

TRAFFIC SIMULATION METHOD AND APPARATUS, ELECTRONIC DEVICE AND COMPUTER-READABLE STORAGE MEDIUM

Technical Field

The embodiments of the present disclosure relate to a technical field of data simulation, and particularly to a traffic simulation method and apparatus, an electronic device and a computer-readable storage medium.

Background Art

With the development of society, the holding volume of motor vehicles keeps rising, and a pressure of traffic flow in traffic areas is also increasing. How to effectively relieve the traffic pressure and how to controllably adjust the traffic conditions are urgent problems to be solved at present. A computer technology can be adopted to simulate and analyze traffic data, which not only provides a data support for a formulation of traffic management strategies, but also reduces the number of configured traffic detection devices to greatly decrease the detection cost. However, most of the traffic simulation technologies in the prior arts are based on an agent mode, in which an agent either may represent one individual, such as a pedestrian, a vehicle, etc., or may be composed of a plurality of individuals, such as a driver, passengers and a vehicle per se. In practical applications, the inventor finds that this technology is limited by an cooperation mechanism between the agents, e.g., when dynamic traffic data of one or several individuals in an agent is related to a plurality of simulation calculation nodes, i.e., when traffic behaviors of the one or several individuals in the agent span the plurality of simulation calculation nodes, it is difficult for a system to accurately compute and simulate the dynamic traffic data of the agent in real time because of a huge amount of data communicated between the simulation calculation nodes. Thus, whenever a startup time is triggered, a simulation system based on the agent mode will traverse all of the agents to update statuses thereof, which leads to a

decline of the simulation performance. In addition, any individual concerned in the agent mode is a vehicle, which cannot solve the problem of updating dynamic road network data during a road network maintenance. Therefore, the agent mode is only suitable for the static road network, while cannot well solve the problem of the upgrade of road network information and cannot meet the need of large-scale traffic simulation.

Summary of the Disclosure

The embodiments of the present disclosure provide a traffic simulation method and apparatus, an electronic device and a computer-readable storage medium.

In a first aspect, the embodiments of the present disclosure provide a traffic simulation method.

Specifically, the traffic simulation method comprises:

acquiring traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

performing a road-based traffic simulation based on the traffic simulation initialization data; and

outputting a traffic simulation result.

In conjunction with the first aspect, in a first implementation of the first aspect of the embodiments of the present disclosure, performing the road-based traffic simulation based on the traffic simulation initialization data comprises:

determining a traffic simulation calculation node;

acquiring traffic area road attribute information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node; and

determining a traffic simulation model, and performing a node-parallel traffic simulation using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel information.

In conjunction with the first aspect and the first implementation thereof, in a second implementation of the first aspect of the embodiments of the present disclosure, performing the road-based traffic simulation based on the traffic simulation initialization data further comprises:

acquiring attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

establishing a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on to the attribute information of the adjacent traffic simulation calculation node; and

sending traffic simulation data related to the moving object having moved to the next adjacent traffic area to the adjacent traffic simulation calculation node.

In conjunction with the first aspect and the first and second implementations thereof, in a third implementation of the first aspect of the embodiments of the present disclosure, outputting the traffic simulation result comprises:

outputting the traffic simulation result at a preset simulation time interval.

In conjunction with the first aspect and the first to third implementations thereof, in a fourth implementation of the first aspect of the embodiments of the present disclosure, outputting the traffic simulation result at the preset simulation time interval comprises:

collecting traffic simulation data generated by the traffic simulation calculation node to obtain a traffic simulation data packet, in response to an expiration of the preset simulation time interval; and

performing a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

In conjunction with the first aspect and the first to fourth implementations thereof, in a fifth implementation of the first aspect of the embodiments of the present disclosure, the method further comprises:

updating, in response to receipt of g the traffic area road update information, the

traffic area road attribute information and related traffic area road data in the traffic simulation calculation node based on the traffic area road update information.

In conjunction with the first aspect and the first to fifth implementations thereof, in a sixth implementation of the first aspect of the embodiments of the present disclosure, the method further comprises:

performing a time alignment management for the traffic simulation calculation node.

In conjunction with the first aspect and the first to sixth implementations thereof, in a seventh implementation of the first aspect of the embodiments of the present disclosure, the method further comprises: executing, based on the traffic simulation result, at least one of:

a traffic facility control, a dynamically variable lane setting, a traffic guidance, a traffic flow restriction, or a navigation data adjustment.

In a second aspect, the embodiments of the present disclosure provide a traffic simulation apparatus.

Specifically, the traffic simulation apparatus comprises:

an acquisition module configured to acquire traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

a simulation module configured to perform a road-based traffic simulation based on the traffic simulation initialization data; and

an output module configured to output a traffic simulation result.

In conjunction with the second aspect, in a first implementation of the second aspect of the embodiments of the present disclosure, the simulation module comprises:

a determination sub-module configured to determine a traffic simulation calculation node;

a first acquisition sub-module configured to acquire traffic area road attribute information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node; and

a simulation sub-module configured to determine a traffic simulation model, and

perform a node-parallel traffic simulation using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel information.

In conjunction with the second aspect and the first implementation thereof, in a second implementation of the second aspect of the embodiments of the present disclosure, the simulation module further comprises:

- a second acquisition sub-module configured to acquire attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

- an establishing sub-module configured to establish a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on the attribute information of the adjacent traffic simulation calculation node; and

- a transmission sub-module configured to send traffic simulation data related to the moving object having moved to the next adjacent traffic area to the adjacent traffic simulation calculation node.

In conjunction with the second aspect and the first and second implementations thereof, in a third implementation of the second aspect of the embodiments of the present disclosure, the output module is configured to:

- output a traffic simulation result at a preset simulation time interval.

In conjunction with the second aspect and the first to third implementations thereof, in a fourth implementation of the second aspect of the embodiments of the present disclosure, the output module comprises:

- a collection sub-module configured to collect traffic simulation data generated by the traffic simulation calculation node to obtain a traffic simulation data packet, in response to an expiration of the preset simulation time interval; and

- a processing sub-module configured to perform a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

In conjunction with the second aspect and the first to fourth implementations thereof, in a fifth implementation of the second aspect of the embodiments of the present disclosure, the apparatus further comprises:

an updating module configured to update, in response to receipt of the traffic area road update information, the traffic area road attribute information and related traffic area road data in the traffic simulation calculation node based on the traffic area road update information.

In conjunction with the second aspect and the first to fifth implementations thereof, in a sixth implementation of the second aspect of the embodiments of the present disclosure, the apparatus further comprises:

a management module configured to perform a time alignment management for the traffic simulation calculation node.

In conjunction with the second aspect and the first to sixth implementations thereof, in a seventh implementation of the second aspect of the embodiments of the present disclosure, the apparatus further comprises:

an execution module configured to execute, based on the traffic simulation result, at least one of:

a traffic facility control, a dynamically variable lane setting, a traffic guidance, a traffic flow restriction, or a navigation data adjustment.

In a third aspect, the embodiments of the present disclosure provide a traffic simulation system.

Specifically, the traffic simulation system comprises:

a memory configured to store and update traffic simulation initialization data, and provide corresponding requested data in response to a data acquisition request, wherein the traffic simulation initialization data comprises one or more of road attribute information, moving object attribute information and moving object travel information;

a traffic simulation calculation cluster coupled to the memory, and configured to perform a road-based traffic simulation based on the traffic simulation initialization data, wherein the traffic simulation calculation cluster comprises two or more traffic simulation

calculation nodes; and

an aggregation server coupled to the traffic simulation calculation cluster, and configured to aggregate traffic simulation data of the traffic simulation calculation cluster and output a traffic simulation result.

In conjunction with the third aspect, in a first implementation of the third aspect of the embodiments of the present disclosure, the two or more traffic simulation calculation nodes perform region-parallel simulation for the respective traffic areas.

In conjunction with the third aspect and the first implementation thereof, in a second implementation of the second aspect of the embodiments of the present disclosure, the traffic simulation calculation node is further configured to:

acquire attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

establish a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on the attribute information of the adjacent traffic simulation calculation node; and

send traffic simulation data related to the moving object having moved to the next adjacent traffic area to the adjacent traffic simulation calculation node.

