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(54) **Title:** METHOD AND SYSTEM FOR DETERMINING A SPATIAL TOPOLOGY OF A WIRELESS CONFERENCING NETWORK

Figure 2

(57) **Abstract:** The invention pertains to a method for determining a spatial topology of a wireless network comprising a plurality of conference termin-als, the method comprising: obtaining a plurality of values indicative of a dis-tance or an angle between pairs of conference terminals from among said plurality of conference terminals, said plurality of values being obtained by analyzing signals exchanged between members of said respective pairs of conference terminals; combining said plurality of values to determine relative positions of said plurality of conference terminals, said relative positions forming said spatial topology. The invention also pertains to a corresponding computer program product and a corresponding system.

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Method and system for determining a spatial topology of a wireless conferencing network

Field of the Invention

5

The present invention pertains to the field of wireless networks, in particular wireless conferencing systems.

Background

10

In conferencing systems, conference terminals (or "delegate units") allow individual delegates to transmit and receive audio and optionally video, in particular delegates' speech and/or translations thereof, and data to and from each other, optionally

15   via one or more centralized servers or access points.

In wireless conferencing systems, a relatively large number of conference terminals must be able to communicate with each other and/or with an access point via radio waves in a limited space.

20

A wireless conferencing system of this type is described in unpublished European patent application no. 15160935.1, filed on 25 March 2015, in the name of the present applicant.

25   When the terminals are connected by means of a wireless network, they are easily moved around from time to time, which may make it difficult for an operator such as the chairperson or the conference organizer to keep track of which terminal is being used by which delegate. Hence, there is a need for a method or a system

30   that facilitates tracking of movable wireless conference terminals.

It is an object of embodiments of the present invention to facilitate location tracking of movable wireless conference

35   terminals.

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Summary of the invention

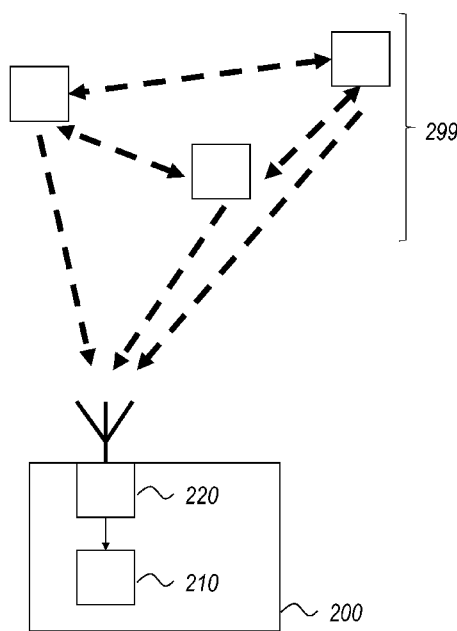According to an aspect of the present invention, there is provided a method for determining a spatial topology of a wireless network comprising a plurality of conference terminals, the method comprising: obtaining a plurality of values indicative of a distance or an angle between pairs of conference terminals from among the plurality of conference terminals, the plurality of values being obtained by analyzing signals exchanged between members of the respective pairs of conference terminals; combining the plurality of values to determine relative positions of the plurality of conference terminals, the relative positions forming the spatial topology. At least one of the values is indicative of an angle between a pair of conference terminals, the angle being determined by operating a first one of the pair of conference terminals in an omnidirectional mode and a second one of the pair of conference terminals in a directional mode and attempting to exchange signals while the transceiver of the second conference terminal is operated so as to vary a direction of operation.

It is an advantage of the present invention that it generates a spatial topology of the conference terminals, i.e. a map showing where each conference terminal is physically located, with a minimum of signal exchanges and without human intervention. The topology information obtained in this manner may be used to facilitate equipment tracking and configuration, increase security, improve the user interface of the chairperson's or the administrator's unit, and generally conduct meetings more efficiently.

The "directional mode" may be a beam-forming mode or a mode using a sectorial antenna to substantially direct the power at the output of the antenna in a particular direction.

It is a further advantage of the invention, that it facilitates the generation of a topologically accurate map, because the topological information based on the inter-terminal distances

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(typically attenuation or time based) can be complemented with
information about relative angles of arrival.

In an embodiment, the method according to the present invention
further comprises displaying a graphical representation of the
spatial topology as a map in a graphical user interface.

