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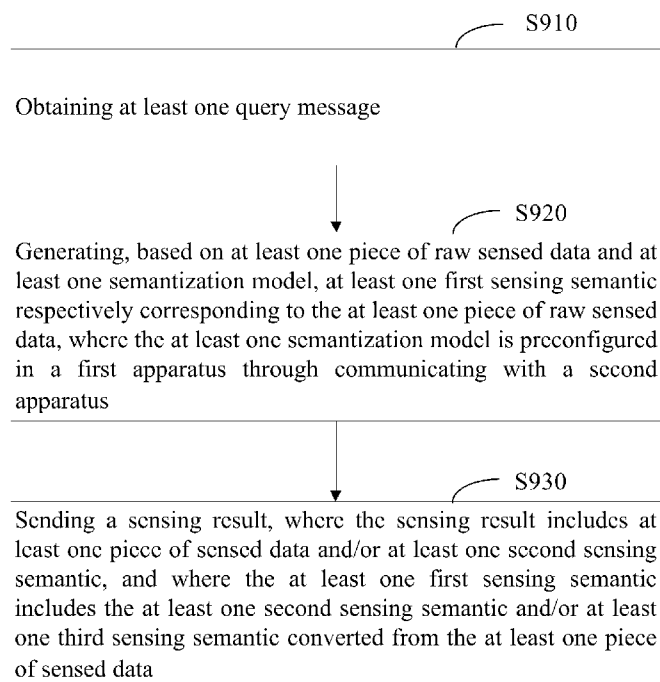


FIG. 9

(57) Abstract: Provided are a sensing communication method, apparatus, and system. An apparatus such as a central device can broadcast or multi-cast or unicast query message(s), so that other apparatus(es) such as one or more sensing devices can obtain the query message(s) and respond with sensing result(s) in response to the obtained query message(s). The sensing result(s) may include the at least one piece of sensed data and/or the at least one second sensing semantic, where the at least one second sensing semantic and/or the at least one third sensing semantic converted from the at least one piece of sensed data are included in the at least one first sensing semantic, which is generated based on at least one piece of raw sensed data and at least one semantization model preconfigured in the sensing device through communicating with the central device. Thus, query may be conducted more flexibly and reasonably based on the at least one semantization model. Moreover, the at least one semantization model can be trained by the sensing device jointly



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with the central device, and thus the consistence of the at least one semantization model may be guaranteed, and thus flexibility and reasonability of query may be further improved based on the consistent semantization model. Furthermore, the outdated semantization model may be updated, and thus the accuracy of query could be improved.

# METHOD, APPARATUS, AND SYSTEM FOR SEMANTIC COMMUNICATIONS

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to US provisional patent application No. 63/509,393, filed on June 21, 2023, which is hereby incorporated by reference in its entirety.

## TECHNICAL FIELD

[0002] The present disclosure relates generally to the field of sensing communication technologies and, in particular, to a sensing communication method, apparatus, and system.

## BACKGROUND

[0003] A sensing function will be integrated into the 6th generation (6G) system. A large number of the sensing user equipments (UEs) or sensing devices will be densely deployed in cities, factories, farms and so on. In addition to mobile phones, sensing devices will become an important type of UEs or devices that claim an arrival of IoT time.

[0004] Like internet searching engines, 6G will come up with the counterpart, an internet of thing (IoT) searching engine, in a true physical world. In fact, billions of IoT-based applications such as driverless cars, automation factories, smart cities, and autonomous farms, will heavily depend on an efficient and real-time searching engine in our physical world.

[0005] Recently, artificial intelligence (AI) has conquered various intellectual and cognitive domains. Some AI is exploring the cutting edge of our intellectual knowledge in chemistry, gaming, mathematic, gene engineering. Some other AI is providing a human-level Q&A platform in the digital world; the domain that AI hasn't conquered is real-time physical world. Physical-world AI, in which AI technologies are to penetrate into all the aspects of our society and life, may be built on omnipresent IoT connections thanks to 6G.

[0006] More challenging than internet searching engine, real-world searching engine would have to search the

physical world in real time over a large scale of physical areas and to deal with a multitude of types of data and information (some may be novel and some may haven't been invented yet). Furthermore, green technology, low-energy and low-emission, are also raised as key feature of 6G. A sensing device may be battery powered and/or completely powered by solar and wind. It would be costly and impracticable to ask all the sensing devices in a large scale to feedback what they are sensing at the same time. On one hand, the frequent sensing and transmission consumes a sensing device much energy and reduce their battery life time; on other hand, such a high density of the IoT deployment may block the uplink channels, especially the uplink (UL) bandwidth is more expensive than the downlink (DL) one.

[0007] This background information is provided to reveal information believed by the applicant to be of possible relevance to the present disclosure. No admission is necessarily intended, nor should be construed, that any of the preceding information constitutes prior art against the present disclosure.

## SUMMARY

[0008] In a first aspect, the present disclosure provides a sensing communication method, where the method includes:

obtaining at least one query message;  
generating, based on at least one piece of raw sensed data and at least one semantization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data, where the at least one semantization model is preconfigured in a first apparatus through communicating with a second apparatus; and  
sending a sensing result, where the sensing result includes at least one piece of sensed data and/or at least one second sensing semantic, and where the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

[0009] Because the at least one first sensing semantic may be generated based on the at least one piece of raw sensed data and the at least one semantization model preconfigured in the first apparatus through communicating with the second apparatus, query may be conducted more flexibly and reasonably based on the at least one semantization model.

[0010] In a possible implementation of the first aspect, before the obtaining at least one query message, the method further includes:

obtaining a semantization model configuration, where the semantization model configuration indicates the at least one semantization model.

[0011] Because the semantization model configuration may be obtained in advance, the semantization model indicated in the semantization model configuration can be used to convert the sensed data to a sensing semantic (and/or convert the query message to a query semantic if necessary), thereby realizing the configuration of the semantization model, and thus facilitating the generation of the sensing semantic and further improving the flexibility of query.

[0012] In a possible implementation of the first aspect, the at least one semantization model is represented by  $\{M_1, M_2, \dots M_s\}$ ,  $s \geq 1$ , where the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$  corresponds to a task and/or a modality.

[0013] Because each of the at least one semantization model may correspond to a task and/or a modality, query may be conducted more flexibly and reasonably according to the task and/or modality.

[0014] In a possible implementation of the first aspect, the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0015] Because the semantization model configuration may further indicate the at least one identifier, the semantization model can be determined for a task with a task identifier, or a modality with a modality identifier, or a combination of a task and a modality with task and modality identifiers when generating the sensing semantic, and thus flexibility and reasonability of query may be further improved based on the at least one identifier indicated in the semantization model configuration.

[0016] In a possible implementation of the first aspect, the generating, based on at least one piece of raw sensed data and at least one semantization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data includes:

generating the at least one first sensing semantic  $\{o_1, o_2, \dots, o_s\}$  based on the at least one piece of raw sensed data and at least one semantization model  $\{M_1, M_2, \dots M_s\}$ , where a first sensing semantic  $o_i$  is generated based on a piece of raw sensed data to which the first sensing semantic  $o_i$  corresponds and a semantization model  $M_i$ ,  $i \in [1, s]$ .

[0017] Because the at least one piece of raw sensed data may be converted to at least one first sensing semantic based on the at least one semantization model which is obtained in advance, whether the raw sensed data is matched with the query message can be determined from the perspective of the semantic, and thus the query can

be conducted more conveniently.

[0018] In a possible implementation of the first aspect, when the at least one identifier includes a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; M_1, M_2, \dots M_s\}$ , where  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

5 [0019] In a possible implementation of the first aspect, when the at least one identifier includes a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; t'_1, t'_2, \dots t'_s; M_1, M_2, \dots M_s\}$ , where  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0020] Different representations of the semantization model configuration are provided for the case where the  
10 at least one identifier includes a single identifier, i.e., a task identifier or a modality identifier, and the case where the at least one identifier includes both a task identifier and a modality, and thus the configuration of the semantization model is more conveniently, and flexibility and reasonability of query may be further improved based on the identifier(s) indicated in the semantization model configuration.

[0021] In a possible implementation of the first aspect, one or more semantization models of the at least one  
15 semantization model in the semantization model configuration are compressed.

[0022] Because one or more semantization models of the at least one semantization model in the semantization model configuration may be compressed, the resource consumption may be reduced.

[0023] In a possible implementation of the first aspect, a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in  
20 the semantization model configuration.

[0024] In a possible implementation of the first aspect, a compression approach for each of the one or more semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0025] Because the compression approach and/or compression parameters for each of the one or more semantization models may be configured previously, pre-defined, or carried in the semantization model  
25 configuration, where various compression approaches could be adopted, the compression may be conducted more flexibly and reasonably.

[0026] In a possible implementation of the first aspect, when at least one semantization model in the semantization model configuration is outdated, the method further includes:

obtaining a semantization model update, where the semantization model update includes at least one  
30 updated semantization model respectively corresponding to at least one outdated semantization model.

[0027] Because the outdated semantization model may be updated, the accuracy of query could be improved.

[0028] In a possible implementation of the first aspect, one or more updated semantization models of the at least one updated semantization model in the semantization model update are compressed.

5 [0029] Because one or more updated semantization models of the at least one updated semantization model in the semantization model update may be compressed, the resource consumption may be generally reduced.

[0030] In a possible implementation of the first aspect, a compression approach for each of the one or more updated semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0031] Because the various compression approaches could be adopted, the compression may be conducted more flexibly and reasonably.

10 [0032] In a possible implementation of the first aspect, the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

[0033] Because the at least one updated semantization model may be compressed based on the difference between the updated semantization model and the corresponding outdated semantization model, the resource consumption may be further reduced.

15 [0034] In a possible implementation of the first aspect, a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update.

[0035] Because the compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update, the  
20 flexible and reasonable compression can be further improved.

[0036] In a possible implementation of the first aspect, the method further includes:  
training, by the first apparatus, at least one semantization model, jointly with the second apparatus.

[0037] Because the at least one semantization model can be trained by the first apparatus jointly with the second apparatus, the consistence of the at least one semantization model may be guaranteed, and thus flexibility  
25 and reasonability of query may be further improved based on the consistent semantization model.

[0038] In a possible implementation of the first aspect, the training, by the first apparatus, at least one semantization model, jointly with the second apparatus includes:

communicating, by the first apparatus, with the second apparatus, intermediate information generated in the training of the at least one semantization model, where the intermediate information includes intermediate  
30 features, or gradients generated in the training; and

training, by the first apparatus, the at least one semantization model, jointly with the second apparatus based on the intermediate information.

[0039] Because the intermediate information which may include intermediate features or gradients generated in the training of the at least one semantization model is communicated between the first apparatus and the second apparatus, the training is conducted based on the intermediate information, and thus the training of the semantization model can be jointly conducted by the first apparatus and the second apparatus without knowing the exact structure of the semantization model used on the other side, which is especially suitable for a situation where the semantization model is required to be kept private or cannot be known by the other side, for example, a situation where first apparatus and the second apparatus belong to different parties or corporations, and thereby, another way for configuring the semantization model is provided.

[0040] In a possible implementation of the first aspect, the method further includes:

obtaining at least one identifier for the at least one semantization model to be trained, where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0041] Because the at least one identifier including a task identifier, or a modality identifier, or both a task identifier and a modality identifier may be obtained, the semantization model to be trained can be determined according to the task identifier, or the modality identifier, or the combination of task and modality identifiers, thereby facilitating the training of the semantization model and further improving the flexibility and reasonability of query.

[0042] In a possible implementation of the first aspect, when at least one semantization model trained by the first apparatus jointly with the second apparatus is outdated, the method further includes:

updating, by the first apparatus, the at least one outdated semantization model, jointly with the second apparatus.

[0043] In a possible implementation of the first aspect, the updating, by the first apparatus, the at least one outdated semantization model, jointly with the second apparatus includes:

when multiple outdated semantization models exist, updating, by the first apparatus, one or more outdated semantization models, jointly with the second apparatus at a time.

[0044] Because the outdated semantization model may be updated, the accuracy of query can be improved. When multiple outdated models exist, one or more outdated models may be updated at a time, which can be determined according to actual demands, thereby improving the flexibility of the updating of the outdated semantization models.

[0045] In a possible implementation of the first aspect, the obtaining a semantization model configuration includes:

obtaining the semantization model configuration via a broadcast message;

5 obtaining the semantization model configuration via a multicast message targeted to a group of first apparatuses; or

obtaining the semantization model configuration via a dedicated message to the first apparatus.

[0046] By means of broadcasting or multicasting, a large number of apparatuses may be scheduled rather than one-to-one individual scheduling, the resource consumption can be reduced. By means of unicasting, one-to-one individual scheduling can be achieved for special query dedicated to a specific apparatus.

10 [0047] In a possible implementation of the first aspect, the broadcast message includes:

a synchronization signal and physical broadcast channel block (SSB); or

a system information block (SIB) message.

[0048] In a possible implementation of the first aspect, each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

15 [0049] Because each query message may correspond to a task, a modality, or a combination of the task and the modality, the query may be conducted more flexibly and reasonably according to the task and/or modality.

[0050] In a possible implementation of the first aspect, each of the at least one query message includes at least one identifier, where the at least one identifier includes a task identifier, a modality identifier, or both a task identifier and a modality identifier.

20 [0051] In a possible implementation of the first aspect, the method further includes:

obtaining the at least one semantization model based on the at least one identifier for the at least one semantization model in the at least one query message.

[0052] Because the at least one query message may include at least one identifier and the at least one semantization model may be obtained based on the at least one identifier, the at least one semantization model may  
25 be directly obtained in a high efficiency way, and a suitable semantization model can be obtained for a specific task and/or a specific modality.

[0053] In a possible implementation of the first aspect, the at least one piece of sensed data includes at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

[0054] Because the at least one piece of sensed data may include at least one piece of raw sensed data, half  
30 raw sensed data, or compressed sensed data, diversity of sensed data would be obtained.

[0055] In a second aspect, the present disclosure provides a sensing communication method, where the method includes:

sending at least one query message; and

obtaining one or more sensing results, where each of the one or more sensing results includes at least one piece of sensed data and/or at least one second sensing semantic, and where at least one first sensing semantic respectively corresponds to at least one piece of raw sensed data and is generated based on the at least one piece of raw sensed data and at least one semantization model which is preconfigured in at least one first apparatus through communicating with a second apparatus, and the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

10 [0056] Because the at least one first sensing semantic may be generated based on the at least one piece of raw sensed data and the at least one semantization model preconfigured in the at least one first apparatus through communicating with the second apparatus, query may be conducted more flexibly and reasonably based on the at least one semantization model.

15 [0057] In a possible implementation of the second aspect, before the sending at least one query message, the method further includes:

sending a semantization model configuration, where the semantization model configuration indicates the at least one semantization model.

20 [0058] Because the semantization model configuration may be sent in advance, the semantization model indicated in the semantization model configuration can be used to convert the sensed data to a sensing semantic (and/or convert the query message to a query semantic if necessary), thereby realizing the configuration of the semantization model, and thus facilitating the generation of the sensing semantic and further improving the flexibility of query.

[0059] In a possible implementation of the second aspect, the at least one semantization model is represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , where the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$  corresponds to a task and/or a modality.

[0060] Because each of the at least one semantization model may correspond to a task and/or a modality, query may be conducted more flexibly and reasonably according to the task and/or modality.

30 [0061] In a possible implementation of the second aspect, the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0062] Because the sent semantization model configuration may further indicate the at least one identifier, the semantization model can be determined for a task with a task identifier, or a modality with a modality identifier, or the combination of task and modality with task and modality identifiers when generating the sensing semantic, and thus flexibility and reasonability of query may be further improved based on the at least one identifier indicated in the semantization model configuration.

[0063] In a possible implementation of the second aspect, when the at least one identifier includes a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; M_1, M_2, \dots M_s\}$ , where  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0064] In a possible implementation of the second aspect, when the at least one identifier includes a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; t'_1, t'_2, \dots t'_s; M_1, M_2, \dots M_s\}$ , where  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0065] Different representations of the semantization model configuration are provided for the case where the at least one identifier includes a single identifier, i.e., a task identifier or a modality identifier, and the case where the at least one identifier includes both a task identifier and a modality, and thus the configuration of the semantization model is more conveniently, and flexibility and reasonability of query may be further improved based on the identifier(s) indicated in the semantization model configuration.

[0066] In a possible implementation of the second aspect, the method further includes:

compressing one or more semantization models of the at least one semantization model in the semantization model configuration.

[0067] Because one or more semantization models of the at least one semantization model in the semantization model configuration may be compressed, the resource consumption may be reduced.

[0068] In a possible implementation of the second aspect, a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

[0069] In a possible implementation of the second aspect, a compression approach for each of the one or more semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0070] Because the compression approach and/or compression parameters for each of the one or more semantization models may be configured previously, pre-defined, or carried in the semantization model configuration, where various compression approaches could be adopted, the compression may be conducted more

flexibly and reasonably.

[0071] In a possible implementation of the second aspect, when at least one semantization model in the semantization model configuration is outdated, the method further includes:

5 sending a semantization model update, where the semantization model update includes at least one updated semantization model respectively corresponding to at least one outdated semantization model.

[0072] Because the outdated semantization model may be updated, the accuracy of query could be improved.

[0073] In a possible implementation of the second aspect, the method further includes:

compressing one or more updated semantization models of the at least one updated semantization model in the semantization model update.

10 [0074] Because one or more updated semantization models of the at least one updated semantization model in the semantization model update may be compressed, the resource consumption may be generally reduced.

[0075] In a possible implementation of the second aspect, a compression approach for each of the one or more updated semantization models includes at least one of projection, codebook, quantization, or entropy coding.

15 [0076] Because the various compression approaches could be adopted, the compression may be conducted more flexibly and reasonably.

[0077] In a possible implementation of the second aspect, the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

[0078] Because the at least one updated semantization model may be compressed based on the difference between the updated semantization model and the corresponding outdated semantization model, the resource  
20 consumption may be further reduced.

[0079] In a possible implementation of the second aspect, a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update.

25 [0080] Because the compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update, the flexible and reasonable compression can be further improved.

[0081] In a possible implementation of the second aspect, the method further includes:

training, by the second apparatus, at least one semantization model, jointly with the at least one first apparatus.

30 [0082] Because the at least one semantization model can be trained by the second apparatus jointly with the at

least one first apparatus, the consistence of the at least one semantization model may be guaranteed, and thus flexibility and reasonability of query may be further improved based on the consistent semantization model.

[0083] In a possible implementation of the second aspect, the training, by the second apparatus, at least one semantization model, jointly with the at least one first apparatus includes:

5 communicating, by the second apparatus, with the at least one first apparatus, intermediate information generated in the training of the at least one semantization model, where the intermediate information includes intermediate features, or gradients generated in the training; and

training, by the second apparatus, the at least one semantization model, jointly with the at least one first apparatus based on the intermediate information.

10 [0084] Because the intermediate information which may include intermediate features or gradients generated in the training of the at least one semantization model is communicated between the second apparatus and the at least one first apparatus, the training is conducted based on the intermediate information, and thus the training of the semantization model can be jointly conducted by the second apparatus and the at least one first apparatus without knowing the exact structure of the semantization model used on the other side, which is especially suitable  
15 for a situation where the semantization model is required to be kept private or cannot be known by the other side, for example, a situation where the second apparatus and the at least one first apparatus belong to different parties or corporations, and thereby, another way for configuring the semantization model is provided.

[0085] In a possible implementation of the second aspect, the method further includes:

20 sending at least one identifier for the at least one semantization model to be trained, where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0086] Because the at least one identifier including a task identifier, or a modality identifier, or both a task identifier and a modality identifier may be obtained, the semantization model to be trained can be determined according to the task identifier, or the modality identifier, or the combination of task and modality identifiers, thereby facilitating the training of the semantization model and further improving the flexibility and reasonability  
25 of query.

[0087] In a possible implementation of the second aspect, when at least one semantization model trained by the second apparatus jointly with the at least one first apparatus is outdated, the method further includes:

updating, by the second apparatus, the at least one outdated semantization model, jointly with the at least one first apparatus.

30 [0088] In a possible implementation of the second aspect, the updating, by the second apparatus, the at least

one outdated semantization model, jointly with the at least one first apparatus includes:

when multiple outdated semantization models exist, updating, by the second apparatus, one or more outdated semantization models, jointly with the at least one first apparatus at a time.

[0089] Because the outdated semantization model may be updated, the accuracy of query can be improved.

5 When multiple outdated models exist, one or more outdated models may be updated at a time, which can be determined according to actual demands, thereby improving the flexibility of the updating of the outdated semantization models.

[0090] In a possible implementation of the second aspect, the sending a semantization model configuration includes:

10 sending the semantization model configuration via a broadcast message;

sending the semantization model configuration via a multicast message targeted to a group of first apparatuses; or

sending the semantization model configuration via a dedicated message to a first apparatus.

[0091] By means of broadcasting or multicasting, a large number of apparatuses may be scheduled rather than  
15 one-to-one individual scheduling, the resource consumption can be reduced. By means of unicasting, one-to-one individual scheduling can be achieved for special query dedicated to a specific apparatus.

[0092] In a possible implementation of the second aspect, the broadcast message includes:

a synchronization signal and physical broadcast channel block (SSB); or

a system information block (SIB) message.

20 [0093] In a possible implementation of the second aspect, each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

[0094] Because each query message may correspond to a task, a modality, or a combination of a task and a modality, the query may be conducted more flexibly and reasonably according to the task and/or modality.

[0095] In a possible implementation of the second aspect, each of the at least one query message includes at  
25 least one identifier, where the at least one identifier includes a task identifier, a modality identifier, or both a task identifier and a modality identifier.

[0096] Because the at least one query message may include at least one identifier and the at least one semantization model may be obtained by the at least one first apparatus based on the at least one identifier, the at least one semantization model may be directly obtained by the at least one first apparatus in a high efficiency way,  
30 and a suitable semantization model can be obtained by the at least one first apparatus for a specific task and/or

modality.

[0097] In a possible implementation of the second aspect, the at least one identifier for the at least one semantization model in the at least one query message is used for the at least one first apparatus to obtain the at least one semantization model.

5 [0098] Because the at least one query message may include at least one identifier and the at least one semantization model may be obtained based on the at least one identifier, the at least one semantization model may be directly obtained in a high efficiency way, and a suitable semantization model can be obtained for a specific task and/or a specific modality.

10 [0099] In a possible implementation of the second aspect, the at least one piece of sensed data includes at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

[0100] Because the at least one piece of sensed data may include at least one piece of raw sensed data, half raw sensed data, or compressed sensed data, diversity of sensed data would be obtained.

15 [0101] In a third aspect, a possible implementation of the present disclosure provides a first apparatus, including various modules configured to execute the sensing communication method according to the first aspect or any possible implementation of the first aspect.

[0102] In a fourth aspect, a possible implementation of the present disclosure provides a second apparatus, including various modules configured to execute the sensing communication method according to the second aspect or any possible implementation of the second aspect.

20 [0103] In a fifth aspect, a possible implementation of the present disclosure provides a third apparatus, including a processing circuitry for executing the sensing communication method according to the first aspect or any possible implementation of the first aspect.

[0104] In a sixth aspect, a possible implementation of the present disclosure provides a fourth apparatus, including a processing circuitry for executing the sensing communication method according to the second aspect or any possible implementation of the second aspect.

25 [0105] In a seventh aspect, a possible implementation of the present disclosure provides a wireless communication system, including: at least one first apparatus according to the third aspect or any possible implementation of the third aspect or at least one third apparatus according to the fifth aspect; at least one second apparatus according to the fourth aspect or any possible implementation of the fourth aspect or at least one fourth apparatus according to the sixth aspect; and at least one fifth apparatus, where each of the at least one fifth  
30 apparatus includes: a sending module, configured to send at least one query message to the at least one second

apparatus; and an obtaining module, configured to obtain at least one fused sensing result sent by the at least one second apparatus, where the at least one fused sensing result is generated based on one or more sensing results.

[0106] In an eighth aspect, a possible implementation of the present disclosure provides a wireless communication system, including: a first processing circuitry for executing the sensing communication method according to the first aspect or any possible implementation of the first aspect; a second processing circuitry for executing the sensing communication method according to the second aspect or any possible implementation of the second aspect; and a third processing circuitry for executing following steps: sending at least one query message to the second processing circuitry; and obtaining at least one fused sensing result sent by the second processing circuitry, where the at least one fused sensing result is generated based on one or more sensing results.

[0107] In a ninth aspect, a possible implementation of the present disclosure provides a computer-readable storage medium storing computer execution instructions which, when executed by a processor, cause the processor to execute the sensing communication method according to the first aspect or any possible implementation of the first aspect or the second aspect or any possible implementation of the second aspect.

[0108] In a tenth aspect, a possible implementation of the present disclosure provides a computer program product including computer execution instructions which, when executed by a processor, cause the processor to execute the sensing communication method according to the first aspect or any possible implementation of the first aspect or the second aspect or any possible implementation of the second aspect.

[0109] The present disclosure provides a sensing communication method, apparatus, and system. An apparatus such as a central device can broadcast or multi-cast or unicast query message(s), so that other apparatus(es) such as one or more sensing devices can obtain the query message(s) and respond with sensing result(s) in response to the obtained query message(s). The sensing result(s) may include the at least one piece of sensed data and/or the at least one second sensing semantic, where the at least one second sensing semantic and/or the at least one third sensing semantic converted from the at least one piece of sensed data are included in the at least one first sensing semantic, which is generated based on at least one piece of raw sensed data and at least one semantization model preconfigured in the sensing device through communicating with the central device. Thus, query may be conducted more flexibly and reasonably based on the at least one semantization model. Moreover, the at least one semantization model can be trained by the sensing device jointly with the central device, and thus the consistence of the at least one semantization model may be guaranteed, and thus flexibility and reasonability of query may be further improved based on the consistent semantization model. Furthermore, the outdated semantization model may be updated, and thus the accuracy of query could be improved.

## BRIEF DESCRIPTION OF DRAWINGS

[0110] Reference will now be made, by way of example, to the accompanying drawings which show example embodiments of the present disclosure, and in which:

5 [0111] FIG. 1 is a simplified schematic illustration of a communication system according to one or more example embodiments of the present disclosure.

[0112] FIG. 2 is a schematic illustration of an example communication system according to one or more example embodiments of the present disclosure.

[0113] FIG. 3 is a schematic illustration of a basic component structure of a communication system according to one or more example embodiments of the present disclosure.

10 [0114] FIG. 4 is a block diagram of a device in a communication system according to one or more example embodiments of the present disclosure.

[0115] FIG. 5 is a schematic illustration of a sensing communication scenario according to one or more example embodiments of the present disclosure.

15 [0116] FIG. 6 is a schematic illustration of a plurality of the sensing devices in a sensing communication scenario according to one or more example embodiments of the present disclosure.

[0117] FIG. 7 is a schematic illustration of interaction among devices in a sensing communication scenario according to one or more example embodiments of the present disclosure.

[0118] FIG. 8 is another schematic illustration of interaction among devices in a sensing communication scenario according to one or more example embodiments of the present disclosure.

20 [0119] FIG. 9 is a schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.

[0120] FIG. 10 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.

25 [0121] FIG. 11 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.

[0122] FIG. 12 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.

[0123] FIG. 13 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.

- [0124] FIG. 14 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.
- [0125] FIG. 15 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.
- 5 [0126] FIG. 16 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.
- [0127] FIG. 17 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure.
- [0128] FIG. 18 is another schematic flowchart of a sensing communication method according to one or more  
10 example embodiments of the present disclosure.
- [0129] FIG. 19 is a schematic illustration of realizing a chain of thoughts according to one or more example embodiments of the present disclosure.
- [0130] FIG. 20 is another schematic illustration of interaction among devices in a sensing communication scenario according to one or more example embodiments of the present disclosure.
- 15 [0131] FIG. 21 is another schematic illustration of interaction among devices in a sensing communication scenario according to one or more example embodiments of the present disclosure.
- [0132] FIG. 22 is a schematic illustration of generating a query message.
- [0133] FIG. 23 is a schematic illustration of reversing a semantic.
- [0134] FIG. 24 is a schematic illustration of tokenizing a query semantic into a query token.
- 20 [0135] FIG. 25 is a schematic illustration of responding to a query token.
- [0136] FIG. 26 is a schematic illustration of scoring the relevance with tokens.
- [0137] FIG. 27 is another schematic illustration of responding to a query token.
- [0138] FIG. 28 is a schematic illustration of scoring a relevance with semantic.
- [0139] FIG. 29 is another schematic illustration of responding to a query token.
- 25 [0140] FIG. 30 is a schematic illustration of scoring the relevance with tokens converted from semantics.
- [0141] FIG. 31 is a schematic illustration of generating query tokens.
- [0142] FIG. 32 is a schematic illustration of generating query semantics.
- [0143] FIG. 33 is a schematic illustration of responding to two queries with a common semantization model and two tokenization models.
- 30 [0144] FIG. 34 is a schematic illustration of responding to two queries with a common semantization model

and a common tokenization model.

[0145] FIG. 35 is another schematic illustration of responding to two queries with two semantization models and two tokenization models.

5 [0146] FIG. 36 is another schematic illustration of responding to two queries with two semantization models and a common tokenization model.

[0147] FIG. 37 is a schematic illustration of responding to two query semantics with a common semantization model and two different tokenization models.

[0148] FIG. 38 is a schematic illustration of responding to two query semantics with a common semantization model and a common tokenization model.

10 [0149] FIG. 39 is a schematic illustration of responding to two query semantics with two semantization models and two tokenization models.

[0150] FIG. 40 is a schematic illustration of responding to two query semantics with two semantization models and one tokenization model.

15 [0151] FIG. 41 is a schematic illustration of responding to two query semantics with one semantization model without tokenization model.

[0152] FIG. 42 is a schematic illustration of responding to two query semantics with two semantization models without tokenization model.

[0153] FIG. 43 is a schematic illustration of processing two sensing semantics independently.

20 [0154] FIG. 44 is a schematic illustration of processing one sensing semantic but with two tasks independently.

[0155] FIG. 45 is a schematic structural diagram of a first apparatus according to one or more example embodiments of the present disclosure.

[0156] FIG. 46 is a schematic structural diagram of a second apparatus according to one or more example embodiments of the present disclosure.

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## DESCRIPTION OF EMBODIMENTS

[0157] In the following description, reference is made to the accompanying figures, which form part of the present disclosure, and which show, by way of illustration, specific aspects of embodiments of the present disclosure or specific aspects in which embodiments of the present disclosure may be used. It is understood that

embodiments of the present disclosure may be used in other aspects and include structural or logical changes not depicted in the figures. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present disclosure is defined by the appended claims.

[0158] To assist in understanding the present disclosure, examples of wireless communication systems and devices are described below.

[0159] **Example communication systems and devices**

[0160] The present disclosure uses the interaction and processing procedures among at least one UE (i.e., the sensing device which is also called sensing node, which is marked as ED in FIG. 1), at least one BS (i.e., the central device) and at least one GPT devices in a wireless system as an illustrative example. The exchanged information and protocol flows can also be used between other network nodes described below, for example, between ED 110 and TRP 170, between ED 110 and core network, between ED 110 and ED 110, between TRP 170 and TRP 170, between TRP 170 and GPT device 180. The UE in the procedure described in the present disclosure may be replaced with a sensing node mentioned below. The BS in the procedure described in the present disclosure may be replaced with a sensing coordinator. Sensing coordinator are nodes in a network that can assist in the sensing operation. These nodes can be stand-alone nodes dedicated to just sensing operations or other nodes (for example TRP 170, ED 110, or core network node shown in FIG.1) doing the sensing operations in parallel with communication transmissions.

[0161] Referring to FIG. 1, as an illustrative example without limitation, a simplified schematic illustration of a communication system according to one or more example embodiments of the present disclosure is provided.

The communication system 100 (which may be the wireless system in FIG. 1) includes a radio access network 120. The radio access network 120 may be a next generation (e.g. sixth generation (6G) or later) radio access network, or a legacy (e.g. 5G, 4G, 3G or 2G) radio access network. One or more communication electric device (ED) 110a, 110b, 110c, 110d, 110e, 110f, 110g, 110h, 110i, 110j (generically referred to as 110) may be interconnected to one another or connected to one or more network nodes (170a, 170b, generically referred to as 170) in the radio access network 120. A core network 130 may be a part of the communication system and may be dependent or independent of the radio access technology used in the communication system 100. Also the communication system 100 includes a public switched telephone network (PSTN) 140, the internet 150, and other networks 160.

[0162] The uplink messages/data transmitted between the central device (e.g., the network node 170) and the sensing device (e.g., ED 110) could be carried in higher layer signaling, such as RRC signaling, or MAC layer signaling. Or, they could be carried in physical layer signaling, e.g., UCI. Or they could be carried in the

combination of the higher layer signaling and the physical signaling. It could be noted that the message in the present disclosure could be replaced with information, which may be carried in one single message, or be carried in more than one separate message. The downlink messages/data transmitted between the central device and the ED 110 could be carried in higher layer signaling, such as RRC signaling, or MAC layer signaling. Or, they could be carried in physical layer signaling, e.g., UCI. Or they could be carried in the combination of the higher layer signaling and the physical signaling. It could be noted that the message in the present disclosure could be replaced with information, which may be carried in one single message, or be carried in more than one separate message.

[0163] In addition, the communication system 100 includes at least one GPT device 180. The GPT device 180 may be located within the one or more network node 170. The GPT device 180 may be an independent device connected to the network 170, such as an ED 110 which connected to the network node 170 via Uu interface. The GPT device 180 may be a device connected to the network node 170 via core network 130. When the GPT device 180 is an ED, the uplink messages/data transmitted between the central device (e.g., the network node 170) and the GPT device 180 could be carried in higher layer signaling, such as RRC signaling, or MAC layer signaling. Or, they could be carried in physical layer signaling, e.g., UCI. Or they could be carried in the combination of the higher layer signaling and the physical signaling. It could be noted that the message in the present disclosure could be replaced with information, which may be carried in one single message, or be carried in more than one separate message. The downlink messages/data transmitted between the central device and the GPT device 180 could be carried in higher layer signaling, such as RRC signaling, or MAC layer signaling. Or, they could be carried in physical layer signaling, e.g., UCI. Or they could be carried in the combination of the higher layer signaling and the physical signaling. It could be noted that the message in the present disclosure could be replaced with information, which may be carried in one single message, or be carried in more than one separate message.

[0164] FIG. 2 is a schematic illustration of an example communication system according to one or more example embodiments of the present disclosure, where FIG. 2 illustrates an example communication system 100. In general, the communication system 100 enables multiple wireless or wired elements to communicate data and other content. The purpose of the communication system 100 may be to provide content, such as voice, data, video, signaling and/or text, via broadcast, multicast and unicast, etc. The communication system 100 may operate by sharing resources, such as carrier spectrum bandwidth, between its constituent elements. The communication system 100 may include a terrestrial communication system and/or a non-terrestrial communication system. The communication system 100 may provide a wide range of communication services and applications (such as earth monitoring, remote sensing, passive sensing and positioning, navigation and tracking, autonomous delivery and

mobility, etc.). The communication system 100 may provide a high degree of availability and robustness through a joint operation of a terrestrial communication system and a non-terrestrial communication system. For example, integrating a non-terrestrial communication system (or components thereof) into a terrestrial communication system can result in what may be considered a heterogeneous network including multiple layers. Compared to conventional communication networks, the heterogeneous network may achieve better overall performance through efficient multi-link joint operation, more flexible functionality sharing, and faster physical layer link switching between terrestrial networks and non-terrestrial networks.

[0165] The terrestrial communication system and the non-terrestrial communication system could be considered as sub-systems of the communication system. In the example shown in FIG. 2, the communication system 100 includes electronic devices (ED) 110a, 110b, 110c, 110d (generically referred to as ED 110), radio access networks (RANs) 120a-120b, a non-terrestrial communication network 120c, a core network 130, a public switched telephone network (PSTN) 140, the Internet 150, and other networks 160. The RANs 120a-120b include respective base stations (BSs) 170a-170b, which may be generically referred to as terrestrial transmit and receive points (T-TRPs) 170a-170b. The non-terrestrial communication network 120c includes an access node 172, which may be generically referred to as a non-terrestrial transmit and receive point (NT-TRP) 172.

[0166] Any ED 110 may be alternatively or additionally configured to interface, access, or communicate with any T-TRP 170a-170b and NT-TRP 172, the Internet 150, the core network 130, the PSTN 140, the other networks 160, or any combination of the preceding. In some examples, ED 110a may communicate an uplink and/or downlink transmission over a terrestrial air interface 190a with T-TRP 170a. In some examples, the EDs 110a, 110b, 110c and 110d may also communicate directly with one another via one or more sidelink air interfaces 190b. In some examples, ED 110d may communicate an uplink and/or downlink transmission over a non-terrestrial air interface 190c with NT-TRP 172.

[0167] The air interfaces 190a and 190b may use similar communication technology, such as any suitable radio access technology. For example, the communication system 100 may implement one or more channel access methods, such as code division multiple access (CDMA), space division multiple access (SDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), Direct Fourier Transform spread OFDMA (DFT-OFDMA) or single-carrier FDMA (SC-FDMA) in the air interfaces 190a and 190b. The air interfaces 190a and 190b may utilize other higher dimension signal spaces, which may involve a combination of orthogonal and/or non-orthogonal dimensions.

[0168] The non-terrestrial air interface 190c can enable communication between the ED 110d and one or

multiple NT-TRPs 172 via a wireless link or simply a link. For some examples, the link is a dedicated connection for unicast transmission, a connection for broadcast transmission, or a connection between a group of EDs 110 and one or multiple NT-TRPs 172 for multicast transmission.

[0169] The RANs 120a and 120b are in communication with the core network 130 to provide the EDs 110a 110b, and 110c with various services such as voice, data, and other services. The RANs 120a and 120b and/or the core network 130 may be in direct or indirect communication with one or more other RANs (not shown), which may or may not be directly served by core network 130, and may or may not employ the same radio access technology as RAN 120a, RAN 120b or both. The core network 130 may also serve as a gateway access between (i) the RANs 120a and 120b or EDs 110a 110b, and 110c or both, and (ii) other networks (such as the PSTN 140, the Internet 150, and the other networks 160). In addition, some or all of the EDs 110a 110b, and 110c may include functionality for communicating with different wireless networks over different wireless links using different wireless technologies and/or protocols. Instead of wireless communication (or in addition thereto), the EDs 110a 110b, and 110c may communicate via wired communication channels to a service provider or switch (not shown), and to the Internet 150. PSTN 140 may include circuit switched telephone networks for providing plain old telephone service (POTS). Internet 150 may include a network of computers and subnets (intranets) or both, and incorporate protocols, such as Internet Protocol (IP), Transmission Control Protocol (TCP), User Datagram Protocol (UDP). EDs 110a 110b, and 110c may be multimode devices capable of operation according to multiple radio access technologies, and incorporate multiple transceivers necessary to support such.

[0170] **Basic component structure**

[0171] FIG. 3 is a schematic illustration of a basic component structure of a communication system according to one or more example embodiments of the present disclosure, where FIG. 3 illustrates another example of an ED 110 and a base station 170a, 170b and/or 170c. The ED 110 is used to connect persons, objects, machines, etc. The ED 110 may be widely used in various scenarios, for example, cellular communications, device-to-device (D2D), vehicle to everything (V2X), peer-to-peer (P2P), machine-to-machine (M2M), machine-type communications (MTC), Internet of things (IOT), virtual reality (VR), augmented reality (AR), mixed reality (MR), metaverse, digital twin, industrial control, self-driving, remote medical, smart grid, smart furniture, smart office, smart wearable, smart transportation, smart city, drones, robots, remote sensing, passive sensing, positioning, navigation and tracking, autonomous delivery and mobility, etc.

[0172] Each ED 110 represents any suitable end user device for wireless operation and may include such devices (or may be referred to) as a user equipment/device (UE), a wireless transmit/receive unit (WTRU), a

mobile station, a fixed or mobile subscriber unit, a cellular telephone, a station (STA), a machine type communication (MTC) device, a personal digital assistant (PDA), a smartphone, a laptop, a computer, a tablet, a wireless sensor, a consumer electronics device, a smart book, a vehicle, a car, a truck, a bus, a train, or an IoT device, wearable devices such as a watch, head mounted equipment, a pair of glasses, an industrial device, or apparatus (e.g. communication module, modem, or chip) in the forgoing devices, among other possibilities. Future generation EDs 110 may be referred to using other terms. Each base station 170a and 170b is a T-TRP and will hereafter be referred to as T-TRP 170. Also shown in FIG. 3, a NT-TRP will hereafter be referred to as NT-TRP 172. Each ED 110 connected to T-TRP 170 and/or NT-TRP 172 can be dynamically or semi-statically turned-on (i.e., established, activated, or enabled), turned-off (i.e., released, deactivated, or disabled) and/or configured in response to one of more of: connection availability and connection necessity.

