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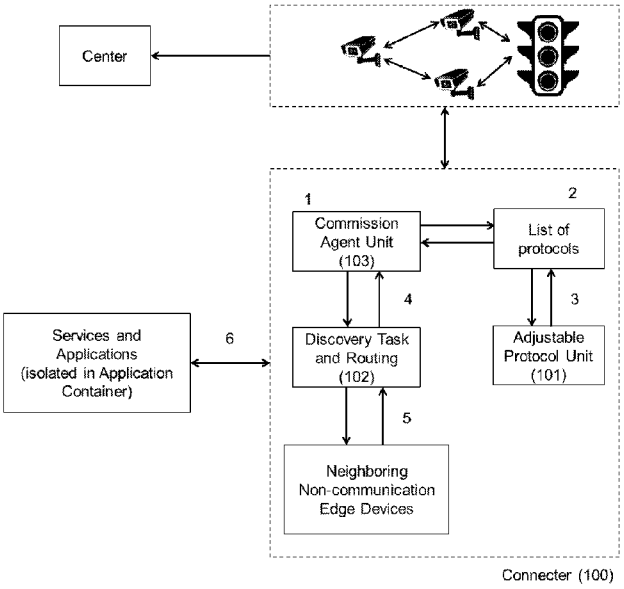


FIGURE 1

(57) **Abstract:** The present invention discloses a system and a method for enabling edge processing at non-communication edge devices in an edge mesh network. The system comprises a connecter (100) attachable to a non-communication edge device. The connecter (100) comprises an adjustable protocol unit (101), a discovery task and routing unit (102) and a commission agent unit (103). The connecter (100) communicates with neighboring connecters (100) of the neighboring non-communication edge devices through a dedicated long-range wireless data network. The connecter (100) processes, during active mode, data transmitted by the neighboring connecters (100) locally within the edge mesh network.

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SYSTEM FOR ENABLING EDGE PROCESSING AT NON-COMMUNICATION EDGE DEVICES AND METHOD THEREOF

FIELD OF THE INVENTION

The present invention relates generally to arrangement for device communication. More particularly, the present invention relates to a system and a method for enabling edge processing at non-communication devices locally within an edge mesh network.

BACKGROUND OF THE INVENTION

An edge device can be a computer, a gateway or some other devices that perform local processing internally within its boundary. It is a piece of hardware that controls data flow at the boundary between two networks. This edge device may fulfill a variety of roles, depending on what type of device it is, but it essentially serves as network entry (or exit) points. Some common functions of edge devices are the transmission, routing, processing, monitoring, filtering, translation and storage of data passing between networks.

In the era of merging technology such as Internet of Things and Smart City, there requires each and every edge device to become accessible and cooperatively connected to each other at all time. Traffic control system, for example, consists of several connected devices such as cameras and traffic lights which are used for one singular application, i.e. traffic monitoring. This system however demands external data processing where the data related to the traffic monitoring thereof must be transmitted to a remote data center or controller instead of being locally processed within its network. It is due to the fact that these connected devices are conventionally designed not for communication and hence, such local processing or operation at “edge level” is not possible. Being dedicated for a singular application, these connected devices are also unable to perform another application (such as communication application) simultaneously during active mode.

Numerous attempts have been made heretofore to tackle these problems. See, for example, United States Patent Application Publication No. 2017/0207960 A1 (hereinafter "the '960 publication") which discloses a network controller that identifies a first sign of life for an edge device in a communication network (e.g., when the network controller receives an encapsulated workflow request for the edge device over a control plane of the communication network). According to the '960 publication, the network controller further imports the encapsulated workflow request from the edge device over the control plane, determines configuration parameters for a tenant and a tenant network from the encapsulated workflow request, and transmits the configuration parameters to the edge device to provision the edge device for the tenant according to the configuration parameters.

Consequently, there is a long-felt need for a system and method to enable edge processing for non-communication edge devices locally during active mode thereby overcoming the problems and shortcomings of the prior art.

SUMMARY OF THE INVENTION

The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

Accordingly, the present invention provides a system for enabling edge processing at non-communication edge devices in an edge mesh network.

The system of the present invention may be characterized by a connecter attachable to a non-communication edge device comprising an adjustable protocol unit connected to a protocol database configured for regulating a device protocol in association with the non-communication edge device; a discovery task and routing unit configured for identifying neighboring non-communication edge devices present in the edge mesh network thereof, wherein the discovery task and routing unit computes a distance to each of the neighboring non-communication

edge devices; and a commission agent unit configured for monitoring the adjustable protocol unit and the discovery task and routing unit, and for coordinating position of the non-communication edge device and the neighboring non-communication edge devices thereof, wherein the connecter communicates with neighboring connecters of the neighboring non-communication edge devices detected thereof through a dedicated long-range wireless data network, wherein the connecter is configured, during active mode, for processing data transmitted by the neighboring connecters thereof locally within the edge mesh network.

Preferably, the non-communication edge device and the neighboring non-communication edge devices each comprises a device identifier, a device media access control (MAC) address and an Internet Protocol (IP) address for use during a verification process once a trust recognizer is issued.

Preferably, the non-communication edge device and the neighboring non-communication edge devices each comprises Global Position System (GPS) coordinates.

Preferably, the connecter is in communication with a control center which issues a list containing non-communication edge devices in the edge mesh network.

Preferably, the connecter analyzes and pushes the data and submits processed information resulting therefrom directly to the neighboring non-communication edge devices.

Preferably, the commission agent unit is in communication with an application container which isolates services and applications for performing tasks assigned thereof.

In accordance with another aspect of the present invention, there is provided a method of enabling edge processing at non-communication edge devices in an edge mesh network.