It is an advantage of this embodiment that a user, typically a
chairperson or a system administrator, can refer to a visual
representation of the conference floor, showing the terminals in
their true (relative) physical positions, and select individual
terminals on which management tasks must be performed (e.g.,
muting a microphone, starting a recording function, sending a
signal, etc.) on the basis of this visual representation. In this
way, the selection of the appropriate terminal is rendered more
intuitive, and mistakes can be reduced.

In a particular embodiment, the obtaining and the combining are
performed periodically, and the displayed graphical representation
is updated when the relative positions have changed.

It is an advantage of this embodiment that the graphical
representation of the topology remains up to date, even as
terminals are being moved around during the conference.

In an embodiment, the method according to the present invention
further comprises using the spatial topology to determine a
spanning tree for relaying messages within the wireless network.

Spanning tree protocols are used in networks that rely on the
relaying (bridging) of messages to avoid forwarding loops. In
mesh-type networks, each network end point is potentially a
forwarding point (bridge), and must be involved in the
determination of the spanning tree. It is an advantage of mesh
networks with a spanning tree that they provide a logical network
topology in which every conference terminal is able to communicate
with every other conference terminal, either directly or through

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other conference terminals, without having any loops in the network. The various paths (or directions) that may be available for transmission between a conference terminal and its peers are treated as different links for the purpose of the spanning tree

5   protocol, each of which is assigned a different cost or weight. Depending on the application, this cost or weight may take into account signal-to-noise ratio, available bitrate, bit error rate, latency, link stability, and similar metrics. It is an advantage of this embodiment of the invention, that spatial topology

10   information is taken into account to determine a candidate spanning tree. This embodiment is based on the insight that the metrics of interest, such as signal-to-noise ratio, available bitrate, bit error rate, latency, and link stability, all tend to be distance-dependent, such that a distance between terminals

15   obtained from the topology information may be considered a good predictor of the relevant link metrics.

In an embodiment of the method according to the present invention, the conference terminals exchange the signals in an ISM band

20   between 57 GHz and 66 GHz.

It is an advantage of this embodiment that it allows highly directional beam forming. It is a further advantage of this embodiment that it allows beams to bounce off walls, ceilings, or

25   objects, thus increasing the chances of finding a path for direct wireless exchange between any two given locations in an indoor environment. It is a further advantage of this embodiment that it substantially confines the wireless transmissions to the indoor environment, which is a privacy benefit, as radio waves in this

30   frequency range do not significantly traverse walls or structural elements. It is a further advantage of this embodiment that it uses an unlicensed band.

In a particular embodiment, at least one conference terminal from

35   among the plurality of conference terminals comprises means to determine an absolute orientation, and wherein information pertaining to the absolute orientation is used in the combining to

determine absolute positions of the plurality of conference
terminals.

It is an advantage of this particular embodiment that the topology
information, which would otherwise retain one unresolved degree of
freedom (the overall orientation of the map), can be fixed in a
correct absolute orientation.

In an embodiment, the method according to the present invention
further comprises verifying whether each conference terminal from
among the plurality of conference terminals meets a predetermined
topological constraint, and generating an alarm signal if the
verifying reveals that at least one conference terminal does not
meet the topological constraint.

It is an advantage of this embodiment that the unauthorized
removal of a conference terminal from the premises (theft), or the
unauthorized use of a conference terminal outside the conference
perimeter (eavesdropping) can be detected, allowing the conference
organizers to take an appropriate measure.

In a particular embodiment, the method further comprises disabling
the conference terminal that does not meet the topological
constraint.

This is a particularly appropriate measure in response to the
detection of an unauthorized conference terminal outside the
conference perimeter, i.e. a suspected eavesdropper.

According to an aspect of the present invention, there is provided
a computer program product comprising code means configured to
cause a processor to carry out the steps of the method described
above.

According to an aspect of the present invention, there is provided
a system for determining a spatial topology of a wireless network
comprising a plurality of conference terminals, the system

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comprising an interface for obtaining data from the plurality of
conference terminals and a processor operatively connected to the
interface, the processor being configured to carry out the steps
of the method described above using values obtained through the
5   interface.

The technical effects and advantages of the embodiments of the
computer program product and the system according to the present
invention correspond *mutatis mutandis* to those of the
10   corresponding embodiments of the method according to the present
invention.