[0173] The ED 110 includes a transmitter 201 and a receiver 203 coupled to one or more antennas 204. Only one antenna 204 is illustrated. One, some, or all of the antennas 204 may alternatively be panels. The transmitter 201 and the receiver 203 may be integrated, e.g. as a transceiver. The transceiver is configured to modulate data or other content for transmission by at least one antenna 204 or network interface controller (NIC). The transceiver is also configured to demodulate data or other content received by the at least one antenna 204. Each transceiver includes any suitable structure for generating signals for wireless or wired transmission and/or processing signals received wirelessly or by wire. Each antenna 204 includes any suitable structure for transmitting and/or receiving wireless or wired signals.

[0174] The ED 110 includes at least one memory 208. The memory 208 stores instructions and data used, generated, or collected by the ED 110. For example, the memory 208 could store software instructions or modules configured to implement some or all of the functionality and/or embodiments described herein and that are executed by one or more processing unit(s) (e.g., a processor 210). Each memory 208 includes any suitable volatile and/or non-volatile storage and retrieval device(s). Any suitable type of memory may be used, such as random access memory (RAM), read only memory (ROM), hard disk, optical disc, subscriber identity module (SIM) card, memory stick, secure digital (SD) memory card, on-processor cache, and the like.

[0175] The ED 110 may further include one or more input/output devices (not shown) or interfaces (such as a wired interface to the Internet 150 in FIG. 1). The input/output devices permit interaction with a user or other devices in the network. Each input/output device includes any suitable structure for providing information to or receiving information from a user, such as through operation as a speaker, a microphone, a keypad, a keyboard, a display, or a touch screen, including network interface communications.

[0176] The ED 110 includes the processor 210 for performing operations including those operations related to preparing a transmission for uplink transmission to the NT-TRP 172 and/or the T-TRP 170, those operations related to processing downlink transmissions received from the NT-TRP 172 and/or the T-TRP 170, and those operations related to processing sidelink transmission to and from another ED 110. Processing operations related to preparing a transmission for uplink transmission may include operations such as encoding, modulating, transmit beamforming, and generating symbols for transmission. Processing operations related to processing downlink transmissions may include operations such as receive beamforming, demodulating and decoding received symbols. Depending upon the embodiment, a downlink transmission may be received by the receiver 203, possibly using receive beamforming, and the processor 210 may extract signaling from the downlink transmission (e.g. by detecting and/or decoding the signaling). An example of signaling may be a reference signal transmitted by the NT-TRP 172 and/or by the T-TRP 170. In some embodiments, the processor 210 implements the transmit beamforming and/or the receive beamforming based on the indication of beam direction, e.g. beam angle information (BAI), received from the T-TRP 170. In some embodiments, the processor 210 may perform operations relating to network access (e.g. initial access) and/or downlink synchronization, such as operations relating to detecting a synchronization sequence, decoding and obtaining the system information, etc. In some embodiments, the processor 210 may perform channel estimation, e.g. using a reference signal received from the NT-TRP 172 and/or from the T-TRP 170.

[0177] Although not illustrated, the processor 210 may form part of the transmitter 201 and/or part of the receiver 203. Although not illustrated, the memory 208 may form part of the processor 210.

[0178] The processor 210, the processing components of the transmitter 201 and the processing components of the receiver 203 may each be implemented by the same or different one or more processors that are configured to execute instructions stored in a memory (e.g. in the memory 208). Alternatively, some or all of the processor 210, the processing components of the transmitter 201 and the processing components of the receiver 203 may each be implemented using dedicated circuitry, such as a programmed field-programmable gate array (FPGA), a graphical processing unit (GPU), a Central Processing Unit (CPU) or an application-specific integrated circuit (ASIC).

[0179] In some implementations, the ED 110 may be an apparatus (also called component) for example, communication module, modem, chip, or chipset, it includes at least one processor 210, and an interface or at least one pin. In this scenario, the transmitter 201 and receiver 203 may be replaced by the interface or at least one pin, where the interface or at least one pin is to connect the apparatus (e.g., chip) and other apparatus (e.g., chip, memory, or bus). Accordingly, the transmitting information to the NT-TRP 172 and/or the T-TRP 170 and/or

another ED 110 may be referred as transmitting information to the interface or at least one pin, or as transmitting information to the NT-TRP 172 and/or the T-TRP 170 and/or another ED 110 via the interface or at least one pin, and receiving information from the NT-TRP 172 and/or the T-TRP 170 and/or another ED 110 may be referred as receiving information from the interface or at least one pin, or as receiving information from the NT-TRP 172 and/or the T-TRP 170 and/or another ED 110 via the interface or at least one pin. The information may include control signaling and/or data.

[0180] The T-TRP 170 may be known by other names in some implementations, such as a base station, a base transceiver station (BTS), a radio base station, a network node, a network device, a device on the network side, a transmit/receive node, a Node B, an evolved NodeB (eNodeB or eNB), a Home eNodeB, a next Generation NodeB (gNB), a transmission point (TP), a site controller, an access point (AP), a wireless router, a relay station, a remote radio head, a terrestrial node, a terrestrial network device, a terrestrial base station, a base band unit (BBU), a remote radio unit (RRU), an active antenna unit (AAU), a remote radio head (RRH), a central unit (CU), a distributed unit (DU), a positioning node, among other possibilities. The T-TRP 170 may be a macro BS, a pico BS, a relay node, a donor node, or the like, or combinations thereof. The T-TRP 170 may refer to the forgoing devices or refer to apparatus (e.g. a communication module, a modem, or a chip) in the forgoing devices.

[0181] In some embodiments, the parts of the T-TRP 170 may be distributed. For example, some of the modules of the T-TRP 170 may be located remote from the equipment that houses the antennas 256 for the T-TRP 170, and may be coupled to the equipment that houses the antennas 256 over a communication link (not shown) sometimes known as front haul, such as common public radio interface (CPRI). Therefore, in some embodiments, the term T-TRP 170 may also refer to modules on the network side that perform processing operations, such as determining the location of the ED 110, resource allocation (scheduling), message generation, and encoding/decoding, and that are not necessarily part of the equipment that houses the antennas 256 of the T-TRP 170. The modules may also be coupled to other T-TRPs. In some embodiments, the T-TRP 170 may actually be a plurality of T-TRPs that are operating together to serve the ED 110, e.g. through the use of coordinated multipoint transmissions.

[0182] The T-TRP 170 includes at least one transmitter 252 and at least one receiver 254 coupled to one or more antennas 256. Only one antenna 256 is illustrated. One, some, or all of the antennas 256 may alternatively be panels. The transmitter 252 and the receiver 254 may be integrated as a transceiver. The T-TRP 170 further includes a processor 260 for performing operations including those related to: preparing a transmission for downlink transmission to the ED 110, processing an uplink transmission received from the ED 110, preparing a

transmission for backhaul transmission to the NT-TRP 172, and processing a transmission received over backhaul from the NT-TRP 172. Processing operations related to preparing a transmission for downlink or backhaul transmission may include operations such as encoding, modulating, precoding (e.g. multiple input multiple output (MIMO) precoding), transmit beamforming, and generating symbols for transmission. Processing operations related to processing received transmissions in the uplink or over backhaul may include operations such as receive beamforming, demodulating received symbols and decoding received symbols. The processor 260 may also perform operations relating to network access (e.g. initial access) and/or downlink synchronization, such as generating the content of synchronization signal blocks (SSBs), generating the system information, etc. In some embodiments, the processor 260 also generates an indication of beam direction, e.g. BAI, which may be scheduled for transmission by a scheduler 253. The processor 260 performs other network-side processing operations described herein, such as determining the location of the ED 110, determining where to deploy the NT-TRP 172, etc. In some embodiments, the processor 260 may generate signaling, e.g. to configure one or more parameters of the ED 110 and/or one or more parameters of the NT-TRP 172. Any signaling generated by the processor 260 is sent by the transmitter 252. Note that “signaling”, as used herein, may alternatively be called control signaling. Dynamic signaling may be transmitted in a control channel, e.g. a physical downlink control channel (PDCCH), and static or semi-static higher layer signaling may be included in a packet transmitted in a data channel, e.g. in a physical downlink shared channel (PDSCH).

[0183] The scheduler 253 may be coupled to the processor 260. The scheduler 253 may be included within or operated separately from the T-TRP 170. The scheduler 253 may schedule uplink, downlink, and/or backhaul transmissions, including issuing scheduling grants and/or configuring scheduling-free (“configured grant”) resources. The T-TRP 170 further includes a memory 258 for storing information and data. The memory 258 stores instructions and data used, generated, or collected by the T-TRP 170. For example, the memory 258 could store software instructions or modules configured to implement some or all of the functionality and/or embodiments described herein and that are executed by the processor 260.

[0184] Although not illustrated, the processor 260 may form part of the transmitter 252 and/or part of the receiver 254. Also, although not illustrated, the processor 260 may implement the scheduler 253. Although not illustrated, the memory 258 may form part of the processor 260.

[0185] The processor 260, the scheduler 253, the processing components of the transmitter 252 and the processing components of the receiver 254 may each be implemented by the same or different one or more processors that are configured to execute instructions stored in a memory, e.g. in the memory 258. Alternatively,

some or all of the processor 260, the scheduler 253, the processing components of the transmitter 252 and the processing components of the receiver 254 may be implemented using dedicated circuitry, such as a FPGA, a GPU, a CPU, or an ASIC.

[0186] When the T-TRP 170 is an apparatus (also called as component), for example, communication module, modem, chip, or chipset in a device, it includes at least one processor, and an interface or at least one pin. In this scenario, the transmitter 252 and receiver 254 may be replaced by the interface or at least one pin, where the interface or at least one pin is to connect the apparatus (e.g., chip) and other apparatus (e.g., chip, memory, or bus). Accordingly, the transmitting information to the NT-TRP 172 and/or the T-TRP 170 and/or ED 110 may be referred as transmitting information to the interface or at least one pin, and receiving information from the NT-TRP 172 and/or the T-TRP 170 and/or ED 110 may be referred as receiving information from the interface or at least one pin. The information may include control signaling and/or data.

[0187] Although the NT-TRP 172 is illustrated as a drone only as an example, the NT-TRP 172 may be implemented in any suitable non-terrestrial form, such as high altitude platforms, satellite, high altitude platform as international mobile telecommunication base stations and unmanned aerial vehicles, which forms will be discussed hereinafter. Also, the NT-TRP 172 may be known by other names in some implementations, such as a non-terrestrial node, a non-terrestrial network device, or a non-terrestrial base station. The NT-TRP 172 includes a transmitter 272 and a receiver 274 coupled to one or more antennas 280. Only one antenna 280 is illustrated. One, some, or all of the antennas may alternatively be panels. The transmitter 272 and the receiver 274 may be integrated as a transceiver. The NT-TRP 172 further includes a processor 276 for performing operations including those related to: preparing a transmission for downlink transmission to the ED 110, processing an uplink transmission received from the ED 110, preparing a transmission for backhaul transmission to T-TRP 170, and processing a transmission received over backhaul from the T-TRP 170. Processing operations related to preparing a transmission for downlink or backhaul transmission may include operations such as encoding, modulating, precoding (e.g. MIMO precoding), transmit beamforming, and generating symbols for transmission. Processing operations related to processing received transmissions in the uplink or over backhaul may include operations such as receive beamforming, demodulating received symbols and decoding received symbols. In some embodiments, the processor 276 implements the transmit beamforming and/or receive beamforming based on beam direction information (e.g. BAI) received from the T-TRP 170. In some embodiments, the processor 276 may generate signaling, e.g. to configure one or more parameters of the ED 110. In some embodiments, the NT-TRP 172 implements physical layer processing, but does not implement higher layer functions such as functions at the

medium access control (MAC) or radio link control (RLC) layer. As this is only an example, more generally, the NT-TRP 172 may implement higher layer functions in addition to physical layer processing.

[0188] The NT-TRP 172 further includes a memory 278 for storing information and data. Although not illustrated, the processor 276 may form part of the transmitter 272 and/or part of the receiver 274. Although not  
5 illustrated, the memory 278 may form part of the processor 276.

[0189] The processor 276, the processing components of the transmitter 272 and the processing components of the receiver 274 may each be implemented by the same or different one or more processors that are configured to execute instructions stored in a memory, e.g. in the memory 278. Alternatively, some or all of the processor 276, the processing components of the transmitter 272 and the processing components of the receiver 274 may be  
10 implemented using dedicated circuitry, such as a programmed FPGA, a GPU, a CPU, or an ASIC. In some embodiments, the NT-TRP 172 may actually be a plurality of NT-TRPs that are operating together to serve the ED 110, e.g. through coordinated multipoint transmissions.

[0190] When the NT-TRP 172 is an apparatus (e.g. communication module, modem, chip, or chipset) in a device, it includes at least one processor, and an interface or at least one pin. In this scenario, the transmitter 272 and receiver 257 may be replaced by the interface or at least one pin, where the interface or at least one pin is to  
15 connect the apparatus (e.g., chip) and other apparatus (e.g., chip, memory, or bus). Accordingly, the transmitting information to the T-TRP 170 and/or another NT-TRP 172 and/or ED 110 may be referred as transmitting information to the interface or at least one pin, and receiving information from the T-TRP 170 and/or another NT-TRP 172 and/or ED 110 may be referred as receiving information from the interface or at least one pin. The  
20 information may include control signaling and/or data.

[0191] Note that “TRP”, as used herein, may refer to a T-TRP or a NT-TRP. A T-TRP may alternatively be called a terrestrial network TRP (“TN TRP”) and a NT-TRP may alternatively be called a non-terrestrial network TRP (“NTN TRP”).

[0192] The T-TRP 170, the NT-TRP 172, and/or the ED 110 may include other components, but these have  
25 been omitted for the sake of clarity.

[0193] Any or all of the EDs 110 and BS 170 may be sensing nodes in the system 100. Sensing nodes are network entities that perform sensing by transmitting and receiving sensing signals. Some sensing nodes are communication equipment that perform both communications and sensing. However, it is possible that some sensing nodes do not perform communications, and are instead dedicated to sensing. The sensing agent 174 is an  
30 example of a sensing node that is dedicated to sensing. Unlike the EDs 110 and BS 170, the sensing agent 174 does

not transmit or receive communication signals. However, the sensing agent 174 may communicate configuration information, sensing information, signaling information, or other information within the communication system 100. The sensing agent 174 may be in communication with the core network 130 to communicate information with the rest of the communication system 100. By way of example, the sensing agent 174 may determine the location of the ED 110a, and transmit this information to the base station 170a via the core network 130. Although only one sensing agent 174 is shown in FIG. 2, any number of sensing agents may be implemented in the communication system 100. In some embodiments, one or more sensing agents may be implemented at one or more of the RANs 120.

[0194] A sensing node may combine sensing-based techniques with reference signal-based techniques to enhance UE pose determination. This type of sensing node may also be known as a sensing management function (SMF). In some networks, the SMF may also be known as a location management function (LMF). The SMF may be implemented as a physically independent entity located at the core network 130 with connection to the multiple BSs 170. In other aspects of the present application, the SMF may be implemented as a logical entity co-located inside a BS 170 through logic carried out by the processor 260.

[0195] Although not presented in FIG. 3, a GPT device 180 may be included, which has similar structure to ED 110, e.g., GPT device 180 includes at least one processor, a transmitter and a receiver.

[0196] **Basic module structure**

[0197] FIG. 4 is a block diagram of a device in a communication system according to one or more example embodiments of the present disclosure, where one or more steps of the embodiment methods provided herein may be performed by corresponding units or modules, according to FIG. 4. FIG. 4 illustrates units or modules in a device, such as in the ED 110, in the T-TRP 170, in the NT-TRP 172, or in the GPT device 180. For example, a signal may be transmitted by a transmitting unit or by a transmitting module. A signal may be received by a receiving unit or by a receiving module. A signal may be processed by a processing unit or a processing module. Other steps may be performed by an artificial intelligence (AI) or machine learning (ML) module. The respective units or modules may be implemented using hardware, one or more components or devices that execute software, or a combination thereof. For instance, one or more of the units or modules may be an integrated circuit, such as a programmed FPGA, a GPU, a CPU, or an ASIC. It will be appreciated that where the modules are implemented using software for execution by a processor for example, the modules may be retrieved by a processor, in whole or part as needed, individually or together for processing, in single or multiple instances, and that the modules themselves may include instructions for further deployment and instantiation. The transmitter mentioned with

reference to FIG. 3 may be a detailed implementation for the transmitting module. The receiver mentioned with reference to FIG. 3 may be a detailed implementation for the receiving module. The processor mentioned with reference to FIG. 3 may be a detailed implementation for the processing module.

[0198] Additional details regarding the EDs 110, the T-TRP 170, the NT-TRP 172 and the GPT device 180 are known to those of skill in the art. As such, these details are omitted here.

[0199] The details of the present disclosure will be elaborated in the following description.

[0200] FIG. 5 is a schematic illustration of a sensing communication scenario according to one or more example embodiments of the present disclosure, where a wireless system includes a number of sensing devices, GPT device, and a central device.

[0201] In present disclosure, the wireless system is also called communication system, or wireless communication system. Herein the wireless system includes a plurality of devices, for example, the plurality of devices include at least a central device, a plurality of distributed sensing devices and at least a GPT device (in FIG. 5).

[0202] The GPT device is responsible for encoding or decoding query messages and sensed data. In details, it generates a query message that contains one goal or goals in natural language for the central device; the central device semantizes the query message into a semantic vector, tokenizes the semantic vector into a goal semantic token (vector), and then broadcasts the goal token to the sensing devices. A sensing device, triggered by receiving the goal semantic token, measures its sensed data and converts the sensed data into a sensed semantic token. The sensing device compares and scores the relevance between the goal semantic token and sensed semantic token and transmit the sensed data in semantic vector only if the score of relevance is higher than a threshold. The central device fuses the sensed data in semantic vectors and output the fused one to the GPT device that will generate the next query message based on the fused input.

[0203] A central device may be a BS, e.g. gNB, or eNB etc., or the central device may be an access point (AP).

[0204] A sensing device is responsible for measuring and/or collecting local physical-world data. It may be sensing UE, sensing equipment, IoT equipment, UE, mobile phones, handset, or other equipment. The sensing device may be equipped with a sensing gadget or component to measure local physical-world data near it into a sensed data; the sensing encodes and transmits them to the central device.

[0205] A GPT device may generate a sequence of the query messages and receives a fused sensing message from the central device. In the present disclosure, the GPT device could be also called AI agent device, robot

device, or smart controlling device.

[0206] In some implementations, a sensing device may be a UE, a mobile phone or a handset, wherein independence among any two sensing devices are assumed; thereby, a sensing device may be scheduled individually by the wireless system to which the sensing device is associated; and the sensed data that the sensing device measures may be application-level payload for the wireless system and protocol.

[0207] The above scheme of scheduling a sensing device is inefficient in terms of radio bandwidth and energy consumption. For instance, a sensing device blindly keeps transmitting its sensed data to the central device, regardless of whether the sensed data is required or not.

[0208] From a higher level perspective, it is better to wake a plurality of sensing devices to measure and transmit only when their sensed data would serve a goal or goals; for example, when a generative pre-trained transformer (GPT) device such as a driverless car, may request the information about the moving obstacles near itself, it is useless to keep transmitting irrelevant information to the driverless car, or to transmit all the moving obstacles nearby to the car when the car is parking on the roadside.

[0209] To avoid any missing probability of the information, resources in the wireless system in above implementations may be over-scheduled.

[0210] FIG. 6 is a schematic illustration of a plurality of the sensing devices in a sensing communication scenario according to one or more example embodiments of the present disclosure, where sensing devices provide multiple-modality sensed data.

[0211] In details, a plurality of the sensing devices herein may be grouped or classified in terms of types of sensed data. The first group of the sensing devices may measure the first type of sensed data (e.g. red, green, blue (RGB) images or video), whereas the second group of sensing devices may measure the second type of sensed data (e.g. Radio RF point-cloud or Lidar Point cloud) as illustrated in FIG. 6.

[0212] FIG. 7 is a schematic illustration of interaction among devices in a sensing communication scenario according to one or more example embodiments of the present disclosure, where a central device sends a query message to a number of sensing devices and receives the sensed data from the responsive sensing devices.

[0213] The central device actively requests or triggers the sensing devices to transmit their most recent sensed data (in FIG. 7). Accordingly, the sensing devices will transmit their sensed data.

[0214] The central device may transmit the first query message or messages to one or some sensing devices in DL broadcast, multicast, or unicast channel or channel(s), which may be in physical broadcast channel, shared channel, or dedicated channel(s).

[0215] After a sensing device receives the first query message, the sensing device decides whether or not to transmit its sensed data. In details, the sensing device decodes the first query message, measures its data, and decides whether or not to transmit its sensed data, which is called as responding to the first query message. If the sensing device decides to respond to the first query message, the sensing device would encode/encapsulate the sensed data into a payload and then transmit it to the central device in UL channel or channel(s), which may be physical UL shared channel or dedicated UL channel.

[0216] After the central device of the wireless system receives all the payloads from the sensing devices that responded to the first query message, the central device may fuse all or some payloads into a fused payload. Optionally, the central device may input the fused payload into the GPT device that may process them and then generate the second query message.

[0217] The central device may transmit the second query message or messages to one or some sensing devices in DL broadcast, multicast, or unicast channel or channel(s).

[0218] The GPT device transmits the query messages to the central device to inform and configure the central device to schedule when, how, what, and which sensing devices to sense and transmit their sensed data to the central device. The GPT device may be implemented/located together with the central device for shorter latency, or the GPT device may be implemented in a remote data center, to which the central device may access via core network, or the GPT device may be on another connected device in the same wireless system of the central device. Please note that, in the present disclosure, the query message from the central device to the sensing device (downlink message) could be carried in higher layer signaling, such as radio resource control (RRC) signaling, or medium access control (MAC) layer signaling. Or, the query message could be carried in physical layer signaling, e.g., downlink control information (DCI). Or the query message is carried in the combination of the higher layer signaling and the physical signaling. It is similar for other downlink messages/data transmitted from the central device to the sensing device. Similarly, in the present disclosure, for uplink messages/data, they could be carried in higher layer signaling, such as RRC signaling, or MAC layer signaling. Or, they could be carried in physical layer signaling, e.g., uplink control information (UCI). Or they could be carried in the combination of the higher layer signaling and the physical signaling. It could be noted that the message in the present disclosure could be replaced with information, which may be carried in one single message, or be carried in more than one separate message.

[0219] FIG. 8 is another schematic illustration of interaction among devices in a sensing communication scenario according to one or more example embodiments of the present disclosure, where the GPT device generates a sequence of query messages and receives a sequence of sensing messages.

[0220] The wireless system including a central device, sensing devices, and GPT device may form a series of interactions, in which the GPT device generates a sequence of the query messages for the sensing devices, the sensing devices collect and feedback the sensed data, and the central device fuses them and input them to the GPT device as illustrated in FIG. 8.

5 [0221] In some circumstances, some sensing devices may actively transmit their sensed data without receiving any query message from the central device. The sensing devices that transmit the sensed data may respond to some urgency queries such as fire alarming or car accident. In some sense, some query messages have been pre-defined and configured into the system by default.

[0222] FIG. 9 is a schematic flowchart of a sensing communication method according to one or more example  
10 embodiments of the present disclosure. The method can be implemented by a first apparatus. Optionally, the first apparatus can be a sensing device or other device that has similar function (for example, the first apparatus could be a chip), which is not limited herein. As shown in FIG. 9, the method can include the following steps.

[0223] S910, obtaining at least one query message.

[0224] In details, the first apparatus may obtain the at least one query message from a second apparatus.  
15 Optionally, the second apparatus can be a central device or other device that has similar function (for example, the second apparatus could be a chip), which is not limited herein.

[0225] S920, generating, based on at least one piece of raw sensed data and at least one semantization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data, where the at least one semantization model is preconfigured in a first apparatus through communicating with a second  
20 apparatus.

[0226] In details, once the first apparatus obtains a query message, the first apparatus may become waken but with little idea whether or not its sensed data is sufficiently relevant to the goal conveyed by the query message. Thereby the first apparatus may enable its sensing gadget to sense its nearby environment into sensed data and compare the sensed data with the query message. The comparison approach may be, for example, the comparison  
25 between the query semantic and the sensing semantic. In other words, the first apparatus may convert the raw sensed data to a sensing semantic based on a semantization model, and then compare the sensing semantic with the query semantic so as to determine whether or not its sensed data is sufficiently relevant to the goal conveyed by the query semantic. Before being used for generating a sensing semantic, the semantization model may be configured in the first apparatus through communication between the first apparatus and the second apparatus, which means  
30 that before a semantization model is used for converting a piece of sensed data to a sensing semantic, the first

apparatus and the second apparatus have communicated with each other to configure the semantization model. Moreover, the semantization model may also be used for converting the query message to a query semantic if necessary. It is noted that when the first apparatus determines whether or not its sensed data is sufficiently relevant to the goal conveyed by the query message, other comparison approach may also be used, for example, the  
5 comparison between the query token and the sensing token, which is not limited herein.

[0227] S930, sending a sensing result, where the sensing result includes at least one piece of sensed data and/or at least one second sensing semantic, and where the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

10 [0228] In a possible implementation, the at least one piece of sensed data includes at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

[0229] In details, if the first apparatus tells that the sensed data is sufficiently relevant with the query message, the first apparatus encodes and sends the sensed data to the second apparatus. Further, the sensed data can be sent in many forms, such as, raw sensed data, half raw sensed data, compressed sensed data, or sensing semantic  
15 converted from the raw sensed data, which is not limited herein. In other words, if all of the at least one first sensing semantic matches the query semantic, all the sensed data may be sent to the second apparatus in at least one form as described above, while if part of the at least one first sensing semantic match the query semantic, only the matched sensed data may be sent to the second apparatus in at least one form.

[0230] With the sensing communication method provided by the present disclosure, the first apparatus can  
20 obtain the query message(s) from the second apparatus, and then generate the first sensing semantic(s) based on raw sensed data and the semantization model(s) preconfigured in the first apparatus through communicating with the second apparatus. After generating the first sensing semantic(s), the first apparatus may send a sensing result for the second apparatus to obtain, where the sensing result may include sensed data and/or sensing semantic, in particular, at least one second sensing semantic, which is included in the first sensing semantic(s), and/or at least  
25 one piece of sensed data, from which at least one third sensing semantic converted is included in the first sensing semantic(s). Since the generation of the first sensing semantic(s) is based on the semantic model(s) preconfigured in the first apparatus through its communication with the second apparatus, query may be conducted more flexibly and reasonably based on the semantization model(s).

[0231] FIG. 10 is another schematic flowchart of a sensing communication method according to one or more  
30 example embodiments of the present disclosure. The method can be implemented by a first apparatus, and the

preconfiguration of the semantic model(s) is implemented through a semantic model configuration communicated from a second apparatus to the first apparatus. Optionally, the first apparatus can be a sensing device or other device that has similar function (for example, the first apparatus could be a chip), and the second apparatus can be a central device or other device that has similar function (for example, the second apparatus could be a chip), which is not limited herein. In a possible implementation, as shown in FIG. 10, the method can include the following steps.

[0232] S1010, obtaining a semantization model configuration, where the semantization model configuration indicates the at least one semantization model.

[0233] In details, the second apparatus may send the semantization model configuration to the first apparatus so that the first apparatus may obtain the semantization model configuration and use the semantization model indicated in the semantization model configuration to convert sensed data to a sensing semantic.

[0234] In a possible implementation, the semantization model configuration may be obtained by the first apparatus via a broadcast message, via a multicast message targeted to a group of apparatuses including the first apparatus; or via a dedicated message to the first apparatus.

[0235] In details, the first apparatus may obtain the semantization model configuration in different ways. For example, by means of broadcasting or multicasting, a large number of apparatuses may be scheduled rather than one-to-one individual scheduling, the resource consumption can be reduced. By means of unicasting, one-to-one individual scheduling can be achieved for special query dedicated to a specific apparatus.

[0236] In a possible implementation, the broadcast message includes a synchronization signal and physical broadcast channel block (SSB), or a system information block (SIB) message.

[0237] For example, the semantization model configuration can be carried in synchronization signal and physical broadcast channel block (SSB) for broadcast, or in multicast configuration targeted to the group of apparatuses including the first apparatuses, or even dedicated to the first apparatus. For broadcast, it can be in a system information block (SIB) message, and there may be a flag indicating whether there will be such a configuration in SIBx message, and a period may also be indicated. It is noted that, for broadcast, other information may also be used, which is not limited herein.

[0238] S1020, obtaining at least one query message.

[0239] The step S1020 is similar as step S910 shown in FIG. 9, which is not repeated herein for brevity.

[0240] S1030, generating, based on at least one piece of raw sensed data and at least one semantization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data, where the

at least one semantization model is preconfigured in a first apparatus through communicating with a second apparatus.

[0241] The step S1030 is similar as step S920 shown in FIG. 9, which is not repeated herein for brevity.

5 [0242] S1040, sending a sensing result, where the sensing result includes at least one piece of sensed data and/or at least one second sensing semantic, and where the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

[0243] The step S1040 is similar as step S930 shown in FIG. 9, which is not repeated herein for brevity.

10 [0244] With the sensing communication method provided by the present disclosure, the second apparatus may send the semantization model configuration to the first apparatus in advance. In this way, the semantic model(s) can be preconfigured in the first apparatus through the semantic model configuration communicated from the second apparatus to the first apparatus. Then, the first apparatus can use the semantization model indicated in the semantization model configuration to convert the sensed data to a sensing semantic (and/or convert the query message to a query semantic if necessary). Thus, the flexibility and reasonability of query may be further improved.

15 [0245] In a possible implementation, the at least one semantization model is represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , where the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$  corresponds to a task and/or a modality.

20 [0246] In details, different semantization models may correspond to different tasks, or different semantization models may correspond to different modalities, or different semantization models may correspond to different combinations of task and modality. For example, the semantization model 1 may correspond to task 1 “find moving obstacles” and the semantization model 2 may correspond to task 2 “localize incoming pedestrians”, which is not limited herein. Because each of the at least one semantization model may correspond to a task and/or a modality, query may be conducted more flexibly and reasonably according to the task and/or modality.

25 [0247] In a possible implementation, the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

30 [0248] In details, in addition to the semantization model, the semantization model configuration may further indicate at least one identifier for the semantization model. Because the semantization model configuration may be further used to indicate the at least one identifier, the first apparatus can directly obtain a semantization model for a

task with a specific task identifier, or the semantization model for a modality with a specific modality identifier, or the semantization model for a combination of task and modality with specific task and modality identifiers when generating the sensing semantic. For example, the semantization model 1 may correspond to task 1 “find moving obstacles” with identifier  $t_1$  and the semantization model 2 may correspond to task 2 “localize incoming pedestrians” with identifier  $t_2$ , which is not limited herein. Thus flexibility and reasonability of query may be further improved based on the at least one identifier indicated in the semantization model configuration.

[0249] In a possible implementation, the generating, based on at least one piece of raw sensed data and at least one semantization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data includes: generating the at least one first sensing semantic  $\{o_1, o_2, \dots, o_s\}$  based on the at least one piece of raw sensed data and at least one semantization model  $\{M_1, M_2, \dots, M_s\}$ , where a first sensing semantic  $o_i$  is generated based on a piece of raw sensed data to which the first sensing semantic  $o_i$  corresponds and a semantization model  $M_i$ ,  $i \in [1, s]$ .

[0250] In details, once the first apparatus obtains the query message, the first apparatus may become waken but with little idea whether or not its sensed data is sufficiently relevant to the goal conveyed by the query message. Thereby the first apparatus may enable its sensing gadget to sense its nearby environment into sensed data and compare the sensed data with the query message. The comparison approach may be, for example, the comparison between the query semantic and the sensing semantic(s)  $\{o_1, o_2, \dots, o_s\}$ . In other words, the first apparatus may convert the raw sensed data to sensing semantic(s)  $\{o_1, o_2, \dots, o_s\}$  based on the semantization model(s)  $\{M_1, M_2, \dots, M_s\}$  sent from the second apparatus to the first apparatus in advance, and then compare the sensing semantic(s)  $\{o_1, o_2, \dots, o_s\}$  with the query semantic so as to determine whether or not its sensing semantic(s)  $\{o_1, o_2, \dots, o_s\}$  is sufficiently relevant to the goal conveyed by the query semantic. Moreover, the semantization model(s)  $\{M_1, M_2, \dots, M_s\}$  may also be used for converting the query message to the query semantic if necessary. It is noted that when the first apparatus determines whether or not its sensed data is sufficiently relevant to the goal conveyed by the query message, other comparison approach may also be used, for example, the comparison between the query token and the sensing token, which is not limited herein. Because the at least one piece of raw sensed data may be converted to sensing semantic(s)  $\{o_1, o_2, \dots, o_s\}$  based on the semantization model(s)  $\{M_1, M_2, \dots, M_s\}$  sent from the second apparatus to the first apparatus in advance, whether the raw sensed data is matched with the query message can be determined from the perspective of the semantic, and thus the query can be conducted more conveniently.

[0251] In a possible implementation, when the at least one identifier includes a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots, (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s;$

$M_1, M_2, \dots, M_s\}$ , where  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0252] In a possible implementation, when the at least one identifier includes a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots, (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; t'_1, t'_2, \dots, t'_s; M_1, M_2, \dots, M_s\}$ , where  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ , or,  $t_i$  is a modality identifier of model  $M_i$ , and  $t'_i$  is a task identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0253] Different representations of the semantization model configuration are provided for different cases of identifiers. For example, when the at least one identifier includes a single identifier, i.e., a task identifier or a modality identifier, the semantization model configuration may be represented by  $\{(t_1, M_1), (t_2, M_2), \dots, (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; M_1, M_2, \dots, M_s\}$ , or when the at least one identifier includes both a task identifier and a modality identifier, the semantization model configuration may be represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots, (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; t'_1, t'_2, \dots, t'_s; M_1, M_2, \dots, M_s\}$ . Thus the configuration of the semantization model is more conveniently, and flexibility and reasonability of query may be further improved based on the identifier(s) indicated in the semantization model configuration.

[0254] In a possible implementation, one or more semantization models of the at least one semantization model in the semantization model configuration are compressed.

[0255] In details, for saving transmission resources, one or more semantization models of the at least one semantization model in the semantization model configuration may be compressed. It is noted that not all of the at least one semantization model is required to be compressed, which depends on the amount of the transmission resource and the processing capability of the apparatus. Because the one or more semantization models of the at least one semantization model in the semantization model configuration may be compressed, the resource consumption may be generally reduced.

[0256] In a possible implementation, a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

[0257] In a possible implementation, a compression approach for each of the one or more semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0258] In details, the compression approach and/or compression parameters for each of the one or more semantization models may be known by both sides in various ways. For example, the compression approach and/or compression parameters for each of the one or more semantization models may be configured previously, pre-defined, or carried in the semantization model configuration, which is not limited herein. Moreover, various

compression approaches could be adopted, which may include but not limited to projection, codebook, quantization, or entropy coding, thus the compression may be conducted more flexibly and reasonably according to actual application situations.

[0259] FIG. 11 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure, where a sensing device may be configured one or multiple semantization models from the central device, which will be used to calculate the sensing semantic at sensing device side. In details, at least one of the following steps are included.

[0260] S1110: The central device sends semantization model configuration to sensing device.

[0261] In details, the central device broadcasts/multicasts/unicasts semantization model configuration to sensing device. The semantization model configuration can be carried in synchronization signal and physical broadcast channel block (SSB) for broadcast, or in multicast configuration targeted to a group of sensing devices, or even dedicated to one sensing device. For broadcast, it can be in a system information block (SIB) message, and there may be a flag indicating whether there will be such a configuration in SIBx message, and the period may also be indicated. The semantization model configuration includes one or multiple semantization models, which can be represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ ,  $s$  is the number of semantization models configured, and different  $M_t$  represents the semantization model for different tasks (or modalities),  $t \in [1, s]$ . For example,  $M_t$  can be the semantization model for task with index  $t$ .

[0262] Optionally, the identifier for the semantization model  $M_t$  can be included in the configuration, to indicate its task ID (or modality ID, or both task ID and modality ID). Then the semantization model configuration becomes  $\{(t_1, M_1), (t_2, M_2), \dots, (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; M_1, M_2, \dots, M_s\}$ , where  $t_i$  is the task identifier (or modality identifier) of model  $M_i$ ,  $i \in [1, s]$ . Or the semantization model configuration can also become  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots, (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; t'_1, t'_2, \dots, t'_s; M_1, M_2, \dots, M_s\}$ , where  $t_i$  is the task identifier of model  $M_i$ , and  $t'_i$  is the modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0263] Optionally,  $M_t$  in the semantization model configuration can be compressed. The compression approaches can include but not limited to projections, codebooks, quantization, entropy coding, etc. For example, the original semantization model  $M_t$  can be projected to another space based a projection base  $U$ :  $M'_t = UM_t$ ,  $M'_t$  or quantized  $M'_t$  can have fewer bits than the original  $M_t$ . Then the semantization model configuration becomes  $\{M'_1, M'_2, \dots, M'_s\}$ . Note that the compression approach and compression parameters for each model need to be configured previously, or pre-defined, or transmitted together within the semantization model configuration.

[0264] S1120: The sensing device receives the semantization model configuration.

[0265] The sensing device receives the semantization model configuration, which includes one or multiple semantization models:  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ . The sensing device can implicitly or explicitly obtain the task/modality identifier for each model  $M_i$ .

[0266] If there is a task identifier for model  $M_i$ , or modality identifier for model  $M_i$ , or both task identifier and modality identifier for model  $M_i$  in the semantization model configuration, as introduced in step 1110, the sensing device can directly obtain the task/modality identifier.

[0267] Otherwise, the task/modality identifier can be implicitly calculated. For example, based on order of configured models:  $M_t$  for task/modality with index  $t$ .

[0268] Optionally, if the configured semantization models are compressed ones, i.e.  $\{M^c_1, M^c_2, \dots, M^c_s\}$ , then sensing device decompress the models first to obtain the reconstructed models  $M_1, M_2, \dots, M_s$ . The compression approach and compression parameters for each model can be configured previously, or pre-defined, or transmitted together within the semantization model configuration.

[0269] S1130: The central device sends query message. The central device broadcasts or multicasts query message.

[0270] The query message can include one or more queries:  $\{q_1, q_2, \dots, q_n\}$ , where  $n$  is the number of queries. And the queries can be for single task, single modality, or multiple tasks or multiple modalities.

[0271] Optionally, the identifier for the query can be included in the query message. For example, for query  $q_i$ , its identifier  $t_i$  can included to indicate its task ID (or modality ID, or both task ID and modality ID).

[0272] S1140: The sensing device receives/detects the query message.

[0273] Based on the sensing environment and previously obtained semantization models  $\{M_1, M_2, \dots, M_s\}$ , sensing device obtains its sensing semantics  $\{o_1, o_2, \dots, o_s\}$ , where  $o_t$  is obtained based on semantization model  $M_t$ ,  $t \in [1, s]$ . Note that the modality of sensing environment input of sensing device may be the same or different from the modality with which the central device obtains the query. If any  $o_t$  matches the query, sensing device will respond with sensed data.

[0274] Optionally, if the identifier for the query is included in the query Message, e.g. if the identifier  $t_i$  for query  $q_i$  is included to indicate its task ID (or modality ID, or both task ID and modality ID), then sensing device may use the identifier to obtain the previously configured semantization model for query  $q_i$ .

[0275] S1150: The sensing device responds with sensed data.

[0276] The sensed data from sensing device can include matched raw sensed data and/or sensing semantics in S1140.

[0277] In a possible implementation, when at least one semantization model in the semantization model configuration is outdated, a semantization model update may be obtained to update the outdated semantization model, and specifically, the method may further include obtaining a semantization model update, where the semantization model update includes at least one updated semantization model respectively corresponding to at least one outdated semantization model.

[0278] In details, a previously configured semantization model may be outdated and need to be updated. For example, if a previous semantization model is outdated, or if a previous semantization model has been refined at the second apparatus, this previous semantization model may be required to be updated. At this time, the second apparatus may send the semantization model update to the first apparatus so that the first apparatus can obtain the semantization model update to update the outdated semantization model. Because the outdated semantization model may be updated, the accuracy of query could be improved.