In conjunction with the third aspect and the first and second implementations thereof, in a third implementation of the second aspect of the embodiments of the present disclosure, the memory comprises:

a name server configured to store the road attribute information; and

a simulation memory configured to store the moving object attribute information and the moving object travel information.

In conjunction with the third aspect and the first to third implementations thereof, in a fourth implementation of the second aspect of the embodiments of the present disclosure, the name server is a master-slave backup server.

In conjunction with the third aspect and the first to fourth implementations thereof, in

a fifth implementation of the second aspect of the embodiments of the present disclosure, the memory is further configured to update, in response to receipt of the road update information, the road attribute information based on the road update information; and

the traffic simulation calculation node is further configured to update, in response to receipt of the road update information, related traffic area road data based on the road update information.

In conjunction with the third aspect and the first to fifth implementations thereof, in a sixth implementation of the second aspect of the embodiments of the present disclosure, the aggregation server is further configured to output a traffic simulation result at a preset simulation time interval.

In conjunction with the third aspect and the first to sixth implementations thereof, in a seventh implementation of the second aspect of the embodiments of the present disclosure, the aggregation server is configured to:

collect traffic simulation data generated by the traffic simulation calculation node to obtain a traffic simulation data packet, in response to an expiration of the preset simulation time interval; and

perform a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

In conjunction with the third aspect and the first to seventh implementations thereof, in an eighth implementation of the second aspect of the embodiments of the present disclosure, the system further comprises:

a clock synchronization server coupled to the traffic simulation calculation cluster and/or the aggregation server, and configured to perform a time alignment management for data in the traffic simulation calculation node and/or the aggregation server.

In a fourth aspect, the embodiments of the present disclosure provide an electronic device, comprising a memory and a processor, wherein the memory is configured to store one or more computer instructions for supporting a traffic simulation apparatus to perform the traffic simulation method in the first aspect, and the processor is configured to execute the computer instructions stored in the memory. The traffic simulation apparatus may

further comprise a communication interface for the traffic simulation apparatus to communicate with other devices or a communication network.

In a fifth aspect, the embodiments of the present disclosure provide a computer-readable storage medium, which stores computer instructions used by a traffic simulation apparatus, and which comprises computer instructions for performing the traffic simulation method in the first aspect.

The technical solutions provided by the embodiments of the present disclosure can achieve the following advantageous effects:

The technical solutions take roads as simulation objects for a traffic simulation to output a traffic simulation result. The technical solutions do not depend on individuals, only pay attention to road conditions, simulate changes in traffic flow by means of message transfer between roads, and can also update changes in road attributes at a lowest cost, thereby well solving the problems of updating dynamic road network data and upgrading road network information during a road network maintenance, meeting the need of large-scale traffic simulation, and providing a timely and reliable data support for effectively relieving the traffic pressure and controllably adjusting the traffic conditions.

It should be understood that the above general description and the following detailed description are only exemplary and explanatory, rather than limiting the embodiments of the present disclosure.

Brief Description of the Drawings

Other features, objectives and advantages of the embodiments of the present disclosure will become more apparent from the following detailed descriptions of the non-limiting embodiments with reference to the drawings. In which,

Fig. 1 illustrates a flowchart of a traffic simulation method according to an embodiment of the present disclosure;

Fig. 2 illustrates a flowchart of step S102 of a traffic simulation method according to an embodiment illustrated in Fig. 1;

Fig. 3 illustrates a flowchart of step S102 of a traffic simulation method according to

another embodiment illustrated in Fig. 1;

Fig. 4 illustrates a flowchart of step S103 of a traffic simulation method according to an embodiment illustrated in Fig. 1;

Fig. 5 illustrates a flowchart of a traffic simulation method according to another embodiment of the present disclosure;

Fig. 6 illustrates a flowchart of a traffic simulation method according to still another embodiment of the present disclosure;

Fig. 7 illustrates a flowchart of a traffic simulation method according to yet another embodiment of the present disclosure;

Fig. 8 illustrates a structural block diagram of a traffic simulation apparatus according to an embodiment of the present disclosure;

Fig. 9 illustrates a structural block diagram of a simulation module 802 of a traffic simulation apparatus according to an embodiment illustrated in Fig. 8;

Fig. 10 illustrates a structural block diagram of a simulation module 802 of a traffic simulation apparatus according to another embodiment illustrated in Fig. 8;

Fig. 11 illustrates a structural block diagram of an output module 803 of a traffic simulation apparatus according to an embodiment illustrated in Fig. 8;

Fig. 12 illustrates a structural block diagram of a traffic simulation apparatus according to another embodiment of the present disclosure;

Fig. 13 illustrates a structural block diagram of a traffic simulation apparatus according to still another embodiment of the present disclosure;

Fig. 14 illustrates a structural block diagram of a traffic simulation apparatus according to yet another embodiment of the present disclosure;

Fig. 15 illustrates a structural block diagram of a traffic simulation system according to an embodiment of the present disclosure;

Fig. 16 illustrates a block diagram of the memory 1501 of a traffic simulation system according to an embodiment illustrated in Fig. 15;

Fig. 17 illustrates a structural block diagram of an electronic device according to an embodiment of the present disclosure; and

Fig. 18 is a structural schematic diagram of a computer system suitable to implement a traffic simulation method according to an embodiment of the present disclosure.

Detailed Description of the Preferred Embodiments

Hereinafter, exemplary implementations of the embodiments of the present disclosure will be described in detail with reference to the drawings, so that they can be easily realized by persons skilled in the art. In addition, for the sake of clarity, parts unrelated to the description of the exemplary implementations are omitted in the drawings.

In the embodiments of the present disclosure, it should be understood that terms such as ‘comprise’ and ‘have’ are intended to indicate the presence of features, numerals, steps, behaviors, components, parts or combinations thereof disclosed in this specification, rather than excluding a possibility of presence or addition of one or more other features, numerals, steps, actions, components, parts or combinations thereof.

In addition, it should be noted that the embodiments of the present disclosure and the features in the embodiments can be combined with each other if there is no conflict. The embodiments of the present invention will be described in detail with reference to the drawings and in conjunction with the implementations.

A technical solution provided by an embodiment of the present disclosure takes roads as simulation objects for a traffic simulation to output a traffic simulation result. The technical solution does not depend on individuals, only pays attention to road conditions, simulates changes in traffic flow by means of message transfer between roads, and can also update changes in road attributes at a lowest cost, thereby well solving the problems of updating dynamic road network data and upgrading road network information during a road network maintenance, meeting the need of large-scale traffic simulation, and providing a timely and reliable data support for effectively relieving the traffic pressure and controllably adjusting the traffic conditions.

Fig. 1 illustrates a flowchart of a traffic simulation method according to an embodiment of the present disclosure. As illustrated in Fig. 1, the traffic simulation method comprises the following steps S101 to S103:

S101: acquiring traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

S102: performing a road-based traffic simulation based on the traffic simulation initialization data; and

S103: outputting a traffic simulation result.

As mentioned above, With the development of society, the holding volume of motor vehicles keeps rising, and a pressure of traffic flow in traffic areas is also increasing. How to effectively relieve the traffic pressure and how to controllably adjust the traffic conditions are urgent problems to be solved at present. A computer technology can be adopted to simulate and analyze traffic data, which not only provides a data support for a formulation of traffic management strategies, but also reduces the number of configured traffic detection devices to greatly decrease the detection cost. However, most of the traffic simulation technologies in the prior arts are based on an agent mode, in which an agent either may represent one individual, such as a pedestrian, a vehicle, etc., or may be composed of a plurality of individuals, such as a driver, passengers and a vehicle per se. In practical applications, the inventor finds that this technology is limited by an cooperation mechanism between the agents, e.g., when dynamic traffic data of one or several individuals in an agent is related to a plurality of simulation calculation nodes, i.e., when traffic behaviors of the one or several individuals in the agent span the plurality of simulation calculation nodes, it is difficult for a system to accurately compute and simulate the dynamic traffic data of the agent in real time because of a huge amount of data communicated between the simulation calculation nodes. Thus, whenever a startup time is triggered, a simulation system based on the agent mode will traverse all of the agents to update statuses thereof, which leads to a decline of the simulation performance. In addition, any individual concerned in the agent mode is a vehicle, which cannot solve the problem of updating dynamic road network data during a road network maintenance. Therefore, the agent mode is only suitable for the static road network, while cannot well solve the problem of the upgrade of road network information and cannot meet the need of

large-scale traffic simulation.

