

Translation

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5 A method and a system for time synchronisation in an
ad-hoc network

The invention relates to a method and a system for time synchronisation in an ad-hoc network.

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In mobile networks without an infrastructure - so-called ad-hoc networks - the management, monitoring and control of data traffic are processed directly between the individual network participants - the so-called nodes or network nodes.

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In this context, one essential function is the time synchronisation between all of the nodes in an ad-hoc network. An identical time basis for all of the nodes in the ad-hoc network is an absolute prerequisite for accurate time

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synchronisation of all nodes in the ad-hoc network with the synchronisation bit pattern transmitted in a given time window for synchronising with the correct phase and frequency of the transmission signal, for example, within a given time segment of a frequency-hop method used in an ad-hoc network.

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US 2005/0169233 A1 describes a method for time synchronisation of network nodes in an ad-hoc network. The time information for the time synchronisation in this context is transmitted via timestamps in individual data packets.

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A time synchronisation in an ad-hoc network is known from WO 2011/154911 A1. In this context, clusters of respectively regionally adjacent nodes are initially formed. An intra-cluster time synchronisation is implemented in each individual

cluster formed in this manner in that, according to a fixed sequence, individual nodes of the cluster transmit a message for time synchronisation with the transmission time of the message at the local time of the transmitting node, by means of which the other nodes of the cluster synchronise their local time with the local time of the transmitting node. The disadvantage with the time synchronisation from WO 2011/154911 A1 is, on the one hand, the time delay in the implementation of the time synchronisation, which results from the time required to form the cluster, and, on the other hand, the cost for implementing the time synchronisation, which includes a specification of the sequence for transmitting messages for the time synchronisation.

US 2003/0117991 A1 discloses a time synchronisation of network nodes in a mobile-radio network in which the hierarchy which determines reference nodes for every network node with which the respective network node can synchronise its time is specified in advance. The disadvantage with this synchronisation method is the time delay in determining the time-reference hierarchy and in communicating this hierarchy of reference network nodes to every network node of the ad-hoc network.

US 2010/0238890 A1 discloses a time synchronisation between individual network nodes of an ad-hoc network which functions according to the master-slave principle. A master network-node which provides the time reference for a total of M slave network-nodes is specified. The disadvantage with this synchronisation method is also the time delay in specifying the master network-node and in communicating the master network-node to all of the M slave network-nodes of the ad-hoc network.

The object of the invention is therefore to provide a method and a system for time synchronisation in an ad-hoc network which achieves a time synchronisation as fast as possible and with minimum cost with all of the nodes of the ad-hoc network.

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This object is achieved by a method according to the invention for time synchronisation in a mobile ad-hoc network with the features of claim 1 and by a system according to the invention for time synchronisation in a mobile ad-hoc network with the
10 features of claim 17. Advantageous technical developments are specified in the respectively dependent claims.

For this purpose, each node of an ad-hoc network transmits a message signalling a presence, in each case, within a given
15 time frame, which is acknowledged respectively by network nodes disposed within the reception range of the transmitting node, by transmitting an acknowledgement message. Starting from two nodes each positioned within the transmission range of one another, with regard to the messages of an
20 acknowledgement message, that node is specified by the node receiving the acknowledgement message, with the local time of which the respectively other node synchronises its local time. The node of which the local time is used for the
25 synchronisation of the local time of the respectively other node therefore represents the local master of the respectively other node in the ad-hoc network formed from two nodes.

The two nodes can be nodes, which, in each case do not yet belong to an ad-hoc network and accordingly form a common ad-
30 hoc network through the process of time synchronisation. The two nodes can also be nodes which also both belong to a different ad-hoc network respectively. In this case, the ad-hoc networks associated respectively with one of the two nodes are combined, and the nodes associated with the two ad-hoc

networks each synchronise their local time with the local time of the specified node. Moreover, the two nodes can be, respectively, one node which does not belong to an ad-hoc network and one node which is associated with an ad-hoc network. In this case, the node without integration in an ad-hoc network is integrated into the ad-hoc network of the respectively other node, and the individual nodes of the original ad-hoc network synchronise their local time with the local time of the specified node.

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In all three cases, that node of the two nodes disposed within the transmission range of which the local time provides respectively the maximum time accuracy, or which is linked to a node in an ad-hoc network of which the local time provides respectively the maximum time accuracy, is preferably specified with the highest priority. This guarantees that all of the nodes in the ad-hoc network now formed are time synchronised with the maximum possible time accuracy relative to one another, and accordingly, an optimum phase and frequency synchronisation of all nodes of the ad-hoc network now formed with the phase and respectively the frequency of the transmission signal utilised in the ad-hoc network used is made possible within a time segment of the frequency hop method.

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If an ad-hoc network is formed comprising only two nodes of which the local times have an identical time accuracy, that node is preferably specified to provide its local time for the synchronisation of the local time of the respectively other node, which first transmits an acknowledgement message in response to a message transmitted to both nodes signalling a presence - typically a "hello message". Accordingly, a node which signals its presence to a potential adjacent node by transmitting a message signalling a presence and seeks to form

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an ad-hoc network with this potential, adjacent node, the responding adjacent node to be its local time master and synchronises its local time with the local time of the responding adjacent node. In this manner, the process of
5 determining which of the two nodes will become the local time master is simplified and accordingly accelerated.

If at least one of the two nodes disposed within the transmission range of one another is integrated in an ad-hoc
10 network with at least one other node, and the local times of all nodes in the ad-hoc network now formed have an identical time accuracy, that node of the two nodes disposed within transmission range of one another which is already connected to a relatively larger number of nodes in a previously
15 existing ad-hoc network is preferably specified with the next lower priority as the local time master. The local times of all nodes which are integrated in the ad-hoc network now formed are synchronised directly or indirectly with its local time. Such a specification of a node determines a minimally
20 necessary synchronisation cost between the individual nodes of the ad-hoc network now formed.

If the two nodes disposed within transmission range of one another and the nodes previously integrated in an ad-hoc
25 network with these two nodes each have a local time with an identical time accuracy, and the number of nodes integrated respectively in an ad-hoc network with the two nodes disposed within transmission range of one another is identical, that node of the two nodes disposed within transmission range of
30 one another in the connected ad-hoc network of which a node with the lowest identity number is integrated is specified with the lowest priority to act as the local time master. The
Medium-Access-Control (MAC) Address - German: Medium-Zugriffs-

Kontroll-Adresse of the respective node is preferably selected as the identity number.

If at least one node is completely removed from an existing
5 ad-hoc network, and if the moving node was a local time master in the previous ad-hoc network, that node of the remaining ad-hoc network of which the local time has the maximum time accuracy of the local times of all nodes disposed in the remaining ad-hoc network is preferably specified with the
10 highest priority as the local time master.

