

TOKEN MANAGEMENT AND INFORMATION FORWARDING METHODS AND APPARATUSES, DEVICE, AND STORAGE MEDIUM

TECHNICAL FIELD

[0001] The present disclosure relates to the technology field of network communication, and in particular to a token management method and apparatus, an information forwarding method and apparatus, an electronic device, and a non-transitory computer readable storage medium storing computer instructions.

BACKGROUND

[0002] In a network transmission scenario, there is often a need for rate limiting and shaping of traffic. Main algorithms used for traffic rate limiting and traffic shaping are the token bucket algorithm and the leaky bucket algorithm. The basic principle thereof is the producer-consumer model. A producer produces tokens at a constant rate and uses a token bucket to store the produced tokens, while a consumer randomly arrives to consume the tokens in the token bucket. When there is no token in the token bucket, the consumer cannot consume, thereby achieving the effect of rate limiting and shaping.

[0003] In a high-speed network transmission scenario, network traffic is quite large, and network devices mostly use multi-core processors to concurrently process data messages. However, for the token bucket algorithm, it forms a scenario of a producer and multiple consumers (each central processor CPU core is one consumer). In a case where multiple cores share the same token bucket, it easily leads to CPU cache conflict, and cross-core access by the consumers when they have needs is easy to cause performance degradation, the efficiency of token scheduling is low, resulting in that the efficiency of information forwarding is low.

SUMMARY

[0004] The present disclosure at least provides a token management method and apparatus, an information forwarding method and apparatus, an electronic device, and a non-transitory computer readable storage medium storing computer instructions, to solve the above at least one technical problem.

[0005] According to one aspect of the present disclosure, there is provided a token management method, applied to a token scheduling module, which includes:

[0006] acquiring token data corresponding to respective autonomous token objects respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1;

[0007] analyzing the token data corresponding to the respective autonomous token objects to obtain a comprehensive token supply and demand state; and

[0008] allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and respective token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

[0009] In one possible implementation, a speed of producing the tokens by the autonomous token objects producing the tokens is one-Nth of a preset rate; wherein N is a number of the autonomous token objects producing the tokens; and/or,

[0010] the autonomous token object is provided with a token bucket for storing the tokens.

[0011] In one possible implementation, the analyzing the token data corresponding to the respective autonomous token objects to obtain the comprehensive token supply and demand state, includes:

[0012] analyzing the token data corresponding to the respective autonomous token objects, to determine token statistical data; and

[0013] determining the comprehensive token supply and demand state according to the token statistical data.

[0014] In one possible implementation, the token data includes a number of lacked tokens of the corresponding autonomous token object; the token data of the autonomous token object for producing the tokens further includes a number of surplus tokens; the token statistical data include a total number of surplus tokens, a total number of lacked tokens, a total number of basic tokens, and a total number of negative tokens;

[0015] the analyzing the token data corresponding to the respective autonomous token objects, to determine the token statistical data, includes:

[0016] for each of the autonomous token objects, determining a number of basic tokens and a number of negative tokens of the autonomous token object according to a

preset maximum basic token number and a number of lacked tokens corresponding to the autonomous token object;

[0017] calculating a sum of numbers of surplus tokens corresponding to at least part of the autonomous token objects, to obtain the total number of surplus tokens;

[0018] calculating a sum of numbers of lacked tokens corresponding to at least part of the autonomous token objects, to obtain the total number of lacked tokens; and

[0019] calculating a sum of numbers of basic tokens corresponding to at least part of the autonomous token objects, to obtain the total number of basic tokens; and

[0020] calculating a sum of numbers of negative tokens corresponding to at least part of the autonomous token objects, to obtain the total number of negative tokens.

[0021] In one possible implementation, the token statistical data includes the total number of surplus tokens and the total number of lacked tokens;

[0022] the determining the comprehensive token supply and demand state according to the token statistical data, includes:

[0023] in a case where the total number of surplus tokens is greater than the total number of lacked tokens, determining the comprehensive token supply and demand state to be a first supply and demand state; wherein the first supply and demand state is used for representing that an overall token producing speed is greater than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of basic tokens of each of the respective autonomous token objects is the preset maximum basic token number.

[0024] In one possible implementation, the token data includes a number of surplus tokens and a number of lacked tokens of the corresponding autonomous token object;

[0025] the allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the token data, includes:

[0026] in a case where the comprehensive token supply and demand state is the first supply and demand state, for each first autonomous token object whose number of basic tokens is less than the maximum basic token number, setting a number of reward tokens of the first autonomous token object as a number of lacked tokens of the first autonomous token object.

[0027] In one possible implementation, the token statistical data include a total number of surplus tokens, a total number of basic tokens, and a total number of negative tokens;

[0028] the determining the comprehensive token supply and demand state according to the token statistical data, includes:

[0029] in a case where a sum of the total number of surplus tokens and the total number of basic tokens is less than the total number of negative tokens, determining the comprehensive token supply and demand state to be a second supply and demand state; wherein the second supply and demand state is used for representing that an overall token producing speed is less than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of negative tokens of each of the respective autonomous token objects is greater than zero.

[0030] In one possible implementation, the allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the token data, includes:

[0031] in a case where the comprehensive token supply and demand state is the second supply and demand state, calculating a difference value obtained by subtracting the total number of surplus tokens and the total number of basic tokens from the total number of negative tokens;

[0032] calculating a quotient obtained by dividing the difference value by the number of the autonomous token objects, to obtain an average number of negative tokens; and

[0033] for each of the autonomous token objects, determining a number of reward tokens of the autonomous token object according to the token data of the autonomous token object and the average number of negative tokens.

[0034] In one possible implementation, the token statistical data include a total number of surplus tokens, a total number of basic tokens, and a total number of negative tokens;

[0035] the determining the comprehensive token supply and demand state according to the token statistical data, includes:

[0036] in a case where a sum of the total number of surplus tokens and the total number of basic tokens is greater than the total number of negative tokens, and the total number of negative tokens is greater than the total number of surplus tokens, determining

the comprehensive token supply and demand state to be a third supply and demand state; wherein the third supply and demand state is used for representing that an overall token producing speed is less than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of basic tokens of each of the respective autonomous token objects is greater than zero, and is less than or equal to a maximum basic token number.

[0037] In one possible implementation, the token data includes a number of surplus tokens and a number of lacked tokens of the corresponding autonomous token object;

[0038] the allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the token data, includes:

[0039] in a case where the comprehensive token supply and demand state is the third supply and demand state, for each second autonomous token object whose number of basic tokens is less than the maximum basic token number, determining a token lacking proportion of the second autonomous token object according to a number of lacked tokens of the second autonomous token object and the total number of lacked tokens; and

[0040] determining a number of reward tokens of the second autonomous token object according to the total number of surplus tokens and the token lacking proportion.