[0279] In a possible implementation, one or more updated semantization models of the at least one updated semantization model in the semantization model update are compressed.

[0280] In details, for saving transmission resources, one or more updated semantization models of the at least one updated semantization model in the semantization model update may be compressed. It is noted that not all of the at least one updated semantization model is required to be compressed, which depends on the amount of the transmission resource and the processing capability of the apparatus. Because the one or more updated semantization models of the at least one updated semantization model in the semantization model update may be compressed, the resource consumption may be generally reduced.

[0281] In a possible implementation, a compression approach for each of the one or more updated semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0282] In a possible implementation, the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

[0283] In a possible implementation, a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update.

[0284] In details, the compression approach and/or compression parameters for each of the one or more updated semantization models may be known by both sides in various ways. For example, the compression approach and/or compression parameters for each of the one or more updated semantization models may be configured previously, pre-defined, or carried in the semantization model update, which is not limited herein.

Moreover, various compression approaches could be adopted, which may include but not limited to projection, codebook, quantization, or entropy coding, thus the compression may be conducted more flexibly and reasonably. Meanwhile, the at least one updated semantization model may be compressed based on the difference between the updated semantization model and the corresponding outdated semantization model, thus the resource consumption  
5 may be further reduced.

[0285] FIG. 12 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure, where the central device needs to update previously configured semantization model, for example, if the previous model is outdated or the model has been refined, the procedures of at least one of the following steps will be executed.

10 [0286] S1210: The central device sends Semantization Model Update to sensing device.

[0287] In details, the central device broadcast/multicast/unicast Semantization Model Update to sensing device.

[0288] The central device uses Semantization Model Update to update all or part of the semantization models. The Semantization Model Update is information which can be carried in SSB for broadcast, or in multicast  
15 messages targeted to a group of sensing devices, or even dedicated to one sensing device. For broadcast, it can be in a SIB message, and there may be a flag indicating whether there will be such a message in SIBx message. The Semantization Model Update includes one or multiple updated semantization models, which can be represented by  $\{M'_1, M'_2, \dots, M'_{s'}\}$ ,  $s' \geq 1$ ,  $s'$  is the number of updated semantization models, and can be the same as or different from  $s$  in the Semantization Model Configuration.

20 [0289] Optionally, the identifier for the semantization model  $M'_i$  can be included in the Update, to indicate its task ID (or modality ID, or both task ID and modality ID). Then the Semantization Model Update becomes  $\{(t_1, M'_1), (t_2, M'_2), \dots, (t_{s'}, M'_{s'})\}$ , or  $\{t_1, t_2, \dots, t_{s'}; M'_1, M'_2, \dots, M'_{s'}\}$ , where  $t_i$  is the task identifier (or modality identifier) of model  $M'_i$ ,  $i \in [1, s']$ . Or the Semantization Model Update can also become  $\{(t_1, t'_1, M'_1), (t_2, t'_2, M'_2), \dots, (t_{s'}, t'_{s'}, M'_{s'})\}$ , or  $\{t_1, t_2, \dots, t_{s'}; t'_1, t'_2, \dots, t'_{s'}; M'_1, M'_2, \dots, M'_{s'}\}$ , where  $t_i$  is the task identifier of model  $M'_i$ , and  $t'_i$  is  
25 modality identifier of model  $M'_i$ ,  $i \in [1, s']$ .

[0290] Optionally,  $M'_i$  in the Semantization Model Update can be compressed. For example,  $M'_i$  can differentially compressed based on the previously configured models. Suppose the previously configured mode is  $M_i$ . Then the difference between  $M'_i$  and  $M_i$  can be compressed based on, but not limited to projections, codebooks, quantization, entropy coding, etc. Note that the compression approach and compression parameters for each  
30 updated model need to be configured previously, or pre-defined, or transmitted together within the Semantization

Model Update.

[0291] S1220: The sensing device receives the Semantization Model Update.

[0292] The sensing device receives the Semantization Model Update, which includes one or multiple semantization models:  $\{M'_1, M'_2, \dots, M'_s\}$ ,  $s' \geq 1$ . The sensing device can implicitly or explicitly obtain the task/modality identifier for each model  $M'_t$ .

[0293] If there is a task identifier for model  $M'_t$ , or modality identifier for model  $M'_t$ , or both task identifier and modality identifier for model  $M'_t$  in the Semantization Model Update, as introduced in S1210, sensing device can directly obtain the task/modality identifier.

[0294] Otherwise, the task/modality identifier can be implicitly calculated. For example, based on order of configured models:  $M_t$  for task/modality with index  $t$ .

[0295] Then sensing device updates local semantization models based on the received ones.

[0296] Optionally, if the updated semantization models are compressed ones, then sensing device decompresses the models first to obtain the reconstructed models.

[0297] FIG. 13 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure. The method can be implemented by a first apparatus, and the preconfiguration of the semantic model(s) is implemented through jointly training the semantic model(s) by the first apparatus with a second apparatus. Optionally, the first apparatus can be a sensing device or other device that has similar function (for example, the first apparatus could be a chip), and the second apparatus can be a central device or other device that has similar function (for example, the second apparatus could be a chip), which is not limited herein. In a possible implementation, as shown in FIG. 13, the method can include the following steps.

[0298] S1310, training, by the first apparatus, at least one semantization model, jointly with the second apparatus.

[0299] In details, the first apparatus and the second apparatus may jointly train at least one semantization model at a time. This provides another way for configuring the semantization model(s). Instead of communicating a semantic model configuration which indicates the semantic model(s) from the second apparatus to the first apparatus, jointly training of the semantic model(s) may be conducted jointly by the first apparatus and the second apparatus. Through jointly training, configuration of the semantic model(s) can still be implemented even when the semantization models used by the first apparatus and the second apparatus are different, or when the semantization models are required to be kept private, which may happen, for example, when the first apparatus and the second apparatus belong to different parties or corporations. The semantization model(s) may be trained by the first

apparatus jointly with the second apparatus, which could guarantee the consistence of the semantization models on the two sides, and thus accuracy of query can be maintained based on the consistent semantization model(s).

[0300] In a possible implementation, the training, by the first apparatus, at least one semantization model, jointly with the second apparatus includes: communicating, by the first apparatus, with the second apparatus, intermediate information generated in the training of the at least one semantization model, where the intermediate information includes intermediate features, or gradients generated in the training; and training, by the first apparatus, the at least one semantization model, jointly with the second apparatus based on the intermediate information.

[0301] As discussed above, the first apparatus and the second apparatus may belong to different parties or corporations, which may use different semantization models and may not hope to share their own semantization models. Therefore, the intermediate information including intermediate features, or gradients generated in the training may be used to train the semantization model(s) of both sides.

[0302] In a possible implementation, the method further includes: obtaining at least one identifier for the at least one semantization model to be trained, where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0303] In details, the second apparatus may send the identifier for the semantization model to be trained to the first apparatus, so that the first apparatus may directly obtain the identifier. The identifier may include a task identifier, or a modality identifier, or both a task identifier and a modality identifier. The first apparatus can directly obtain the semantization model to be trained according to the task identifier, or the modality identifier, or the combination of task and modality identifiers, thereby facilitating the training of the semantization model(s) and further improving flexibility and reasonability of query. For example, the semantization model 1 to be trained may correspond to task 1 "find moving obstacles" with identifier  $t_1$  and the semantization model 2 to be trained may correspond to task 2 "localize incoming pedestrians" with identifier  $t_2$ , which is not limited herein.

[0304] S1320, obtaining at least one query message.

[0305] The step S1320 is similar as step S910 shown in FIG. 9, which is not repeated herein for brevity.

[0306] S1330, generating, based on at least one piece of raw sensed data and at least one semantization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data, where the at least one semantization model is preconfigured in a first apparatus through communicating with a second apparatus.

[0307] The step S1330 is similar as step S920 shown in FIG. 9, which is not repeated herein for brevity.

[0308] S1340, sending a sensing result, where the sensing result includes at least one piece of sensed data and/or at least one second sensing semantic, and where the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

5 [0309] The step S1340 is similar as step S930 shown in FIG. 9, which is not repeated herein for brevity.

[0310] It is noted that the step 1310 is not necessary to be performed before the step 1320. For example, if a semantization model for one certain task at both sides is consistent, the step 1310 may not be performed, and if a semantization model for another certain task at both sides is inconsistent, the step 1310 may be performed to train that semantization model. The inconsistency could be found by the first apparatus and/or the second apparatus,  
10 which is not limited herein.

[0311] With the sensing communication method provided by the present disclosure, another way for configuring the semantization model(s) is provided. The at least one semantization model can be trained by the first apparatus jointly with the second apparatus, and thus the consistence of the at least one semantization model may be guaranteed, and thus accuracy of query can be maintained based on the consistent semantization model(s)  
15 without communicating a semantization model configuration indicating the semantization model(s).

[0312] FIG. 14 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure, where the central device and sensing device can jointly train one or multiple semantization models, which will be used to calculate the sensing semantics at sensing device side. The procedures includes at least one of the following steps.

20 [0313] S1410: The central device and sensing device jointly train one or multiple semantization models.

[0314] The central device and sensing device jointly train one or multiple semantization models. Following approaches can be used:

[0315] The central device and sensing device jointly train one semantization model  $M_i$  at a time, i.e.  $M_i^1$  at sensing device side and at  $M_i^2$  the central device side. The information communicated between the central device  
25 and sensing device can include the intermediate features, or gradients, or other intermediate values generated in training. Optionally, the identifier for the semantization model can be included in the communicated information, to indicate its task ID (or modality ID, or both task ID and modality ID). After training, sensing device can get  $M_i^1$  and the central device can get  $M_i^2$  for this semantization model. Then after training several models, sensing device can get  $\{M^1_1, M^1_2, \dots, M^1_s\}$ , and the central device can get  $\{M^2_1, M^2_2, \dots, M^2_s\}$  respectively, where  $s$  is the total  
30 number of semantization models.

[0316] The central device and sensing device jointly train multiple semantization models  $\{M_1, M_2, \dots, M_s\}$  at a time,  $s > 1$ , i.e.  $M^1_t$  at sensing device side and at  $M^2_t$  the central device side,  $t \in [1, s]$ .  $s$  is the number of semantization models trained at a time. The information communicated between the central device and sensing device can include the intermediate features, or gradients, or other intermediate values generated in training for multiple models. Optionally, the identifier  $t_i$  for the semantization model  $M_i$  can be included in the communicated information, to indicate its task ID (or modality ID, or both task ID and modality ID),  $i \in [1, s]$ . After training, sensing device can get  $\{M^1_1, M^1_2, \dots, M^1_s\}$ , and the central device can get  $\{M^2_1, M^2_2, \dots, M^2_s\}$  respectively.

[0317] S1420: The central device sends query message.

[0318] In details, the central device broadcast or multicast query message. The query message can include one or more queries:  $\{q_1, q_2, \dots, q_n\}$ , where  $n$  is the number of queries. And the queries can be for single task, single modality, or multiple tasks or multiple modalities.

[0319] Optionally, the identifier for the query can be included in the query message. For example, for query  $q_i$ , its identifier  $t_i$  can be included to indicate its task ID (or modality ID, or both task ID and modality ID).

[0320] S1430: The sensing device receives/detects the query message.

[0321] Based on the sensing environment and previously trained semantization models  $\{M^1_1, M^1_2, \dots, M^1_s\}$  at sensing device side, sensing device obtains its sensing semantics  $\{o_1, o_2, \dots, o_s\}$ , where  $o_t$  is obtained based on semantization model  $M^1_t$ ,  $t \in [1, s]$ . Note that the modality of sensing environment input of sensing device may be the same or different from the modality with which the central device obtains the query. If any  $o_t$  matches the query, sensing device will respond with sensed data.

[0322] Optionally, if the identifier for the query is included in the query Message, e.g. if the identifier  $t_i$  for query  $q_i$  is included to indicate its task ID (or modality ID, or both task ID and modality ID), then sensing device may use the identifier to obtain the previously trained semantization model for query  $q_i$ .

[0323] S1440: The sensing device responds with sensed data.

[0324] The sensed data from sensing device can include matched raw sensed data and/or sensing semantics in s1430.

[0325] In a possible implementation, when at least one semantization model trained by the first apparatus jointly with the second apparatus is outdated, the method further includes: updating, by the first apparatus, the at least one outdated semantization model, jointly with the second apparatus.

[0326] In a possible implementation, the updating, by the first apparatus, the at least one outdated semantization model, jointly with the second apparatus includes: when multiple outdated semantization models

exist, updating, by the first apparatus, one or more outdated semantization models, jointly with the second apparatus at a time.

[0327] In details, the first apparatus and the second apparatus may jointly update/refine one or multiple semantization models, and thus the accuracy of query can be improved. For example, the first apparatus and the second apparatus may jointly update one semantization model  $M'_t$  at a time, i.e.  $M'^t_1$  at first apparatus side and  $M'^t_2$  at the second apparatus side. The information communicated between the first apparatus and the second apparatus can include the intermediate features, or gradients, or other intermediate values generated in update training. Optionally, the identifier for the semantization model can be included in the communicated information, to indicate its task identifier, or modality identifier, or both task identifier and modality identifier. After update training, the first apparatus can get  $M'^t_1$  and the second apparatus can get  $M'^t_2$  for the updated semantization model. Then, after updating several semantization models, the first apparatus can get  $\{M'^1_1, M'^1_2, \dots, M'^1_{s'}\}$ , and the second apparatus can get  $\{M'^2_1, M'^2_2, \dots, M'^2_{s'}\}$  respectively, where  $s'$  is the number of updated semantization models. The first apparatus and the second apparatus may jointly update multiple semantization models  $\{M'_1, M'_2, \dots, M'_{s'}\}$  at a time,  $s' > 1$ , i.e.  $M'^t_1$  at first apparatus side and  $M'^t_2$  at the second apparatus side,  $t \in [1, s']$ .  $s'$  is the number of semantization models updated at a time. The information communicated between the central device and sensing device can include the intermediate features, or gradients, or other intermediate values generated in update training for multiple models. Optionally, the identifier  $t_i$  for the semantization model  $M'_i$  can be included in the communicated information, to indicate its task identifier or modality identifier, or both task identifier and modality identifier,  $i \in [1, s']$ . After update training, the first apparatus can get updated  $\{M'^1_1, M'^1_2, \dots, M'^1_{s'}\}$ , and the second apparatus can get updated  $\{M'^2_1, M'^2_2, \dots, M'^2_{s'}\}$  respectively.

[0328] FIG. 15 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure, where the central device and sensing device need to update previously trained semantization model, for example, if the previous model is outdated or the model need to be refined. Then procedures of at least one of the following steps will be executed.

[0329] S1510: The central device and sensing device jointly update/refine one or multiple semantization models.

[0330] The central device and sensing device jointly update/refine one or multiple semantization models. Following approaches can be used:

[0331] The central device and sensing device jointly update one semantization model  $M'_t$  at a time, i.e.  $M'^t_1$  at sensing device side and at  $M'^t_2$  the central device side. The information communicated between the central device

and sensing device can include the intermediate features, or gradients, or other intermediate values generated in update training. Optionally, the identifier for the semantization model can be included in the communicated information, to indicate its task ID (or modality ID, or both task ID and modality ID). After update training, sensing device can get  $M^1_t$  and the central device can get  $M^2_t$  for the updated semantization model. Then after  
 5 updating several models, sensing device can get  $\{M^1_1, M^1_2, \dots, M^1_{s'}\}$ , and the central device can get  $\{M^2_1, M^2_2, \dots, M^2_{s'}\}$  respectively, where  $s'$  is the number of updated semantization models.

[0332] The central device and sensing device jointly update multiple semantization models  $\{M^1_1, M^1_2, \dots, M^1_{s'}\}$  at a time,  $s' > 1$ , i.e.  $M^1_t$  at sensing device side and at  $M^2_t$  the central device side,  $t \in [1, s']$ .  $s'$  is the number of semantization models updated at a time. The information communicated between the central device and sensing  
 10 device can include the intermediate features, or gradients, or other intermediate values generated in update training for multiple models. Optionally, the identifier  $t_i$  for the semantization model  $M^1_i$  can be included in the communicated information, to indicate its task ID (or modality ID, or both task ID and modality ID),  $i \in [1, s']$ . After update training, sensing device can get updated  $\{M^1_1, M^1_2, \dots, M^1_{s'}\}$ , and the central device can get updated  $\{M^2_1, M^2_2, \dots, M^2_{s'}\}$  respectively.

15 [0333] In a possible implementation, each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

[0334] For example, the query message 1 may correspond to task 1 “find moving obstacles” and the query message 2 may correspond to task 2 “localize incoming pedestrians”, which is not limited herein. Because each query message may correspond to a task, a modality, or a combination of the task and the modality, the query may  
 20 be conducted more flexibly and reasonably according to the task and/or modality.

[0335] In a possible implementation, each of the at least one query message includes at least one identifier, where the at least one identifier includes a task identifier, a modality identifier, or both a task identifier and a modality identifier.

[0336] In a possible implementation, the method further includes: obtaining the at least one semantization  
 25 model based on the at least one identifier for the at least one semantization model in the at least one query message.

[0337] In details, when the semantization model configuration is obtained by the first apparatus from the second apparatus, where the semantization model may corresponds to the identifier(s) (for example, the task identifier, the modality identifier, or both the task identifier and the modality identifier). Then once obtaining the  
 30 query message(s) including the identifier(s) from the second apparatus, the first apparatus may directly obtain the

semantization model corresponding to the identifier(s) in a high efficiency way. When the semantization model update is obtained by the first apparatus from the second apparatus, where the updated semantization model may corresponds to the identifier(s) (for example, the task identifier, the modality identifier, or both the task identifier and the modality identifier). Then once obtaining the query message(s) including the identifier(s) from the second apparatus, the first apparatus may directly obtain the updated semantization model corresponding to the identifier(s) in a high efficiency way. When the semantization model is trained by the first apparatus jointly with the second apparatus, where the trained semantization model may corresponds to the identifier(s) (for example, the task identifier, the modality identifier, or both the task identifier and the modality identifier). Then once obtaining the query message(s) including the identifier(s) from the second apparatus, the first apparatus may directly obtain the trained semantization model corresponding to the identifier(s) in a high efficiency way. When the semantization model is jointly updated by the first apparatus and the second apparatus, where the jointly updated semantization model may corresponds to the identifier(s) (for example, the task identifier, the modality identifier, or both the task identifier and the modality identifier). Then once obtaining the query message(s) including the identifier(s) from the second apparatus, the first apparatus may directly obtain the jointly updated semantization model corresponding to the identifier(s) in a high efficiency way.

[0338] With the sensing communication method provided by the present disclosure, an apparatus such as a sensing device may obtain query message(s) from other apparatus such as a central device and respond with sensing result(s) in response to the obtained query message(s). The sensing result(s) may include the at least one piece of sensed data and/or the at least one second sensing semantic, where the at least one second sensing semantic and/or the at least one third sensing semantic converted from the at least one piece of sensed data are included in the at least one first sensing semantic, which is generated based on at least one piece of raw sensed data and at least one semantization model preconfigured in the sensing device through communicating with the central device. Thus, query may be conducted more flexibly and reasonably based on the at least one semantization model. Moreover, the at least one semantization model can be trained by the sensing device jointly with the central device, and thus the consistence of the at least one semantization model may be guaranteed, and thus flexibility and reasonability of query may be further improved based on the consistent semantization model. Furthermore, the outdated semantization model may be updated, and thus the accuracy of query could be improved.

[0339] In the above, the sensing communication method of the present disclosure is described from the perspective of the first apparatus (such as the sensing device) in combination with FIG. 9 to FIG. 15. In the following, a sensing communication method of the present disclosure will be described from the perspective of the

second apparatus (such as the central device) in combination with FIG. 16 to FIG. 18.

[0340] FIG. 16 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure. The method can be implemented by a second apparatus. Optionally, the second apparatus can be a central device or other device that has similar function (for example, the second apparatus could be a chip), which is not limited herein. As shown in FIG. 16, the method can include the following steps.

[0341] S1610, sending at least one query message.

[0342] In details, the second apparatus may send the at least one query message to at least one first apparatus. Optionally, the at least one first apparatus can be a sensing device or other device that has similar function (for example, the at least one first apparatus could be a chip), which is not limited herein.

[0343] S1620, obtaining one or more sensing results, where each of the one or more sensing results includes at least one piece of sensed data and/or at least one second sensing semantic, and where at least one first sensing semantic respectively corresponds to at least one piece of raw sensed data and is generated based on the at least one piece of raw sensed data and at least one semantization model which is preconfigured in a first apparatus through communicating with a second apparatus, and the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

[0344] In details, the second apparatus may send at least one query message to the at least one first apparatus, and one or more of the at least one first apparatus may respond with the query message. That is, not all of the at least one first apparatus may be required to respond with the query message, where some first apparatuses that are not relevant may not respond with the query message. Certainly, there is also case where all of the at least one first apparatus may respond with the query message. Then the second apparatus may obtain one or more sensing results from one or more of the at least one first device, where each of the one or more sensing results is from a different one of the at least one first device, and each of the one or more sensing results includes at least one piece of sensed data and/or at least one second sensing semantic. The at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data may be included in the at least one first sensing semantic, where the at least one first sensing semantic may respectively corresponds to at least one piece of raw sensed data and may be generated based on the at least one piece of raw sensed data and at least one semantization model which is preconfigured in the at least one first apparatus through communicating with the second apparatus.

[0345] Taking one of the at least one first apparatus as an example, the second apparatus may send the query message to the first apparatus, and once the first apparatus obtains the query message, the first apparatus may become waken but with little idea whether or not its sensed data is sufficiently relevant to the goal conveyed by the query message. Thereby the first apparatus may enable its sensing gadget to sense its nearby environment into sensed data and compare the sensed data with the query message. The comparison approach may be, for example, the comparison between the query semantic and the sensing semantic. In other words, the first apparatus may convert the raw sensed data to a sensing semantic based on a semantization model, and then compare the sensing semantic with the query semantic so as to determine whether or not its sensed data is sufficiently relevant to the goal conveyed by the query semantic. Before being used for generating a sensing semantic, the semantization model may be configured in the first apparatus through communication between the first apparatus and the second apparatus, which means that before a semantization model is used for converting a piece of sensed data to a sensing semantic, the first apparatus and the second apparatus have communicated with each other to configure the semantization model. Moreover, the semantization model may also be used for converting the query message to a query semantic if necessary. It is noted that when the first apparatus determines whether or not its sensed data is sufficiently relevant to the goal conveyed by the query message, other comparison approach may also be used, for example, the comparison between the query token and the sensing token, which is not limited herein.

[0346] Further, if the first apparatus tells that the sensed data is sufficiently relevant with the query message, the first apparatus encodes and sends the sensed data to the second apparatus. In a possible implementation, the at least one piece of sensed data includes at least one piece of raw sensed data, half raw sensed data, or compressed sensed data. In other words, the sensed data can be sent in many forms, such as, raw sensed data, half raw sensed data, compressed sensed data, or sensing semantic converted from the raw sensed data, which is not limited herein. Specifically, if all of the at least one first sensing semantic matches the query semantic, all the sensed data may be sent to the second apparatus in at least one form as described above, while if part of the at least one first sensing semantic match the query semantic, only the matched sensed data may be sent to the second apparatus in at least one form.

[0347] With the sensing communication method provided by the present disclosure, the second apparatus can send the query message(s) to the at least one first apparatus, and after obtaining the query message(s), the at least one first apparatus may generate the first sensing semantic(s) based on raw sensed data and the semantization model(s) preconfigured in the at least one first apparatus through communicating with the second apparatus. After generating the first sensing semantic(s), the at least one first apparatus may send the sensing result(s) for the

second apparatus to obtain, where the sensing result(s) may include sensed data and/or sensing semantic, in particular, at least one second sensing semantic, which is included in the first sensing semantic(s), and/or at least one piece of sensed data, from which at least one third sensing semantic converted is included in the first sensing semantic(s). Since the generation of the first sensing semantic(s) is based on the semantic model(s) preconfigured in the at least one first apparatus through its communication with the second apparatus, query may be conducted more flexibly and reasonably based on the semantization model(s).

[0348] FIG. 17 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure. The method can be implemented by a second apparatus, and the preconfiguration of the semantic model(s) is implemented through a semantic model configuration communicated from at least one first apparatus to the second apparatus. Optionally, the second apparatus can be a central device or other device that has similar function (for example, the second apparatus could be a chip), and the at least one first apparatus can be a sensing device or other device that has similar function (for example, the at least one first apparatus could be a chip), which is not limited herein. In a possible implementation, as shown in FIG. 17, the method can include the following steps.

[0349] S1710, sending a semantization model configuration, where the semantization model configuration indicates the at least one semantization model.

[0350] In details, the second apparatus may send the semantization model configuration(s) to the at least one first apparatus so that the at least one first apparatus may obtain the semantization model configuration(s) and use the semantization model indicated in the semantization model configuration(s) to convert sensed data to a sensing semantic.

[0351] In a possible implementation, the semantization model configuration may be sent by the second apparatus via a broadcast message, via a multicast message targeted to a group of apparatuses including the first apparatus; or via a dedicated message to a first apparatus.

[0352] In details, the at least one first apparatus may obtain the semantization model configuration(s) in different ways. For example, by means of broadcasting or multicasting, a large number of apparatuses may be scheduled rather than one-to-one individual scheduling, the resource consumption can be reduced. By means of unicasting, one-to-one individual scheduling can be achieved for special query dedicated to a specific apparatus.

[0353] In a possible implementation, the broadcast message includes a synchronization signal and physical broadcast channel block (SSB), or a system information block (SIB) message.

[0354] For example, the semantization model configuration can be carried in synchronization signal and

physical broad cast channel block (SSB) for broadcast, or in multicast configuration targeted to the group of apparatuses including the first apparatuses, or even dedicated to the first apparatus. For broadcast, it can be in a system information block (SIB) message, and there may be a flag indicating whether there will be such a configuration in SIBx message, and a period may also be indicated. It is noted that, for broadcast, other  
 5 information may also be used, which is not limited herein.

[0355] S1720, sending at least one query message.

[0356] The step S1720 is similar as step S1610 shown in FIG. 16, which is not repeated herein for brevity.

[0357] S1730, obtaining one or more sensing results, where each of the one or more sensing results includes at least one piece of sensed data and/or at least one second sensing semantic, and where at least one first sensing  
 10 semantic respectively corresponds to at least one piece of raw sensed data and is generated based on the at least one piece of raw sensed data and at least one semantization model which is preconfigured in at least one first apparatus through communicating with a second apparatus, and the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

15 [0358] The step S1730 is similar as step S1620 shown in FIG. 16, which is not repeated herein for brevity.

[0359] With the sensing communication method provided by the present disclosure, the second apparatus may send the semantization model configuration to the at least one first apparatus in advance. In this way, the semantic model(s) can be preconfigured in the at least one first apparatus through the semantic model configuration(s) communicated from the second apparatus to the at least one first apparatus. Then, the at least one first apparatus  
 20 can use the semantization model indicated in the semantization model configuration(s) to convert the sensed data to a sensing semantic (and/or convert the query message to a query semantic if necessary). Thus, the flexibility and reasonability of query may be further improved.

[0360] In a possible implementation, the at least one semantization model is represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , where the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$   
 25 corresponds to a task and/or a modality.

[0361] In details, different semantization models may correspond to different tasks, or different semantization models may correspond to different modalities, or different semantization models may correspond to different combinations of task and modality. For example, the semantization model 1 may correspond to task 1 “find moving obstacles” and the semantization model 2 may correspond to task 2 “localize incoming pedestrians”, which  
 30 is not limited herein. Because each of the at least one semantization model may correspond to a task and/or a

modality, query may be conducted more flexibly and reasonably according to the task and/or modality.

[0362] In a possible implementation, the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

5 [0363] In details, in addition to the semantization model, the semantization model configuration(s) may further indicate at least one identifier for the semantization model. Because the semantization model configuration(s) may be further used to indicate the at least one identifier, the at least one first apparatus can directly obtain a semantization model for a task with a specific task identifier, or the semantization model for a modality with a specific modality identifier, or the semantization model for a combination of task and modality  
10 with specific task and modality identifiers when generating the sensing semantic. For example, the semantization model 1 may correspond to task 1 “find moving obstacles” with identifier  $t_1$  and the semantization model 2 may correspond to task 2 “localize incoming pedestrians” with identifier  $t_2$ , which is not limited herein. Thus flexibility and reasonability of query may be further improved based on the at least one identifier indicated in the semantization model configuration(s).

15 [0364] In a possible implementation, when the at least one identifier includes a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; M_1, M_2, \dots M_s\}$ , where  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0365] In a possible implementation, when the at least one identifier includes a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; t'_1, t'_2, \dots t'_s; M_1, M_2, \dots M_s\}$ , where  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ , or,  $t_i$  is a modality identifier of model  $M_i$ , and  $t'_i$  is a task identifier of model  $M_i$ ,  $i \in [1, s]$ .  
20

[0366] Different representations of the semantization model configuration(s) are provided for different cases of identifiers. For example, when the at least one identifier includes a single identifier, i.e., a task identifier or a modality identifier, the semantization model configuration(s) may be represented by  $\{(t_1, M_1), (t_2, M_2), \dots (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; M_1, M_2, \dots M_s\}$ , or when the at least one identifier includes both a task identifier and a modality identifier, the semantization model configuration(s) may be represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; t'_1, t'_2, \dots t'_s; M_1, M_2, \dots M_s\}$ . Thus the semantization model configuration(s) is more conveniently, and flexibility and reasonability of query may be further improved based on the identifier(s) indicated in the semantization model configuration(s).  
25

30 [0367] In a possible implementation, the method further includes: compressing one or more semantization

models of the at least one semantization model in the semantization model configuration.

[0368] In details, for saving transmission resources, one or more semantization models of the at least one semantization model in the semantization model configuration(s) may be compressed. It is noted that not all of the at least one semantization model is required to be compressed, which depends on the amount of the transmission resource and the processing capability of the apparatus. Because the one or more semantization models of the at least one semantization model in the semantization model configuration(s) may be compressed, the resource consumption may be generally reduced.

[0369] In a possible implementation, a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

[0370] In a possible implementation, a compression approach for each of the one or more semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0371] In details, the compression approach and/or compression parameters for each of the one or more semantization models may be known by both sides in various ways. For example, the compression approach and/or compression parameters for each of the one or more semantization models may be configured previously, pre-defined, or carried in the semantization model configuration(s), which is not limited herein. Moreover, various compression approaches could be adopted, which may include but not limited to projection, codebook, quantization, or entropy coding, thus the compression may be conducted more flexibly and reasonably according to actual application situations.

[0372] In a possible implementation, when at least one semantization model in the semantization model configuration is outdated, a semantization model update may be sent to update the outdated semantization model, and specifically, the method may further include sending a semantization model update, where the semantization model update includes at least one updated semantization model respectively corresponding to at least one outdated semantization model.

[0373] In details, a previously configured semantization model may be outdated and need to be updated. For example, if a previous semantization model is outdated, or if a previous semantization model has been refined at the second apparatus, this previous semantization model may be required to be updated. At this time, the second apparatus may send the semantization model update(s) to the at least one first apparatus so that the at least one first apparatus can obtain the semantization model update(s) to update the outdated semantization model. Because the outdated semantization model may be updated, the accuracy of query could be improved.

[0374] In a possible implementation, the method further includes: compressing one or more updated semantization models of the at least one updated semantization model in the semantization model update.

[0375] In details, for saving transmission resources, one or more updated semantization models of the at least one updated semantization model in the semantization model update(s) may be compressed. It is noted that not all of the at least one updated semantization model is required to be compressed, which depends on the amount of the transmission resource and the processing capability of the apparatus. Because the one or more updated semantization models of the at least one updated semantization model in the semantization model update(s) may be compressed, the resource consumption may be generally reduced.

[0376] In a possible implementation, a compression approach for each of the one or more updated semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0377] In a possible implementation, the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

[0378] In a possible implementation, a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update(s).

[0379] In details, the compression approach and/or compression parameters for each of the one or more updated semantization models may be known by both sides in various ways. For example, the compression approach and/or compression parameters for each of the one or more updated semantization models may be configured previously, pre-defined, or carried in the semantization model update(s), which is not limited herein.

Moreover, various compression approaches could be adopted, which may include but not limited to projection, codebook, quantization, or entropy coding, thus the compression may be conducted more flexibly and reasonably. Meanwhile, the at least one updated semantization model may be compressed based on the difference between the updated semantization model and the corresponding outdated semantization model, thus the resource consumption may be further reduced.

[0380] FIG. 18 is another schematic flowchart of a sensing communication method according to one or more example embodiments of the present disclosure. The method can be implemented by a second apparatus, and the preconfiguration of the semantic model(s) is implemented through jointly training the semantic model(s) by the second apparatus with at least one first apparatus. Optionally, the second apparatus can be a central device or other device that has similar function (for example, the second apparatus could be a chip), and the at least one first apparatus can be a sensing device or other device that has similar function (for example, the a least one first

apparatus could be a chip), which is not limited herein. In a possible implementation, as shown in FIG. 18, the method can include the following steps.

[0381] S1810, training, by the second apparatus, at least one semantization model, jointly with the first apparatus.

5 [0382] In details, the second apparatus and the at least one first apparatus may jointly train at least one semantization model at a time. This provides another way for configuring the semantization model(s). Instead of communicating a semantic model configuration(s) which indicates the semantic model(s) from the second apparatus to the at least one first apparatus, jointly training of the semantic model(s) may be conducted jointly by the second apparatus and the at least one first apparatus. Through jointly training, configuration of the semantic  
10 model(s) can still be implemented even when the semantization models used by the second apparatus and the at least one first apparatus are different, or when the semantization models are required to be kept private, which may happen, for example, when the second apparatus and the at least one first apparatus belong to different parties or corporations. The semantization model(s) may be trained by the second apparatus jointly with the at least one first apparatus, which could guarantee the consistence of the semantization models on the two sides, and thus accuracy  
15 of query can be maintained based on the consistent semantization model(s).

[0383] In a possible implementation, the training, by the second apparatus, at least one semantization model, jointly with the at least one first apparatus includes: communicating, by the second apparatus, with the at least one first apparatus, intermediate information generated in the training of the at least one semantization model, where the intermediate information includes intermediate features, or gradients generated in the training; and training, by  
20 the second apparatus, the at least one semantization model, jointly with the at least one first apparatus based on the intermediate information.

[0384] As discussed above, the at least one first apparatus and the second apparatus may belong to different parties or corporations, which may use different semantization models and may not hope to share their own semantization models. Therefore, the intermediate information including intermediate features, or gradients  
25 generated in the training may be used to train the semantization model(s) of both sides.

[0385] In a possible implementation, the method further includes: sending at least one identifier for the at least one semantization model to be trained, where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0386] In details, the second apparatus may send the identifier for the semantization model to be trained to the  
30 at least one first apparatus, so that the at least one first apparatus may directly obtain the identifier. The identifier

may include a task identifier, or a modality identifier, or both a task identifier and a modality identifier. The at least one first apparatus can directly obtain the semantization model to be trained according to the task identifier, or the modality identifier, or the combination of task and modality identifiers, thereby facilitating the training of the semantization model(s) and further improving flexibility and reasonability of query. For example, the  
5 semantization model 1 to be trained may correspond to task 1 “find moving obstacles” with identifier  $t_1$  and the semantization model 2 to be trained may correspond to task 2 “localize incoming pedestrians” with identifier  $t_2$ , which is not limited herein.

[0387] S1820, sending at least one query message.

[0388] The step S1820 is similar as step S1610 shown in FIG. 16, which is not repeated herein for brevity.

10 [0389] S1830, obtaining one or more sensing results, where each of the one or more sensing results includes at least one piece of sensed data and/or at least one second sensing semantic, and where at least one first sensing semantic respectively corresponds to at least one piece of raw sensed data and is generated based on the at least one piece of raw sensed data and at least one semantization model which is preconfigured in at least one first apparatus through communicating with a second apparatus, and the at least one first sensing semantic includes the  
15 at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

[0390] The step S1830 is similar as step S1620 shown in FIG. 16, which is not repeated herein for brevity.

[0391] It is noted that the step 1810 is not necessary to be performed before the step 1820. For example, if a semantization model for one certain task at both sides is consistent, the step 1810 may not be performed, and if a  
20 semantization model for another certain task at both sides is inconsistent, the step 1810 may be performed to train that semantization model. The inconsistency could be found by the second apparatus and/or the at least one first apparatus, which is not limited herein.

[0392] With the sensing communication method provided by the present disclosure, another way for configuring the semantization model(s) is provided. The at least one semantization model can be trained by the  
25 second apparatus jointly with the at least one first apparatus, and thus the consistency of the at least one semantization model may be guaranteed, and thus accuracy of query can be maintained based on the consistent semantization model(s) without communicating a semantization model configuration indicating the semantization model(s).

[0393] In a possible implementation, when at least one semantization model trained by the second apparatus  
30 jointly with the at least one first apparatus is outdated, the method further includes: updating, by the second

apparatus, the at least one outdated semantization model, jointly with the at least one first apparatus.

[0394] In a possible implementation, the updating, by the second apparatus, the at least one outdated semantization model, jointly with the at least one first apparatus includes: when multiple outdated semantization models exist, updating, by the second apparatus, one or more outdated semantization models, jointly with the at least one first apparatus at a time.

[0395] In details, the second apparatus and the at least one first apparatus may jointly update/refine one or multiple semantization models, and thus the accuracy of query can be improved. For example, the second apparatus and the at least one first apparatus may jointly update one semantization model  $M'_t$  at a time, i.e.  $M'_t$  at first apparatus side and  $M^{2'}_t$  at the second apparatus side. The information communicated between the second apparatus and the at least one first apparatus can include the intermediate features, or gradients, or other intermediate values generated in update training. Optionally, the identifier for the semantization model can be included in the communicated information, to indicate its task identifier, or modality identifier, or both task identifier and modality identifier. After update training, the at least one first apparatus can get  $M^{1'}_t$  and the second apparatus can get  $M^{2'}_t$  for the updated semantization model. Then, after updating several semantization models, the at least one first apparatus can get  $\{M^{1'}_1, M^{1'}_2, \dots, M^{1'}_{s'}\}$ , and the second apparatus can get  $\{M^{2'}_1, M^{2'}_2, \dots, M^{2'}_{s'}\}$  respectively, where  $s'$  is the number of updated semantization models. The second apparatus and the at least one first apparatus may jointly update multiple semantization models  $\{M'_1, M'_2, \dots, M'_{s'}\}$  at a time,  $s' > 1$ , i.e.  $M'_t$  at first apparatus side and  $M^{2'}_t$  at the second apparatus side,  $t \in [1, s']$ .  $s'$  is the number of semantization models updated at a time. The information communicated between the central device and sensing device can include the intermediate features, or gradients, or other intermediate values generated in update training for multiple models. Optionally, the identifier  $t_i$  for the semantization model  $M'_i$  can be included in the communicated information, to indicate its task identifier or modality identifier, or both task identifier and modality identifier,  $i \in [1, s']$ . After update training, the at least one first apparatus can get updated  $\{M^{1'}_1, M^{1'}_2, \dots, M^{1'}_{s'}\}$ , and the second apparatus can get updated  $\{M^{2'}_1, M^{2'}_2, \dots, M^{2'}_{s'}\}$  respectively.

[0396] In a possible implementation, each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

[0397] For example, the query message 1 may correspond to task 1 “find moving obstacles” and the query message 2 may correspond to task 2 “localize incoming pedestrians”, which is not limited herein. Because each query message may correspond to a task, a modality, or a combination of the task and the modality, the query may be conducted more flexibly and reasonably according to the task and/or modality.

[0398] In a possible implementation, each of the at least one query message includes at least one identifier, where the at least one identifier includes a task identifier, a modality identifier, or both a task identifier and a modality identifier.

[0399] In a possible implementation, the at least one identifier for the at least one semantization model in the at least one query message is used for the at least one first apparatus to obtain the at least one semantization model.