If all nodes of the remaining ad-hoc network provide a local time with an identical time accuracy, that node of the remaining ad-hoc network which provides the largest number of
15 respectively directly adjacent nodes after the complete removal of at least one node from the previous ad-hoc network is specified with the next lower priority to act as the local time master.

20 Finally, if all nodes of the remaining ad-hoc network have a local time with an identical time accuracy and, in each case, have an identical number of directly adjacent nodes, that node of the remaining ad-hoc network which provides the lowest identity number after the complete removal of at least one
25 node from the previous ad-hoc network is preferably specified with the lowest priority as the local time master.

The complete removal of a node from an existing ad-hoc network is preferably identified by the nodes of the remaining ad-hoc
30 network if no further message signalling the presence of the moving node has been received since the last reception time within a constant time frame in which, in each case, a message signalling a presence is transmitted by at least one node of the remaining ad-hoc network.

A node of a previously existing ad-hoc network, from the transmission range of which a node is removed with the local time of which the node previously synchronised its local time, will generally specify another node of the remaining ad-hoc network disposed within the transmission range in order to synchronise its local time with the local time of the node specified as the local time master. In this context, the node moving from the transmission range of the node can continue to be disposed within the transmission range of at least one further node of the remaining ad-hoc network.

The synchronisation of the local time of a node with the local time of the node it has specified as the local time master preferably takes place on the basis of the transmission time transmitted by the specified node in its message signalling a presence or in its acknowledgement message, and on the basis of the reception time of the associated acknowledgement message or message updating a presence, which is also transmitted. The node receiving the message signalling a presence or the acknowledgement message can synchronise its local time to the local time of the node specified as the local time master by comparing the reception time of the message signalling a presence or the acknowledgement message with the transmitted transmission time of the message signalling a presence or the acknowledgement message.

A consideration of the transmission time occurring between the node specified as the local time master and the node implementing the time synchronisation preferably takes place on the basis of a comparison of the transmission time with the transmitted reception time of the message signalling a presence or the acknowledgement message. This time synchronisation of the local time of the respective node with

the local time of the node specified as the local time master takes place not only in the initial contact between these two nodes but in a cyclical manner at every reception time of a message signalling a presence or an acknowledgement message.

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In an ad-hoc network which evolves according to the mechanisms described above, since only a single node acts as the local time master for at least one other node, which, in turn, acts as local time master for other nodes in the ad-hoc network,
10 the local time of every node in the ad-hoc network is synchronised with the local time of this single node indirectly, in a successive manner and without its own local time master.

15 In order to reduce a clock drift of a local time of a node within the ad-hoc network, which has lower time accuracy than the local time of the node specified as the local time master, the constant time frame for the cyclical transmission of messages signalling a presence is preferably minimised by
20 synchronising nodes. In particular, the transmission time of a message signalling a presence is calculated in advance by the synchronising node in order to limit the influence of clock drift on the time accuracy of the local time of the synchronising node to a given value.

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Exemplary embodiments of the method according to the invention and the system according to the invention for time synchronisation in a mobile ad-hoc network are explained in detail below by way of example on the basis of the drawings.

30 The figures in the drawings show:

Figure 1 a presentation of an exemplary embodiment of the system according to the invention for time synchronisation in a mobile ad-hoc network;

Figure 2 an exemplary presentation of a first scenario for
an ad-hoc network and a time diagram of the
messages transmitted between the participating
nodes;

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Figure 3 an exemplary presentation of a second scenario for
an ad-hoc network and a time diagram of the
messages transmitted between the participating
nodes;

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Figure 4 an exemplary presentation of a third scenario for
an ad-hoc network and a time diagram of the
messages transmitted between the participating
nodes;

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Figure 5 an exemplary presentation of a fourth scenario for
an ad-hoc network and a time diagram of the
messages transmitted between the participating
nodes;

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Figure 6 an exemplary presentation of a fifth scenario for
an ad-hoc network and a time diagram of the
messages transmitted between the participating
nodes;

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Figure 7 an exemplary presentation of a sixth scenario for
an ad-hoc network and a time diagram of the
messages transmitted between the participating
nodes;

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Figure 8 an exemplary presentation of a seventh scenario
for an ad-hoc network and a time diagram of the

messages transmitted between the participating nodes;

Figure 9 an exemplary presentation of a time diagram of the time accuracies occurring in individual nodes of an ad-hoc network respectively; and

Figure 10 a flow chart of an exemplary embodiment of the method according to the invention for time synchronisation in a mobile ad-hoc network.

The system according to the invention for time synchronisation in a mobile ad-hoc network is explained in detail in the following section with reference to the illustration shown in Figure 1, and the method according to the invention for time synchronisation in a mobile ad-hoc network is explained in detail with reference to the flow diagram shown in Figure 10.

In the first method step S10 of the method according to the invention, every node inside or outside an ad-hoc network continually transmits a message within a given, constant time frame signalling its presence 1, especially a "hello message" ("hello message"), in order to signal its presence to adjacent nodes which are disposed within its transmission range. This constant time frame for the transmission of a message signalling its presence is typically not identical in each node, but, in each case, provides a different value for each node.

The message signalling a presence 1 of the node i typically includes the following contents:

- an identity code of the node i , which is typically the Medium-Access-Control (MAC) address - German: Medium-Zugriffs-Kontroll-Adresse - of the node i ,
- the transmission time TS_i of the node i at the local time of
5 the node i ,
- the adjacent nodes $N(i_1, i_2, i_3, \dots)$ in the case of identified nodes within the transmission range of the node i ,
- the reception times $RxTS(i_1, i_2, i_3, \dots)$ of messages signalling a presence which are disposed within the transmission range of
10 the node i and
- the time accuracy of the local time of the node i .

In the following paragraphs, the node transmitting a message signalling a presence 1 is referred to as the transmitting
15 node.

In the next method step S20, the message transmitted by a node i signalling a presence 1 of a node j , which is disposed within the transmission range of the node i and accordingly
20 receives the message signalling a presence 1 of the node i , is acknowledged with an acknowledgement message 2, especially an "I-hello message". This acknowledgement message 2 is transmitted by the node j immediately after the reception of the message signalling a presence 1. To avoid the simultaneous
25 transmission of an acknowledgement message 2 by several nodes which receive the message signalling a presence 1 of the node i at more or less the same time, and therefore to avoid blocking the transmission channel in the ad-hoc network, the transmission of the acknowledgement message 2 is implemented
30 by the individual node in each case delayed by a small delay time, which varies from node to node, by comparison with the reception time of the message signalling a presence 1.

An acknowledgement message 2 includes the same contents as a message signalling a presence 1. The node receiving a message signalling a presence 1 and transmitting an acknowledgement message 2 is referred to in the following paragraphs as the receiving node.