In view of the above problems, this embodiment proposes a traffic simulation method, which takes roads as simulation objects for a traffic simulation to output a traffic simulation result. This technical solution does not depend on individuals, only pays attention to road conditions, simulates changes in traffic flow by means of message transfer between roads, and can also update changes in road attributes at a lowest cost, thereby well solving the problems of updating dynamic road network data and upgrading road network information during a road network maintenance, and meeting the need of large-scale traffic simulation.

In one optional implementation of this embodiment, the traffic simulation initialization data comprises one or more of road attribute information, moving object attribute information, and moving object travel information, wherein the road attribute information comprises one or more of a traffic area to which a road belongs, a connectivity between roads, a road length, starting and ending positions of a road, a road shape, the number of available lanes of a road, a maximum number of vehicles drivable on a road, an average speed per hour on a road, etc., wherein each road belongs to a specific traffic area, and the roads in different traffic areas do not cross. The moving object attribute information comprises one or more of: a moving object category, an moving object average speed per hour, a moving object maximum speed per hour, etc., wherein the moving object category may comprise a heavy motor vehicle, a medium motor vehicle, a small motor vehicle, a three-wheeled electric vehicle, a two-wheeled electric vehicle, a three-wheeled rickshaw, a bicycle, a pedestrian, etc. The moving object travel information comprises one or more of: a moving object departure place, a moving object destination, a moving object average speed per hour, a moving object travel route plan, a moving object travel preference, etc.

In one optional implementation of this embodiment, the traffic area may be either an administrative area, or a virtual geographical area artificially determined according to a need of regional traffic monitoring, such as an area composed of several blocks. That is, the traffic area may be determined according to the actual need of traffic simulation, and is

not specifically limited in the present disclosure.

In one optional implementation of this embodiment, the traffic simulation initialization data may be stored in a same device or in different devices respectively. For example, the traffic simulation initialization data may be stored in a same server or memory. Of course, considering that the road information may be updated later, or requested to acquire the road information of different traffic areas, in order to simplify the requesting procedure, the road attribute information may be stored in a name server, while the moving object attribute information and the moving object travel information may be stored in a simulation database or a simulation memory, so that when the road information is to be updated or requested while the moving object attribute information and the moving object travel information is unchanged, it only needs to directly access, request or modify the name server.

In one optional implementation of this embodiment, the numbers of the name servers and the simulation databases may be set according to the needs of practical applications, and are not specifically limited in the present disclosure.

In one optional implementation of this embodiment, the name server adopts a master-slave backup server to ensure the fault tolerance and robustness. Assuming that a single-point failure probability of a single name server is 10%, then a probability that two single-point name servers are failed at the same time is reduced to 1%, and a system availability can be up to 99%.

After the traffic simulation initialization data is acquired, a simulation system may be initialized based on the traffic simulation initialization data, and then a road-based traffic simulation may be performed. In which, the road-based traffic simulation refers to a simulation taking a road in a preset traffic area (a certain traffic area) as a simulation object of traffic simulation, i.e., the simulation object is changed into a road from the agent in the prior art. Specifically, in the traffic simulation, road data is focused on, and the simulation of changes in traffic flow is realized by counting data generated on the road in the certain traffic area road and communications between data of roads in different traffic areas.

In one optional implementation of this embodiment, as illustrated in Fig. 2, the step

S102, i.e., performing a road-based traffic simulation based on the traffic simulation initialization data, comprises the following steps S201 to S203:

S201: determining a traffic simulation calculation node;

S202: acquiring traffic area road attribute information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node;

S203: determining a traffic simulation model, and performing a node-parallel traffic simulation using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel information.

In order to update the changes in road attributes at a lowest cost, and solve the problem of a huge computation amount caused by the update of the dynamic road network data and the upgrade of the road network information during the road network maintenance, in this implementation, the road-based traffic simulation is performed based on the traffic simulation initialization data, and specifically:

Firstly, the traffic simulation calculation nodes are determined. Considering that the traffic simulation involves simulation computations of a plurality of traffic areas, in order to improve a simulation data precision and a simulation efficiency, in this implementation, a plurality of traffic simulation calculation nodes corresponding to the traffic areas are adopted for a parallel simulation. Specifically, each traffic simulation calculation node may be responsible for a traffic simulation of one traffic area. Of course, two or more traffic simulation calculation nodes may be configured for a large traffic area. Similarly, a traffic simulation calculation node with a strong computing power may be responsible for two or more traffic areas. The traffic simulation calculation nodes may be configured by persons skilled in the art according to the needs of practical applications, and are not specifically limited in the present disclosure. Before a plurality of traffic simulation calculation nodes are adopted for a parallel simulation, it is necessary to determine traffic simulation calculation nodes needed to complete the simulation task and their corresponding relationships with the responsible traffic areas, and store the configuration information in a

preset memory or a name server for a request or calling by the traffic simulation calculation nodes.

In one optional implementation of this embodiment, the traffic simulation calculation node may be a computer, a single chip microcomputer and other computing devices.

Next, traffic area road attribute information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node is acquired. As mentioned above, the traffic simulation initialization data such as the road attribute information, the moving object attribute information and the moving object travel information of the traffic area may be stored in a same device or in different devices respectively. When the traffic simulation initialization data is acquired, corresponding data may be requested from a destination storage source among different storage sources.

Finally, a traffic simulation model is determined, and a node-parallel traffic simulation are performed using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel information, wherein the node-parallel traffic simulation refer to a simultaneous simulation performed by a plurality of traffic simulation calculation nodes to improve the simulation efficiency.

In which, the traffic simulation model is built for a purpose of simulating relatively independent entities or behaviors in a road traffic system, and configured to describe the behaviors and interactions of various entities and obtain corresponding simulation data. In one optional implementation of this embodiment, the traffic simulation model may be set according to the needs of practical applications, the purpose of traffic simulation and the characteristics of the traffic simulation data, and the specific form of the traffic simulation model is not particularly limited in the present disclosure.

In one optional implementation of this embodiment, the step S102 may also comprise transmitting simulation data across traffic areas, i.e., as illustrated in Fig. 3, the step S102 of performing a road-based traffic simulation based on the traffic simulation initialization data comprises the following steps S301 to S306:

S301: determining a traffic simulation calculation node;

S302: acquiring traffic area road attribute information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node;

S303: determining a traffic simulation model, and performing a node-parallel traffic simulation using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel information;

S304: acquiring attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

S305: establishing a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on the attribute information of the adjacent traffic simulation calculation node;

S306: sending traffic simulation data related to the moving object having moved to the next adjacent traffic area to the adjacent traffic simulation calculation node.

As mentioned above, different traffic simulation calculation nodes are responsible for the traffic simulation in different traffic areas. That is, when a moving object such as a pedestrian or a motor vehicle moves within the traffic area, all of the generated data and messages may be processed within the corresponding traffic simulation calculation node, without involving the communication between different traffic simulation calculation nodes. However, if the moving object such as the pedestrian or the motor vehicle moves across areas, in order to integrate the traffic simulation data and ensure the integrity of the traffic simulation data, in this implementation, when the moving object is detected as leaving the current traffic area and entering the next adjacent traffic area in the moving direction, it is necessary to acquire the attribute information of the adjacent traffic simulation calculation node corresponding to the next adjacent traffic area, and establish a communication between the two nodes based on the attribute information of the adjacent traffic simulation calculation node, so as to transmit the traffic simulation data related to

the moving object to the adjacent traffic simulation calculation node to ensure the integrity of the traffic simulation data.

In one optional implementation of this embodiment, in order to ensure the correctness of the traffic simulation data process by the adjacent traffic simulation calculation node, when the traffic simulation data related to the moving object is transmitted to the adjacent traffic simulation calculation node, identification information may also be added to the transmitted traffic simulation data to explain a source of the traffic simulation data, related information of the moving object, etc.