[0400] In details, when the semantization model configuration(s) is sent by the second apparatus to the at least one first apparatus, where the semantization model may corresponds to the identifier(s) (for example, the task identifier, the modality identifier, or both the task identifier and the modality identifier). Then once obtaining the query message(s) including the identifier(s) from the second apparatus, the at least one first apparatus may directly

obtain the semantization model corresponding to the identifier(s) in a high efficiency way. When the semantization model update(s) is sent by the second apparatus to the at least one first apparatus, where the updated semantization model may corresponds to the identifier(s) (for example, the task identifier, the modality identifier, or both the task identifier and the modality identifier). Then once obtaining the query message(s) including the identifier(s) from the second apparatus, the at least one first apparatus may directly obtain the updated semantization model

corresponding to the identifier(s) in a high efficiency way. When the semantization model is trained by the second apparatus jointly with the at least one first apparatus, where the trained semantization model may corresponds to the identifier(s) (for example, the task identifier, the modality identifier, or both the task identifier and the modality identifier). Then once obtaining the query message(s) including the identifier(s) from the second apparatus, the at least one first apparatus may directly obtain the trained semantization model corresponding to the identifier(s) in a high efficiency way. When the semantization model is jointly updated by the second apparatus and the at least one first apparatus, where the jointly updated semantization model may corresponds to the identifier(s) (for example, the task identifier, the modality identifier, or both the task identifier and the modality identifier). Then once obtaining the query message(s) including the identifier(s) from the second apparatus, the at least one first apparatus may directly obtain the jointly updated semantization model corresponding to the identifier(s) in a high efficiency way.

[0401] With the sensing communication method provided by the present disclosure, an apparatus such as a central device can broadcast or multi-cast or unicast query message(s), so that other apparatus(es) such as one or more sensing devices can obtain the query message(s) and respond with sensing result(s) in response to the obtained query message(s). The sensing result(s) may include the at least one piece of sensed data and/or the at least one second sensing semantic, where the at least one second sensing semantic and/or the at least one third

sensing semantic converted from the at least one piece of sensed data are included in the at least one first sensing semantic, which is generated based on at least one piece of raw sensed data and at least one semantization model preconfigured in the at least one sensing device through communicating with the central device. Thus, query may be conducted more flexibly and reasonably based on the at least one semantization model. Moreover, the at least one semantization model can be trained by the central device jointly with the at least one sensing device, and thus the consistence of the at least one semantization model may be guaranteed, and thus flexibility and reasonability of query may be further improved based on the consistent semantization model. Furthermore, the outdated semantization model may be updated, and thus the accuracy of query could be improved.

[0402] FIG. 19 is a schematic illustration of realizing a chain of thoughts according to one or more example embodiments of the present disclosure, where a chain of thoughts is realized by generative AI model and is embodied by a sequence of query messages.

[0403] A GPT device may generate a sequence of the query messages based on the previous sensing messages, wherein the previous sensing messages are received and/or fused by the central device. The GPT device may inference one or several generative AI models. The generative AI model or model inferences deep neural network or networks to output a query message or messages. The GPT device generates a sequence of the query messages, called as “a chain of the thoughts” by interacting with a sequence of the fused sensing messages into which the central device fuses the sensed data transmitted by the responsive sensing devices; as illustrated in FIG. 19.

[0404] A query message that the GPT device generate may convey semantic goals, tasks, or objectives. For example, a query message of “localize an incoming pedestrians” explicitly establishes a semantic goal for the sensing devices to focus on its nearby pedestrian and to prevent the sensing devices from being distracted. Since a query message conveys a semantic goal or goals, the query message that the central device transmits to the sensing devices may trigger a goal-oriented sensing task at each responsive sensing device that receives and responds to the very query message. Please note that a message may convey several goals. For example, a message of “find a moving pedestrian with white coat” conveys two semantic goals or tasks: a moving pedestrian and a pedestrian with white coat.

[0405] FIG. 20 is another schematic illustration of interaction among devices in a sensing communication scenario according to one or more example embodiments of the present disclosure. In the example, the sensing device #1 responds to the query message and the sensing device #2 doesn't respond to the query message.

[0406] In a possible implementation, as shown in FIG. 20, the central device may broadcast a sequence of the query messages, because it may be too costly or even forbidden to schedule sensing device individually in a

wireless system including such a high density of sensing devices. Therefore, once a sensing device receives a query message, the sensing device may become waken but with little idea whether or not its sensed data is sufficiently relevant to the goal conveyed by the query message. Thereby the sensing device may enable its sensing gadget to sense its nearby environment into a sensed data and compare the sensed data with the query message. If the sensing device tells that the sensed data is sufficiently relevant with the query message, the sensing device encodes and transmits the sensed data to the central device (Sensing Device #1 in FIG. 20). Otherwise, the sensing may not respond to the query message at all (Sensing Device #2 in FIG. 20). In this sense, the wireless system doesn't schedule individual sensing device but schedule a common task across a collectivity of sensing devices.

[0407] FIG. 21 is another schematic illustration of interaction among devices in a sensing communication scenario according to one or more example embodiments of the present disclosure. In the example, the central device receives the two sensed data from the two responsive sensing devices and fuse the two sensed data into a fused sensing message for the GPT device.

[0408] In a possible implementation, as shown in FIG. 21, the central device may receive a plurality of sensed data from some or all the sensing devices that respond to the query message at the end of a pre-defined responding timing interval. The central device may fuse all the sensed data into one sensing message and input the sensing message to the GPT device that would generate the next query message based on the sensing message, as shown in FIG. 21. Because only those sensing devices that respond to the query message would transmit the sensed data, lots of radio resource would be saved in comparison with one-to-one scheduling algorithm.

[0409] FIG. 22 is a schematic illustration of generating a query message, where GPT device uses generative AI model to generate the query message and then use semantization model to translate the query message into a query semantic. FIG. 23 is a schematic illustration of reversing a semantic, where semantic is reversible, meaning that if someone had a de-semantization model, he could recover a query message from a query semantic.

[0410] A sequence of the query messages that the GPT device generates and the central device broadcasts is in a natural language, that is, human-readable. The GPT device may employ a LLM (large-language-model) to inference over a fused sensing message (in a natural language too) input to generate a new query message. The LLM model may be a "standard" foundation model like a transformer, or a "custom" model that is built for a narrower vocabulary and specific scenarios. For example, a customized LLM for dealing with industry 4.0 or a customized LLM for dealing with wireless communication signaling and protocols. The GPT device may change, update, downsize, upsize, replace its LLM or LLMs anytime as it wishes. Please note that broadcast, multicast or unicast is allowed.

[0411] A query message that the GPT device generates is in a natural language. Because of randomness in generating, two different query messages may convey very similar semantic goal or goals. For example, “find a pedestrian” and “localize a walking man” may have the same semantic goal. Therefore, the GPT device may semantize a query message into a query semantic, which is called as “embedding”, “semantization”, “encoding”, “natural-language to machine translation” and so on. The GPT device may translate a query message into a query semantic that may include a vector, a matrix, or a tensor of scalars. The translation may be realized by deep-neural network or other classic functions. A query semantic may preserve all the key semantic goals conveyed by the query message such that the query semantic can be well translated (de-semantized) back to a query message. Optionally, the GPT device may transmit a query semantic instead of a query message to the central device, as illustrated in FIG. 22. Please note that if all the LLMs outputs to a common natural language (e.g. English), these LLMs are said to be aligned by the natural language; then whatever LLMs are used, everyone can be smoothly hooked into the GPT device and work well within the wireless system.

[0412] FIG. 24 is a schematic illustration of tokenizing a query semantic into a query token, where a GPT device tokenize a query semantic into a query token.

[0413] In one implementation, the central device may further tokenize a query semantic into a query token. A query token is a fixed-length semantic but including a vector of scalars, simpler for transmission and comparison purposes. The wireless system may pre-specify a plurality of lengths for query tokens. Thus, the central device may choose a right token length when tokenizing a query semantic according to the size range of the query semantic. The tokenization can be such a harsh function to prevent a sensing device from recovering a complete query message from a query token. The tokenization may come up with certain privacy protection for query messages. The tokenization may be realized by deep-neural network or other classic functions; as shown in FIG. 24.

[0414] Optionally, the central device receives a query semantic from the GPT device, and then the central device converts the query semantic into a query token with a fixed length; the central device may broadcast the query token with the length to all the sensing devices; the central device may keep the query semantic in its memory or storage to check the feedback sensed data.

[0415] FIG. 25 is a schematic illustration of responding to a query token, where a sensing device responds to a query token. FIG. 26 is a schematic illustration of scoring the relevance with tokens, where score the relevance with tokens. FIG. 27 is another schematic illustration of responding to a query token, where a sensing device responds to a query token. FIG. 28 is a schematic illustration of scoring a relevance with semantic, where score the

relevance with semantic. FIG. 29 is another schematic illustration of responding to a query token, where a sensing device responds to a query token. FIG. 30 is a schematic illustration of scoring the relevance with tokens converted from semantics, where score the relevance with tokens converted from semantics.

[0416] A sensing device may compare its sensed data with the query message; after the sensing device receives a query token (with its length or indicator of its length), the sensing device is waked up to enable its sensing gadget to measure its nearby physical-word environment into a sensed data; the sensing device may be equipped with one LLM or LLMs as semantization model and input the sensed data into the semantization model to output a sensing semantic; optionally, the sensing device may choose a right length and format of the sensing semantic; and the sensing device may continue to tokenize the sensing semantic into a sensing token with the same length as the query token that the sensing device has received; the sensing device compares or scores the relevance between the query message and sensed data, which is based on what the sensing device has received.

[0417] Alternative #1 (FIG. 25 and FIG. 26): the sensing device receives a query token and scoring function; it compares and scores the relevance between the query token and the sensing token; if the score of relevance was greater than or equal to a pre-defined threshold, the sensing device would tell that the sensed data is sufficiently relevant with the query message from the central device.

[0418] Alternative #2 (FIG. 27 and FIG. 28): the sensing device receives a query semantic and scoring function; it compares and scores the relevance between the query semantic with the sensing semantic, if both semantics are in a similar size and format; if the score of relevance was greater than or equal to a pre-defined threshold, the sensing device would tell that the sensed data is sufficiently relevant with the query message from the central device.

[0419] Alternative #3 (FIG. 29 and FIG. 30): the sensing device receives a query semantic and scoring function; it firstly converts the query semantic into a query token by the local tokenization model; and it compares and scores the relevance between the query token and sensing token; if the score of relevance was greater than or equal to a pre-defined threshold, the sensing device would tell that the sensed data is sufficiently relevant with the query message from the central device.

[0420] If the score of relevance is greater than or equal to a pre-defined threshold, the sensing device may transmit information including the sensed data and optionally the score of relevance to the central device. The following are some alternatives of the contents in the transmitted information:

Alternative #1: raw sensed data;

Alternative #2: sensing semantic;

Alternative #3: half raw sensed data (e.g. exact value or number) + sensing semantic;

Alternative #4: raw sensed data + score of relevance;

Alternative #5: sensing semantic + score of relevance;

5 Alternative #6: half raw sensed data (e.g. exact value or number) + sensing semantic + score of relevance.

[0421] A sensing device may be equipped with one or several semantization models to generate sensing semantic from sensed (raw) data, may be equipped with tokenization model to generate sensing token from sensing semantic, and may be configured to have a scoring function; unlike the GPT device, the LLMs, tokenization model, and scoring functions that a sensing device may use are configured by the central device; the central device may  
10 configure and inform the sensing devices of a common LLMs and/or tokenization model and scoring function at all the beginning or on the run.

[0422] A plurality of sensing devices, either in one type or in multiple types, may serve one or several tasks simultaneously; in an efficient way, a sensing device may be triggered once to serve as many tasks as possible.

[0423] A wireless system may include two GPT devices, or one GPT device that can conduct two separated  
15 tasks; in the following disclosure, two GPT devices is mentioned as an example. And the two GPT devices may be easily extended to one GPT device with two separated tasks.

[0424] Although the two GPT devices have their own separate and independent tasks, the two GPT devices may trigger the same sensing devices simultaneously; for example, a driverless car GPT device and a traffic-light GPT device may trigger the same roadside camera sensing devices; nevertheless, although the same sensing  
20 devices may be triggered by two GPT devices at the same time interval, the query message from the first GPT device may be different from the query message from the second GPT device; for example, the driverless car GPT device may broadcast a query message about "moving obstacles" and the traffic-light GPT device may broadcast a query message about "density of vehicles", both of which may be somehow relevant but not similar.

[0425] FIG. 31 is a schematic illustration of generating query tokens, where GPT devices generate the query  
25 tokens. FIG. 32 is a schematic illustration of generating query semantics, where GPT devices generate the query semantics.

[0426] The first GPT device generates the first query semantic to the central device and the second GPT device generates the second query semantic to the central device. There are two options shown as follows:

Alternative #1: as shown in FIG. 31, the central device may tokenize the first query message into the  
30 first query token and tokenize the second query message into the second query token; the central device may use

the first tokenization model to tokenize the first query message and the second tokenization model to tokenize the second query message, or the central device may use a common tokenization model to tokenize the first query message and the second query message; then the central device may broadcast the first query token, the length of the first token, the first scoring function related to the first token, and the first threshold related to the first scoring function, and the second query token the length of the second token, the second scoring function related to the second token, and the second threshold related to the second scoring function in a multiplex way in DL channel(s);

Alternative #2: as shown in FIG. 32, the central device may not perform the tokenization, and the central device may broadcast the first query semantic, the length and format of the first semantic, the first scoring function related to the first semantic, and the first threshold related to the first scoring function, and the second query message the length of the second message, the second scoring function related to the second message, and the second threshold related to the second scoring function in a multiplex way in DL channel(s).

[0427] FIG. 33 is a schematic illustration of responding to two queries with a common semantization model and two tokenization models, where a sensing device responds to two queries with a common semantization model and two tokenization models. FIG. 34 is a schematic illustration of responding to two queries with a common semantization model and a common tokenization model, where a sensing device responds to two queries with a common semantization model and a common tokenization model. FIG. 35 is another schematic illustration of responding to two queries with two semantization models and two tokenization models, where a sensing device responds to two queries with two semantization models and two tokenization models. FIG. 36 is another schematic illustration of responding to two queries with two semantization models and a common tokenization model, where a sensing device responds to two queries with two semantization models and a common tokenization model.

[0428] A sensing device may receive both the first query token and the second query token and wakes to enable its sensing gadget to sense the physical-world around itself into a sensed data. There are two options shown as follows:

Alternative #1: the sensing device may convert the sensed data into one common sensing semantic by one LLM or LLMs; and then the sensing device may tokenize the sensing semantic into the first sensing token in terms of the length of the first query token and tokenize the sensing semantic into the second sensing token in terms of the length of the second query token, in which the sensing device may use the first tokenization model to tokenize the sensing semantic into the first sensing token and the second tokenization model to tokenize the sensing semantic into the second sensing token (as shown in FIG. 33), or may use a common tokenization model to tokenize the sensing semantic into both the first sensing token and the second sensing token (as shown in FIG. 34);

the sensing device may score the relevance between the first query token and the first sensing token and the relevance between the second query token and the second sensing token; the sensing device may tell whether or not the sensed data provides an enough relevance to the first query token if the first score of the relevance is greater than or equal to the first threshold, and the sensing device may tell whether or not the sensed data provides an enough relevance to the second query token if the second score of the relevance is greater than or equal to the second threshold; the sensing device may transmit at least one of the sensed data, sensing semantic or the first score of relevance if deciding the first score of relevance is high enough; the sensing device may transmit at least one of the sensed data, sensing semantic or the second score of relevance if deciding the second score of relevance is high enough;

Alternative #2: as shown in FIG. 34, the sensing device may convert the sensed data into the first sensing semantic by one LLM or LLMs and convert the same sensed data into the second sensing semantic by one LLM or LLMs; and then the sensing device may tokenize the first sensing semantic into the first sensing token in terms of the length of the first query token and tokenize the second sensing semantic into the second sensing token in terms of the length of the second query token, in which the sensing device may use the first tokenization model to tokenize the first sensing semantic into the first sensing token and the second tokenization model to tokenize the second sensing semantic into the second sensing token (as shown in FIG. 35), or may use a common tokenization model to tokenize the sensing semantic into both the first sensing token and the second sensing token (as shown in FIG. 36); the sensing device may score the relevance between the first query token and the first sensing token and the relevance between the second query token and the second sensing token; the sensing device may tell whether or not the sensed data provides an enough relevance to the first query token if the first score of the relevance is greater than or equal to the first threshold, and the sensing device may tell whether or not the sensed data provides an enough relevance to the second query token if the second score of the relevance is greater than or equal to the second threshold; the sensing device may transmit at least one of the sensed data, the first sensing semantic or the first score of relevance if deciding the first score of relevance is high enough; the sensing device may transmit at least one of the sensed data, the second sensing semantic or the second score of relevance if deciding the second score of relevance is high enough.

[0429] FIG. 37 is a schematic illustration of responding to two query semantics with a common semantization model and two different tokenization models, where a sensing device responds to two query semantics with a common semantization model and two different tokenization models. FIG. 38 is a schematic illustration of responding to two query semantics with a common semantization model and a common tokenization model, where

a sensing device responds to two query semantics with a common semantization model and a common tokenization model. FIG. 39 is a schematic illustration of responding to two query semantics with two semantization models and two tokenization models, where a sensing device responds to two query semantics with two semantizations model and two tokenization models. FIG. 40 is a schematic illustration of responding to two query semantics with two semantization models and one tokenization model, where a sensing device responds to two query semantics with two semantizations model and one tokenization model. FIG. 41 is a schematic illustration of responding to two query semantics with one semantization model without tokenization model, where a sensing device responds to two query semantics with one semantization model without tokenization model. FIG. 42 is a schematic illustration of responding to two query semantics with two semantization models without tokenization model, where a sensing device responds to two query semantics with two semantization models without tokenization model.

[0430] A sensing device may receive both the first query semantic and the second query semantic and wakes to enable its sensing gadget to sense the physical-world around itself into a sensed data. There are several options shown as follows:

Alternative #1: the sensing device may convert the sensed data into one common sensing semantic by one LLM or LLMs; and then the sensing device may tokenize the sensing semantic into the first sensing token and the first query semantic into the first query token, both tokens of which are with the same first length that the sensing device decides, while the sensing device may tokenize the sensing semantic into the second sensing token and the second query semantic into the second query token, both tokens of which are with the same second length that the sensing device decides, wherein the sensing device may use the first tokenization model to tokenize the sensing semantic into the first sensing token and the second tokenization model to tokenize the sensing semantic into the second sensing token (FIG. 37), or may use a common tokenization model to tokenize the sensing semantic into both the first sensing token and the second sensing token (FIG. 38); the sensing device may score the relevance between the first query token and the first sensing token and the relevance between the second query token and the second sensing token; the sensing device may tell whether or not the sensed data provides an enough relevance to the first query token if the first score of the relevance is greater than or equal to the first threshold, and the sensing device may tell whether or not the sensed data provides an enough relevance to the second query token if the second score of the relevance is greater than or equal to the second threshold; the sensing device may transmit at least one of the sensed data, sensing semantic or the first score of relevance if deciding the first score of relevance is high enough; the sensing device may transmit at least one of the sensed data, sensing semantic or the

second score of relevance if deciding the second score of relevance is high enough;

Alternative #2: the sensing device may convert the sensed data into the first sensing semantic by one LLM or LLMs and convert the same sensed data into the second sensing semantic by one LLM or LLMs; and tokenize the first sensing semantic into the first sensing token and the first query semantic into the first query token, both tokens of which are with the same first length that the sensing device decides, while the sensing device may tokenize the second sensing semantic into the second sensing token and the second query semantic into the second query token, both tokens of which are with the same second length that the sensing device decides, where the sensing device may use the first tokenization model to tokenize the first sensing semantic into the first sensing token and the second tokenization model to tokenize the second sensing semantic into the second sensing token (FIG. 39), or may use a common tokenization model (FIG. 40) to tokenize the first and second sensing semantics into both the first sensing token and the second sensing token; the sensing device may score the relevance between the first query token and the first sensing token and the relevance between the second query token and the second sensing token; the sensing device may tell whether or not the sensed data provides an enough relevance to the first query token if the first score of the relevance is greater than or equal to the first threshold, and the sensing device may tell whether or not the sensed data provides an enough relevance to the second query token if the second score of the relevance is greater than or equal to the second threshold; the sensing device may transmit at least one of the sensed data, the first sensing semantic or the first score of relevance if deciding the first score of relevance is high enough; the sensing device may transmit at least one of the sensed data, the second sensing semantic or the second score of relevance if deciding the second score of relevance is high enough;

Alternative #3 (FIG. 41): the sensing device may convert the sensed data into one common sensing semantic by one LLM or LLMs; and then the sensing device may score the relevance between the first query semantic and the sensing semantic and the relevance between the second query semantic and the sensing semantic; the sensing device may tell whether or not the sensed data provides an enough relevance to the first query semantic if the first score of the relevance is greater than or equal to the first threshold, and the sensing device may tell whether or not the sensed data provides an enough relevance to the second query semantic if the second score of the relevance is greater than or equal to the second threshold; the sensing device may transmit at least one of the sensed data, the sensing semantic or the first score of relevance if deciding the first score of relevance is high enough; the sensing device may transmit at least one of the sensed data, the sensing semantic or the second score of relevance if deciding the second score of relevance is high enough;

Alternative #4 (FIG. 42): the sensing device may convert the sensed data into the first sensing semantic

by one LLM or LLMs and convert the same sensed data into the second sensing semantic by one LLM or LLMs; and then the sensing device may score the relevance between the first query semantic and the first sensing semantic and the relevance between the second query semantic and the second sensing semantic; the sensing device may tell whether or not the sensed data provides an enough relevance to the first query semantic if the first score of the relevance is greater than or equal to the first threshold, and the sensing device may tell whether or not the sensed data provides an enough relevance to the second query semantic if the second score of the relevance is greater than or equal to the second threshold; the sensing device may transmit at least one of the sensed data, the first sensing semantic or the first score of relevance if deciding the first score of relevance is high enough; the sensing device may transmit at least one of the sensed data, the second sensing semantic or the second score of relevance if deciding the second score of relevance is high enough.

[0431] FIG. 43 is a schematic illustration of processing two sensing semantics independently, where a central device processes the two sensing semantics independently.

[0432] If the central device receives a number of the first sensing semantics plus the first scores of relevance and a number of the second sensing semantics plus the second scores of relevance, the central device may fuse these first sensing semantics according to their first scores of relevance into the first fused sensing semantic and the central device may fuse these second sensing semantics according to their second scores of relevance into the second fused sensing semantic; the central device may score the first fused sensing semantic by measuring the relevance between the first fused semantic and the first query semantic, and score the second fused sensing semantic by measuring the relevance between the second fused sensing semantic and the second query semantic; the central device may transmit the first fused sensing semantic with the first score of relevance to the first GPT device and transmit the second fused sensing semantic with the second score of relevance to the second GPT device; as shown in FIG. 43.

[0433] FIG. 44 is a schematic illustration of processing one sensing semantic but with two tasks independently, where a central device processes the one sensing semantics but with two tasks independently.

[0434] If the central device receives a number of the sensing semantics plus the first scores of relevance and the second scores of relevance, the central device may fuse these sensing semantics according to their first scores of relevance into the first fused sensing semantic and the central device may fuse the second sensing semantics according to their second scores of relevance into the second fused sensing semantic; the central device may score the first fused sensing semantic by measuring the relevance between the first fused semantic and the first query semantic, and score the second fused sensing semantic by measuring the relevance between the second fused

sensing semantic and the second query semantic; the central device may transmit the first fused sensing semantic with the first score of relevance to the first GPT device and transmit the second fused sensing semantic with the second score of relevance to the second GPT device; as shown in FIG. 44.

[0435] The first GPT device may receive the first fused sensing semantic and the first score of relevance to the first query semantic; the first GPT device may de-semanticize the first fused sensing semantic into the first sensing message; the first GPT device may input the first sensing message into the LLM(s) to inference to generate the next first query message; optionally, the first GPT device may input the first sensing message plus the first score of relevance to the LLM(s).

[0436] The second GPT device may receive the second fused sensing semantic and the second score of relevance to the second query semantic; the second GPT device may de-semanticize the second fused sensing semantic into the second sensing message; the second GPT device may input the second sensing message into the LLM(s) to inference to generate the next second query message; optionally, the second GPT device may input the second sensing message plus the second score of relevance to the LLM(s).

[0437] Next, examples of products related to the sensing communication methods will be described.

[0438] FIG. 45 is a schematic structural diagram of a first apparatus according to one or more example embodiments of the present disclosure.

[0439] As shown in FIG. 45, the first apparatus 4500 includes: an obtaining module 4510, configured to obtain at least one query message; a generating module 4520, configured to generate, based on at least one piece of raw sensed data and at least one semanticization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data, where the at least one semanticization model is preconfigured in a first apparatus through communicating with a second apparatus; and a sending module 4530, configured to send a sensing result, where the sensing result includes at least one piece of sensed data and/or at least one second sensing semantic, and where the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

[0440] In a possible implementation, before the obtaining at least one query message, the obtaining module 4510 is further configured to obtain a semanticization model configuration, where the semanticization model configuration indicates the at least one semanticization model.

[0441] In a possible implementation, the at least one semanticization model is represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , where the  $s$  is the number of the at least one semanticization model, and a semanticization model  $M_i$  for  $i \in [1, s]$

corresponds to a task and/or a modality.

[0442] In a possible implementation, the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

5 [0443] In a possible implementation, the generating module 4520 is further configured to generate the at least one first sensing semantic  $\{o_1, o_2, \dots, o_s\}$  based on the at least one piece of raw sensed data and at least one semantization model  $\{M_1, M_2, \dots, M_s\}$ , where a first sensing semantic  $o_i$  is generated based on a piece of raw sensed data to which the first sensing semantic  $o_i$  corresponds and a semantization model  $M_i, i \in [1, s]$ .

10 [0444] In a possible implementation, when the at least one identifier includes a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots, (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; M_1, M_2, \dots, M_s\}$ , where  $t_i$  is the task identifier or modality identifier of model  $M_i, i \in [1, s]$ .

[0445] In a possible implementation, when the at least one identifier includes a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots, (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; t'_1, t'_2, \dots, t'_s; M_1, M_2, \dots, M_s\}$ , where  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i, i \in [1, s]$ .

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[0446] In a possible implementation, one or more semantization models of the at least one semantization model in the semantization model configuration are compressed.

[0447] In a possible implementation, a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

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[0448] In a possible implementation, a compression approach for each of the one or more semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0449] In a possible implementation, when at least one semantization model in the semantization model configuration is outdated, the obtaining module 4510 is further configured to obtain a semantization model update, where the semantization model update includes at least one updated semantization model respectively corresponding to at least one outdated semantization model.

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[0450] In a possible implementation, one or more updated semantization models of the at least one updated semantization model in the semantization model update are compressed.

[0451] In a possible implementation, a compression approach for each of the one or more updated semantization models includes at least one of projection, codebook, quantization, or entropy coding.

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[0452] In a possible implementation, the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

[0453] In a possible implementation, a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update.

[0454] In a possible implementation, the first apparatus 4500 further includes: a training module 4540, configured to train at least one semantization model jointly with the second apparatus.

[0455] In a possible implementation, the first apparatus 4500 further includes: a communicating module 4550, configured to communicate, with the second apparatus, intermediate information generated in the training of the at least one semantization model, where the intermediate information includes intermediate features, or gradients generated in the training; and where the training module 4540 is further configured to train the at least one semantization model jointly with the second apparatus based on the intermediate information.

[0456] In a possible implementation, the obtaining module 4510 is further configured to obtain at least one identifier for the at least one semantization model to be trained, where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0457] In a possible implementation, when at least one semantization model trained by the first apparatus jointly with the second apparatus is outdated, the first apparatus 4500 further includes: an updating module 4560, configured to update the at least one outdated semantization model jointly with the second apparatus.

[0458] In a possible implementation, the updating module 4560 is further configured to, when multiple outdated semantization models exist, update one or more outdated semantization models jointly with the second apparatus at a time.

[0459] In a possible implementation, the obtaining module 4510 is further configured to: obtain the semantization model configuration via a broadcast message; obtain the semantization model configuration via a multicast message targeted to a group of first apparatuses; or obtain the semantization model configuration via a dedicated message to the first apparatus.

[0460] In a possible implementation, the broadcast message includes: a synchronization signal and physical broadcast channel block (SSB); or a system information block (SIB) message.

[0461] In a possible implementation, each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

[0462] In a possible implementation, each of the at least one query message includes at least one identifier,

where the at least one identifier includes a task identifier, a modality identifier, or both a task identifier and a modality identifier.

[0463] In a possible implementation, the obtaining module 4510 is further configured to obtain the at least one semantization model based on the at least one identifier for the at least one semantization model in the at least one query message.

[0464] In a possible implementation, the at least one piece of sensed data includes at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

[0465] The first apparatus may be applied to the above first apparatus such as the sensing device as described in the above possible method implementations. It should be understood by a person skilled in the art that, the relevant description of the above modules in these possible implementations of the present disclosure may be understood with reference to the relevant description of the sensing communication method in these possible implementations of the present disclosure. The technical effect achieved by the above first apparatus is similar as that achieved by the above possible method implementation, which is not repeated herein.

[0466] FIG. 46 is a schematic structural diagram of a second apparatus according to one or more example embodiments of the present disclosure.

[0467] As shown in FIG. 46, the second apparatus 4600 includes: a sending module 4610, configured to send at least one query message; and an obtaining module 4620, configured to obtain one or more sensing results, where each of the one or more sensing results includes at least one piece of sensed data and/or at least one second sensing semantic, and where at least one first sensing semantic respectively corresponds to at least one piece of raw sensed data and is generated based on the at least one piece of raw sensed data and at least one semantization model which is preconfigured in at least one first apparatus through communicating with a second apparatus, and the at least one first sensing semantic includes the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

[0468] In a possible implementation, before the sending at least one query message, the sending module 4610 is further configured to send a semantization model configuration, where the semantization model configuration indicates the at least one semantization model.

[0469] In a possible implementation, the at least one semantization model is represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , where the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$  corresponds to a task and/or a modality.

[0470] In a possible implementation, where the semantization model configuration further indicates at least

one identifier for the semantization model  $M_i$ , where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0471] In a possible implementation, when the at least one identifier includes a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; M_1, M_2, \dots M_s\}$ , where  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0472] In a possible implementation, when the at least one identifier includes a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; t'_1, t'_2, \dots t'_s; M_1, M_2, \dots M_s\}$ , where  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

[0473] In a possible implementation, the second apparatus 4600 further includes: a compressing module 4630, configured to compress one or more semantization models of the at least one semantization model in the semantization model configuration.

[0474] In a possible implementation, a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

[0475] In a possible implementation, a compression approach for each of the one or more semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0476] In a possible implementation, when at least one semantization model in the semantization model configuration is outdated, the sending module 4610 is further configured to send a semantization model update, where the semantization model update includes at least one updated semantization model respectively corresponding to at least one outdated semantization model.

[0477] In a possible implementation, the second apparatus 4600 further includes: a compressing module 4630, configured to compress one or more updated semantization models of the at least one updated semantization model in the semantization model update.

[0478] In a possible implementation, a compression approach for each of the one or more updated semantization models includes at least one of projection, codebook, quantization, or entropy coding.

[0479] In a possible implementation, the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

[0480] In a possible implementation, a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization

model update.

[0481] In a possible implementation, the second apparatus 4600 further includes: a training module 4640, configured to train at least one semantization model jointly with the at least one first apparatus.

5 [0482] In a possible implementation, the second apparatus 4600 further includes: a communicating module 4650, configured to communicate, with the at least one first apparatus, intermediate information generated in the training of the at least one semantization model, where the intermediate information includes intermediate features, or gradients generated in the training; and where the training module 4640 is further configured to train the at least one semantization model jointly with the at least one first apparatus based on the intermediate information.

10 [0483] In a possible implementation, the sending module 4610 is further configured to send at least one identifier for the at least one semantization model to be trained, where the at least one identifier includes a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

[0484] In a possible implementation, when at least one semantization model trained by the second apparatus jointly with the at least one first apparatus is outdated, the second apparatus further includes: an updating module 4660, configured to update the at least one outdated semantization model jointly with the at least one first apparatus.

[0485] In a possible implementation, the updating module 4660 is further configured to, when multiple outdated semantization models exist, update one or more outdated semantization models jointly with the at least one first apparatus at a time.

20 [0486] In a possible implementation, the sending module 4610 is further configured to: send the semantization model configuration via a broadcast message; send the semantization model configuration via a multicast message targeted to a group of first apparatuses; or send the semantization model configuration via a dedicated message to a first apparatus.

[0487] In a possible implementation, the broadcast message includes: a synchronization signal and physical broadcast channel block (SSB); or a system information block (SIB) message.

25 [0488] In a possible implementation, each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

[0489] In a possible implementation, each of the at least one query message includes at least one identifier, where the at least one identifier includes a task identifier, a modality identifier, or both a task identifier and a modality identifier.

30 [0490] In a possible implementation, the at least one identifier for the at least one semantization model in the

at least one query message is used for the at least one first apparatus to obtain the at least one semantization model.

[0491] In a possible implementation, the at least one piece of sensed data includes at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

[0492] The second apparatus may be applied to the above second apparatus such as the central device as described in the above possible method implementations. It should be understood by a person skilled in the art that, the relevant description of the above modules in these possible implementations of the present disclosure may be understood with reference to the relevant description of the sensing communication method in these possible implementations of the present disclosure. The technical effect achieved by the above second apparatus is similar as that achieved by the above possible method implementations, which is not repeated herein.

[0493] A possible implementation of the present disclosure provides a third apparatus including processing circuitry for executing any of the above corresponding sensing communication methods at the first apparatus side, which is not repeated herein.

[0494] A possible implementation of the present disclosure provides a fourth apparatus including processing circuitry for executing any of the above corresponding sensing communication methods at the second apparatus side, which is not repeated herein.

[0495] A possible implementation of the present disclosure provides a wireless communication system, including at least one first apparatus for executing any of the above corresponding sensing communication methods at the first apparatus side or at least one third apparatus for executing any of the above corresponding sensing communication methods at the first apparatus side; at least one second apparatus for executing any of the above corresponding sensing communication methods at the second apparatus side or at least one fourth apparatus for executing any of the above corresponding sensing communication methods at the second apparatus side; and at least one fifth apparatus, where each of the at least one fifth apparatus includes: a sending module, configured to send at least one query message to the at least one second apparatus; and an obtaining module, configured to obtain at least one fused sensing result sent by the at least one second apparatus, where the at least one fused sensing result is generated based on one or more sensing results. The above method is not repeated herein.

[0496] A possible implementation of the present disclosure provides a wireless communication system including: a first processing circuitry for executing any of the above corresponding sensing communication methods at the first apparatus side; a second processing circuitry for executing any of the above corresponding sensing communication methods at the second apparatus side; and a third processing circuitry for executing following steps: sending at least one query message to the second processing circuitry; and obtaining at least one

fused sensing result sent by the second processing circuitry, where the at least one fused sensing result is generated based on one or more sensing results. The above method is not repeated herein.

[0497] A possible implementation of the present disclosure provides a computer-readable storage medium storing computer execution instructions which, when executed by a processor, cause the processor to execute any  
5 of the above sensing communication methods, which is not repeated herein.

[0498] A possible implementation of the present disclosure provides a computer program product including computer execution instructions which, when executed by a processor, causes the processor to execute any of the above sensing communication methods, which is not repeated herein.

[0499] A method, apparatus and system for semantization model configuration and update is provided in the  
10 present disclosure.

[0500] Some aspects of the present disclosure relate to a scheme of a semantic-based communication to manage and schedule a large number of sensing devices, in which the sensing devices may belong to different types. The query semantics are goal-oriented and only the sensing device whose sensed data has sufficient relevance with the semantic message(s) would response and transmit their sensed data that are preferably in  
15 semantic form too.

[0501] Some aspects of the present disclosure relate to a scheme of a collective semantic token-based scheduling over a large number of sensing devices rather than one-to-one individual scheduling.

[0502] Some aspects of the present disclosure relate to a scheme of using the large-Language-model (LLM) to turn query and sensed data into a common semantic domain on which they can be easily compared to each other  
20 and fused.

[0503] The above one or more aspects of the present disclosure may have at least one of the following benefits:

scheduling may be task-oriented or goal-oriented; only the sensing devices that has contributions to a scheduled task or goal will response and transmit their sensed data;

25 privacy may be protected: both the task, goal, or query and sensed data are well protected; no raw data or minimum raw data or message is transmitted over the air;

forward compatible: semantic-based sensing system in this disclosure may be forward compatible in a sense that any new sensing mechanism can be supported.

[0504] In some aspects of the present disclosure, there is provided a computer program including instructions.  
30 The instructions, when executed by a processor, may cause the processor to implement the method of the present

disclosure.

[0505] In some aspects of the present disclosure, there is provided a non-transitory computer-readable medium storing instructions, the instructions, when executed by a processor, may cause the processor to implement the method of the present disclosure.

5 [0506] In some aspects of the present disclosure, there is provided an apparatus/chipset system including means to implement the method implemented by the sensing device of the present disclosure.

[0507] In some aspects of the present disclosure, there is provided an apparatus/chipset system including means to implement the method implemented by the central device of the present disclosure.

[0508] In some aspects of the present disclosure, there is provided an apparatus/chipset system including  
10 means to implement the method implemented by the GPT device of the present disclosure.

[0509] In some aspects of the present disclosure, there is provided a system including at least two of an apparatus in the sensing device of the present disclosure, an apparatus in the central device of the present disclosure and an apparatus in the GPT device of the present disclosure.

[0510] In some aspects of the present disclosure, there is provided an apparatus/chipset system including at  
15 least one processor executing instructions stored in a computer-readable medium to implement the method implemented by the sensing device of the present disclosure.

[0511] In some aspects of the present disclosure, there is provided an apparatus/chipset system including at least one processor executing instructions stored in a computer-readable medium to implement the method implemented by the central device of the present disclosure.

20 [0512] In some aspects of the present disclosure, there is provided an apparatus/chipset system including at least one processor executing instructions stored in a computer-readable medium to implement the method implemented by the GPT device of the present disclosure.

[0513] **Example concepts of some terms**

Message: a payload in a natural language, e.g. English, French, or Chinese ...;

25 Query message: a query sentence in a natural language;

Sensing message: a description about an observation or sensed data in a natural language;

Semantic: a vector, a matrix, a tensor of scalars to embed a message;

Query semantic: a semantic that embeds a query message;

Sensing semantic: a semantic that embeds a sensing message;

30 Token: a vector of scalars encoded from a semantic;

Query token: a token that is encoded from a query semantic;

Sensing token: a token that is encoded from a sensing semantic;

GPT device: a device that runs over generative AI model or models to generate one query message or messages given a sensing message or messages;

5                   Central device: a device as BS that connects a plurality of terminal devices via radio access in DL and UL, and connects with the core network via backbone network;

Sensing device: a device as terminal that connects to one BS or BSs and that is equipped with the sensing gadget to measure data of interest near it.

[0514]       Please note that the different embodiments may be implemented separately or combined. Although a  
10                   combination of features is shown in the illustrated embodiments, not all of them need to be combined to realize the benefits of various embodiments of this disclosure. In other words, a system or method designed according to an embodiment of this disclosure will not necessarily include all of the features shown in any one of the Figures or all of the portions schematically shown in the Figures. Moreover, selected features of one example embodiment may be combined with selected features of other example embodiments.

15                   [0515]       Although this disclosure has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of the disclosure, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

20                   [0516]       Although the present disclosure describes methods and processes with steps in a certain order, one or more steps of the methods and processes may be omitted or altered as appropriate. One or more steps may take place in an order other than that in which they are described, as appropriate.

[0517]       Note that the expression “at least one of A or B”, as used herein, is interchangeable with the expression “A and/or B”. It refers to a list in which you may select A or B or both A and B. Similarly, “at least one of A, B, or  
25                   C”, as used herein, is interchangeable with “A and/or B and/or C” or “A, B, and/or C”. It refers to a list in which you may select: A or B or C, or both A and B, or both A and C, or both B and C, or all of A, B and C. The same principle applies for longer lists having a same format.

[0518]       Although the present disclosure is described, at least in part, in terms of methods, a person of ordinary skill in the art will understand that the present disclosure is also directed to the various components for performing  
30                   at least some of the aspects and features of the described methods, be it by way of hardware components, software

or any combination of the two. Accordingly, the technical solution of the present disclosure may be embodied in the form of a software product. A suitable software product may be stored in a pre-recorded storage device or other similar non-volatile or non-transitory computer readable storage medium, including DVDs, CD-ROMs, USB flash disk, a removable hard disk, or other storage media, for example. The software product includes instructions tangibly stored thereon that enable a processing device (e.g., a personal computer, a server, or a network device) to execute examples of the methods disclosed herein. The machine-executable instructions may be in the form of code sequences, configuration information, or other data, which, when executed, cause a machine (e.g., a processor or other processing device) to perform steps in a method according to examples of the present disclosure.