Brief Description of the Figures

15   These and other technical effects and advantages of embodiments of
the present invention will now be further described with reference
to the accompanying drawings, in which:

- Figure 1 provides a flow chart of a method according to an
20   embodiment of the present invention; and

- Figure 2 provides diagrams of a system according to an
embodiment of the present invention.

25   **Description of Embodiments**

Figure 1 presents a flow chart of an embodiment of the method
according to the present invention. The method may be carried out
by a centralized computer, a chairperson's unit, an
30   administrator's unit, a designated conference terminal, or the
like; hereinafter, the entity performing the method will be
referred to as the processing system, without loss of generality.
The method comprises obtaining **100** a plurality of values
indicative of a distance or an angle between pairs of conference
35   terminals from among the plurality of conference terminals. These
values are obtained by analyzing signals exchanged between members
of the respective pairs of conference terminals. It is known that

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the delay and attenuation of signals transmitted through free space are distance-dependent, and this distance-dependence may advantageously be used to estimate the distance between two terminals. This estimation can be performed by (one of) the
5   terminals participating in the exchange, and the estimate can be forwarded to the processing system, or the raw signal parameters can be forwarded to the processing system for estimation of the distance. In systems that have a way to transmit and/or receive signals in a strongly directional manner (this may be the case
10   when using sectorial antennae, MIMO transmitters, short-wavelength communications, etc.), information about the angles under which signals could be exchanged between specific pairs of terminals may be shared with the processing system in the same manner.

15   The obtained values are combined **110** to determine relative positions of the plurality of conference terminals, the relative positions forming the spatial topology. The combination of distances and angles into a topological map is done on the basis of the basic rules of trigonometry, which are known to the person
20   skilled in the art. Advantageously, the calculation may take into account the assumption that all conference terminals are substantially located in a common horizontal plane, such that the problem of reconstructing the topological map is substantially a two-dimensional problem.
25

A graphical representation of the spatial topology may be displayed **120** as a map in a graphical user interface. This graphical user interface may be part of a chairman's unit or an administrator's unit. Preferably, the map is shown in overlay on a
30   photograph or video image of the conference room (after an appropriate perspective transformation), to make it intuitively clear to the user which delegate is associated with which terminal. This greatly facilitates the remote operation of the terminals by the chairperson or administrator.
35

As indicated by the arrows returning to step **100** in the illustrated flow chart, the obtaining **100** and the combining **120**

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are preferably performed periodically, and the optional displayed
graphical representation **120** is updated when the relative
positions have changed.

5   In a particularly advantageous embodiment, the conference
terminals exchange the signals in an ISM band between 57 GHz and
66 GHz, which allows highly directional operation, and thus allows
the retrieval of angular information. When at least one of the
values to be used in the combining step **110** is indicative of an

10   angle between a pair of conference terminals, the angle may be
determined by operating a first one of the pair of conference
terminals in an omnidirectional mode and a second one of the pair
of conference terminals in a directional mode and attempting to
exchange signals while the transceiver of the second conference

15   terminal is operated so as to vary a direction of operation. Thus,
one terminal of the pair performs an angular sweep of the room to
find out at which angles communication with another terminal is
possible; this procedure results in the detection of the angle
under which the other terminal can be "seen".

20

Preferably, at least one conference terminal from among the
plurality of conference terminals comprises means to determine an
absolute orientation, such as an integrated compass, and
information pertaining to the absolute orientation is used in the

25   combining step **100** to determine absolute positions of the
plurality of conference terminals. A single measurement of
absolute direction can indeed suffice to remove the remaining
degree of freedom that would otherwise remain in the topological
information.

30

For security reasons, the method may further comprise verifying
130 whether each conference terminal meets a predetermined
topological constraint, such as being within a certain distance
from the chairperson's unit, being within a predefined perimeter,

35   and the like. An alarm signal may be generated (not shown in the
flow chart) if the verifying reveals that at least one conference

terminal does not meet the topological constraint. The offending
terminal may subsequently be disabled **140.**

The present invention also relates to a computer program product
5   comprising code means configured to cause a processor to carry out
the steps of the method described above. The computer program
product may consist of the code means as provided on a computer-
readable medium, including but not limited to magnetic, optical,
or solid-state storage media.
10

