1. (WO2017066912) METHOD FOR COMMUNICATION, SERVER, ROADSIDE UNIT AND NODE

Description

Claims

Drawings

Description

Title of Invention : METHOD FOR COMMUNICATION, SERVER, ROADSIDE UNIT AND NODE

TECHNICAL FIELD

[0001] The present invention generally relates to the field of communications technologies, and more particularly to a method for communication, a server, a roadside unit and a node.

BACKGROUND

[0002] Vehicular Ad hoc Networks (VANETs) enable communications among nearby vehicles and between vehicles and nearby fixed infrastructures. A variety of applications are expected to be designed to improve safety of the future transport systems and provide many industrial and entertainment services. Dedicated Short Range Communication (DSRC) is proposed as the main communication technology to enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications to implement such applications. Large-scale and dense vehicular networks in terms of large geographical size of the network and the large number of nodes are expected to be formed in both highway and urban VANETs, due to high number of cars and complex road architecture.

[0003] The Medium Access Control (MAC) sub-layer of a widely used DSRC system relies on random access channel sharing techniques such as Carrier Sensing Medium Access/Collision Avoidance (CSMA/CA) , extended with Enhanced Distributed Channel Access (EDCA) service differentiation and multi-channel functions. For example, Wireless Access in Vehicular Environment (WAVE) and European Telecommunications Standards Institute (ETSI) Intelligent Transport Systems (ITS) G5 standards use Institute of Electrical and Electronics Engineers (IEEE) 802.11p MAC sub-layer with IEEE 1609.4 multi-channel function.

[0004] In existing standard, there are six service channels (SCH) and a control channel (CCH) , and the channel access time is divided into sync intervals. Each interval contains guard intervals and alternating fixed-length intervals called CCH interval and SCH interval. The duration of CCH and SCH intervals is defined as 50 ms in the standard. During the CCH interval, all nodes monitor the CCH for exchanging safety messages and other control packets. During the SCH interval, nodes transmit potential non-safety application data on SCHs.

[0005] However, in the above existing standard, radio resource cannot be effectively utilized that adapts to the network conditions: in a congested urban area with dense VANETs, large volume of safety and control messages need to be delivered in the CCH interval. The fixed length of CCH may not be able to provide sufficient bandwidth in these scenarios, leading to potential collisions and QoS degradation. On the other hand, if the node density is sparse, the CCH interval will may be left idle for significant periods of time.

[0006] SUMMARY

[0007] An embodiment of the present invention provides a method for communication, a server, a roadside unit and a node which can improve the utilization of radio resource.

[0008] In a first aspect, the present application provides a method for communication. An RRM server receives network state information sent by at least one RSU. The network state information sent from each of the at least one RSU indicates density of nodes in the coverage of the RSU. The RRM server performs segmentation of an area in a communication network according to the network state information to form at least one segment for the at least one RSU respectively. The RRM server allocates channels for the at least one segment. The RRM server sends network segmentation information and channel allocation information to each of the at least one RSU. The network segmentation information indicates a segment for the RSU and the channel allocation information indicates channels allocated for the segment so that RSU communicates with a node which enter the segment through the channels allocated for the segment.

[0009] According to the embodiment of the present invention, the RRM server performs network segmentation and channel allocation for segments according to the network state information reported by the RSU, and notifies the RSU of the network segmentation information and channel allocation information, so that the RSU can communicate with a node which enters the segment through the channels allocated for the segment, reducing collision probabilities and QoS degradation and thus improve the utilization of radio resource.

[0010] According to a first implementation of the method according to the first aspect, the density of nodes includes numbers of nodes within different distances away from the RSU. In this case, before performing segmentation of the area in the communication network, the RRM server further determines that the area is congested according to the numbers of nodes within different distances away from the RSU. Thus, instead of adopting a fixed length of CCH, the segmentation and channel allocation may be performed based on whether the area is congested, so as to reduce collision probabilities and achieving dynamic channel allocation according to different network conditions.

[0011] According to a second implementation of the method according to the first implementation, the method further includes: the RRM server determines that the area becomes uncongested, and sends segmentation revocation information to each of the at least one RSU. The segmentation revocation information indicates revoking the segmentation and channel allocation so that the RSU communicates with a node which enters coverage of the RSU through legacy channels. Since the segmentation may be revoked when the area became uncongested, the solution of the present application may be compatible with the conventional channel allocation solution.

[0012] According to a third implementation of the method according to any preceding implementation of the first aspect or the first aspect as such, the RRM server divides the area into multiple squares each of which has an RSU in its centre, and the length of sides L_S of a square for RSU (a) is given by:

[0013] $L_S = \min(D_{max}, L)$, wherein:

[0014] [Math. 0001]

$$L = \min\left(\frac{dist((x_a,y_a),(x_b,y_b))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_c,y_c))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_d,y_d))}{\sqrt{2}}, \ldots\right),$$

[0015] $D_{max} = \max(\{D_i | N_i \le N_{desired}(a)\})$,

[0016] wherein (x_a, y_a) is the longitude and latitude of RSU (a) , N_i is the number of nodes within different ranges of the RSU (a) , and $N_{desired}$ (a) is a desired node density of the squire for RSU (a) . Due to the above L and D_{max}, neighbouring segments may use non-overlapping channels to avoid interference from nodes in the neighbouring segments.

[0017] In a second aspect, the present application provides a method for transmitting data. An RSU sends network state information to a Radio Resource Management RRM server. The network state information indicates density of nodes in coverage of the RSU. The RSU receives network segmentation information and channel allocation information sent by a server. The network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively. The RSU sends network segmentation information and the channel allocation information to nodes which are in coverage of the RSU. The RSU communicates with nodes which are in the segment through the channels allocated for the segment.

[0018] According to the embodiment of the present invention, the RRM server performs network segmentation and channel allocation for segments according to the network state information reported by the RSU, and notifies the RSU of the network segmentation information and channel allocation information, so that the RSU can communicate with a node which enters the segment through the channels allocated for the segment, reducing collision probabilities and QoS degradation and thus improve the utilization of radio resource.

[0019] According to a first implementation of the method according to the second aspect, the method further includes: the RSU obtains network state information according to report by the nodes in the coverage of the RSU.

[0020] According to a second implementation of the method according to any preceding implementation of the second aspect or the second aspect as such, the density of nodes includes numbers of nodes within different distances away from the RSU, and the method further includes: the RSU determines that the coverage of the RSU is congested according to the numbers of nodes within different distances away from the RSU.

[0021] According to a third implementation of the method according to any preceding implementation of the second aspect or the first aspect as such, the method further includes: the RSU receives segmentation revocation information from the RRM serve, and communicate with a node which enters coverage of the RSU by switching to the legacy channels. The segmentation revocation information indicates revoking the segmentation and channel allocation.

[0022] According to a fourth implementation of the method according to any preceding implementation of the second aspect or the first aspect as such, the RSU periodically reports the network state information to NCC, or reports the network state information to NCC when at least one of pre-defined conditions is met.

[0023] In a third aspect, the present application provides a method for transmitting data. A node receives network segmentation information and the channel allocation information from a Roadside Unit RSU, determines that the node is in the segment according to the network segmentation information, and communicates with the RSU through the channels allocated for the segment. The network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively.

[0024] According to a first implementation of the method according to the third aspect, the method further includes: the node receives segmentation revocation information from the RSU, and communicates with the RSU through legacy channels. The segmentation revocation information indicates revoking the segmentation and channel allocation.

[0025] In a fourth aspect, the present application provides a server. The server includes units for performing the method of the first aspect.

[0026] In a fifth aspect, the present application provides an RSU. The RSU includes units for performing the method of the second aspect.

[0027] In a sixth aspect, the present application provides a node. The Node includes units for performing the method of the third aspect.

[0028] In some implementations, the node is a vehicle which includes an OBU.

[0029] In some implementations, the allocating channels for the at least one segment includes: allocating channels for the at least one segment from one PCCH, two LCCHs and four LSCHs, wherein the PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment. The PCCH may is shared between neighbouring segments so as to be compatible with the conventional solution. Within each segment, nodes are allowed to use one LCCH and two LSCHs. Adjacent segments may use non-overlapping channels to avoid interference from nodes in the neighbouring segments. Since each segment is allocated with an LCCH for transmitting control message, collision probabilities and QoS degradation are reduced and thus the utilization of radio resource is improved. In addition, the LCCHs may be used for data transmission if both LCCH for the segment are occupied so as to support more nodes in the segment.

[0030] BRIEF DESCRIPTION OF DRAWINGS

[0031] In order to illustrate the technical solutions in the embodiment of the present invention more clearly, accompanying drawings needed for describing the embodiments are introduced briefly in the following. Obviously, the accompanying drawings in the following description are some embodiments of the present invention, and those skilled in the art may further obtain other accompanying drawings according to these accompanying drawings without making creative efforts.

[0032] FIG. 1 depicts an architecture diagram of a communication system in accordance with an embodiment of the present invention；

[0033] FIG. 2 depicts a schematic diagram of functional entities of the communication system 100 in accordance with an embodiment of the present invention；

[0034] FIG. 3 depicts a schematic flowchart of a method for communication in accordance with an embodiment of the present invention；

[0035] FIG. 4 depicts a schematic flowchart of a method for communication in accordance with another embodiment of the present invention；

[0036] FIG. 5 depicts a schematic flowchart of a method for communication in accordance with another embodiment of the present invention；

[0037] FIG. 6 depicts a schematic flowchart of a process for communication in accordance with another embodiment of the present invention.