[0041] In one possible implementation, the token management method further includes:

[0042] setting a balance horizontal line for a token bucket of the autonomous token object; wherein a value corresponding to the balance horizontal line is a number of tokens in the token bucket when token production of the autonomous token object is balanced with token consumption;

[0043] taking tokens in a token area above the balance horizontal line as surplus tokens;

[0044] taking tokens in a token area below the balance horizontal line and above a zero line as basic tokens; wherein the zero line represents a positive and negative boundary line of the number of tokens in the token bucket;

[0045] in a case where the number of tokens in the token bucket is less than the value corresponding to the balance horizontal line, and the number of tokens in the token

bucket is a positive value, taking tokens in an empty token area between the basic tokens and the balance horizontal line as lacked tokens; and

[0046] in a case where the number of tokens in the token bucket is a negative value, taking tokens in an empty token area below the zero line as negative tokens, and taking tokens in an empty token area below the balance horizontal line and below the zero line as lacked tokens.

[0047] According to another aspect of the present disclosure, there is provided an information forwarding method, which includes:

[0048] reporting, by respective autonomous token objects, token data to a token scheduling module respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1; and

[0049] receiving, by the token scheduling module, the token data reported by the respective autonomous token objects, determining a comprehensive token supply and demand state based on the received token data, and allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

[0050] According to another aspect of the present disclosure, there is provided a token management apparatus, applied to a token scheduling module, which includes:

[0051] a data acquisition unit, configured for acquiring token data corresponding to respective autonomous token objects respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1;

[0052] a supply and demand analysis unit, configured for analyzing the token data corresponding to the respective autonomous token objects to obtain a comprehensive token supply and demand state; and

[0053] a token allocation unit, configured for allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

[0054] According to another aspect of the present disclosure, there is provided an information forwarding apparatus, which includes at least one token processing module

provided with an autonomous token object and a token scheduling module; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1;

[0055] the token processing module is configured for using respective autonomous token objects to report token data to the token scheduling module respectively; and

[0056] the token scheduling module is configured for receiving the token data reported by the respective autonomous token objects, determining a comprehensive token supply and demand state based on the received token data, and allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

[0057] According to another aspect of the present disclosure, there is provided an electronic device, which includes:

[0058] at least one processor; and

[0059] a memory communicatively connected to the at least one processor; wherein,

[0060] the memory stores instructions that are executable by the at least one processor, and the instructions are executed by the at least one processor, to enable the at least one processor to perform the method in any one of the embodiments of the present disclosure.

[0061] According to another aspect of the present disclosure, there is provided a non-transitory computer readable storage medium storing computer instructions, wherein the computer instructions are used for causing a computer to perform the method in any one of the embodiments of the present disclosure.

[0062] The present disclosure provides a token management method and apparatus, an information forwarding method and apparatus, an electronic device, and a non-transitory computer readable storage medium storing computer instructions. According to the present disclosure, a token scheduling module is used to analyze token data corresponding to respective autonomous token objects, to obtain a comprehensive token supply and demand state; and reward tokens are allocated to the respective autonomous token objects according to the comprehensive token supply and demand state and the token data corresponding to the respective autonomous token objects.

Herein, at least part of the autonomous token objects is used to produce and consume tokens, forming a multi-producer-multi-consumer model. According to the present disclosure, the manner for uniformly scheduling the reward tokens for the respective autonomous token objects by the token scheduling module can overcome the defect of performance degradation caused by accusing a public token bucket by the autonomous token objects in a cross-core way, when they have token requirements in a multi-core scenario, thereby improving the token allocation efficiency, and being beneficial to improve the information forwarding efficiency. In addition, the autonomous token object in the present disclosure may produce tokens, and is provided with a token bucket for storing the tokens, so that the problem of CPU cache conflict caused by multi-core access to the public token bucket can be effectively solved.

[0063] It should be understood that the contents described in this section are not intended to identify key or important features of embodiments of the present disclosure, and also are not intended to limit the scope of the present disclosure. Other features of the present disclosure will become easily understood from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0064] The drawings are used to better understand the solution and do not constitute a limitation to the present disclosure. In the drawings:

[0065] FIG. 1 is a flow chart of a token management method according to the present disclosure;

[0066] FIG. 2 is a schematic diagram of a multi-producer-multi-consumer model according to the present disclosure;

[0067] FIG. 3 is a schematic diagram of a token bucket according to the present disclosure;

[0068] FIG. 4 is a schematic flow chart of an information forwarding method according to the present disclosure;

[0069] FIG. 5 is a flow chart of another information forwarding method according to the present disclosure;

[0070] FIG. 6 is a schematic structural diagram of a token management apparatus according to the present disclosure;

[0071] FIG. 7 is a schematic structural diagram of an information forwarding apparatus according to the present disclosure; and

[0072] FIG. 8 is a schematic structural diagram of an electronic device according to the present disclosure.

DETAILED DESCRIPTION

[0073] The exemplary embodiments of the present disclosure will be described below in combination with drawings, including various details of the embodiments of the present disclosure to facilitate understanding, which should be considered as exemplary only. Therefore, those of ordinary skill in the art should realize that various changes and modifications may be made to the embodiments described herein without departing from the scope and spirit of the present disclosure. Likewise, the description of well-known functions and structures are omitted in the following description for clarity and conciseness.

[0074] In order to solve a problem about performance of token buckets under a multi-core heavy traffic scenario, the present disclosure provides token management and information forwarding methods and apparatuses, an electronic device, and a storage medium. According to the present disclosure, a token scheduling module is used to analyze token data corresponding to respective autonomous token objects, to obtain a comprehensive token supply and demand state; and reward tokens are allocated to the respective autonomous token objects according to the comprehensive token supply and demand state and the token data corresponding to the respective autonomous token objects. Herein, at least part of the autonomous token objects is used to produce and consume tokens. According to the present disclosure, the defect of performance degradation caused by accessing a public token bucket by the autonomous token objects in a cross-core way, when they have token requirements in a multi-core scenario, can be overcome, thereby improving the token allocation efficiency, and being beneficial to improve the information forwarding efficiency. In addition, the autonomous token object in the present disclosure may produce tokens, and is provided with a token bucket for storing the tokens, so that the problem of CPU cache conflict caused by multi-core access to the public token bucket can be effectively solved.

[0075] The token management method of the present disclosure will be described below by specific embodiments.