The method of the present invention may be characterized by the steps of deploying a connecter to a non-communication edge device; regulating a device protocol in association with the non-communication edge device; identifying neighboring non-communication edge devices present in the edge mesh network thereof; and computing a distance to each of the neighboring non-communication edge devices, wherein the step of deploying a connecter includes communicating, by the connecter, with neighboring connecters of the neighboring non-communication edge devices detected thereof through a dedicated long-range wireless data network, wherein the connecter is configured, during active mode, for processing data transmitted by the neighboring connecters thereof locally within the edge mesh network.

It is an objective of the present invention to provide a system and method for enabling edge processing at non-communication edge devices in an edge mesh network that permits the edge devices connected thereto to become manageable, accessible and cooperative within a cluster of edge devices.

It is another objective of the present invention to provide a system and method for enabling edge processing at non-communication edge devices in an edge mesh network that allows the edge devices to collect raw data from other edge devices and that performs required tasks on raw data locally and share the same via local communication among each other.

It is yet another objective of present invention to provide a system and method for enabling edge processing at non-communication edge devices in an edge mesh network that allows the edge devices to automatically take action upon execution of applications, tasks or services.

Essentially, the non-communication edge devices of the present invention may independently process and communicate to each other. Each of these non-communication edge devices may analyze the data, push data during communication and submit the information directly to each other. It advantageously creates environment at the edge that devices use local data to produce information for other devices.

The foregoing and other objects, features, aspects and advantages of the present invention will become better understood from a careful reading of a detailed description provided herein below with appropriate reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1 shows an architecture of a connecter linked to non-communication edge devices and a center according to one embodiment of the present invention;

Figure 2 is a flow diagram depicting overall steps of a method of enabling edge processing at non-communication edge devices in an edge mesh network according to one embodiment of the present invention;

Figure 3 is a flow diagram of the step of starting a process of communication to a center and a discovery of commission agent units in Figure 2 according to one embodiment of the present invention;

Figure 4 is a flow diagram of the step of clustering the commission agent units in edge devices in Figure 2 according to one embodiment of the present invention;

Figure 5 is a flow diagram of the step of applying application management (request and response) between the commission agent units in Figure 2 according to one embodiment of the present invention; and

Figure 6 is a flow diagram of the step of establishing a vice versa communication between edge devices in Figure 2 according to one embodiment of the present invention.

It is noted that the drawings may not be to scale. The drawings are intended to depict only typical aspects of the invention, and therefore should not be considered as limiting the scope of the invention. In the drawings, like numberings represent like elements between the drawings.

DETAILED DESCRIPTION OF THE INVENTION

According to one preferred embodiment, the system of the present invention enables edge processing for these non-communication edge devices present in the edge mesh network. The non-communication edge device and its neighboring non-communication edge devices each preferably comprises a device identifier, a device media access control (MAC) address and an Internet Protocol (IP) address for use during a verification process once a trust recognizer is issued. The trust recognizer can be based on at least on information of edge devices in database. By performing the trust recognizer, sharing, discovery, routing and clustering edge devices may cooperate together locally. As long as clustering is required, the trust recognizer between edge devices must be obtained. The trust recognizer preferably seeks recognition from every edge device to establish a cluster as a legitimate and reliable for clustering. The non-communication edge device and the neighboring non-communication edge devices each preferably further comprises Global Position System (GPS) coordinates.

The system preferably comprises a connecter **100** that can be attached to each of the non-communication edge devices. The connecter **100** may be in the form of a physical device supported by a predefined software and is attachable to non-communication edge devices such as cameras, traffic lights, billboards, patrol cars and many more. Each category of edge devices has a specific list of protocols to function.

The connecter **100** has an adjustable protocol unit **101** which is a changeable component, a discovery task and routing unit **102**, and a main module called a commission agent unit **103**, as shown in Figure 1. The connecter **100** is further connected to an application container through pull and push. The connecter **100** can create a request or a response for some certain tasks. The request or the response of application is to be forwarded to the commission agent

unit **103** who will respond should the information given is complete. It is implemented as a way to differentiate applications within a cluster comprising the non-communication edge devices having attached with the commission agent unit **103** or from a control center. It is essential that the connecter **100** comprises information including, but not limited to, port or path of applications, tasks or services which are virtualized and isolated for the commission agent unit **103** to recognize the application container connected thereto.

It is preferred that the connecter **100** can communicate with each other (among its neighboring connecters **100**) via a long-range wireless data network dedicated thereto for supporting different mode situations. The preferred long-range wireless data network includes, but not limited to, Institute of Electrical and Electronics Engineers (IEEE) 802.11p which is an approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments, a vehicular communication system. The connection established through this long-range wireless data network is collected as a profile for verification together with the GPS coordinates, device identifiers or cell identifiers which shall be registered in protected database as a profile before being utilized in an application. If the trust recognizer matches with the criteria provided in the database (i.e. information of edge devices), then allow for a clustering of edge devices. If otherwise, the clustering request by edge devices will be rejected. The connecter **100** shall keep looking for a valid trust recognizer and shall be trusted for clustering edge devices with a valid profile.

It is also preferred that the connecter **100** in communication with the control center which is configured to issue a list containing non-communication edge devices in the edge mesh network. The connecter **100** can analyze and push the data transmitted by neighboring connecters **100** and hence, submits processed or analyzed information resulting therefrom directly to the neighboring non-communication edge devices. The data being transmitted by the neighboring connecters **100** may include, but not limited to, data that is collected by the neighboring connecters **100** while monitoring or performing a particular application like traffic monitoring and that is deemed relevant and associated with the edge processing. The connecter **100** communicates with neighboring connecters **100** of the neighboring non-communication edge devices detected thereof. The

connecter **100** is preferably configured, during active mode, for processing the data transmitted by the neighboring connecters **100** thereof locally within the edge mesh network.