[0038] FIG. 7 depicts a format of a packet sent from the RSU to the RRM server in accordance with an embodiment of the present invention；.

[0039] FIG. 8 depicts a format of a packet sent from the RRM server to the RSU in accordance with an embodiment of the present invention.

[0040] FIG. 9 depicts a format of a packet sent from the RSU to nodes in accordance with an embodiment of the present invention.

[0041] FIG. 10 depicts a table indicating a example of number of the nodes different distances away from the RSU in accordance with an embodiment of the present invention.

[0042] FIG. 11 depicts a schematic flowchart of a process for communication in accordance with another embodiment of the present invention.

[0043] FIG. 12 depicts a format of another packet sent from the RRM server to the RSU in accordance with an embodiment of the present invention.

[0044] FIG. 13 depicts a schemtaic diagram of segmentation of a network in accordance with an embodiment of the present invention.

[0045] FIG. 14 is a schemtaic network model in accordance with an embodiment of the present invention.

[0046] FIG. 15 is a simplified block diagram of a server according to an embodiment of the present invention.

[0047] FIG. 16 is a simplified block diagram of an RSU according to an embodiment of the present invention.

[0048] FIG. 17 is a simplified block diagram of a node according to another embodiment of the present invention.

[0049] FIG. 18 is a simplified block diagram of the computing device.

[0050] DESCRIPTION OF EMBODIMENTS

[0051] The technical solution of the present invention is hereinafter described in detail with reference to the accompanying drawings. It is evident that the embodiments are only some exemplary embodiments of the present invention, and the present invention is not limited to such embodiments. Other embodiments that those skilled in the art obtain based on embodiments of the present invention also all within the protection scope of the present invention.

[0052] The technique involved in the embodiments of the present invention may be dubbed as Dynamic Network Segmentation based Multichannel MAC Protocol (DNSM-MAC) .

[0053] FIG. 1 depicts an architecture diagram of a communication system 100 in accordance with an embodiment of the present invention.

[0054] The communication system 100 may be a VANET, including a network control centre (NCC) 110, a plurality of Roadside Units (RSUs) 120 and a plurality of nodes (e.g., vehicles) 130. It is to be understood that the naming of these network nodes in the communication system 100 is for the identification purpose only, and it should not be interpreted as a limitation.

[0055] The NCC 110 includes an RRM server 111 which plays a key role in the implementation of embodiment of the present invention and further implements other functions； however, for the purpose of convenience of description, only the RRM server 111 will be described in detail. The RRM server 111 is used for performing segmentation of an area in the network and performing channel allocation for segments.

[0056] The RSUs 120 are connected to the NCC 110 via wired or wireless links, for example, Long Term Evolution (LTE) or Internet 140. The RSUs 120 are usually located on the roadside with approximate distance between them. The distance between two RSUs 120 may be equal to the effective communication range of the underlying DSRC technology (e.g., 500 m for IEEE 802.11p) . The RSUs 120 are used for collecting network state information from nodes 130 in their coverage, and forwarding packets between the nodes 130 and the NCC 110.

[0057] FIG. 2 depicts a schematic diagram of functional entities of the communication system 100 in accordance with an embodiment of the present invention.

[0058] Referring to FIG. 2, functional blocks of these entities as shown in FIG. 2 include a NCC 110, a RSU 120, and an OBU 131 in nodes 130. An RRM server 111 resides in the NCC 110, which hosts the functionality of channel allocation. The network segmentation functionality is distributed among the RSUs 120 and the RRM server 111. Each node 130 is equipped with a DSRC network interface to communicate with each other and the RSUs. The DSRC interface may include a DNSM-MAC layer, a 802.11p PHY layer and other layers. And the RRM server and the RSU may communicate with each other via an Internet interface.

[0059] Embodiments of the present invention provide an effective and dynamic technique for allocation of channels in a multichannel VANET, in which the available channels are dynamically allocated to different segments of the network that are dynamically defined in the vicinity of the RSUs depending on the network load (or density of nodes) on assistance of RSU and an RRM server.

[0060] FIG. 3 depicts a schematic flowchart of a method for communication in accordance with an embodiment of the present invention. The method of FIG. 3 is implemented by the RRM in FIG. 1.

[0061] 310, An RRM server receives network state information sent by at least one RSU, wherein the network state information sent from each of the at least one RSU indicates density of nodes in the coverage of the RSU.

[0062] 320, An RRM server performs segmentation of an area in a communication network according to the network state information to form at least one segment for at least one RSU respectively.

[0063] For example, the area may refer to a section of a highway or an urban area. After segmentation, each RSU may only correspond to one segment, and each RSU may be located in the centre of the segment. Segments for different RSUs may have different sizes or same size.

[0064] 330, The RRM server allocates channels for the at least one segment.

[0065] For example, the RRM server may allocate a plurality of channels for each segment, for example, the channels allocated for each segment may include a public CCH, a local CCH and two local SCHs. The public CCH may be shared by the neighbouring segments, and the neighbouring segments may have different local CCHs and local SCHs.

[0066] 340, The RRM server sends network segmentation information and channel allocation information to each of the at least one RSU, wherein the network segmentation information indicates a segment for the RSU and the channel allocation information indicates channels allocated for the segment so that RSU communicates with a node which enters the segment through the channels allocated for the segment.

[0067] According to the embodiments of the present invention, the RRM server performs network segmentation and channel allocation channel for segments according to the network state information reported by the RSU, and notifies the RSU of the network segmentation information and channel allocation information, so that the RSU can communicate with a node which enters the segment through the channels allocated for the segment, reducing collision probabilities and QoS degradation and thus improve the utilization of radio resource.

[0068] Specifically, when a node which is equipped with an On-board Unit (OBU) is in a communication range or coverage range of an RSU, the node shall communicate with the RSU. The RSU may determine network state information according to information reported by nodes in the coverage of the RSU, and sends the network state information to the RRM server. For example, in a normal state, during a CCH interval, the RSU and the nodes monitor a CCH for exchanging a safety message and other control packets, and during a SCH interval, the RSU and the nodes transmit potential non-safety application data on a SCH. However, when the RRM server detects a congested area according to the network state information, the RRM server may perform network segmentation according to network state information to provide a plurality of segments which centre at the RSU, respectively, and allocates channels for each segment. The RRM server sends network segmentation information which indicates a segment for the RSU and channel allocation information which indicates channels allocated for the segment to the RSU, and the RSU broadcasts the network segmentation information and channel allocation information to the nodes. The nodes then communicate with the RSU through the channels allocated for the segment.

[0069] Optionally, as another embodiment, the density of nodes comprises numbers of nodes within different distances away from the RSU, and before 320, the method further comprises: the RRM server determines that the area is congested according to the numbers of nodes within different distances away from the RSU.

[0070] For example, if the numbers of nodes within 50m away from an RSU exceeds 10 or the numbers of nodes within 100m away from the RSU exceeds 20, the coverage range of the RSU is considered as a congested area. In addition, multiple thresholds may be set for determining a congested area. The purpose of introducing multiple thresholds is to allow some super popular areas to have more nodes than other areas. For instance, the node density in the town centre is much higher than that of the sub-rural areas. Different thresholds are set for coverage ranges so as to avoid some super popular area being split into super small segments, which may not be able to be supported by enough RSUs and leads to too many issues such as channel allocation, interference among adjacent segments and lack of knowledge of CAMs from neighboring vehicles. Thus, instead of adopting a fixed length of CCH, the segmentation and channel allocation may be performed based on whether the area is congested, so as to reduce collision probabilities and achieving dynamic channel allocation according to different network conditions.

[0071] Optionally, as another embodiment, the method of FIG. 3 further comprising: the RRM server determines that the area becomes uncongested, and sends segmentation revocation information to each of the at least one RSU, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation so that the RSU communicates with the node which enters coverage of the RSU through legacy channels. Since the segmentation may be revoked when the area became uncongested, the solution of the present application may be compatible with the conventional channel allocation solution.

[0072] For example, if the numbers of nodes within 50m away from an RSU becomes less than 10 or the numbers of nodes within 100m away from the RSU becomes less than 20, the coverage range of the RSU is considered as an uncongested area. In this case, the segmentation is unnecessary and thus the segmentation is revoked. Then the RSU and the vehicles are switched to the legacy channels for listening control messages and data, which provides a flexible channel allocation scheme.

[0073] In 320, the RRM server divides the area into multiple squares each of which has an RSU in its centre, and the length of sides L of a square for RSU (a) is given by:

[0074] $L_S = \min(D_{max}, L)$, wherein:

[0075] [Math. 0002]

$$L = \min\left(\frac{dist((x_a, y_a), (x_b, y_b))}{\sqrt{2}}, \frac{dist((x_a, y_a), (x_c, y_c))}{\sqrt{2}}, \frac{dist((x_a, y_a), (x_d, y_d))}{\sqrt{2}}, \ldots\right),$$

[0076] $D_{max} = \max(\{D_i | N_i \le N_{desired}(a)\})$,

[0077] wherein (x_a, y_a) is the longitude and latitude of RSU (a) , N_i is the number of nodes within different ranges of the RSU (a) , and $N_{desired}(a)$ is a desired node density of the square for RSU (a) . Herein, N, a, b, c and i are positive integers.

[0078] Due to the above L and D_{max}, neighbouring segments may use non-overlapping channels to avoid interference from nodes in the neighbouring segments.

