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(56) Documents Cited:
EP 2523013 A1
US 20230121104 A1
US 20220065979 A1
US 20220046386 A1
US 20210099832 A1

(58) Field of Search:
INT CL **G01S, H04W**
Other: **WPI, EPODOC, Patent Fulltext, XP3GPP**

(54) Title of the Invention: **Method, apparatus and computer program**
Abstract Title: **Determining position information of a second user device by duplicating the measurements for a first co-located user device**

(57) Apparatus comprising means for receiving capability information from user devices (UEs). The apparatus further comprising means for determining position information of a first UE based on measurement information of the UE and means for determining position information of a second UE by duplicating the measurement information of the first device. The second device is co-located with the first UE. The capability information may be indicative of support for measurement aggregation. The device may comprise means for transmitting a positioning measurement request message based on the capability information and means for receiving measurement information from the first user device. The capability information may include information related to battery level, processor capability, memory capability. Determining whether the devices are co-located may be based on sidelink communication. The method disclosed may improve the positioning measurement overhead. E.g. this may reduce signalling associated with positioning. Positioning measurements are requested only from a sub-set of co-located UEs, the rest of the co-located UEs do not measure or report any position measurements. The position of the remaining UEs can then be duplicated from the position estimated for the UE in the sub-set.

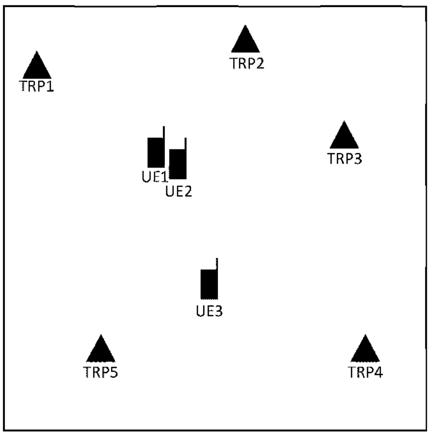


Fig. 3

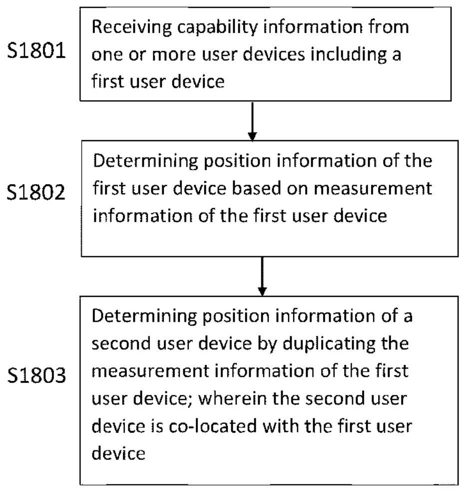


Fig. 18

GB 2624027 A

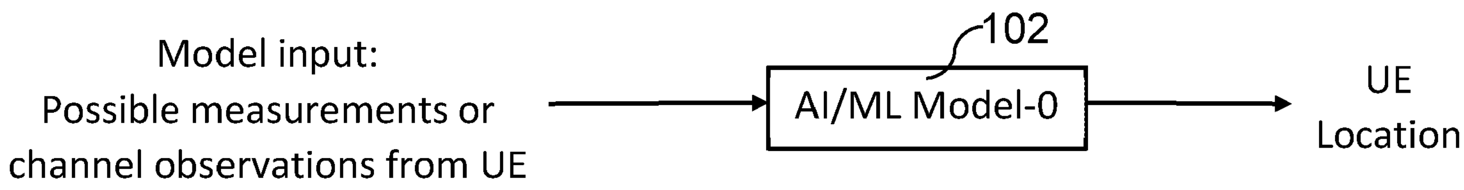

Model input:
Possible measurements or
channel observations from UE
102
AI/ML Model-0
UE
Location

Fig. 1

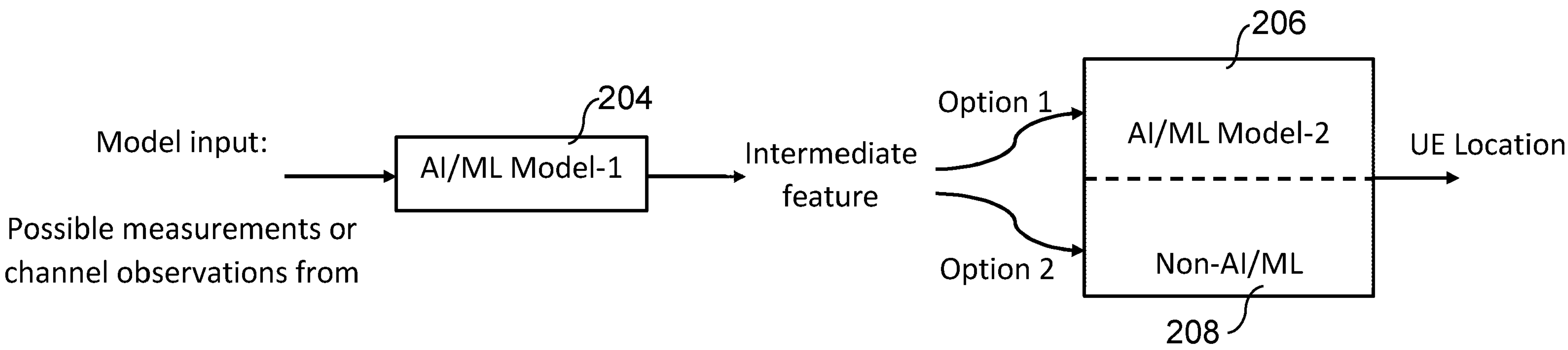

Model input:
Possible measurements or
channel observations from
204
AI/ML Model-1
Intermediate
feature
Option 1
Option 2
206
AI/ML Model-2
Non-AI/ML
208
UE Location

Fig. 2

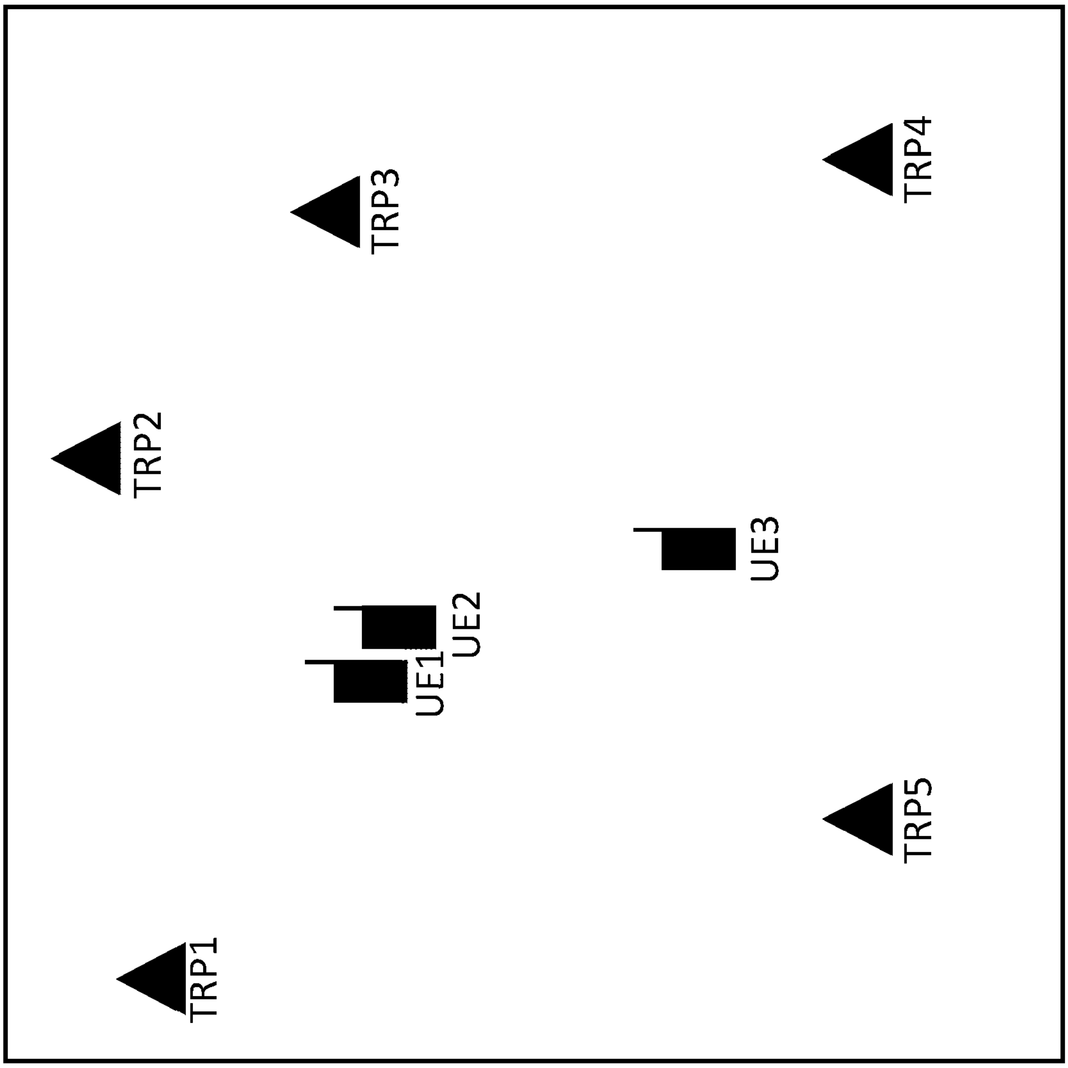


Fig. 3

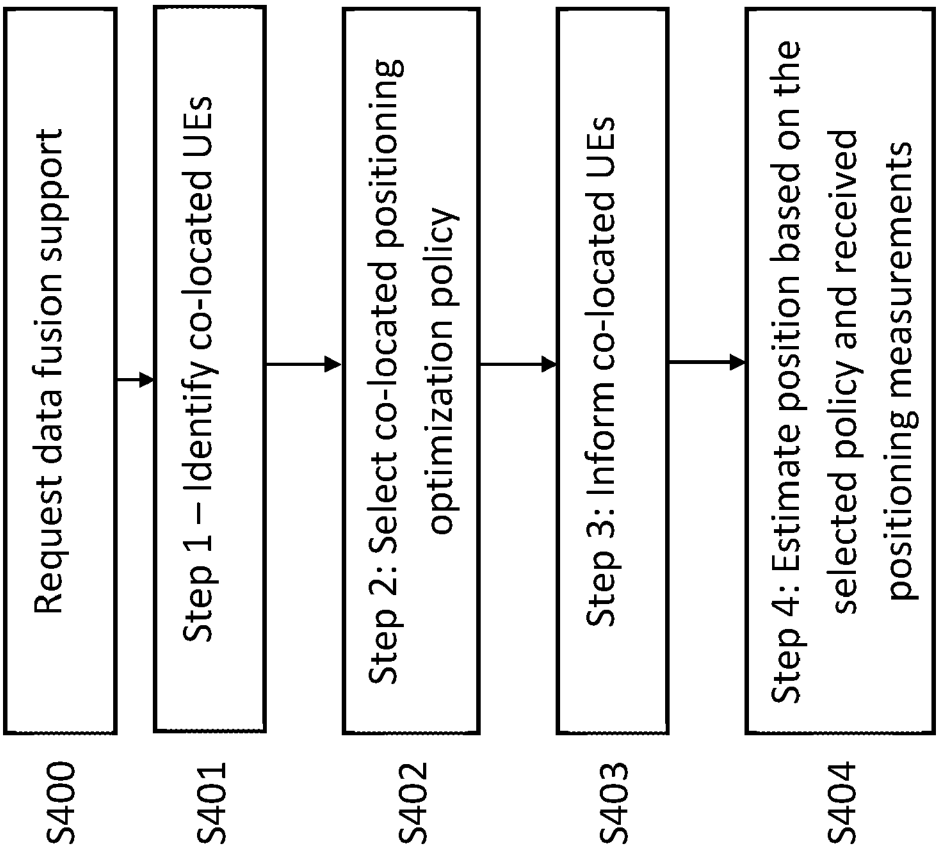

S400
Request data fusion support
S401
Step 1 – Identify co-located UEs
S402
Step 2: Select co-located positioning optimization policy
S403
Step 3: Inform co-located UEs
S404
Step 4: Estimate position based on the selected policy and received positioning measurements

Fig. 4

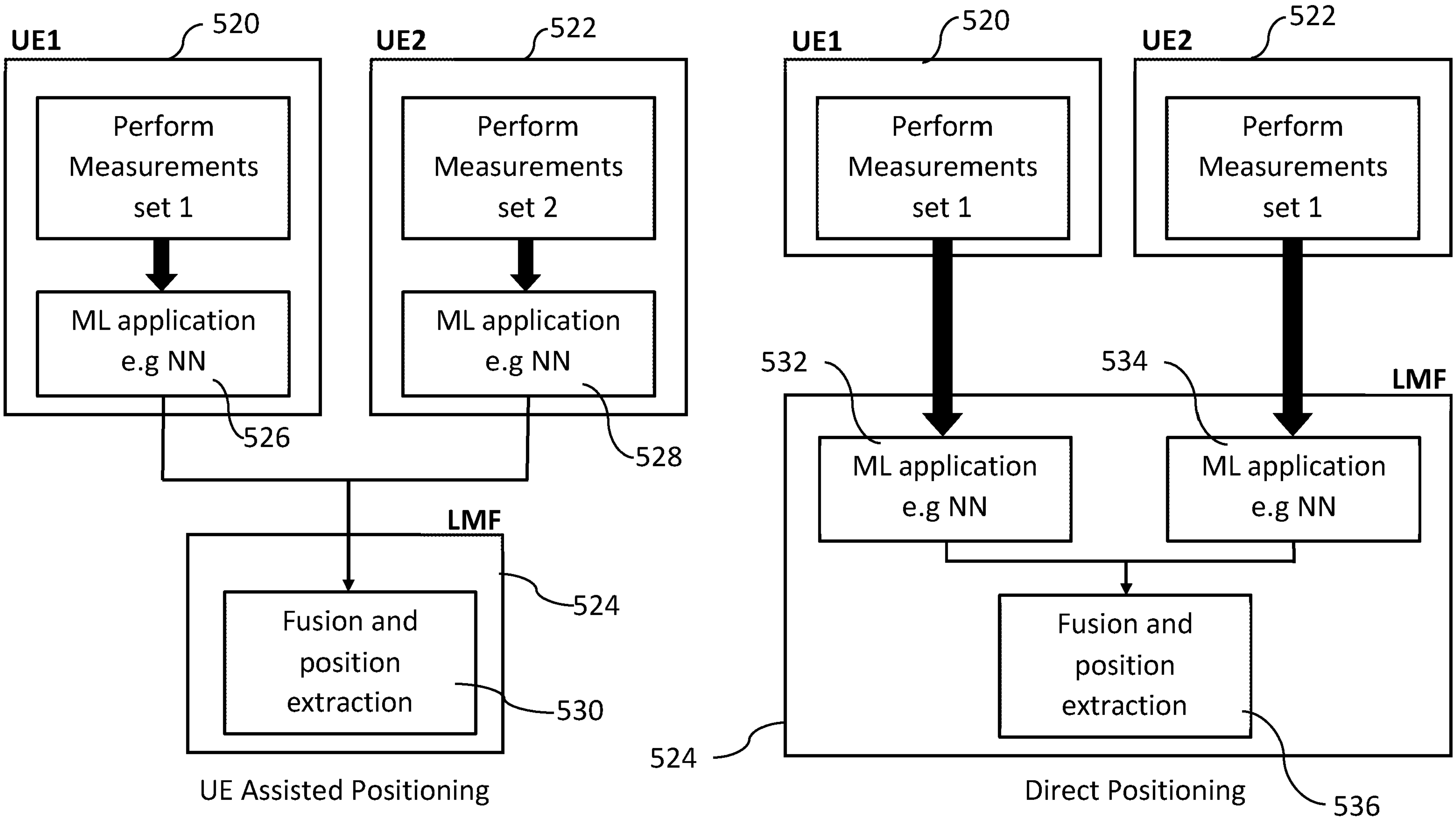

UE1
520
Perform Measurements set 1
ML application e.g NN
526
UE2
522
Perform Measurements set 2
ML application e.g NN
528
LMF
524
Fusion and position extraction
530
UE Assisted Positioning
UE1
520
Perform Measurements set 1
UE2
522
Perform Measurements set 1
532
534
LMF
ML application e.g NN
ML application e.g NN
Fusion and position extraction
524
536
Direct Positioning