[0519] All values and sub-ranges within disclosed ranges are also disclosed. Also, although the systems, devices and processes disclosed and shown herein may include a specific number of elements/components, the systems, devices and assemblies could be modified to include additional or fewer of such elements/components. For example, although any of the elements/components disclosed may be referenced as being singular, the possible implementations disclosed herein could be modified to include a plurality of such elements/components. The subject matter described herein intends to cover and embrace all suitable changes in technology.

## CLAIMS

1. A sensing communication method, comprising:

obtaining at least one query message;

generating, based on at least one piece of raw sensed data and at least one semantization model, at least one

5 first sensing semantic respectively corresponding to the at least one piece of raw sensed data, wherein the at least one semantization model is preconfigured in a first apparatus through communicating with a second apparatus; and

sending a sensing result, wherein the sensing result comprises at least one piece of sensed data and/or at least one second sensing semantic, and wherein the at least one first sensing semantic comprises the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

10 2. The method according to claim 1, wherein before the obtaining at least one query message, the method further comprises:

obtaining a semantization model configuration, wherein the semantization model configuration indicates the at least one semantization model.

3. The method according to claim 2, wherein the at least one semantization model is represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , wherein the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$  corresponds to a task and/or a modality.

4. The method according to claim 3, wherein the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , wherein the at least one identifier comprises a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

20 5. The method according to claim 3 or 4, wherein the generating, based on at least one piece of raw sensed data and at least one semantization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data comprises:

generating the at least one first sensing semantic  $\{o_1, o_2, \dots, o_s\}$  based on the at least one piece of raw sensed data and at least one semantization model  $\{M_1, M_2, \dots, M_s\}$ , wherein a first sensing semantic  $o_i$  is generated based  
25 on a piece of raw sensed data to which the first sensing semantic  $o_i$  corresponds and a semantization model  $M_i$ ,  $i \in [1, s]$ .

6. The method according to claim 4 or 5, wherein when the at least one identifier comprises a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots, (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; M_1, M_2, \dots, M_s\}$ , wherein  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

7. The method according to claim 4 or 5, wherein when the at least one identifier comprises a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots t_s; t'_1, t'_2, \dots t'_s; M_1, M_2, \dots M_s\}$ , wherein  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

5 8. The method according to any one of claims 2 to 7, wherein one or more semantization models of the at least one semantization model in the semantization model configuration are compressed.

9. The method according to claim 8, wherein a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

10 10. The method according to claim 8 or 9, wherein a compression approach for each of the one or more semantization models comprises at least one of projection, codebook, quantization, or entropy coding.

11. The method according to any one of claims 1 to 10, wherein when at least one semantization model in the semantization model configuration is outdated, the method further comprises:

15 obtaining a semantization model update, wherein the semantization model update comprises at least one updated semantization model respectively corresponding to at least one outdated semantization model.

12. The method according to claim 11, wherein one or more updated semantization models of the at least one updated semantization model in the semantization model update are compressed.

13. The method according to claim 12, wherein a compression approach for each of the one or more updated semantization models comprises at least one of projection, codebook, quantization, or entropy coding.

20 14. The method according to claim 12 or 13, wherein the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

15. The method according to any one of claims 12 to 14, wherein a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update.

25 16. The method according to claim 1, further comprising:

training, by the first apparatus, at least one semantization model, jointly with the second apparatus.

17. The method according to claim 16, wherein the training, by the first apparatus, at least one semantization model, jointly with the second apparatus comprises:

30 communicating, by the first apparatus, with the second apparatus, intermediate information generated in the training of the at least one semantization model, wherein the intermediate information comprises intermediate

features, or gradients generated in the training; and

training, by the first apparatus, the at least one semantization model, jointly with the second apparatus based on the intermediate information.

18. The method according to claim 17, further comprising:

5 obtaining at least one identifier for the at least one semantization model to be trained, wherein the at least one identifier comprises a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

19. The method according to any one of claims 16 to 18, wherein when at least one semantization model trained by the first apparatus jointly with the second apparatus is outdated, the method further comprises:

10 updating, by the first apparatus, the at least one outdated semantization model, jointly with the second apparatus.

20. The method according to claim 19, wherein the updating, by the first apparatus, the at least one outdated semantization model, jointly with the second apparatus comprises:

when multiple outdated semantization models exist, updating, by the first apparatus, one or more outdated semantization models, jointly with the second apparatus at a time.

15 21. The method according to any one of claims 2 to 20, wherein the obtaining a semantization model configuration comprises:

obtaining the semantization model configuration via a broadcast message;

obtaining the semantization model configuration via a multicast message targeted to a group of first apparatuses; or

20 obtaining the semantization model configuration via a dedicated message to the first apparatus.

22. The method according to claim 21, wherein the broadcast message comprises:

a synchronization signal and physical broadcast channel block (SSB); or

a system information block (SIB) message.

25 23. The method according to any one of claims 1 to 22, wherein each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

24. The method according to claim 23, wherein each of the at least one query message comprises at least one identifier, wherein the at least one identifier comprises a task identifier, a modality identifier, or both a task identifier and a modality identifier.

25. The method according to claim 24, further comprising:

30 obtaining the at least one semantization model based on the at least one identifier for the at least one

semantization model in the at least one query message.

26. The method according to any one of claims 1 to 25, wherein the at least one piece of sensed data comprises at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

27. A sensing communication method, comprising:

5 sending at least one query message; and

obtaining one or more sensing results, wherein each of the one or more sensing results comprises at least one piece of sensed data and/or at least one second sensing semantic, and wherein at least one first sensing semantic respectively corresponds to at least one piece of raw sensed data and is generated based on the at least one piece of raw sensed data and at least one semantization model which is preconfigured in at least one first apparatus through communicating with a second apparatus, and the at least one first sensing semantic comprises the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

28. The method according to claim 27, wherein before the sending at least one query message, the method further comprises:

15 sending a semantization model configuration, wherein the semantization model configuration indicates the at least one semantization model.

29. The method according to claim 28, wherein the at least one semantization model is represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , wherein the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$  corresponds to a task and/or a modality.

20 30. The method according to claim 29, wherein the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , wherein the at least one identifier comprises a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

31. The method according to claim 30, wherein when the at least one identifier comprises a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots, (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; M_1, M_2, \dots, M_s\}$ , wherein  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

32. The method according to claim 30, wherein when the at least one identifier comprises a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots, (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; t'_1, t'_2, \dots, t'_s; M_1, M_2, \dots, M_s\}$ , wherein  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

30 33. The method according to any one of claim 28 to 32, further comprising:

compressing one or more semantization models of the at least one semantization model in the semantization model configuration.

34. The method according to claim 33, wherein a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

35. The method according to claim 33 or 34, wherein a compression approach for each of the one or more semantization models comprises at least one of projection, codebook, quantization, or entropy coding.

36. The method according to any one of claims 27 to 35, wherein when at least one semantization model in the semantization model configuration is outdated, the method further comprises:

10 sending a semantization model update, wherein the semantization model update comprises at least one updated semantization model respectively corresponding to at least one outdated semantization model.

37. The method according to claim 36, further comprising:

compressing one or more updated semantization models of the at least one updated semantization model in the semantization model update.

15 38. The method according to claim 37, wherein a compression approach for each of the one or more updated semantization models comprises at least one of projection, codebook, quantization, or entropy coding.

39. The method according to claim 37 or 38, wherein the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

20 40. The method according to any one of claims 37 to 39, wherein a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update.

41. The method according to claim 27, further comprising:

training, by the second apparatus, at least one semantization model, jointly with the at least one first apparatus.

25 42. The method according to claim 41, wherein the training, by the second apparatus, at least one semantization model, jointly with the at least one first apparatus comprises:

communicating, by the second apparatus, with the at least one first apparatus, intermediate information generated in the training of the at least one semantization model, wherein the intermediate information comprises intermediate features, or gradients generated in the training; and

30 training, by the second apparatus, the at least one semantization model, jointly with the at least one first

apparatus based on the intermediate information.

43. The method according to claim 42, further comprising:

sending at least one identifier for the at least one semantization model to be trained, wherein the at least one identifier comprises a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

5 44. The method according to any one of claims 41 to 43, wherein when at least one semantization model trained by the second apparatus jointly with the at least one first apparatus is outdated, the method further comprises:

updating, by the second apparatus, the at least one outdated semantization model, jointly with the at least one first apparatus.

10 45. The method according to claim 44, wherein the updating, by the second apparatus, the at least one outdated semantization model, jointly with the at least one first apparatus comprises:

when multiple outdated semantization models exist, updating, by the second apparatus, one or more outdated semantization models, jointly with the at least one first apparatus at a time.

15 46. The method according to any one of claims 28 to 45, wherein the sending a semantization model configuration comprises:

sending the semantization model configuration via a broadcast message;

sending the semantization model configuration via a multicast message targeted to a group of first apparatuses;

or

sending the semantization model configuration via a dedicated message to a first apparatus.

20 47. The method according to claim 46, wherein the broadcast message comprises:

a synchronization signal and physical broadcast channel block (SSB); or

a system information block (SIB) message.

48. The method according to any one of claims 27 to 47, wherein each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

25 49. The method according to claim 48, wherein each of the at least one query message comprises at least one identifier, wherein the at least one identifier comprises a task identifier, a modality identifier, or both a task identifier and a modality identifier.

30 50. The method according to claim 49, wherein the at least one identifier for the at least one semantization model in the at least one query message is used for the at least one first apparatus to obtain the at least one semantization model.

51. The method according to any one of claims 27 to 50, wherein the at least one piece of sensed data comprises at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

52. A first apparatus comprising:

an obtaining module, configured to obtain at least one query message;

5 a generating module, configured to generate, based on at least one piece of raw sensed data and at least one semantization model, at least one first sensing semantic respectively corresponding to the at least one piece of raw sensed data, wherein the at least one semantization model is preconfigured in a first apparatus through communicating with a second apparatus; and

10 a sending module, configured to send a sensing result, wherein the sensing result comprises at least one piece of sensed data and/or at least one second sensing semantic, and wherein the at least one first sensing semantic comprises the at least one second sensing semantic and/or at least one third sensing semantic converted from the at least one piece of sensed data.

53. The first apparatus according to claim 52, wherein before the obtaining at least one query message, the obtaining module is further configured to obtain a semantization model configuration, wherein the semantization model configuration indicates the at least one semantization model.

54. The first apparatus according to claim 53, wherein the at least one semantization model is represented by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , wherein the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$  corresponds to a task and/or a modality.

55. The first apparatus according to claim 54, wherein the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , wherein the at least one identifier comprises a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

56. The first apparatus according to claim 54 or 55, wherein the generating module (4520) is further configured to generate the at least one first sensing semantic  $\{o_1, o_2, \dots, o_s\}$  based on the at least one piece of raw sensed data and at least one semantization model  $\{M_1, M_2, \dots, M_s\}$ , wherein a first sensing semantic  $o_i$  is generated based on a piece of raw sensed data to which the first sensing semantic  $o_i$  corresponds and a semantization model  $M_i$ ,  $i \in [1, s]$ .

57. The first apparatus according to claim 55 or 56, wherein when the at least one identifier comprises a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots, (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; M_1, M_2, \dots, M_s\}$ , wherein  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

58. The first apparatus according to claim 55 or 56, wherein when the at least one identifier comprises a task

identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; t'_1, t'_2, \dots, t'_s; M_1, M_2, \dots, M_s\}$ , wherein  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

59. The first apparatus according to any one of claims 53 to 58, wherein one or more semantization models of  
5 the at least one semantization model in the semantization model configuration are compressed.

60. The first apparatus according to claim 59, wherein a compression approach and/or compression parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

61. The first apparatus according to claim 59 or 60, wherein a compression approach for each of the one or  
10 more semantization models comprises at least one of projection, codebook, quantization, or entropy coding.

62. The first apparatus according to any one of claims 52 to 61, wherein when at least one semantization model in the semantization model configuration is outdated, the obtaining module is further configured to obtain a semantization model update, wherein the semantization model update comprises at least one updated semantization model respectively corresponding to at least one outdated semantization model.

63. The first apparatus according to claim 62, wherein one or more updated semantization models of the at  
15 least one updated semantization model in the semantization model update are compressed.

64. The first apparatus according to claim 63, wherein a compression approach for each of the one or more updated semantization models comprises at least one of projection, codebook, quantization, or entropy coding.

65. The first apparatus according to claim 63 or 64, wherein the compressing is performed based on a  
20 difference between an updated semantization model and a corresponding outdated semantization model.

66. The first apparatus according to any one of claims 63 to 65, wherein a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update.

67. The first apparatus according to claim 52, further comprising:  
25 a training module, configured to train at least one semantization model jointly with the second apparatus.

68. The first apparatus according to claim 67, further comprising:  
a communicating module, configured to communicate, with the second apparatus, intermediate information generated in the training of the at least one semantization model, wherein the intermediate information comprises intermediate features, or gradients generated in the training; and

30 wherein the training module is further configured to train the at least one semantization model jointly with the

second apparatus based on the intermediate information.

69. The first apparatus according to claim 68, wherein the obtaining module is further configured to obtain at least one identifier for the at least one semantization model to be trained, wherein the at least one identifier comprises a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

5 70. The first apparatus according to any one of claims 67 to 69, wherein when at least one semantization model trained by the first apparatus jointly with the second apparatus is outdated, the first apparatus further comprises:

an updating module, configured to update the at least one outdated semantization model jointly with the second apparatus.

10 71. The first apparatus according to claim 70, wherein the updating module is further configured to, when multiple outdated semantization models exist, update one or more outdated semantization models jointly with the second apparatus at a time.

72. The first apparatus according to any one of claims 53 to 71, wherein the obtaining module is further configured to:

15 obtain the semantization model configuration via a broadcast message;

obtain the semantization model configuration via a multicast message targeted to a group of first apparatuses;

or

obtain the semantization model configuration via a dedicated message to the first apparatus.

73. The first apparatus according to claim 72, wherein the broadcast message comprises:

20 a synchronization signal and physical broadcast channel block (SSB); or

a system information block (SIB) message.

74. The first apparatus according to any one of claims 53 to 61, wherein each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

25 75. The first apparatus according to claim 74, wherein each of the at least one query message comprises at least one identifier, wherein the at least one identifier comprises a task identifier, a modality identifier, or both a task identifier and a modality identifier.

76. The first apparatus according to claim 75, wherein the obtaining module is further configured to obtain the at least one semantization model based on the at least one identifier for the at least one semantization model in the at least one query message.

30 77. The first apparatus according to any one of claims 52 to 76, wherein the at least one piece of sensed data

comprises at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

78. A second apparatus, comprising:

a sending module, configured to send at least one query message; and

an obtaining module, configured to obtain one or more sensing results, wherein each of the one or more

5 sensing results comprises at least one piece of sensed data and/or at least one second sensing semantic, and wherein at least one first sensing semantic respectively corresponds to at least one piece of raw sensed data and is generated based on the at least one piece of raw sensed data and at least one semantization model which is preconfigured in at least one first apparatus through communicating with a second apparatus, and the at least one first sensing semantic comprises the at least one second sensing semantic and/or at least one third sensing semantic  
10 converted from the at least one piece of sensed data.

79. The second apparatus according to claim 78, wherein before the sending at least one query message, the sending module is further configured to send a semantization model configuration, wherein the semantization model configuration indicates the at least one semantization model.

80. The second apparatus according to claim 79, wherein the at least one semantization model is represented  
15 by  $\{M_1, M_2, \dots, M_s\}$ ,  $s \geq 1$ , wherein the  $s$  is the number of the at least one semantization model, and a semantization model  $M_i$  for  $i \in [1, s]$  corresponds to a task and/or a modality.

81. The second apparatus according to claim 80, wherein the semantization model configuration further indicates at least one identifier for the semantization model  $M_i$ , wherein the at least one identifier comprises a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

20 82. The second apparatus according to claim 81, wherein when the at least one identifier comprises a task identifier, or a modality identifier, the semantization model configuration is represented by  $\{(t_1, M_1), (t_2, M_2), \dots, (t_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; M_1, M_2, \dots, M_s\}$ , wherein  $t_i$  is the task identifier or modality identifier of model  $M_i$ ,  $i \in [1, s]$ .

83. The second apparatus according to claim 81, wherein when the at least one identifier comprises a task identifier and a modality identifier, the semantization model configuration is represented by  $\{(t_1, t'_1, M_1), (t_2, t'_2, M_2), \dots, (t_s, t'_s, M_s)\}$ , or  $\{t_1, t_2, \dots, t_s; t'_1, t'_2, \dots, t'_s; M_1, M_2, \dots, M_s\}$ , wherein  $t_i$  is a task identifier of model  $M_i$ , and  $t'_i$  is a modality identifier of model  $M_i$ ,  $i \in [1, s]$ .  
25

84. The second apparatus according to any one of claim 79 to 83, further comprising:

a compressing module, configured to compress one or more semantization models of the at least one semantization model in the semantization model configuration.

30 85. The second apparatus according to claim 84, wherein a compression approach and/or compression

parameters for each of the one or more semantization models are configured previously, pre-defined, or carried in the semantization model configuration.

86. The second apparatus according to claim 84 or 85, wherein a compression approach for each of the one or more semantization models comprises at least one of projection, codebook, quantization, or entropy coding.

5        87. The second apparatus according to any one of claims 78 to 86, wherein when at least one semantization model in the semantization model configuration is outdated, the sending module is further configured to send a semantization model update, wherein the semantization model update comprises at least one updated semantization model respectively corresponding to at least one outdated semantization model.

88. The second apparatus according to claim 87, further comprising:

10       a compressing module, configured to compress one or more updated semantization models of the at least one updated semantization model in the semantization model update.

89. The second apparatus according to claim 88, wherein a compression approach for each of the one or more updated semantization models comprises at least one of projection, codebook, quantization, or entropy coding.

15       90. The second apparatus according to claim 88 or 89, wherein the compressing is performed based on a difference between an updated semantization model and a corresponding outdated semantization model.

91. The second apparatus according to any one of claims 88 to 90, wherein a compression approach and/or compression parameters for each of the one or more updated semantization models are configured previously, pre-defined, or carried in the semantization model update.

92. The second apparatus according to claim 78, further comprising:

20       a training module, configured to train at least one semantization model jointly with the at least one first apparatus.

93. The second apparatus according to claim 92, further comprising:

25       a communicating module, configured to communicate, with the at least one first apparatus, intermediate information generated in the training of the at least one semantization model, wherein the intermediate information comprises intermediate features, or gradients generated in the training; and

wherein the training module is further configured to train the at least one semantization model jointly with the at least one first apparatus based on the intermediate information.

30       94. The second apparatus according to claim 93, wherein the sending module is further configured to send at least one identifier for the at least one semantization model to be trained, wherein the at least one identifier comprises a task identifier, or a modality identifier, or both a task identifier and a modality identifier.

95. The second apparatus according to any one of claims 92 to 94, wherein when at least one semantization model trained by the second apparatus jointly with the at least one first apparatus is outdated, the second apparatus further comprises:

5 an updating module, configured to update the at least one outdated semantization model jointly with the at least one first apparatus.

96. The second apparatus according to claim 95, wherein the updating module is further configured to, when multiple outdated semantization models exist, update one or more outdated semantization models jointly with the at least one first apparatus at a time.

10 97. The second apparatus according to any one of claims 79 to 96, wherein the sending module is further configured to:

send the semantization model configuration via a broadcast message;

send the semantization model configuration via a multicast message targeted to a group of first apparatuses;

or

send the semantization model configuration via a dedicated message to a first apparatus.

15 98. The second apparatus according to claim 97, wherein the broadcast message comprises:

a synchronization signal and physical broadcast channel block (SSB); or

a system information block (SIB) message.

99. The second apparatus according to any one of claims 78 to 98, wherein each of the at least one query message corresponds to a task, a modality, or a combination of a task and a modality.

20 100. The second apparatus according to claim 99, wherein each of the at least one query message comprises at least one identifier, wherein the at least one identifier comprises a task identifier, a modality identifier, or both a task identifier and a modality identifier.

25 101. The second apparatus according to claim 100, wherein the at least one identifier for the at least one semantization model in the at least one query message is used for the at least one first apparatus to obtain the at least one semantization model.

102. The second apparatus according to any one of claims 78 to 101, wherein the at least one piece of sensed data comprises at least one piece of raw sensed data, half raw sensed data, or compressed sensed data.

103. A third apparatus, comprising:

a processing circuitry for executing the method according to any one of claims 1 to 26.

30 104. A fourth apparatus, comprising:

a processing circuitry for executing the method according to any one of claims 27 to 51.

105. A wireless communication system, comprising:

at least one first apparatus according to any one of claims 52 to 77 or at least one third apparatus according to claim 103;

5       at least one second apparatus according to any one of claims 78 to 102 or at least one fourth apparatus according to claim 104; and

at least one fifth apparatus, wherein each of the at least one fifth apparatus comprises:

a sending module, configured to send at least one query message to the at least one second apparatus; and

an obtaining module, configured to obtain at least one fused sensing result sent by the at least one second

10       apparatus, wherein the at least one fused sensing result is generated based on one or more sensing results.

106. A wireless communication system, comprising:

a first processing circuitry for executing the method according to any one of claims 1 to 26;

a second processing circuitry for executing the method according to any one of claims 27 to 51; and

a third processing circuitry for executing following steps:

15       sending at least one query message to the second processing circuitry; and

obtaining at least one fused sensing result sent by the second processing circuitry, wherein the at least one fused sensing result is generated based on one or more sensing results.

107. A computer-readable storage medium storing computer execution instructions which, when executed by a processor, cause the processor to execute the method according to any one of claims 1 to 51.

20       108. A computer program product comprising computer execution instructions which, when executed by a processor, cause the processor to execute the method according to any one of claims 1 to 51.

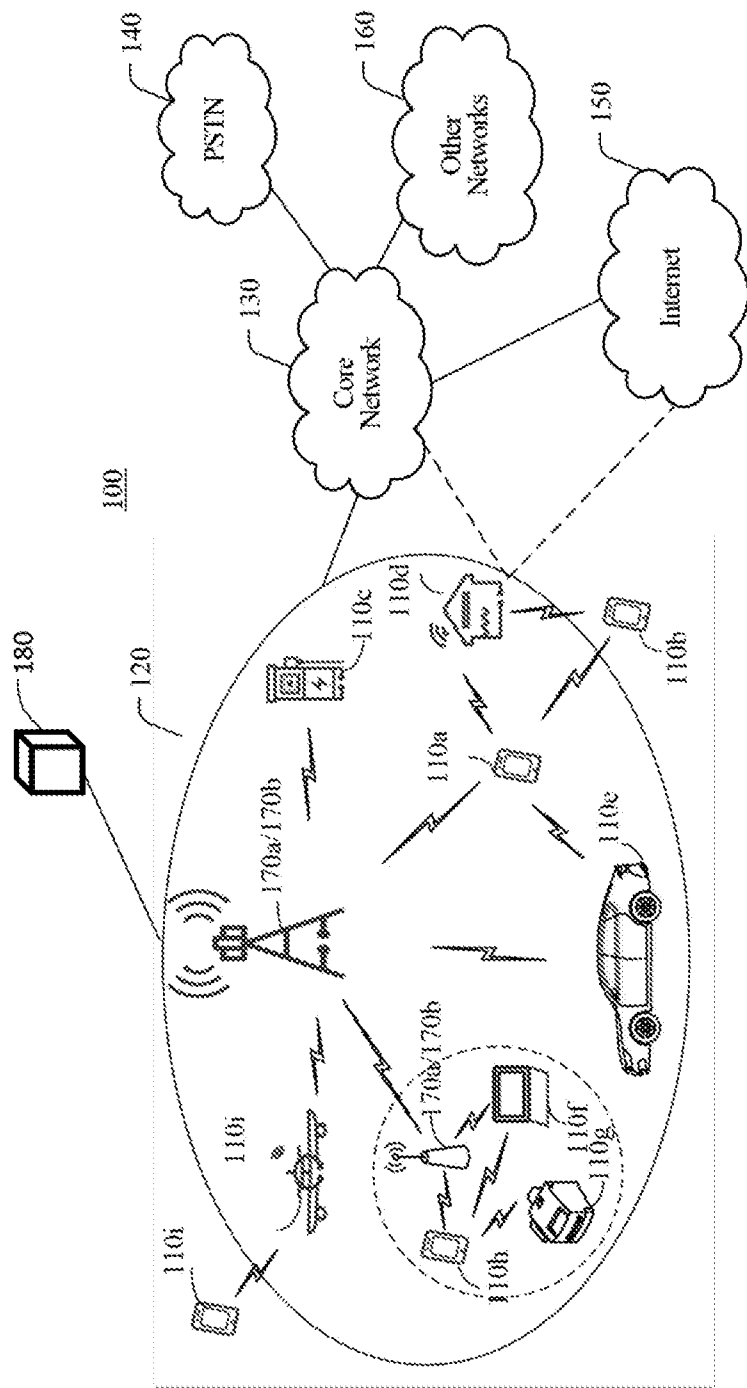


FIG. 1

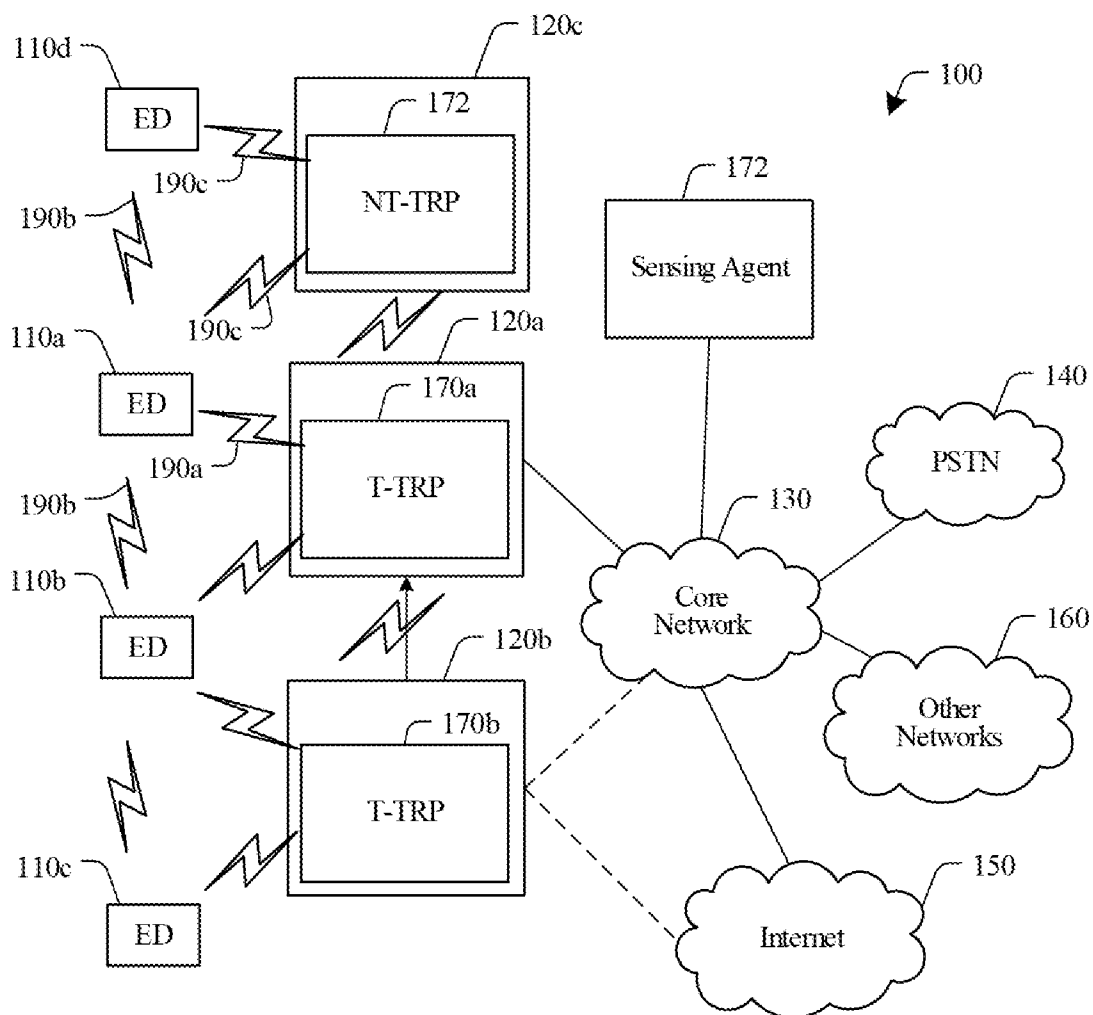


FIG. 2

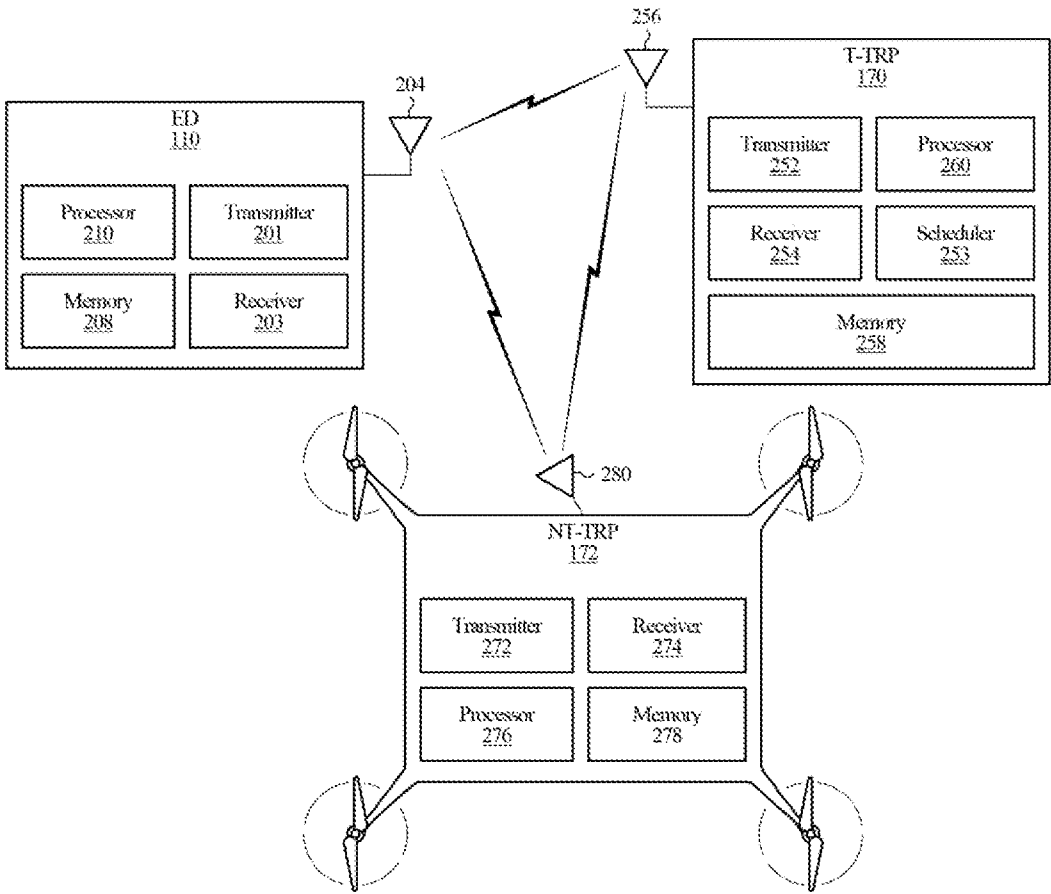


FIG. 3

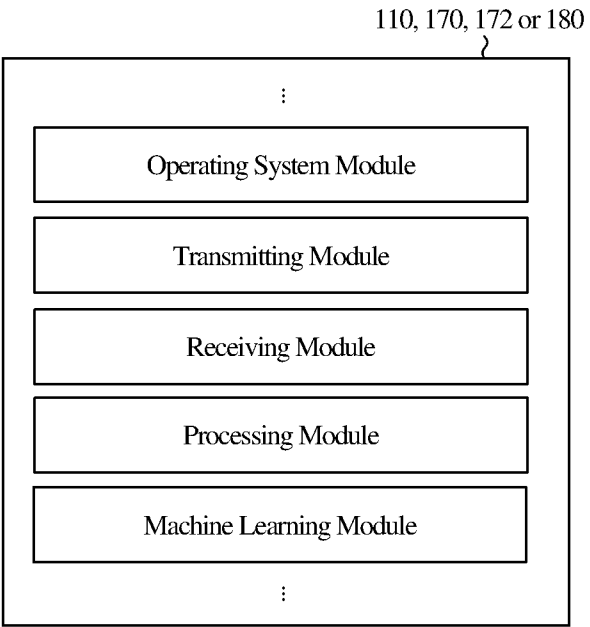


FIG. 4

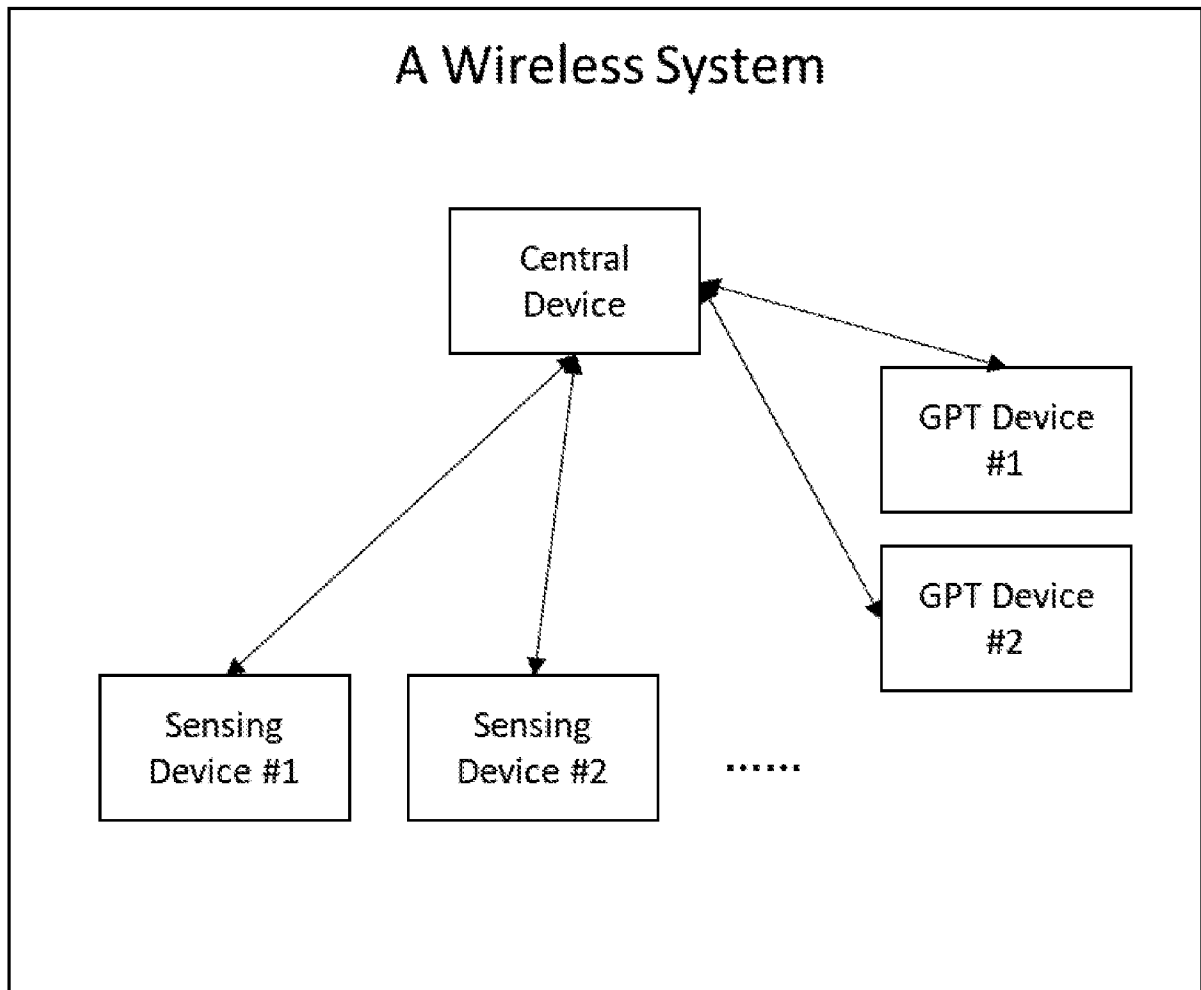
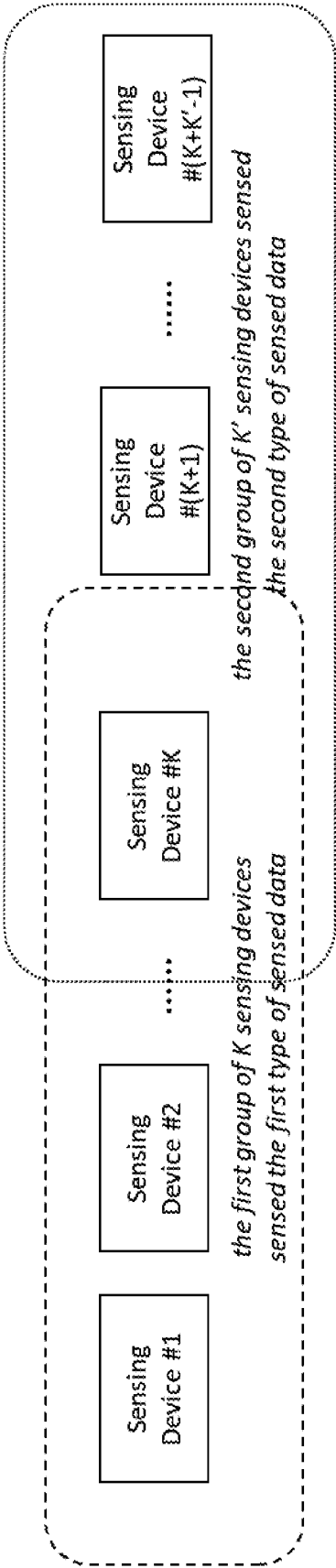