[0079] In 330, the RRM server allocates channels for the at least one segment from one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs, wherein the PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0080] In the conventional channel allocation scheme, seven channels (one CCH and six SCHs) are allocated for RSUs in the communication network. In other words, two neighbouring RSUs must share one CCH, which may not be able to provide sufficient bandwidth in these scenarios, leading to potential high collision rate and QoS degradation. However, in the embodiments of the present invention, two LCCHs may be allocated for two neighbouring RSUs, respectively, thus further reducing collision probabilities and QoS degradation and achieving dynamic channel allocation.

[0081] FIG. 4 depicts a schematic flowchart of a method for communication in accordance with another embodiment of the present invention. The method of FIG. 3 is implemented by the RSUs in FIG. 1.

[0082] 410, A Roadside Unit (RSU) sends network state information to a Radio Resource Management RRM server, wherein the network state information indicates density of nodes in coverage of the RSU.

[0083] 420, The RSU receives network segmentation information and channel allocation information sent by an RRM server, wherein the network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively.

[0084] 430, The RSU sends network segmentation information and the channel allocation information to nodes which are in coverage of the RSU. For example, the RSU may broadcast the segmentation information and the channel allocation information to the nodes.

[0085] 440, The RSU communicates with nodes which are in the segment through the channels allocated for the segment.

[0086] According to the embodiments of the present invention, the RRM server performs network segmentation and channel allocation channel for segments according to the network state information reported by the RSU, and notifies the RSU of the network segmentation information and channel allocation information, so that the RSU can communicate with a node which enters the segment through the channels allocated for the segment, thus reducing collision probabilities and QoS degradation and thus improve the utilization of radio resource.

[0087] Optionally, as another embodiment, the method of FIG. 4 further comprises: the RSU obtains network state information.

[0088] Optionally, as another embodiment, the density of nodes comprises numbers of nodes within different distances away from the RSU, and before 430, the method of FIG. 4 further comprises: determining, by the RSU, that the coverage of the RSU is congested according to the numbers of nodes within different distances away from the RSU.

[0089] Optionally, as another embodiment, the method of FIG. 4 further comprises: the RSU receives segmentation revocation information from the RRM server, and communicates with the node which enters coverage of the RSU by switching to the legacy channels, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation.

[0090] In 430, the RSU periodically reports the network state information to NCC.

[0091] Optionally, as another embodiment, in 430, the RSU reports the network state information to NCC when at least one of pre-defined conditions is met.

[0092] According to embodiments of the present invention, one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0093] FIG. 5 depicts a schematic flowchart of a method for communication in accordance with another embodiment of the present invention. The method of FIG. 3 is implemented by the nodes in FIG. 1.

[0094] 510, A node receives network segmentation information and the channel allocation information from a Roadside Unit RSU, wherein the network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively.

[0095] 520, The node determines that the node is in the segment according to the network segmentation information.

[0096] 530, The node communicates with the RSU through the channels allocated for the segment.

[0097] According to the embodiments of the present invention, the RRM server performs network segmentation and channel allocation channel for segments according to the network state information reported by the RSU, and notifies the RSU of the network segmentation information and channel allocation information, so that the RSU can communicate with node which enters the segment through the channels allocated for the segment, thus reducing collision probabilities and QoS degradation and thus improve the utilization of radio resource.

[0098] Optionally, as another embodiment, the method of FIG. 5 further comprises: , by the node receives segmentation revocation information from the RSU, and communicates with the RSU through legacy channels, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation.

[0099] According to embodiments of the present invention, one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0100] According to embodiments of the present invention, the node is a vehicle which includes an On-board Unit OBU.

[0101] FIG. 6 depicts a schematic flowchart of a process for communication in accordance with another embodiment of the present invention.

[0102] 610, An RSU collects node ID and position information from nodes in the coverage range of the RSU through a packet.

[0103] For example, once a new node (e.g., a vehicle) enters a coverage range (or communication range) of an RSU, every time it sends a packet (e.g., ACK, RTS, CTS, DATA) , the RSU obtains a node ID of the node, and makes an entry for the node in a table. Next, when the node broadcasts a Cooperative Awareness Message (CAM) or a Decentralized Environmental Notification Message (DENM) or sends a packet through multicast/unicast, the RSU collects position information and movement information, and updates the entry in the table for the node. For example, this may be implemented by a Local Dynamic Map (LDM) in ITS architecture ETSI TR 102 863 (V1.1.1) .

[0104] 615, The RSU determines the network state information according to collected position information of the nodes.

[0105] For example, the RSU may determine the number of the nodes within the communication range and different distances away from the RSU according to the position information of the nodes.

[0106] FIG. 10 is a table indicating number of the nodes different distances away from the RSU in accordance with an embodiment of the present invention. Referring to FIG. 10, in the Range 0-100m corresponding to Range index 1, the number of neighbouring nodes of the RSU is 50, in the range 0-200m corresponding to Range index 2, the number of neighbouring nodes of the RSU is 80, and in the range 0-500 corresponding to Range index 3, the number of neighbouring vehicles of the RSU is 200, and so on.

[0107] 620, the RSU sends a report to an RRM Server in an NCC.

[0108] The RSU may send a report to the RRM sever in the NCC in order to help find the suitable coverage of network segments. The report contains the network state information.

[0109] FIG. 7 depicts a format of a packet sent from the RSU to the RRM server in accordance with an embodiment of the present invention. Referring to FIG. 7, Sender ID field 710 indicates an ID of an RSU, and the length of the field 710 may be 32 bits. The Destination ID field 720 indicates an ID of an RRM, and the length of the field 720 may be 32 bits. Since the embodiments of the present invention are implemented in an MAC sub-layer, an MAC address can be used as the ID of a network node. The Packet Type field 730 indicates the type of the packet, for example, the Packet type indicates that the packet is a RSU report packet, and the length of the field 730 may be 4 bits. The Length field 740 indicates the size of the packet, and the length of the field 740 may be 16 bits. Range No. field 750 indicates Range index 1 of the RSU, and the length of the field 750 may be 8bits. The No. of Veh. field 760 indicates the total number of active vehicles within distance D1 corresponding to Range index 1, and the length of the field 760 may be 16bits. Range No. field 770 indicates Range index n of the RSU, and the length of the field 770 may be 8bits. The No. of Veh. field 770 indicates the total number of active vehicles within distance Dn corresponding to Range index 1, and the length of the field 780 may be 16bits. Similarly, Range index field 2 to n-1 and corresponding No. of Veh. field D_2 to D_{n-1} are omitted in FIG. 7 for the sake of simplicity, where n indicates the number of coverage ranges of the RSU, and n is a positive integer.

[0110] In addition, RSU could send reports to the NCC either periodically or only when some trigger conditions (for sending a networks state information update) are met. One example in the latter case is to define a set of predefined thresholds for a network congestion level can be configured for the individual RSUs. An RSU can only alert the RRM server if the numbers of vehicles in the corresponding range of the RSU is greater than the predefined threshold.

[0111] It should be understood that each RSU in communication network may collect position information and movement information from vehicles in the coverage range of the RSU, and send a report carrying network state information to the RRM Server.

[0112] 630, the RRM server detects congested areas of the network.

[0113] The RRM server may identify whether there is congestion in an area according to the number of active nodes (node density) in the communication range of RSUs in this area. Congestion is identified if node density in a certain area is greater than a threshold $N_{desired}$ (which can be adjusted or preset) .

[0114] Optionally, as another embodiment, congestion can be identified for different ranges of each RSU. For instance, the thresholds for different communication ranges can be pre-defined in the RRM server.

[0115] 640, the RRM server performs network segmentation if the RRM sever determines there is a congested area in the communication network.

[0116] The RRM can divide the congested area into a plurality of segments, for example, a plurality of squares each of which centres one RSU. Embodiments of the present invention are not limited thereto, for example, the segment may have other shapes, for example, circle, hexagon or the like.

[0117] The network segmentation of a congested is described as follows by taking a square segment as an example.

[0118] The RRM server first calculates the length of sides L_S of a square (segment) which centres at the RSU. The length of sides of the square can also be adaptive to at least one of the existence of nearby RSUs, the latency limits of ITS use cases, and the node density.

[0119] The network segmentation is described as follows by taking the existence of nearby RSUs and the node density network as an example.

[0120] a) Consideration on the existence of nearby RSUs:

[0121] If multiple RSUs are available in a congested area, the RRM server divides the area into multiple squares that each square has an RSU in its centre. The length of sides L is given by:

[0122] [Math. 0003]

$$L = \min\left(\frac{dist((x_a,y_a),(x_b,y_b))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_c,y_c))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_d,y_d))}{\sqrt{2}}, \ldots\right),$$

[0123] where (x_a, y_a) is the longitude and latitude of RSU (a) , and a, b and c may be integer.

[0124] b) Consideration on desired node density:

[0125] The RRM server calculates the length of side taking the reported node density around each RSU into account. The RRM server derives the maximum distance D_{max} when the node density within a certain area satisfied the desired node density by:

[0126] $D_{max} = \max(\{D_i | N_i \le N_{desired}(a)\})$

[0127] where N_i is the number of nodes within the certain area (0 ~ D_i m away from the RSU (a)) , and i may be integer, and $N_{desired}$ (a) is a desired node density of the squire for RSU (a) .

[0128] c) Finally, RRM server chooses the minimum value between D_{max} and L as the decision of length of side L_S for each segment.

[0129] $L_S = \min(D_{max}, L)$.