Fig. 5

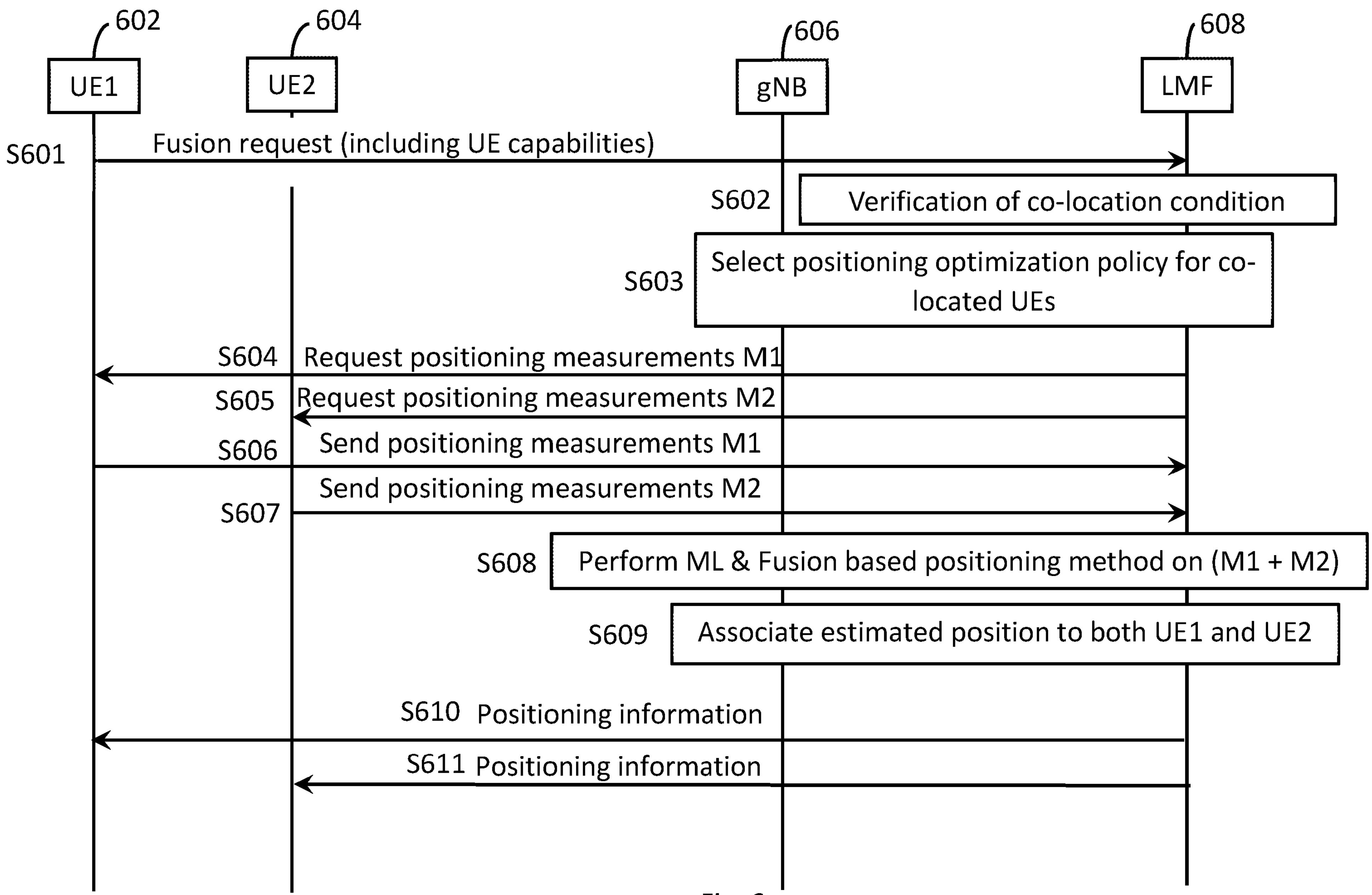

602
604
606
608
UE1
UE2
gNB
LMF
S601
Fusion request (including UE capabilities)
S602
Verification of co-location condition
S603
Select positioning optimization policy for co-located UEs
S604
Request positioning measurements M1
S605
Request positioning measurements M2
S606
Send positioning measurements M1
S607
Send positioning measurements M2
S608
Perform ML & Fusion based positioning method on (M1 + M2)
S609
Associate estimated position to both UE1 and UE2
S610
Positioning information
S611
Positioning information

Fig. 6

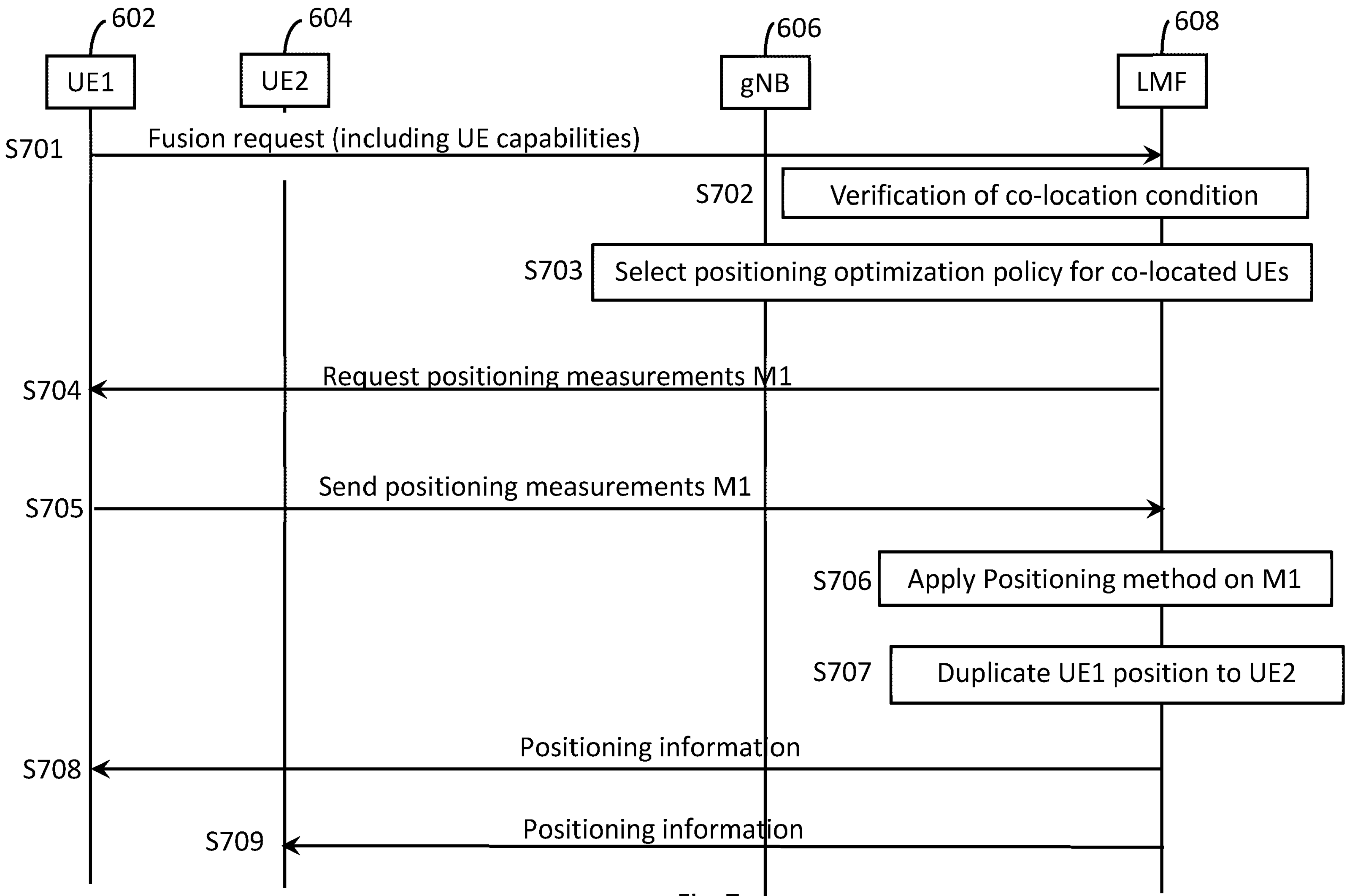

602
604
606
608
UE1
UE2
gNB
LMF
S701
Fusion request (including UE capabilities)
S702
Verification of co-location condition
S703
Select positioning optimization policy for co-located UEs
S704
Request positioning measurements M1
S705
Send positioning measurements M1
S706
Apply Positioning method on M1
S707
Duplicate UE1 position to UE2
S708
Positioning information
S709
Positioning information

Fig. 7

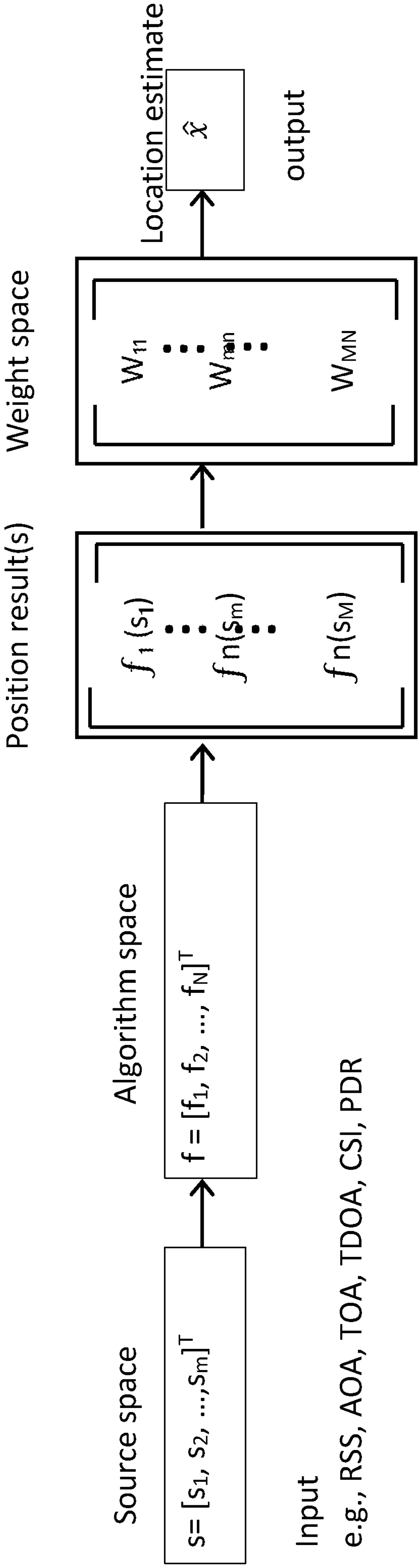
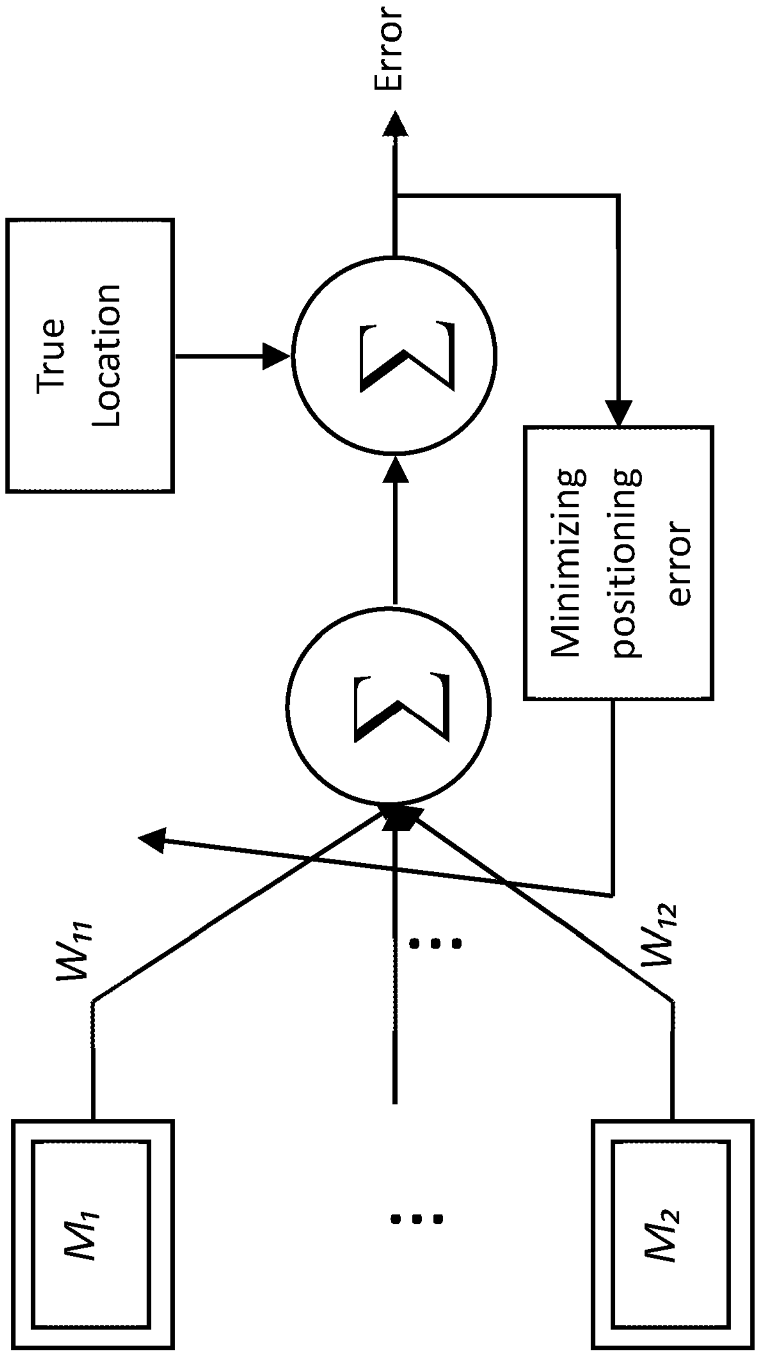

Source space
s= [s1, s2, …,sm]T
Input
e.g., RSS, AOA, TOA, TDOA, CSI, PDR
Algorithm space
f = [f1, f2, …, fN]T
Position result(s)
f1 (s1)
fn(sm)
fn(sM)
Weight space
W11
Wmn
WMN
Location estimate
x̂
output