FIG. 5



Note that some sensing device can be grouped into two groups of types

FIG. 6

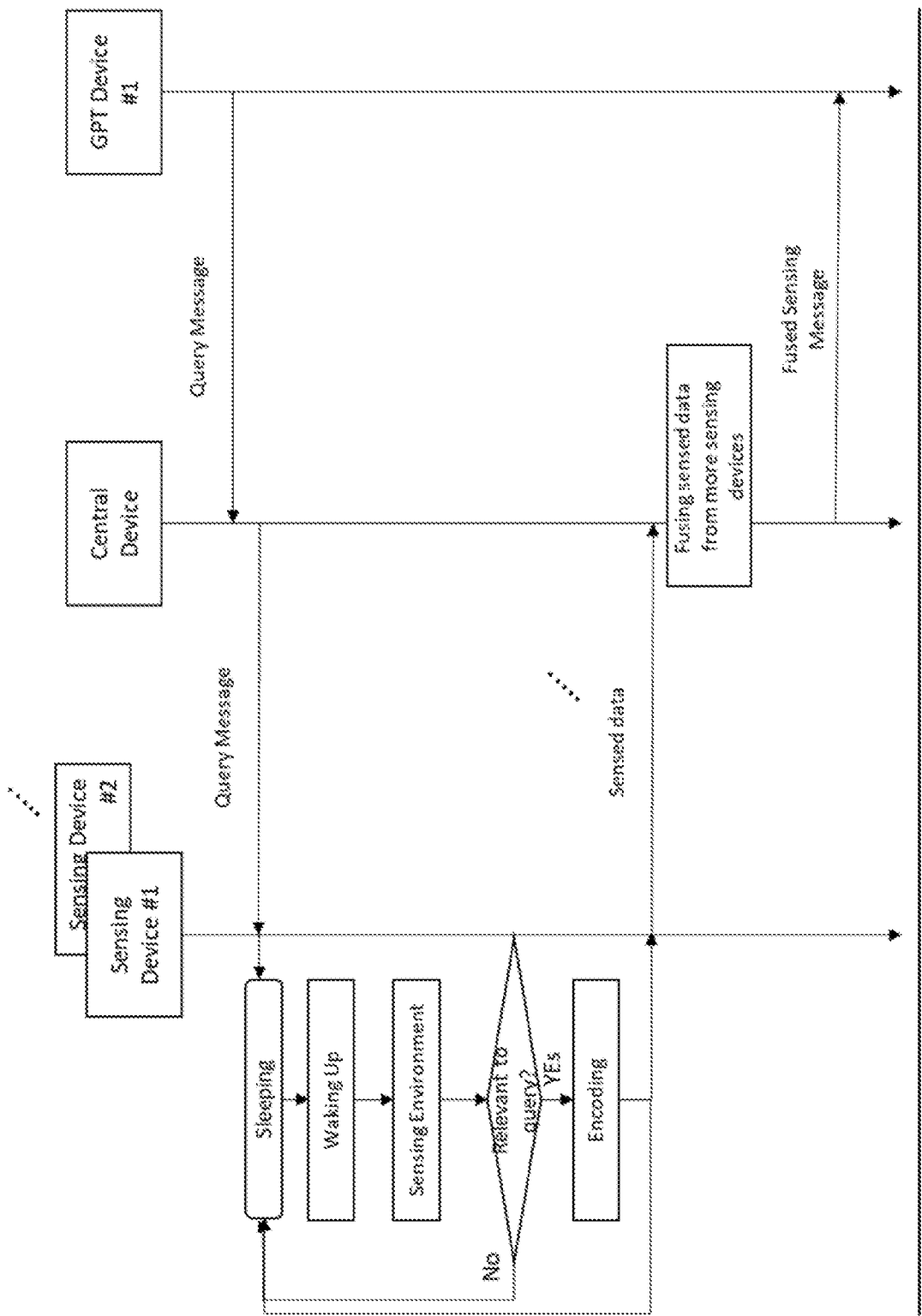


FIG. 7

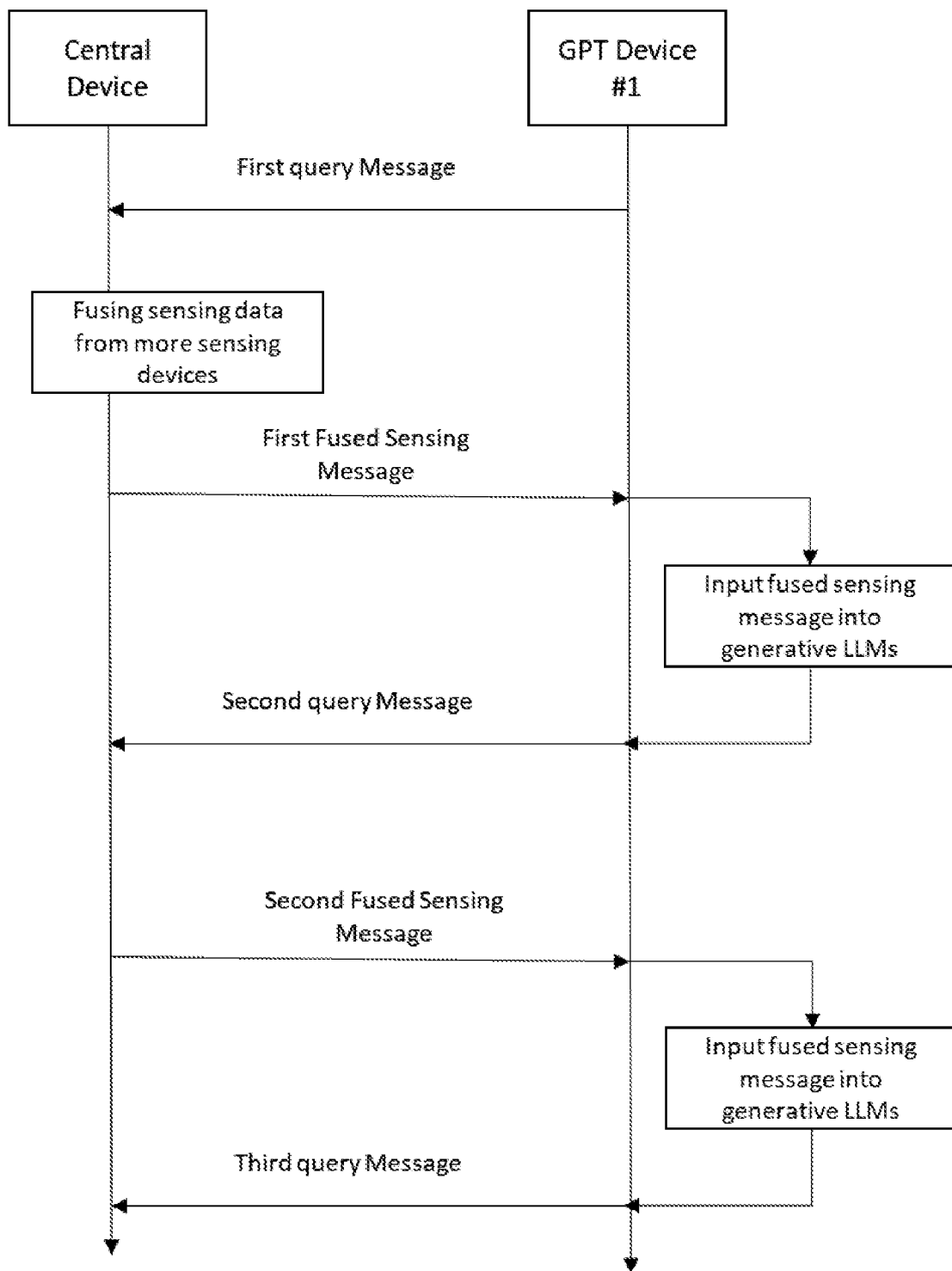


FIG. 8

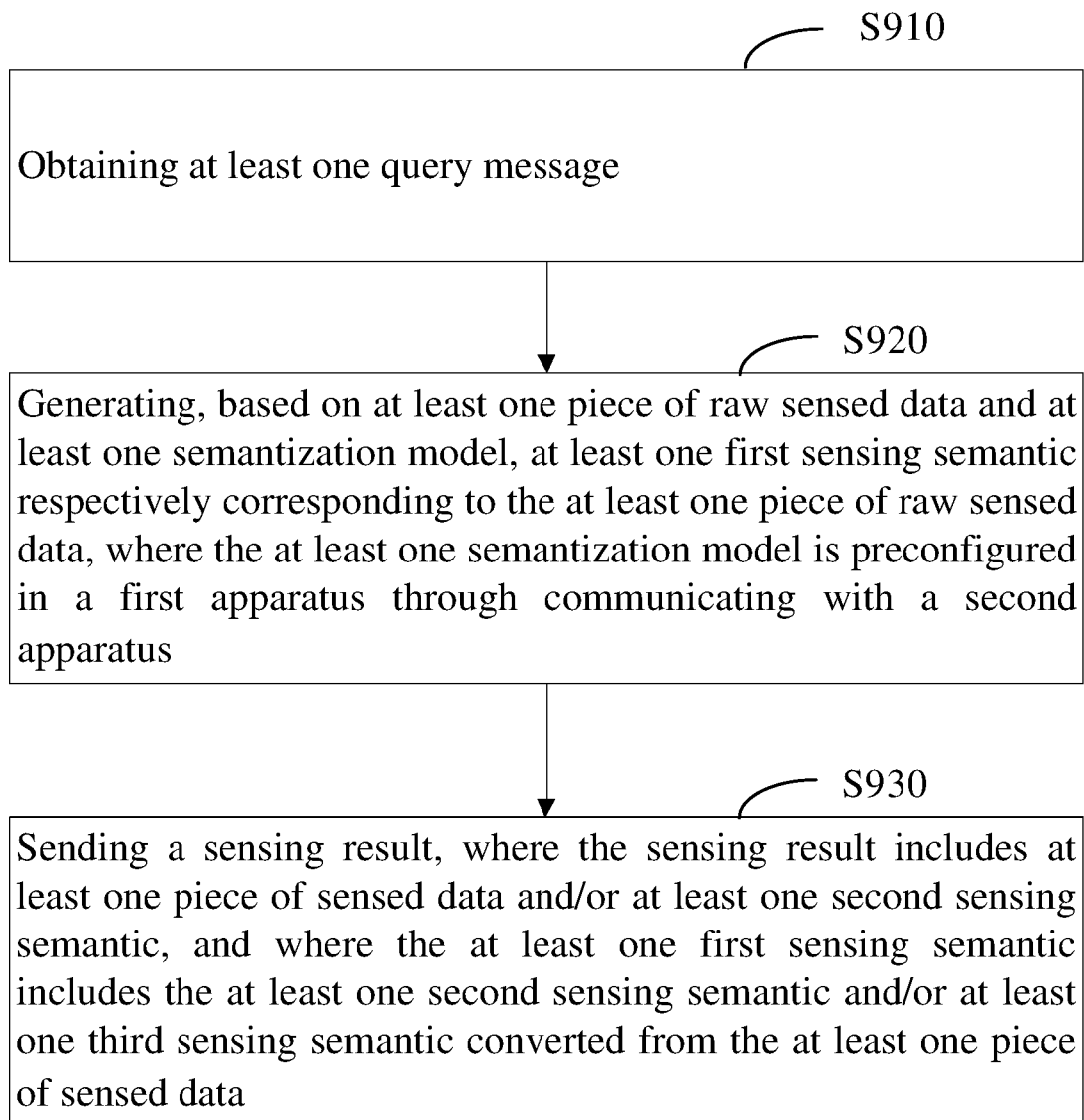


FIG. 9

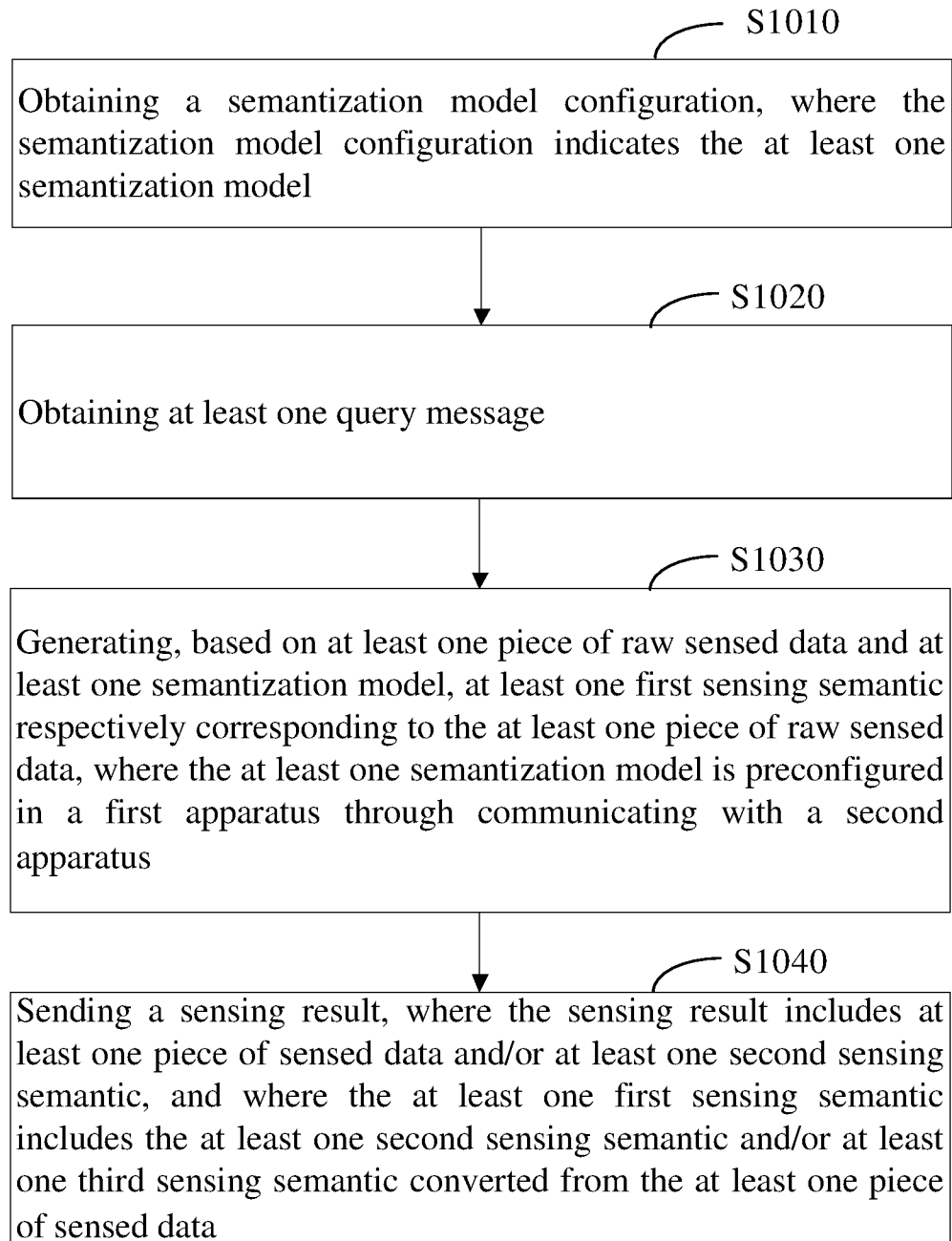


FIG. 10

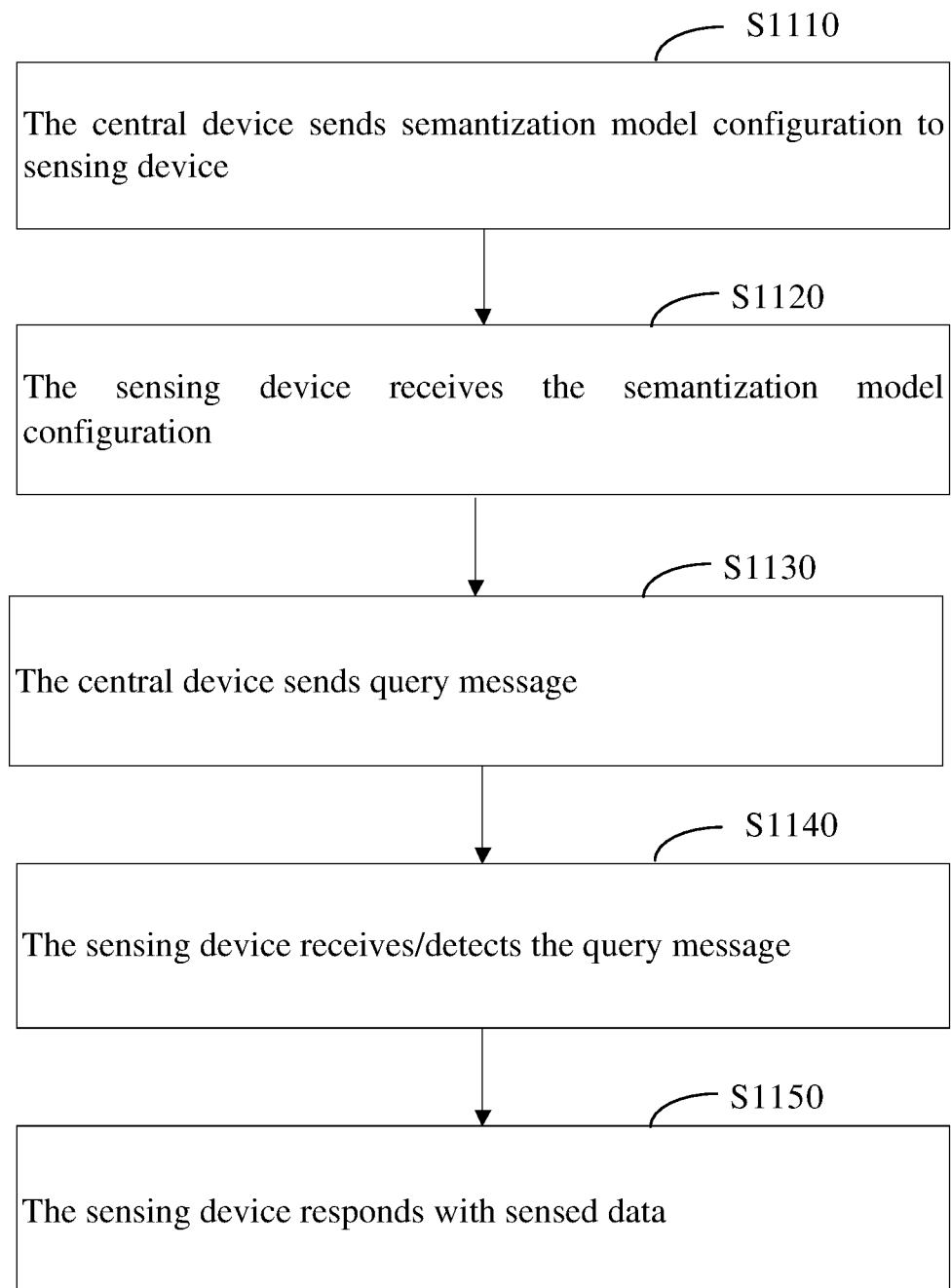


FIG. 11

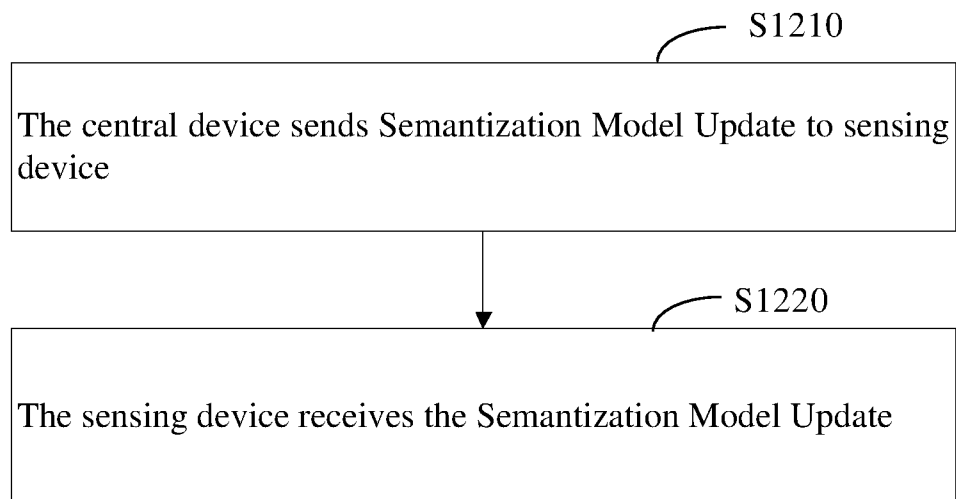


FIG. 12

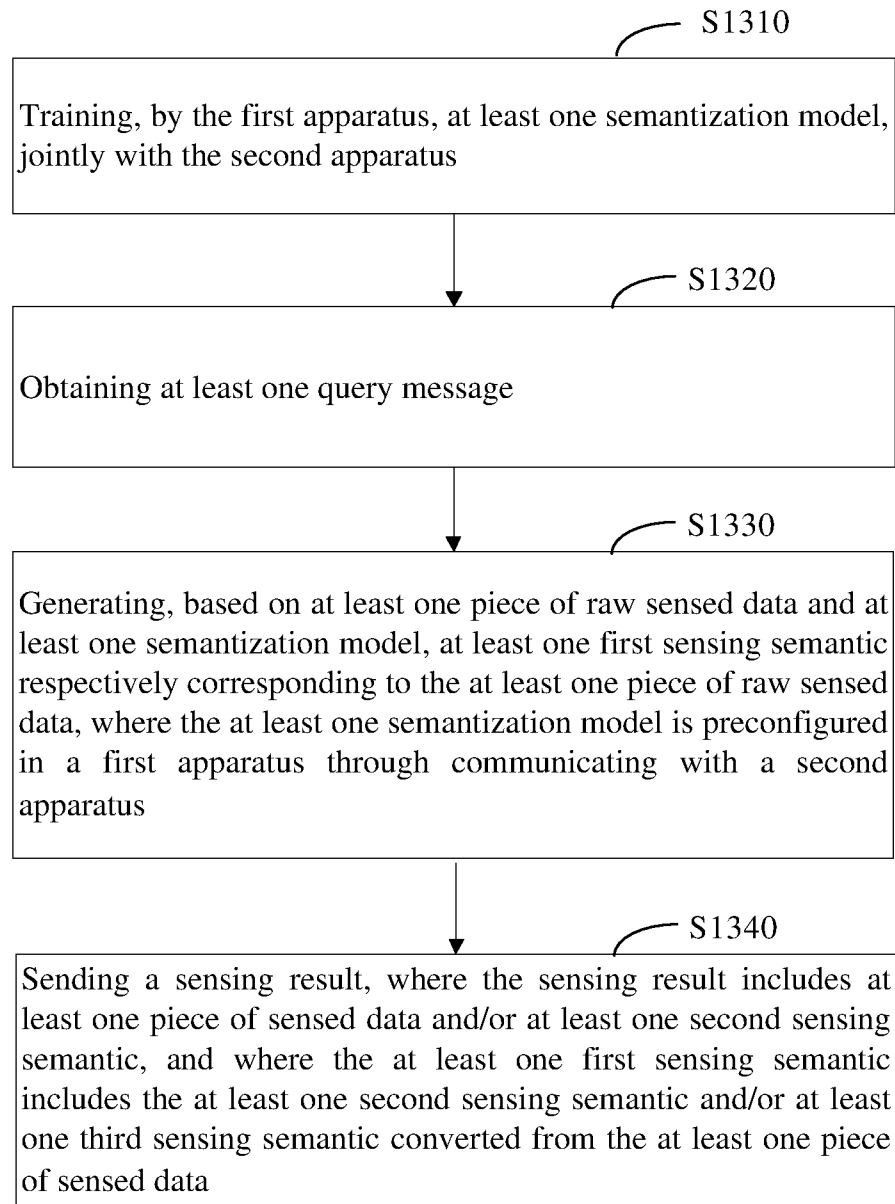


FIG. 13

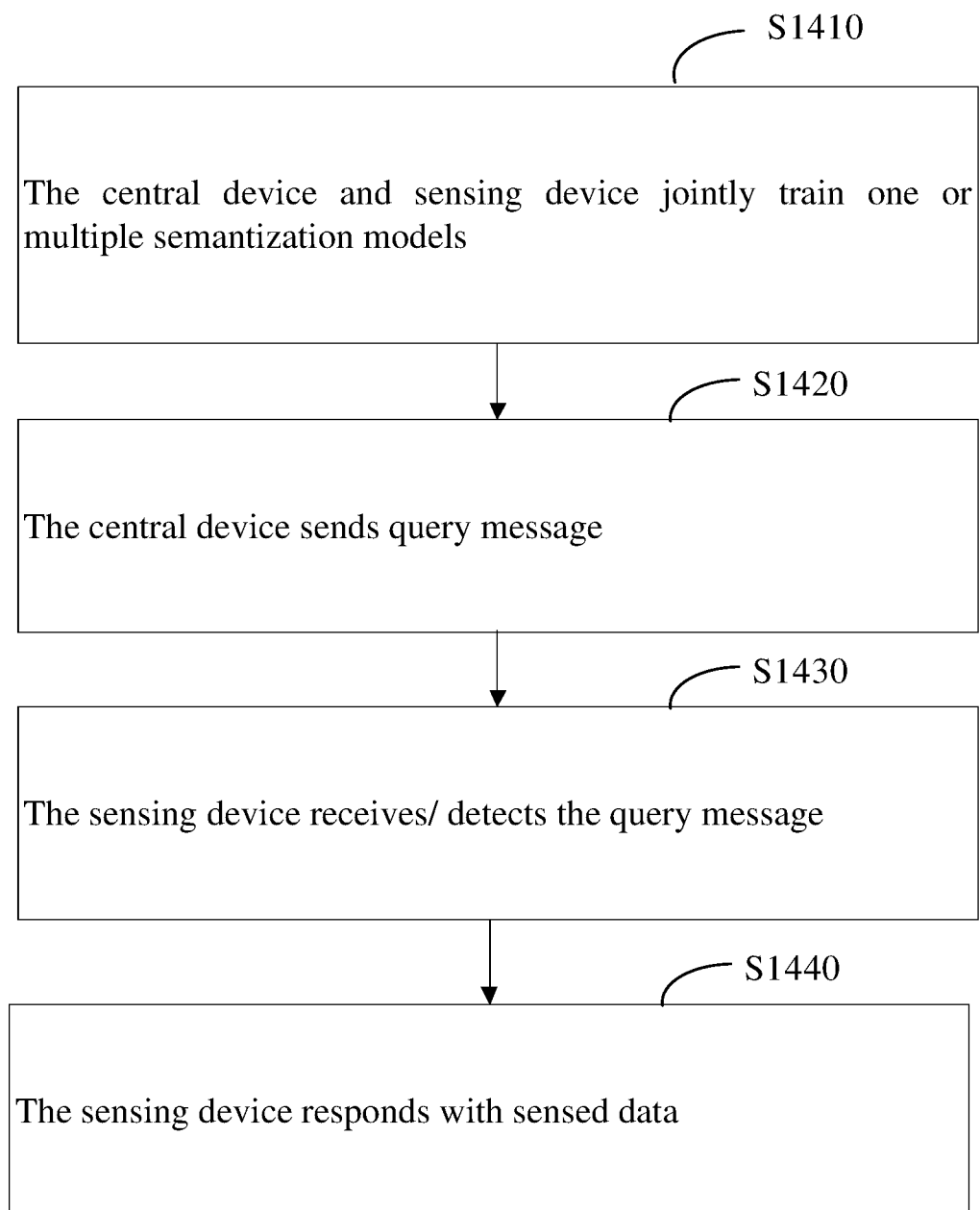


FIG. 14

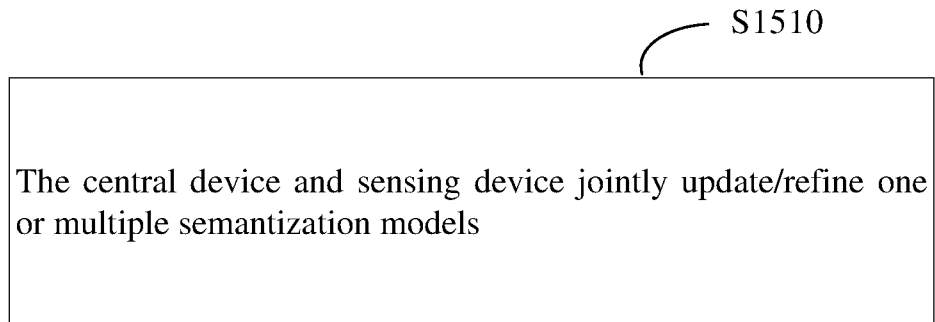


FIG. 15

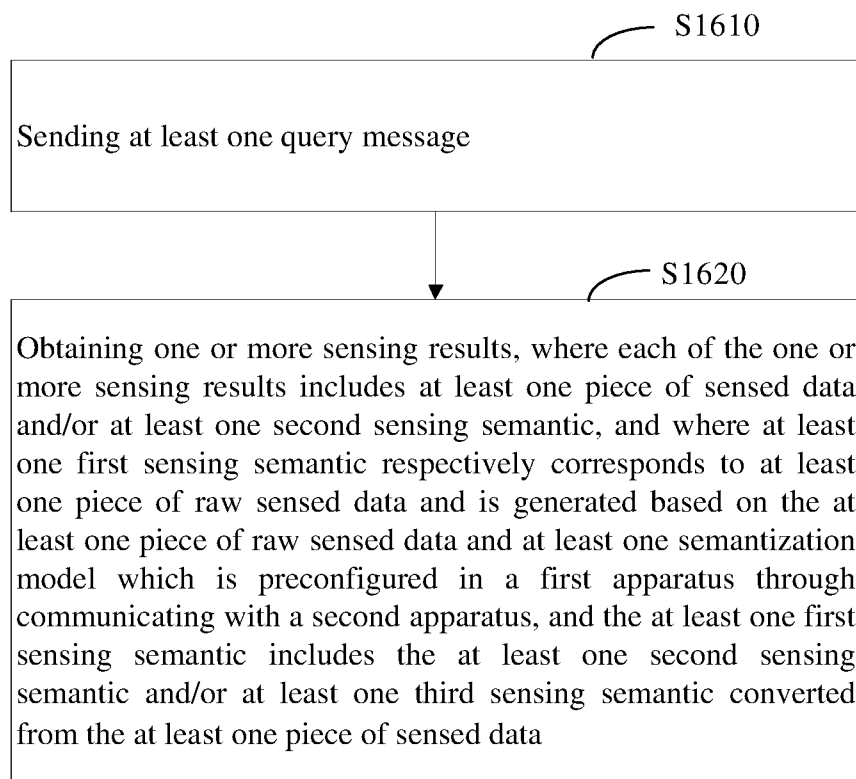


FIG. 16

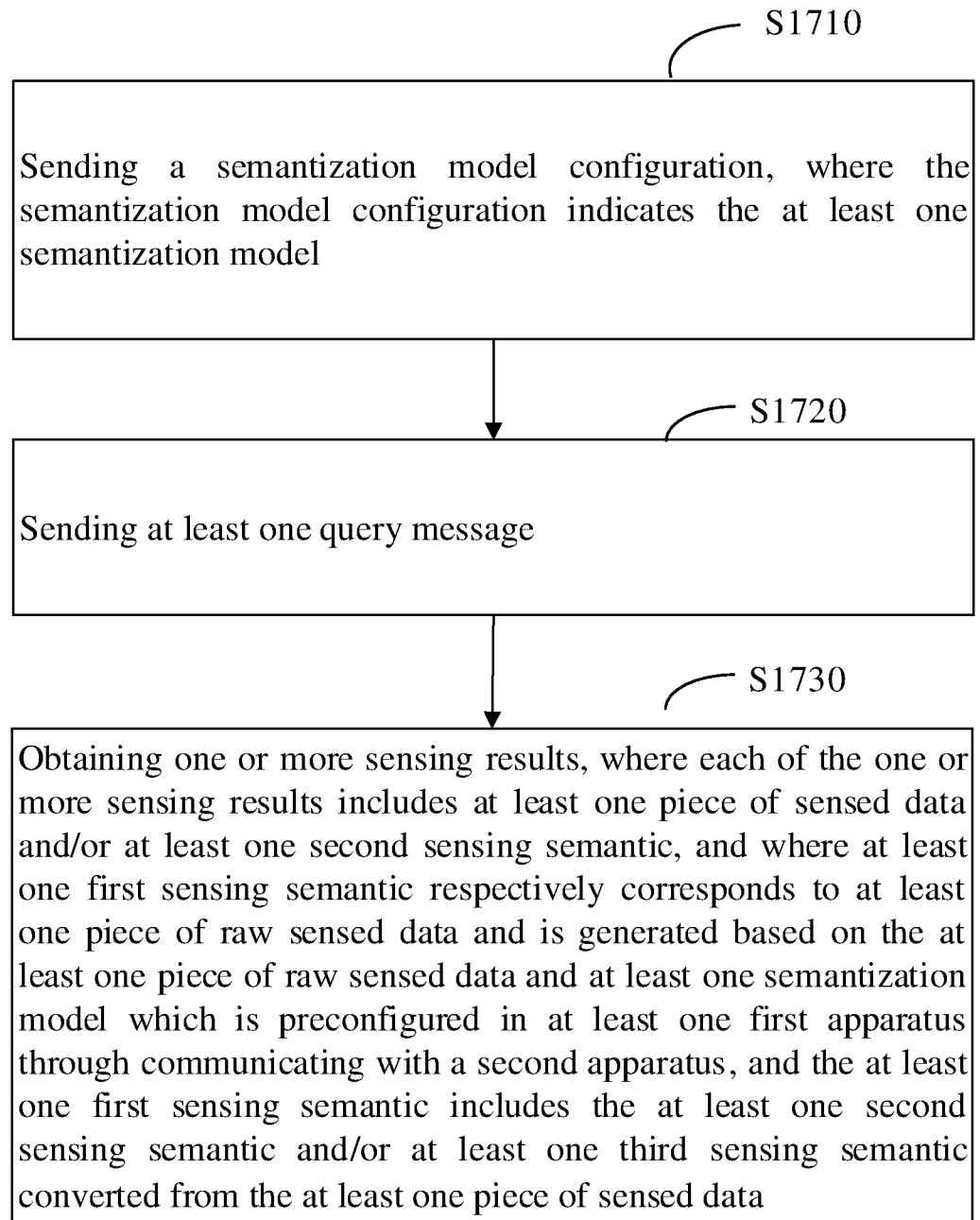


FIG. 17

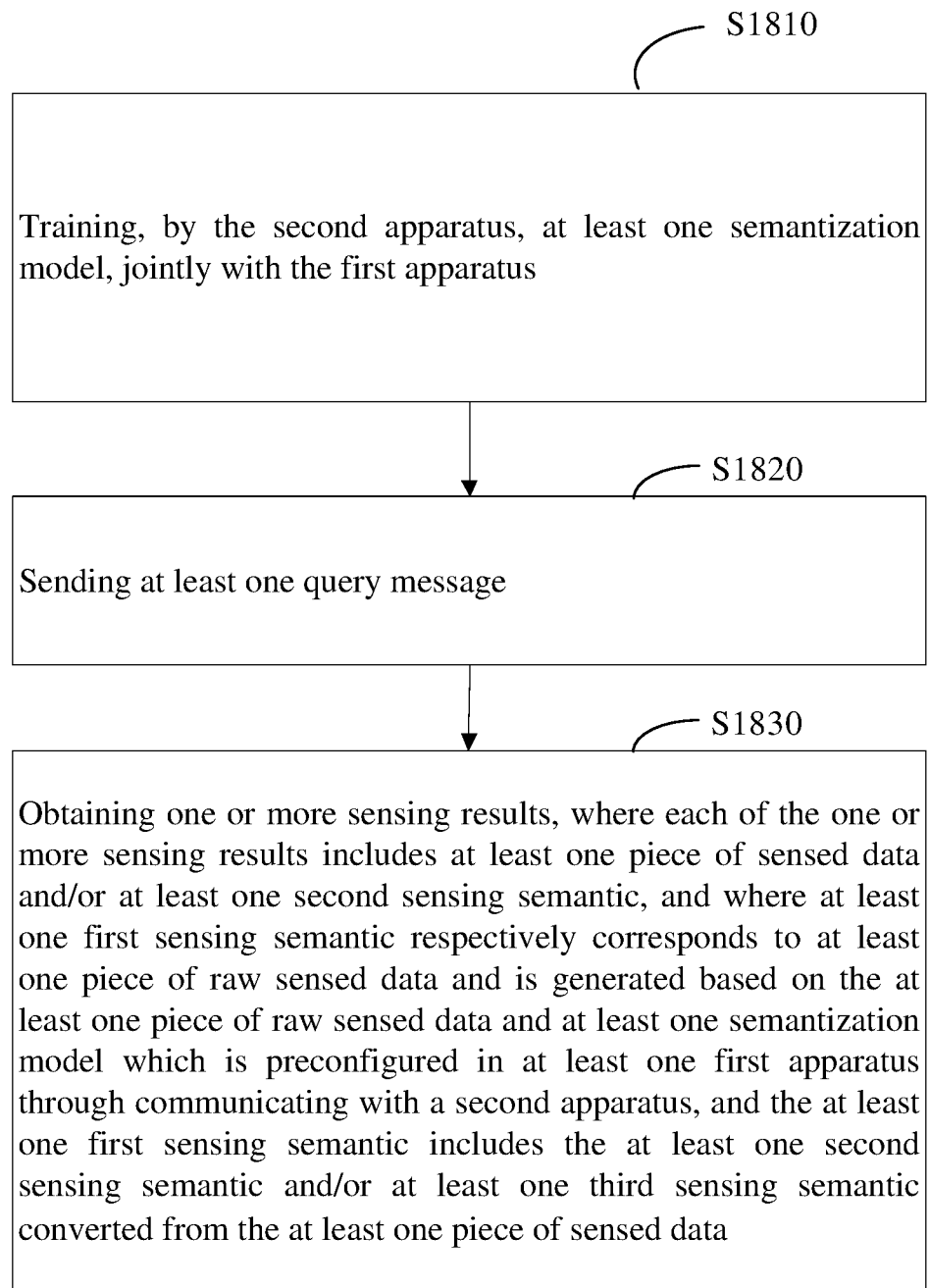


FIG. 18

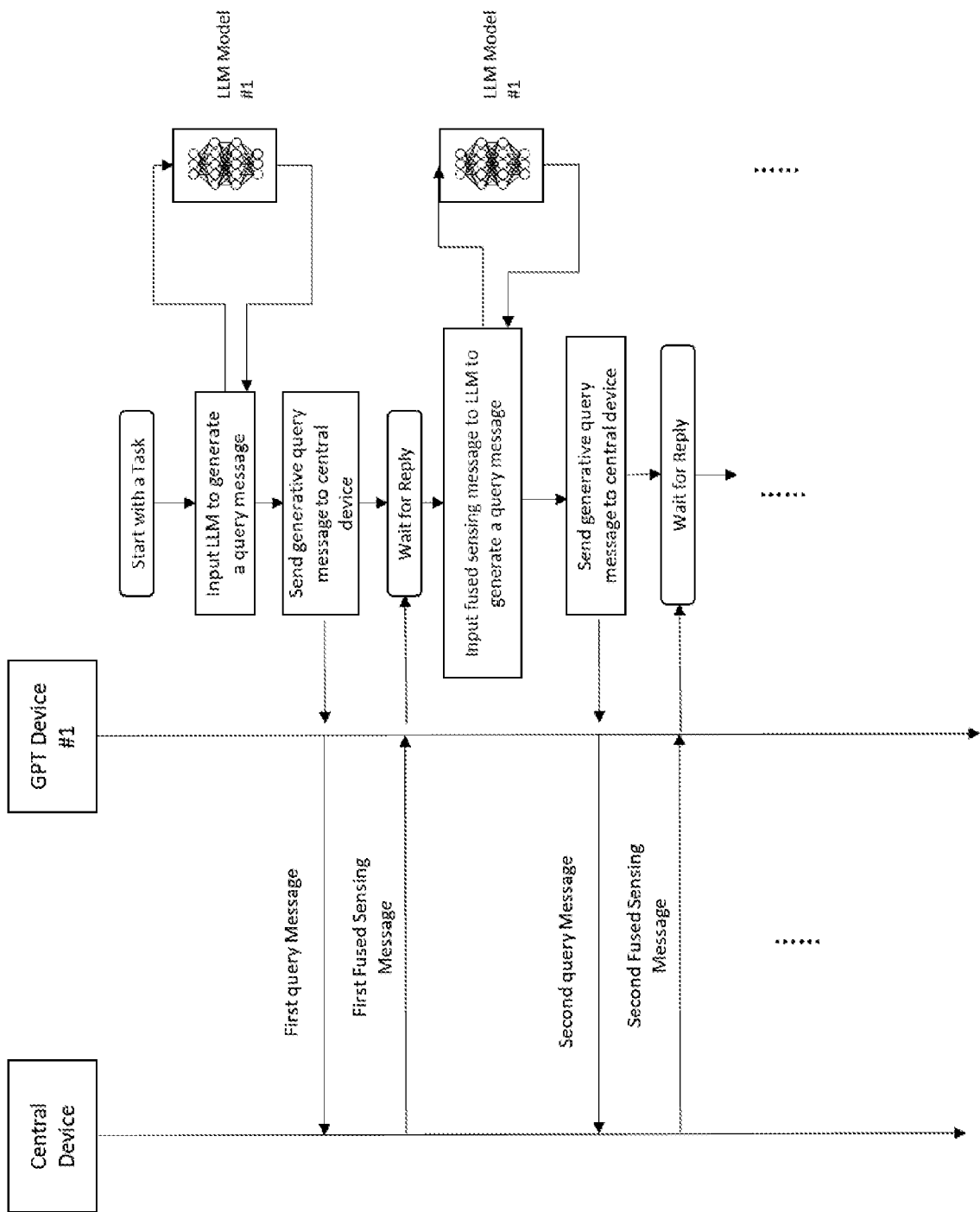


FIG. 19

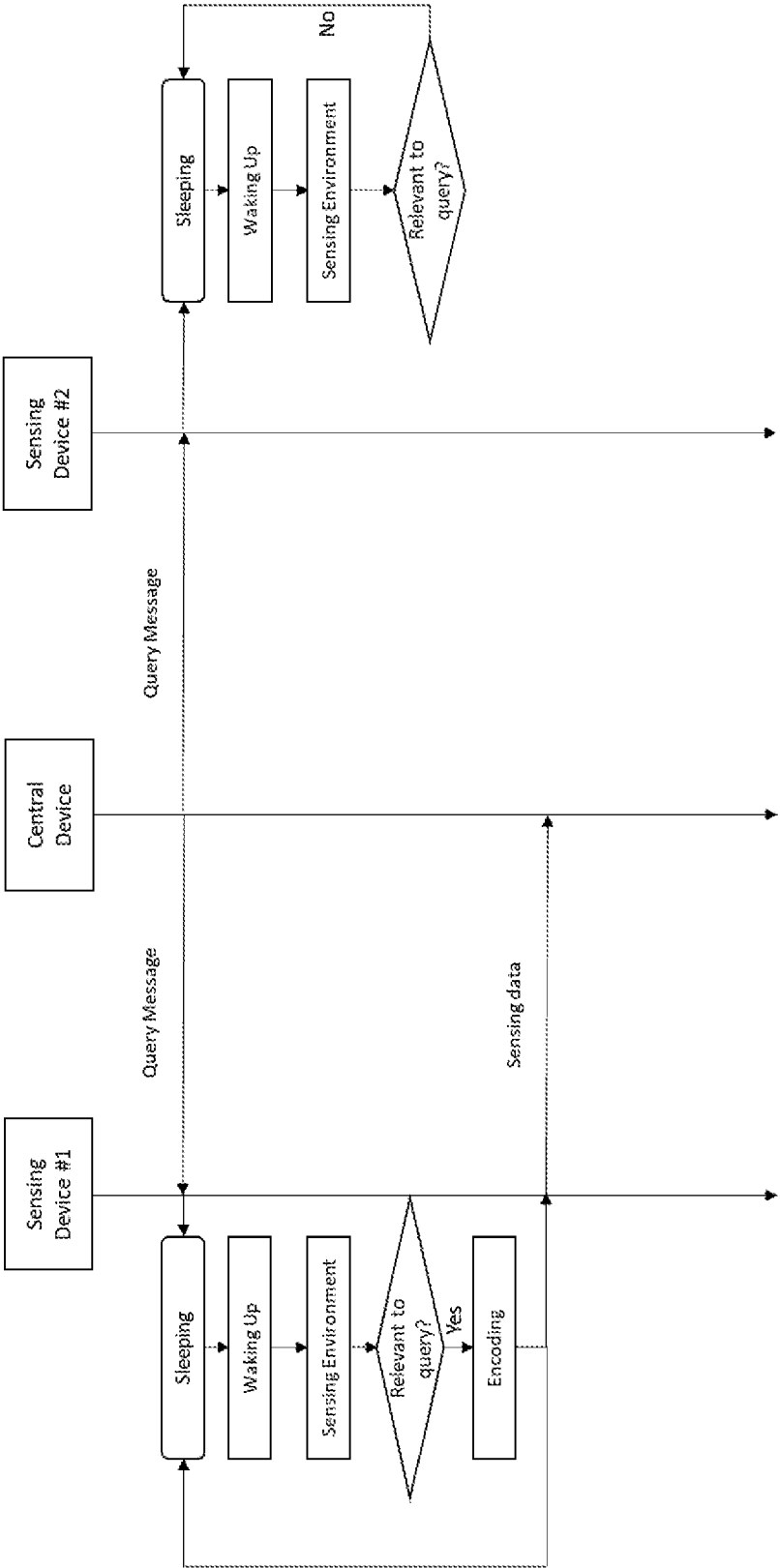


FIG. 20