The adjustable protocol unit **101** contained in the connecter **100** is attached to different edge devices in order to regulate including to adjust a protocol in association with the non-communication edge device. Preferably, the adjustable protocol unit **101** is connected to a protocol database.

The discovery task and routing unit **102** is configured to locate or identify neighboring non-communication edge devices present in the edge mesh network thereof. In continuation to that, the discovery task and routing unit **102** computes a distance to each of the neighboring non-communication edge devices. As the GPS coordinates and identifiers are loaded and made available for the edge devices, the source edge device which is a non-communication edge device sourcing for any neighboring non-communication edge devices in the vicinity will find and look for destination GPS coordinates in the list of protocols transmitted by the control center. If any of neighboring non-communication edge device is found, the source device will find a route to destination of the neighboring non-communication edge devices based on relevancy of coordination to the destination in order to finalize a path. All neighboring non-communication edge devices present in the edge mesh network will be identified and found by the discovery tasks and routing unit **102** thereof.

The commission agent unit **103** is preferably embedded to the connecter **100** which communicates with the edge devices. The commission agent unit **103** is configured for monitoring the adjustable protocol unit **101** and the discovery task and routing unit **102**. It is also configured for coordinating position of the non-communication edge device and the neighboring non-communication edge devices thereof as well as synchronizing different protocols and applications.

According to one exemplary embodiment, the system of the present invention can be used in exchange of application and data between neighbor applications in a tracking plate number scenario. In this regard, the connecter **100** of a source edge device discovers neighboring edge devices and the connecter

100 performs computation locally based on an application pushed from the application container that is running at the connecter **100**. For instance, consider a vehicle registered plate number available in a form of "ABC 1234". If an application for detecting vehicle registered plate number is available and pushable from the application container at the connecter **100** of the source edge device, then start a search process by way of scanning and identifying vehicle registered plate numbers of every vehicle traversing an area being monitored by the source edge device. If the application is not available and pushable from the application container at the connecter **100** of the source edge device, then the source edge device pulls an application for performing the detection of vehicle registered plate number from any of neighboring edge devices. Once the vehicle registered plate number is detected by the source edge device, the connecter **100** attached thereto shall communicate the detection of the same with a police car geographically nearest within the vicinity of the connecter **100** of the source edge device.

According to another exemplary embodiment, the system of the present invention can be used in exchange of raw data between each edge device in a traffic monitoring scenario. In this regard, raw data will be obtained from a camera (which is a non-communication edge device – being a source edge device) and will be processed in respect of vehicle density. If vehicle density detected exceeds a predefined threshold, then an on-demand application will trigger traffic lights to control the traffic thereof by the connecter **100**. The on-demand application is preferably an application running at the connecter **100** and is made readily available at the connecter **100** without the need for the source edge device to pull the same from the application container. This traffic monitoring scenario is adapted to show that information or data pertaining to the traffic monitoring can be exchanged between the non-communication edge devices during an on-demand, ad-hoc situation in order to accelerate the discovery by utilizing neighboring edge devices' information and capability, which proven to efficiently reduce time of discovery and improve performance of the traffic management system.

In yet another exemplary embodiment, the method of the present invention are disclosed and described with reference to Figures 2-6 in the accompanying drawings. Figure 2 describes the overall process flow of enabling edge processing

for these non-communication edge devices that contains of four sub-steps. The sub-steps include the first step of starting a process of communication to a center and a discovery of commission, the second step of clustering the commission agent units **103** in edge devices, the third step of applying application management (request and response) between the commission agent units **103**, and the fourth step of establishing a vice versa communication between edge devices.

Meanwhile, Figures 3-6 each describes the sub-steps respectively. According to Figure 3, all edge devices, through the respective connecters **100**, will send GPS location and identifier (or simply known as ID) to the control center. Once an application pushed from the application container is about to deploy, the GPS location and ID are sent to a specific edge device. Since that specific edge device has the GPS location and ID of the neighboring non-communication edge devices, it starts to discover those neighboring edge devices that are present in the range of wireless access. If any edge device is found, such edge device will verify each other based on the GPS location and ID thereof. Subsequently, those detected or discovered edge devices will be assigned as valid where trust recognizers will be issued accordingly. By performing the trust recognizer, sharing, discovery, routing and clustering of these edge devices can be made together locally.

Figure 4 describes the step of clustering of commission agent units **103** attached to the detected or discovered edge devices. It involves with identification of the edge devices with comparison against the database which stores information of non-communication edge devices to create a single or multiple category of cluster IDs for management. Once the detected or discovered edge devices are registered to a cluster, these edge devices shall undergo a management by the cluster including preparation for sharing, discovering, routing and clustering with other neighboring edge devices within the edge mesh network.

In Figure 5, the application management (i.e. request and response) is applied between the commission agent units **103**. Under the request application management, the edge device receives an application from the center, retrieves the discovered devices, generates a request message with collected data

attachment, issues clustering, checks trust recognizer and finally, sends the request message. Under the response application management, the edge device receives a request from other clustered edge devices. If the request cannot be responded to, then generate a request message with attached data if required. If extra or additional data is required, then collect new data. Else, the edge device creates a response message with identified results.

Figure 6 is a flow diagram which describes the step of establishing a vice versa communication between the edge devices. It mainly involves with the trust recognizer and profile matching using parameters such as GPS coordinates, MAC addresses and IP addresses. In the event that the profile matches, then the edge device performs sharing and localization prior to communication vice versa in the clustering.