Fig. 8



Error
True Location
Minimizing positioning error
W_{11}
W_{12}
...
M_1
M_2

Fig. 9

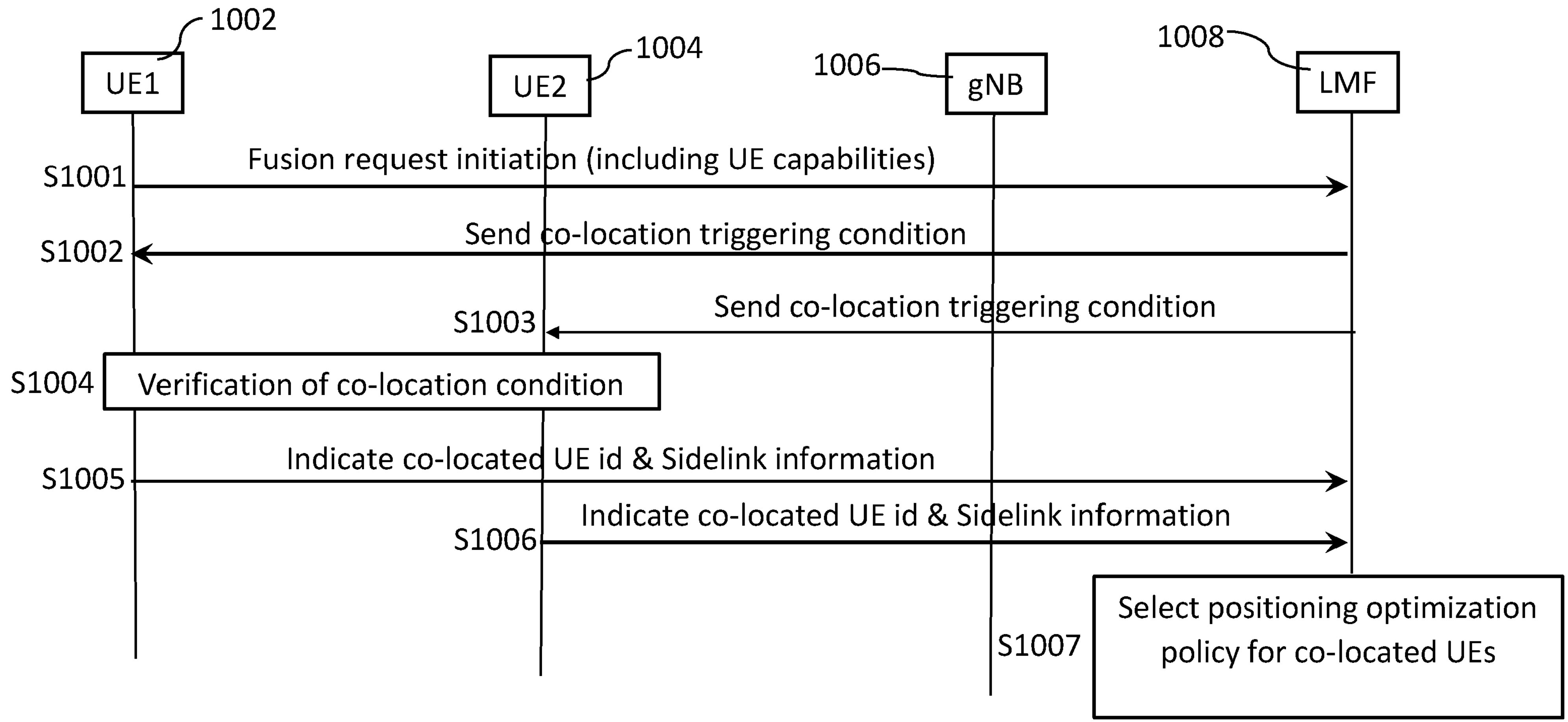
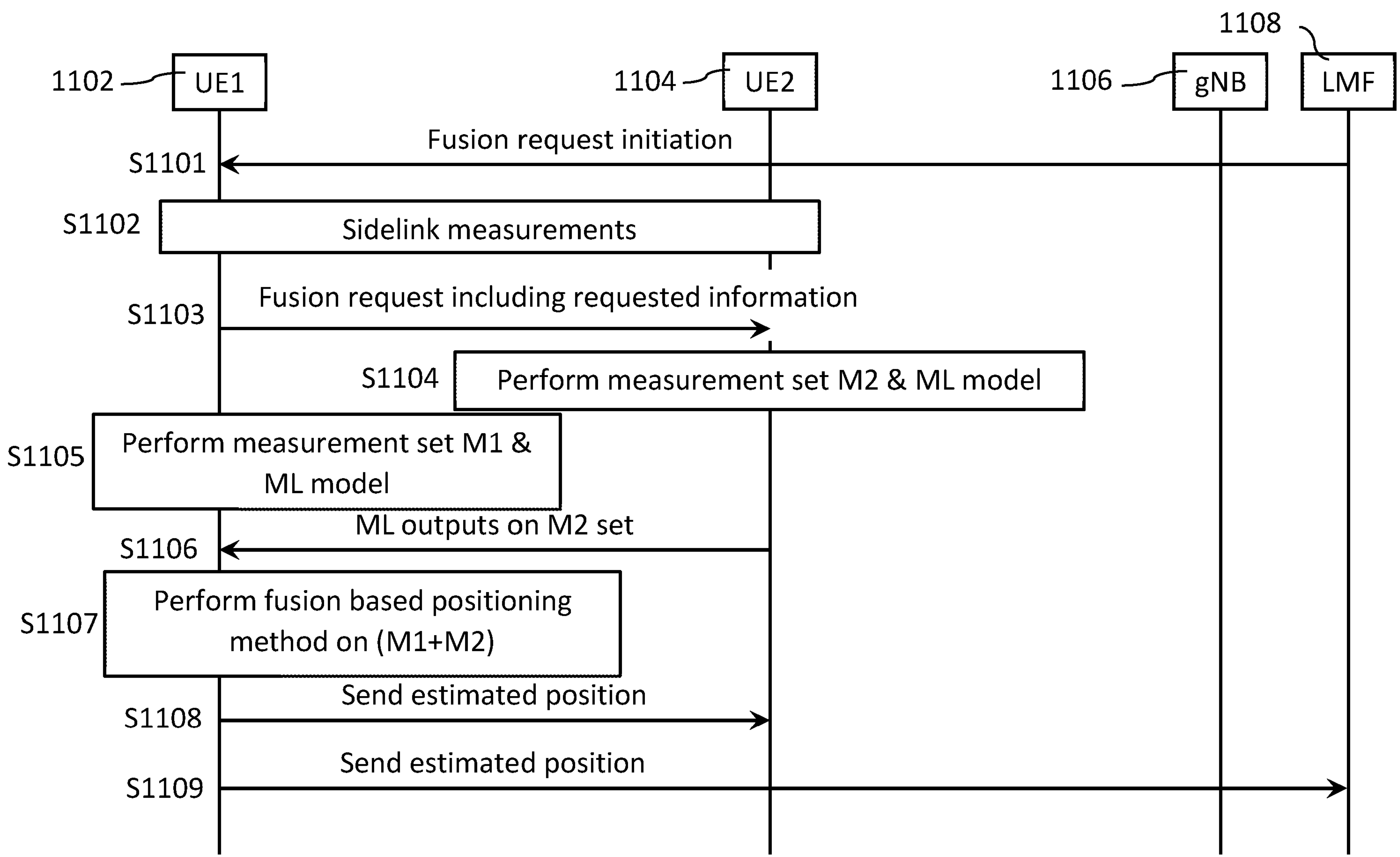

1002
UE1
1004
UE2
1006
gNB
1008
LMF
S1001
Fusion request initiation (including UE capabilities)
S1002
Send co-location triggering condition
S1003
Send co-location triggering condition
S1004
Verification of co-location condition
S1005
Indicate co-located UE id & Sidelink information
S1006
Indicate co-located UE id & Sidelink information
S1007
Select positioning optimization policy for co-located UEs

Fig. 10



1102
UE1
1104
UE2
1106
gNB
1108
LMF
S1101
Fusion request initiation
S1102
Sidelink measurements
S1103
Fusion request including requested information
S1104
Perform measurement set M2 & ML model
S1105
Perform measurement set M1 & ML model
S1106
ML outputs on M2 set
S1107
Perform fusion based positioning method on (M1+M2)
S1108
Send estimated position
S1109
Send estimated position

Fig. 11

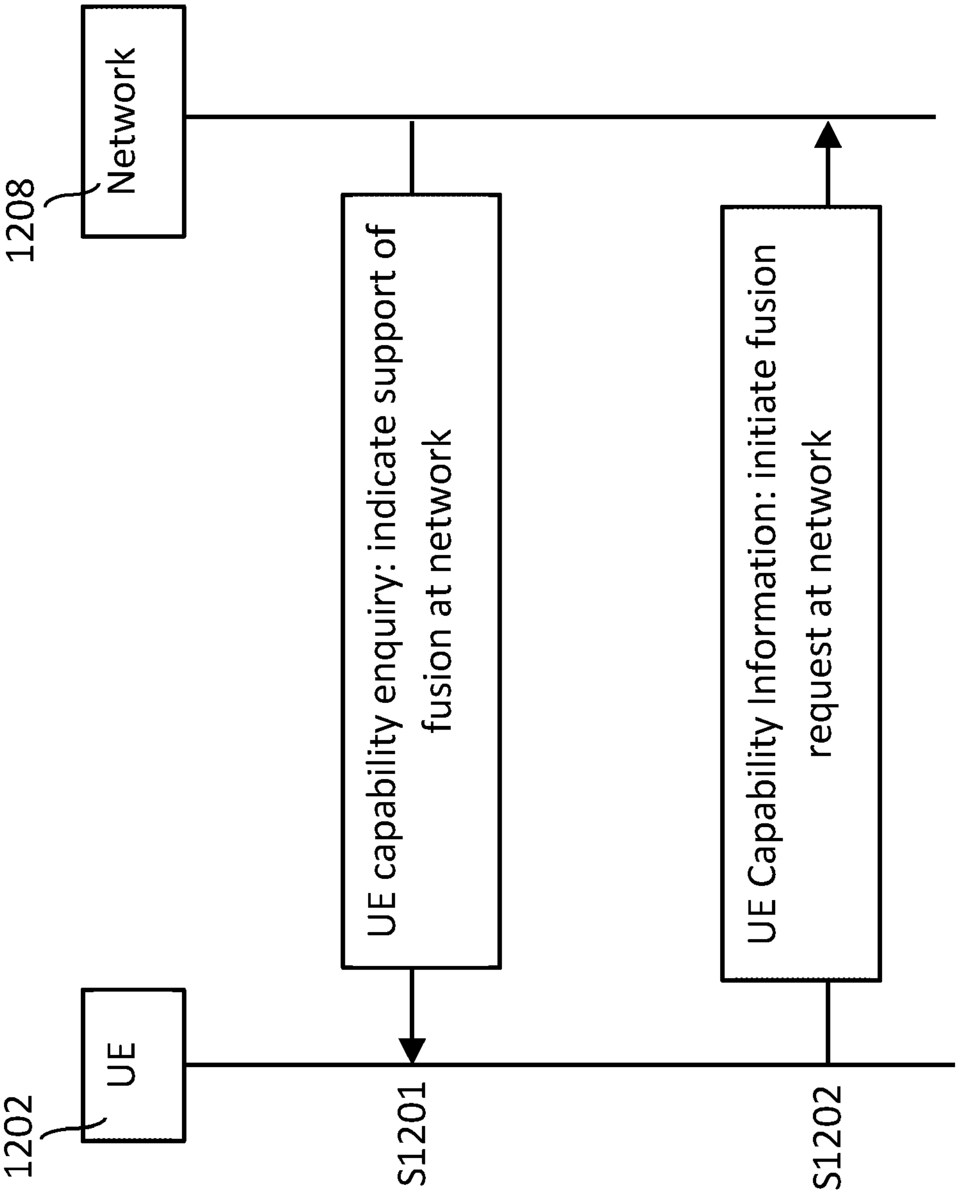
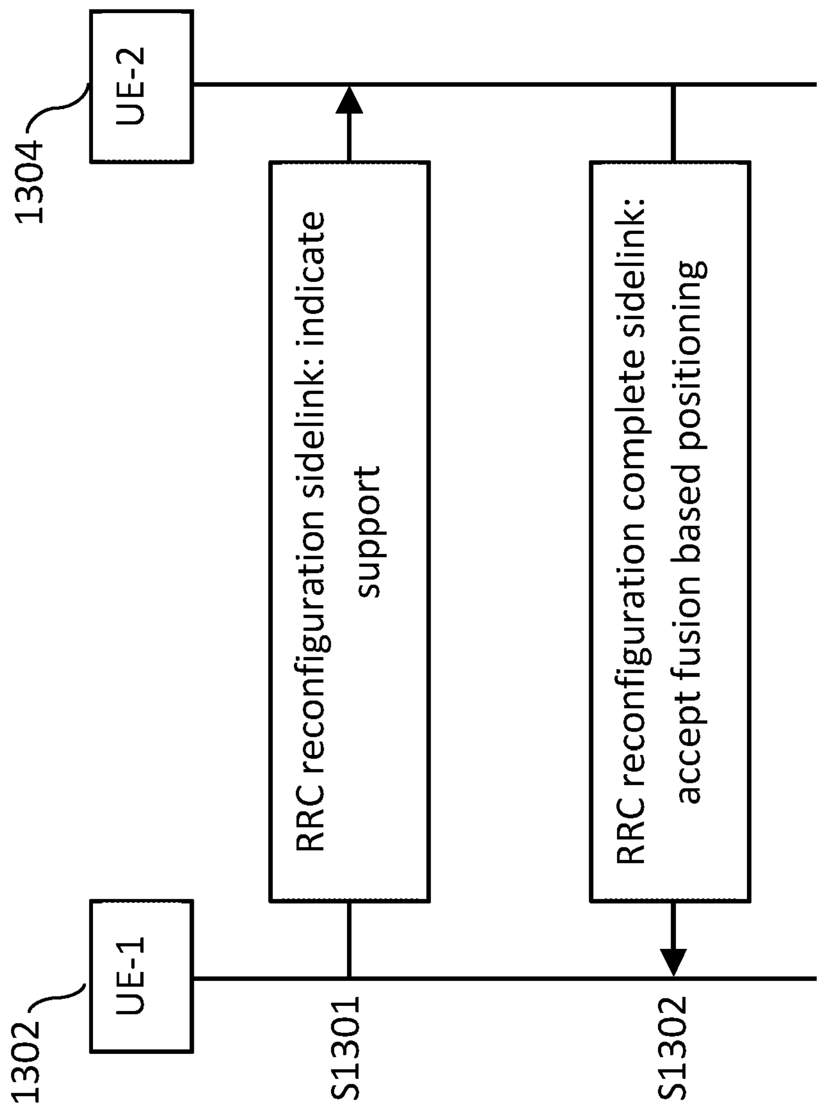

1208
Network
1202
UE
UE capability enquiry: indicate support of fusion at network
UE Capability Information: initiate fusion request at network
S1201
S1202

Fig. 12



1304
UE-2
1302
UE-1
RRC reconfiguration sidelink: indicate support
RRC reconfiguration complete sidelink: accept fusion based positioning
S1301
S1302