Alongside the nodes each transmitting a message signalling a presence 1 or each transmitting an acknowledgement message 2 which already belong to an ad-hoc network and are accordingly time synchronised with all of the nodes of the ad-hoc network, there are also nodes which each transmit a message signalling a presence 1 or each transmit an acknowledgement message 2 in response to receiving a message signalling a presence 1 but which do not yet belong to an ad-hoc network. For such nodes which are searching for an ad-hoc network, the possibility is offered to form an ad-hoc network with this other node upon receiving a message signalling a presence 1 or an acknowledgement message 2 from another node. If the respectively other node is itself not yet disposed in an ad-hoc network, a new formation of an ad-hoc network takes place between these two nodes. If the respectively other node is already integrated in an ad-hoc network, the node which is searching for an ad-hoc network is accepted into the existing ad-hoc network of the respectively other node. Finally, the two nodes which enter into contact with one another via the transmission and the reception of a message signalling a presence 1 or an acknowledgement message 2 can each belong to a different ad-hoc network. As a result of these two nodes taking up contact, a combination of the two ad-hoc networks to form a single combined ad-hoc network can be achieved.

In order to realise a time synchronisation between the two nodes in the ad-hoc network to be formed or to realise a time synchronisation between all of the nodes in the expanded ad-

hoc network, a node disposed in the direct neighbourhood which represents a local master for the respectively other nodes and with the local time of which the respectively other node synchronises its local time is specified for every node of the ad-hoc network to be formed or to be expanded. Since every node in the now existing ad-hoc network synchronises its local time with the local time of the associated local time master, all of the nodes of the now existing ad-hoc network are time synchronised with one another. Figure 1, which represents the exemplary embodiment of the system according to the invention for time synchronisation in a mobile ad-hoc network, shows individual nodes 31, 32, 33, 34, 35, 36 and 37 which are each positioned within transmission range of one another and accordingly form an ad-hoc network. The local time master specified for each individual one of these nodes 31, 32, 33, 34, 35, 36 and 37 is evident here from the direction of the arrow of the connecting straight line in each case between two adjacent nodes.

The specification of the local time master associated with each node within the now existing ad-hoc network is implemented via a priority hierarchy.

The node of the existing ad-hoc network which, in each case, provides the local time with the maximum time accuracy is identified with the highest priority and is therefore specified as the local time master. According to the next method step S30, it is determined whether, in each case, the time accuracy of the local time of the two nodes - transmitting node or receiving node - contained in the transmitted message signalling a presence 1 or in the transmitted acknowledgement message 2 provides a higher value.

In the next method step S40, if the transmitting node or the receiving node provides higher time accuracy in its local time, that node which provides the relatively higher time accuracy in its local time becomes the local time master of the respectively other node. Because of the time referencing of every node with a directly adjacent node within an ad-hoc network according to Figure 1, all of the nodes which are already connected in an ad-hoc network to the transmitting or receiving node which references its local time to the local time of the receiving or transmitting node acting as the local time master synchronise their local time indirectly with the local time of this local time master. The nodes which are already connected within an ad-hoc network to the node acting as the local time master remain unchanged in their time referencing relative to a respectively adjacent node acting as the local time master.

In the next method step S50, if the local times of the transmitting and receiving node each provide an identical time accuracy, it is determined with the next lower priority, whether, in each case, the two nodes entering into contact with one another - transmitting node and receiving node - are nodes without integration in an existing ad-hoc network, or respectively whether one of the two nodes or both nodes are already integrated in an ad-hoc network.

According to the next method step S60, if both the transmitting node and respectively also the receiving node are not yet integrated in an ad-hoc network, the node receiving a message signalling a presence 1 is specified as the local time master of the node transmitting a message signalling a presence 1.

In a subsequent method step S70, if at least one node is already integrated in an ad-hoc network, it is determined whether both nodes are each integrated in an ad-hoc network with an identical number of nodes. In the next method step
5 S80, if this is the case, that node of the two nodes entering into contact with one another which has so far been integrated in an ad-hoc network with a node which provides the lowest Medium-Access-Control (MAC) address - German: Medium-Zugriffs-Kontroll-Adresse - is specified as the local time master. This
10 node becomes the local time master not only for the respectively other node of the two nodes entering into contact, but acts indirectly as the local time master for all nodes which are integrated with the respectively other nodes in an ad-hoc network, because of the successive time
15 referencing between every node of the ad-hoc network and its associated, adjacent node acting as the local time master.

If both of the nodes entering respectively into contact with one another are already integrated in an ad-hoc network with a
20 different number of nodes in each case, or if one node is not integrated in an ad-hoc network at all, while the respectively other node is already associated with an ad-hoc network, according to the next method step S90, that node of the two nodes entering into contact with one another which is
25 integrated in the ad-hoc network with the largest number of nodes becomes the local time master of the respectively other node. The nodes which are disposed in an ad-hoc network with the node of the two nodes entering into contact with one another which has not been specified as the local time master
30 also synchronise their local time indirectly with the local time of this node specified as the local time master because of the successive time referencing between every node of the ad-hoc network and its associated adjacent node acting as the local time master.

In the next method step S100, every node in the resulting ad-hoc network synchronises its local time with the local time of its associated local time master. For this purpose, the
5 respective node uses the time information which is contained in a message signalling a presence 1 or an acknowledgement message 2 currently received from the associated node acting as the local time master. This relates, on the one hand, to the transmission time of the respective message signalling a
10 presence 1 or the respective acknowledgement message 2 determined at the local time of the node acting as the local time master, and also to the reception time of the message signalling a presence 1 or acknowledgement message 2 last transmitted from the respective node by the node acting as the
15 local time master.

The node synchronising its local time with the local time of the respective local time master synchronises its local time by determining the synchronisation of its local time with the
20 local time of the node acting as the local time master and also the determination of the transmission time between the synchronising node and the node acting as the local time master, on the one hand, from the transmission time determined at the local time of the synchronising node and the reception
25 time of the respective message signalling a presence 1 or the respective acknowledgement message 2 determined at the local time of the node acting as the local time master and, on the other hand, from the reception time determined at the local time of the synchronising node and the transmission time of
30 the subsequent acknowledgement message 2 or the message signalling a presence 1 determined at the local time of the node acting as the local time master.

In the subsequent method step S110, a removal, which may occur under some circumstances, of one node or of several nodes from the existing ad-hoc network is identified. For this purpose, a check is carried out by every node of the ad-hoc network to
5 determine whether a further message signalling a presence 1 of the respective adjacent node is received from every adjacent node positioned within the transmission range of the respective node, in each case, within a fixed time interval since the last reception time of a message signalling a
10 presence 1 of the respective adjacent node. If this is the case, the respective adjacent node is still disposed within the transmission range of the checking node. However, if the respective node does not receive a further message signalling a presence 1 of the respective adjacent node within the fixed
15 time interval, the respective adjacent node has moved at least out of the transmission range of the node checking, and, under some circumstances, even out of the transmission range of the combined ad-hoc network. If the node which has moved out of the transmission range of the node checking is a local time
20 master for the checking node, the checking node must search for a new node to act as the local time master. Under some circumstances, the checking node may, in the meantime, also be disposed outside the ad-hoc network, because of the removal of the node acting as the local time master from the transmission
25 range of the checking node.

