 and 13 monitor the dispatching of the message, i.e. wait for a predefined time period in the millisecond range. If the emergency message is not forwarded by the fourth vehicle 14, the dispatching will be initially undertaken by the third
20 vehicle 13. If the message is also not dispatched by the latter within the predefined time period which is waited by the second vehicle 12, the message is forwarded by the second vehicle 12 after the time period has elapsed.

25 The fourth vehicle 14 by which the emergency message has now been forwarded has a range R14. Located within this range R14 in addition to the accident-damaged or defective vehicle 11 by which the message has been sent are the second and the third vehicle 12, 13 as well as a fifth vehicle 15, a sixth
30 vehicle 16 and the infrastructure component RSU. The forwarded emergency message is therefore received by the vehicles 11, 12, 13, 15, 16 and by the infrastructure component RSU.

The accident-damaged or defective vehicle 11 recognises that the emergency message has been dispatched by it. It is established by the second and third vehicle 12, 13 that the emergency message has already been received by them, as their positions are further downstream. Both the accident-damaged or defective vehicle 11 and the second and third vehicle 12, 13 are therefore unsuitable for forwarding the emergency message, i.e. the messages will not be forwarded by these vehicles 11, 12, 13.

The fifth vehicle 15, the sixth vehicle 16 and the infrastructure component RSU are therefore possibilities for forwarding the emergency message. When automatically deciding whether or not to forward the emergency message, the sixth vehicle 16 recognises that, on the one hand, the fifth vehicle 15 and, on the other, the infrastructure component RSU are more favourably located for forwarding the message.

It is indeed established by the fifth vehicle 15 on the basis of the signal strength of the received emergency message that it is at the edge of the range R14 of the fourth vehicle 14 and is therefore most favourably located for forwarding the message. However, the fifth vehicle 15 also recognises e.g. on the basis of beacon information that an infrastructure component RSU is also located within the range R14 of the fourth vehicle 14.

Because of its fixed installation, the infrastructure component RSU is better suited (e.g. in terms of radio direction, transmission power, mounting height of the antenna, etc.) for forwarding emergency messages. In addition, in the exemplary illustration of the method according to the invention, the infrastructure component RSU is installed where the side road S1 joins the road S. The

infrastructure component RSU therefore also has the advantage that, due to its range RRSU - e.g. by using antennas having a directional characteristic - the emergency message can be forwarded upstream in the road S and in the side road S1.

As the infrastructure component RSU has been detected by the fifth vehicle 15 as being within the range R14 of the fourth vehicle 14, the fifth vehicle 15 gives the infrastructure component RSU precedence for forwarding the emergency message. The emergency message is transmitted by the infrastructure component RSU within its range RRSU, which means that the other vehicles 17, 18 downstream in the road S and a vehicle 19 in the side road S1 are reached by the message. However, should the message not be forwarded by the infrastructure component RSU, forwarding of the emergency message is undertaken by the fifth vehicle 15 e.g. after waiting for a predefined period of time (e.g. 2 to 5 milliseconds), so that the remaining vehicles 17, 18, 19 in the road S or in the side road S1 are also reached by the message.

For forwarding, it is also taken into account, for example, that, because of its type (e.g. lorry, emergency vehicle, etc.) or design (e.g. vehicle height, etc.), one of the vehicles 10 to 19 is more suitable for forwarding emergency messages. Thus, for example, a lorry - similarly to an infrastructure component RSU - can be given precedence for dispatching messages, as, in the case of the latter, e.g. the antenna is higher-mounted or has a directional characteristic in the upstream direction.

Figure 2 now shows in an exemplary and schematic manner the sequence of the method according to the invention for

optimally forwarding messages in a space subject to radio limitations such as e.g. for car-to-X communication. The method is initiated with a start step 20.

5 In a second method step 21, a receiving station (e.g. vehicle, infrastructure element) is waiting to receive a message sent out by another transmitting station (e.g. vehicle, infrastructure element). These messages can contain, for example, warnings, information about the traffic
10 situation, etc.). In addition to waiting for messages, method step 21 can also be waiting to receive beacon information (e.g. distances to adjacent stations, transmission and reception powers of the adjacent stations, speeds, directions of travel, etc.) which can additionally be used for
15 determining important parameters (e.g. radio channel characteristics, geographical positions of stations, speeds, direction of travel, etc.) for forwarding messages.