Fig. 13

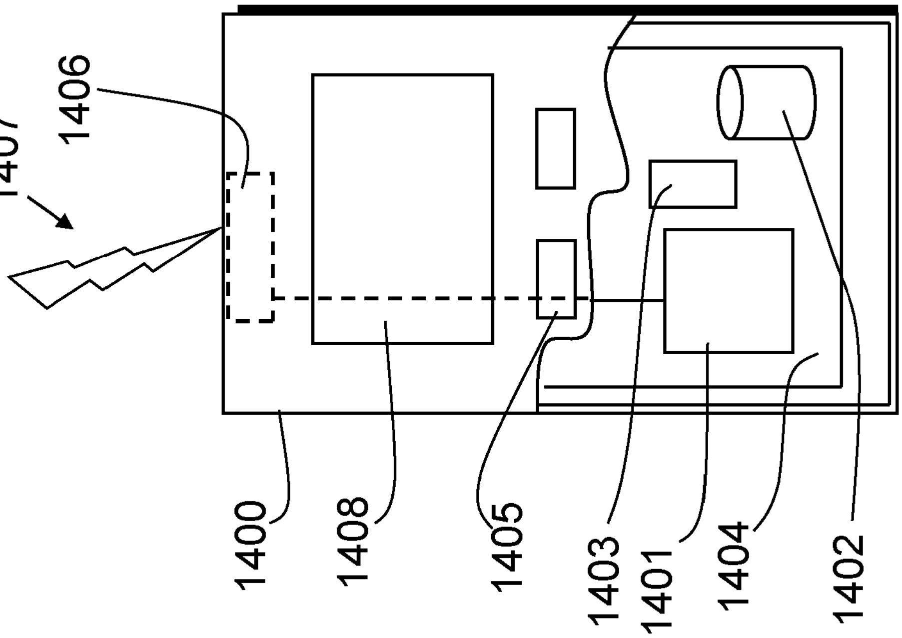


Fig. 14

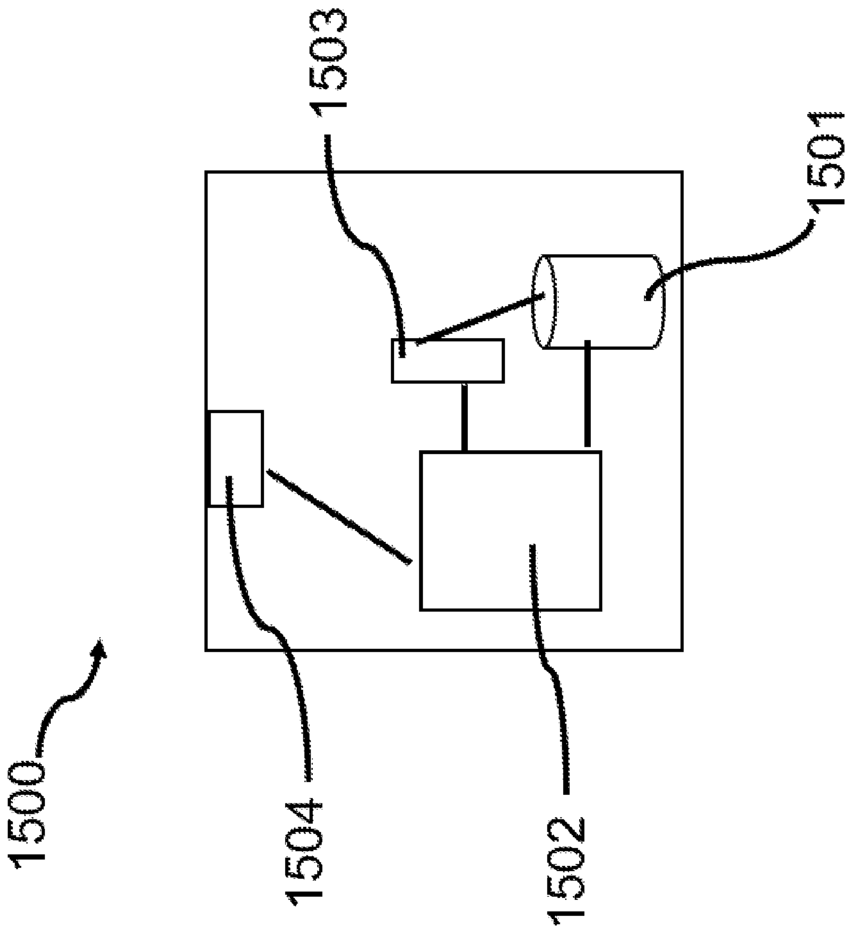


Fig. 15

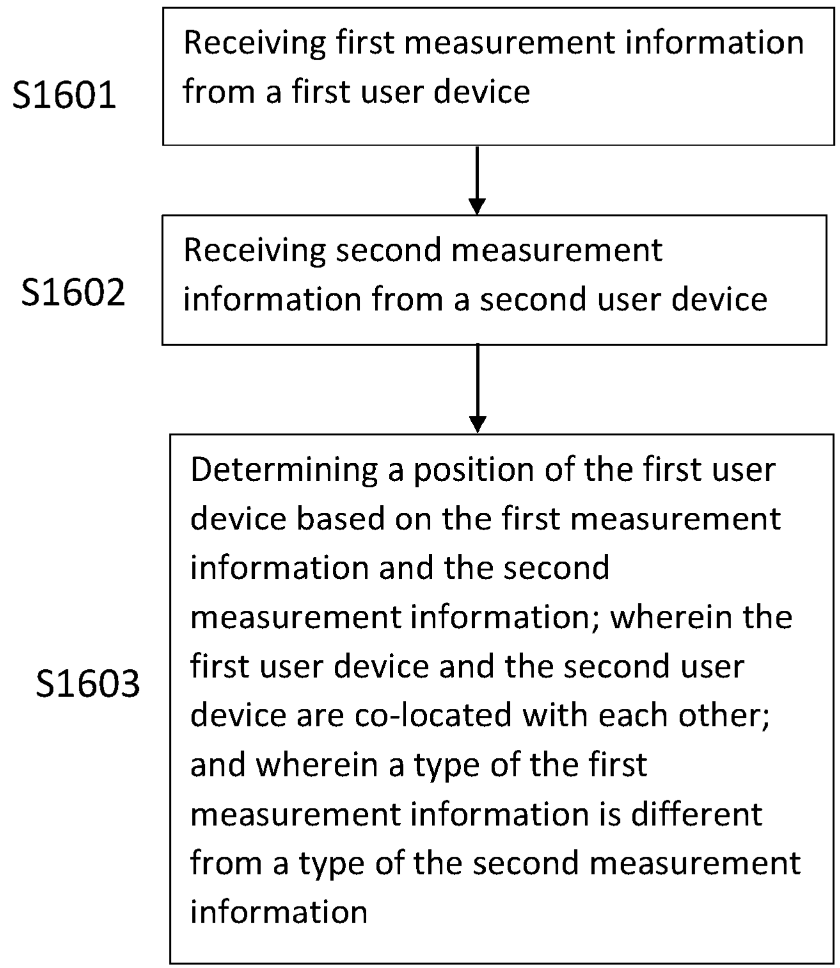

S1601
Receiving first measurement information from a first user device
S1602
Receiving second measurement information from a second user device
S1603
Determining a position of the first user device based on the first measurement information and the second measurement information; wherein the first user device and the second user device are co-located with each other; and wherein a type of the first measurement information is different from a type of the second measurement information

Fig. 16

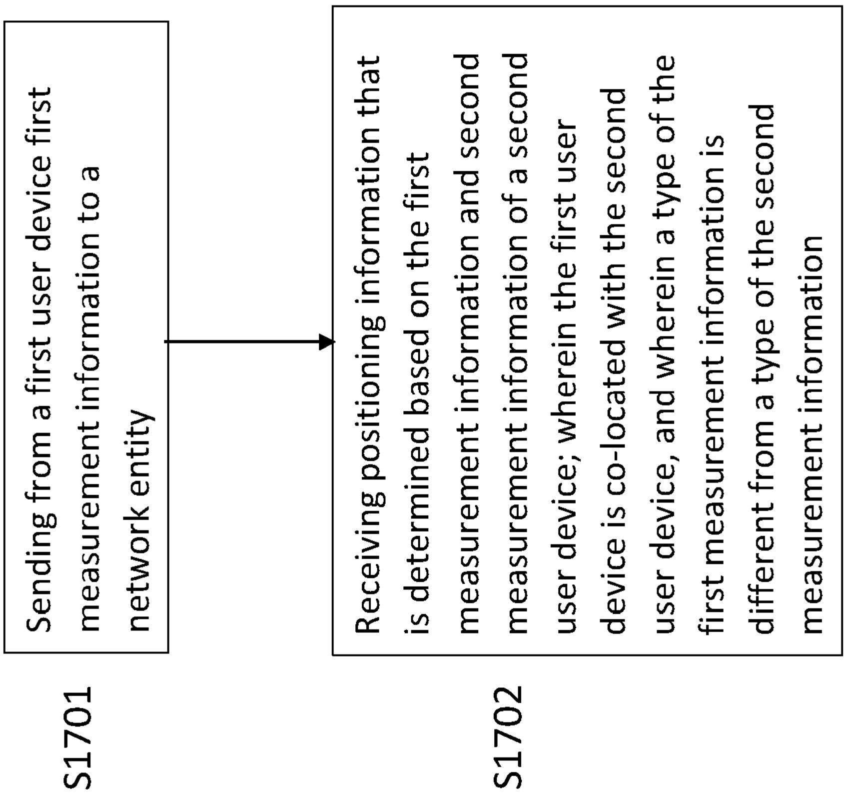

S1701
Sending from a first user device first measurement information to a network entity
S1702
Receiving positioning information that is determined based on the first measurement information and second measurement information of a second user device; wherein the first user device is co-located with the second user device, and wherein a type of the first measurement information is different from a type of the second measurement information

Fig. 17

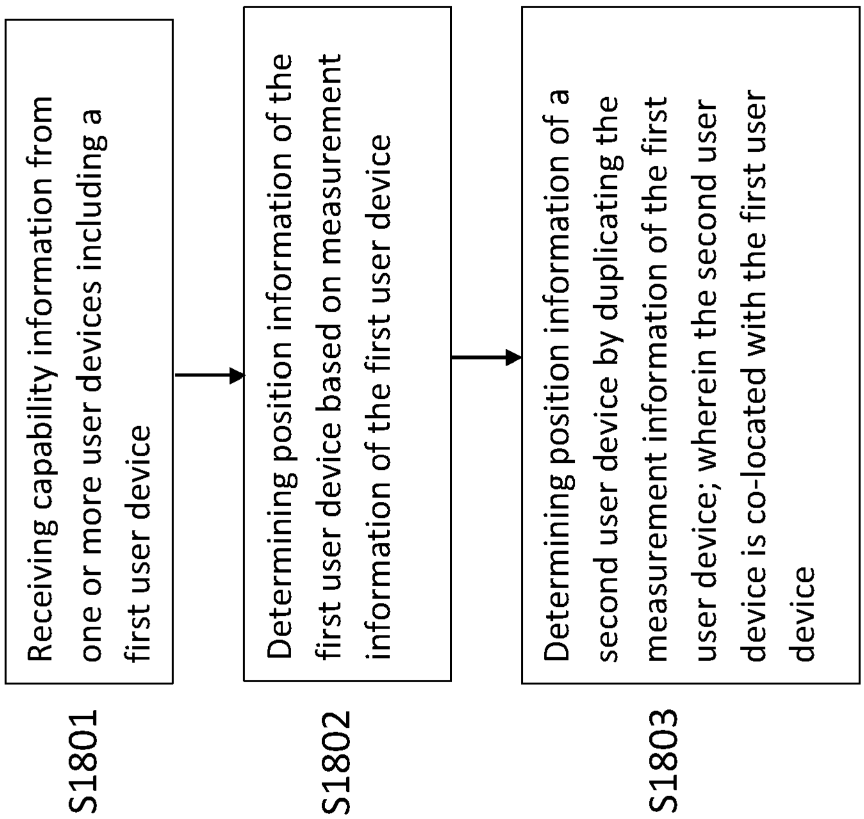

S1801
Receiving capability information from one or more user devices including a first user device
S1802
Determining position information of the first user device based on measurement information of the first user device
S1803
Determining position information of a second user device by duplicating the measurement information of the first user device; wherein the second user device is co-located with the first user device

Fig. 18

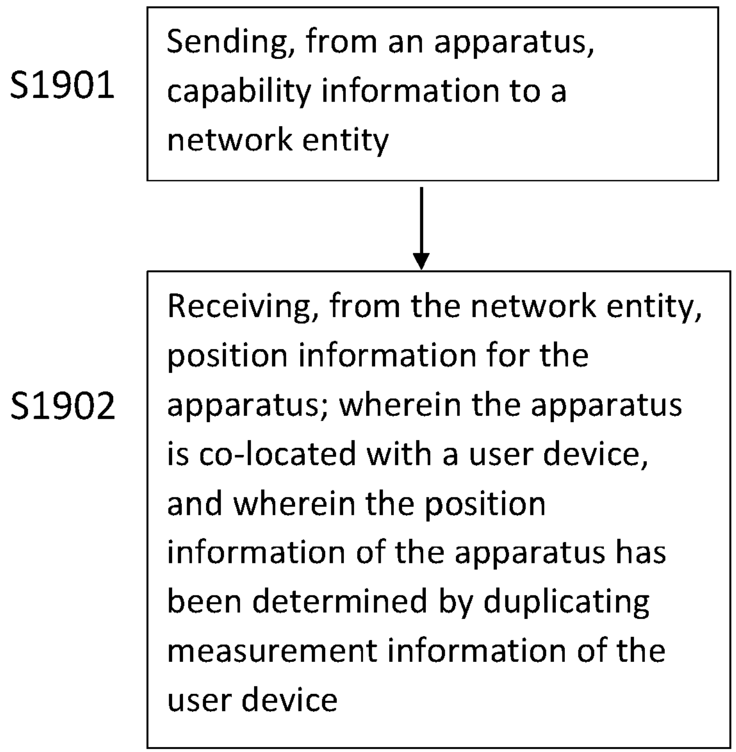

S1901
Sending, from an apparatus, capability information to a network entity
S1902
Receiving, from the network entity, position information for the apparatus; wherein the apparatus is co-located with a user device, and wherein the position information of the apparatus has been determined by duplicating measurement information of the user device

Fig. 19

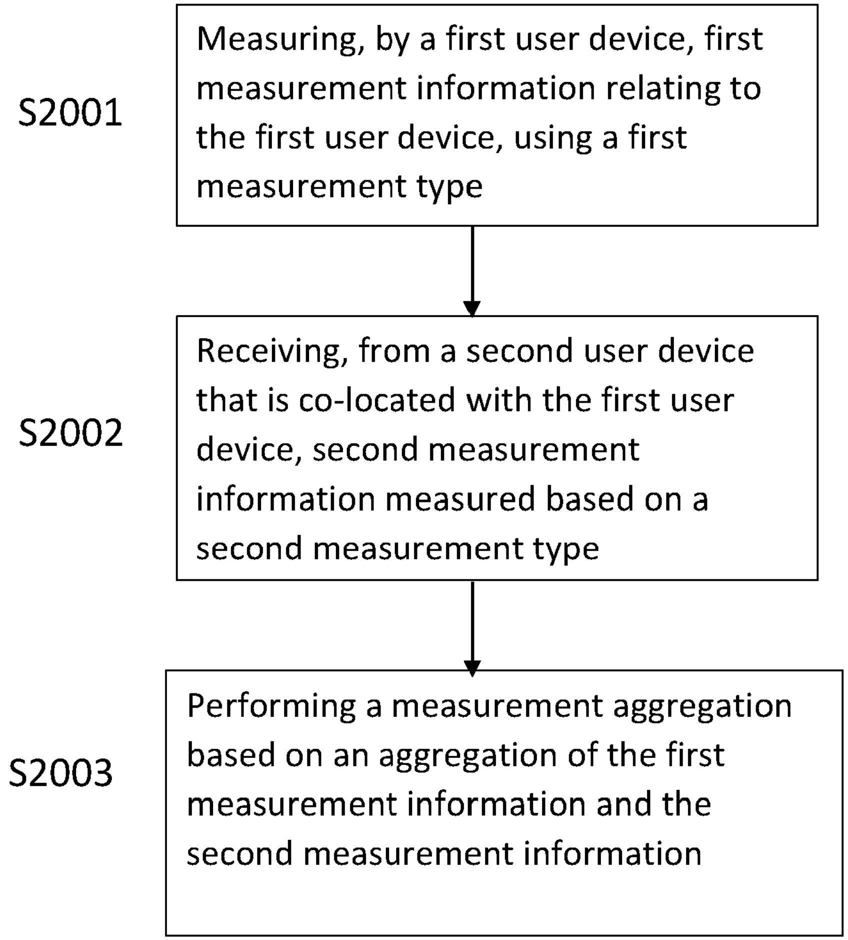

S2001
Measuring, by a first user device, first measurement information relating to the first user device, using a first measurement type
S2002
Receiving, from a second user device that is co-located with the first user device, second measurement information measured based on a second measurement type
S2003
Performing a measurement aggregation based on an aggregation of the first measurement information and the second measurement information

Fig. 20

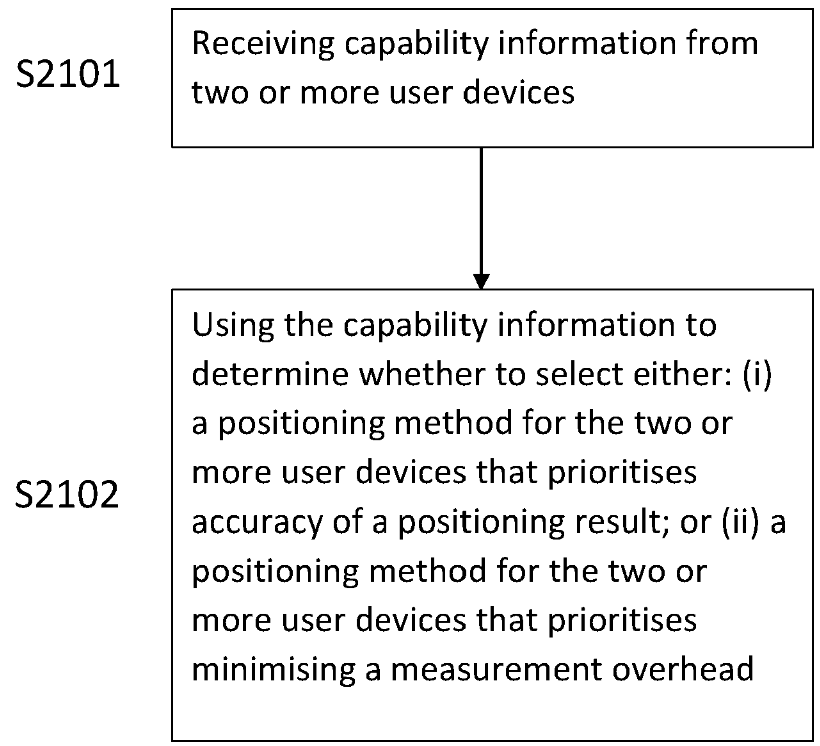

S2101
Receiving capability information from two or more user devices
S2102
Using the capability information to determine whether to select either: (i) a positioning method for the two or more user devices that prioritises accuracy of a positioning result; or (ii) a positioning method for the two or more user devices that prioritises minimising a measurement overhead

Fig. 21

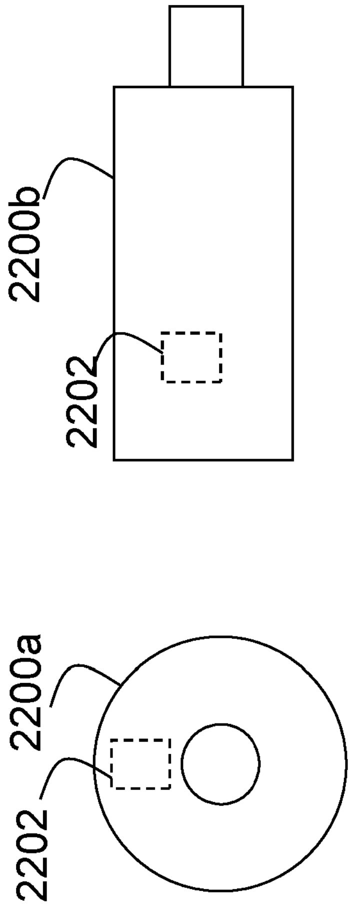


Fig. 22

The following terms are registered trade marks and should be read as such wherever they occur in this document:

3GPP

METHOD, APPARATUS AND COMPUTER PROGRAM

FIELD

[0001] The present application relates to a method, apparatus, and computer program, and in particular but not exclusively to user equipment positioning.