In essence, to enable edge processing at the non-communication edge devices in the edge mesh network, the method of the present invention generally can be summarized by the step of deploying a connecter **100** to the non-communication edge device including communicating, by the connecter **100**, with neighboring connecters **100** of the neighboring non-communication edge devices detected thereof through a dedicated long-range wireless data network, the step of regulating a device protocol in association with the non-communication edge device, the step of identifying neighboring non-communication edge devices present in the edge mesh network thereof, and the step of computing a distance to each of the neighboring non-communication edge devices. The connecter **100**, as stated in the preceding paragraphs, is configured, during active mode, for processing data transmitted by the neighboring connecters **100** thereof locally within the edge mesh network. The steps are consistent with the embodiments described herein and Figures 2-6 of the accompanying drawings although are not necessarily to contain exact sentences.

The terms “a” and “an,” as used herein, are defined as one or more than one. The term “plurality,” as used herein, is defined as two or more than two. The term “another,” as used herein, is defined as at least a second or more. The terms “including” and/or “having,” as used herein, are defined as comprising (i.e., open language).

While this invention has been particularly shown and described with reference to the exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention as defined by the appended claims.

CLAIMS

1. A system for enabling edge processing at non-communication edge devices in an edge mesh network, **characterized in that**, the system comprising:

a connecter (100) attachable to a non-communication edge device, comprising:

an adjustable protocol unit (101) connected to a protocol database configured for regulating a device protocol in association with the non-communication edge device;

a discovery task and routing unit (102) configured for identifying neighboring non-communication edge devices present in the edge mesh network thereof, wherein the discovery task and routing unit (102) computes a distance to each of the neighboring non-communication edge devices; and

a commission agent unit (103) configured for monitoring the adjustable protocol unit (101) and the discovery task and routing unit (102), and for coordinating position of the non-communication edge device and the neighboring non-communication edge devices thereof,

wherein the connecter (100) communicates with neighboring connecters (100) of the neighboring non-communication edge devices detected thereof through a dedicated long-range wireless data network, and

wherein the connecter (100) is configured, during active mode, for processing data transmitted by the neighboring connecters (100) thereof locally within the edge mesh network.

2. The system according to Claim 1, wherein the non-communication edge device and the neighboring non-communication edge devices each comprises a device identifier, a device media access control, MAC, address and an Internet Protocol, IP, address for use during a verification process once a trust recognizer is issued.

3. The system according to Claim 1, wherein the non-communication edge device and the neighboring non-communication edge devices each comprises Global Position System, GPS, coordinates.

4. The system according to Claim 1, wherein the connecter (100) is in communication with a control center which issues a list containing non-communication edge devices in the edge mesh network.

5. The system according to Claim 1, wherein the connecter (100) analyzes and pushes the data and submits processed information resulting therefrom directly to the neighboring non-communication edge devices.

6. The system according to Claim 1, wherein the commission agent unit (103) is in communication with an application container which isolates services and applications for performing tasks assigned thereof.

7. A method of enabling edge processing at non-communication edge devices in an edge mesh network, **characterized in that**, the method comprising the steps of:

deploying a connecter (100) to a non-communication edge device;

regulating a device protocol in association with the non-communication edge device;

identifying neighboring non-communication edge devices present in the edge mesh network thereof; and

computing a distance to each of the neighboring non-communication edge devices,

wherein the step of deploying a connecter (100) includes communicating, by the connecter (100), with neighboring connecters (100) of the neighboring non-communication edge devices detected thereof through a dedicated long-range wireless data network, and

wherein the connecter (100) is configured, during active mode, for processing data transmitted by the neighboring connecters (100) thereof locally within the edge mesh network.