If, in the second method step 21, a message is received by a
20 station, in a third method step 22 the position of this receiving station within a range of the station by which the message has been sent is automatically determined by the receiving station. In order to automatically determine the position, a signal strength of the received message is used
25 by the receiving station. For determining the position within the range, the receiving station generates and uses e.g. a difference between the signal strength of the received message and a known minimum required reception power of the receiving station. In addition, in the third method step 22,
30 parameters such as e.g. direction of travel in relation to the transmitting station, distance from the transmitting station, speed relative to the transmitting station, etc. can be determined by the receiving station 22 e.g. using a so-called Global Navigation Satellite System (GNSS).

On the basis of the position of the receiving station determined in the third method step 22 and the parameters determined, in a fourth method state 23 it is ascertained whether the receiving station is located upstream in relation to the transmitting station. In the case of the vehicles 10 to 19 as shown in Figure 1, for example, upstream means that a receiving vehicle 10 to 19 is travelling towards the transmitting station if the receiving vehicle 10 to 19 is in the same traffic lane as the transmitting station, or that the receiving vehicle is travelling away from the transmitting station on the opposite lane. If it is established in the fourth method step 23 that the position of the receiving station is not upstream in relation to the transmitting station, the second method step 21 is invoked by the receiving station. The station then waits to receive new messages, as its current position is unsuitable for forwarding the received message.

However, if the receiving station is upstream in relation to the transmitting station, in the fifth method step 24 it is checked whether one of the adjacent stations within the range of the transmitting station is an infrastructure element RSU (e.g. traffic lights, road sign, etc.) which, being installed in a fixed manner, for example, may have better prerequisites (e.g. radio direction, transmission power, antenna with directional characteristic, etc.).

If, in a fifth method step 25, an infrastructure element RSU is found as an adjacent station, in a sixth method step 25 the infrastructure element RSU is given precedence for forwarding the message. The receiving station waits for an predefined period of time (e.g. 2 to 5 milliseconds) to see

if the messages is transmitted by the infrastructure element
RSU.

Verification of forwarding is carried out by the receiving
5 station in the seventh method step 26. If the seventh method
step 26 indicates that the message has been forwarded by the
infrastructure element RSU, this terminates the method for the
receiving station. The receiving station reverts to the second
method step 21 and waits to see if new messages are received
10 for possible forwarding.

If, in the seventh method step 26, it is established that the
message has not been forwarded by the infrastructure element
RSU within the predefined time period, the receiving station
15 continues with an eighth method step 27. The eighth method
step 27 is also executed by the receiving station if, in the
fifth method step 25, no infrastructure element RSU was found
as an adjacent station within the range of the transmitting
station.

20

In the eighth method step 27, the receiving station checks,
on the basis of the determined position within the range of
the transmitting station, whether adjacent stations are more
suitable candidates for forwarding the message. For each
25 adjacent station, a distance of the transmitting station from
a respective adjacent station of the receiving station, a
signal attenuation between the transmitting station and a
respective adjacent station of the receiving station and/or a
signal strength on the message received by an adjacent
30 station, for example, can be calculated by the receiving
station on the basis of the signal attenuation. For example,
beacon information (e.g. distances from adjacent stations,
transmission and reception powers of the adjacent stations,
speeds, directions of travel, etc.) which is exchanged

between the stations, or GNSS information, can be used as the basis for these calculations.

In the eighth method step 27, it can additionally be
5 determined, on the basis of the calculations cited, whether an adjacent station is located further upstream in relation to the transmitting station than the receiving station. It is also checked whether the message has yet been completely received by this adjacent station. Because this means that
10 said adjacent station represents a more suitable candidate for forwarding the message, as it is located closer to the edge of the range of the transmitting station.

In a ninth method step 28 it is then checked whether there is
15 a more suitable adjacent station for forwarding - i.e. one located closer to the edge of the range of the transmitting station or having a greater distance in the direction upstream of the transmitting station. If such an adjacent station is found by the receiving station, in a tenth method
20 step 29 a predefined period of time (e.g. 2 to 5 milliseconds) is waited and then, once this period has elapsed, in an eleventh method step 30 it is checked whether the message has been forwarded.