[0076] FIG. 1 shows a flow chart of a token management method of an embodiment of the present disclosure. The execution subject of the embodiment may be a terminal having a computing capability or a token scheduling module provided on a terminal having a computing capability. As shown in FIG. 1, the token management method of the present disclosure may include the following steps S110-S130.

[0077] At S110, acquiring token data corresponding to respective autonomous token objects respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1;

[0078] The above autonomous token objects are used for forwarding information by using a token(s), which may be a CPU core or an instance of a CPU core. In addition, at least part of the autonomous token objects may also be used for producing tokens for sending information, and a rate at which the autonomous token objects produce the tokens is one-Nth of a preset rate, wherein N is the number of the autonomous token objects for producing the tokens. The autonomous token object may also be a pure token consumption object, that is, it cannot produce a token, and can only consume a token(s) to send or transmit information. The autonomous token object is provided with a token bucket for storing tokens.

[0079] Illustratively, the token scheduling module may actively acquire the token data corresponding to the respective autonomous token objects according to a preset period. The respective autonomous token objects may upload the corresponding token data to the token scheduling module according to the preset period, and the token scheduling module passively acquires the token data corresponding to the respective autonomous token objects.

[0080] Illustratively, the respective autonomous token objects may synchronously upload the token data, and also may asynchronously upload the token data, which is not limited by the present disclosure.

[0081] A local timer on each autonomous token object is triggered to report local token data to the token scheduling module. The reporting mode may use function call, memory sharing and the like.

[0082] Illustratively, the token data of an autonomous token object may include the number of lacked tokens. The token data of an autonomous token object for

producing tokens also include the number of surplus tokens. On the premise that an autonomous token object has already got required tokens to forward information, the surplus tokens are remaining tokens of the autonomous token object other than the above tokens required for forwarding information. This part of tokens can be provided to other autonomous token objects for use. The lacked tokens refer to additional tokens required for the autonomous token object to meet its requirements to forward information. If an autonomous token object is capable of producing tokens and the number of lacked tokens is greater than zero, it indicates that the speed of producing the tokens by the autonomous token object is less than the speed of consuming the tokens by the autonomous token object.

[0083] At S120, analyzing the token data corresponding to the respective autonomous token objects to obtain a comprehensive token supply and demand state.

[0084] Because at least part of the autonomous token objects produces the tokens while consuming the tokens, analyzing the token data corresponding to the respective autonomous token objects may determine the comprehensive token supply and demand state, and the comprehensive token supply and demand state is used for representing whole token production and consumption condition of the respective autonomous token objects.

[0085] At S130, allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and respective token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

[0086] The reward token is allocated for the respective autonomous token objects according to the whole token production and consumption condition, which can improve the rationality and fairness of reward token allocation.

[0087] At least part of autonomous token object may produce and consume the token, realizing a multi-producer-multi-consumer model. As shown in FIG. 2, the autonomous token object capable of producing tokens is provided with a local producer and a local consumer (local data packet queue) to maintain a local token bucket. The local producer puts the produced tokens into the local token bucket, and the consumer consumes tokens from the local token bucket. When there is no token in the local token bucket, the data packet is discarded, achieving the rate limiting effect. An autonomous token object who only consumes, namely a pure token consumption object, is provided

with a local consumer (local data packet queue) to maintain a local token bucket. The consumer consumes tokens from the local token bucket, which is not used for producing tokens.

[0088] In the above embodiment, one token scheduling module is used to coordinate the number of tokens in the token buckets of the respective autonomous token objects, thereby solving the problem about performance of token buckets under the multi-core heavy traffic scenario, realizing the token scheduling among the multiple token buckets, improving the token scheduling rate under the multi-core heavy traffic scenario, while taking into account the fairness among the autonomous token objects.

[0089] In some embodiments, a balance horizontal line is set for the token bucket, wherein a value corresponding to the balance horizontal line is the number of tokens meeting supply and demand balance. The value is the number of tokens in the token bucket when token production is balanced with token consumption. The balance horizontal line is presented by a reference number 31 in FIG. 3.

[0090] The tokens of the autonomous token object that are more than the number of tokens meeting supply and demand balance are surplus tokens. As shown in FIG. 3, the surplus tokens 32 are tokens in a token area above the balance horizontal line. The maximum number of surplus tokens 33 corresponds to the upper limit of the token bucket capacity, and tokens exceeding the upper limit are directly discarded. As long as the token scheduling module allocates reward tokens at a sufficiently small interval, for example, less than a preset value, the number of tokens in the token bucket will not exceed the upper limit of the token bucket capacity.

[0091] As shown in FIG. 3, tokens in the token area below the balance horizontal line and above a zero line are basic tokens 34. The maximum basic token number 35 is the number of tokens meeting supply and demand balance corresponding to the balance horizontal line. The zero line represents the positive and negative boundary line for the number of tokens in the token bucket, and if the number of tokens in the token bucket is lower than the boundary line, the suppression of consumption is triggered, such as discarding packets or caching data packets.

[0092] As shown in FIG. 3, if the number of tokens in the token bucket is less than the number of tokens meeting supply and demand balance corresponding to the balance horizontal line, tokens corresponding to this empty token area between the basic tokens to the balance horizontal line are lacked tokens 36.

[0093] As shown in FIG. 3, the number of lacked tokens 36 may be greater than the maximum basic token number. At this time, the number of tokens in the token bucket may be a negative number, and the lacked tokens below the zero line are taken as negative tokens 37, that is, tokens in the empty token area below the zero line are taken as negative tokens. The state that there is a negative token is generally caused by burst traffic or a special scenario. Since token consumption is suppressed in this state, it will not stay in this state for a long time.

[0094] When the number of tokens in the token bucket of a certain autonomous token object is greater than the value corresponding to the balance horizontal line, it represents that the production speed of the autonomous token object is greater than the consumption speed. At this time, surplus tokens may be provided to the token scheduling module to be allocated by the token scheduling module to other autonomous token objects for use. When the number of tokens in the token bucket is less than the value corresponding to the balance horizontal line, and is a positive value, it represents that the production speed of the autonomous token object is slightly less than the consumption speed, and is close to the balance state. At this time, the number of lacked tokens needs to be reported to the token scheduling module, and tokens from other autonomous token objects are allocated by the token scheduling module to satisfy the token demand of this autonomous token object. When the number of tokens in the token bucket is less than 0, it represents that the consumption speed is far greater than the production speed. At this time, data packets are cached or discarded, so as to reach the rate limiting effect. The purpose of control via the token allocation algorithm of the present disclosure is to ensure as much as possible that the number of tokens in the token bucket is between the zero line and the balance horizontal line.