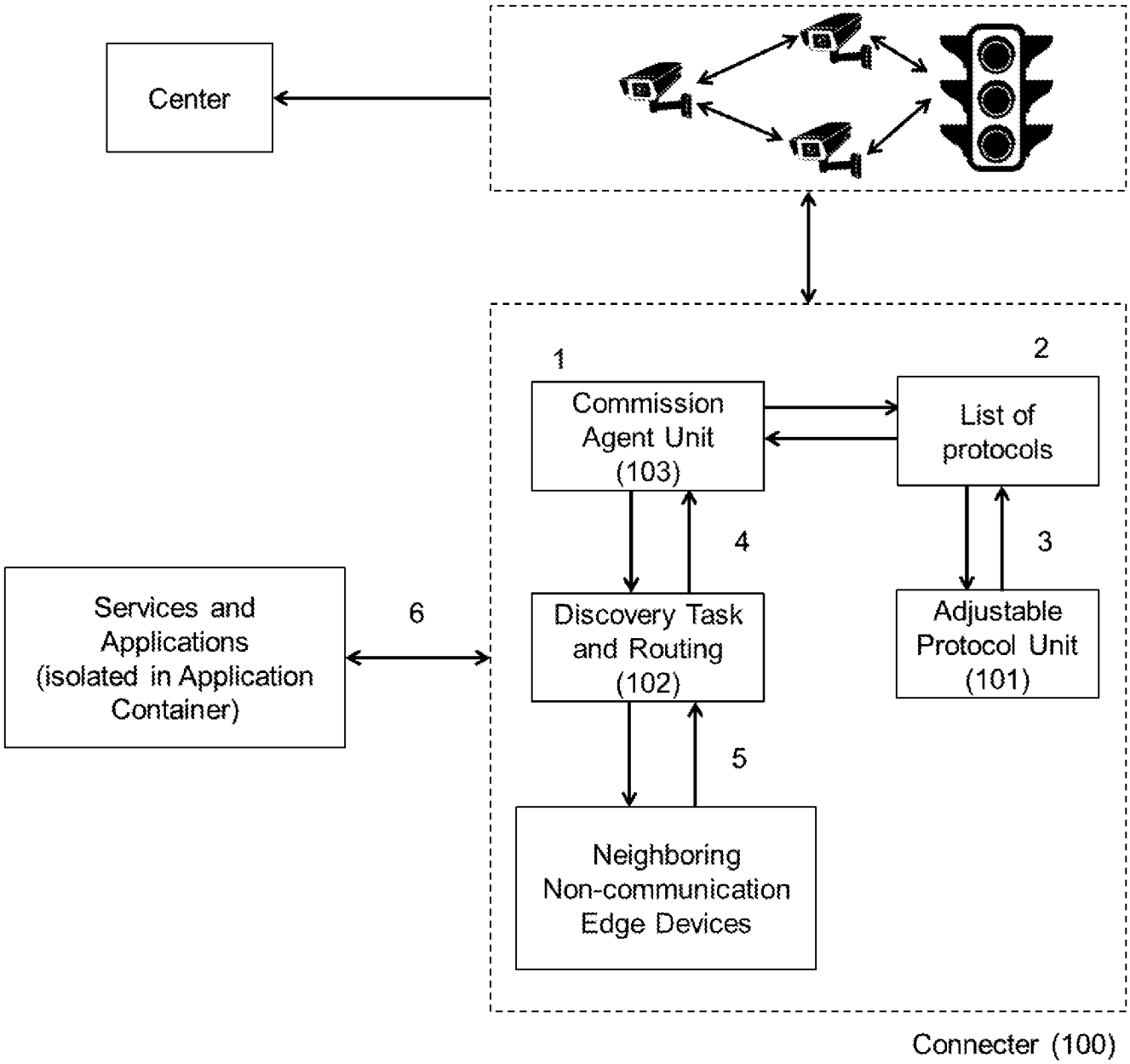

Center
1
2
Commission Agent Unit (103)
List of protocols
4
3
Services and Applications (isolated in Application Container)
6
Discovery Task and Routing (102)
Adjustable Protocol Unit (101)
5
Neighboring Non-communication Edge Devices
Connecter (100)

FIGURE 1

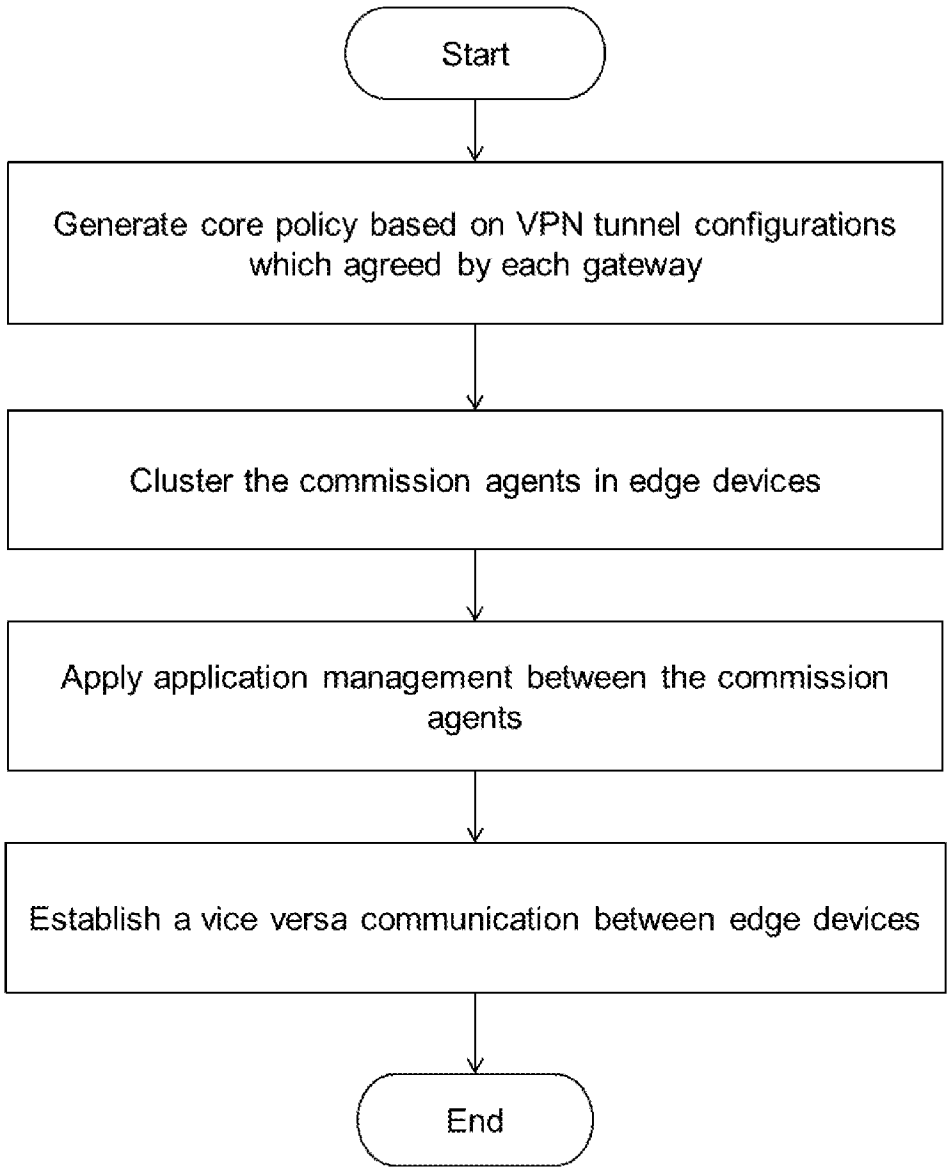

Start
Generate core policy based on VPN tunnel configurations which agreed by each gateway
Cluster the commission agents in edge devices
Apply application management between the commission agents
Establish a vice versa communication between edge devices
End