BACKGROUND

[0002] A communication system can be seen as a facility that enables communication sessions between two or more entities such as user terminals, base stations and/or other nodes by providing carriers between the various entities involved in the communications path. A communication system can be provided for example by means of a communication network and one or more compatible communication devices. The communication sessions may comprise, for example, communication of data for carrying communications such as voice, video, electronic mail (email), text message, multimedia and/or content data and so on. Non-limiting examples of services provided comprise two-way or multi-way calls, data communication or multimedia services and access to a data network system, such as the Internet.

SUMMARY

[0003] According to an aspect there is provided an apparatus comprising: means for receiving first measurement information from a first user device; means for receiving second measurement information from a second user device; and means for determining a position of the first user device based on the first measurement information and the second measurement information; wherein the first user device and the second user device are co-located with each other; and wherein a type of the first measurement information is different from a type of the second measurement information.

[0004] According to some examples, the apparatus comprises means for receiving capability information indicative of supporting a measurement aggregation from at least one of the first user device or the second user device.

[0005] According to some examples, the apparatus comprises means for indicating to at least one of the first user device or the second user device that the apparatus supports the measurement aggregation.

[0006] According to some examples, the first measurement information or the second measurement information includes at least one of: frequency measurement information; cell measurement information; time of arrival measurement information; angle of arrival measurement information; or reference signal received power measurement information.

[0007] According to some examples, the first measurement information or the second measurement information has been output from respective machine learning models at the first user device or the second user device.

[0008] According to some examples, the apparatus comprises one or more machine learning models, and wherein the first measurement information and the second measurement information are input in to the one or more machine learning models.

[0009] According to some examples, the apparatus comprises means for determining whether the first user device is co-located with the second user device based on coarse location estimates of the first and second user device, or using received sidelink information of the first and second user device.

[0010] According to some examples, the apparatus comprises means for sending the determined position information to at least one of the first user device or the second user device.

[0011] According to some examples, the apparatus comprises a location management function.

[0012] According to some examples, the means comprises at least one processor; and at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performance of the apparatus.

[0013] According to an aspect there is provided an apparatus comprising at least one processor; and at least one memory including computer program code; the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform: receiving first measurement information from a first user device; receiving second measurement information from a second user device; and determining a position of the first user device based on the first measurement information and the second measurement information; wherein the first user device and the second user device are co-located with each other; and wherein a type of the first measurement information is different from a type of the second measurement information.

[0014] According to an aspect there is provided a first user device comprising: means for sending first measurement information to a network entity; and means for receiving positioning information that is determined based on the first measurement information and second measurement information of a second user device; wherein the first user device is co-located with the second user device, and wherein a type of the first measurement information is different from a type of the second measurement information.

[0015] According to some examples, the apparats comprises means for sending capability information indicative of supporting a measurement aggregation to the network entity.

[0016] According to some examples, the apparatus comprises means for receiving an indication indicative that the network entity supports the measurement aggregation.

[0017] According to some examples the first measurement information or the second measurement information includes at least one of: frequency measurement information; cell measurement information; time of arrival measurement information; angle of arrival measurement information; reference signal received power measurement information.

[0018] According to some examples the first measurement information or the second measurement information has been output from respective machine learning models at the first user device or the second user device.

[0019] According to some examples, the apparatus comprises a user device.

[0020] According to some examples there is provided a method comprising: receiving first measurement information from a first user device; receiving second measurement information from a second user device; determining a position of the first user device based on the first measurement information and the second measurement information; wherein the first user device and the second user device are co-located with each other; and wherein a type of the first measurement information is different from a type of the second measurement information.

[0021] According to some examples the method comprises receiving capability information indicative of supporting a measurement aggregation from at least one of the first user device or the second user device.

[0022] According to some examples the method comprises indicating to at least one of the first user device or the second user device that the apparatus supports the measurement aggregation.

[0023] According to some examples the first measurement information or the second measurement information includes at least one of: frequency measurement information; cell measurement information; time of arrival measurement information; angle of arrival measurement information; or reference signal received power measurement information.

[0024] According to some examples the first measurement information or the second measurement information has been output from respective machine learning models at the first user device or the second user device.

[0025] According to some examples the apparatus comprises one or more machine learning models, and wherein the first measurement information and the second measurement information are input in to the one or more machine learning models.

[0026] According to some examples the method comprises determining whether the first user device is co-located with the second user device based on coarse location estimates of the first and second user device, or using received sidelink information of the first and second user device.

[0027] According to some examples the method comprises sending the determined position information to at least one of the first user device or the second user device.

[0028] According to an aspect there is provided a method comprising: sending from a first user device first measurement information to a network entity; and receiving positioning information that is determined based on the first measurement information and second measurement information of a second user device; wherein the first user device is co-located with the second user device, and wherein a type of the first measurement information is different from a type of the second measurement information.

[0029] According to some examples the method comprises sending capability information indicative of supporting a measurement aggregation to the network entity.

[0030] According to some examples the method comprises receiving an indication indicative that the network entity supports the measurement aggregation.

[0031] According to some examples the first measurement information or the second measurement information includes at least one of: frequency measurement information; cell measurement information; time of arrival measurement information; angle of arrival measurement information; reference signal received power measurement information.

[0032] According to some examples the first measurement information or the second measurement information has been output from respective machine learning models at the first user device or the second user device.

[0033] According to an aspect there is provided a computer program comprising instructions for causing an apparatus to perform at least the following: receiving first measurement information from a first user device; receiving second measurement information from a second user device; determining a position of the first user device based on the first measurement information and the second measurement information; wherein the first user device and the second user device are co-located with each other; and wherein a type of the first measurement information is different from a type of the second measurement information.

[0034] According to an aspect there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: receiving first measurement information from a first user device; receiving second measurement information from a second user device; determining a position of the first user device based on the first measurement information and the second measurement information; wherein the first user device and the second user device are co-located with each other; and wherein a type of the first measurement information is different from a type of the second measurement information

[0035] According to an aspect there is provided a computer program comprising instructions for causing an apparatus to perform at least the following: sending from a first user device first measurement information to a network entity; and receiving positioning information that is determined based on the first measurement information and second measurement information of a second user device; wherein the first user device is co-located with the second user device, and wherein a type of the first measurement information is different from a type of the second measurement information.

[0036] According to an aspect there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: sending from a first user device first measurement information to a network entity; and receiving positioning information that is determined based on the first measurement information and second measurement information of a second user device; wherein the first user device is co-located with the second user device, and wherein a type of the first measurement information is different from a type of the second measurement information.

[0037] According to an aspect there is provided an apparatus comprising: means for receiving capability information from one or more user devices including a first user device; means for determining position information of a first user device based on measurement information of the first user device; and means for determining position information of a second user device by duplicating the measurement information of the first user device; wherein the second user device is co-located with the first user device.

[0038] According to some examples, the capability information is indicative of support for measurement aggregation of measurements, and wherein at least the first user device supports measurement aggregation.

[0039] According to some examples, the apparatus comprises means for transmitting a positioning measurement request message based on the capability information; and

[0040] means for receiving measurement information from the first user device.

[0041] According to some examples, the capability information further comprises information related to one or more of: battery level; processor capability; memory capability of the first user device.

[0042] According to some examples the apparatus comprises means for performing a time difference of arrival determination on the received measurement information.

[0043] According to some examples, the means for determining position information of the second user device is configured to do so without receiving any measurement information from the second user device.

[0044] According to some examples, the apparatus comprises means for determining whether the first user device is co-located with the second user device.

[0045] According to some examples the apparatus comprises means for implementing a rule for determining that the first user equipment is co-located with the second user equipment.

[0046] According to some examples the rule is based on coarse location estimates of the first and second user equipment.

[0047] According to some examples, the apparatus comprises means for receiving information that the first user equipment is co-located with the second user equipment, based on sidelink information communicated between the first and second user equipment.

[0048] According to some examples, capability information of the first user device is included in a positioning request transmitted from the first user device.

[0049] According to some examples, the apparatus comprises means for sending the determined position information to at least one of the first user equipment or the second user equipment.

[0050] According to some examples the apparatus comprises a location management function.

[0051] According to some examples the means comprises at least one processor; and at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performance of the apparatus.

[0052] According to an aspect there is provided an apparatus comprising at least one processor; and at least one memory including computer program code; the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform: receiving capability information from one or more user devices including a first user device; determining position information of a first user device based on measurement information of the first user device; determining position information of a second user device by duplicating the measurement information of the first user device; wherein the second user device is co-located with the first user device.

[0053] According to an aspect there is provided an apparatus comprising: means for sending capability information to a network entity; means for receiving, from the network entity, position information for the apparatus; and wherein the apparatus is co-located with a user device, and

[0054] wherein the position information of the apparatus has been determined by duplicating measurement information of the user device.

[0055] According to some examples, the capability information is indicative of support for measurement aggregation of measurements, and wherein the apparatus supports measurement aggregation.

[0056] According to some examples, the apparatus is configured to receive the position information without having to send measurement information to the network entity.

[0057] According to some examples, the capability information further comprises information related to one or more of: battery level; processor capability; memory capability of the apparatus.

[0058] According to some examples, the apparatus comprises means for determining whether the apparatus is co-located with the user device, based on sidelink communication between the apparatus and the user device.

[0059] According to some examples the apparatus comprises a user device.

[0060] According to an aspect there is provided a method comprising: receiving capability information from one or more user devices including a first user device; determining position information of the first user device based on measurement information of the first user device; and determining position information of a second user device by duplicating the position information of the first user device; wherein the second user device is co-located with the first user device.

[0061] According to some examples, the capability information is indicative of support for measurement aggregation of measurements, and wherein at least the first user device supports measurement aggregation.

[0062] According to some examples, the method comprises transmitting a positioning measurement request message based on the capability information; and receiving measurement information from the first user device.

[0063] According to some examples, the capability information further comprises information related to one or more of: battery level; processor capability; memory capability of the first user device.

[0064] According to some examples the method comprises performing a time difference of arrival determination on the received measurement information.

[0065] According to some examples, the determining position information of the second user device is done so without receiving any measurement information from the second user device.

[0066] According to some examples, the method comprises determining whether the first user device is co-located with the second user device.

[0067] According to some examples, the method comprises implementing a rule for determining that the first user equipment is co-located with the second user equipment.

[0068] According to some examples the rule is based on coarse location estimates of the first and second user equipment.

[0069] According to some examples the method comprises receiving information that the first user equipment is co-located with the second user equipment, based on sidelink information communicated between the first and second user equipment.

[0070] According to some examples, capability information of the first user device is included in a positioning request transmitted from the first user device.

[0071] According to some examples the method comprises sending the determined position information to at least one of the first user equipment or the second user equipment.

[0072] According to an aspect there is provided a method comprising: sending, from an apparatus, capability information to a network entity; receiving, from the network entity, position information for the apparatus; and wherein the apparatus is co-located with a user device, and wherein the position information of the apparatus has been determined by duplicating measurement information of the user device.

[0073] According to some examples, the capability information is indicative of support for measurement aggregation of measurements, and wherein the apparatus supports measurement aggregation.

[0074] According to some examples, the method comprises receiving the position information without having to send measurement information to the network entity.

[0075] According to some examples, the capability information further comprises information related to one or more of: battery level; processor capability; memory capability of the apparatus.

[0076] According to some examples, the method comprises determining whether the apparatus is co-located with the user device, based on sidelink communication between the apparatus and the user device.

[0077] According to some examples there is provided a computer program comprising instructions for causing an apparatus to perform at least the following: receiving capability information from one or more user devices including a first user device; determining position information of the first user device based on measurement information of the first user device; and determining position information of a second user device by duplicating the measurement information of the first user device; wherein the second user device is co-located with the first user device.

[0078] According to some examples there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: receiving capability information from one or more user devices including a first user device; determining position information of the first user device based on measurement information of the first user device; and determining position information of a second user device by duplicating the measurement information of the first user device; wherein the second user device is co-located with the first user device.

[0079] According to some examples there is provided a computer program comprising instructions for causing an apparatus to perform at least the following: sending capability information to a network entity; receiving, from the network entity, position information for the apparatus; and wherein the apparatus is co-located with a user device, and wherein the position information of the apparatus has been determined by duplicating measurement information of the user device.

[0080] According to some examples there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: sending capability information to a network entity; receiving, from the network entity, position information for the apparatus; and wherein the apparatus is co-located with a user device, and wherein the position information of the apparatus has been determined by duplicating measurement information of the user device.

[0081] According to an aspect there is provided a first user device comprising: means for measuring first measurement information relating to the first user device, using a first measurement type; means for receiving, from a second user device that is co-located with the first user device, second measurement information measured based on a second measurement type; and means for performing a measurement aggregation based on an aggregation of the first measurement information and the second measurement information.

[0082] According to some examples, the request comprises a triggering condition, and wherein the first user device comprises means for performing the determining a position when the triggering condition is met.

[0083] According to some examples, the triggering condition comprises an identification that the first user device is co-located with the second user device

[0084] According to some examples, the triggering condition comprises a threshold reference signal received power.

[0085] According to some examples, the second measurement information is output from a machine learning model of the second user device.

[0086] According to some examples, the apparatus comprises a machine learning model to which the first measurement information is applied.

[0087] According to some examples, the first measurement type or second measurement type comprises at least one of: frequency measurement information; cell measurement information; time of arrival measurement information; angle of arrival measurement information; reference signal received power measurement information.

[0088] According to some examples, the apparatus comprises means for exchanging capability information with the second user device, wherein the exchanging capability information comprises an indication indicative of support for measurement aggregation to the second user device, and receiving an indication from the second user device that the second user device supports the measurement aggregation.

[0089] According to some examples, the exchanging capability information comprises configuring the second user device not to report its location to the network.

[0090] According to some examples, the apparats comprises means for sending position information of the first user device that has been determined by the measurement aggregation.

[0091] According to some examples the means comprises at least one processor; and at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performance of the apparatus.

[0092] According to an aspect there is provided a first user device comprising at least one processor; and at least one memory including computer program code; the at least one memory and the computer program code configured to, with the at least one processor, cause the first user device at least to perform: measuring first measurement information relating to the first user device, using a first measurement type; receiving, from a second user device that is co-located with the first user device, second measurement information measured based on a second measurement type; and performing a measurement aggregation based on an aggregation of the first measurement information and the second measurement information.

[0093] According to an aspect there is provided a method comprising: measuring, by a first user device, first measurement information relating to the first user device, using a first measurement type; receiving, from a second user device that is co-located with the first user device, second measurement information measured based on a second measurement type; and performing a measurement aggregation based on an aggregation of the first measurement information and the second measurement information.

[0094] According to some examples, the request comprises a triggering condition, and the method comprises performing the determining a position when the triggering condition is met.

[0095] According to some examples, the triggering condition comprises an identification that the first user device is co-located with the second user device

[0096] According to some examples, the triggering condition comprises a threshold reference signal received power.

[0097] According to some examples, the second measurement information is output from a machine learning model of the second user device.

[0098] According to some examples, the method comprises applying the first measurement information to a machine learning model.

[0099] According to some examples, the first measurement type or second measurement type comprises at least one of: frequency measurement information; cell measurement information; time of arrival measurement information; angle of arrival measurement information; reference signal received power measurement information.

[0100] According to some examples, the method comprises exchanging capability information with the second user device, wherein the exchanging capability information comprises indicating support for measurement aggregation to the second user device, and receiving an indication from the second user device that the second user device supports measurement aggregation.

[0101] According to some examples, the exchanging capability information comprises configuring the second user device not to report its location to the network.

[0102] According to some examples, the method comprises sending position information of the first user device that has been determined by the measurement aggregation.

[0103] According to some examples, the method is performed by a user equipment.

[0104] According to an aspect there is provided a computer program comprising instructions for causing a first user device to perform at least the following: measuring, by the first user device, first measurement information relating to the first user device, using a first measurement type; receiving, from a second user device that is co-located with the first user device, second measurement information measured based on a second measurement type; and performing a measurement aggregation based on an aggregation of the first measurement information and the second measurement information.

[0105] According to an aspect there is provided a non-transitory computer readable medium comprising program instructions for causing a first user device to perform at least the following: measuring, by the first user device, first measurement information relating to the first user device, using a first measurement type; receiving, from a second user device that is co-located with the first user device, second measurement information measured based on a second measurement type; and performing a measurement aggregation based on an aggregation of the first measurement information and the second measurement information.