[0130] It should be understood that the above method for performing segmentation is merely an example. The embodiments of the present invention are not limited thereto, and other methods for performing segmentation (e.g., dividing the congested area equally) may be adopted.

[0131] 650, the RRM server performs channel allocation for the network segments.

[0132] After network segmentation, the RRM server may allocate channel for network segments. To be compatible with exiting standard (e.g., IEEE 1609.4) , seven channels are still adopted. One of the seven channels is designated as a Public Control Channel (PCCH) , which is shared between neighboring segments. Among the rest six channels, two channels are named Local Control Channels (LCCHs) and the rest four channels are used as Local Service Channels (LSCHs) . In the present embodiment, vehicles initially work with the multichannel MAC. The Public Control Channel (PCCH) is occupied for broadcasting segmentation information by RSUs in a segmented network in case new vehicles (which enter the network after the segmentation) miss the information. Within each segment, nodes are allowed to use one LCCH and two LSCHs. Neighbouring segments may use non-overlapping channels to avoid interference from nodes in the neighbouring segments. For instance, in the example scenario shown in FIG. 13, it is assumed that an area in road 1310 may be divided into segments 1311, 1312 and 1313, and another area in road 1320 may be divided into segments 1321, 1322, 1323. In addition, LCCH 1, LSCH1 and LSCH 2 may be allocated for segment 1321 ； and LCCH 2, LSCH 3, and LSCH 4 are allocated for segment 1322. Then, nodes in segment 1323 may reuse the same channels as segment 1321 without any interference with the nodes in segment 1323, since the nodes in segment 1323 are far away enough.

[0133] An LCCH is used as a local CCH for a segment, on which emergency messages, channel negotiations and segmentation cancelation transmit ; while an LSCH is used as a local SCH for data transmissions for the segment. Since only two service channels may be used for data transmission in each segment, it is possible that there is no channel available for multiple pairs of nodes. Thus, LCCHs may be allowed to be used for data transmission after a successful channel negotiation if both service channels for the segment are occupied at the moment. The channel access mechanism inside each segment is similar to an Asynchronous MultiChannel MAC (AMCMAC) scheme.

[0134] 660, the RRM server sends network segmentation information and channel allocation information to the RSUs.

[0135] After the network segmentation and channel allocation, the RRM server sends a packet carrying the network segmentation information and the channel allocation information to each RSU. The network segmentation information includes the length of sides of the segment for the RSU, and the channel allocation information includes a list of channels allocated for the segment.

[0136] FIG. 8 depicts format of a packet sent from the RRM server to the RSU in accordance with an embodiment of the present invention. Referring to FIG. 8, Sender ID field 810 indicates an ID of the RRM server, and the length of the field 810 may be 32 bits. The Destination ID field 820 indicates an ID of an RSU, and the length of the field 820 may be 32 bits. Since the embodiments of the present invention are implemented in an MAC sub-layer, an MAC address can be used as the ID of a network node. The Packet Type field 830 indicates the type of the packet, and the length of the field 830 may be 4 bits. The LS field 840 indicates the length of sides of the segment for the RSU, and the length of the field 840 may be 12 bits. Channels field 850 indicates a list of channels allocated for the segment, and the length of the field 850 may be (8bits) *total number of channels allocated for the segment.

[0137] 670, RSUs notifies nodes of the network segmentation information and the channel allocation information.

[0138] Having received the network segmentation information and the channel allocation information from the NCC, the RSU will then broadcast the network segmentation information and the channel allocation information to the vehicles within its coverage through the PCCH. The network segmentation information and the channel allocation information may be carried in a packet.

[0139] FIG. 9 depicts a format of a packet sent from the RSU to nodes in accordance with an embodiment of the present invention.

[0140] Referring to FIG. 9, Sender ID field 910 indicates an ID of the RSU, and the length of the field 910 may be 32 bits. The Destination ID field 920 contains an ID of a vehicle, and the length of the field 920 may be 32 bits. The Packet Type field 930 indicates the type of the packet, and the length of the field 930 may be 4 bits. The Centre of seg. field 940 indicates longitude and latitude of the centre of the segment, and the length of the field 940 may be 64 bits (32bits for longitude, 32bits for latitude) . The LS field 950 indicates the length of sides of the segment for the RSU, and the length of the field 950 may be 12 bits. Channels field 960 indicates a list of channels allocated for the segment, and the length of the field 960 may be (8bits) *total number of channels allocated for the segment.

[0141] 680, after receiving the network segmentation information and the channel allocation information from the RSU, the nodes switch to LCCHs to listen for control messages.

[0142] Since in a normal network state no congestion occurs in the communication range of the RSU, vehicles listen for control messages on a legacy CCH and listen for service data in a legacy SCH. In a congestion state, the vehicles shall receive the network segmentation information and the corresponding channel allocation information broadcasted by the RSU on the PCCH. Having received the segmentation information and the corresponding channel allocation information, vehicles shall switch to the corresponding dedicated LCCHs immediately to listen for control messages. Further, when vehicles receive updated network segmentation information and channel allocation information again, the vehicles shall update their own Segment ID (SID) according to the updated network segmentation information and channel allocation information, and switch to the corresponding dedicated LCCHs immediately to listen for control messages.

[0143] FIG. 11 depicts a schematic flowchart of a process for communication in accordance with another embodiment of the present invention.

[0144] In the present embodiment, it is assumed that the RRM server has performed network segmentation and channel allocation for a congested area, and if the congested area becomes uncongested, the network segmentation and channel allocation shall be revoked.

[0145] 1110, The RRM server determines that the congested area becomes uncongested.

[0146] Similarly as described in 630, the RRM server may identify whether the congested area become uncongested according to the number of active nodes (node density) in the communication range of RSUs in this area. For example, it is identified that congested area becomes uncongested if node density in a certain area is less than a threshold $N_{desired}$ (which can be adjusted or preset) . Optionally, as another embodiment, the thresholds for different communication ranges can be pre-defined in the RRM server.

[0147] 1120, The RRM server sends a segmentation revocation packet to the RSUs.

[0148] Having been provided the network state information, the RRM server in NCC then decides that the network becomes uncongested and the previous segmentation is thus unnecessary. Consequently, NCC will send the segmentation revocation packet to the RSUs to revoke previous segmentations and channel allocations.

[0149] FIG. 12 depicts a format of a packet sent from the RRM server to the RSU.

[0150] Referring to FIG. 12, Sender ID field 1210 contains an ID of the RRM server, and the length of the field 1210 may be 32 bits. The Destination ID field 1220 contains an ID of an RSU, and the length of the field 1220 may be 32 bits. The Packet Type field 1230 contains the type of the packet, for indicating that the packet is a network segmentation revocation message, and the length of the field 1230 may be 4 bits. The Revocation flag field 1240 contains the length of sides of the segment for the RSU for indicating that the segmentation is revoked, and the length of the field 1240 may be 4 bits.

[0151] 1130, RSUs sends the segmentation revocation packet to nodes in its coverage.

[0152] Upon receiving the segmentation revocation packet from the NCC, the RSU will then broadcast the same packet to the vehicles within its coverage.

[0153] 1140, The nodes switch back to a legacy CCH to listen for control messages.

[0154] For example, upon receiving this packet, the vehicles will then switch back to listen to a legacy CCH and perform medium access based on a multichannel MAC protocol.

[0155] FIG. 14 illustrates a schematic diagram of a network model according to an embodiment of the present invention. In the scenario of FIG. 14, a network with multiple hops within a large reference area is considered.

[0156] The well-known simulation tool, NS-2 is used for evaluating the performance of the embodiment of the present invention in terms of throughput, packet delivery rate, and transmission collision rate in the example scenario

[0157] For example, the considered area is a 500m by 1500m region with Manhattan Grid pattern traffic, where nodes travel along the grids (i.e., representing lanes) . RSUs are assumed available in the system model. For urban areas, RSUs are commonly available in busy/congested areas (e.g., traffic lights) . For highway scenarios, along the popular highways, RSUs are usually placed to assist ITS and help collect and disseminate information for various applications. Segmentation mechanism is based on the geographical locations. Each segment employs one RSU as the local coordinator to help forward packets to far-away hops, to disseminate emergency messages, and to offer information to ITS service subscribers as a service provider. It is assumed that RSUs have another network interface (e.g., Ethernet/LTE) besides the DSRC access.

[0158] Different network sizes are considered, i.e., the single-hop and multiple hops for different evaluations. The single-hop scenario covers a 500 m by 500 m area ; and the multiple-hop scenario consists of three single-hop areas. RSUs are assumed placed every 500 m along the area border. Vehicles are randomly distributed in the grids as shown in FIG. 14. The average speed for the nodes is 27 mi/h, which approaches the speed limit for urban traffic scenarios. The density of nodes in each sub-network equals to each other.

[0159] A result of the aggregate throughput against the total number of nodes in the large-scale reference area illustrates that the DNSM-MAC scheme outperform the other multichannel MAC schemes from small-scale to large-scale networks, except in very sparse networks.

[0160] To analyze the system performance in the real world, the middle area is chosen as the reference area, since nodes in this area naturally receive interference coming from nodes outside the area from both sides. A result of the normalized throughput of the nodes in the middle area against the total number of nodes in the reference area illustrates that the DNSM-MAC scheme achieves higher normalized throughput than the other three benchmarking multichannel schemes in all the dense and sparse networks. The DNSM-MAC scheme reaches 357％more of the normalized throughput of AMCP and AMCMAC in the network with 90 nodes.