[0095] In some embodiments, the analyzing the token data corresponding to the respective autonomous token objects to obtain the comprehensive token supply and demand state may be specifically realized by the following steps:

[0096] firstly, analyzing the token data corresponding to the respective autonomous token objects, to determine token statistical data; and then determining the comprehensive token supply and demand state according to the token statistical data.

[0097] Illustratively, the token statistical data include the total number of surplus tokens, the total number of lacked tokens, the total number of basic tokens, and the total number of negative tokens. In addition to the number of surplus tokens and the number

of lacked tokens, the token data of the autonomous token object may also include the number of negative tokens and the number of basic tokens. Herein, the number of basic tokens is the number of basic tokens actually owned by the autonomous token object, i.e., the number of actual basic tokens. The maximum basic token number is preset, and the number of basic tokens and the number of negative tokens of the autonomous token object may be determined according to the number of lacked tokens and the maximum basic token number of the autonomous token object. Specifically, if the number of lacked tokens is less than or equal to the maximum basic token number, the maximum basic token number subtracts the number of lacked tokens to obtain the number of basic tokens, and the number of negative tokens is zero. If the number of lacked tokens is greater than the maximum basic token number, the number of basic tokens of the autonomous token object is zero, and the number of lacked tokens subtracts the maximum basic token number to obtain the number of negative tokens.

[0098] The number of basic tokens and the number of negative tokens of each autonomous token object may be determined in accordance with the above manner. In addition, the number of basic tokens and the number of negative tokens of each autonomous token object may also be reported to the token scheduling module by each autonomous token object, which is not limited by the present disclosure.

[0099] After the number of surplus tokens, the number of lacked tokens, the number of basic tokens and the number of negative tokens of each autonomous token object are obtained, the following steps may be used to determine the token statistical data:

[0100] calculating a sum of numbers of surplus tokens corresponding to at least part of the autonomous token objects, to obtain the total number of surplus tokens; calculating a sum of numbers of lacked tokens corresponding to at least part of the autonomous token objects, to obtain the total number of lacked tokens; calculating a sum of numbers of basic tokens corresponding to at least part of the autonomous token objects, to obtain the total number of basic tokens; and calculating a sum of numbers of negative tokens corresponding to at least part of the autonomous token objects, to obtain the total number of negative tokens.

[0101] The token statistical data may represent the overall numbers of tokens. According to the numbers, the comprehensive token supply and demand state may be determined more accurately. Illustratively, it may be realized by the following steps:

[0102] in a case where the total number of surplus tokens is greater than the total number of lacked tokens, determining the comprehensive token supply and demand state to be a first supply and demand state; wherein the first supply and demand state is used for representing that an overall token producing speed is greater than an overall token consuming speed, which can satisfy token requirements of all autonomous token objects, and after reward tokens are allocated for the respective autonomous token objects, the number of basic tokens of each of the respective autonomous token objects is the preset maximum basic token number; or after reward tokens are allocated for the respective autonomous token objects, the number of surplus tokens of each of the respective autonomous token objects is greater than or equal to zero.

[0103] In the first supply and demand state, tokens of the same number as the number of lacked tokens are supplemented to autonomous token objects lacking tokens. Specifically, the following steps may be used to schedule the tokens:

[0104] firstly, for each first autonomous token object whose number of basic tokens is less than the maximum basic token number, setting a number of reward tokens of the first autonomous token object as a number of lacked tokens of the first autonomous token object. Here, the number of the reward tokens is a positive value.

[0105] Herein, for each third autonomous token object whose number of surplus tokens is greater than zero, the surplus tokens of the third autonomous token object have been contributed and provided to the token scheduling module when the token data are reported. At this time, the number of surplus tokens of the third autonomous token object is 0, the number of reward tokens is 0, and the number of basic tokens is the maximum basic token number.

[0106] In some embodiments, determining the comprehensive token supply and demand state according to the token statistical data may also be realized by the following steps:

[0107] in a case where a sum of the total number of surplus tokens and the total number of basic tokens is less than the total number of negative tokens, determining the comprehensive token supply and demand state to be a second supply and demand state; wherein the second supply and demand state is used for representing that an overall token producing speed is far less than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of negative tokens of each of the respective autonomous token objects is greater than zero.

In this state, the tokens in all token buckets cannot be maintained between the zero line and the balance horizontal line. After the reward token(s) is allocated to each autonomous token object, each token bucket is in a negative token state.

[0108] In the second supply and demand state, the following steps may be specifically used to schedule the tokens:

[0109] firstly, calculating a difference value obtained by subtracting the total number of surplus tokens and the total number of basic tokens from the total number of negative tokens; then, calculating a quotient obtained by dividing the difference value by the number of the autonomous token objects, to obtain an average number of negative tokens; wherein the average number of negative tokens represents the number of negative tokens of each autonomous token object when the token scheduling is completed; finally, for each autonomous token object, determining the number of reward tokens of the autonomous token object according to the token data of the autonomous token object and the average number of negative tokens. Here, when the number of reward tokens is determined, it is necessary to take the average number of negative tokens as a target, combining the token data of each autonomous token object. Here, the number of the reward tokens may be a negative value, or a positive value. For example, the number of reward tokens for each autonomous token object may be determined according to the number of surplus tokens, the number of basic tokens, the number of lacked tokens, etc. For example, if the number of basic tokens of a certain autonomous token object is greater than zero, the number of reward tokens of the autonomous token object is a negative value with the same absolute value as the sum of the number of basic tokens of this autonomous token object and the average number of negative tokens.

[0110] In some embodiments, determining the comprehensive token supply and demand state according to the token statistical data may also be realized by the following steps:

[0111] in a case where a sum of the total number of surplus tokens and the total number of basic tokens is greater than the total number of negative tokens, and the total number of negative tokens is greater than the total number of surplus tokens, determining the comprehensive token supply and demand state to be a third supply and demand state; wherein the third supply and demand state is used for representing that an overall token producing speed is less than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of basic tokens of

each of the respective autonomous token objects is greater than zero, and is less than or equal to the maximum basic token number. That is, after the reward tokens are allocated for respective autonomous token objects, tokens in the token buckets of all the autonomous token objects may be maintained between the zero line and the balance horizontal line. In this state, the token consumption requirements of all autonomous token objects cannot be met by the scheduling of the token scheduling module.