Without time reference to a node acting as a local time master, the respective node is compelled to search for a new node to act as the local time master. If the respective node
30 still continues to be disposed within the transmission range of another node without a time reference and accordingly within an ad-hoc network with the other node, it can select this other node as its local time master. However, if the respective node without time reference is no longer disposed

in the transmission range of another node and is accordingly also no longer in an ad-hoc network with one or more nodes, then it is compelled to take up contact with another node with or without linked ad-hoc network according to method steps S10
5 to S90 described above.

In the final method step S120, by analogy with method step S100, a synchronisation of the local time of the node which has established contact with a node with or without linked ad-
10 hoc network and specified this node to be its local time master takes place at the local time of node specified as the local time master.

In the following section, the exemplary embodiment of the
15 method according to the invention for time synchronisation in a mobile ad-hoc network as just described will be described in greater detail on the basis of the scenarios illustrated in Figures 2 to 8 respectively.

20 In the first scenario in Figure 2, two nodes without a linked ad-hoc network which are moving towards one another and positioned, from a given time, within the transmission range of one another are considered.

25 At time (1) at which node 3_1 transmits a message signalling a presence 1, the two nodes 3_1 and 3_2 do not recognise the presence of the respectively other node. Node 3_1 consequently transmits a "hello message", which contains only the identity of node 3_1 , the transmission time TS_1 of the "hello message"
30 transmitted by node 3_1 at the local time of node 3_1 , the time accuracy of the local time of node 3_1 and the MAC address of node 3_1 .

This "hello message" of node 3_1 is received at time (2) by node 3_2 and immediately acknowledged with an acknowledgement message 2 in the form of an "I-hello message" which, alongside the identity of node 3_2 , the time accuracy of the local time of node 3_2 and the MAC address of node 3_2 , contains the transmission time TS_2 of the "I-hello message" of node 3_2 at the local time of node 3_2 , the identified adjacent node 3_1 and the reception time $RxTS(1)$ of the "hello message" of node 3_1 . For node 3_2 , node 3_1 acts as the local time master at time (2), because node 3_2 can synchronise its local time, at least roughly - without taking into consideration the transmission time of the "hello message" transmitted by node 3_1 between node 3_1 and node 3_2 - with the local time of node 3_1 , by matching its local time, by the difference between the reception time of the "hello message" from node 3_1 determined at its local time and the transmission time of the "hello message" from node 3_1 determined at the local time of node 3_1 , to the local time of node 3_1 acting as the local time master. At time (2), there exists for node 3_2 only the knowledge that a functioning transmission connection from node 3_1 to node 3_2 exists. Accordingly, at time (2) only an asymmetric transmission connection between node 3_1 and node 3_2 is present.

At time (3), the "I-hello message" of node 3_2 is received by node 3_1 . At time (3), there exists for node 3_1 only the knowledge that a functioning transmission connection from node 3_1 to node 3_2 and from node 3_2 to node 3_1 exists. Accordingly, at time (2) also, only an asymmetric transmission connection is present between node 3_1 and node 3_2 . At time (3) node 3_1 will specify node 3_2 as its local time master, because the time accuracy of node 3_2 corresponds to the fence accuracy of node 3_1 , and node 3_1 learns via the "I-hello message" from node 3_2 that node 3_2 does not possess an adjacent node within its transmission range and is therefore not integrated in an ad-

hoc network. Accordingly, since node 3_1 and node 3_2 provide an identical number of respectively adjacent nodes - namely, precisely one single adjacent node, node 3_1 recognises that node 3_2 has become its local time master, because it was that node, which first transmitted a "hello message". Node 3_1 will synchronise its local time to the local time of node 3_2 acting as its local time master, and in this context, by contrast with the rough synchronisation of node 3_2 , this will achieve an exact synchronisation taking into consideration the transmission time between node 3_1 and node 3_2 .

It is evident from Figure 2 that, within its cyclical time frame, node 3_2 transmits a "hello message" at time (4) immediately after transmitting an "I-hello message". In order to avoid unnecessarily overloading the transmission capacity of the transmission channel by transmitting "hello messages" and "I-hello messages", the transmission of a "hello message", which is conventionally implemented within a fixed time interval after the transmission of an "I-hello message", can be suppressed.

A further "hello message" transmitted within the cyclical time frame ΔT_1 by node 3_1 , in which, by contrast with the first "hello message" of node 3_1 , node 3_2 , which has been identified as the adjacent node $N(2)$, and the reception time $RxTS(2)$ of the "hello message" transmitted by the identified adjacent node 3_2 are transmitted at the local time of node 3_1 , is received by node 3_2 at time (5). From time (5), a symmetrical transmission connection is present between node 3_1 and node 3_2 , since node 3_1 and also node 3_2 have both recognised that a functioning transmission connection exists from node 3_1 to node 3_2 and from node 3_2 to node 3_1 .

A further "hello message" transmitted in the cyclical time frame ΔT_2 by node 3_2 is received at time (6) by node 3_1 . At time (6), a new cyclical synchronisation by node 3_1 of its local time with the local time of node 3_2 acting as the local time master for node 3_1 is implemented.

In the second scenario in Figure 3, a node 3_1 approaches a node 3_2 which is positioned in the transmission range of a node 3_3 and therefore already forms an ad-hoc network with this node 3_3 .

At time (1), node 3_1 , which does not form an ad-hoc network with any other node, transmits a "hello message". This "hello message" is received at time (2) by node 3_2 positioned within the transmission range of node 3_1 . While a symmetrical transmission connection exists for node 3_2 at time (2) relative to node 3_2 because of the common ad-hoc network already existing for a relatively long time, only an asymmetrical transmission connection exists between node 3_2 and node 3_1 because only node 3_2 recognises that a correct transmission from node 3_1 to node 3_2 is realised. At time (2), node 3_3 disposed in the common ad-hoc network is specified by node 3_2 as its local time master.

The "hello message" received by node 3_2 at time (2) is acknowledged by node 3_2 with an "I-hello message", which, alongside the identity of node 3_2 , the time accuracy of the local time of node 3_2 and the MAC address of node 3_2 , contains the adjacent nodes 3_1 and 3_3 known to node 3_2 at time (2) and the reception times $RxTS(1,3)$ of the "hello message" just received from node 3_1 and the last "hello message" received in the cyclical time frame ΔT_3 from node 3_3 .