The present invention also relates to a system for determining a
spatial topology of a wireless network comprising a plurality of
conference terminals, an exemplary embodiment of which is
illustrated in Figure 2. Such a system **200** may be integrated with
15   a centralized computer, a chairperson's unit, an administrator's
unit, a designated conference terminal, or the like, or it may be
implemented as a stand-alone unit. The system comprises an
interface **210** for obtaining data from the plurality of conference
terminals **299** and a processor **220** operatively connected to the
20   interface, the processor being configured to carry out the steps
of the method described above using values obtained through the
interface. All the optional features and details described above
with reference to the method according to the invention, apply
with the same effect to embodiments of the system according to the
25   invention. The processor **220** may be implemented in dedicated
hardware (e.g., ASIC), configurable hardware (e.g., FPGA),
programmable components (e.g., a DSP or general purpose processor
with appropriate software), or any combination thereof. The same
component(s) may also include other functions.
30

While the invention has been described hereinabove with respect to
some specific examples, this was done to illustrate and not to
limit the invention, the scope of which is defined by the attached
claims. The skilled person will understand that any features and
35   advantages described in connection with the method of the present
invention may also be applied to the system of the present
invention, and vice versa.

Claims

1. A method for determining a spatial topology of a wireless
network comprising a plurality of conference terminals, the method
comprising:
- obtaining (100) a plurality of values indicative of a distance
or an angle between pairs of conference terminals from among said
plurality of conference terminals, said plurality of values being
obtained by analyzing signals exchanged between members of said
respective pairs of conference terminals;
- combining (110) said plurality of values to determine relative
positions of said plurality of conference terminals, said relative
positions forming said spatial topology;
wherein at least one of said values is indicative of an angle
between a pair of conference terminals, said angle being
determined by operating a first one of said pair of conference
terminals in an omnidirectional mode and a second one of said pair
of conference terminals in a directional mode and attempting to
exchange signals while said transceiver of said second conference
terminal is operated so as to vary a direction of operation.

2. The method according to claim 1, further comprising:
- displaying a graphical representation of said spatial topology
as a map in a graphical user interface.

3. The method according to claim 2, wherein said obtaining (100)
and said combining (110) are performed periodically, and wherein
said displayed graphical representation is updated (120) when said
relative positions have changed.

4. The method according to any of the preceding claims, further
comprising:
- using said spatial topology to determine a spanning tree for
relaying messages within said wireless network.

5. The method according to any of the preceding claims, wherein said conference terminals exchange said signals in an ISM band between 57 GHz and 66 GHz.

5   6. The method according to any of the preceding claims, wherein at least one conference terminal from among said plurality of conference terminals comprises means to determine an absolute orientation, and wherein information pertaining to said absolute orientation is used in said combining to determine absolute
10   positions of said plurality of conference terminals.

7. The method according to any of the preceding claims, further comprising verifying (130) whether each conference terminal from among said plurality of conference terminals meets a predetermined
15   topological constraint, and generating an alarm signal if said verifying reveals that at least one conference terminal does not meet said topological constraint.

8. The method according to claim 7, further comprising disabling
20   (140) said conference terminal that does not meet said topological constraint.

9. A computer program product comprising code means configured to cause a processor to carry out the steps of the method according
25   to any of claims 1-8.