[0112] In the third supply and demand state, in order to ensure the fairness, the token scheduling may be performed according to a token lacking proportion of each autonomous token object, specifically:

[0113] for each second autonomous token object whose number of basic tokens is less than the maximum basic token number, determining a token lacking proportion of the second autonomous token object according to the number of lacked tokens of the second autonomous token object and the total number of lacked tokens; for example, the value obtained by dividing the number of lacked tokens by the total number of lacked tokens is taken as the token lacking proportion of the second autonomous token object; then, determining the number of reward tokens of the second autonomous token object according to the total number of surplus tokens and the token lacking proportion. For example, the product of the token lacking proportion and the total number of surplus tokens is calculated to obtain the number of the reward tokens of the second autonomous token object. The number of the reward tokens here is a positive value or zero.

[0114] Herein, for each third autonomous token object whose number of surplus tokens is greater than zero, the surplus tokens of the third autonomous token object have been contributed and provided to the token scheduling module when the token data are reported. At this time, the number of surplus tokens of the third autonomous token object is 0, the number of reward tokens is 0, and the number of basic tokens is the maximum basic token number.

[0115] After the numbers of reward tokens of respective autonomous token objects are determined, the reward token distribution stage is entered, and tokens are allocated to the respective autonomous token objects respectively according to the numbers of reward tokens of the respective autonomous token objects.

[0116] According to the above embodiments, the single-producer-multi-consumer token scheduling mode is converted into the multi-producer-multi-consumer mode, and the token scheduling module schedules the surplus tokens, solving the

problem of token scheduling efficiency under the multi-core heavy traffic scenario, while taking into account the fairness of token allocation among the respective autonomous token objects.

[0117] As shown in FIG. 4, corresponding to the above token management method, the present disclosure also provides an information forwarding method, including:

[0118] S410, reporting, by respective autonomous token objects, token data to a token scheduling module respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1.

[0119] S420, receiving, by the token scheduling module, the token data reported by the respective autonomous token objects, determining a comprehensive token supply and demand state based on the received token data, and allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

[0120] The autonomous token objects and the token scheduling module in this embodiment are the same as the autonomous token objects and the token scheduling module in the above embodiment, so the duplicate content will not be repeated.

[0121] In some embodiments, as shown in FIG. 5, the information forwarding method of the present disclosure may include the following steps:

[0122] step one, reporting, by respective autonomous token objects, token data to a token scheduling module;

[0123] step two, checking, by the token scheduling module, whether all the autonomous token objects have completed the reporting, if all the autonomous token objects have completed the reporting, executing step three, otherwise, continuing to wait, or notifying the autonomous token objects to report the token data.

[0124] step three, analyzing the token data corresponding to the respective autonomous token objects, and determining token statistical data.

[0125] step four, determining the comprehensive token supply and demand state according to the token statistical data; if the comprehensive token supply and demand state is a first supply and demand state, an overall token producing speed is greater than an overall token consuming speed, setting the number of reward tokens of each autonomous token object lacking tokens as the number of lacked tokens thereof; if the

comprehensive token supply and demand state is a second supply and demand state, the overall token producing speed is far less than the overall token consuming speed, determining an average number of negative tokens, and determining the number of reward tokens of each autonomous token object according to the average number of negative tokens; if the comprehensive token supply and demand state is a third supply and demand state, the overall token producing speed is less than the overall token consuming speed, determining a token lacking proportion, and determining the number of reward tokens of each autonomous token object lacking tokens according to the token lacking proportion.

[0126] step five, allocating tokens to the respective autonomous token objects respectively according to the numbers of reward tokens of the respective autonomous token objects.

[0127] The above information forwarding method may realize traffic rate limiting. In an actual application, it may be published as a Linux kernel module and loaded into a kernel through insmod, and three-layer data packets (IP messages) are hooked through a kernel netfilter mechanism. When the Linux kernel module is loaded, multiple instances are established according to the core number of the CPU, namely autonomous token objects, each instance corresponds to one CPU core, a data packet received by the CPU core is received, and calculation is performed on local token buckets. As long as the local token bucket is not in a negative token state, the data packet is released. If the local token bucket is in the negative token state, the data packet is cached or discarded.

[0128] When a user configures a rate limiting parameter, a configuration interface averages the configuration parameter (generally the limiting rate, i.e., a preset rate of producing tokens) according to the number of the instances, and sends the averaged configuration parameter to respective instances. Local producers of the respective instances produce tokens according to the issued/received rate.

[0129] Based on the same inventive concept, an embodiment of the present disclosure also provides a token management apparatus corresponding to the token management method. Because the principle of solving the problem by the apparatus in the embodiment of the present disclosure is similar to that of the token management method in the embodiment of the present disclosure, the implementation of the apparatus

may refer to the implementation of the method, and the duplicate content will not be repeated.

[0130] As shown in FIG. 6, FIG. 6 is a schematic structural diagram of a token management apparatus provided by the embodiment of the present disclosure, including:

[0131] a data acquisition unit 610, configured for acquiring token data corresponding to respective autonomous token objects respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1;

[0132] a supply and demand analysis unit 620, configured for analyzing the token data corresponding to the respective autonomous token objects to obtain a comprehensive token supply and demand state; and

[0133] a token allocation unit 630, configured for allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

[0134] In some embodiments, a speed of producing the tokens by the autonomous token objects producing the tokens is one-Nth of a preset rate; wherein N is a number of the autonomous token objects producing the tokens; and/or, the autonomous token object is provided with a token bucket for storing the tokens.

[0135] In some embodiments, the supply and demand analysis unit 620, when analyzing the token data corresponding to the respective autonomous token objects to obtain the comprehensive token supply and demand state, is configured for:

[0136] analyzing the token data corresponding to the respective autonomous token objects, to determine token statistical data;

[0137] determining the comprehensive token supply and demand state according to the token statistical data.

[0138] In some embodiments, the token data includes a number of lacked tokens of the corresponding autonomous token object; the token data of the autonomous token object for producing the tokens further includes a number of surplus tokens; the token statistical data include a total number of surplus tokens, a total number of lacked tokens, a total number of basic tokens, and a total number of negative tokens;

[0139] the supply and demand analysis unit 620, when analyzing the token data corresponding to the respective autonomous token objects, to determine token statistical data, is configured for:

[0140] for each of the autonomous token objects, determining a number of basic tokens and a number of negative tokens of the autonomous token object according to a preset maximum basic token number and a number of lacked tokens corresponding to the autonomous token object;

[0141] calculating a sum of numbers of surplus tokens corresponding to at least part of the autonomous token objects, to obtain the total number of surplus tokens;

[0142] calculating a sum of numbers of lacked tokens corresponding to at least part of the autonomous token objects, to obtain the total number of lacked tokens; and

[0143] calculating a sum of numbers of basic tokens corresponding to at least part of the autonomous token objects, to obtain the total number of basic tokens; and

[0144] calculating a sum of numbers of negative tokens corresponding to at least part of the autonomous token objects, to obtain the total number of negative tokens.