At time (3), the "I-hello message" of node 3_2 is received by node 3_1 and node 3_3 . At time (3), node 3_1 recognises that node 3_2 has become its local time master, since node 3_1 learns via the "I-hello message" of node 3_2 that node 3_2 is disposed in an ad-hoc network with node 3_3 , and accordingly, node 3_2 provides a larger number of adjacent nodes in its ad-hoc network than node 3_1 . At time (3), the transmission connection between node 3_1 and node 3_2 continues to be asymmetric, because only node 3_1 recognises that the transmission from node 3_1 to node 3_2 and from node 3_2 to node 3_1 is functioning correctly.

At time (4), node 3_2 transmits within its cyclical time frame ΔT_2 a further "hello message", which node 3_1 receives at time (5). Node 3_1 synchronises its local time at time (5) with the local time of its local time master, node 3_2 , from the time information which is contained in the "hello message" of node 3_2 .

Within its cyclical time frame ΔT_3 at time (6), node 3_3 transmits a "hello message" which is received by node 3_2 at time (7). Since node 3_3 represents the local time master of node 3_2 , node 3_2 synchronises its local time with the local time of the node 3_3 in a repeated cyclical manner at time (7) using the time information transmitted in the "hello message" of the node 3_3 .

A "hello message" transmitted by node 3_1 within its cyclical time frame ΔT_1 at time (8) in which the information $N(2)$ about the identified adjacent node 3_2 and the reception time $RxTS(2)$ of the "hello message" transmitted by node 3_2 is contained is received by node 3_2 at time (9). From time (9), a symmetrical transmission connection is present between node 3_1 and node 3_2 , since node 3_1 and also node 3_2 have both recognised the correct

transmission from node 3_1 to node 3_2 and from node 3_2 to node 3_1 .

In the third scenario in Figure 4, a node 3_1 also approaches a node 3_2 which is positioned in the transmission range of a node 3_3 and accordingly forms an ad-hoc network with node 3_3 .

At time (1), node 3_2 transmits within its cyclical time frame ΔT_2 a "hello message" which contains, alongside its identity, the time accuracy of its local time and its MAC address, the information $N(3)$ about the known adjacent node 3_3 and the reception time $RxTS(3)$ of the last received "hello message" of the adjacent node 3_3 . This "hello message" of node 3_2 is received at time (2) by node 3_1 . Since node 3_1 learns in this "hello message" from node 3_2 that node 3_2 forms an ad-hoc network with node 3_3 , node 3_1 will specify its adjacent node 3_2 as its local time master. A synchronisation of the local time of node 3_1 at time (2) with the local time of the adjacent node 3_2 is not yet possible, since a time information for determining the transmission time between node 3_1 and node 3_2 is not yet available.

Node 3_1 will acknowledge the "hello message" of node 3_2 immediately after its reception with an "I-hello message" in which it communicates to node 3_2 its identity, the transmission time TS_1 of the "I-hello message" at the local time of node 3_1 , the identified identity $N(2)$ of the adjacent node 3_2 and the reception time $RxTS(2)$ of the "hello message" of the adjacent node 3_2 . This "I-hello message" of node 3_1 is received by node 3_2 at time (3). The identification of the adjacent node 3_1 upon reception of the "I-hello message" by node 3_2 is acknowledged with a further "I-hello message" of node 3_2 , in which the identified identity $N(1,3)$ of the two adjacent nodes 3_1 and 3_3 and the reception times $RxTS(1,3)$ of the "I-hello message"

received from node 3_1 and the "hello message" received from node 3_3 are contained alongside other information.

This "I-hello message" of node 3_2 is received at time (4) by
 5 node 3_1 which synchronises its local time from the time
 information of this "I-hello message" with the local time of
 node 3_2 acting as the local time master. From time (4), a
 symmetrical transmission connection exists between node 3_1 and
 node 3_2 , since nodes 3_1 and also node 3_2 have both recognised
 10 the correct transmission from node 3_1 to node 3_2 and from node
 3_2 to node 3_1 .

A "hello message" transmitted by node 3_3 at time (5) within its
 cyclical time frame ΔT_3 is received by node 3_2 at time (6) and
 15 used for synchronising the local time of node 3_2 with the local
 time of node 3_3 acting as the associated local time master.
 From time (7), node 3_1 transmits a "hello message", in each
 case, within its cyclical time frame ΔT_1 .

20 In the fourth scenario in Figure 5, a node 3_1 moves from an ad-
 hoc network which originally consists of the nodes 3_1 , 3_2 and
 3_3 .

At time (1), a symmetrical transmission connection exists in
 25 each case between node 3_1 and node 3_2 , also between node 3_2 and
 node 3_3 and also between node 3_1 and node 3_3 , since each of the
 nodes 3_1 , 3_2 and 3_3 has recognised respectively the correctness
 of a bidirectional transmission to each of the other two
 nodes. Node 3_1 represents the local time master for both of the
 30 other nodes 3_2 and 3_3 because it has the lowest MAC address.

At both of the first times (1) and (4) of the cyclical time
 frame ΔT_2 respectively, node 3_2 transmits a "hello message"
 which is received only by node 3_3 , because node 3_1 has moved

out of the transmission range of node 3_2 . At both times (1) and (4), node 3_2 does not yet recognise the removal of node 3_1 from the common ad-hoc network and therefore also transmits the identified identity $N(1,3)$ of the two adjacent nodes 3_1 and 3_3 in the common ad-hoc network and the reception times $RxTS(1,3)$ of the last received "hello messages" of the two adjacent nodes 3_1 and 3_3 in its "hello message", along with other information.

Node 3_3 also does not yet recognises the removal of node 3_1 from the common ad-hoc network at the transmission times (3) and (5) of the "hello message" transmitted in the cyclical time frame ΔT_3 and therefore also transmits the identified identity $N(1,2)$ of the two adjacent nodes 3_1 and 3_2 in the common ad-hoc network and the reception times $RxTS(1,2)$ of the last received "hello messages" of the two adjacent nodes 3_1 and 3_2 in its "hello message" along with other information.

Node 3_2 only recognises the removal of node 3_1 from its transmission range at transmission time (6) and therefore only transmits the identified identity $N(3)$ of the adjacent node 3_3 and the reception time $RxTs(3)$ of the "hello message" last received from node 3_3 in its "hello message" along with other information. The information contained in the "hello message" from node 3_2 that node 3_1 has moved out of the transmission range of node 3_2 is acknowledged by node 3_2 with an "I-hello message" immediately after the reception of the "hello message" from node 3_2 .

At the reception time (7) by node 3_2 of the "I-hello message" transmitted from node 3_3 , node 3_3 becomes the new local time master of node 3_2 . Node 3_2 synchronises its local time at the time (7) with the local time of the node 3_3 using the time information of the "I-hello message" of node 3_3 .

From a given time (8), node 3_3 recognises that node 3_1 has moved out of its transmission range and infers from this that, with immediate effect, it has itself become the local time master for node 3_2 and, accordingly, no longer need synchronise its own local time with the local time of another node of the ad-hoc network.