10. A system for determining a spatial topology of a wireless network comprising a plurality of conference terminals, the system comprising an interface for obtaining data from said plurality of
30   conference terminals and a processor operatively connected to said interface, the processor being configured to carry out the steps of the method according to any of claims 1-8 using values obtained through said interface.
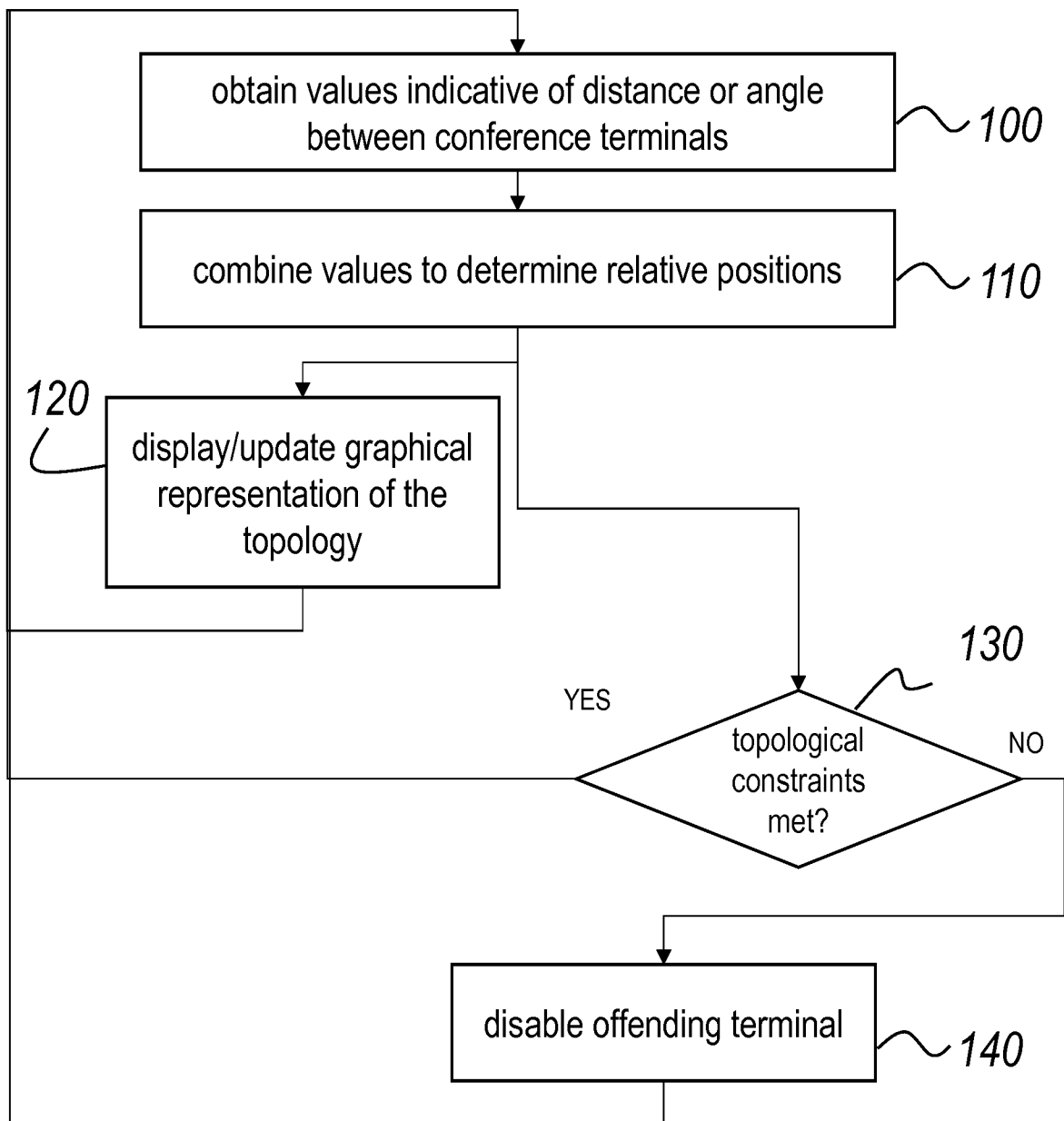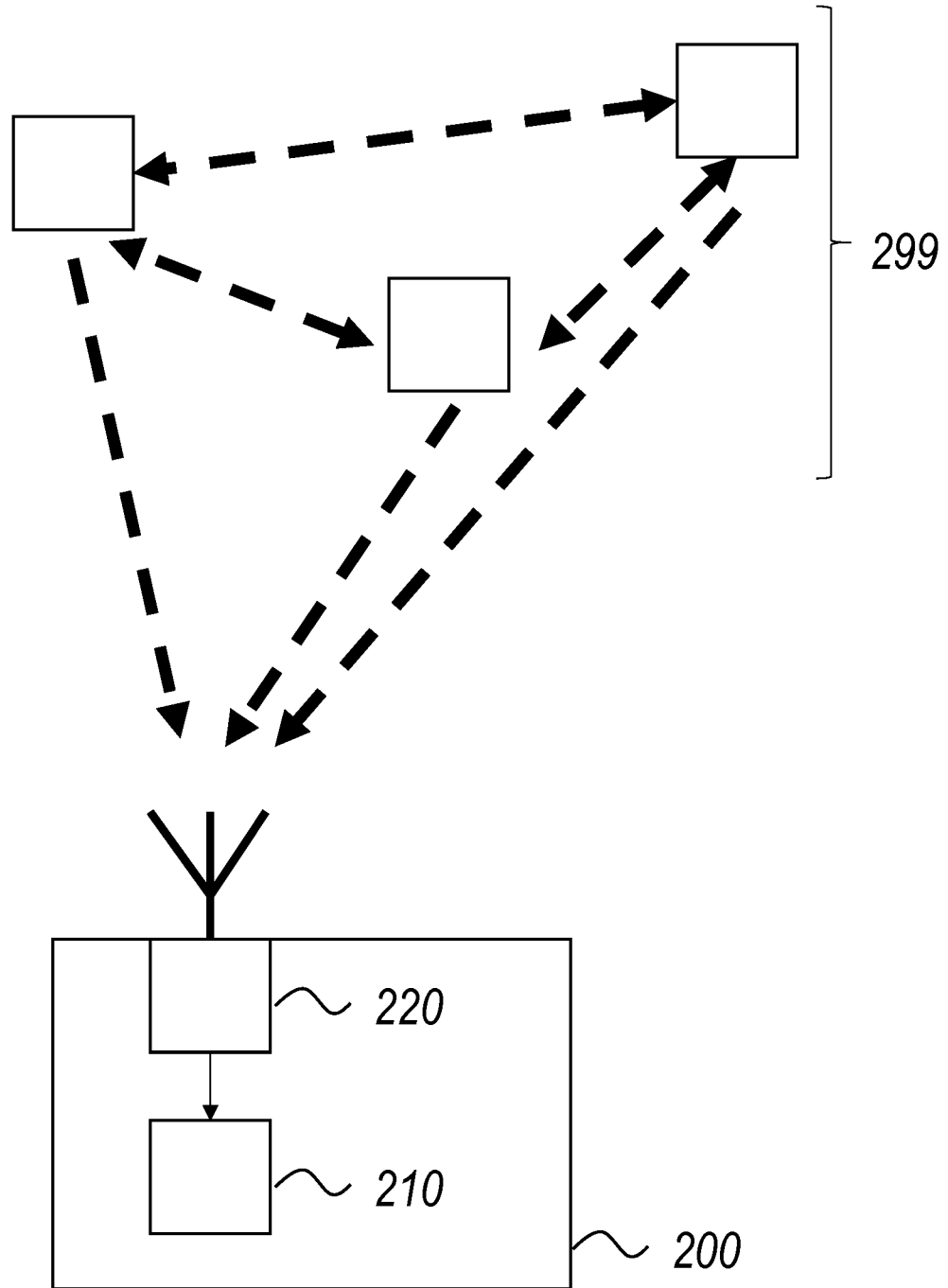
1/2

```
         ┌──────────────────────────────────────┐
         │  obtain values indicative of distance │
         │  or angle between conference terminals │ ⟋ 100
         └──────────────────────────────────────┘
                          │
         ┌──────────────────────────────────────┐
         │  combine values to determine relative │ ⟋ 110
         │  positions                            │
         └──────────────────────────────────────┘
```

120

display/update graphical representation of the topology

130

YES   topological constraints met?   NO

disable offending terminal   ⟋ 140

Figure 1

2/2

Figure 2

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W64/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W G01S H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/082341 A1 (STANFORTH PETER J [US]) 29 April 2004 (2004-04-29) paragraphs [0016] - [0021], [0043]; figure 5 -----	1-10
Y	US 2005/032531 A1 (GONG YI [CN] ET AL) 10 February 2005 (2005-02-10) paragraphs [0036], [0039], [0051] -----	1-10
A	EP 1 039 689 A2 (ROCKWELL SCIENCE CENTER LLC [US]) 27 September 2000 (2000-09-27) paragraphs [0019], [0021], [0038], [0064]; figure 7 -----	1-10
A	US 9 007 416 B1 (MURGIA CARLO [US] ET AL) 14 April 2015 (2015-04-14) column 1, line 50 - line 63 column 8, line 28 - line 63 -----	1-10

-/--

| X | Further documents are listed in the continuation of Box C. | X | See patent family annex. |

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 April 2017	28/04/2017

| Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016 | Authorized officer Dionisi, M |

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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1

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