[0161] Another result is obtained by comparing the packet delivery rates and collision rates on service channels among different multichannel MAC schemes in the large-scale vehicular environment. This result illustrates that the DNSM-MAC scheme and the AMCMAC scheme outperform the other two multichannel MAC schemes, in terms of both packet delivery rate and the collision rate on service channels. For different network scales, the DNSM-MAC scheme and the AMCMAC show higher and more stable packet delivery rates on service channels than the AMCP scheme and the IEEE 1609.4 standard. As for the collision rate on service channels, the proposed scheme achieves lower collision rates comparing to AMCP scheme and maintains a similar level of collisions as the standard IEEE 1609.4 does.

[0162] Another result of accumulative penetration rates of segmentation information against the times that the information is broadcast in the scenarios with different network scales is obtained. It is noted that usually after the first two broadcasts of the segmentation information ; it can penetrate above half of the nodes in most scenarios.

[0163] Another result of penetration rates against time in millisecond shows that the switching delay between different MAC modes (i.e., AMCMAC scheme and DNSM-MAC scheme) is less than 1 ms, and all the nodes can be informed about the segmentation of the reference network within 2 seconds.

[0164] The above discussed processes may be performed by units in apparatuses or software modules in computing devices. These apparatuses and computing devices will be described in the following part of application.

[0165] FIG. 15 is a simplified block diagram of a server according to an embodiment of the present invention.

[0166] The server 1500 includes a receiving unit 1510, a segmentation unit 1520, an allocating unit 1530 and a sending unit 1540.

[0167] The receiving unit 1510 is configured to receive network state information sent by at least one RSU, wherein the network state information sent from each of the at least one RSU indicates density of nodes in the coverage of the RSU. The segmentation unit 1520 is configured to perform segmentation of an area in a communication network according to the network state information to form at least one segment for the at least one RSU respectively. The allocating unit 1530 is configured to allocate channels for the at least one segment. The sending unit 1540 is configured to send network segmentation information and channel allocation information to each of the at least one RSU, wherein the network segmentation information indicates a segment for the RSU and the channel allocation information indicates channels allocated for the segment so that RSU communicates with a node which enters the segment through the channels allocated for the segment.

[0168] Optionally, the density of nodes comprises numbers of nodes within different distances away from the RSU, the server further comprises a determining unit 1550, configured to determine that the area is congested according to the numbers of nodes within different distances away from the RSU.

[0169] Optionally, the determining unit 1550 is further configured to determine that the area becomes uncongested, the sending unit 1540 is further configured to send segmentation revocation information to each of the at least one RSU, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation so that the RSU communicates with the node which enters coverage of the RSU through legacy channels.

[0170] Optionally, the segmentation is configured to divide the area into multiple squares each of which has an RSU in its centre, and the length of sides L_S of a square for RSU (a) is given by:

[0171] $L_S = \min(D_{max}, L)$, wherein:

[0172] [Math. 0004]

$$L = \min\left(\frac{dist((x_a,y_a),(x_b,y_b))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_c,y_c))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_d,y_d))}{\sqrt{2}}, \ldots\right),$$

[0173] $D_{max} = \max(\{D_i | N_i \le N_{desired}(a)\})$,

[0174] wherein (x_a, y_a) is the longitude and latitude of RSU (a) , N_i is the number of nodes within different ranges of the RSU (a) , and $N_{desired}$ (a) is a desired node density of the squire for RSU (a) .

[0175] Optionally, the allocating unit 1530 allocates channels for the at least one segment from one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs, wherein the PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0176] The server may perform each process of the method as shown in FIG. 4, and thus will not be described redundantly herein.

[0177] FIG. 16 is a simplified block diagram of an RSU 1600 according to an embodiment of the present invention.

[0178] The server 1600 includes a sending unit 1610, a receiving unit 1620, and a communicating unit 1630.

[0179] The sending unit 1610 is configured to send network state information to a Radio Resource Management RRM server, wherein the network state information indicates density of nodes in coverage of the RSU.

[0180] The receiving unit 1620 is configured to receive network segmentation information and channel allocation information sent by a server, wherein the network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively, wherein the sending unit 1610 is further configured to send network segmentation information and the channel allocation information to nodes which are in coverage of the RSU.

[0181] The communicating unit 1630 is configured to communicate with nodes which are in the segment through the channels allocated for the segment.

[0182] Optionally, the RSU 1600 further includes an obtaining unit 1640. The obtaining unit 1640 is configured to obtain network state information according to report by the nodes in the coverage of the RSU.

[0183] Optionally, the density of nodes comprises numbers of nodes within different distances away from the RSU, and the RSU further comprises: a determining unit 1650. The determining unit 1650 is configured to determine that the coverage of the RSU is congested according to the numbers of nodes within different distances away from the RSU.

[0184] Optionally, the receiving unit 1620 is further configured to receive segmentation revocation information from the RRM server, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation, and the communicating unit 1630 is further configured to communicate with the nodes which enters coverage of the RSU by switching to the legacy channels.

[0185] Optionally, the sending unit 1610 is configured to: periodically reporting, by the RSU, the network state information to NCC ； or reporting, by the RSU, the network state information to NCC when at least one of pre-defined conditions is met.

[0186] Optionally, one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0187] The RSU may perform each process of the method as shown in FIG. 4, and thus will not be described redundantly herein.

[0188] FIG. 17 is a simplified block diagram of a node 1700 according to another embodiment of the present invention.

[0189] The node 1700 includes a receiving unit 1710, a determining unit 1720, and a communicating unit 1730.

[0190] The receiving unit 1710 is configured to receive network segmentation information and the channel allocation information from an RSU, wherein the network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively.

[0191] The determining unit 1720 is configured to determine that the node is in the segment according to the network segmentation information.

[0192] The communicating unit 1730 is configured to communicate with the RSU through the channels allocated for the segment.

[0193] Optionally, the receiving unit 1710 is further configured to receive segmentation revocation information from the RSU, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation, and the communicating unit 1730 is configured to communicate with the RSU through legacy channels.

[0194] Optionally, one PCCH, two LCCHs and four LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0195] Optionally, the node is a vehicle which includes an OBU.

[0196] The node may perform each process of the method as shown in FIG. 5, and thus will not be described redundantly herein.

[0197] It is noted that the server 1500, the RSU 1600 and the node 1700 are present here in forms of functional units. As used herein and without limitation, the term “unit” may refer to an Application Specific Integrated Circuit (ASIC) , an electronic circuit, a processor (shared, dedicated or group) and memory that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality. In a very specific example, persons skilled in the art would appreciate that the server 1500, the RSU 1600 and the node 1700 may take the form of the host computer 1700 of FIG. 18. For example, the determining unit, the allocation unit, the segmentation unit, obtaining unit and communicating unit, etc. can be realized by the processor, the memory unit and communication interface of the host computer, specifically by the processor executing modules in the memory unit.

[0198] Figure 18 is a simplified block diagram of the computing device 1800. The computing device includes a processor 1810, which is coupled with one or more data storage means. The data storage means may include a storage medium 1850 and a memory unit 1820. The storage medium 1850 may be read-only, like a read-only memory (ROM) , or readable/writeable, like a hard disk or a flash memory. The memory unit 1820 may be a random access memory (RAM) . The memory unit 1820 may be either physically integrated with or within the processor or constructed in a stand-alone unit or units.

[0199] The processor 1810 provides sequencing and processing facilities for executing instructions, performing interruption actions, providing timing functions and may other functions. Optionally, the processor 1810 includes one or multiple central processing units (CPUs) . Optionally, the computing device 1800 includes more than one processor. The term “processor” refers to one or more devices, circuits and/or processing cores configured to process data, such as computer program instructions.

[0200] Program codes to be executed by the processor 1810 may be stored in the memory unit 1820 or storage medium 1850. Optionally, program codes stored in the storage medium 1850 may be copied into the memory unit for the processor 1810 to execute.

[0201] The computing device 1800 further includes a communication interface 1860 for communication with another device or system directly or via an external network. Optionally, the computing device 1800 further includes an output device 1830 and an input device 1840. The output device 1830 is coupled with the processor 1810, and capable of displaying information in one or more ways. The input device 1840 is also coupled with the processor 1810, capable of receiving an input from a user of the computing device 1800 in one or more ways.

[0202] The above elements of the computing device 1800 may be coupled with each other by a bus.

[0203] The computing device 1800 can be a general-purpose computing device or an application-specific computing device. As practical examples, the above-described computing device may be a desktop computer, a laptop computer, a network server, a personal digital assistant (PDA) , a mobile phone, a tablet computer, a wireless terminal device, a telecommunication device, an embedded system or any other devices having similar structure as show in FIG. 18. However, the present application is certainly not limited by any particular types of the computing device.

[0204] As another embodiment, the present application provides a server. The functions of the server may be implemented by the computing device described in FIG. 18.

[0205] The server includes: a memory unit storing computer executable program codes ; a communication interface ; and a processor, coupled with the memory unit and the communication interface, wherein the program codes includes instructions which, when executed by processor, cause the processor to: receive network state information sent by at least one Roadside Unit RSU, perform segmentation of an area in a communication network according to the network state information to form at least one segment for the at least one RSU respectively, allocate channels for the at least one segment, and send network segmentation information and channel allocation information to each of the at least one RSU. The network state information sent from each of the at least one RSU indicates density of nodes in the coverage of the RSU. The network segmentation information indicates a segment for the RSU and the channel allocation information indicates channels allocated for the segment so that RSU communicates with a node which enters the segment through the channels allocated for the segment.