FIGURE 2

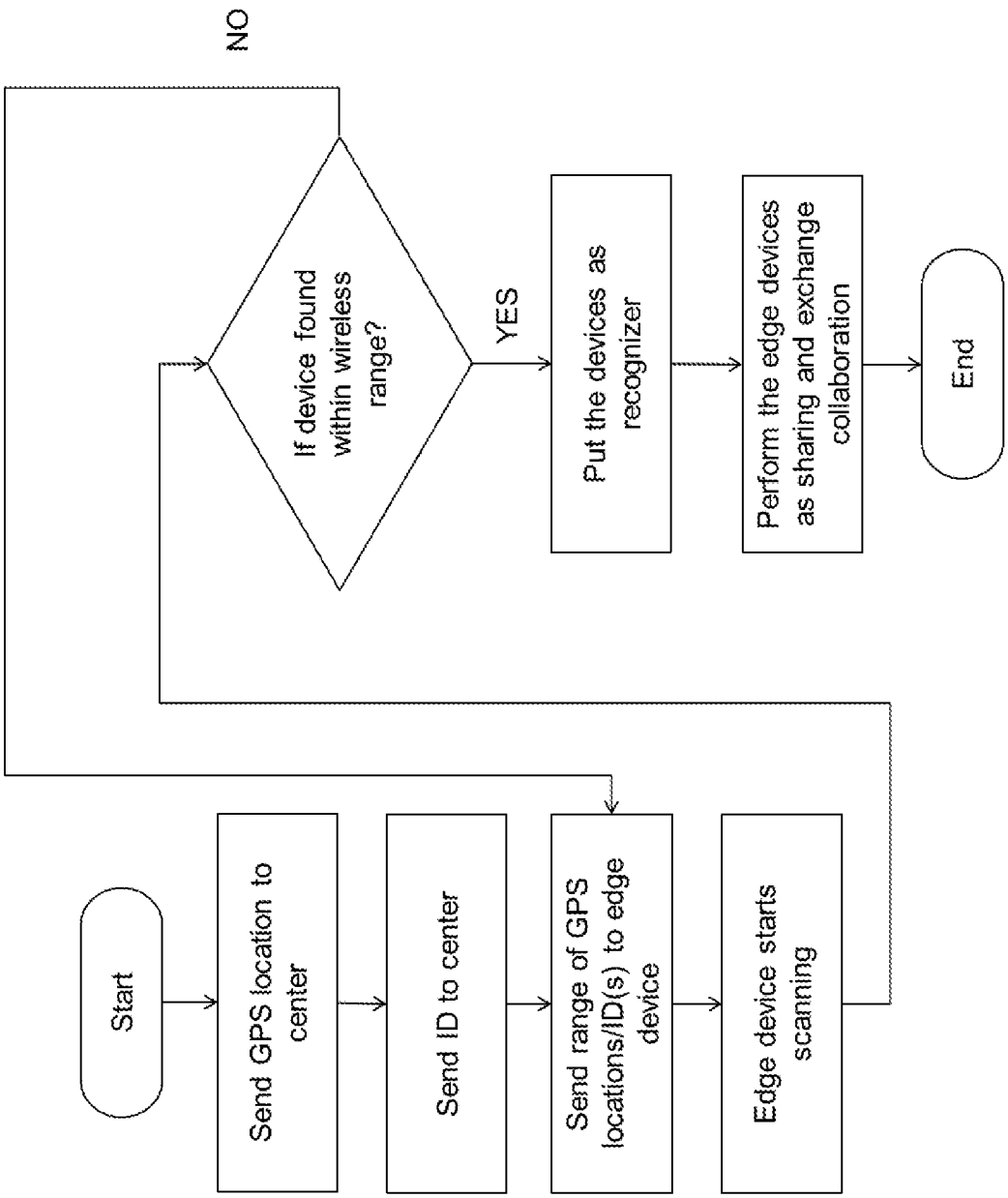

Start
Send GPS location to center
Send ID to center
Send range of GPS locations/ID(s) to edge device
Edge device starts scanning
If device found within wireless range?
NO
YES
Put the devices as recognizer
Perform the edge devices as sharing and exchange collaboration
End