In one optional implementation of this embodiment, the step S103 of outputting a traffic simulation results comprises:

outputting a traffic simulation result at a preset simulation time interval.

In one optional implementation of this embodiment, the preset simulation time interval refers to a preset time interval for outputting a traffic simulation result, thereby indicating an output frequency of the traffic simulation result, and also reflecting a granularity of the traffic simulation, such as 40ms, 1s, etc. In which, the preset simulation time interval may be set according to the needs of practical applications, the granularity requirement of the traffic simulation result and the characteristics of the traffic simulation data, and the specific value thereof is not specifically limited in the present disclosure.

In one optional implementation of this embodiment, as illustrated in Fig. 4, the step S103 of outputting the traffic simulation result at the preset simulation time interval comprises the following steps S401 to S402:

S401: collecting traffic simulation data generated by the traffic simulation calculation node to obtain a traffic simulation data packet, in response to an expiration of the preset simulation time interval;

S402: performing a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

In order to integrate and unify the traffic simulation data generated by a plurality of traffic simulation calculation nodes and present the complete traffic simulation data, in this implementation, when the preset simulation time interval expires, the traffic simulation

data generated by the traffic simulation calculation nodes is collected to form a traffic simulation data packet, and then preset aggregation process is performed on the traffic simulation data packet according to the needs of practical applications, so as to finally obtain the traffic simulation result.

In which, the preset aggregation process may comprise data compression, data alignment, data denoising, etc. In one optional implementation of this embodiment, the traffic simulation data packet is subjected to the data compression process before being transmitted, so that a data transmission delay caused by frequent network communications can be avoided.

In one optional implementation of this embodiment, the method may further comprise updating road data, i.e., as illustrated in Fig. 5, the method comprises the following steps S501 to S504:

S501: acquiring traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

S502: performing a road-based traffic simulation based on the traffic simulation initialization data;

S503: outputting a traffic simulation result;

S504: updating, in response to receipt of the road update information, the road attribute information and related traffic area road data in the traffic simulation calculation node based on the road update information.

Considering that a road network maintenance and a road network change often occur in practical applications, in order to respond to the road network maintenance and the road network change in time and correct the traffic simulation data, in this implementation, after the road update information is received, the road attribute information stored in the memory or the server and the related traffic area road data in the traffic simulation calculation nodes is updated based on the road update information.

As mentioned above, in one optional implementation of this embodiment, the road attribute information is stored in the name server, while the moving object attribute

information and the moving object travel information is stored in the simulation database. Thus, after the road update information is received, only the related information stored in the name server may be updated without increasing a signaling overhead of the simulation database, thereby achieving the purposes of saving the operation cost and reducing the computational complexity.

In one optional implementation of this embodiment, the method may further comprise performing a time alignment management for the traffic simulation calculation node, i.e., as illustrated in Fig. 6, the method comprises the following steps S601 to S604:

S601: acquiring traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

S602: performing a road-based traffic simulation based on the traffic simulation initialization data;

S603: outputting a traffic simulation result;

S604: performing a time alignment management for the traffic simulation calculation node.

Since a plurality of traffic simulation calculation nodes perform the simulation in parallel, it is necessary to ensure the time consistency of the simulation data of all of the traffic simulation calculation nodes in order to obtain an effective traffic simulation result and avoid the integration from being impossible due to a time misalignment. Thus, in this implementation, it is necessary to perform a time alignment management for the traffic simulation calculation nodes, wherein the time alignment management may be realized when the traffic simulation calculation nodes perform the simulation, or during a data aggregation, or by combining the two manners, i.e., the time stamps of the simulation data of the plurality of traffic simulation calculation nodes are kept to be consistent when the traffic simulation calculation nodes perform the simulation, and a time alignment check is performed for the simulation data of different traffic simulation calculation nodes when a data aggregation is carried out later, so as to make a time alignment correction for the simulation data with inconsistent time stamps.

In one optional implementation of this embodiment, the method further comprises performing a traffic management based on the traffic simulation result, i.e., as illustrated in Fig. 7, the method comprises the following steps S701 to S704:

S701: acquiring traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

S702: performing a road-based traffic simulation based on the traffic simulation initialization data;

S703: outputting a traffic simulation result;

S704: executing, based on the traffic simulation result, at least one of:

a traffic facility control, a dynamically variable lane setting, a traffic guidance, a traffic flow restriction, or a navigation data adjustment.

In one optional implementation of this embodiment, a traffic facility such as a traffic light can be controlled based on the traffic simulation result, including controlling startup time and continuous startup time of the traffic facilities. In addition, based on the traffic simulation result, a setting of dynamic variable lanes, a traffic guidance, a traffic flow restriction, a traffic ban, etc. may be carried out, and user navigation data may be adjusted, so as to reduce the overall traffic pressure, while shortening the travel time of the user and providing a reliable data support for the traffic management and the formulation of related strategies.

An apparatus embodiment of the present disclosure is described below, which can carry out the method embodiment of the present disclosure.

Fig. 8 illustrates a structural block diagram of a traffic simulation apparatus according to an embodiment of the present disclosure. The apparatus may be implemented as a part or a whole of an electronic device by software, hardware or a combination thereof. As illustrated in Fig. 8, a traffic simulation apparatus comprises:

an acquiring module 801 configured to acquire traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

a simulation module 802 configured to perform a road-based traffic simulation based on the traffic simulation initialization data;

an output module 803 configured to output a traffic simulation result.

As mentioned above, With the development of society, the holding volume of motor vehicles keeps rising, and a pressure of traffic flow in traffic areas is also increasing. How to effectively relieve the traffic pressure and how to controllably adjust the traffic conditions are urgent problems to be solved at present. A computer technology can be adopted to simulate and analyze traffic data, which not only provides a data support for a formulation of traffic management strategies, but also reduces the number of configured traffic detection devices to greatly decrease the detection cost. However, most of the traffic simulation technologies in the prior arts are based on an agent mode, in which an agent either may represent one individual, such as a pedestrian, a vehicle, etc., or may be composed of a plurality of individuals, such as a driver, passengers and a vehicle per se. In practical applications, the inventor finds that this technology is limited by an cooperation mechanism between the agents, e.g., when dynamic traffic data of one or several individuals in an agent is related to a plurality of simulation calculation nodes, i.e., when traffic behaviors of the one or several individuals in the agent span the plurality of simulation calculation nodes, it is difficult for a system to accurately compute and simulate the dynamic traffic data of the agent in real time because of a huge amount of data communicated between the simulation calculation nodes. Thus, whenever a startup time is triggered, a simulation system based on the agent mode will traverse all of the agents to update statuses thereof, which leads to a decline of the simulation performance. In addition, any individual concerned in the agent mode is a vehicle, which cannot solve the problem of updating dynamic road network data during a road network maintenance. Therefore, the agent mode is only suitable for the static road network, while cannot well solve the problem of the upgrade of road network information and cannot meet the need of large-scale traffic simulation.

In view of the above problems, this embodiment proposes a traffic simulation apparatus, which takes roads as simulation units for a traffic simulation to output a traffic

simulation result. This technical solution does not depend on individuals, only pays attention to road conditions, simulates changes in traffic flow by means of message transfer between roads, and can also update changes in road attributes at a lowest cost, thereby well solving the problems of updating dynamic road network data and upgrading road network information during a road network maintenance, and meeting the need of large-scale traffic simulation.

In one optional implementation of this embodiment, the traffic simulation initialization data comprises one or more of road attribute information, moving object attribute information, and moving object travel information, wherein the road attribute information comprises one or more of a traffic area to which a road belongs, a connectivity between roads, a road length, starting and ending positions of a road, a road shape, the number of available lanes of a road, a maximum number of vehicles drivable on a road, an average speed per hour on a road, etc., wherein each road belongs to a specific traffic area, and the roads in different traffic areas do not cross. The moving object attribute information comprises one or more of: a moving object category, an moving object average speed per hour, a moving object maximum speed per hour, etc., wherein the moving object category may comprise a heavy motor vehicle, a medium motor vehicle, a small motor vehicle, a three-wheeled electric vehicle, a two-wheeled electric vehicle, a three-wheeled rickshaw, a bicycle, a pedestrian, etc. The moving object travel information comprises one or more of: a moving object departure place, a moving object destination, a moving object average speed per hour, a moving object travel route plan, a moving object travel preference, etc.