[0206] Optionally, the density of nodes comprises numbers of nodes within different distances away from the RSU, and the program codes further includes instructions which, when executed by the processor, cause the processor to determine that the area is congested according to the numbers of nodes within different distances away from the RSU before performing segmentation of an area in a communication network.

[0207] Optionally, the program codes further includes instructions which, when executed by the processor, cause the processor to determine that the area becomes uncongested, and send segmentation revocation information to each of the at least one RSU. The segmentation revocation information indicates revoking the segmentation and channel allocation so that the RSU communicates with the a node which enters coverage of the RSU through legacy channels.

[0208] According to embodiment of the present invention, the instructions, when executed by the processor, cause the processor to divide the area into multiple squares each of which has an RSU in its centre in the process of segmentation, and the length of sides L_S of a square for RSU (a) is given by:

[0209] $L_S = \min(D_{max}, L)$, wherein:

[0210] [Math. 0005]

$$L = \min\left(\frac{dist((x_a,y_a),(x_b,y_b))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_c,y_c))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_d,y_d))}{\sqrt{2}}, \ldots\right),$$

[0211] $D_{max} = \max(\{D_i | N_i \leq N_{desired}(a)\})$,

[0212] wherein (x_a, y_a) is the longitude and latitude of RSU (a) , N_i is the number of nodes within different ranges of the RSU (a) , and $N_{desired}$ (a) is a desired node density of the squire for RSU (a) .

[0213] According to embodiment of the present invention, the instructions, when executed by the processor, cause the processor to allocate channels for the at least one segment from one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs in the process of channel allocation, wherein the PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0214] The server may perform each process of the method as shown in FIG. 3, and thus will not be described redundantly herein.

[0215] As another embodiment, the present application provides a RSU. The functions of the RSU may be implemented by the computing device described in FIG. 18.

[0216] The server includes: a memory unit storing computer executable program codes ; a communication interface ; and a processor, coupled with the memory unit and the communication interface, wherein the program codes includes instructions which, when executed by processor, cause the processor to: send network state information to a Radio Resource Management RRM server, receive network segmentation information and channel allocation information sent by a server, send network segmentation information and the channel allocation information to nodes which are in coverage of the RSU, and communicate with nodes which are in the segment through the channels allocated for the segment. The network state information indicates density of nodes in coverage of the RSU. The network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively.

[0217] Optionally, the program codes further includes instructions which, when executed by the processor, cause the processor to obtain network state information according to report by the nodes in the coverage of the RSU.

[0218] Optionally, the density of nodes comprises numbers of nodes within different distances away from the RSU, and the program codes further includes instructions which, when executed by the processor, cause the processor to determine that the coverage of the RSU is congested according to the numbers of nodes within different distances away from the RSU before sending network state information to a Radio Resource Management RRM server.

[0219] Optionally, the program codes further includes instructions which, when executed by the processor, cause the processor to receive segmentation revocation information from the RRM server, and communicate with a node which enters coverage of the RSU by switching to the legacy channels. The segmentation revocation information indicates revoking the segmentation and channel allocation,

[0220] According to embodiments of the present invention, the instructions, when executed by the processor, cause the processor to periodically report the network state information to NCC, or report the network state information to NCC when at least one of pre-defined conditions is met.

[0221] According to embodiments of the present invention, one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0222] The RSU may perform each process of the method as shown in FIG. 4, and thus will not be described redundantly herein.

[0223] As another embodiment, the present application provides a node. The functions of the node may be implemented by the computing device described in FIG. 18.

[0224] The node includes: a memory unit storing computer executable program codes； a communication interface； and a processor, coupled with the memory unit and the communication interface, wherein the program codes includes instructions which, when executed by processor, cause the processor to: receive network segmentation information and the channel allocation information from a Roadside Unit RSU, and determine that the node is in the segment according to the network segmentation information； communicate with the RSU through the channels allocated for the segment. The network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively；

[0225] Optionally, the program codes further includes instructions which, when executed by the processor, cause the processor to receive segmentation revocation information from the RSU, and communicate with the RSU through legacy channels. The segmentation revocation information indicates revoking the segmentation and channel allocation,

[0226] According to embodiments of the present invention, one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[0227] According to embodiments of the present invention, the node is a vehicle which includes an On-board Unit OBU.

[0228] The node may perform each process of the method as shown in FIG. 5, and thus will not be described redundantly herein.

[0229] According to the above mentioned embodiments of the present invention, the RRM server performs network segmentation and channel allocation channel for segments according to the network state information reported by the RSU, and notifies the RSU of the network segmentation information and channel allocation information, so that the RSU can communicate with a node which enters the segment through the channels allocated for the segment, reducing collision probabilities and QoS degradation and thus improve the utilization of radio resource.

[0230] It may be clearly understood by a person skilled in the art that, for the purpose of convenient and brief description, for a detailed working process of the foregoing system, device, and unit, reference may be made to a corresponding process in the foregoing method embodiments, which will not be repeated herein.

[0231] In the several embodiments provided in the present application, it should be understood that the disclosed system, device, and method may be implemented in another manner. For example, the described device embodiment is merely exemplary. For example, the unit division is merely logical function division and there may be other division in actual implementation. For example, a plurality of units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings, direct couplings, or communications connections may be implemented through some interfaces, and the indirect couplings or communications connections between the devices or units may be implemented in electronic, mechanical, or another form.

[0232] The units described as separate parts may or may not be physically separate, and the parts displayed as units may or may not be physical units, may be located in one position, or may also be distributed on a plurality of network units. Some or all of the units may be selected to achieve the objective of the solution of the embodiment according to an actual need.

[0233] In addition, functional units in the embodiments of the present invention may be integrated into one processing unit, or each of the units may also exist alone physically, or two or more units may also be integrated into one unit. The integrated units may be implemented in a form of hardware, or may also be implemented in a form of a software functional unit.

[0234] When the integrated units are implemented in a form of a software functional unit and sold or used as an independent product, the integrated units may be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions of the present invention essentially, a part contributing to the prior art, or all or a part of the technical solutions may be presented in a form of a software product. The computer software product is stored in a storage medium and includes several instructions for enabling a computer device (which may be a personal computer, a server, a network device, or the like) to perform all or a part of the steps of the methods described in the embodiments of the present invention. The foregoing storage medium includes: any medium that can store program codes, such as a USB flash disk, a removable hard disk, a read-only memory (ROM, Read-Only Memory) , a random access memory (RAM, Random Access Memory) , a magnetic disk, or an optical disk.

[0235] A transmit diversity method, a related device, and a system according to the present invention are described above in detail. A person of ordinary skill in the art may make modifications to the specific implementation and application scope of the present invention based on the spirit of the embodiments of the present invention. Therefore, the content of the specification shall not be construed as a limitation on the present invention.

Claims

[Claim 1] A method for communication, comprising:receiving, by a Radio Resource Management RRM server, network state information sent by at least one Roadside Unit RSU, wherein the network state information sent from each of the at least one RSU indicates density of nodes in the coverage of the RSU；performing, by the RRM server, segmentation of an area in a communication network according to the network state information to form at least one segment for the at least one RSU respectively；allocating, by the RRM server, channels for the at least one segment；sending, by the RRM server, network segmentation information and channel allocation information to each of the at least one RSU, wherein the network segmentation information indicates a segment for the RSU and the channel allocation information indicates channels allocated for the segment so that RSU communicates with a node which enters the segment through the channels allocated for the segment.

[Claim 2] The method according to claim 1, wherein the density of nodes comprises numbers of nodes within different distances away from the RSU, and before the performing, by the RRM server, segmentation of an area in a communication network, the method further comprises:determining, by the RRM server, that the area is congested according to the numbers of nodes within different distances away from the RSU.

[Claim 3] The method according to claim 2, further comprising:determining, by the RRM server, that the area becomes uncongested；sending, by the RRM server, segmentation revocation information to each of the at least one RSU, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation so that the RSU communicates with the a node which enters coverage of the RSU through legacy channels.

[Claim 4] The method according to any of claims 1 to 3, wherein the performing, by the RRM server, segmentation of an area in a communication network according to the area according to network state information, comprises:dividing, by the RRM server, the area into multiple squares each of which has an RSU in its centre, and the length of sides L_S of a square for RSU (a) is given by:L_S = min (D_{max}, L) , wherein: [Math. 0001]

$$L = \min(\frac{dist((x_a,y_a),(x_b,y_b))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_c,y_c))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_d,y_d))}{\sqrt{2}}, \ldots),$$

D_{max} = max ({D_i|N_i≤$N_{desired}$ (a) }) ,wherein (x_a, y_a) is the longitude and latitude of RSU (a) , N_i is the number of nodes within different ranges of the RSU (a) , and $N_{desired}$ (a) is a desired node density of the squire for RSU (a) .

[Claim 5] The method according to any of claims 1-4, wherein the allocating channels for the at least one segment comprises:allocating channels for the at least one segment from one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs, wherein the PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[Claim 6] A method for transmitting data, comprising:sending, by a Roadside Unit RSU, network state information to a Radio Resource Management RRM server, wherein the network state information indicates density of nodes in coverage of the RSU；receiving, by the RSU, network segmentation information and channel allocation information sent by a server, wherein the network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively；sending, by the RSU, network segmentation information and the channel allocation information to nodes which are in coverage of the RSU；communicating, by the RSU, with nodes which are in the segment through the channels allocated for the segment.