[0106] According to an aspect there is provided an apparatus comprising: means for receiving capability information from two or more user devices; and means for using the capability information to determine whether to select either: (i) a positioning method for the two or more user devices that prioritises accuracy of a positioning result; or (ii) a positioning method for the two or more user devices that prioritises minimising a measurement overhead.

[0107] According to an aspect there is provided an apparatus comprising at least one processor; and at least one memory including computer program code; the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform: receiving capability information from two or more user devices; using the capability information to determine whether to select either: (i) a positioning method for the two or more user devices that prioritises accuracy of a positioning result; or (ii) a positioning method for the two or more user devices that prioritises minimising a measurement overhead.

[0108] According to an aspect there is provided a method comprising: receiving capability information from two or more user devices; and using the capability information to determine whether to select either: (i) a positioning method for the two or more user devices that prioritises accuracy of a positioning result; or (ii) a positioning method for the two or more user devices that prioritises minimising a measurement overhead.

[0109] According to an aspect there is provided a computer program comprising instructions for causing a first user device to perform at least the following: receiving capability information from two or more user devices; and using the capability information to determine whether to select either: (i) a positioning method for the two or more user devices that prioritises accuracy of a positioning result; or (ii) a positioning method for the two or more user devices that prioritises minimising a measurement overhead.

[0110] According to an aspect there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: receiving capability information from two or more user devices; and using the capability information to determine whether to select either: (i) a positioning method for the two or more user devices that prioritises accuracy of a positioning result; or (ii) a positioning method for the two or more user devices that prioritises minimising a measurement overhead.

DESCRIPTION OF FIGURES

[0111] Embodiments will now be described, by way of example only, with reference to the accompanying Figures in which:

[0112] Figure 1 schematically shows a one-step positioning approach;

[0113] Figure 2 schematically shows a two-step positioning approach;

[0114] Figure 3 schematically shows a positioning scenario involving multiple user devices;

[0115] Figure 4 is a flow chart of a method according to an example;

[0116] Figure 5 schematically shows a UE assisted positioning scheme and a direct positioning scheme;

[0117] Figure 6 is a signalling diagram according to an example;

[0118] Figure 7 is a signalling diagram according to an example;

[0119] Figure 8 schematically shows a formulation for measurement aggregation;

[0120] Figure 9 schematically shows a formulation for measurement aggregation;

[0121] Figure 10 is a signalling diagram according to an example;

[0122] Figure 11 is a signalling diagram according to an example;

[0123] Figure 12 is a signalling diagram according to an example;

[0124] Figure 13 is a signalling diagram according to an example;

[0125] Figure 14 schematically shows a user device according to an example;

[0126] Figure 15 schematically shows a control apparatus according to an example;

[0127] Figures 16 to 21 are flow charts according to some examples;

[0128] Figure 22 schematically shows a schematic representation of non-volatile memory media.

DETAILED DESCRIPTION

[0129] In the following, certain embodiments are explained with reference to mobile communication devices or user equipment (UEs) capable of communication via a wireless cellular system and mobile communication systems serving such mobile communication devices. The backbone structure of a communication system, for example UEs, radio access network (RAN) and core network (CN) is known, and for conciseness is not discussed further in detail.

[0130] In Rel-17, 3GPP started new radio (NR) positioning enhancement work [RP-210897], focusing on increasing accuracy, reducing latency and increasing efficiency (low complexity; low power consumption; low overhead) based on Rel-16 solutions. Reduced Capability (RedCap) devices are being designed and standardized in Rel-17 [RP-211574]. RedCap NR devices are designed with relatively longer battery life as compared to other IoT devices.

[0131] 3GPP RAN1 has initiated a study item on AI/ML (artificial intelligence / machine learning) for air interface. One of the use cases being considered is positioning accuracy enhancements with the use of AI/ML.

[0132] Figure 1 schematically shows a one-step positioning approach for AI/ML-based solutions that has been proposed in Rel-18. In the example of Figure 1, the model input comprises possible measurements or channel observations from a UE, that are fed into an AI/ML model 102. The output from the model 102 is a UE location or information pertaining to UE location.

[0133] A one-step positioning approach could have an AI/ML model hosted/deployed at UE or network/LMF (location management function). The inputs to the model could include various channel observations such as RSRP (reference signal received power) measurements, CIR (channel impulse response), cell IDs, beam IDs, angle of arrival/departure, etc. These values may be provided as an input to an AI/ML model (for e.g., Model-0 102 in Figure 1) which provides the UE location as an output.

[0134] This approach has potential for high-accuracy performance, even in heavy NLOS (non-line of sight) conditions, as well as relative simplicity in terms of training and deployment – with a single node being used for such scenarios. A potential disadvantage could be its sensitivity to changes in the propagation environment, as frequency-selective fading channels, which may result in a poor generalization of the trained model and higher computational complexity required to achieve sufficiently high positioning accuracy and scenario dependence for model usage.

[0135] A two-step positioning approach for AI/ML positioning is schematically shown in Figure 2.

[0136] A two-step positioning approach may have two main options:

- option 1: separate AI/ML models – “model-1” 204 hosted at UE, and “model-2” 206 hosted at the network/LMF, with possible intermediate features exchanged between UE and network, or
- option 2: an AI/ML model (Model-1 204) hosted at UE or network, with possible intermediate features along with improved channel observations sent to classical methods (e.g. non-AI/ML methods schematically shown at 208) hosted at the network. The network then derives the UE location.

[0137] It is to be noted that for both the one- and two-step approach, each step could be performed in separate entities or in a single entity, and the present disclosure is not limited as such. Moreover, for example, instead of UE and the network, a sidelink scenario (in which UEs are able to communicate with each other without relaying their data via the network) could also be considered for use e.g., with model-1 204 at a first UE (UE-1) and model-2 206 at a second UE (UE-2).

[0138] A potential advantage of the two-step approach is that it has the option to distribute computational complexity and storage requirements between the UE and the network. The two-step approach may also use AI/ML to enhance existing approaches, for example to improve accuracy.

[0139] For example, in the two-step “option-1” discussed above, a lightweight AI/ML model (model-1) could be deployed at the UE, which either provides intermediate features that could only be understood by a more complex AI/ML model (model-2) hosted by the network. Or the UE could provide measurements such as RSRP measurements, ToA (time of arrival) estimation, AoA/AoD (angle of arrival / angle of departure). Or the UE could provide an intermediate result that is obtained from a model, such as LOS/NOS classification. Information from the UE can then be used by model-2 at the network to derive the UE location.

[0140] In the two-step “option-2”, a similarly lightweight AI/ML model at the UE could provide “classical” or legacy measurements with improved accuracy to the network, and the network may then use known approaches to derive UE location. Since the output of AI/ML model-1 in option-2 would have higher accuracy than legacy methods (providing information such as LOS/NLOS classification, RSRP measurements, ToA, AoA/AoD, etc.), such approach could provide improved positioning performance with minimal complexity and almost no impact on legacy implementation at the network side, in examples.

[0141] In some examples, the one-step approach is referred to as direct AI/ML positioning. In some examples, the two-step approach is referred to as indirect AI/ML positioning.

[0142] Thus, while examples of the disclosure may enable UE location to be determined with high-accuracy, it will be noted that there may be various ways in which AI/ML could help this to be achieved.

[0143] It will also be noted that UE location, which may be the outcome or output of both one- and two-step approaches, may be implemented using either approach.

[0144] With UE location being the potential output, the one-step approach may use model inputs that include one or more of: UE cell IDs; beam IDs; and/or other cell-specific parameters which would enable the model to identify the UE location. This may mean that either the model is trained using a large amount of data – that represents the entire network area - or the model may be retrained/updated/fine-tuned each time the model moves from one geographical zone to another. Therefore; this approach may require a relatively large amount of computation of data.

[0145] In the case of a two-step approach (for e.g., two-step option-2), by way of example the output of the AI/ML model may be one or more of a LOS/NLOS classification and/or other angular or time-based features. In such a case there may not be any cell-specific dependency on the training data, and hence the model may not need to be retrained / updated / fine-tuned each time the UE moves from one geographical zone to another.

[0146] The example embodiments of the invention consider, inter alia, a scenario of two step and/or AI/ML assisted positioning. The scenario may involve Uu (UE-gNB interface) and/or sidelink (UE-UE interface). The scenario may use ML models involving collaboration among a selected set of UEs.

[0147] The present disclosure identifies a potential problem in cases where multiple UEs are co-located. For examples the UEs may be co-located in a mall, train station, indoor factory, V2X (vehicle to everything). The co-located UEs may require positioning. Conventionally, the network will handle the positioning process for each UE separately. The separate process for each UE may include a request for positioning measurements, reporting positioning measurements, and processing of positioning measurements to estimate the UE position. Typically, in such a scenario determination of relative position is sufficient as compared to absolute position. Moreover, in case of positioning RedCap

UEs, the performance KPIs (key performance indicators) may be bounded by the UE capability (e.g. computational power). Therefore, it may be difficult for a UE alone to compute a complex AI/ML model, particularly where the UE is a RedCap UE.

[0148] One of the aspects therefore considered in the embodiments is how to optimize a localization procedure among UEs, so that the measurement overhead / processing per UE is decreased, while ensuring highly accurate positioning. Therefore, some examples of the present disclosure address optimization of positioning for co-located UEs, and provides a set-up of procedure and related required signalling enhancements.

[0149] Approaches to positioning that combine (or fuse) data from multiple sources and/or multiple different types of data, may be referred to as a fusion-based positioning or positioning measurement aggregation.

[0150] Considering the above, the embodiments propose a method and apparatus for optimization of positioning of co-located UEs. The co-located UEs may for example be located in a stadium, station, vehicles in platooning, or also co-located devices in a factory or the like.

[0151] Figure 3 shows an example where positioning is required for three UEs, namely UE1, UE2, and UE3. Five transmission and reception points (TRPs) are shown, namely TRP1, TRP2, TRP3, TRP4 and TRP5. Conventionally the positioning procedure is performed separately for each UE. In this example, UE1 and UE2 are close to each other and may therefore be considered as co-located. Therefore, position estimate optimization may be used to avoid unnecessary separate processing for each of UE1 and UE2.

[0152] According to some examples, the following procedure described below and depicted in Figure 4 is proposed to enable the optimization of positioning co-located UEs.

[0153] At S400, a request is sent for positioning support. For example, the request may be sent from a UE to LMF. The UE may proactively send the request so that data fusion techniques, described in more detail below, can be used. In some examples, the request may be sent based on one or more of: UE capability; positioning requirements. For instance, the request can be initiated based on a threshold battery level or threshold computational resources of the UE. In some examples, these thresholds may be pre-configured by the network. For example, if a UE determines that it needs accurate positioning but does not have the threshold computational resource to perform measurement with required accuracy, then this may trigger the request from UE to LMF.

[0154] At S401, identification of co-located UEs is performed. In this step, UEs that are co-located with the UE that sent the request are identified. In some examples, identification of co-located UEs is performed by LMF. For example, LMF may use coarse (non-exact) location data of the UEs, initially. LMF may then utilize a locality database to identify the co-located UEs. In some examples this can be achieved by using the coarse locations and past history of the UEs, for example using information from corresponding serving gNBs. In some examples, coarse location information may be obtained using, for example, beam-ID and/or cell-ID information. In some examples, identification of co-located UEs may be performed by the UE that initiated the request. For example, the UE that initiated the request may use one or more sidelink channel(s) with other UEs to determine whether they are co-located.

[0155] At S402, a policy for optimizing positioning is selected. Once a set of UEs which are co-located are identified in S401 (for example by LMF), then one or more different policies may be selected from to perform a positioning procedure. It is appreciated that there may be a tradeoff between positioning accuracy and measurement overhead reduction. Therefore, in some examples UE capability or UE requirement information may be analyzed, for example by the LMF, to determine which policy to use.

[0156] In some examples the capability and/or requirements of the UE which made the request are analyzed and taken into account. Additionally or alternatively, the capability and/or requirements of the co-located UEs are analyzed and taken in to account. For example, if one or more of the UEs requires highly accurate positioning information, then a policy which prioritizes accuracy of positioning information may be selected. On the other hand, if one or more of the UEs has a reduced capability or low battery capacity, or depending on the channel status (or LoS/NLoS indication), then a policy which minimizes measurement overhead may be selected.

[0157] Another scenario could be that the network has limited radio resources for configuring feedback for positioning measurement reports, in which case the measurement overhead policy could be selected.

[0158] In some examples, a rule may be implemented and followed (for example in the UE or LMF), for instances where one or more UEs requires accurate positioning and one or more UEs has reduced capability. In some examples, the rule is selected by LMF and applied at the UEs. For example, the rule may be that the capabilities of the UE that made the request are prioritized. In another example, the rule may be to prioritize a policy that favours a majority of UEs.

[0159] Two different policy options are briefly described below, as option 1 and option 2.

[0160] <u>Option 1: Positioning accuracy boosting:</u>

[0161] This option may improve the positioning accuracy. In some examples, the same amount of positioning measurements are requested from UE that initiated the request and from co-located UEs: This may include requesting different measurements and/or different measurement types from co-located UEs. For example, different measurement types may comprise one or more of: information from different cells; information on different frequencies; information on different type of measurements. For example, the type of measurement information may comprises at least one of: signal time of arrival (ToA); signal angle of arrival (AoA); reference signal received power (RSRP). The different type of measurement information may then be aggregated to infer an accurate position. This aggregation may also be referred to as fusion, in some examples.

[0162] Option 2: Measurement overhead reduction:

[0163] This option may improve the positioning measurement overhead. For example, this option may reduce signalling associated with positioning. According to some examples, in this option the positioning measurements are requested only from a sub-set of co-located UEs {A}. The rest of co-located UEs {B} do not measure or report any positioning measurements. The position of UEs in set {B} can then be duplicated from the position estimated for the UEs in set {A}. The subset of co-located UEs may include at least one UE.

[0164] At S403, UEs that were identified as co-located (including the requesting UE) are informed that they need to provide measurements. For example, the type of measurements that the co-located UEs are indicated to provide may be based on the positioning optimization policy selected in S402. For example, the LMF may request the positioning measurements from the identified UEs. If the measurement overhead reduction policy had been selected (option 2), then signals (e.g. Positioning Reference Signals (PRS)) for the UEs in set {B} are muted/not transmitted.

[0165] At S404, UE position is estimated based on the selected policy and based on the positioning measurements received from UEs. In examples, the received positioning measurements from the co-located UEs are processed in a manner dependent upon the selected positioning optimization policy.

[0166] For example, if an accuracy improvement policy (option 1) was selected, then an aggregation or fusion-based scheme may be used. This aggregates positioning measurements from co-located UEs. In some examples the aggregation is performed at LMF side. In some examples, two positioning use cases are proposed, namely UE assisted positioning and direct positioning (see Figure 5):

- UE assisted positioning: Each of the co-located UEs performs a different type of measurement. An ML model is run at UE level to process the measurements.

Outputs from the ML model at the UE are sent to LMF to perform the fusion of data and infer the position.

- Direct positioning: Each UE performs a different type of measurement. These sets of measurements are directly reported to LMF. Thereafter, one or more ML models is run on the received measurements at LMF side to process the positioning measurements received from the UEs. This may then be followed by an aggregation or fusion step to estimate the position of the co-located UEs.

[0167] For measurement overhead reduction policy (option 2), in some examples the UE position for UEs in set {A} may be estimated using conventional methods for the selected UEs to report their positioning measurements. For the other UEs (i.e. UEs in set {B}), their position may be duplicated from those in set {A}.

[0168] Figure 5 schematically shows the difference between a UE assisted positioning method and a direct positioning method.

[0169] The left-hand side of Figure 5 schematically shows a UE assisted positioning method. UE1 520 and UE2 522 are in communication with LMF 524. As shown, UE1 520 performs measurement set 1 which are run through an ML application 526. UE2 performs a measurement set 2 that are run through an ML application 528. Outputs from ML application 526 and ML application 528 are sent to LMF 524. At LMF 524, data fusion and position extraction is performed, as schematically shown at 530.

[0170] The right-hand side of Figure 5 schematically shows a direct positioning method. UE1 520 and UE2 522 are in communication with LMF 524. As shown, UE1 520 performs a measurement set 1. UE2 performs a measurement set 2. In this example measurement set 1 is sent to ML application 532 in LMF 524. Measurement set 2 is sent to ML application 534 in LMF 524. In some examples ML applications 532 and 534 may be separate applications. In some examples, ML applications 532 and 534 may be the same ML application. Data fusion and position extraction is then performed at LMF 524, as schematically shown at 536.

[0171] In examples, each of the ML applications may employ a neural network (NN).