FIGURE 3

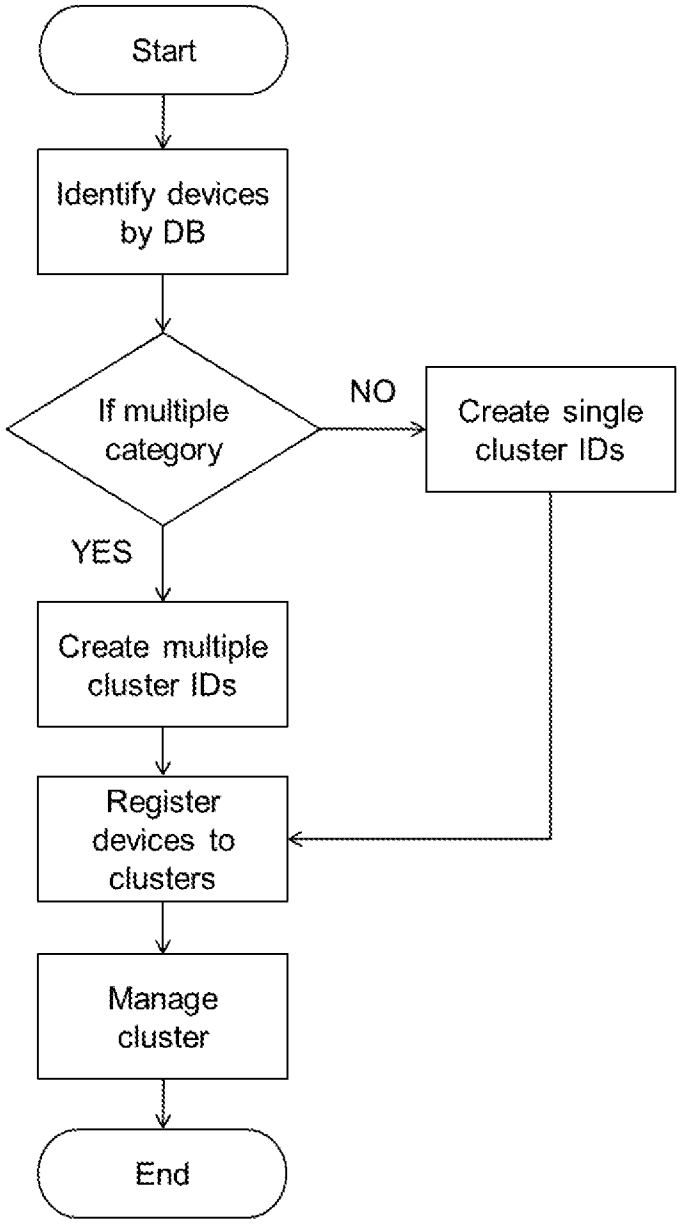

Start
Identify devices by DB
If multiple category
NO
Create single cluster IDs
YES
Create multiple cluster IDs
Register devices to clusters
Manage cluster
End

FIGURE 4

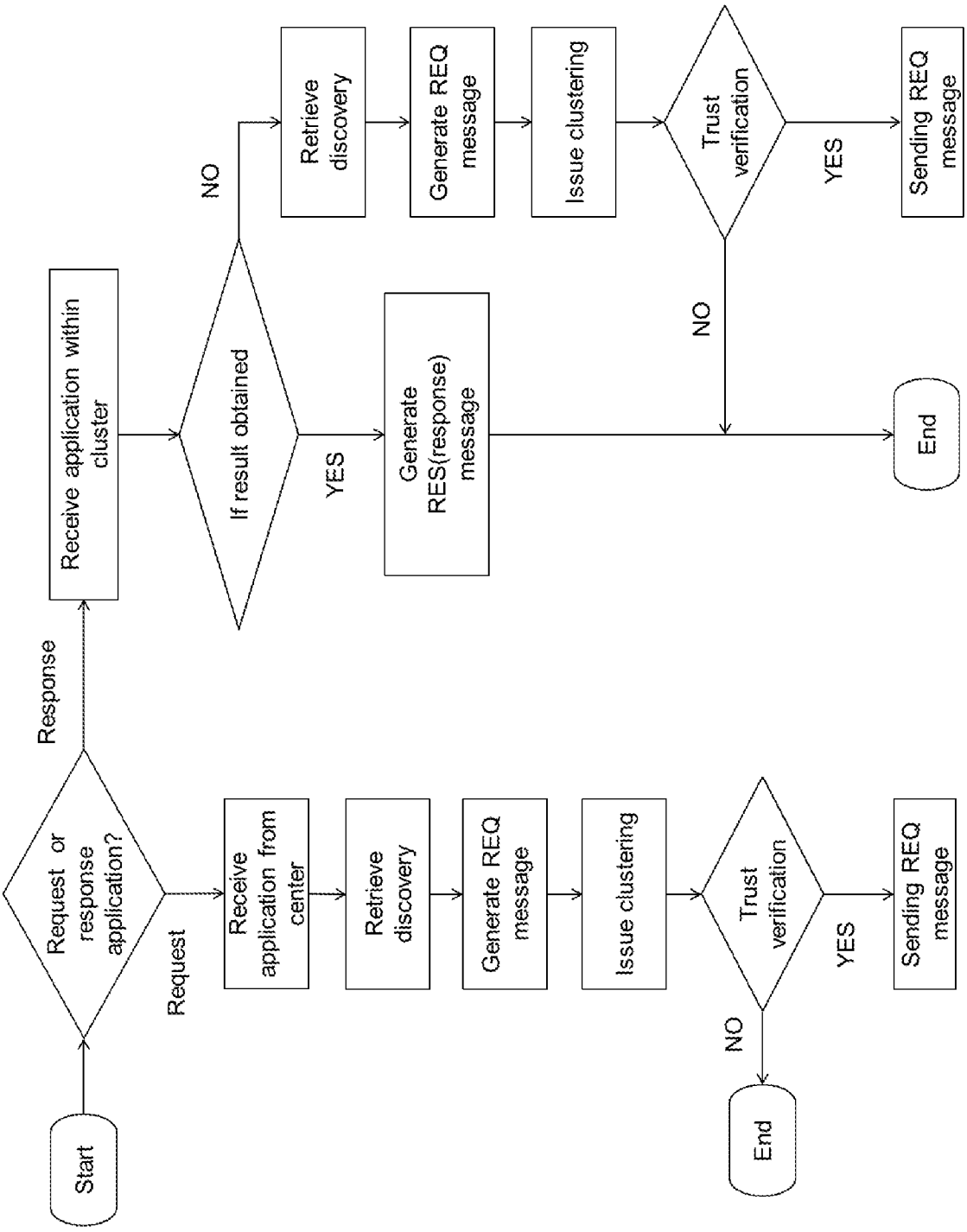

Start
Request or response application?
Request
Receive application from center
Retrieve discovery
Generate REQ message
Issue clustering
Trust verification
NO
End
YES
Sending REQ message
Response
Receive application within cluster
If result obtained
NO
Retrieve discovery
Generate REQ message
Issue clustering
Trust verification
YES
Sending REQ message
YES
Generate RES(response) message
NO
End