In one optional implementation of this embodiment, the traffic area may be either an administrative area, or a virtual geographical area artificially determined according to a need of regional traffic monitoring, such as an area composed of several blocks. That is, the traffic area may be determined according to the actual need of traffic simulation, and is not specifically limited in the present disclosure.

In one optional implementation of this embodiment, the traffic simulation initialization data may be stored in a same device or in different devices respectively. For

example, the traffic simulation initialization data may be stored in a same server or memory. Of course, considering that the road information may be updated later, or requested to acquire the road information of different traffic areas, in order to simplify the requesting procedure, the road attribute information may be stored in a name server, while the moving object attribute information and the moving object travel information may be stored in a simulation database or a simulation memory, so that when the road information is to be updated or requested while the moving object attribute information and the moving object travel information is unchanged, it only needs to directly access, request or modify the name server.

In one optional implementation of this embodiment, the numbers of the name servers and the simulation databases may be set according to the needs of practical applications, and are not specifically limited in the present disclosure.

In one optional implementation of this embodiment, the name server adopts a master-slave backup server to ensure the fault tolerance and robustness. Assuming that a single-point failure probability of a single name server is 10%, then a probability that two single-point name servers are failed at the same time is reduced to 1%, and a system availability can be up to 99%.

After the acquisition module 801 acquires the traffic simulation initialization data, the simulation module 80 may initialize a simulation system based on the traffic simulation initialization data, and then perform a road-based traffic simulation. In which, the road-based traffic simulation refers to a simulation taking a road in a preset traffic area (a certain traffic area) as a simulation object of traffic simulation, i.e., the simulation object is changed into a road from the agent in the prior art. Specifically, when the simulation module 802 performs the traffic simulation, road data is focused on, and the simulation of changes in traffic flow is realized by counting data generated on the road in the certain traffic area road and communications between data of roads in different traffic areas.

In one optional implementation of this embodiment, as illustrated in Fig. 9, the simulation module 802 comprises:

a determination sub-module 901 configured to determine a traffic simulation

calculation node;

a first acquisition sub-module 902 configured to acquire traffic area road attribute information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node;

a simulation sub-module 903 configured to determine a traffic simulation model, and perform a node-parallel traffic simulation using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel information.

In order to update the changes in road attributes at a lowest cost, and solve the problem of a huge computation amount caused by the update of the dynamic road network data and the upgrade of the road network information during the road network maintenance, in this implementation, the simulation module 802 performs the road-based traffic simulation based on the traffic simulation initialization data, and specifically:

The determination sub-module 901 determines the traffic simulation calculation nodes. Considering that the traffic simulation involves simulation computations of a plurality of traffic areas, in order to improve a simulation data precision and a simulation efficiency, in this implementation, a plurality of traffic simulation calculation nodes corresponding to the traffic areas are adopted for a parallel simulation. Specifically, each traffic simulation calculation node may be responsible for a traffic simulation of one traffic area. Of course, two or more traffic simulation calculation nodes may be configured for a large traffic area. Similarly, a traffic simulation calculation node with a strong computing power may be responsible for two or more traffic areas. The traffic simulation calculation nodes may be configured by persons skilled in the art according to the needs of practical applications, and are not specifically limited in the present disclosure. Before a plurality of traffic simulation calculation nodes are adopted for a parallel simulation, it is necessary to determine traffic simulation calculation nodes needed to complete the simulation task and their corresponding relationships with the responsible traffic areas, and store the configuration information in a preset memory or a name server for a request or calling by the traffic simulation calculation nodes.

In one optional implementation of this embodiment, the traffic simulation calculation node may be a computer, a single chip microcomputer and other computing devices.

The first acquisition sub-module 902 acquires traffic area road attribute information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node. As mentioned above, the traffic simulation initialization data such as the road attribute information, the moving object attribute information and the moving object travel information of the traffic area may be stored in a same device or in different devices respectively. When the traffic simulation initialization data is acquired, corresponding data may be requested from a destination storage source among different storage sources.

The simulation sub-module 903 determines a traffic simulation model, and performs a node-parallel traffic simulation using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel information, wherein the node-parallel traffic simulation refer to a simultaneous simulation performed by a plurality of traffic simulation calculation nodes to improve the simulation efficiency.

In which, the traffic simulation model is built for a purpose of simulating relatively independent entities or behaviors in a road traffic system, and configured to describe the behaviors and interactions of various entities and obtain corresponding simulation data. In one optional implementation of this embodiment, the traffic simulation model may be set according to the needs of practical applications, the purpose of traffic simulation and the characteristics of the traffic simulation data, and the specific form of the traffic simulation model is not particularly limited in the present disclosure.

In one optional implementation of this embodiment, the simulation module 802 may further comprise a portion for transmitting simulation data across traffic areas, i.e., as illustrated in Fig. 10, the simulation module 802 comprises:

- a determination sub-module 1001 configured to determine a traffic simulation calculation node;

- a first acquisition sub-module 1002 configured to acquire traffic area road attribute

information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node;

a simulation sub-module 1003 configured to determine a traffic simulation model, and perform a node-parallel traffic simulation using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel information;

a second acquisition sub-module 1004 configured to acquire attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

an establishing sub-module 1005 configured to establish a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on the attribute information of the adjacent traffic simulation calculation node;

a transmission sub-module 1006 configured to send traffic simulation data related to the moving object having moved to the next adjacent traffic area to the adjacent traffic simulation calculation node.

As mentioned above, different traffic simulation calculation nodes are responsible for the traffic simulation in different traffic areas. That is, when a moving object such as a pedestrian or a motor vehicle moves within the traffic area, all of the generated data and messages may be processed within the corresponding traffic simulation calculation node, without involving the communication between different traffic simulation calculation nodes. However, if the moving object such as the pedestrian or the motor vehicle moves across areas, in order to integrate the traffic simulation data and ensure the integrity of the traffic simulation data, in this implementation, when the moving object is detected as leaving the current traffic area and entering the next adjacent traffic area in the moving direction, it is necessary for the second acquisition sub-module 1004 to acquire the attribute information of the adjacent traffic simulation calculation node corresponding to the next adjacent traffic area, and the establishing sub-module 1005 establishes a communication between the two nodes based on the attribute information of the adjacent

traffic simulation calculation node, so that the transmission sub-module 1006 transmits the traffic simulation data related to the moving object to the adjacent traffic simulation calculation node to ensure the integrity of the traffic simulation data.

In one optional implementation of this embodiment, in order to ensure the correctness of the traffic simulation data process by the adjacent traffic simulation calculation node, when transmitting the traffic simulation data related to the moving object to the adjacent traffic simulation calculation node, the transmission sub-module 1006 may add identification information to the transmitted traffic simulation data to explain a source of the traffic simulation data, related information of the moving object, etc.

In one optional implementation of this embodiment, the output module 803 is configured to:

output a traffic simulation result at a preset simulation time interval.

In one optional implementation of this embodiment, the preset simulation time interval refers to a preset time interval for outputting a traffic simulation result, thereby indicating an output frequency of the traffic simulation result, and also reflecting a granularity of the traffic simulation, such as 40ms, 1s, etc. In which, the preset simulation time interval may be set according to the needs of practical applications, the granularity requirement of the traffic simulation result and the characteristics of the traffic simulation data, and the specific value thereof is not specifically limited in the present disclosure.

In one optional implementation of this embodiment, as illustrated in Fig. 11, the output module 803 comprises:

a collection sub-module 1101 configured to collect traffic simulation data generated by the traffic simulation calculation node to obtain a traffic simulation data packet, in response to an expiration of the preset simulation time interval;

a processing sub-module 1102 configured to perform a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

In order to integrate and unify the traffic simulation data generated by a plurality of traffic simulation calculation nodes and present the complete traffic simulation data, in this implementation, when the preset simulation time interval expires, the collection

sub-module 1101 collects the traffic simulation data generated by the traffic simulation calculation nodes to form a traffic simulation data packet, and then the processing sub-module 1102 performs a preset aggregation process on the traffic simulation data packet according to the needs of practical applications, so as to finally obtain the traffic simulation result.