[0145] In some embodiments, the token statistical data includes the total number of surplus tokens and the total number of lacked tokens;

[0146] the supply and demand analysis unit 620, when determining the comprehensive token supply and demand state according to the token statistical data, is configured for:

[0147] in a case where the total number of surplus tokens is greater than the total number of lacked tokens, determining the comprehensive token supply and demand state to be a first supply and demand state; wherein the first supply and demand state is used for representing that an overall token producing speed is greater than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of basic tokens of each of the respective autonomous token objects is the preset maximum basic token number.

[0148] In some embodiments, the token data includes a number of surplus tokens and a number of lacked tokens of the corresponding autonomous token object;

[0149] the token allocation unit 630, when allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the token data, is configured for:

[0150] in a case where the comprehensive token supply and demand state is the first supply and demand state, for each first autonomous token object whose number of basic tokens is less than the maximum basic token number, setting a number of reward tokens of the first autonomous token object as a number of lacked tokens of the first autonomous token object.

[0151] In some embodiments, the token statistical data includes a total number of surplus tokens, a total number of basic tokens, and a total number of negative tokens;

[0152] the supply and demand analysis unit 620, when determining the comprehensive token supply and demand state according to the token statistical data, is configured for:

[0153] in a case where a sum of the total number of surplus tokens and the total number of basic tokens is less than the total number of negative tokens, determining the comprehensive token supply and demand state to be a second supply and demand state; wherein the second supply and demand state is used for representing that an overall token producing speed is less than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of negative tokens of each of the respective autonomous token objects is greater than zero.

[0154] In some embodiments, the token allocation unit 630, when allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the token data, is configured for:

[0155] in a case where the comprehensive token supply and demand state is the second supply and demand state, calculating a difference value obtained by subtracting the total number of surplus tokens and the total number of basic tokens from the total number of negative tokens;

[0156] calculating a quotient obtained by dividing the difference value by the number of the autonomous token objects, to obtain an average number of negative tokens; and

[0157] for each of the autonomous token objects, determining a number of reward tokens of the autonomous token object according to the token data of the autonomous token object and the average number of negative tokens.

[0158] In some embodiments, the token statistical data includes a total number of surplus tokens, a total number of basic tokens, and a total number of negative tokens;

[0159] the supply and demand analysis unit 620, when determining the comprehensive token supply and demand state according to the token statistical data, is configured for:

[0160] in a case where a sum of the total number of surplus tokens and the total number of basic tokens is greater than the total number of negative tokens, and the total number of negative tokens is greater than the total number of surplus tokens, determining the comprehensive token supply and demand state to be a third supply and demand state; wherein the third supply and demand state is used for representing that an overall token producing speed is less than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of basic tokens of each of the respective autonomous token objects is greater than zero, and is less than or equal to the maximum basic token number.

[0161] In some embodiments, the token data include a number of surplus tokens and a number of lacked tokens of the corresponding autonomous token object;

[0162] the token allocation unit 630, when allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the token data, is configured for:

[0163] in a case where the comprehensive token supply and demand state is the third supply and demand state, for each second autonomous token object whose number of basic tokens is less than the maximum basic token number, determining a token lacking proportion of the second autonomous token object according to a number of lacked tokens of the second autonomous token object and the total number of lacked tokens; and

[0164] determining a number of reward tokens of the second autonomous token object according to the total number of surplus tokens and the token lacking proportion.

[0165] In some embodiments, the apparatus further includes a data definition unit 640 configured for:

[0166] setting a balance horizontal line for a token bucket of the autonomous token object; wherein a value corresponding to the balance horizontal line is a number of tokens in the token bucket when token production of the autonomous token object is balanced with token consumption;

[0167] taking tokens in a token area above the balance horizontal line as surplus tokens;

[0168] taking tokens in a token area below the balance horizontal line and above a zero line as basic tokens; wherein the zero line represents a positive and negative boundary line of the number of tokens in the token bucket;

[0169] in a case where the number of tokens in the token bucket is less than the value corresponding to the balance horizontal line, and the number of tokens in the token bucket is a positive value, taking tokens in an empty token area between the basic tokens and the balance horizontal line as lacked tokens; and

[0170] in a case where the number of tokens in the token bucket is a negative value, taking tokens in an empty token area below the zero line as negative tokens, and taking tokens in an empty token area below the balance horizontal line and below the zero line as lacked tokens.

[0171] Based on the same inventive concept, the present disclosure also provides an information forwarding apparatus corresponding to the information forwarding method. Because the principle of solving the problem by the apparatus in the embodiment of the present disclosure is similar to that of the information forwarding method in the embodiment of the present disclosure, the implementation of the apparatus may refer to the implementation of the method, and the duplicate content will not be repeated.

[0172] As shown in FIG. 7, FIG. 7 is a schematic structural diagram of an information forwarding apparatus provided by the embodiment of the present disclosure, including: at least one token processing module 710 provided with an autonomous token object and a token scheduling module 720.

[0173] The token processing module 710 is configured for using respective autonomous token objects to report token data to the token scheduling module respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1.

[0174] The token scheduling module 720 is configured for receiving the token data reported by the respective autonomous token objects, determining a comprehensive token supply and demand state based on the received token data, and allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

[0175] In the technical solutions of the present disclosure, the acquisition, storage, application, etc., of user personal information involved comply with the provisions of relevant laws and regulations, and do not violate public order and moral.

[0176] According to embodiments of the present disclosure, the present disclosure also provides an electronic device, a readable storage medium, and a computer program product.

[0177] FIG. 8 shows a schematic block diagram of an exemplary electronic device 800 that may be used to implement the embodiments of the present disclosure. The electronic device is intended to represent various forms of digital computers, such as laptop computers, desktop computers, workbenches, personal digital assistants, servers, blade servers, mainframe computers, and other suitable computers. The electronic device may also represent various forms of mobile apparatuses, such as personal digital assistants, cellular phones, smart phones, wearable devices, and other similar computing apparatuses. The components, their connections and relationships, and their functions shown herein are merely examples, and are not intended to limit the implementation of the present disclosure described and/or claimed herein.

[0178] As shown in FIG. 8, the device 800 includes a computing unit 810 that may perform various appropriate actions and processes according to a computer program stored in a read only memory (ROM) 820 or a computer program loaded from the storage unit 880 into a random access memory (RAM) 830. In the RAM 803, various programs and data required for the operation of the device 800 may also be stored. The computing unit 810, the ROM 820, and the RAM 830 are connected to each other through a bus 840. The input/output (I/O) interface 850 is also connected to the bus 840.