FIGURE 5

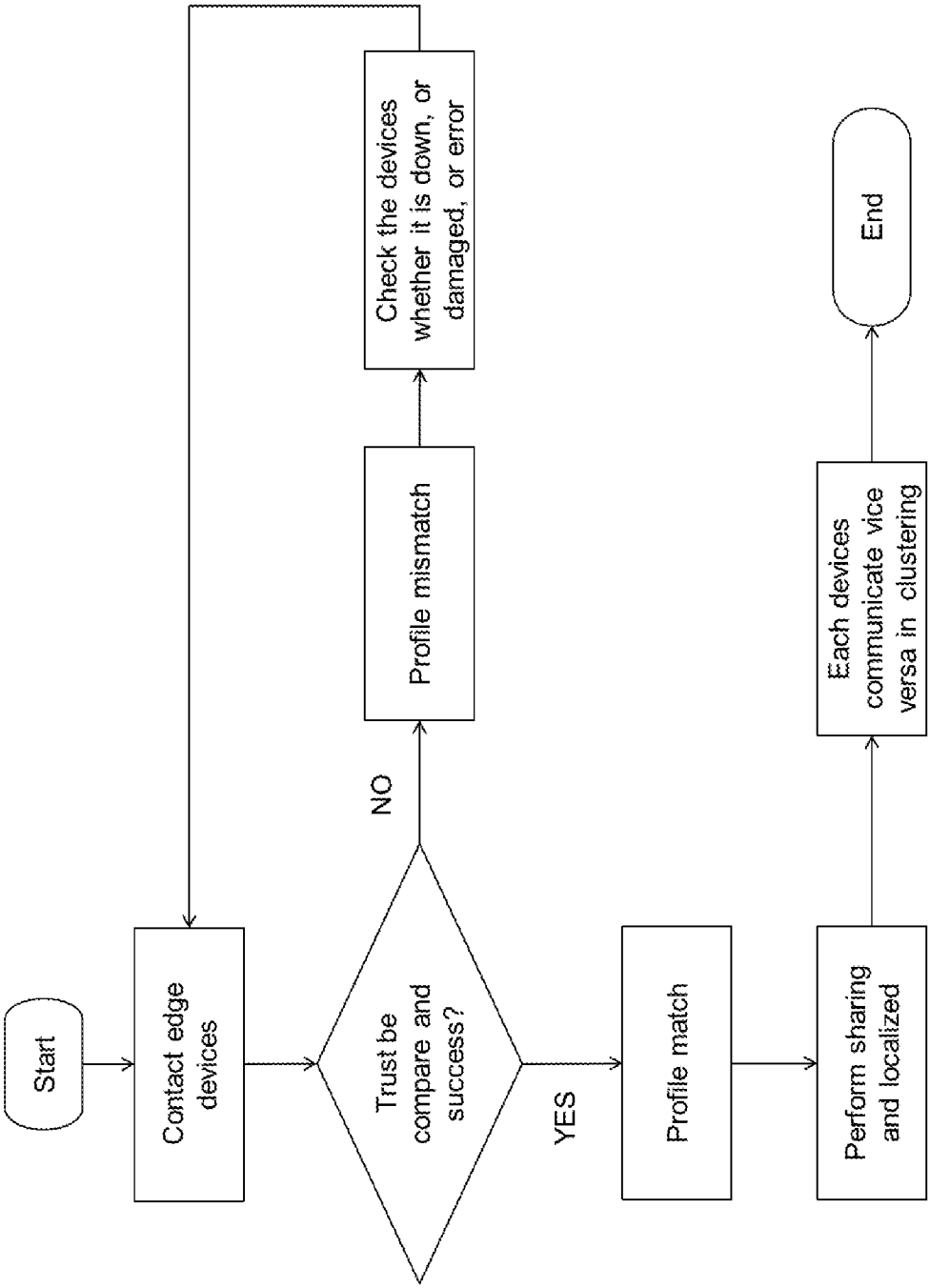

Start
Contact edge devices
Trust be compare and success?
NO
Profile mismatch
Check the devices whether it is down, or damaged, or error
YES
Profile match
Perform sharing and localized
Each devices communicate vice versa in clustering
End

FIGURE 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2019/050074

A. CLASSIFICATION OF SUBJECT MATTER

H04L 12/24(2006.01)i, H04L 29/08(2006.01)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)
H04L 12/24; B60R 25/10; G06F 17/30; H04L 12/28; H04L 29/06; H04L 29/08; H04L 9/32; H04W 48/10; H04W 84/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: non-communication edge device, connector, adjustable protocol unit, discovery task and routing unit, commission agent unit, edge mesh network, device protocol, position, distance

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0002413 A1 (HONGFEI DU et al.) 03 January 2013 paragraphs [0021], [0039]; claims 1-3, 11; and figure 1	1-7
Y	US 2015-0029880 A1 (QUALCOMM INCORPORATED) 29 January 2015 paragraphs [0039]-[0040]; and claim 1	1-7
A	US 2014-0241354 A1 (QUALCOMM INCORPORATED) 28 August 2014 paragraphs [0070]-[0074]; and figure 6	1-7
A	US 2016-0285979 A1 (INTEL CORPORATION) 29 September 2016 paragraphs [0065]-[0073]; and figure 4	1-7
A	KR 10-2015-0005225 A (LG UPLUS CORP.) 14 January 2015 paragraphs [0046]-[0054]; and figure 5	1-7

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

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Date of the actual completion of the international search	Date of mailing of the international search report
12 March 2020 (12.03.2020)	**12 March 2020 (12.03.2020)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/MY2019/050074

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