In the fifth scenario in Figure 6, a node 3_1 moves out of a common ad-hoc network which was originally formed from the nodes 3_1 , 3_2 , 3_3 and 3_4 .

In the configuration of the fifth scenario at time (1), a symmetrical transmission connection of node 3_1 to the two nodes 3_2 and 3_3 exists, a symmetrical transmission connection of node 3_2 to the two nodes 3_1 and 3_3 exists, a symmetrical transmission connection of the node 3_3 to the nodes 3_1 , 3_2 and 3_4 exists, and a symmetrical transmission connection of the node 3_4 to the two nodes 3_1 and 3_2 exists. Node 3_3 acts as the local time master for the nodes 3_1 , 3_2 and 3_4 , since it represents the only node in the common ad-hoc network with the largest number of adjacent nodes.

The removal of node 3_1 out of the transmission range of node 3_2 at the transmission times (2) and (5) of the "hello message" from node 3_2 has not yet been recognised, so that this "hello message" from node 3_2 contains information on all of the adjacent nodes 3_1 and 3_3 of node 3_2 . In an equivalent manner, the removal of node 3_1 from the transmission range of node 3_3 has not yet been recognised at the transmission times (3), and (6) of the "hello message" from node 3_3 , so that the "hello message" from node 3_3 contains the information on all of the adjacent nodes 3_1 , 3_2 and 3_4 of node 3_3 . Finally, the removal of node 3_1 from the transmission range of node 3_4 has not yet been

recognised at transmission times (4) and (7) of the "hello message" from node 3_4 , so that the "hello message" from node 3_4 also contains information about two adjacent nodes 3_1 and 3_3 of the node 3_4 .

5

More or less at the same time as time (8), nodes 3_2 , 3_3 and 3_4 recognise the removal of node 3_1 from their respective transmission ranges and accordingly also from the overall ad-hoc network as a result of the absence of a "hello message"

10 from node 3_1 .

Accordingly, at transmission time (9), the "hello message" from node 3_2 contains only information for the remaining adjacent node 3_3 . Similarly, at transmission time (10), the "hello message" from node 3_3 contains only information for the remaining adjacent nodes 3_2 and 3_4 . Finally, at transmission time (13), the "hello message" from node 3_4 contains only information for the remaining adjacent node 3_3 . An

acknowledgement of the information contained in the "hello message" from node 3_2 that node 3_1 has moved out of the transmission range of node 3_2 , through an immediately transmitted "I-hello message" by node 3_3 , is absent, since node 3_3 transmits a "hello message" comparatively close in time to the transmission time (10) from which it is evident that node 3_1 has also moved out of the transmission range of node 3_3 . For the same reason, node 3_4 does not transmit an acknowledgement by means of an "I-hello message" of the information contained in the "hello message" from node 3_3 that node 3_1 has moved out of the transmission range of node 3_3 .

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Node 3_3 becomes the local time master for nodes 3_2 and 3_4 of the remaining ad-hoc network, since it is the only node in the remaining ad-hoc network with the largest number of adjacent nodes. Accordingly, at the reception time (11) of the "hello

message" of node 3_3 , node 3_2 synchronises its local time with the local time of node 3_3 acting as local time master, while, at the reception time (12) of the "hello message" of the node 3_3 , node 3_4 synchronises its local time in an equivalent manner
 5 with the local time of node 3_3 .

In the sixth scenario in Figure 7, node 3_1 does not move away from all of the other nodes 3_2 , 3_3 and 3_4 of the remaining ad-hoc network at the same time, but moves successively out of
 10 the transmission range of the individual nodes 3_4 , 3_3 and 3_2 .

The original configuration of the sixth scenario corresponds to the original configuration of the fifth scenario. Accordingly, node 3_3 functions as the local time master for
 15 nodes 3_1 , 3_2 and 3_4 , and the existing symmetrical transmission connections between the individual nodes correspond to the symmetrical transmission connections in the fifth scenario. At time (1), node 3_1 moves out of the transmission range of node 3_4 .

20 The successive removal of node 3_1 from the common ad-hoc network is not recognised by the other nodes 3_2 , 3_3 and 3_4 at the initial transmission times of their "hello messages". In each case, at transmission times (2), (8), (14), (22), (29),
 25 (35) and (41), node 3_2 transmits a "hello message" with information about all of its adjacent nodes 3_1 and 3_3 . At transmission times (3), (9), (17) and (23), node 3_3 transmits a "hello message" with information about all of its adjacent nodes 3_1 , 3_2 and 3_3 . At transmission times (7) and (13), node 3_4
 30 transmits a "hello message" with information about all of its adjacent nodes 3_1 and 3_3 . Because of the removal of node 3_1 from the transmission range of node 3_4 , the "hello message" transmitted respectively by node 3_1 and node 3_4 does not reach nodes 3_4 and respectively 3_1 .

Node 3_2 synchronises its local time with the local time of node 3_1 at the reception times (5), (11), (20) and (26) of the "hello message" of node 3_1 using the time information contained
 5 in this "hello message". In an equivalent manner, node 3_3 synchronises its local time with the local time of node 3_1 at the reception times (6) and (12) of the "hello message" of node 3_1 using the time information contained in this "hello message".

10

At time (15), node 3_4 recognises the removal of node 3_1 from its transmission range, because it has recently not received a "hello message" of node 3_1 within a specified time interval and, at the next transmission times (21), (27), (34), (40) and
 15 (45), it transmits a "hello message" which contains only information about its remaining adjacent node 3_3 . For the synchronisation of its local time, it selects node 3_3 positioned within its transmission range to be its local time master and synchronises its local time with the local time of
 20 node 3_3 acting as the local time master at the reception times (18), (24), (32), (39) and (44) of a "hello message" of node 3_3 . At time (16), node 3_1 also moves out of the transmission range of node 3_3 .

25 At the transmission time (19) of a "hello message" to be transmitted in a cyclical manner, node 3_1 recognises that it has not received a "hello message" from node 3_4 since the last reception of a "hello message" from node 3_4 within a given time interval, and has therefore moved out of the transmission
 30 range of node 3_4 . Accordingly, at transmission time (19) node 3_1 transmits a "hello message" which contains only information about the still remaining adjacent nodes 3_2 and 3_3 and only reaches node 3_2 .

Only node 3_2 receives this "hello message" of node 3_1 at the reception time (20) and, on the basis of this "hello message", recognises that node 3_1 has moved out of the transmission range of node 3_4 , but, at this time (20), continues to synchronise
 5 its local time with the local time of node 3_1 acting as its local time master.