[0179] Multiple components in the device 800 are connected to the I/O interface 850, including: an input unit 860, for example, a keyboard, a mouse, etc.; an output unit 870, for example, various types of displays, speakers, etc.; a storage unit 880, for example, a magnetic disk, an optical disk, etc.; and a communication unit 890, for example, a network card, a modem, a wireless communication transceiver, etc. The communication unit 890 allows the device 800 to exchange information/data with other devices through computer networks such as the Internet and/or various telecommunication networks.

[0180] The computing unit 810 may be various general-purpose and/or special-purpose processing components with processing and computing capabilities. Some

examples of the computing unit 810 include, but are not limited to, a central processing unit (CPU), a graphics processing unit (GPU), various special-purpose artificial intelligence (AI) computing chips, various computing units running machine learning model algorithms, digital signal processors (DSP), and any appropriate processors, controllers, microcontrollers, etc. The computing unit 810 performs various methods and processes described above, for example, the token management method or the information forwarding method. For example, in some embodiments, the token management method or the information forwarding method may be implemented as a computer software program that is tangibly contained in a machine readable medium, for example, the storage unit 880. In some embodiments, part or all of the computer program may be loaded and/or installed on the device 800 via the ROM 820 and/or the communication unit 890. When the computer program is loaded into the RAM 830 and performed by computing unit 810, one or more steps of the token management method or the information forwarding method described above may be performed. Optionally, in other embodiments, the computing unit 810 may be configured for performing the token management method or the information forwarding method via any other suitable means (for example, by means of firmware).

[0181] Various implementation manners of the systems and technologies described above herein may be implemented in a digital electronic circuit system, an integrated circuit system, a field programmable gate array (FPGA), an application specific integrated circuit (ASIC), an application special standard product (ASSP), a system on chip (SOC), a complex programmable logic device (CPLD), a computer hardware, firmware, software and/or combinations thereof. These various implementation manners may include: implementations in one or more computer programs. The one or more computer programs may be executed and/or interpreted on a programmable system that includes at least one programmable processor. The programmable processor may be a special-purpose or general-purpose programmable processor, and may receive data and instructions from a storage system, at least one input apparatus, and at least one output apparatus, and transmit the data and instructions to the storage system, the at least one input apparatus, and the at least one output apparatus.

[0182] The program codes for implementing the method of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to the processor or controller of a general-purpose

computer, a special-purpose computer or other programmable data processing apparatuses, such that the program codes, when executed by the processor or controller, enables the functions/operations specified in the flowchart and/or block diagram to be implemented. The program codes may be executed completely on the machine, partially on the machine, partially on the machine and partially on the remote machine as a separate software package, or completely on the remote machine or server.

[0183] In the context of the present disclosure, a machine readable medium may be a tangible medium that may contain or store programs for use by or in combination with an instruction execution system, apparatus, or device. The machine readable medium may be a machine readable signal medium or a machine readable storage medium. The machine readable medium may include, but is not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus or device, or any suitable combination of the above contents. A more specific example of the machine readable storage medium will include an electrical connection based on one or more lines, a portable computer disk, a hard disk, a random access memory (RAM), a read only memory (ROM), an erasable programmable read only memory (EPROM or flash memory), an optical fiber, a portable compact disk read only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the above contents.

[0184] In order to provide interactions with a user, the system and technology described herein may be implemented on a computer. The computer has: a display apparatus (for example, a CRT (cathode ray tube) or an LCD (liquid crystal display) monitor) for displaying information to the user; and a keyboard and a pointing apparatus (for example, a mouse or a trackball), through which the user may provide input to the computer. Other kinds of apparatuses may also be used to provide interactions with a user; for example, the feedback provided to a user may be any form of sensory feedback (for example, visual feedback, auditory feedback, or tactile feedback); and input from a user may be received by using any form (including acoustic input, voice input, or tactile input).

[0185] The systems and techniques described herein may be implemented in a computing system (for example, as a data server) that includes back-end components, or be implemented in a computing system (for example, an application server) that includes middleware components, or be implemented in a computing system (for example, a user

computer with a graphical user interface or a web browser through which the user may interact with the implementation manner of the systems and technologies described herein) that includes front-end components, or be implemented in a computing system that includes any combination of such back-end components, intermediate components, or front-end components. The components of the system may be interconnected by any form or medium of digital data communication (for example, a communication network). The example of the communication network includes a local area network (LAN), a wide area network (WAN), and the Internet.

[0186] The computer system may include a client and a server. The client and the server are generally remote from each other and typically interact through a communication network. The client-server relationship is generated by computer programs that run on respective computers and have a client-server relationship with each other. The server may be a cloud server, a server of a distributed system, or a server that combines blockchain.

[0187] It should be understood that various forms of processes shown above may be used to reorder, add, or delete steps. For example, respective steps recited in the present disclosure may be executed in parallel, or may be executed sequentially, or may be executed in a different order, as long as the desired result of the technical solution disclosed in the present disclosure can be achieved, which is not limited herein.

[0188] The above specific implementation manners do not constitute a limitation on the protection scope of the present disclosure. It should be understood by those skilled in the art that various modifications, combinations, sub-combinations, and substitutions may be made according to design requirements and other factors. Any modification, equivalent replacement, and improvement, and the like made within the spirit and principle of the present disclosure shall be contained in the protection scope of the present disclosure.

CLAIMS

What is claimed is:

1. A token management method, applied to a token scheduling module, comprising:

acquiring token data corresponding to respective autonomous token objects respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1;

analyzing the token data corresponding to the respective autonomous token objects to obtain a comprehensive token supply and demand state; and

allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and respective token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

2. The method of claim 1, wherein the autonomous token object is provided with a token bucket for storing the tokens; and/or;

a speed of producing the tokens by the autonomous token objects producing the tokens is one-Nth of a preset rate; wherein N is a number of the autonomous token objects producing the tokens.

3. The method of claim 1 or 2, wherein the analyzing the token data corresponding to the respective autonomous token objects to obtain the comprehensive token supply and demand state, comprises:

analyzing the token data corresponding to the respective autonomous token objects, to determine token statistical data; and

determining the comprehensive token supply and demand state according to the token statistical data.