In which, the preset aggregation process may comprise data compression, data alignment, data denoising, etc. In one optional implementation of this embodiment, the traffic simulation data packet is subjected to the data compression process before being transmitted, so that a data transmission delay caused by frequent network communications can be avoided.

In one optional implementation of this embodiment, the apparatus further comprises a portion for updating road data, i.e., as illustrated in Fig. 12, the apparatus comprises:

- an acquisition module 1201 configured to acquire traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

- a simulation module 1202 configured to perform a road-based traffic simulation based on the traffic simulation initialization data;

- an output module 1203 configured to output a traffic simulation result;

- an updating module 1204 configured to update, in response to receiving the road update information, the road attribute information and related traffic area road data in the traffic simulation calculation node based the on road update information.

Considering that a road network maintenance and a road network change often occur in practical applications, in order to respond to the road network maintenance and the road network change in time and correct the traffic simulation data, in this implementation, after the road update information is received, the updating module 1204 updates the road attribute information stored in the memory or the server and the related traffic area road data in the traffic simulation calculation nodes based on the road update information.

As mentioned above, in one optional implementation of this embodiment, the road attribute information is stored in the name server, while the moving object attribute

information and the moving object travel information is stored in the simulation database. Thus, after the road update information is received, only the related information stored in the name server may be updated without increasing a signaling overhead of the simulation database, thereby achieving the purposes of saving the operation cost and reducing the computational complexity.

In one optional implementation of this embodiment, the apparatus further comprises a portion for performing a time alignment management for the traffic simulation calculation node, i.e., as illustrated in Fig. 13, the apparatus comprises:

- an acquisition module 1301 configured to acquire traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

- a simulation module 1302 configured to perform a road-based traffic simulation based on the traffic simulation initialization data;

- an output module 1303 configured to output a traffic simulation result;

- a management module 1304 configured to perform a time alignment management for the traffic simulation calculation node.

Since a plurality of traffic simulation calculation nodes perform the simulation in parallel, it is necessary to ensure the time consistency of the simulation data of all of the traffic simulation calculation nodes in order to obtain an effective traffic simulation result and avoid the integration from being impossible due to a time misalignment. Thus, in this implementation, it is necessary to provide a management module 1304 to perform a time alignment management for the traffic simulation calculation nodes, wherein the time alignment management may be realized when the traffic simulation calculation nodes perform the simulation, or during a data aggregation, or by combining the two manners, i.e., the time stamps of the simulation data of the plurality of traffic simulation calculation nodes are kept to be consistent when the traffic simulation calculation nodes perform the simulation, and a time alignment check is performed for the simulation data of different traffic simulation calculation nodes when a data aggregation is carried out later, so as to make a time alignment correction for the simulation data with inconsistent time stamps.

In one optional implementation of this embodiment, the apparatus further comprises a portion for performing a traffic management based on the traffic simulation result, i.e., as illustrated in Fig. 14, the apparatus comprises:

- an acquisition module 1401 configured to acquire traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

- a simulation module 1402 configured to perform a road-based traffic simulation based on the traffic simulation initialization data;

- an output module 1403 configured to output a traffic simulation result;

- an execution module 1404 configured to execute, based on the traffic simulation result, at least one of:

 - a traffic facility control, a dynamically variable lane setting, a traffic guidance, a traffic flow restriction, or a navigation data adjustment.

In one optional implementation of this embodiment, the execution module 1404 may control a traffic facility such as a traffic light based on the traffic simulation result, including controlling startup time and continuous startup time of the traffic facilities. In addition, based on the traffic simulation result, a setting of dynamic variable lanes, a traffic guidance, a traffic flow restriction, a traffic ban, etc. may be carried out, and user navigation data may be adjusted, so as to reduce the overall traffic pressure, while shortening the travel time of the user and providing a reliable data support for the traffic management and the formulation of related strategies.

Fig. 15 illustrates a structural block diagram of a traffic simulation system according to an embodiment of the present disclosure. As illustrated in Fig. 15, the traffic simulation system comprises:

- a memory 1501 configured to store and update traffic simulation initialization data, and provide corresponding requested data in response to a data acquisition request, wherein the traffic simulation initialization data comprises one or more of road attribute information, moving object attribute information and moving object travel information;

- a traffic simulation calculation cluster 1502 coupled to the memory, and configured to

perform a road-based traffic simulation based on the traffic simulation initialization data, wherein the traffic simulation calculation cluster comprises two or more traffic simulation calculation nodes 15021;

an aggregation server 1503 coupled to the traffic simulation calculation cluster, and configured to aggregate traffic simulation data of the traffic simulation calculation cluster and output a traffic simulation result.

The traffic simulation system takes roads as simulation objects for a traffic simulation to output a traffic simulation result. The traffic simulation system does not depend on individuals, only pays attention to road conditions, simulates changes in traffic flow by means of message transfer between roads, and can also update changes in road attributes at a lowest cost, thereby well solving the problems of updating dynamic road network data and upgrading road network information during a road network maintenance, and meeting the need of large-scale traffic simulation.

Considering that the traffic simulation involves simulation computations of a plurality of traffic areas, in order to improve a simulation data precision and a simulation efficiency, in one optional implementation of this embodiment, the two or more traffic simulation calculation nodes perform a region-parallel simulation for the respective traffic areas, that is, two or more traffic simulation calculation nodes in the traffic simulation calculation cluster perform the simulation simultaneously and are responsible for different traffic areas. For example, it may be set that each traffic simulation calculation node is responsible for one traffic area, and two or more traffic simulation calculation nodes may be configured for a large traffic area. Similarly, traffic simulation calculation nodes with strong computing power can also be responsible for two or more traffic areas, and those skilled in the art can configure the work of traffic simulation calculation nodes according to the needs of practical applications, which is not specifically limited in the present disclosure. Similarly, a traffic simulation calculation node with a strong computing power may be responsible for two or more traffic areas. The traffic simulation calculation nodes may be configured by persons skilled in the art according to the needs of practical applications, and are not specifically limited in the present disclosure.

In one optional implementation of this embodiment, the traffic simulation result may be adopted for at least one of: controlling a traffic facility such as a traffic light, including controlling the startup time and continuous startup time of the traffic facilities; a setting of dynamic variable lanes; a traffic guidance; a traffic flow restriction, a traffic ban, etc.; or an adjustment of user navigation data, etc., so as to reduce the overall traffic pressure, while shortening the travel time of the user and providing a reliable data support for the traffic management and the formulation of related strategies.

In one optional implementation of this embodiment, the traffic simulation calculation nodes in the traffic simulation calculation cluster are coupled to each other, or at least traffic simulation calculation nodes responsible for the simulation of adjacent traffic areas are coupled to each other, and all of the traffic simulation calculation nodes are coupled to the memory. During the simulation, the traffic simulation calculation nodes in the traffic simulation calculation cluster firstly acquire traffic simulation initialization data of corresponding traffic areas from the memory by means of data requests, and then perform the traffic simulation of different traffic areas based on the traffic simulation initialization data.

In one optional implementation of this embodiment, the traffic simulation calculation node may be implemented as a computer, a single chip microcomputer and other computing devices.

In one optional implementation of this embodiment, the traffic simulation calculation node may be further configured to:

- acquire attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

- establish a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on the attribute information of the adjacent traffic simulation calculation node;

- send traffic simulation data related to the moving object having moved to the next

adjacent traffic area to the adjacent traffic simulation calculation node.

As mentioned above, different traffic simulation calculation nodes are responsible for the traffic simulation in different traffic areas. That is, when a moving object such as a pedestrian or a motor vehicle moves within the traffic area, all of the generated data and messages may be processed within the corresponding traffic simulation calculation node, without involving the communication between different traffic simulation calculation nodes. However, if the moving object such as the pedestrian or the motor vehicle moves across areas, in order to integrate the traffic simulation data and ensure the integrity of the traffic simulation data, in this implementation, when the moving object is detected as leaving the current traffic area and entering a next adjacent traffic area in the moving direction, it is necessary for the current traffic simulation calculation node to acquire the attribute information of the adjacent traffic simulation calculation node corresponding to the next adjacent traffic area, and establish a communication between the two nodes based on the attribute information of the adjacent traffic simulation calculation node, so as to transmit the traffic simulation data related to the moving object to the adjacent traffic simulation calculation node to ensure the integrity of the traffic simulation data.