At time (28), node 3_3 recognises that node 3_1 has moved out of its transmission range, since it has recently not received a
 10 "hello message" from node 3_1 within a specified time interval (especially the "hello messages" of node 3_1 which node 3_2 received at the reception times (20) and (26)), and, at the next transmission times (31), (37) and (43), transmits a "hello message" which contains only information about the
 15 still remaining adjacent nodes 3_2 and 3_4 . Node 3_3 specifies node 3_2 as its local time master for the synchronisation of its local time, since node 3_2 provides the lowest MAC address of all of the nodes 3_2 , 3_3 and 3_4 still disposed in the remaining ad-hoc network. At the next reception times (30), (36) and
 20 (42) of a "hello message" of node 3_2 , node 3_3 accordingly synchronises its local time with the local time of node 3_2 acting as the local time master.

At time (33), node 3_1 finally also moves out of the
 25 transmission range of node 3_2 . The removal of node 3_1 out of the transmission range of node 3_2 is recognised by node 3_2 at time (46). Node 3_2 remains the local time master of node 3_3 and node 3_4 of the remaining ad-hoc network and need not therefore synchronise its local time to the local time of another node.

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In the seventh scenario in Figure 8, two partial ad-hoc networks comprising the nodes 3_1 , 3_2 , 3_3 and 3_4 on the one hand and the nodes 3_5 , 3_6 , 3_7 and 3_8 on the other hand combine to form a single combined ad-hoc network.

In the original configuration, node 3_1 forms a symmetrical transmission connection with node 3_2 , while node 3_2 additionally forms a symmetrical transmission connection with node 3_3 , which in turn forms a symmetrical transmission connection with node 3_4 . Node 3_1 acts as local time master for node 3_2 while node 3_3 acts as local time master for node 3_2 , and node 3_4 acts as local time master for node 3_3 . In an equivalent manner, node 3_5 forms a symmetrical transmission connection with node 3_6 , while node 3_6 additionally forms a symmetrical transmission connection with node 3_7 , which in turn forms a symmetrical transmission connection with node 3_8 . Node 3_5 acts as local time master for node 3_6 , while node 3_7 acts as local time master for node 3_6 , and node 3_8 acts as local time master for node 3_7 .

The individual nodes i each transmit a "hello message" to their respective adjacent nodes within their respective cyclical time frame ΔT_i . At time (1), node 3_1 transmits a "hello message" with information about its identified adjacent node 3_2 . At transmission time (2), node 3_5 transmits a "hello message" with information about its identified adjacent node 3_6 . At time (3), node 3_2 transmits a "hello message" with information about its identified adjacent nodes 3_1 and 3_3 . At time (4), node 3_6 transmits a "hello message" with information about its identified adjacent nodes 3_5 and 3_7 . At time (5), node 3_3 transmits a "hello message" with information about its identified adjacent nodes 3_2 and 3_4 . At time (7), node 3_7 transmits a "hello message" with information about its identified adjacent nodes 3_6 and 3_8 . At time (4), node 3_4 transmits a "hello message" with information about its identified adjacent node 3_3 . At time (8), node 3_8 transmits a "hello message" with information about its identified adjacent node 3_7 .

At a later time (9), node 3_4 once again transmits a "hello message" with information $N(3)$ about its identified adjacent node 3_3 which is received not only by the adjacent node 3_3 , but
 5 also, at time (10), by node 3_5 of the respectively other partial ad-hoc network, which is disposed within the transmission range of node 3_4 . Since, at the first moment, node 3_4 is an alien node for node 3_5 , it acknowledges the reception of the "hello message" from node 3_4 at time (11) with an "I-
 10 hello message" with information $N(4,6)$ about its identified adjacent nodes 3_4 and 3_6 which is received by node 3_4 at time (12). Since, at the first moment, node 3_5 is also an alien node for node 3_4 , node 3_4 will transmit an "I-hello message" with information $N(3,5)$ about its identified adjacent nodes 3_3 and
 15 3_5 immediately after the reception of the "I-hello message" from node 3_5 at time (13).

Since one of the nodes 3_1 , 3_2 , 3_3 and 3_4 of the ad-hoc network shown on the left in Figure 8 provides the lowest MAC address
 20 of all of the nodes 3_1 , 3_2 , 3_3 , 3_4 , 3_5 , 3_6 , 3_7 and 3_8 to be integrated in future in a single ad-hoc network, node 3_4 is specified as the local time master not only by node 3_3 of the ad-hoc network shown on the left in Figure 8, but also by node 3_5 of the ad-hoc network shown on the right in Figure 8. At the
 25 reception time (14) of the "I-hello message" from node 3_4 by node 3_5 , a symmetrical transmission connection exists between node 3_4 and node 3_5 , since both nodes 3_4 and 3_5 have each recognised at this time (14) that a correct transmission from node 3_4 to node 3_5 and from node 3_5 to node 3_4 exists. At the
 30 reception time (14) of the "I-hello message" of node 3_4 by node 3_5 , node 3_5 synchronises its local time with the local time of node 3_4 acting as the local time master from the time information transmitted in the "I-hello message".

Using the time information in the "hello message" transmitted from node 3_5 at time (15), which node 3_6 receives at time (16), node 3_6 synchronises its local time with the local time of node 3_5 acting as its local time master. In an equivalent manner,
 5 node 3_7 synchronises its local time with the local time of node 3_6 acting as its local time master using the time information in the "hello message" transmitted by node 3_6 at time (17), which node 3_7 receives at time (18). Node 3_8 also synchronises its local time with the local time of node 3_7 acting as its
 10 local time master using the time information from the "hello message" transmitted by node 3_7 at time (19), which node 3_8 receives at time (20).

Finally, it should be mentioned that the local time of every
 15 node inside or outside an ad-hoc network provides a certain time inaccuracy because of a clock drift of the clock generator implemented in every node to generate the local time. The characteristic of the time inaccuracy of the local time realised in a node is shown in Figure 9 in each case for
 20 four nodes. These four nodes each synchronise their local time in a serial manner with an adjacent node acting as local time master. Node 2 synchronises its local time with the local time of node 1; node 3 synchronises its local time with the local time of node 2 and so on. From the synchronisation time at
 25 which the time inaccuracy of the respective local time is minimal, the time inaccuracy of the respective local time rises in a linear manner until it is synchronised again.

Through a reduction of the synchronisation interval by
 30 reducing the cyclical time frame in which a "hello message" is transmitted respectively from each node acting as local time master, a minimisation of the time inaccuracy of the local time realised in a node can be realised, as is evident from Figure 9. By preference, the time at which a "hello message"

for time synchronisation is transmitted by the respective local time master is calculated in advance in order to maintain a maximum permitted time inaccuracy in the node to be synchronised.

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The invention is not restricted to the embodiment and the scenarios presented. All combinations of any of the features claimed in the claims, any of the features disclosed in the description and any of the features illustrated in the figures
10 of the drawings are also covered by the invention.