[0172] A signalling enhancement approach is discussed with respect to Figure 6 and Figure 7.

[0173] Prior to discussing Figure 6 and Figure 7 in detail, reference may be first made to Figure 12 which schematically shows an exchange of information (e.g. capability information) between a UE and a network entity (such as gNB and/or an LMF).

[0174] UE capability exchange

[0175] According to some examples, UE capability exchange may be used to assist with network-based fusion and UE-based fusion.

[0176] An example of capability exchange is shown with respect to Figure 12, which shows communication between a UE 1202 and the network 1204.

[0177] At S1201, the network 1208 (e.g. gNB and/or an LMF) may send a UE capability enquiry information element to UE 1202. This enquiry information element may include one or more of the following: indicates support for fusion (e.g., the measurement aggregation) at network; queries one or more of UE processing capability, memory, UE type, battery level, whether fusion should be applied at the network; and sidelink capability for fusion (e.g. as part of SIB12 or new AI/ML positioning SIB).

[0178] At S1202, the UE 1202 may transmit UE capability information to network 1208 in case the UE supports the fusion-based positioning. In some examples this may initiate a fusion request at the network. In some examples the UE capability information may be comprised in a new information element (IE) that is signalled from UE to network, in response to the S1201 enquiry. In some examples this new IE may be comprised within SidelinkUEInformationNR signalling.

[0179] Thus, for network based fusion, for “Option 1: Accuracy Improvement” and “Option 2: Measurement Overhead Reduction” (described for example in Figure 6 and Figure 7 respectively below), the network could signal the support of fusion as part of the UECapabilityEnquiry signaling (e.g. S1201 in Figure 12). The UE would then be aware of network-based fusion capability based on the reception of the associated information element (IE) within the capability enquiry message. As a response to this message (e.g. as shown at S1202), the UE could indicate its processing capability / memory, UE type (RedCap, etc.), and request the activation of the fusion option, along with initiating the search for collocated UEs in order to enable this optimization. This request for activation of the fusion option at the network may require a new IE to be included as part of the UECapabilityInformation response from the UE to the network.

[0180] Signaling enhancement

[0181] Now referring back to Figures 6 and 7, these Figures depict signalling messages between co-located UEs 602 and 604, gNB 606 and LMF 608. Although this example is described with respect to two co-located UEs, it will be understood that it can be extended to multiple co-located devices.

[0182] Consider a case where an area is identified as likely to include co-located UEs, such as a metro station, a stadium, or a factory by way of non-limiting examples. An additional condition may be, in some examples, that the UEs have low probability of high velocity, so that UEs remain co-located for long periods. In some examples the area may correspond to a set of cell IDs.

[0183] In some examples, a fusion based scheme (or measurement aggregation) is initiated with UE 602 request at S601 (e.g., this step may be performed as S1202 of Figure 12). Based on its capabilities (e.g. battery level, memory), the UE or REDCAP UE may request additional support from LMF 608 for positioning. This may comprise activation of the fusion option, and the search of co-located UEs to enable this optimization.

[0184] At S602 the LMF 608 identifies co-located UEs based on a predetermined rule or condition. In some examples this rule can be based on the estimated coarse location of the UEs 602 and 604. LMF 608 may utilize a locality databased to identify the co-located UEs.

[0185] In some examples the locality database comprises one or more of the following:

- Distance between UEs, e.g., locality matrix $M_{(ij)}^{t}$ for pair of UEs UE_i and UE_j
- Adjacency indication of UEs, e.g., indicating whether or not a pair of UEs UE_i and UE_j are within a maximum coverage range d_{Max} from each other, such that:

$$M_{(ij)}^{t} = \begin{cases} 1, & if\ distance\ (UE_i, UE_j) < d_{Max} \\ 0, & otherwise \end{cases}$$

- Sidelink (SL) resource allocation mode $Mode_{index}$ of the UEs, e.g., mode 1 or mode 2
- SL resource pool(s) allocated to UEs
- SL resources allocated RB_{ij} to UEs
- SL channel condition between UEs, e.g., LOS/NLOS, pathloss PL_{ij}, RSRP, CSI, etc.
- Associated time stamp (e.g., time *t*) or validity of the above information

[0186] According to some examples, the LMF 608 selects a policy to optimize the co-located UEs positioning. This is schematically shown at S603.

[0187] A first policy option (option 1) may focus on accuracy improvement, as previously described. A second policy option (option 2) may focus on measurement overhead reduction, as previously described. Option 1 is discussed with respect to Figure 6, and option 2 is discussed with respect to Figure 7.

[0188] In the first option, described with respect to Figure 6, the LMF 608 makes a determination to improve positioning accuracy through collaboration among UE1 602 and UE2 604. This may include requesting different measurements from each device (e.g.

different frequencies, cells, measurement types such as RSRP, AoA.). As shown at S604 a request for a positioning measurement M_1 is sent from LMF 608 to UE1 602.

[0189] As shown at S605 a request for a positioning measurement M_2 is sent from LMF 608 to UE2 604.

[0190] At S606, UE1 602 sends first measurement information (e.g., positioning measurement M1) to LMF 608.

[0191] At S607, UE2 604 sends second measurement information (e.g., positioning measurement M2) to LMF 608.

[0192] Thereafter LMF 608 performs fusion based positioning based on the first and second measurement information. For example, the LMF 608 performs measurement aggregation based on the obtained first and second measurements $\{M_1 + M_2\}$, as shown at S608, to estimate accurate position:

Position (UE1) = $f(M_1, M_2)$

Position (UE2) = $f(M_1, M_2)$

[0193] Where f is a fusion function used to aggregate the received measurements (an example fusion function is described in more detail below).

[0194] Note that in some examples UE2 604 can be a PRU (Positioning Reference Unit).

[0195] As shown at S609, the estimated position may be associated to UE1 602 and UE2 604.

[0196] In some examples, the positioning information that has been calculated/measured by the LMF may be only sent to UE1 602 (i.e. the originally requesting UE) as shown at S610. In some examples, the positioning information is also sent to UE2 604 as shown at S611, as this may save the UE2 604 from needing to make a positioning request in future and thus may further reduce signalling overhead.

[0197] In the second option, described with respect to Figure 7, S701 to S703 are analogous to S601 to S603 from Figure 6. Meanwhile, alternatively, or additionally, at S701 the LMF 608 receives the UE capability information element indicating whether a UE supports the measurement aggregation (or fusion) from plurality of UEs. The LMF, at S702, verifies whether the plurality of UEs is co-located or not. If at least two of the plurality of UEs are co-located, then the LMF 608 selects positioning optimization policy for the co-located UEs. In the example of Figure 7, the LMF 608 makes a determination to reduce measurement overhead. Therefore the LMF 608 may transmit a positioning measurement request for at least two UEs, say UE1 602 and UE2 604 for example, as shown at S704. The selection of the UE 602 to perform the measurement among the co-located UEs 602, 604 can be performed on several criteria. For example, such criteria may include battery level and/or ongoing traffic priority. s

[0198] In the example of Figure 7, LMF 608 may select one of measurement type (or, positioning methods) for example TDOA, and request UE1 602 to send required positioning measurements M_1, as shown at S704. The UE1 602 replies with its positioning measurement M1 (e.g., measurement information) as shown at S705.

[0199] Using the positioning measurement M1, the LMF 608 may apply the positioning method on measurements M1 and determines the position of UE1 602, as shown at S706. For example, applying the positioning method may include applying TDOA on ToA measurements (M1) reported by UE1 602.

[0200] Thereafter, the estimated position for UE1 602 is duplicated to UE2 604, as shown at S707.

Position (UE2) = Position (UE1)

[0201] In some examples, the positioning information is only sent to UE1 602 (i.e. the originally requesting UE) as shown at S708. In some examples, the positioning information is also sent to UE2 604 as shown at S709. The location information sent to UE2 604 may be used for enhancing the location service of the UE2 604. Also, by sending the location information without request from the UE2, the UE2 604 is able to further reduce signalling overhead for the positioning request.

[0202] Error! Reference source not found. Figures 6 and 7 provide signalling flows that enables a fusion-based scheme. In some examples, the flow of Figure 6 corresponds to a case of direct positioning for Option 1. However, it will be appreciated that the disclosed method may also be applied to a UE assisted positioning case, where instead of sending directly the measurement sets M1 and M2, an ML function is run at the level of each UE 602, 604, and the ML function outputs are sent to LMF 608 to perform the fusion of data.

[0203] Additionally or alternatively, the UE2 604 may transmit the UE capability information to the network node (e.g., the gNB 606 and/or LMF 608). If the UE capability information indicates the UE2 604 supports the measurement aggregation (e.g., fusion based measurement), then the network node may transmit positioning information of the UE2 periodically or in an event triggered manner to the UE2 604. In this case, the positioning information of the UE2 is measured based on the embodiments (or examples) described above and describe hereinafter. Also, in some examples. the network node may transmit the positioning information without request from the UE2 604.

[0204] Fusion-based approach

[0205] The fusion-based (or aggregation based) approach is described hereinafter in more detail, and the fusion-based approach may be applied to some or all of the embodiments. Fusion, or combining of data and/or data sources, can in some examples efficiently improve positioning performance by combining complementarity among various systems, information and techniques, for accuracy and robustness/stability. An example fusion formulation is shown in Figure 8. Fusion may also be referred to as aggregation, in some examples.

[0206] According to the formulation of Figure 8, weights w are used to efficiently amalgamate positioning results to yield a better estimate. In some examples, w* may be determined using a gradient method or through an ML method. For example, an ML method may be conducted via offline training with supervised learning, or via unsupervised learning in an online phase.

[0207] In terms of algorithms in the algorithm space, the following may be used (by way of non-limiting example):

[0208] Type 1: maximum likelihood (ML), least squares (LS), maximum a posterior (MAP), minimum mean square error (MMSE), hidden Markov model (HMM), Kalman filter, etc.

[0209] Type 2: ML methods, neural network (NN), support vector machine (SVM), k-nearest neighbors, random forests (RF), etc., may be used to integrate positioning information and improve accuracy.

[0210] Consider an example where there are two co-located UEs. A fusion-based scheme is launched according to a UE request for improving positioning accuracy. Collaboration among a UE1 and UE2 is thus initiated. Measurements $M1$ (for example, RSRP, AoA, ...) are obtained from UE1 and measurements $M2$ are obtained from UE2. f is used to denote a fusion function used to aggregate the received measurements for positioning accuracy improvement.

[0211] To optimally fuse M1 and $M2$ for determining the positions of UE1 and UE2, optimal weights are selected for minimizing positioning error.

Position (UE1) = f(w11*$M1$, w12*$M2$)

Position (UE2) = f(w21*$M1$, w22*$M2$)

where wij corresponds to the fusion weights for computing UE i’s position by using measurements Mj. wij’s are chosen to minimize positioning error (it is also possible to consider other network performance metric in other examples).

[0212] In one example, a learning process as shown in Figure 9 is used to determine w11 and w12 for UE1 (as an example), which corresponds to a linear aggregation of the received measurement:

Position (UE i) = $f(\sum$ j wij*Mj).

[0213] Some examples may instead use a gradient descent method for determining the optimal weights. For example, the gradient of f(w11*M1, w12*M2) is given by

$$f'(w11, w12) = \left[\frac{\partial}{\partial w11} f(w11, w12) \quad \frac{\partial}{\partial w12} f(w11, w12)\right]$$

and similarly we can write the gradient of f(w21*M1, w22*M2) below.

$$f'(w21, w22) = \left[\frac{\partial}{\partial w21} f(w21, w22) \quad \frac{\partial}{\partial w22} f(w21, w22)\right]$$

[0214] For given M1 and M2, by following the gradient of 'f' which points in the direction of greatest change of the performance metric, a direction may be chosen in which the positioning error decreases most quickly for determining w11 and w12 for UE1 (by way of example).

[0215] Thus far, communication between gNB and UE has been discussed for UE positioning. The present disclosure also considers use of sidelink (UE-UE) communications for performing accurate UE positioning estimation. The fusion techniques described above can be used at whichever location fusion is taking place e.g. in network (LMF) or at UE.

[0216] <u>Sidelink measurement example</u>

[0217] Some examples will now be described which can utilize sidelink communications (e.g., UE-UE) to optimize positioning. In some sidelink examples the fusion can take place at LMF side and/or UE side.

[0218] New radio (NR) sidelink transmissions have the following two modes of resource allocations:

- Mode 1: Sidelink resources are scheduled by a gNB.
- Mode 2: The UE autonomously selects sidelink resources from a (pre-configured) sidelink resource pool(s) based on a channel sensing mechanism

[0219] In mode 2, the UE performs resource sensing. When traffic arrives at a UE, the transmitting UE sets a time instant as a trigger of the resource (re)selection, which time instant may be denoted as n. Time instant n may also be considered the time instant at which a UE would need to transmit data to its neighbouring UE through sidelink. Prior to and after n, two windows called the “sensing window” and “selection window” are set, respectively.

[0220] During the sensing window (from the time instant T0 to n), the transmitting UE measures the reference signal received power (RSRP) of all the considered subchannels. In some examples RSRP may be considered the power level of DMRS (demodulation reference signal) on the PSSCH (physical sidelink shared channel) or the DMRS on the PSCCH (physical sidelink control channel) depending on the configuration. To measure the RSRP, a transmitting UE should know the resources of the PSSCH or the PSSCH launched by other UEs. For this purpose, a transmitting UE may detect the PSCCH (and thus receive the sidelink control information (SCI)) launched by other UEs to know which subchannels have been occupied by other sidelink transmitters.

[0221] The described sidelink measurement can be applied to the embodiments related to the sidelink operation of the UEs.

[0222] <u>LMF based fusion for the sidelink measurement</u>

[0223] In the case of network or LMF-based fusion, sidelink information may be used to identify co-located UEs. In some examples and corresponding to S401 of Figure 4, UEs are identified as co-located if the measured RSRP_sidelink is below a predefined threshold. For an area that is likely to have a case of co-located UEs (e.g. a mall), the LMF can send a request to the UEs to use sidelink measurements and inform the LMF if the co-location condition is verified.

[0224] In some examples, the LMF establishes a rule or condition in order to identify co-located UEs. In one example this rule can be in the form of comparing RSRP_sidelink to a predefined threshold. If $RSRP_{sidelink} > th$, then UE indicates to the LMF the UE IDs verifying this condition (with possible sidelink information). In some examples, in order to assist, the network can indicate to the UE the IDs of UEs that are probable to be close to the UE, and the UE can perform side link measurements with those identified UEs accordingly. Additionally or alternatively, in some examples a UE can perform a “sidelink discovery” procedure to check if there are neighboring / close UEs.

[0225] In some examples, the sidelink threshold parameter th is selected based on required localization accuracy. In some examples, this means that if highly accurate location information is required then a correspondingly low sidelink threshold is required, corresponding to very close UEs. However, in case only low accuracy is required, the sidelink threshold condition th can be relaxed.

[0226] Corresponding to S404 of Figure 4, the LMF can then aggregate the obtained measurements $\{M_1 + M_2\}$ to estimate accurate UE position. In some examples the LMF can use the sidelink information $\{SL_{1,2}\}$ to account for a small distance between UE1 and UE2, and can accordingly tune the measurements when estimating the position

Position (UE1) = $f(M_1, M_2, SL_{1,2})$

Position (UE2) = $f(M_1, M_2, SL_{2,1})$

Where f is a fusion function used to aggregate the received measurements.

[0227] Figure 10 shows an example signalling flow for LMF based fusion, with the use of sidelink information.

[0228] Prior to discussing Figure 10 in detail, it is helpful to refer to Figure 13 which shows UE capability exchange on the sidelink.

[0229] UE-based fusion for sidelink

[0230] Currently, sidelink related communication configuration is signalled by the network to the UE using SIB12. Thus, the network could enquire for UE-based fusion using sidelink, by adding a new information element within this SIB (or alternatively using a new AI/ML based positioning SIB) or a separate RRC message or RRC IE. Upon receiving this IE, UE responds to the network, using a new IE within SidelinkUEInformationNR, providing additional information related to fusion capabilities for positioning. In some examples, the network may also determine which UE should be the entity conducting the fusion based positioning, based on such signalling exchange as well.

[0231] An example of the RRC signaling related to UE capability exchange related to UE-based fusion is as shown in Figure 13, which shows communication between UE1 1302 and UE2 1304. The step 1103 in Figure 11 between UE1 and UE2 corresponds to the signalling shown in Figure 13, clarifying the possible RRC signalling involved for the fusion request (e.g., measurement aggregation request) between the UEs.

[0232] As shown at S1301, UE1 1302 indicates to UE2 1304 whether the UE1 supports the fusion-based positioning. In some examples, UE1 1302 may also configure UE2 not to separately report its location to the network. This information may be comprised in an RRCReconfigurationSidelink message. In this case, the UE2 sends the positioning measurement information to the UE1.