25 If a more suitable adjacent station is not found in the ninth method step 29, the tenth method step 29 and the eleventh method step 30 are skipped. In a twelfth method step 31 the message is then transmitted by the receiving station itself, as it has been detected by this station that it is the most
30 favourably located (e.g. the farthest upstream from the transmitting station) within the range of the transmitting station.

If during execution of the eleventh method step 30 it is established by the receiving station that the message has been forwarded by another i.e. adjacent station, this terminates the process for the receiving station. The receiving station
5 reverts to the second method step 21 and waits to receive new messages or beacon information.

If, in the eleventh method step 30, the message was not forwarded by any other station within the range of the
10 transmitting station, in the twelfth method step 31 the message is transmitted by the receiving station itself.

By forwarding the message, the receiving station becomes the new transmitting station within the range of which stations
15 automatically establish which station is most suitable for forwarding the message. Dispatch of the message terminates the process for the receiving station. The receiving station then returns to a waiting state and waits for new messages or beacon information from stations.

20

P a t e n t k r a v

1. Fremgangsmåde til en optimal videresendelse af meddelelser i et radio-
teknisk begrænset rum, især til car-to-x-kommunikation, hvor videresendelsen af meddelelser udføres af stationer, hvilke er både afsendere og modtagere af meddelelserne,
hvor der af hver modtagende station, som er beliggende inden for en sendende stations rækkevidde, ud fra en signalstyrke af de modtagne meddelelser i kombination med en periodisk opdatering af en omgivelsesinformation på basis af en såkaldt radiofyrr-information, via hvilken i det mindste positionsdata, køreretning, hastighed og sendekapacitet udveksles mellem tilstødende stationer, automatisk registreres en respektiv position inden for den sendende stations rækkevidde (21, 22),
hvor der af hver station overvåges (28) en videresendelsesadfærd hos de tilstødende stationer,
hvor der, hvis der inden for et på forhånd angivet tidsrum ikke videresendes (30) en modtaget meddelelse fra nogen af de tilstødende stationer, kun udføres (31) en videresendelse af den modtagne meddelelse af denne modtagende station selv, af hvilken det ved hjælp af signalstyrken og den omgivelsesinformation, der udveksles med de tilstødende stationer, konstateres, at den er beliggende (24, 27, 28) i kanten af den sendende stations rækkevidde,
og hvor tidsrummet indtil videresendelsen af den modtagne meddelelse bestemmes afhængigt af signalstyrken af den modtagne meddelelse.
2. Fremgangsmåde ifølge krav 1, **kendetegnet ved**, at der til brug for en fastlæggelse af den respektive position af den modtagende station inden for den sendende stations rækkevidde anvendes en difference mellem den modtagne signalstyrke af meddelelsen og en kendt i det mindste nødvendig modtagekapacitet af den modtagende station (22, 23).
3. Fremgangsmåde ifølge et af de foregående krav, **kendetegnet ved**, at der derudover udføres en fastlæggelse af en afstand af den modtagende station fra den sendende station ved hjælp af et såkaldt Global Navigation Satellite System eller GNSS.

4. Fremgangsmåde ifølge et af de foregående krav,
kendetegnet ved, at sendekapaciteten af en meddelelse fra den respektive sendende station bestemmes ved hjælp af en prioritet af meddelelsen.
- 5 5. Fremgangsmåde ifølge et af de foregående krav,
kendetegnet ved, at der fastlægges (24) en beslutning vedrørende videresendelsen af meddelelsen gennem en type af stationen.
- 10 6. Fremgangsmåde ifølge et af de foregående krav,
kendetegnet ved, at der fastlægges (24, 28) en beslutning vedrørende videresendelsen af meddelelsen gennem typen af en tilstødende station.
- 15 7. Fremgangsmåde ifølge et af de foregående krav,
kendetegnet ved, at der anvendes køretøjer og/eller såkaldte Road Side Units som typer af stationer.
- 20 8. Fremgangsmåde ifølge et af de foregående krav,
kendetegnet ved, at der til brug for en forsendelse af meddelelser anvendes antenner med retningskarakteristik, især såkaldte Smart Antennas, af hvilke forsendelsen af meddelelserne dirigeres i mindst en foretrukket retning.