Claims

1. A method for time synchronisation in a mobile ad-hoc network with the following method steps:
 - 5 - transmission by every node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) of the mobile ad-hoc network of a message signalling a presence (1), in each case within a given time frame,
 - acknowledgement by every node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) disposed within the transmission range of the
10 transmitting node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) of the received message signalling a presence (1), in each case with an acknowledgement message (2),
 - specification of that node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) of two nodes ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) disposed within
15 the transmission range of one another with the local time of which the respectively other node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) synchronises its local time, on the basis of information in an acknowledgement message (2) which is received by one of the two nodes ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) and
20
 - synchronisation of the local time of the nodes ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) with the local time of the respective specified node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$).
- 25 2. The method according to claim 1,
characterised in that,
of the two nodes ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) disposed within the transmission range of one another, that node
($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) is specified, of which the
30 local time provides the maximum time accuracy or which is integrated in another ad-hoc network with a node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) of which the local time provides the maximum time accuracy.

3. The method according to claim 1 or 2,
characterised in that,

in the case of an ad-hoc network formed from only two nodes (3_1 , 3_2) of which the local times provide an identical time accuracy, that node (3_1 , 3_2) is specified which first transmits an acknowledgement message (2) to a message signalling a presence (1) of the two nodes (3_1 , 3_2).

4. The method according to any one of claims 1 to 3,
characterised in that,

in the case of an identical time accuracy of all of the nodes (3_1 , 3_2 , 3_3 , 3_4 , 3_5 , 3_6 , 3_7 , 3_8) integrated in the ad-hoc network to be formed, that node of the two nodes (3_1 , 3_2 , 3_3 , 3_4 , 3_5 , 3_6 , 3_7 , 3_8) disposed within the transmission range of one another is specified which already forms an ad-hoc network with a relatively larger number of nodes (3_1 , 3_2 , 3_3 , 3_4 , 3_5 , 3_6 , 3_7 , 3_8).

5. The method according to any one of claims 1 to 4,
characterised in that,

in the case of an identical time accuracy of all of the nodes (3_1 , 3_2 , 3_3 , 3_4 , 3_5 , 3_6 , 3_7 , 3_8) integrated in the ad-hoc network to be formed and with an identical number of nodes (3_1 , 3_2 , 3_3 , 3_4 , 3_5 , 3_6 , 3_7 , 3_8) with which the two nodes disposed within the transmission range of one another each form an ad-hoc network, that node (3_1 , 3_2 , 3_3 , 3_4 , 3_5 , 3_6 , 3_7 , 3_8) is specified of which the ad-hoc network provides a relatively lower identity code.

6. The method according to claim 5,
characterised in that

the identity code of the ad-hoc network is the Medium-Access-Control address of the ad-hoc network.

7. The method according to any one of claims 1 to 6,
characterised in that,

in the case of an ad-hoc network from which at least one
node (3_1) is removed, that node ($3_2, 3_3, 3_4$) of the
remaining ad-hoc network which provides the local time
with the maximum time accuracy is specified, with the
local time of which the remaining nodes ($3_2, 3_3, 3_4$) of the
ad-hoc network each synchronise their local time.

8. The method for time synchronisation according to claim 7,
characterised in that,

in the case of an ad-hoc network from which at least one
node (3_1) is removed and in the case of an identical time
accuracy of the local times of the nodes ($3_2, 3_3, 3_4$) of
the remaining ad-hoc network, that node ($3_2, 3_3, 3_4$) of the
remaining ad-hoc network is specified which provides the
maximum number of directly adjacent nodes ($3_2, 3_3, 3_4$).

9. The method according to claim 7 or 8,
characterised in that,

in the case of an ad-hoc network from which at least one
node (3_1) is removed and in the case of an identical time
accuracy of the local times of the nodes ($3_2, 3_3, 3_4$) of
the remaining ad-hoc network and in the case of an
identical number of respectively directly adjacent nodes
($3_2, 3_3, 3_4$) for each node ($3_2, 3_3, 3_4$) of the remaining ad-
hoc network, that node ($3_2, 3_3, 3_4$) of the remaining ad-hoc
network is specified which provides the lowest identity
code.

10. The method according to any one of claims 1 to 6,
characterised in that

a node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ of an ad-hoc network from which a node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$, with the local time of which the node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ of the ad-hoc network previously synchronised its local time, is removed, specifies another node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ of the remaining ad-hoc network disposed within its transmission range, with the local time of which it synchronises its local time.

10 11. The method according to any one of claims 1 to 10,

characterised in that

the synchronisation of the local time of the nodes $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ which each form an ad-hoc network with one of the two nodes $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ disposed within the transmission range of one another is realised at the local time of the specified node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$, in that every node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ of the respective ad-hoc network specifies a directly adjacent node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ of the ad-hoc network as the node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ with the local time of which it synchronises its local time.

12. The method according to any one of claims 1 to 11,

characterised in that

the synchronisation of the local time of a node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ with the local time of the specified node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ is implemented in that the specified node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ communicates to the node the reception time of the message transmitted from the node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ in order to update a presence (1) or an acknowledgement message (2) at the local time of the specified node $(3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8)$ and the transmission time of a

message transmitted to the node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈) in order to signal a presence (1) or an acknowledgement message (2).

5 13. The method according to claim 12,

characterised in that

the synchronisation of the local time of a node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈) with the local time of the specified node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈) takes place with every
10 reception of a message signalling a presence (1) or an acknowledgement message (2) of the specified node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈).

14. The method according to any one of claims 7 to 9,

15 **characterised in that**

the removal of a node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈) from an ad-hoc network is identified if no further message signalling a presence (1) of the moving node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈) has been received from any of the other
20 nodes (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈) of the remaining ad-hoc network since the last reception time of a message signalling a presence (1) of the moving node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈) within a constant time frame in which, respectively, a message signalling a presence (1) is
25 transmitted.

15. The method according to any one of claims 1 to 14,

characterised in that

a constant time frame in which the node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈) transmits a message updating a presence (1) is
30 minimised in order to reduce the influence of a clock-pulse drift on the time accuracy of the local time of a node (3₁, 3₂, 3₃, 3₄, 3₅, 3₆, 3₇, 3₈).

16. The method according to claim 15,

characterised in that

the node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) calculates the transmission time of the message updating a presence (1) in order to limit the influence of the clock-pulse drift on the time accuracy of the local time of the node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$).

17. A system for time synchronisation within a mobile ad-hoc

network comprising several nodes ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) each transmitting a message signalling a presence (1), in each case within a given time frame, whereas an acknowledgement of the message signalling a presence (1) is implemented by means of an acknowledgement message (2) by every node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) disposed within the transmission range of the node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) transmitting a message signalling a presence (1), whereas, in each case from two nodes ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) disposed within the transmission range of one another, a node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) is specified with the local time of which the local time of the respectively other node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) is synchronised, whereas the specification of the node ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) is implemented on the basis of information in the acknowledgement message (2) received from one of the two nodes ($3_1, 3_2, 3_3, 3_4, 3_5, 3_6, 3_7, 3_8$) disposed within the transmission range of one another.