[0233] As shown at S1302, the UE2 S1304 indicates that it accepts the fusion-based positioning method. UE2 1304 may also signal to UE1 1304 its positioning measurements (e.g., M2). In some examples, this information is comprised in an RRCReconfigurationCompleteSidelink message.

[0234] Reference is now made back to Figure 10.

[0235] At S1001, the UE1 1002 sends a request to LMF 1008. For example, this may be a positioning request including UE capability information. The request may also indicate that a fusion technique is sought.

[0236] At S1002 and S1003, LMF 1008 indicates to UE1 1002 and UE2 1004 respectively the co-location triggering conditions (e.g. threshold value th, described above).

[0237] At S1004, UE1 1002 and/or UE2 1004 verify whether they are co-located. In practice this step could occur at one or both of UE1 1002 and UE2 1004.

[0238] In this example, at S1005, the UE1 1002 indicates to LMF 1008 that it is co-located with UE2 1004. UE1 1002 may also provide sidelink information in this step. For example, the sidelink information could include RSRP measured by UE1 on the channel between UE1 and UE2.

[0239] In this example, at S1006, the UE2 1004 indicates to LMF 1008 that it is co-located with UE1 1002. UE2 1004 may also provide sidelink information in this step. S1006 may be optionally performed.

[0240] At S1007, based on received information, the LMF 1008 then selects a positioning optimization policy for co-located UEs.

[0241] Thereafter, the methods described in Figure 6 or Figure 7 may be followed, dependent upon the selected policy.

[0242] <u>UE based fusion for the sidelink measurement</u>

[0243] Also considered in the present disclosure is a case where UE position is estimated at the UE side. A fusion scheme may then be used by the UE using its own measurements, and the measurements (or ML output) from neighbouring co-located UE through sidelink.

[0244] Figure 11 depicts an example signalling diagram for a case of UE based fusion, which shows signalling between a UE1 1102, UE2 1104, gNB 1106 and LMF 1108. Considering an ML model running at UE side to estimate position of a UE, the LMF can assist by way of an indication to the UE to perform fusion based positioning. Such a request is shown at S1101. In some examples this request at S1101 can be performed following determination of the coarse positions of co-located UEs, and the identification of close by devices.

[0245] Upon reception of the LMF request, UE1 1102 performs sidelink measurements and identifies UE2 1104 as close (i.e., co-located) (eg. Sidelink RSRP < predefined threshold). This is shown at S1102. In some examples where the LMF 1108 has already performed an estimation of co-located UEs based on coarse information, then S1102 can be considered a verification step.

[0246] As shown at S1103, a request message is then transmitted to UE2 1104 to indicate which positioning measurements are needed (set M2, for example). The UE1 1102 may also indicate a need to get M2 measurements directly from UE2 1104, or from the output of an ML model using these measurements M2.

[0247] As shown at S1104, the UE2 1104 performs positioning measurement based on the request sent at S1103. For example, the positioning measurements may be based on positioning reference signals (PRS).

[0248] At S1105, UE1 1102 performs its own M1 measurements that is differently measured from M2 measurements. For example, the positioning measurements may be based on PRS.

[0249] At S1106, UE2 1104 sends M2 measurements (e.g., measurement information of the UE2) to UE1 1102. In some examples this could occur before S1105.

[0250] Thereafter, at S1107 UE1 1102 performs a fusion based positioning based on both M1 and M2 measurements. In this case, at least one of the M1 or M2 measurement is ML outputs.

[0251] The estimated position by UE1 1102 is shared with UE2 1104 and LMF 1108, as shown at S1108 and S1109 respectively. The estimated position is transmitted to the LMF 1108.

[0252] In some examples, step S1108 is optionally performed. When step 1108 is performed, future signaling for positioning can be reduced, in case UE2 1104 subsequently needs accurate positioning information (in which case it does not need to perform an additional positioning procedure).

[0253] It will be understood that where ML models are referred to, then these models may be trained in an appropriate way. For example, where a ML model is used for inferring location information based on measurements, then that ML model may be trained with historical or pre-configured data pertaining to associations between location (or relative locations) and measurements. For example, training data may include correlations between RSRP and proximity between UEs.

[0254] As discussed herein, UEs that are within a certain proximity of each other may be considered co-located. In examples, and discussed herein, what constitutes co-located may vary between situations. In some examples, whether UEs are considered co-located is dependent upon one or more threshold values. For example, threshold RSRP values may be used to determine if UEs are co-located. In some examples, GPS coordinates or classical non-AI/ML-based mechanisms such as AoA/TDoA/ToA based position estimation may be used to determine whether UEs are co-located.

[0255] It will be understood that in a number of examples, two co-located UEs (e.g. UE1 and UE2) are depicted for the purpose of explanation. However, it will be appreciated that this is by way of example only and that more than two UEs may be co-located in other examples.

[0256] A possible wireless communication device will now be described in more detail with reference to Figure 14 showing a schematic, partially sectioned view of a communication device 1400. Such a communication device is often referred to as user equipment (UE), user device, or terminal, and these names may be used interchangeably. The wireless device 1400 may receive signals over an air or radio interface 1407 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 14 transceiver apparatus is designated schematically by block 1406. The transceiver apparatus 1406 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the wireless device. A wireless device is typically provided with at least one data processing entity 1401, at least one memory 1402 and other possible components 1403 for use in software and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 1404. The user may control the operation of the wireless device by means of a suitable user interface such as key pad 1405, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 1408, a speaker and a microphone can be also provided. Furthermore, a wireless communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto. UEs described herein (e.g. UEs 520, 522, 602, 604, 1002, 1004, 1102, 1104, 1202, 1302, 1304) may be in the form of communication device 1400 shown in Figure 14.

[0257] Figure 15 shows an example of a control apparatus for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a RAN node, e.g. a base station, gNB, a central unit of a cloud architecture or a node of a core network such as an MME or S-GW, a scheduling entity such as a spectrum management entity, or a server or host, or a network function such as an LMF. The control apparatus 1500 comprises at least one memory 1501, at least one data processing unit 1502, 1503 and an input/output interface 1504. According to some examples, gNBs 606, 1006, 1106 may be in the form of control apparatus 1500. Likewise, LMF 524, 608, 1008, 1108, 1208 may be in the form of control apparatus 1500.

[0258] Figures 16 to 21 are flow charts according to some examples.

[0259] Figure 16 is a flow chart of a method according to an example, viewed from the perspective of an apparatus such as an LMF.

[0260] As shown at S1601, the method comprises receiving first measurement information from a first user device.

[0261] At S1602, the method comprises receiving second measurement information from a second user device.

[0262] At S1603 the method comprises determining a position of the first user device based on the first measurement information and the second measurement information; wherein the first user device and the second user device are co-located with each other; and wherein a type of the first measurement information is different from a type of the second measurement information.

[0263] Figure 17 is a flow chart of a method according to an example, viewed from the perspective of an apparatus such as a user device.

[0264] As shown at S1701, the method comprises sending from a first user device first measurement information to a network entity.

[0265] As shown at S1702, the method comprises receiving positioning information that is determined based on the first measurement information and second measurement information of a second user device; wherein the first user device is co-located with the second user device, and wherein a type of the first measurement information is different from a type of the second measurement information.

[0266] Figure 18 is a flow chart of a method according to an example, viewed from the perspective of an apparatus such as an LMF.

[0267] As shown at S1801, the method comprises receiving capability information from one or more user devices including a first user device.

[0268] At S1802 the method comprises determining position information of the first user device based on measurement information of the first user device.

[0269] At S1803 the method comprises determining position information of a second user device by duplicating the measurement information of the first user device; wherein the second user device is co-located with the first user device.

[0270] Figure 19 is a flow chart of a method according to an example, viewed from the perspective of an apparatus such as a user device.

[0271] As shown at S1901, the method comprises sending, from an apparatus, capability information to a network entity.

[0272] As shown at S1902, the method comprises receiving, from the network entity, position information for the apparatus; wherein the apparatus is co-located with a user device, and wherein the position information of the apparatus has been determined by duplicating measurement information of the user device.

[0273] Figure 20 is a flow chart of a method according to an example, viewed from the perspective of an apparatus such as a user device.

[0274] As shown at S2001, the method comprises measuring, by a first user device, first measurement information relating to the first user device, using a first measurement type.

[0275] As shown at S2002, the method comprises receiving, from a second user device that is co-located with the first user device, second measurement information measured based on a second measurement type.

[0276] As shown at S2003, the method comprises performing a measurement aggregation based on an aggregation of the first measurement information and the second measurement information

[0277] Figure 21 is a flow chart of a method according to an example, viewed from the perspective of an apparatus such as an LMF.

[0278] As shown at S2101, the method comprises receiving capability information from two or more user devices.

[0279] As shown at S2102, the method comprises using the capability information to determine whether to select either: (i) a positioning method for the two or more user devices that prioritises accuracy of a positioning result; or (ii) a positioning method for the two or more user devices that prioritises minimising a measurement overhead.

[0280] Figure 22 shows a schematic representation of non-volatile memory media 2200a (e.g. computer disc (CD) or digital versatile disc (DVD)) and 2200b (e.g. universal serial bus (USB) memory stick) storing instructions and/or parameters 2202 which when executed by a processor allow the processor to perform one or more of the steps of the methods of Figures 16 to 21. In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects of the disclosure may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0281] It should be understood that the apparatuses may comprise or be coupled to other units or modules etc., such as radio parts or radio heads, used in or for transmission and/or reception. Although the apparatuses have been described as one entity, different modules and memory may be implemented in one or more physical or logical entities.

[0282] It is noted that whilst some embodiments have been described in relation to 5G networks, similar principles can be applied in relation to other networks and communication systems. Therefore, although certain embodiments were described above by way of example with reference to certain example architectures for wireless networks, technologies and standards, embodiments may be applied to any other suitable forms of communication systems than those illustrated and described herein.

[0283] It is also noted herein that while the above describes example embodiments, there are several variations and modifications which may be made to the disclosed solution without departing from the scope of the present invention.

[0284] As used herein, “at least one of the following: <a list of two or more elements>” and “at least one of <a list of two or more elements>” and similar wording, where the list of two or more elements are joined by “and” or “or”, mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements, or any combination of the elements. Likewise, it will be understood that the phrase “and/or” between two features can mean either one of the two features alone (“or”), or both features together (“and”).

[0285] In general, the various embodiments may be implemented in hardware or special purpose circuitry, software, logic or any combination thereof. Some aspects of the disclosure may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the disclosure is not limited thereto. While various aspects of the disclosure may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0286] As used in this application, the term “circuitry” may refer to one or more or all of the following:

(a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and

(b) combinations of hardware circuits and software, such as (as applicable):

[0287] a combination of analog and/or digital hardware circuit(s) with software/firmware and

[0288] (ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and

[0289] (c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation.”

[0290] This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.

[0291] The embodiments of this disclosure may be implemented by computer software executable by a data processor of the mobile device, such as in the processor entity, or by hardware, or by a combination of software and hardware. Computer software or program, also called program product, including software routines, applets and/or macros, may be stored in any apparatus-readable data storage medium and they comprise program instructions to perform particular tasks. A computer program product may comprise one or more computer-executable components which, when the program is run, are configured to carry out embodiments. The one or more computer-executable components may be at least one software code or portions of it.

[0292] Further in this regard it should be noted that any blocks of the logic flow as in the Figures may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. The software may be stored on such physical media as memory chips, or memory blocks implemented within the processor, magnetic media such as hard disk or floppy disks, and optical media such as for example DVD and the data variants thereof, CD. The physical media is a non-transitory media.

[0293] The term “non-transitory,” as used herein, is a limitation of the medium itself (i.e., tangible, not a signal) as opposed to a limitation on data storage persistency (e.g., RAM vs. ROM).

[0294] The memory may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The data processors may be of any type suitable to the local technical environment, and may comprise one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASIC), FPGA, gate level circuits and processors based on multi core processor architecture, as non-limiting examples.

[0295] Embodiments of the disclosure may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

[0296] The scope of protection sought for various embodiments of the disclosure is set out by the independent claims. The embodiments and features, if any, described in this specification that do not fall under the scope of the independent claims are to be interpreted as examples useful for understanding various embodiments of the disclosure.

[0297] The foregoing description has provided by way of non-limiting examples a full and informative description of the exemplary embodiment of this disclosure. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this disclosure will still fall within the scope of this invention as defined in the appended claims. Indeed, there is a further embodiment comprising a combination of one or more embodiments with any of the other embodiments previously discussed.

CLAIMS

1. An apparatus comprising:

means for receiving capability information from one or more user devices including a first user device;

means for determining position information of a first user device based on measurement information of the first user device; and

means for determining position information of a second user device by duplicating the measurement information of the first user device;

wherein the second user device is co-located with the first user device.

2. The apparatus of claim 1, wherein the capability information is indicative of support for measurement aggregation of measurements, and wherein at least the first user device supports measurement aggregation.

3. The apparatus of claim 1 or claim 2, further comprising:

means for transmitting a positioning measurement request message based on the capability information; and

means for receiving measurement information from the first user device.

4. The apparatus of any of claims 1 to 3, wherein the capability information further comprises information related to one or more of: battery level; processor capability; memory capability of the first user device.

5. The apparatus of any of claims 1 to 3, wherein the means for determining position information of the second user device is configured to do so without receiving any measurement information from the second user device.

6. The apparatus according to any of claims 1 to 5, wherein the apparatus comprises means for determining whether the first user device is co-located with the second user device.

7. The apparatus according to any of claims 1 to 6, wherein the apparatus comprises means for receiving information that the first user equipment is co-located with the second

user equipment, based on sidelink information communicated between the first and second user equipment.

8. The apparatus according to any of claims 1 to 7, wherein capability information of the first user device is included in a positioning request transmitted from the first user device.

9. The apparatus according to any of claims 1 to 7, comprising means for sending the determined position information to at least one of the first user equipment or the second user equipment.

10. An apparatus comprising:

means for sending capability information to a network entity;

means for receiving, from the network entity, position information for the apparatus; and

wherein the apparatus is co-located with a user device, and

wherein the position information of the apparatus has been determined by duplicating measurement information of the user device.

11, The apparatus of claim 10, wherein the capability information is indicative of support for measurement aggregation of measurements, and wherein the apparatus supports measurement aggregation.

12. The apparatus according to claim 10 or claim 11, wherein the apparatus is configured to receive the position information without having to send measurement information to the network entity.

13. The apparatus according to any of claims 10 to 12, wherein the capability information further comprises information related to one or more of: battery level; processor capability; memory capability of the apparatus.

14. The apparatus according to any of claims 10 to 13, comprising:

means for determining whether the apparatus is co-located with the user device, based on sidelink communication between the apparatus and the user device.

15. A method comprising:

receiving capability information from one or more user devices including a first user device;

determining position information of the first user device based on measurement information of the first user device; and

determining position information of a second user device by duplicating the measurement information of the first user device;

wherein the second user device is co-located with the first user device.

16. A method comprising:

sending, from an apparatus, capability information to a network entity;

receiving, from the network entity, position information for the apparatus; and

wherein the apparatus is co-located with a user device, and

wherein the position information of the apparatus has been determined by duplicating measurement information of the user device.

17. A computer program comprising instructions for causing an apparatus to perform at least the following:

receiving capability information from one or more user devices including a first user device;

determining position information of the first user device based on measurement information of the first user device; and

determining position information of a second user device by duplicating the measurement information of the first user device;

wherein the second user device is co-located with the first user device.

18. A computer program comprising instructions for causing an apparatus to perform at least the following:

sending capability information to a network entity;

receiving, from the network entity, position information for the apparatus; and

wherein the apparatus is co-located with a user device, and

wherein the position information of the apparatus has been determined by duplicating measurement information of the user device.

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Claims searched: 1-18 **Date of search:** 11 May 2023

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-18	US 2021/0099832 A1 (DUAN et al.) - see paragraph [0112].
X	1-18	US 2022/0065979 A1 (BAO et al.) - see paragraph [0081].
X	1-18	EP 2523013 A1 (CAMBRIDGE SILICON RADIO LTD) - see paragraphs [0025] and [0039].
A,E	-	US 2023/0121104 A1 (WU et al.) - see whole document.
A	-	US 2022/0046386 A1 (SUNDARARAJAN et al.) - see whole document, especially paragraph [051].

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

G01S; H04W

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, Patent Fulltext, XP3GPP

International Classification:

Subclass	Subgroup	Valid From
H04W	0064/00	01/01/2009
G01S	0005/02	01/01/2010
H04W	0004/02	01/01/2018