FIG 1

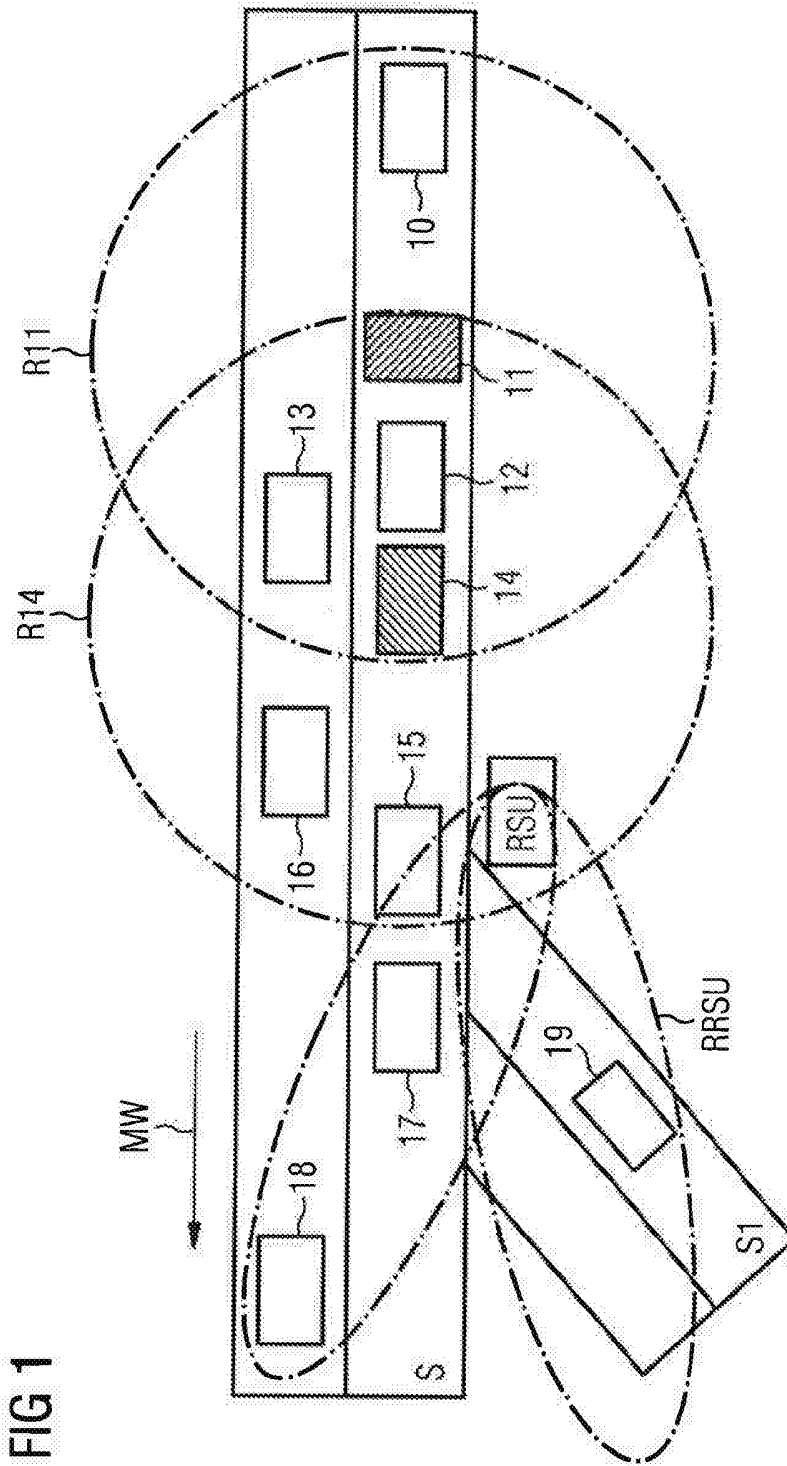


FIG 2