In one optional implementation of this embodiment, in order to ensure the correctness of the traffic simulation data process by the adjacent traffic simulation calculation node, when transmitting the traffic simulation data related to the moving object to the adjacent traffic simulation calculation node, the current traffic simulation calculation node may add identification information to the transmitted traffic simulation data to explain a source of the traffic simulation data, related information of the moving object, etc.

In one optional implementation of this embodiment, as illustrated in Fig. 16, the memory 1501 comprises:

- a name server 1601 configured to store the road attribute information;
- a simulation memory 1602 configured to store the moving object attribute information and the moving object travel information.

According to the needs of practical applications, the traffic simulation initialization data may be stored in a same device or in different devices respectively. For example,

considering that the road information may be updated later, or requested to acquire the road information of different traffic areas, in order to simplify the requesting procedure, the road attribute information may be stored in the name server 1601, while the moving object attribute information and the moving object travel information may be stored in the simulation memory 1602, so that when the road information is to be updated or requested while the moving object attribute information and the moving object travel information is unchanged, it only needs to directly access, request or modify the name server 1601.

In one optional implementation of this embodiment, the numbers of the name servers and the simulation memories may be set according to the needs of practical applications, and are not specifically limited in the present disclosure.

In one optional implementation of this embodiment, the name server is a master-slave backup server to ensure the fault tolerance and robustness. Assuming that a single-point failure probability of a single name server is 10%, then a probability that two single-point name servers are failed at the same time is reduced to 1%, and a system availability can be up to 99%.

In one optional implementation of this embodiment, the memory 1501 is further configured to update, in response to receiving the road update information, the road attribute information based on the road update information; and the traffic simulation calculation node 15021 is further configured to update, in response to receipt of the road update information, related traffic area road data based on the road update information.

Considering that a road network maintenance and a road network change often occur in practical applications, in order to respond to the road network maintenance and the road network change in time and correct the traffic simulation data, in this implementation, after the road update information is received, the memory 1501 updates the stored road attribute information based on the road update information, and the traffic simulation calculation node 15021 updates the related traffic area road data based on the road update information.

As mentioned above, in one optional implementation of this embodiment, the road attribute information is stored in the name server 1601, while the moving object attribute information and the moving object travel information is stored in the simulation memory

1602. Thus, after the road update information is received, only the related information stored in the name server 1601 may be updated without increasing a signaling overhead of the simulation memory 1602, thereby achieving the purposes of saving the operation cost and reducing the computational complexity.

In one optional implementation of this embodiment, the aggregation server 1503 is further configured to output a traffic simulation result at a preset simulation time interval.

In one optional implementation of this embodiment, the preset simulation time interval refers to a preset time interval for outputting a traffic simulation result, thereby indicating an output frequency of the traffic simulation result, and also reflecting a granularity of the traffic simulation, such as 40ms, 1s, etc. In which, the preset simulation time interval may be set according to the needs of practical applications, the granularity requirement of the traffic simulation result and the characteristics of the traffic simulation data, and the specific value thereof is not specifically limited in the present disclosure.

In one optional implementation of this embodiment, the aggregation server 1503 is configured to:

collect traffic simulation data generated by the traffic simulation calculation node to obtain a traffic simulation data packet, in response to an expiration of the preset simulation time interval;

perform a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

In order to integrate and unify the traffic simulation data generated by a plurality of traffic simulation calculation nodes and present the complete traffic simulation data, in this implementation, when the preset simulation time interval expires, the aggregation server 1503 collects the traffic simulation data generated by the traffic simulation calculation nodes to form a traffic simulation data packet, and then performs preset aggregation process on the traffic simulation data packet according to the needs of practical applications, so as to finally obtain the traffic simulation result.

In which, the preset aggregation process may comprise data compression, data alignment, data denoising, etc. In one optional implementation of this embodiment, the

traffic simulation data packet is subjected to the data compression process before being transmitted, so that a data transmission delay caused by frequent network communications can be avoided.

In one optional implementation of this embodiment, the system further comprises:

a clock synchronization server 1504 coupled to the traffic simulation calculation cluster and/or the aggregation server, and configured to perform a time alignment management for data in the traffic simulation calculation node and/or the aggregation server.

Since a plurality of traffic simulation calculation nodes perform the simulation in parallel, it is necessary to ensure the time consistency of the simulation data of all of the traffic simulation calculation nodes in order to obtain an effective traffic simulation result and avoid the integration from being impossible due to a time misalignment. Thus, in this implementation, it is necessary to provide a clock synchronization server 1504 to perform a time alignment management, wherein the clock synchronization server 1504 may be coupled to the traffic simulation calculation nodes to perform a time alignment there, or coupled to the aggregation server to perform a time alignment when a data aggregation is performed by the aggregation server, or coupled to both the traffic simulation calculation nodes and the aggregation server and perform a time alignment by adopting the above two manners in combination. For example, the time stamps of the simulation data of the plurality of traffic simulation calculation nodes are kept to be consistent when the traffic simulation calculation nodes perform the simulation, and a time alignment check is performed for the simulation data of different traffic simulation calculation nodes when a data aggregation is carried out later, so as to make a time alignment correction for the simulation data with inconsistent time stamps.

An embodiment of the present disclosure further discloses an electronic device. Fig. 17 illustrates a structural block diagram of an electronic device according to an embodiment of the present disclosure. As illustrated in Fig. 17, the electronic device 1700 comprises a memory 1701 and a processor 1702, wherein

the memory 1701 is configured to store one or more computer instructions, which are

executed by the processor 1702 to implement any of the above methodical steps.

Fig. 18 is a structural schematic diagram of a computer system suitable to implement a traffic simulation method according to an embodiment of the present disclosure.

As illustrated in Fig. 18, a computer system 1800 comprises a central processing unit (CPU) 1801, which can execute various process in the above embodiments according to a program stored in a read only memory (ROM) 1802 or a program loaded from a storage section 1808 into a random access memory (RAM) 1803. The RAM 1803 further stores various programs and data required for the operations of the system 1800. The CPU 1801, the ROM 1802, and the RAM 1803 are coupled to each other through a bus 1804. An input/output (I/O) interface 1805 is also coupled to the bus 1804.

The following components are coupled to the I/O interface 1805: an input section 1806 including a keyboard, a mouse, etc.; an output section 1807 including a cathode ray tube (CRT), a liquid crystal display (LCD), a speaker, etc.; a storage section 1808 including a hard disk, etc.; and a communication section 1809 including a network interface card such as a LAN card, a modem, etc. The communication section 1809 performs communication process via a network such as the Internet. A driver 1810 is also coupled to the I/O interface 1805 as needed. A removable medium 1811, such as a magnetic disk, an optical disk, a magneto-optical disk, a semiconductor memory, etc., is installed on the driver 1810 as needed, so that a computer program read therefrom can be installed into the storage section 1808 as needed.

Particularly, according to an embodiment of the present disclosure, the method described above may be implemented as a computer software program. For example, the embodiments of the present disclosure comprise a computer program product including a computer program tangibly embodied on a readable medium thereof, the computer program including program codes for executing the traffic simulation method. In such embodiment, the computer program may be downloaded and installed from the network through the communication section 1809, and/or installed from the removable medium 1811.

The flowcharts and block diagrams in the drawings illustrate architectures, functions

and operations of possible implementations of systems, methods and computer program products according to various embodiments of the present disclosure. In this regard, each block in a flowchart or a block diagram may represent a module, a program segment, or a part of codes that include one or more executable instructions for realizing a specified logical function. It should also be noted that in some alternative implementations, the functions marked in the blocks may occur in an order from that illustrated in the drawings. For example, two blocks illustrated in succession may actually be executed in substantially parallel, or sometimes may be executed in a reverse order, depending on the functions involved. It should also be noted that each block in a block diagram and/or a flowchart, and a combination of blocks in a block diagram and/or a flowchart, may be implemented with a dedicated hardware-based system that performs a specified function or operation, or may be implemented with a combination of dedicated hardware and computer instructions.