[Claim 7] The method according to claim 6, further comprising:obtaining, by the RSU, network state information according to report by the nodes in the coverage of the RSU.

[Claim 8] The method according to claim 7, wherein the density of nodes comprises numbers of nodes within different distances away from the RSU, and before the sending, by a Roadside Unit RSU, network state information to a Radio Resource Management RRM server, the method further comprises:determining, by the RSU, that the coverage of the RSU is congested according to the numbers of nodes within different distances away from the RSU.

[Claim 9] The method according to claim 8, further comprising:receiving, by the RSU, segmentation revocation information from the RRM server, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation；communicating, by the RSU, with a node which enters coverage of the RSU by switching to the legacy channels.

[Claim 10] The method according to any of claims 6-9, wherein the sending, by a Roadside Unit RSU, network state information to a Radio Resource Management RRM server, comprises:periodically reporting, by the RSU, the network state information to NCC； orreporting, by the RSU, the network state information to NCC when at least one of pre-defined conditions is met.

[Claim 11] The method according to any of claims 6-10, wherein one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[Claim 12] A method for transmitting data, comprising:receiving, by a node, network segmentation information and the channel allocation information from a Roadside Unit RSU, wherein the network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively；determining, by the node, that the node is in the segment according to the network segmentation information；communicating, by the node, with the RSU through the channels allocated for the segment.

[Claim 13] The method according to claim 12, further comprising:receiving, by the node, segmentation revocation information from the RSU, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation；communicating, by the node, with the RSU through legacy channels.

[Claim 14] The method according to claim 12 or 13, wherein one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[Claim 15] The method of according to any of claims 12 to 14, wherein the node is a vehicle which includes an On-board Unit OBU.

[Claim 16] A server, comprising:a receiving unit, configured to receive network state information sent by at least one Roadside Unit RSU, wherein the network state information sent from each of the at least one RSU indicates density of nodes in the coverage of the RSU；a segmentation unit, configured to perform segmentation of an area in a communication network according to the network state information to form at least one segment for the at least one RSU respectively；an allocating unit, configured to allocate channels for the at least one segment；a sending unit, configured to send network segmentation information and channel allocation information to each of the at least one RSU, wherein the network segmentation information indicates a segment for the RSU and the channel allocation information indicates channels allocated for the segment so that RSU communicates with a node which enters the segment through the channels allocated for the segment.

[Claim 17] The server according to claim 16, wherein the density of nodes comprises numbers of nodes within different distances away from the RSU, the server further comprises a determining unit, configured to determine that the area is congested according to the numbers of nodes within different distances away from the RSU.

[Claim 18] The server according to claim 17, wherein the determining unit is further configured to determine that the area becomes uncongested, the sending unit is further configured to send segmentation revocation information to each of the at least one RSU, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation so that the RSU communicates with the node which enters coverage of the RSU through legacy channels.

[Claim 19] The server according to any of claims 16 to 18, wherein the segmentation is configured to divide the area into multiple squares each of which has an RSU in its centre, and the length of sides L_S of a square for RSU (a) is given by:L_S = min (D_{max}, L) , wherein: [Math. 0002]

$$L = \min(\frac{dist((x_a,y_a),(x_b,y_b))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_c,y_c))}{\sqrt{2}}, \frac{dist((x_a,y_a),(x_d,y_d))}{\sqrt{2}}, \ldots).$$

$D_{max} = \max(\{D_i | N_i \leq N_{desired}(a)\})$,wherein (x_a, y_a) is the longitude and latitude of RSU (a) , N_i is the number of nodes within different ranges of the RSU (a) , and $N_{desired}$ (a) is a desired node density of the squire for RSU (a) .

[Claim 20] The server according to any of claims 16-19, wherein the allocating unit allocates channels for the at least one segment from one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs, wherein the PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[Claim 21] A Roadside Unit, comprising:a sending unit, configured to send network state information to a Radio Resource Management RRM server, wherein the network state information indicates density of nodes in coverage of the RSU.a receiving unit, configured to receive network segmentation information and channel allocation information sent by a server, wherein the network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively, wherein the sending unit is further configured to send network segmentation information and the channel allocation information to nodes which are in coverage of the RSU；a communicating unit, configured to communicate with nodes which are in the segment through the channels allocated for the segment.

[Claim 22] The Roadside Unit according to claim 21, further comprising:an obtaining unit, configured to obtain network state information according to report by the nodes in the coverage of the RSU.

[Claim 23] The Roadside Unit according to claim 21, wherein the density of nodes comprises numbers of nodes within different distances away from the RSU, and the Roadside Unit further comprises:a determining unit, configured to determine that the coverage of the RSU is congested according to the numbers of nodes within different distances away from the RSU.

[Claim 24] The Roadside Unit according to claim 23, wherein the receiving unit is further configured to receive segmentation revocation information from the RRM server, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation, and the communicating unit is further configured to communicate with the node which enters coverage of the RSU by switching to the legacy channels.

[Claim 25] The Roadside Unit according to any of claims 21-24, wherein the sending unit is configured to: periodically reporting, by the RSU, the network state information to NCC； or reporting, by the RSU, the network state information to NCC when at least one of pre-defined conditions is met.

[Claim 26] The Roadside Unit according to any of claims 21-25, wherein one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

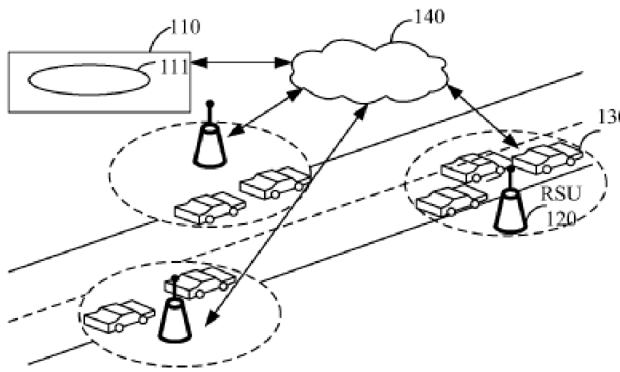
[Claim 27] A node, comprising:a receiving unit, configured to receive network segmentation information and the channel allocation information from a Roadside Unit RSU, wherein the network segmentation information indicates a segment for the RSU, the channel allocation information indicates channels allocated for the segment, and the segment is one of at least one segment formed by the RRM server performing a segmentation of an area in a communication network for at least one RSU respectively；a determining unit, configured to determine that the node is in the segment according to the network segmentation information；a communicating unit, configured to communicate with the RSU through the channels allocated for the segment.

[Claim 28] The node according to claim 27, wherein the receiving unit is further configured to receive segmentation revocation information from the RSU, wherein the segmentation revocation information indicates revoking the segmentation and channel allocation, and the communicating unit is configured to communicate with the RSU through legacy channels.

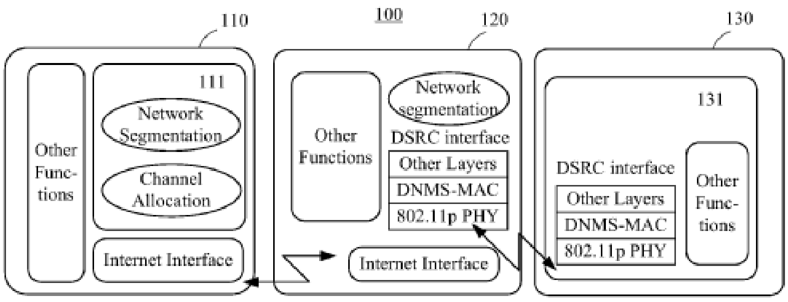
[Claim 29] The node according to claim 27 or 28, wherein one Public Control Channel PCCH, two Local Control Channels LCCHs and four Local Service Channels LSCHs are allocated for the at least one segment, one PCCH, one LCCH and two LSCHs are allocated for the segment, and the PCCH, the other LCCH and the other two LSCHs are allocated for another segment adjacent to the segment.

[Claim 30] The node of according to any of claims 27 to 29, wherein the node is a vehicle which includes an On-board Unit OBU.

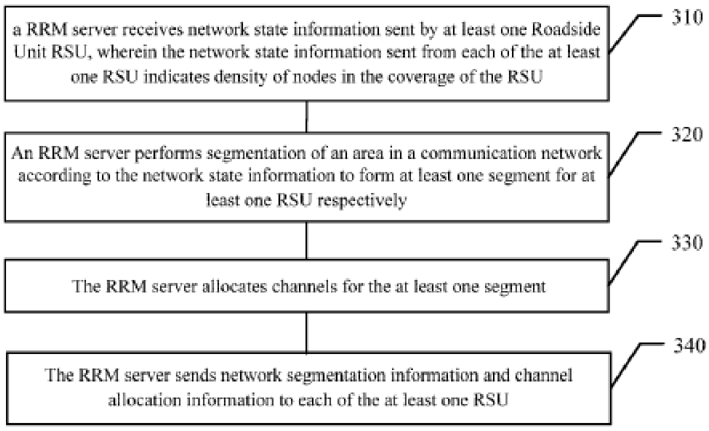
Drawings



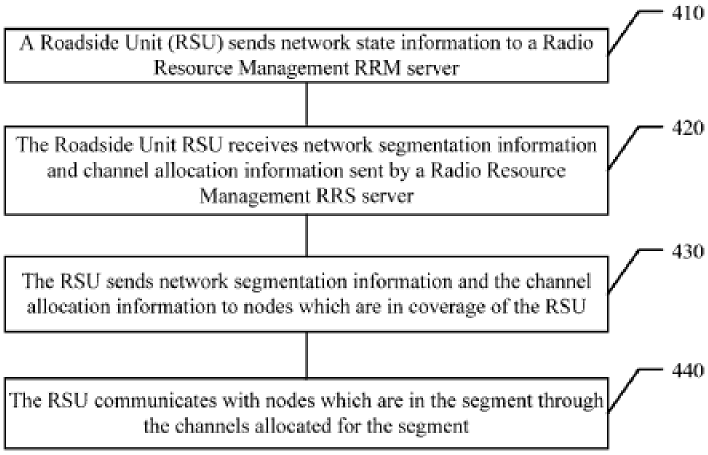
[Fig. 0001]