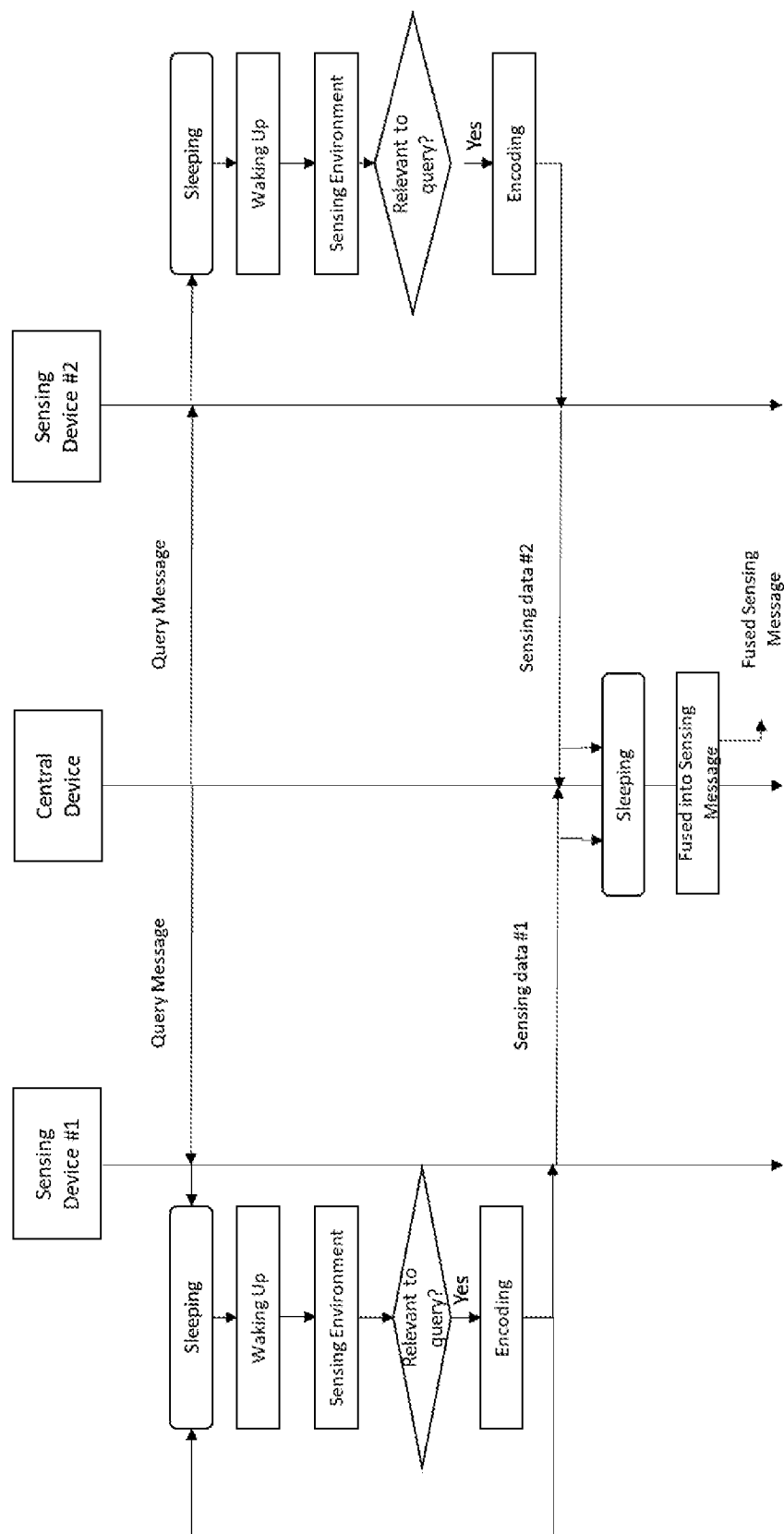


FIG. 21

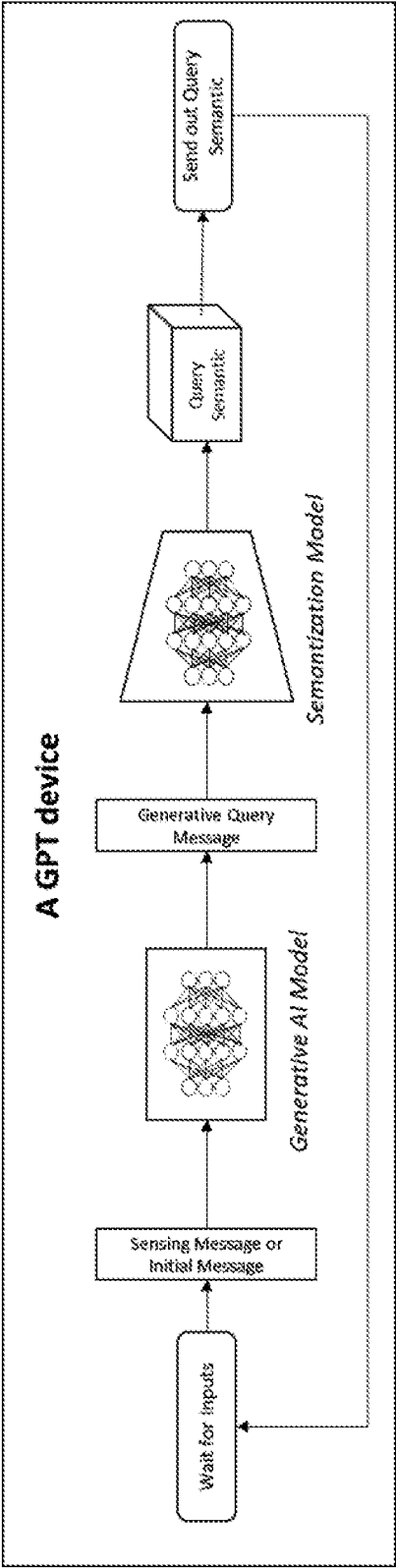


FIG. 22

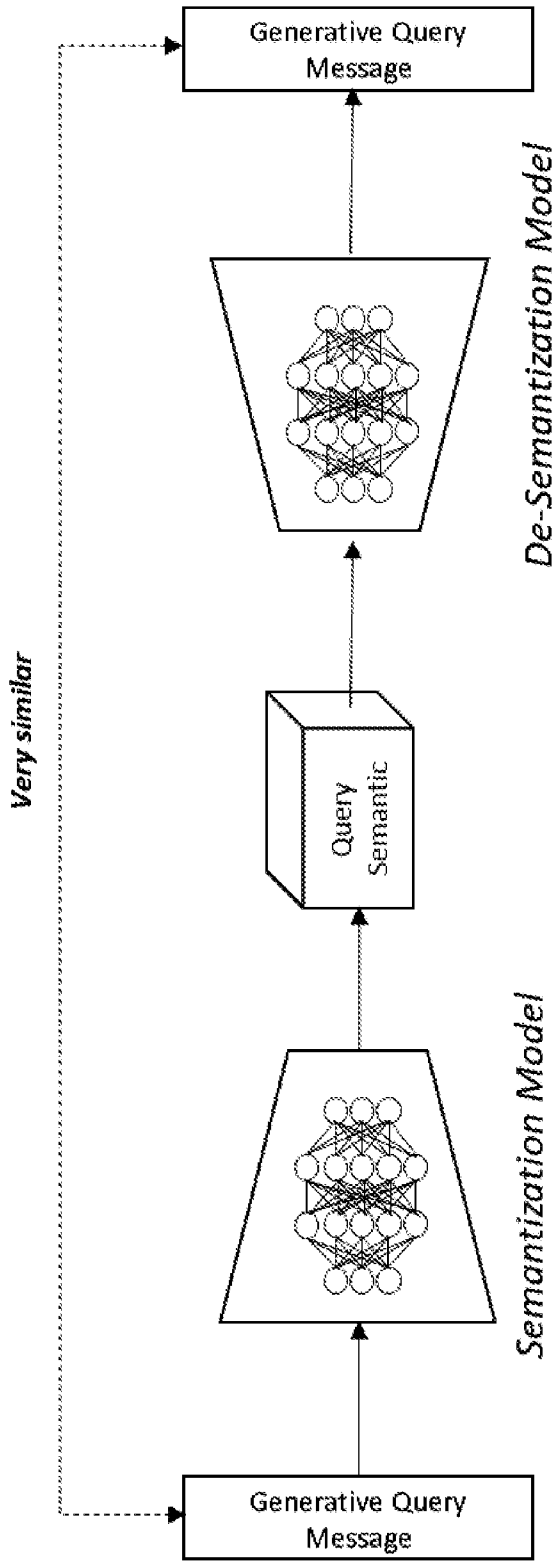


FIG. 23

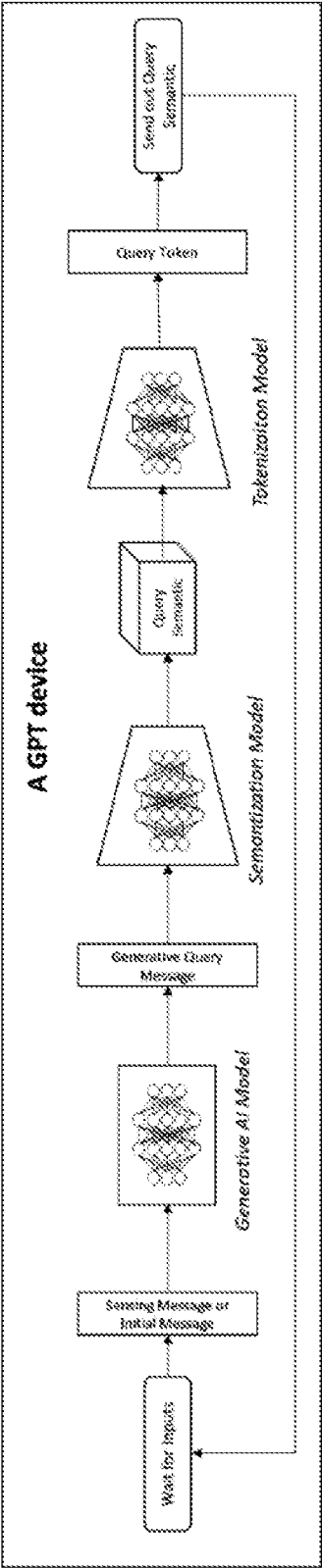


FIG. 24

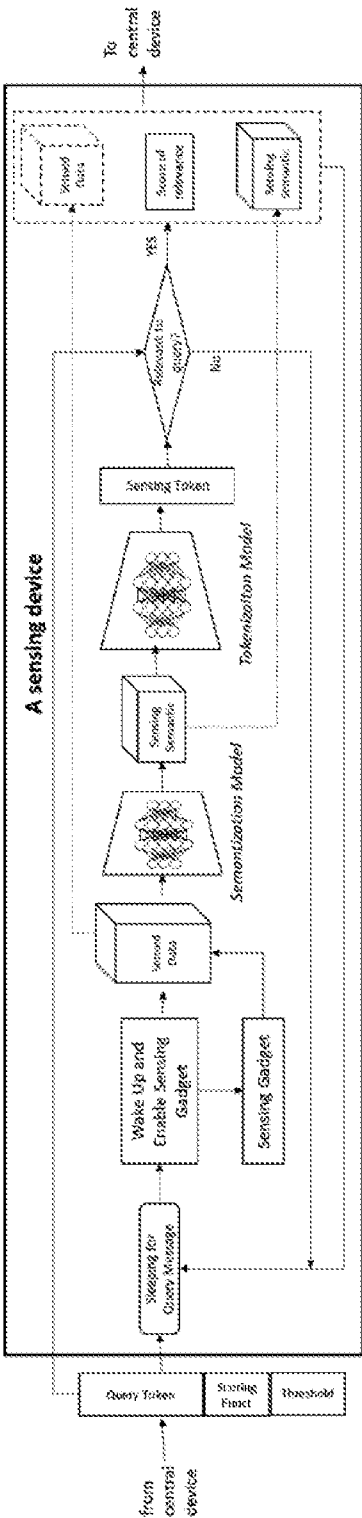
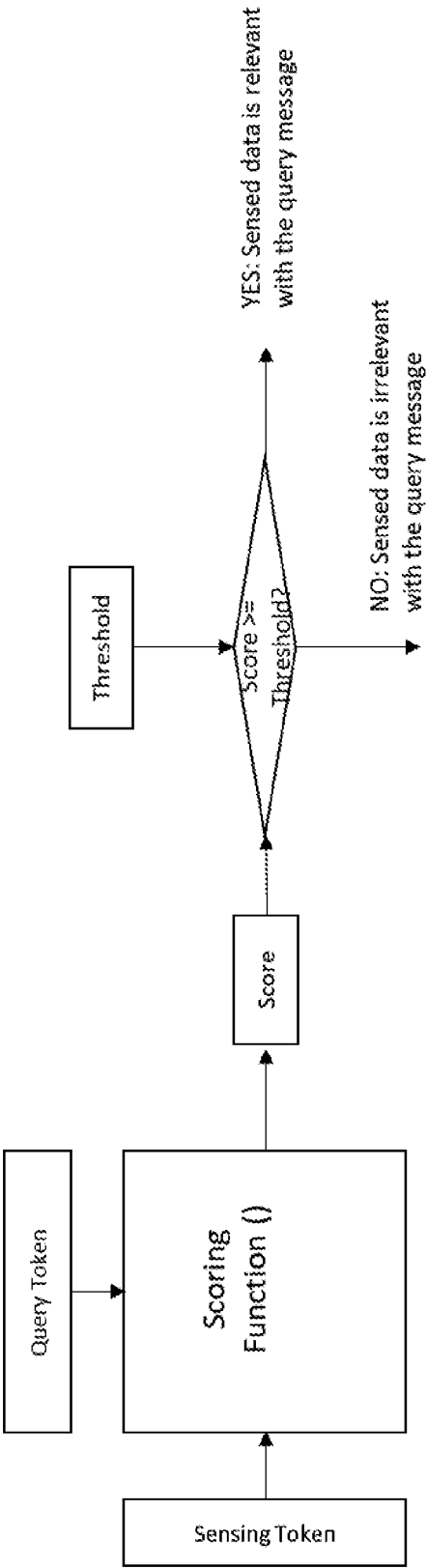


FIG. 25



*A sensing device compares and scores the relevance between the query message and sensed data*

FIG. 26

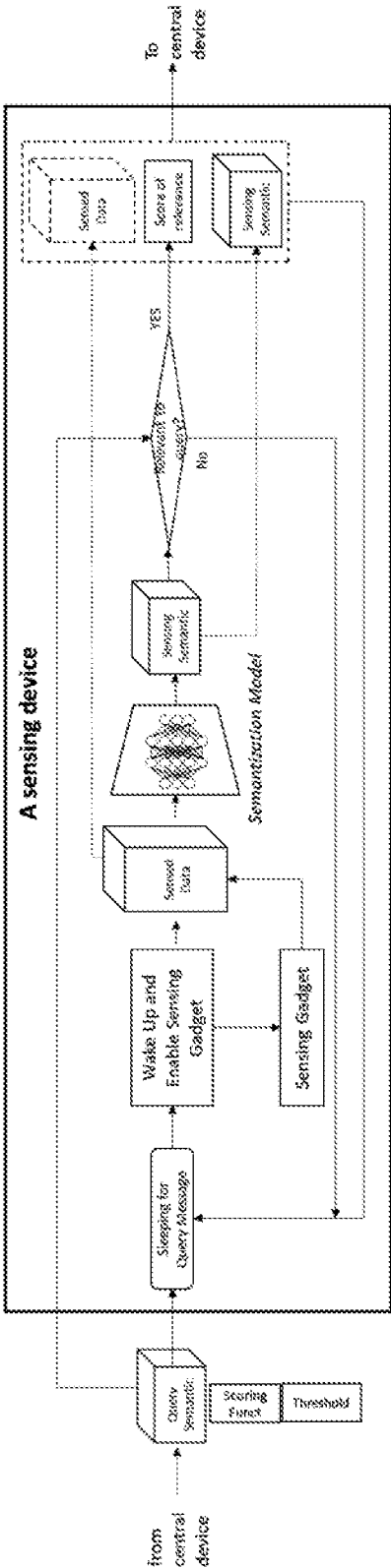
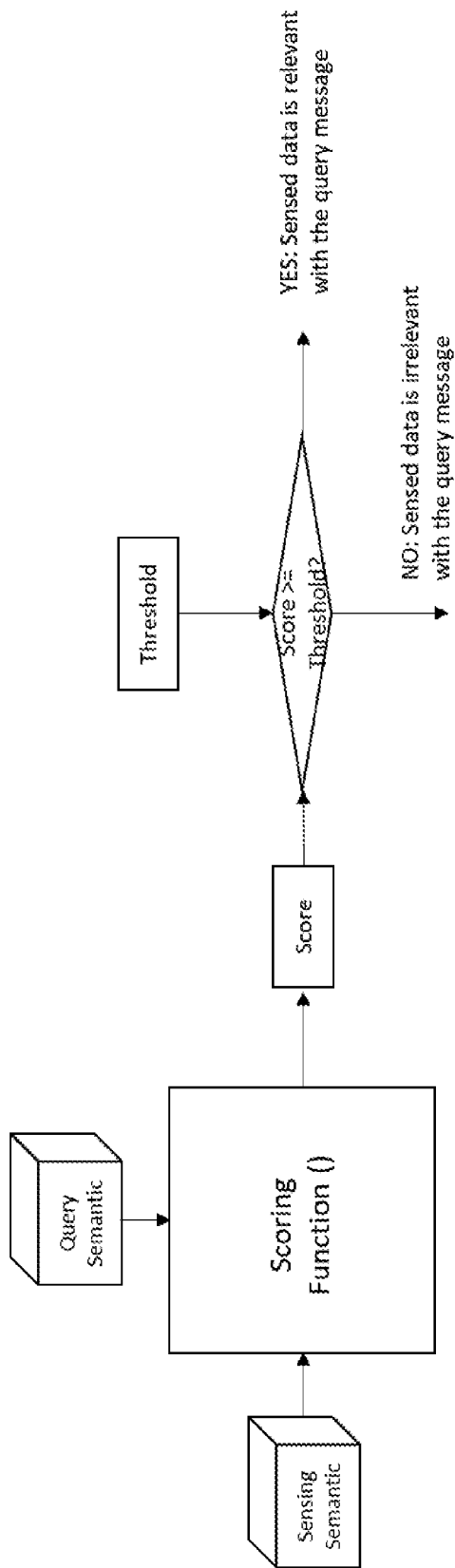


FIG. 27



*A sensing device compares and scores the relevance between the query message and sensed data*

FIG. 28

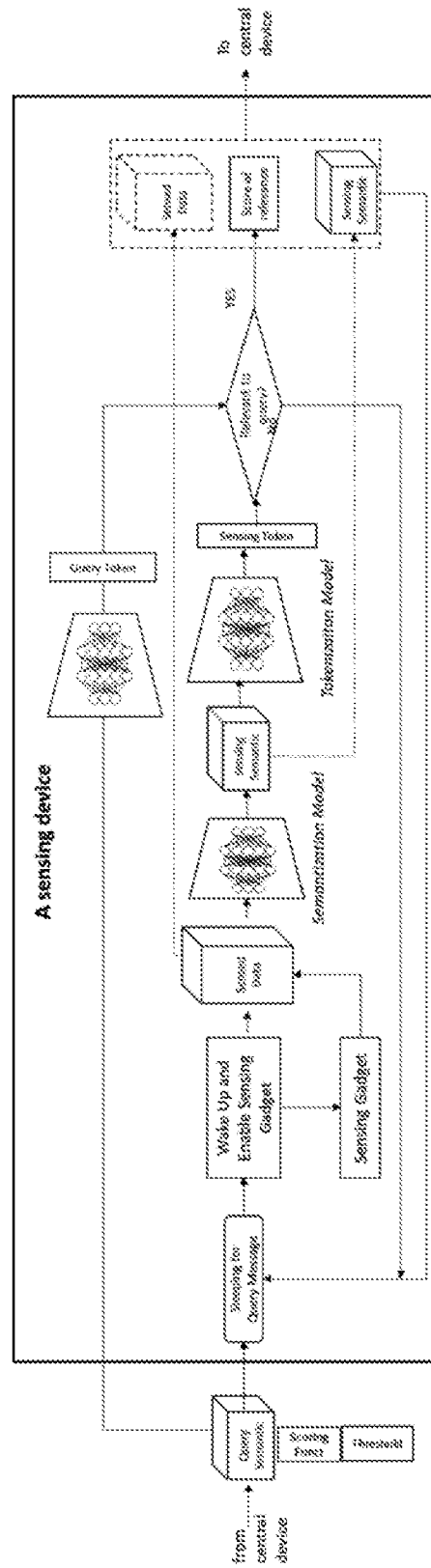
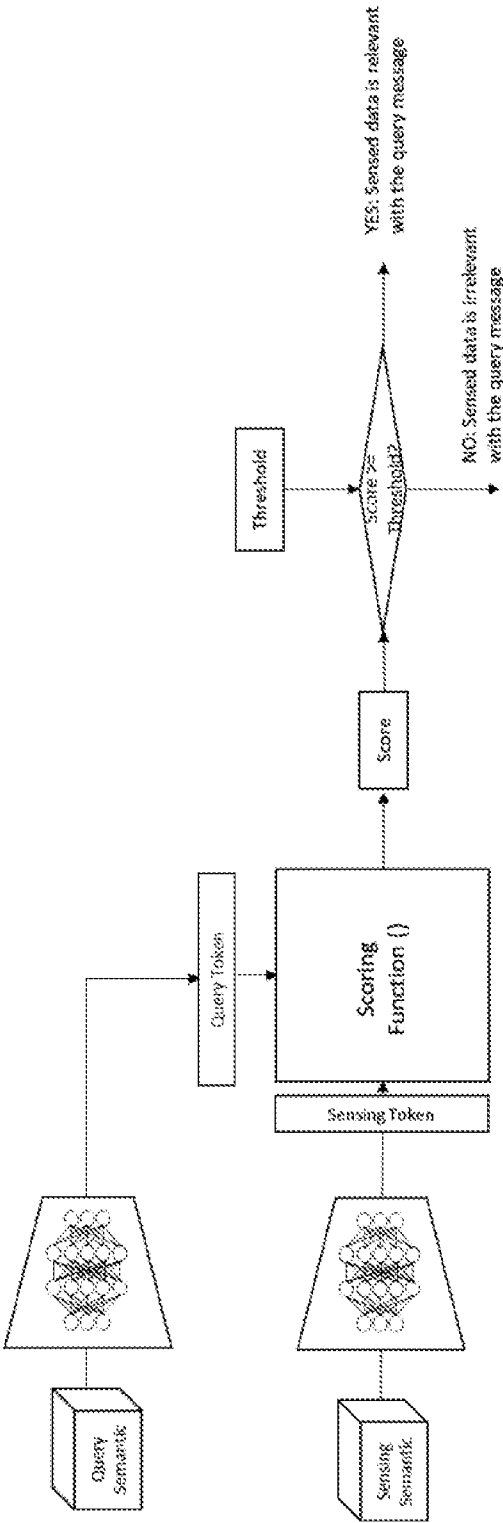
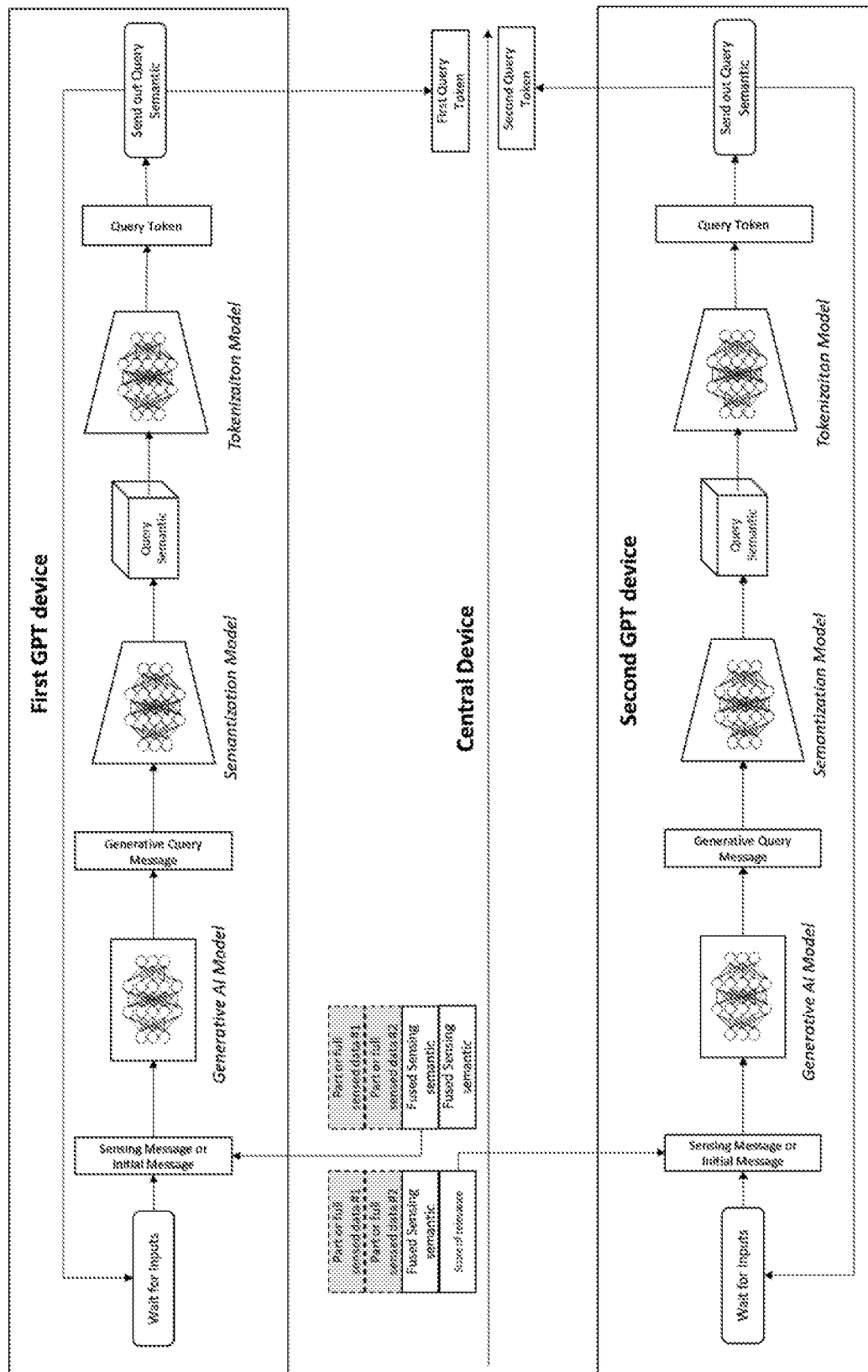


FIG. 29



A sensing device compares and scores the relevance between the query message and sensed data