The units or modules described in the embodiments of the present disclosure may be implemented by software or hardware. The described units or modules may also be disposed in the processor, and their names do not constitute limitations to the units or modules per se in some cases.

On the other hand, an embodiment of the present disclosure further provides a computer-readable storage medium, which may be a computer-readable storage medium comprised in the apparatus described in the above embodiments, or a computer-readable storage medium existed alone and not assembled in the device. The computer-readable storage medium stores one or more programs, which are adopted by one or more processors to perform the methods described in the embodiments of the present disclosure.

Those described above are just descriptions of the preferred embodiments of the present disclosure and the applied technical principles. Persons skilled in the art should understand that the invention scope involved in the embodiments of the present disclosure is not limited to the technical solutions formed by the specific combinations of the above technical features, and should cover other technical solutions formed by any combination of the above technical features or their equivalent features without departing from the invention concept, such as a technical solution formed by replacing the above features with

technical features with similar functions disclosed in (but not limited to) the embodiments of the present disclosure.

CLAIMS

1. A traffic simulation method, comprising:

5 acquiring traffic simulation initialization data, which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

 performing a road-based traffic simulation based on the traffic simulation initialization data; and

10 outputting a traffic simulation result.

2. The method according to claim 1, wherein performing the road-based traffic simulation based on the traffic simulation initialization data comprises:

 determining a traffic simulation calculation node;

 acquiring traffic area road attribute information, moving object attribute information
15 and moving object travel information corresponding to the traffic simulation calculation node; and

 determining a traffic simulation model, and performing a node-parallel traffic simulation using the traffic simulation model based on the traffic area road attribute information, the moving object attribute information and the moving object travel
20 information.

3. The method according to claim 2, wherein performing the road-based traffic simulation based on the traffic simulation initialization data further comprises:

 acquiring attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in
25 response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

 establishing a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on the attribute information of the adjacent traffic simulation calculation node; and

30 sending traffic simulation data related to the moving object having moved to the next adjacent traffic area to the adjacent traffic simulation calculation node.

4. The method according to any one of claims 1 to 3, wherein outputting the traffic simulation result comprises:

outputting the traffic simulation result at a preset simulation time interval.

5. The method according to claim 4, wherein outputting the traffic simulation result at the preset simulation time interval comprises:

collecting traffic simulation data generated by the traffic simulation calculation node
5 to obtain a traffic simulation data packet, in response to expiration of the preset simulation time interval; and

performing a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

6. The method according to any one of claims 2 to 5, further comprising:

10 updating, in response to receipt of traffic area road update information, the traffic area road attribute information and related traffic area road data in the traffic simulation calculation node based on the traffic area road update information.

7. The method according to any one of claims 2 to 6, further comprising:

performing a time alignment management for the traffic simulation calculation node.

15 8. The method according to any one of claims 1 to 7, further comprising executing, based on the traffic simulation result, at least one of:

a traffic facility control, a dynamically variable lane setting, a traffic guidance, a traffic flow restriction, or a navigation data adjustment.

9. A traffic simulation apparatus, comprising:

20 an acquisition module configured to acquire traffic simulation initialization data which comprises one or more of road attribute information, moving object attribute information, and moving object travel information;

a simulation module configured to perform a road-based traffic simulation based on the traffic simulation initialization data; and

25 an output module configured to output a traffic simulation result.

10. The apparatus according to claim 9, wherein the simulation module comprises:

a determination sub-module configured to determine a traffic simulation calculation node;

30 a first acquisition sub-module configured to acquire traffic area road attribute information, moving object attribute information and moving object travel information corresponding to the traffic simulation calculation node; and

a simulation sub-module configured to determine a traffic simulation model, and perform a node-parallel traffic simulation using the traffic simulation model based on the

traffic area road attribute information, the moving object attribute information and the moving object travel information.

11. The apparatus according to claim 10, wherein the simulation module further comprises:

5 a second acquisition sub-module configured to acquire attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

10 an establishing sub-module configured to establish a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on the attribute information of the adjacent traffic simulation calculation node; and

15 a transmission sub-module configured to send traffic simulation data related to the moving object having moved to the next adjacent traffic area to the adjacent traffic simulation calculation node.

12. The apparatus according to any one of claims 9 to 11, wherein the output module is configured to:

output a traffic simulation result at a preset simulation time interval.

13. The apparatus according to claim 12, wherein the output module comprises:

20 a collection sub-module configured to collect traffic simulation data generated by the traffic simulation calculation node to obtain a traffic simulation data packet, in response to expiration of the preset simulation time interval; and

a processing sub-module configured to perform a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

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

an updating module configured to update, in response to receipt of traffic area road update information, the traffic area road attribute information and related traffic area road data in the traffic simulation calculation node based on the traffic area road update information.

30 15. The apparatus according to any one of claims 10 to 14, further comprising:

a management module configured to perform a time alignment management for the traffic simulation calculation node.

16. The apparatus according to any one of claims 9 to 15, further comprising:

an execution module configured to execute, based on the traffic simulation result, at least one of:

a traffic facility control, a dynamically variable lane setting, a traffic guidance, a traffic flow restriction, or a navigation data adjustment.

5 17. A traffic simulation system, comprising:

a memory configured to store and update traffic simulation initialization data, and provide corresponding requested data in response to a data acquisition request, wherein the traffic simulation initialization data comprises one or more of road attribute information, moving object attribute information and moving object travel information;

10 a traffic simulation calculation cluster coupled to the memory, and configured to perform a road-based traffic simulation based on the traffic simulation initialization data, wherein the traffic simulation calculation cluster comprises two or more traffic simulation calculation nodes; and

an aggregation server coupled to the traffic simulation calculation cluster, and
15 configured to aggregate traffic simulation data of the traffic simulation calculation cluster and output a traffic simulation result.

18. The system according to claim 17, wherein the two or more traffic simulation calculation nodes perform a region-parallel simulation for the respective traffic areas.

19. The system according to claim 18, wherein the traffic simulation calculation node
20 is further configured to:

acquire attribute information of an adjacent traffic simulation calculation node corresponding to a next adjacent traffic area in a moving direction of a moving object, in response to detecting that the moving object leaves a traffic area corresponding to a preset traffic simulation calculation node;

25 establish a communication between the preset traffic simulation calculation node and the adjacent traffic simulation calculation node, based on the attribute information of the adjacent traffic simulation calculation node; and

send traffic simulation data related to the moving object having moved to the next adjacent traffic area to the adjacent traffic simulation calculation node.

30 20. The system according to any one of claims 17 to 19, wherein the memory comprises:

a name server configured to store the road attribute information; and

a simulation memory configured to store the moving object attribute information and

the moving object travel information.

21. The system according to claim 20, wherein the name server is a master-slave backup server.

22. The system according to any one of claims 17 to 21, wherein the memory is
5 further configured to update, in response to receipt of road update information, the road attribute information based on the road update information; and

the traffic simulation calculation node is further configured to update, in response to receipt of the road update information, related traffic area road data based on the road update information.

10 23. The system according to any one of claims 17 to 21, wherein the aggregation server is further configured to output a traffic simulation result at a preset simulation time interval.

24. The system according to claim 23, wherein the aggregation server is configured to:

15 collect traffic simulation data generated by the traffic simulation calculation node to obtain a traffic simulation data packet, in response to expiration of the preset simulation time interval; and

perform a preset aggregation process on the traffic simulation data packet to obtain the traffic simulation result.

20 25. The system according to any one of claims 17 to 24, further comprising:

a clock synchronization server coupled to the traffic simulation calculation cluster and/or the aggregation server, and configured to perform a time alignment management for data in the traffic simulation calculation node and/or the aggregation server.

26. An electronic device, comprising a memory and a processor, wherein

25 the memory is configured to store one or more computer instructions, which are executed by the processor to implement the steps in the method according to any one of claims 1 to 8.

27. A computer-readable storage medium storing computer instructions which implement, when executed by a processor, the steps in the method according to any one of
30 claims 1 to 8.