4. The method of claim 3, wherein the token data comprises a number of lacked tokens of the autonomous token object; the token data of the autonomous token object for producing the tokens further comprises a number of surplus tokens; the token statistical data comprises a total number of surplus tokens, a total number of lacked tokens, a total number of basic tokens, and a total number of negative tokens;

the analyzing the token data corresponding to the respective autonomous token objects, to determine the token statistical data, comprises:

for each of the autonomous token objects, determining a number of basic tokens and a number of negative tokens of the autonomous token object according to a preset maximum basic token number and a number of lacked tokens corresponding to the autonomous token object;

calculating a sum of numbers of surplus tokens corresponding to at least part of the autonomous token objects, to obtain the total number of surplus tokens; and calculating a sum of numbers of lacked tokens corresponding to at least part of the autonomous token objects, to obtain the total number of lacked tokens; and

calculating a sum of numbers of basic tokens corresponding to at least part of the autonomous token objects, to obtain the total number of basic tokens; and calculating a sum of numbers of negative tokens corresponding to at least part of the autonomous token objects, to obtain the total number of negative tokens.

5. The method of claim 4, wherein the token statistical data comprises the total number of surplus tokens and the total number of lacked tokens;

the determining the comprehensive token supply and demand state according to the token statistical data, comprises:

in a case where the total number of surplus tokens is greater than the total number of lacked tokens, determining the comprehensive token supply and demand state to be a first supply and demand state; wherein the first supply and demand state is used for representing that an overall token producing speed is greater than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous

token objects, the number of basic tokens of each of the respective autonomous token objects is the preset maximum basic token number.

6. The method of claim 5, wherein the token data comprises the number of surplus tokens and the number of lacked tokens of the autonomous token object;

the allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the respective token data, comprises:

in a case where the comprehensive token supply and demand state is the first supply and demand state, for each first autonomous token object whose number of basic tokens is less than the maximum basic token number, setting a number of reward tokens of the first autonomous token object as a number of lacked tokens of the first autonomous token object.

7. The method of claim 3, wherein the token statistical data comprises a total number of surplus tokens, a total number of basic tokens, and a total number of negative tokens;

the determining the comprehensive token supply and demand state according to the token statistical data, comprises:

in a case where a sum of the total number of surplus tokens and the total number of basic tokens is less than the total number of negative tokens, determining the comprehensive token supply and demand state to be a second supply and demand state; wherein the second supply and demand state is used for representing that an overall token producing speed is less than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of negative tokens of each of the respective autonomous token objects is greater than zero.

8. The method of claim 7, wherein the allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the respective token data, comprises:

in a case where the comprehensive token supply and demand state is the second supply and demand state, calculating a difference value obtained by subtracting the total number of surplus tokens and the total number of basic tokens from the total number of negative tokens;

calculating a quotient obtained by dividing the difference value by the number of the autonomous token objects, to obtain an average number of negative tokens; and

for each of the autonomous token objects, determining a number of reward tokens of the autonomous token object according to the token data of the autonomous token object and the average number of negative tokens.

9. The method of claim 3, wherein the token statistical data comprises a total number of surplus tokens, a total number of basic tokens, and a total number of negative tokens;

the determining the comprehensive token supply and demand state according to the token statistical data, comprises:

in a case where a sum of the total number of surplus tokens and the total number of basic tokens is greater than the total number of negative tokens, and the total number of negative tokens is greater than the total number of surplus tokens, determining the comprehensive token supply and demand state to be a third supply and demand state; wherein the third supply and demand state is used for representing that an overall token producing speed is less than an overall token consuming speed, and after reward tokens are allocated for the respective autonomous token objects, the number of basic tokens of each of the respective autonomous token objects is greater than zero, and is less than or equal to a maximum basic token number.

10. The method of claim 9, wherein the token data comprises a number of surplus tokens and a number of lacked tokens of the autonomous token object; and the token statistical data further comprises a total number of lacked tokens;

the allocating the reward token for the at least one autonomous token object according to the comprehensive token supply and demand state and the respective token data, comprises:

in a case where the comprehensive token supply and demand state is the third supply and demand state, for each second autonomous token object whose number of basic tokens is less than the maximum basic token number, determining a token lacking proportion of the second autonomous token object according to a number of lacked tokens of the second autonomous token object and the total number of lacked tokens; and

determining a number of reward tokens of the second autonomous token object according to the total number of surplus tokens and the token lacking proportion.

11. The method of claim 1, further comprising:

setting a balance horizontal line for a token bucket of the autonomous token object; wherein a value corresponding to the balance horizontal line is a number of tokens in the token bucket when token production of the autonomous token object is balanced with token consumption;

taking tokens in a token area above the balance horizontal line as surplus tokens;

taking tokens in a token area below the balance horizontal line and above a zero line as basic tokens; wherein the zero line represents a positive and negative boundary line of the number of tokens in the token bucket;

in a case where the number of tokens in the token bucket is less than the value corresponding to the balance horizontal line, and the number of tokens in the token bucket is a positive value, taking tokens in an empty token area between the basic tokens and the balance horizontal line as lacked tokens; and

in a case where the number of tokens in the token bucket is a negative value, taking tokens in an empty token area below the zero line as negative tokens, and taking tokens in an empty token area below the balance horizontal line and below the zero line as lacked tokens.

12. An information forwarding method, comprising:

reporting, by respective autonomous token objects, token data to a token scheduling module respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1; and

receiving, by the token scheduling module, the token data reported by the respective autonomous token objects, determining a comprehensive token supply and demand state based on the received token data, and allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

13. A token management apparatus, applied to a token scheduling module, comprising:

a data acquisition unit, configured for acquiring token data corresponding to respective autonomous token objects respectively; wherein P autonomous token objects are used for producing tokens and consuming the tokens; and P is a positive integer greater than 1;

a supply and demand analysis unit, configured for analyzing the token data corresponding to the respective autonomous token objects to obtain a comprehensive token supply and demand state; and

a token allocation unit, configured for allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

14. An information forwarding apparatus, comprising at least one token processing module provided with an autonomous token object and a token scheduling module; wherein,

the token processing module is configured for using respective autonomous token objects to report token data to the token scheduling module respectively; wherein P

autonomous token objects are used for producing tokens and consuming the tokens; and
P is a positive integer greater than 1; and

the token scheduling module is configured for receiving the token data reported by the respective autonomous token objects, determining a comprehensive token supply and demand state based on the received token data, and allocating a reward token for at least one autonomous token object according to the comprehensive token supply and demand state and the token data, so that the at least one autonomous token object uses tokens after receiving the reward token to forward information.

15. An electronic device, comprising:

at least one processor; and

a memory communicatively connected to the at least one processor; wherein,

the memory stores instructions that are executable by the at least one processor, and the instructions are executed by the at least one processor, to enable the at least one processor to perform the method of any one of claims 1 to 12.

16. A non-transitory computer readable storage medium storing computer instructions, wherein the computer instructions are used for causing a computer to perform the method of any one of claims 1 to 12.