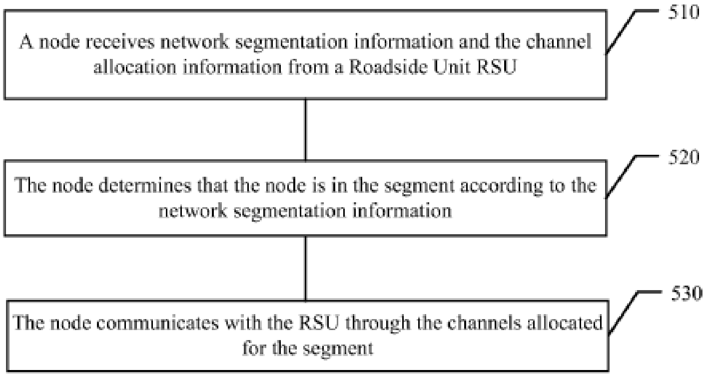
[Fig. 0002]



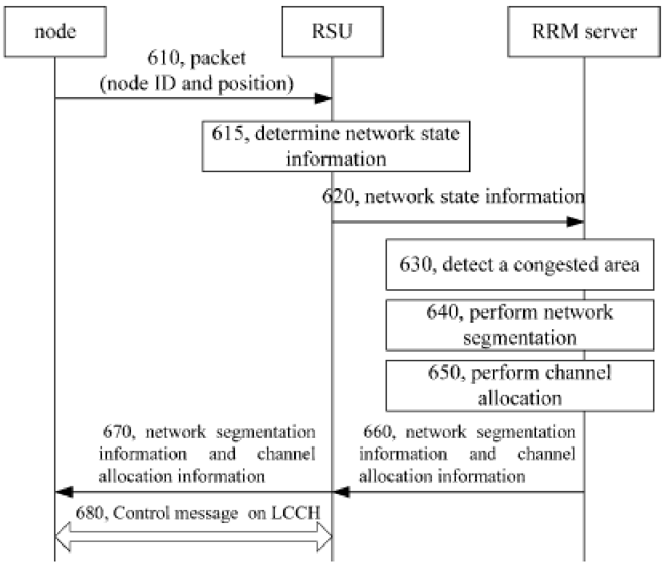
[Fig. 0003]



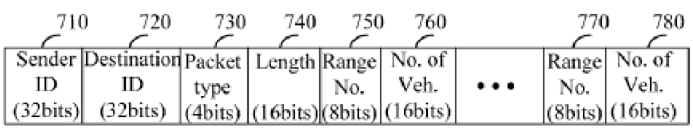
[Fig. 0004]



[Fig. 0005]



[Fig. 0006]



[Fig. 0007]

810	820	830	840	850
Sender ID (32bits)	Destination ID (32bits)	Packet Type (4bits)	LS (12bits)	Channels (8bits)*(Total number of channels)

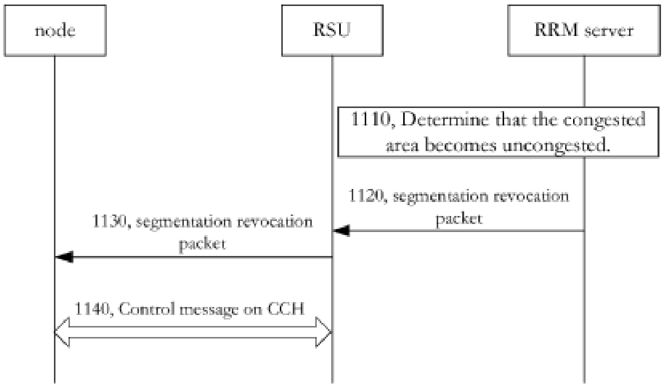
[Fig. 0008]

910	920	930	950	960	970
Sender ID (32bits)	Destination ID (32bits)	Packet type (4bits)	Centre of seg. (longitude, latitude) (32bits) (32bits)	Ls (12bits)	Channels (8bits)*(Total number of channels)

[Fig. 0009]

Range Index	Range (0~Dx m)	Number of neighbouring vehicles (Nx)
1	0~100m	50
2	0~200m	80
3	0~500m	200
...	...	

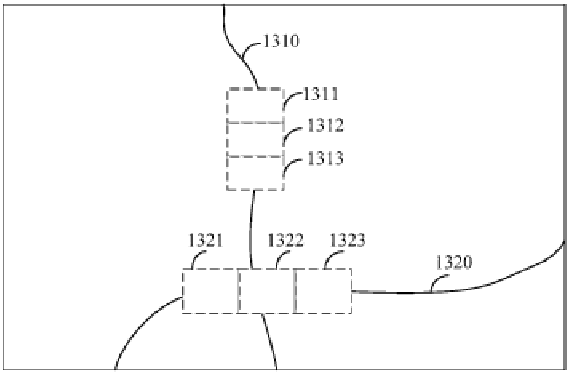
[Fig. 0010]



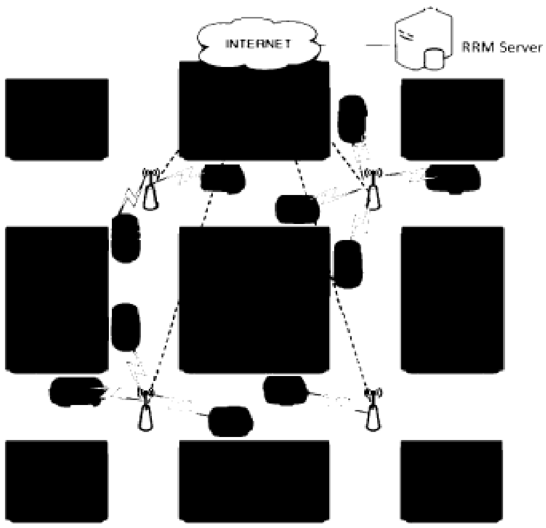
[Fig. 0011]

1210	1220	1230	1240
Sender ID (32bits)	Destination ID (32bits)	Packet type (4bits)	Revocation flag (4bits)

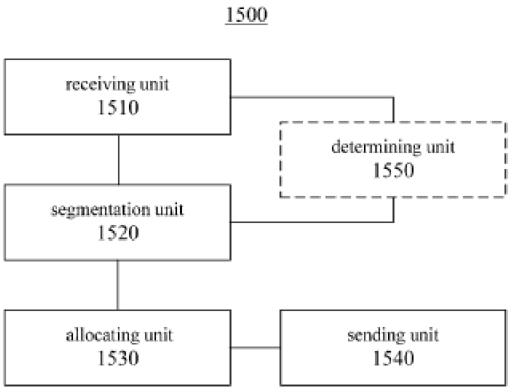
[Fig. 0012]



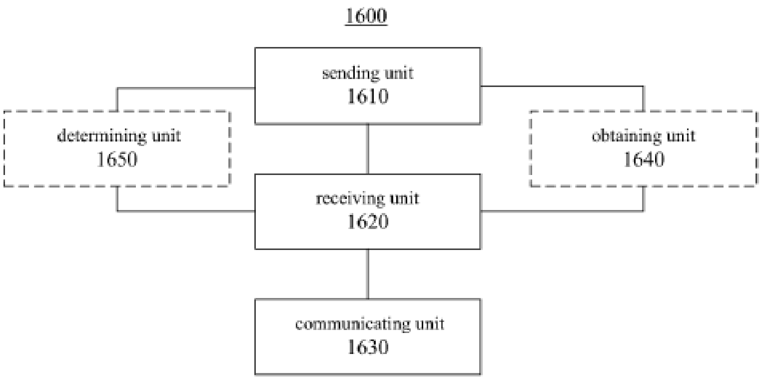
[Fig. 0013]



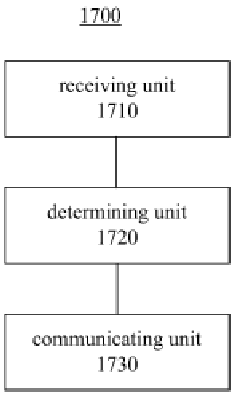
[Fig. 0014]



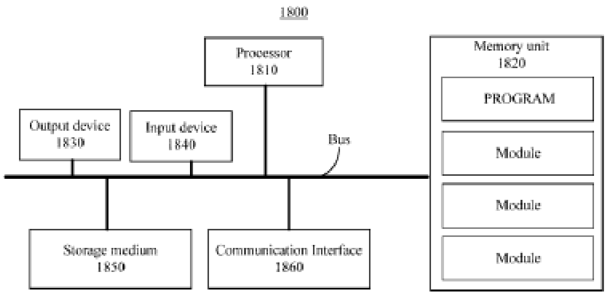
[Fig. 0015]



[Fig. 0016]



[Fig. 0017]



[Fig. 0018]