FIG. 30



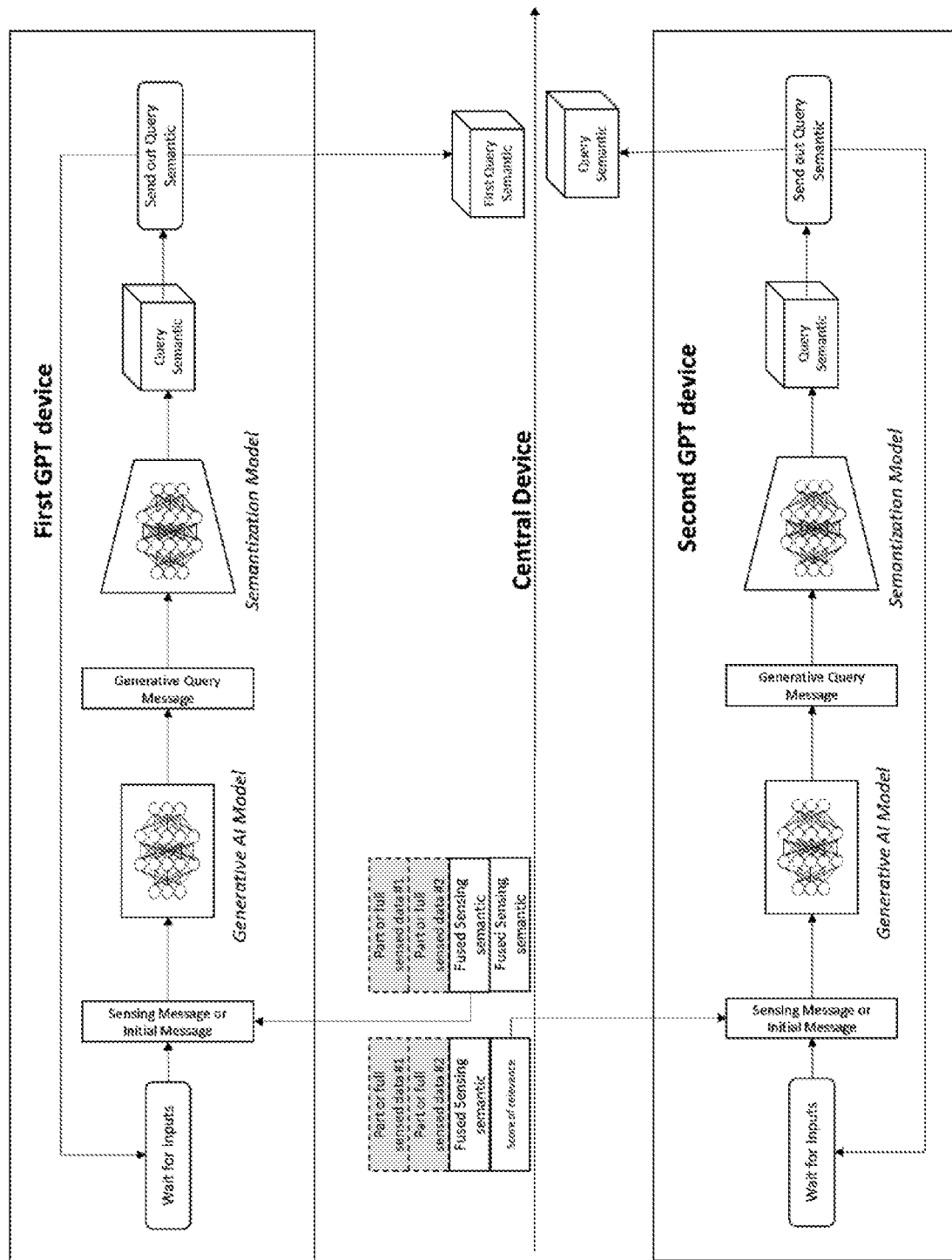


FIG. 32

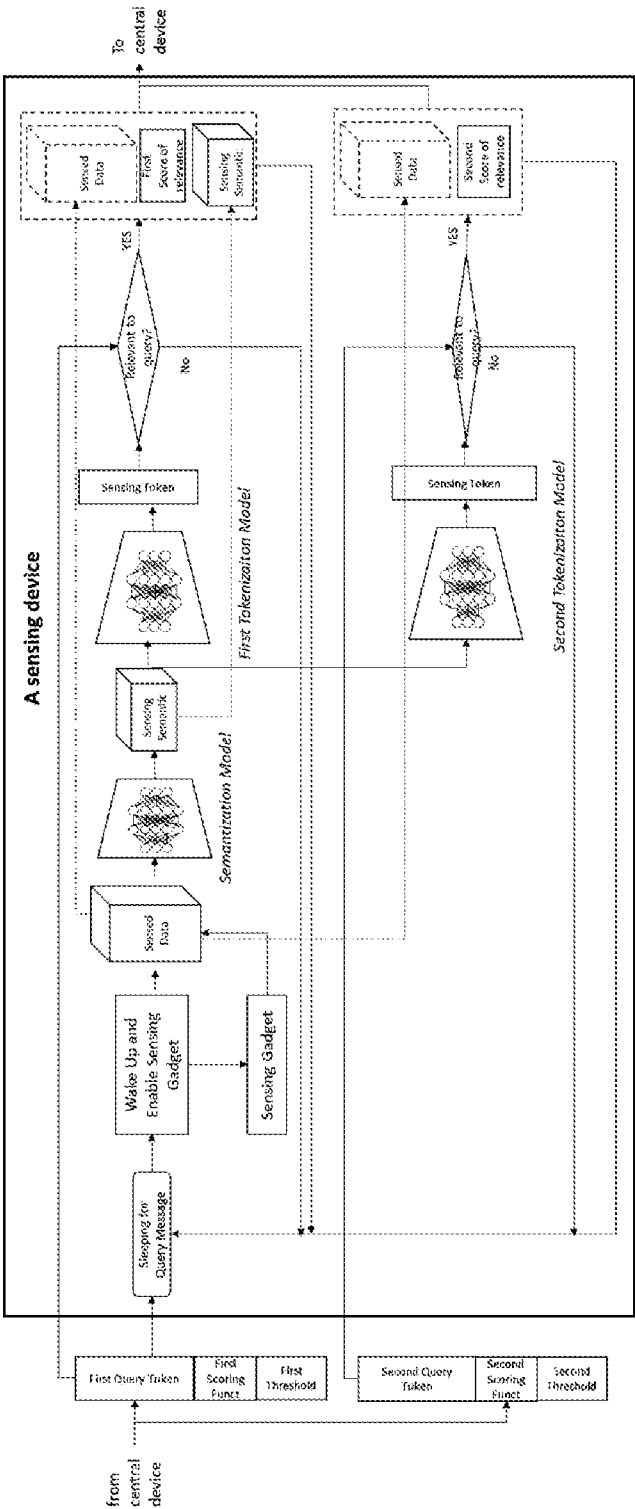


FIG. 33

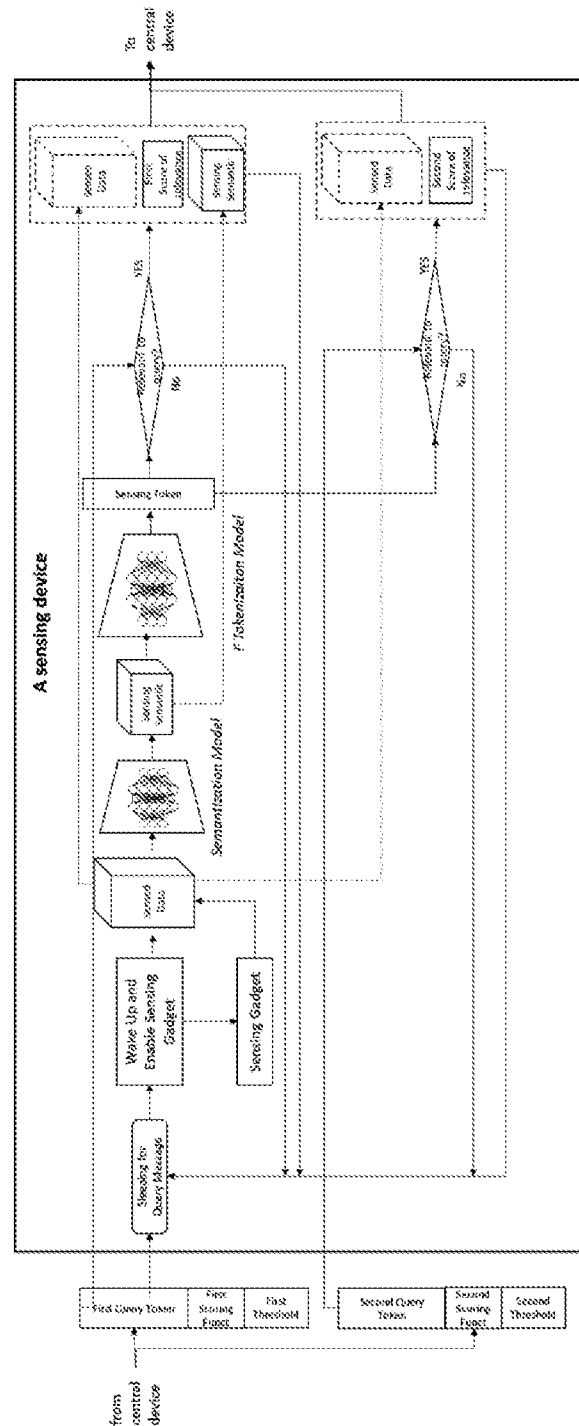


FIG. 34

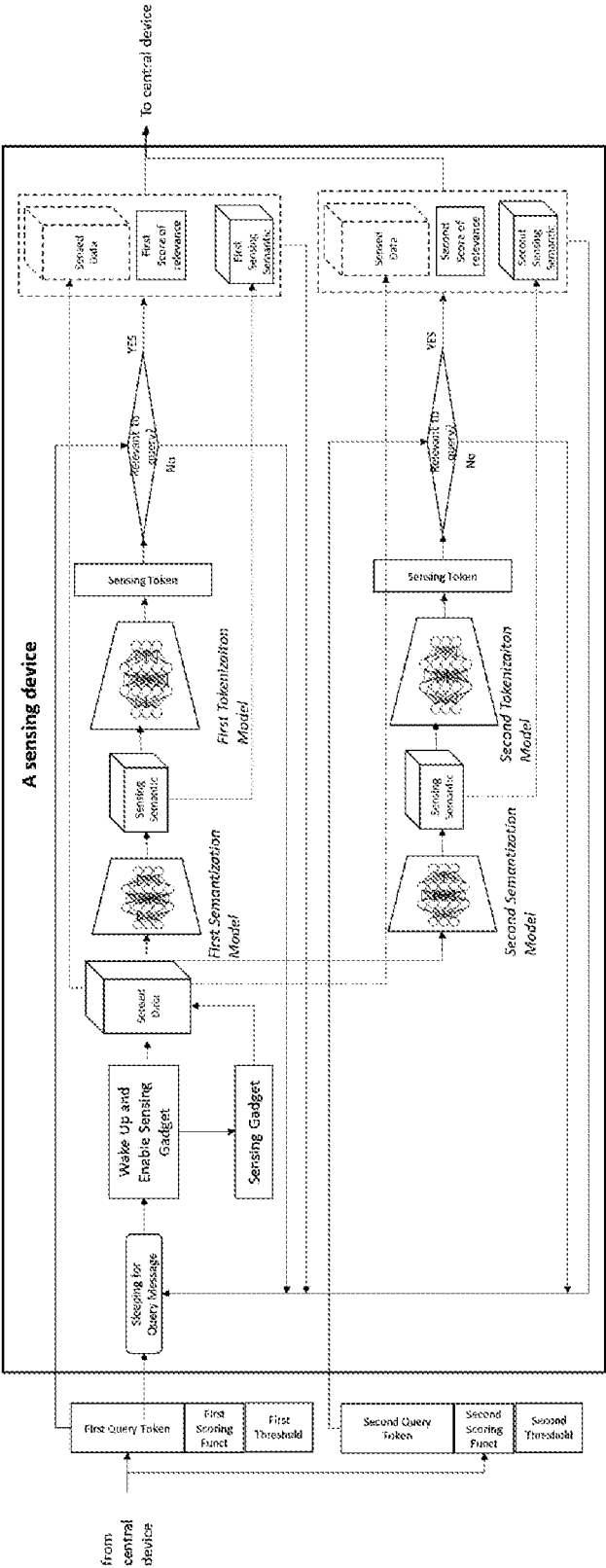


FIG. 35

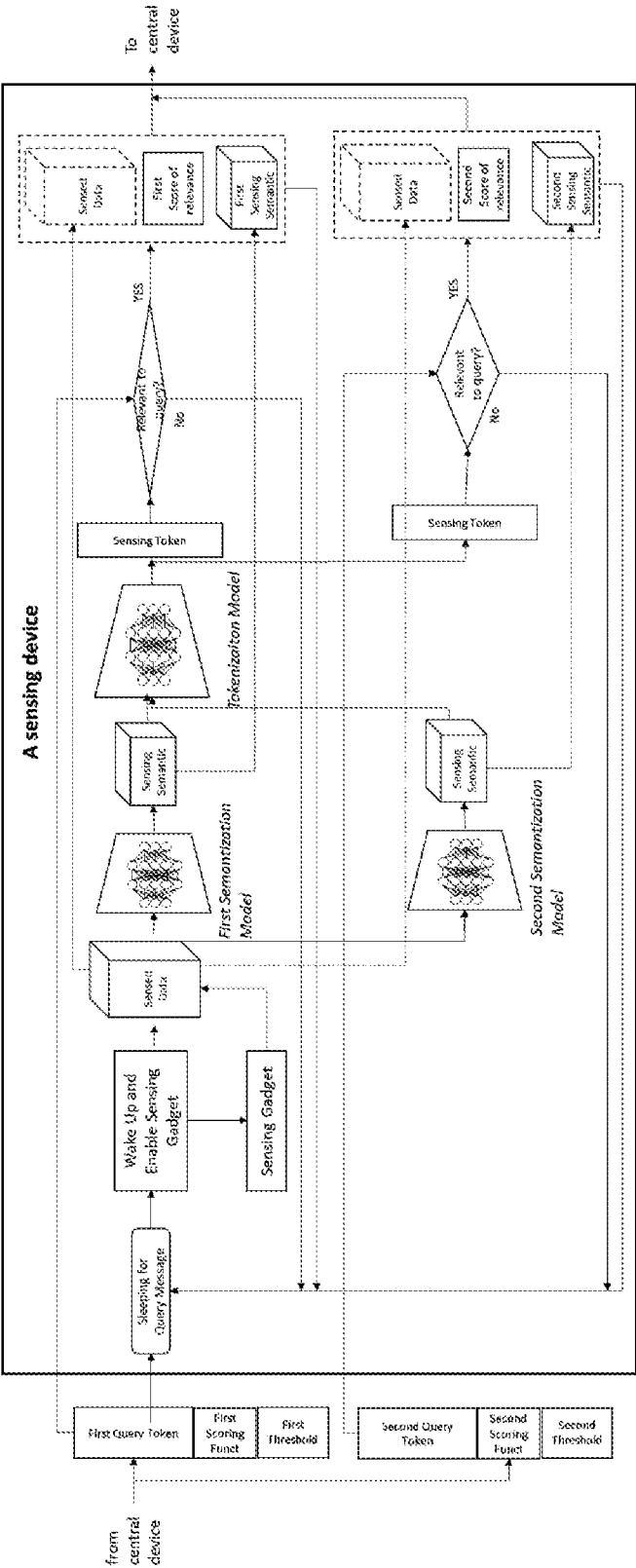


FIG. 36

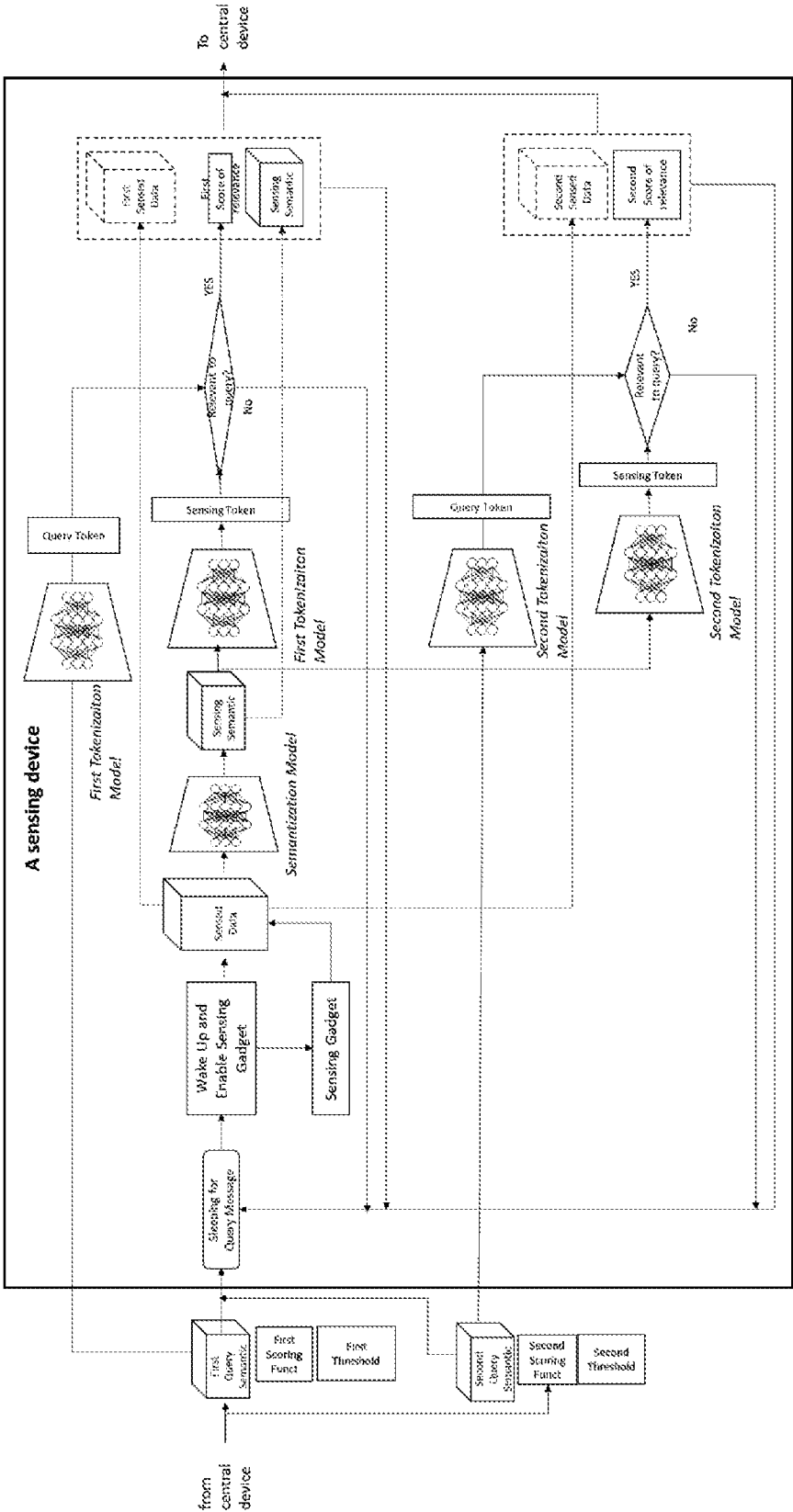


FIG. 37

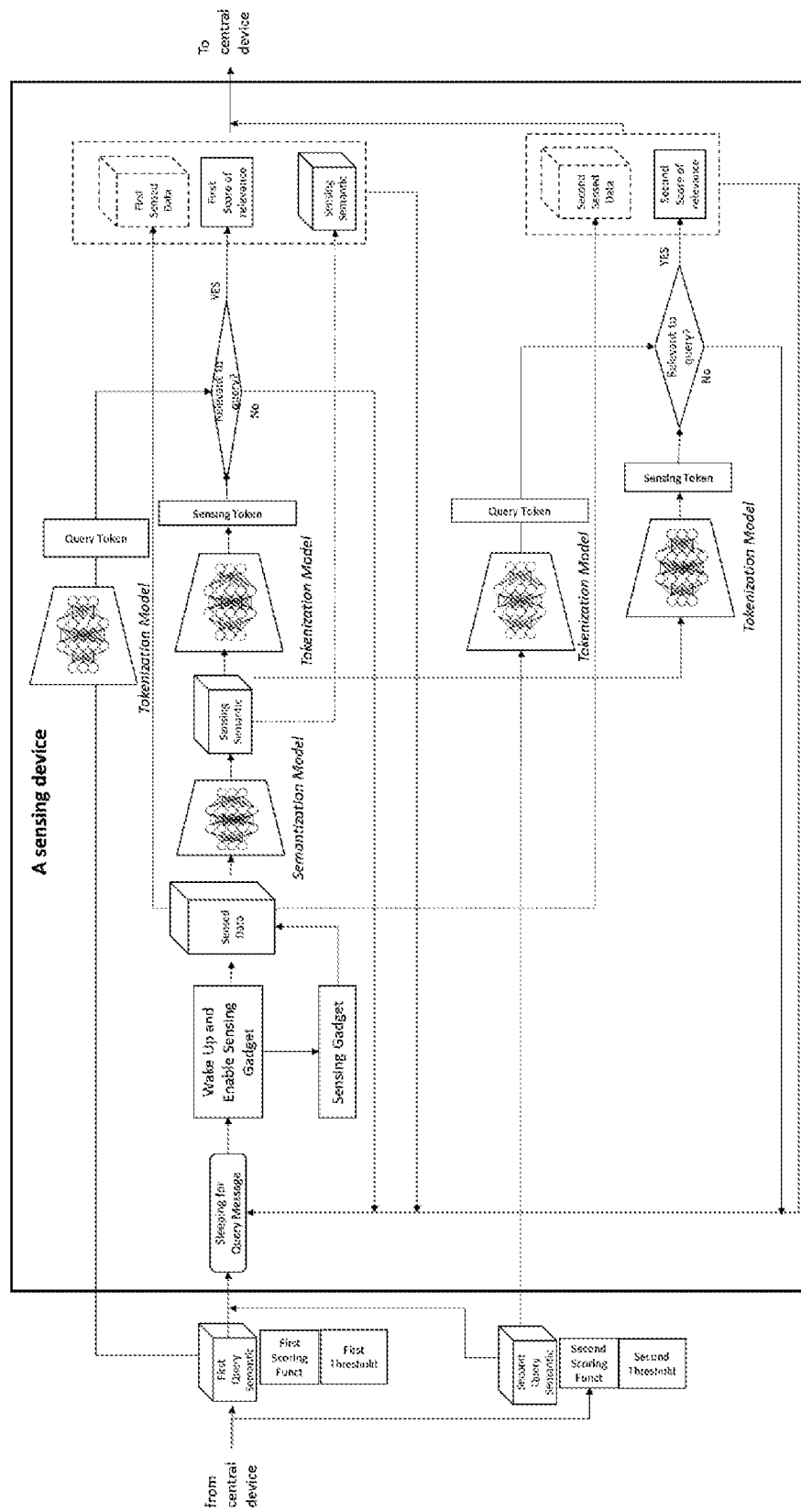


FIG. 38

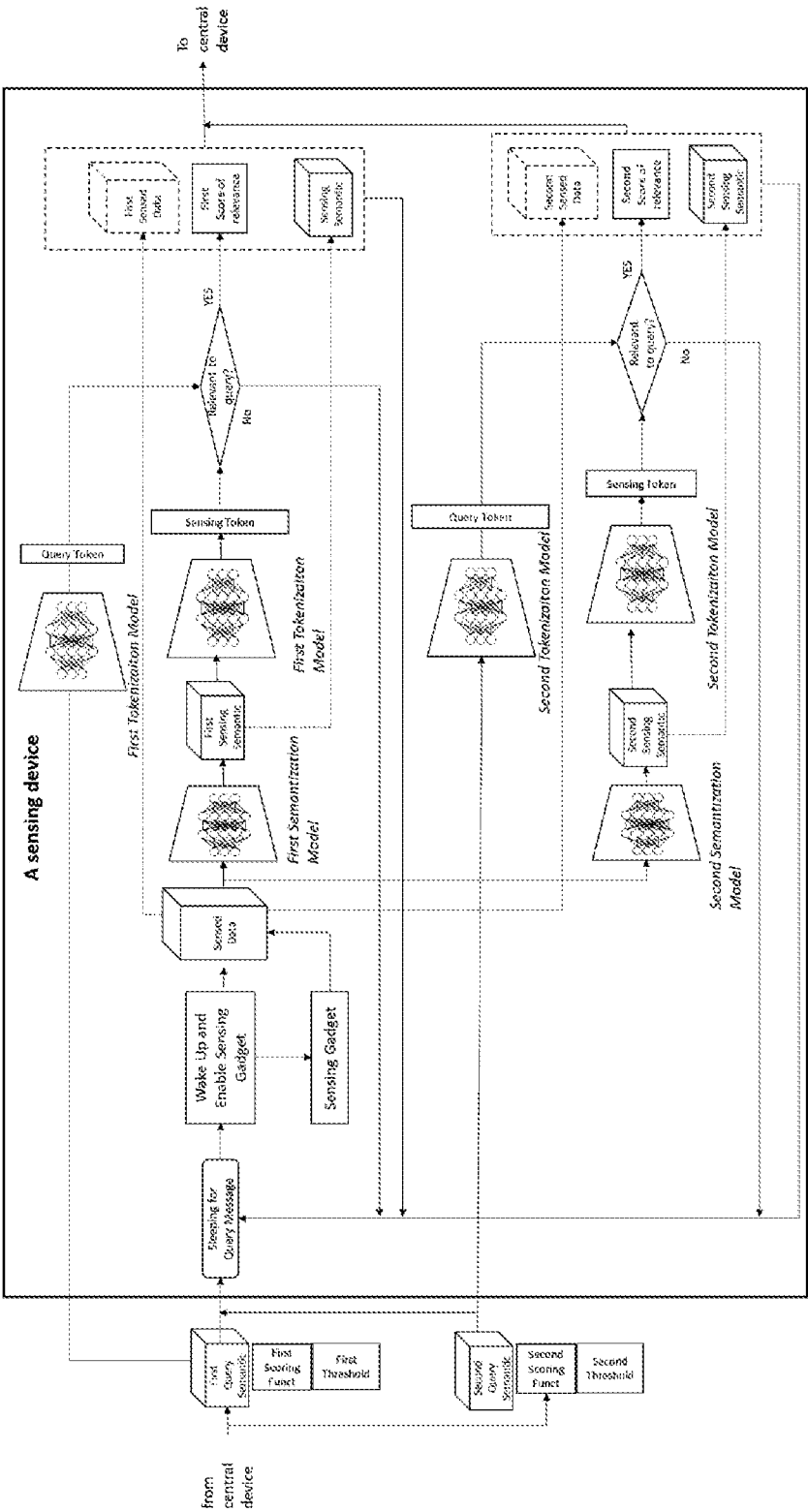


FIG. 39

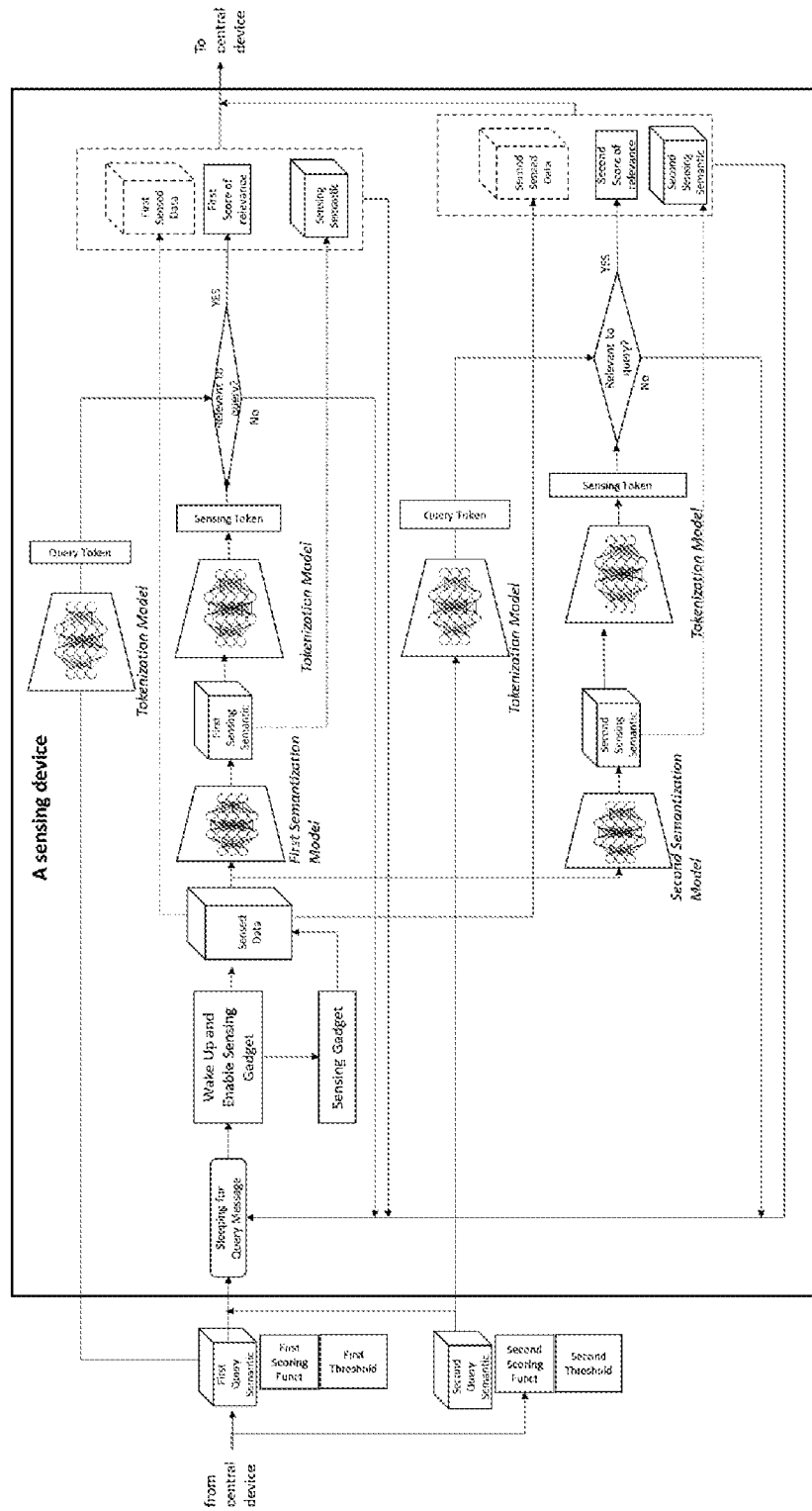


FIG. 40

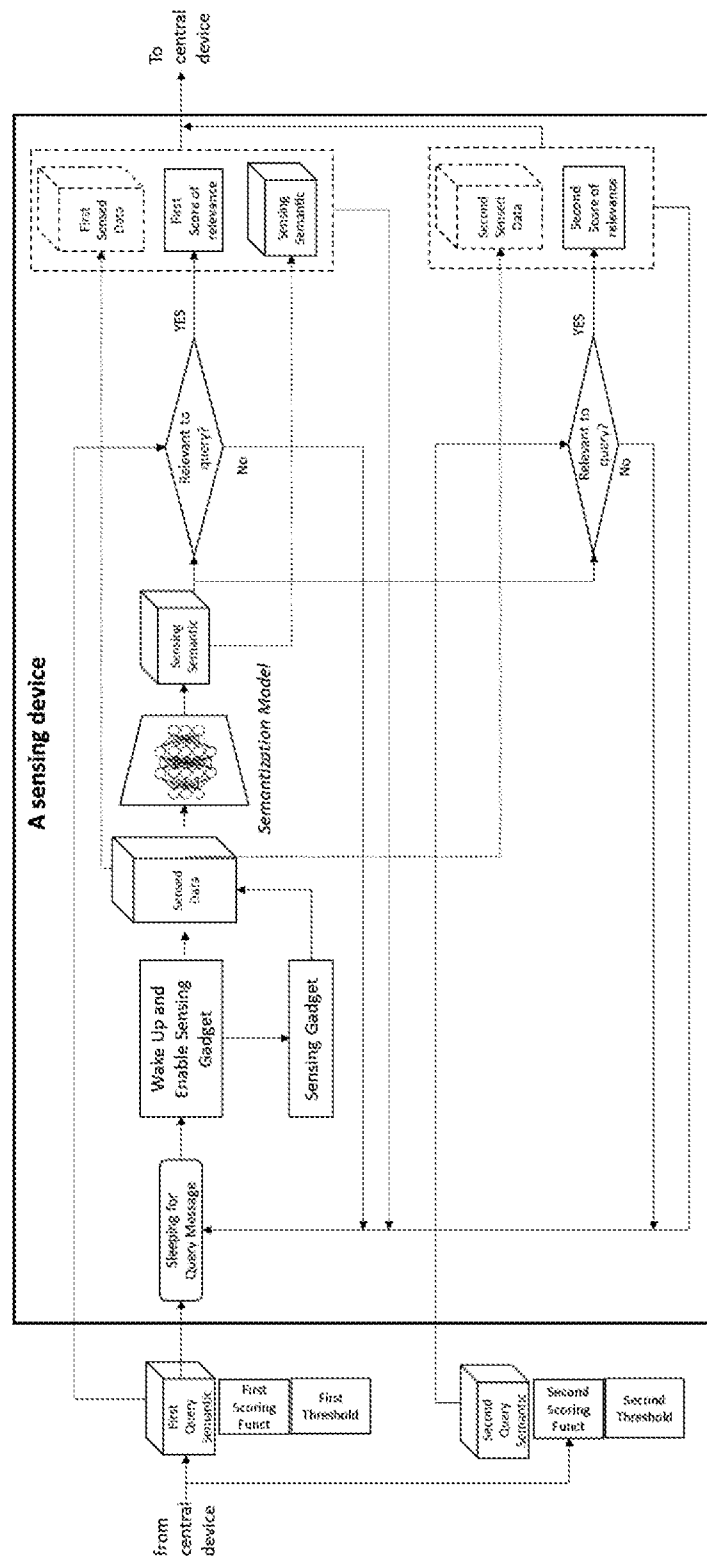


FIG. 41

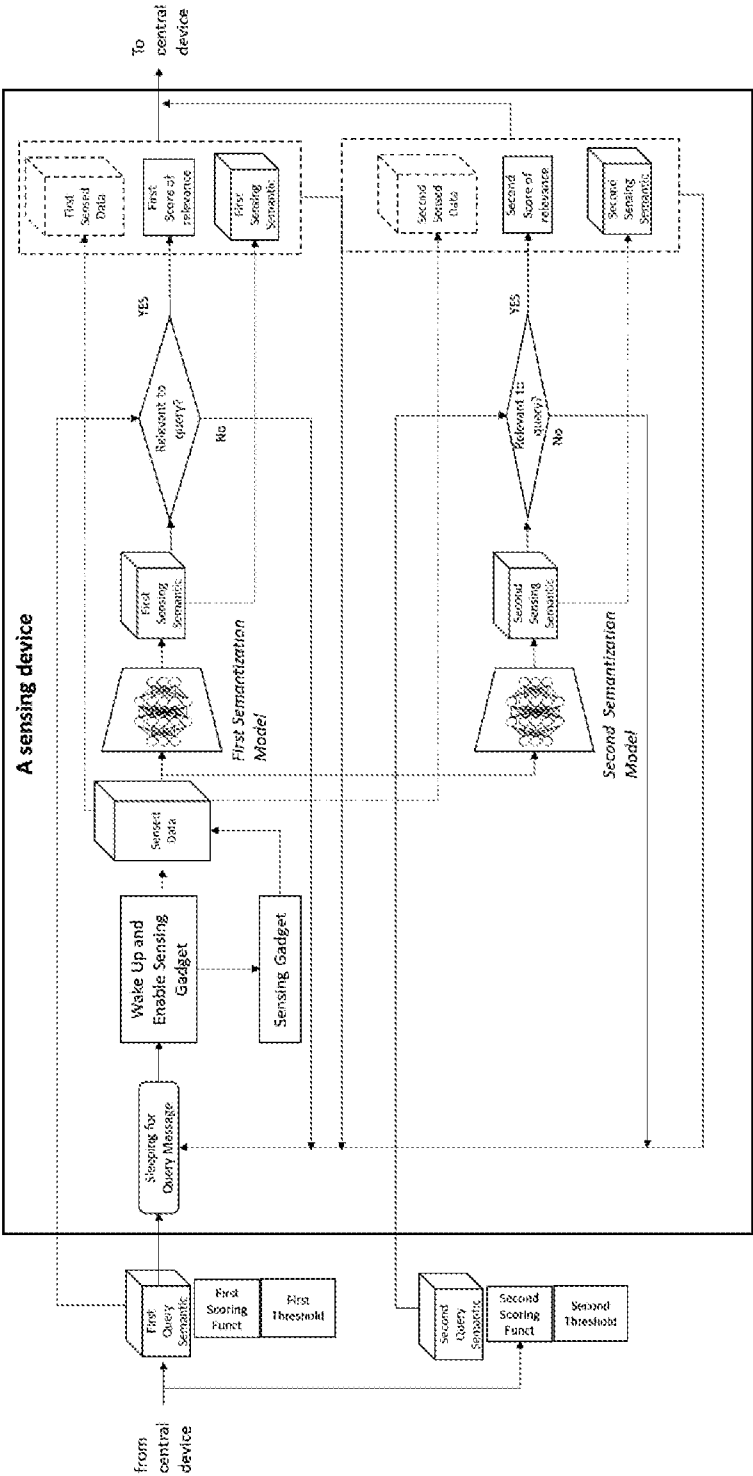


FIG. 42

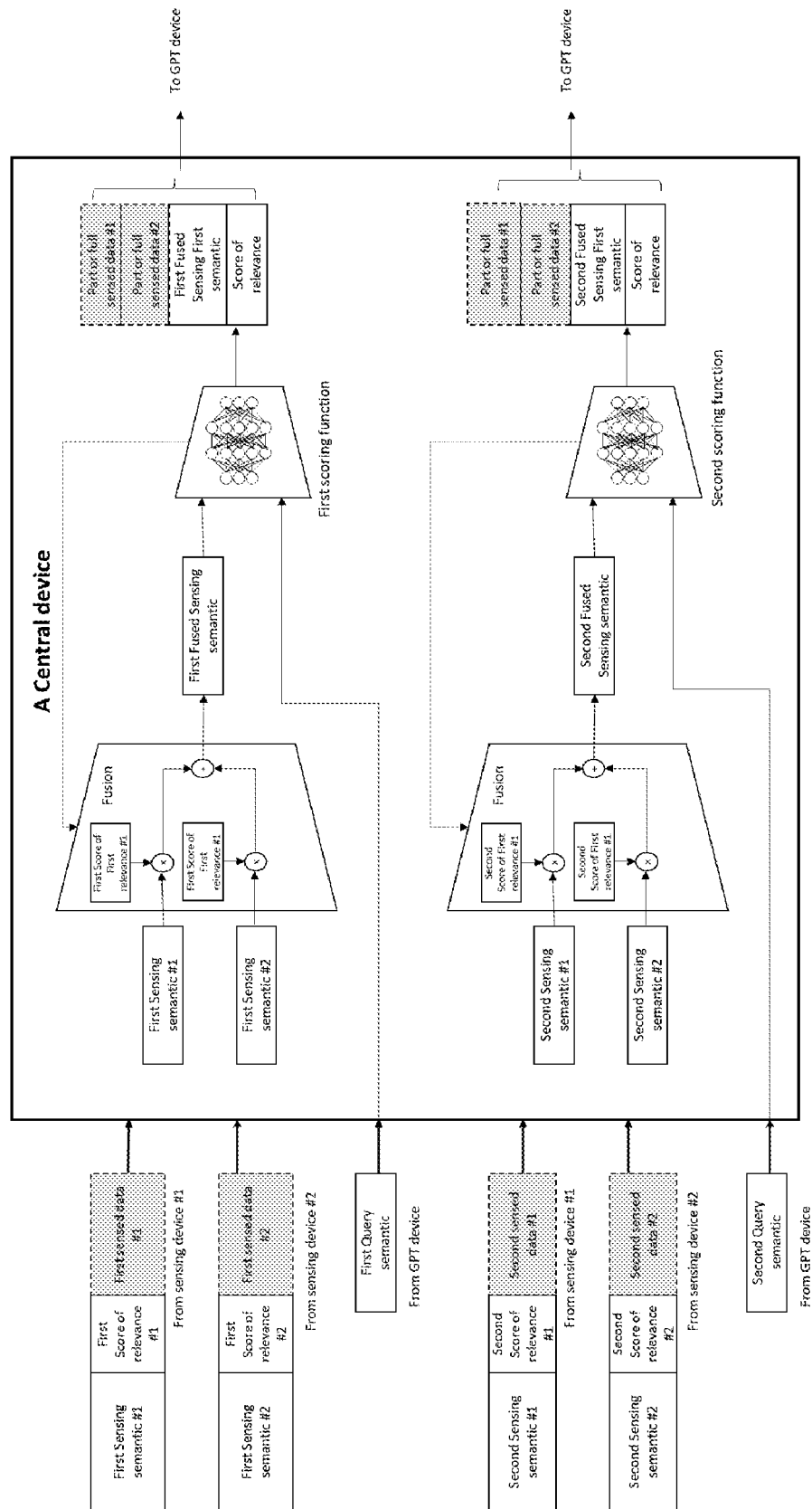


FIG. 43

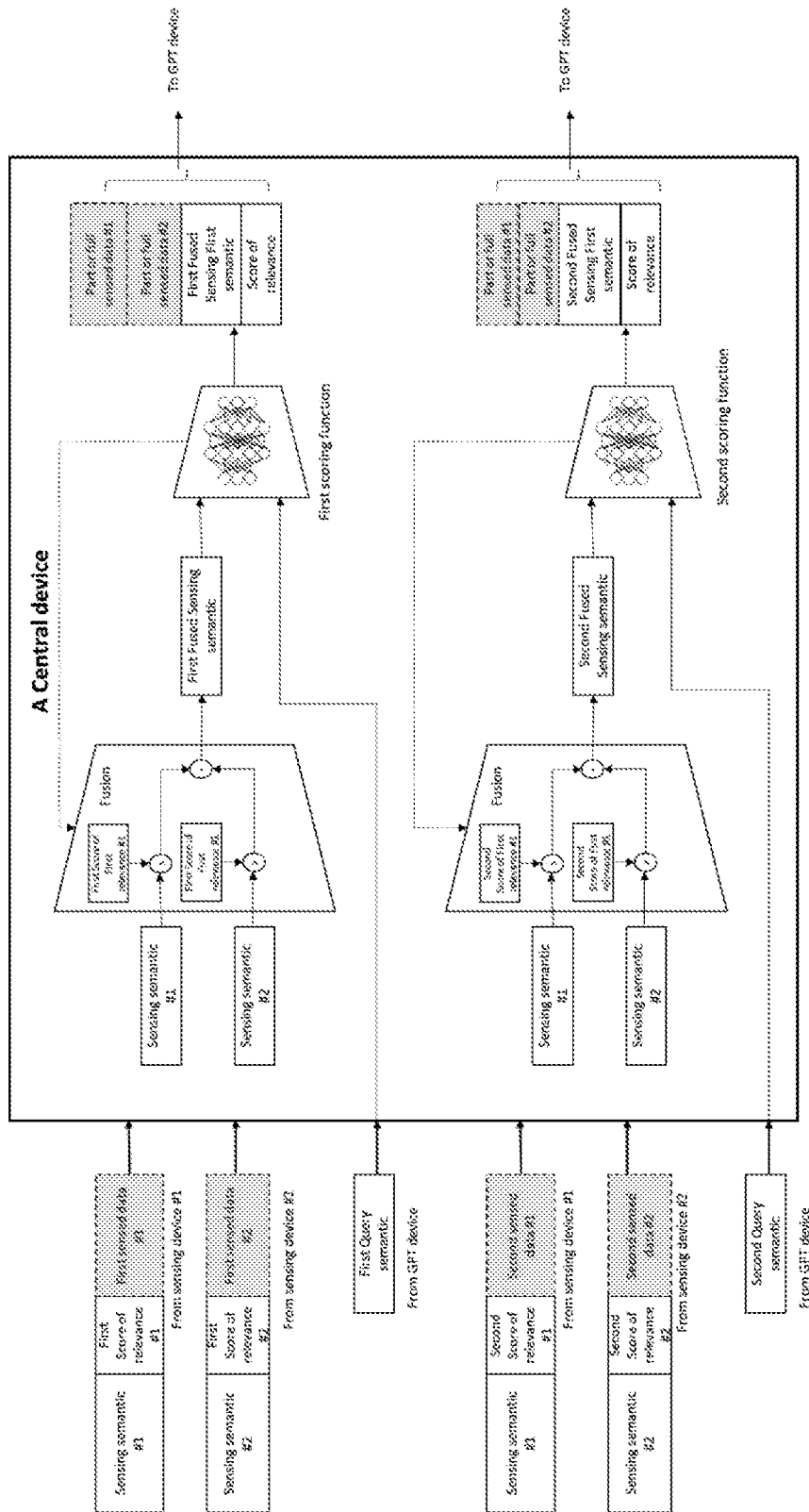


FIG. 44

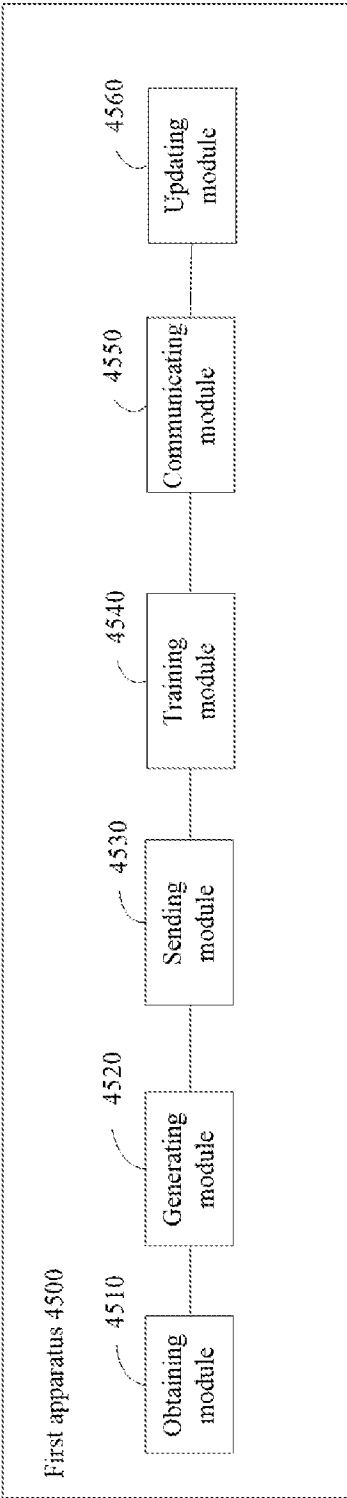


FIG. 45

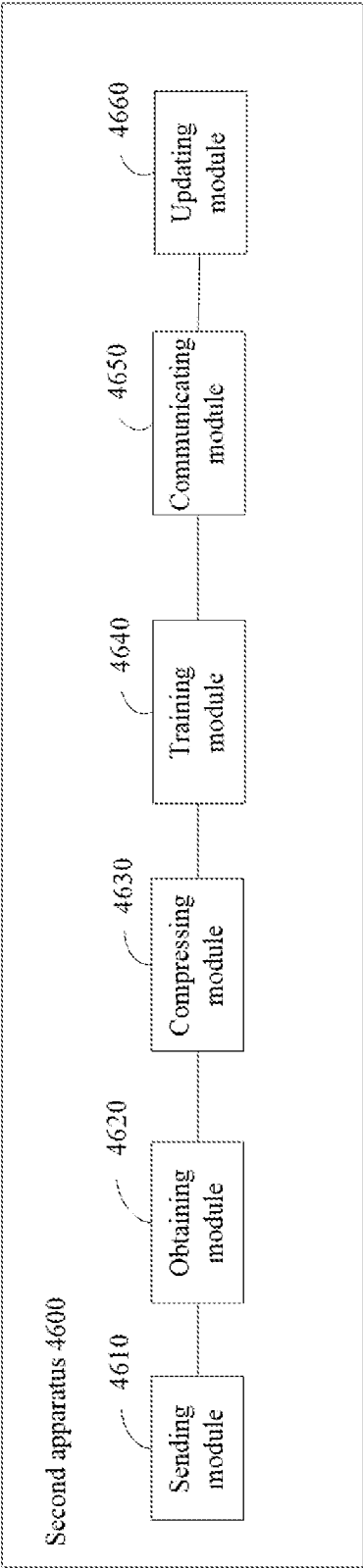


FIG. 46

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/128877

**A. CLASSIFICATION OF SUBJECT MATTER**

G06N3/0495(2023.01)i; G06V20/58(2022.01)i; H04W24/00(2009.01)i

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC: G06N G06V H04W G06F

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

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

CNTXT, ENTXT, DWPI, WPABS, CNKI, 3GPP, ETSI, IEEE: sense, device, node, sensor, group, data, result, raw, fuse, combine, collect, report, send, transmit, query, request, semantic, model

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                 | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | DEUTSCHE TELEKOM et al. "S1-230255, pCR on updating Sensor Groups use case and proposing new definitions"<br><i>3GPP TSG SA WG 1 Meeting #101</i> , 24 February 2023 (2023-02-24),<br>section 5.19                                 | 1-108                 |
| A         | BARNAGHI, Payam et al. "Sense and Sens'ability: Semantic Data Modelling for Sensor Networks"<br><i>Conference Proceedings of ICT Mobile Summit 2009</i> , 31 December 2009 (2009-12-31),<br>the whole document                     | 1-108                 |
| A         | WO 2018101504 A1 (KOREA ELECTRONICS TECHNOLOGY INSTITUTE) 07 June 2018<br>(2018-06-07)<br>the whole document                                                                                                                       | 1-108                 |
| A         | DIBOWSKI, Henrik et al. "Semantic Device and System Modeling for Automation Systems and Sensor Networks"<br><i>IEEE Transactions on Industrial Informatics</i> , Vol. 14, No. 4, 30 April 2018 (2018-04-30),<br>the whole document | 1-108                 |

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

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

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

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

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

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

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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

19 February 2024

Date of mailing of the international search report

23 February 2024

Name and mailing address of the ISA/CN

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/128877

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                      | Relevant to claim No. |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | APPLE. "RWS-230227, Views on Joint Communications and Sensing for Rel-19"<br><i>3GPP TSG RAN Rel-19 workshop</i> , 16 June 2023 (2023-06-16),<br>the whole document                                                     | 1-108                 |
| A         | ZTE et al. "RWS-230283, Discussion on sensing for NR"<br><i>3GPP TSG RAN Rel-19 workshop</i> , 16 June 2023 (2023-06-16),<br>the whole document                                                                         | 1-108                 |
| A         | NOKIA et al. "S1-230078, Updates in use cases 5.13 - 5.26 to align usage of sensing<br>transmitter and sensing receiver"<br><i>3GPP TSG SA WG 1 Meeting #101</i> , 24 February 2023 (2023-02-24),<br>the whole document | 1-108                 |

**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.

**PCT/CN2023/128877**

| Patent document<br>cited in search report | Publication date<br>(day/month/year) | Patent family member(s) | Publication date<br>(day/month/year) |
|-------------------------------------------|--------------------------------------|-------------------------|--------------------------------------|
| WO 2018101504 A1                          | 07 June 2018                         | KR 20180061813 A        | 08 June 2018                         |