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(54) Title: METHODS, SYSTEMS, AND COMPUTER READABLE MEDIA FOR HYPERTEXT TRANSFER PROTOCOL (HTTP)
STREAM TUNING FOR LOAD AND OVERLOAD CONTROL
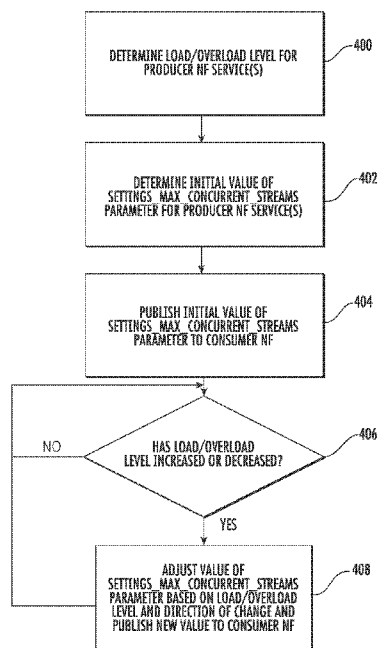
FIG. 4

(57) Abstract: A method for HTTP stream tuning during load and over-
load control includes, at a first NF, determining a load/overload level of the
first. The method further includes determining an initial value for an HTTP
SETTINGS_MAX_CONCURRENT_STREAMS parameter. The method further
includes publishing the initial value of the HTTP SETTINGS_MAX_CONC
URRENT_STREAMS parameter to a second NF that sends traffic to the first
NF. The method further includes determining that the load/overload level of
the first NF has changed. The method further includes, in response to de-
termining that the load/overload level has changed, adjusting the value of
the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter based on
the load/overload level and a direction of change in the load/overload lev-
el. The method further includes publishing the adjusted value of the HTTP
SETTINGS_MAX_CONCURRENT_STREAMS parameter to the second NF.

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METHODS, SYSTEMS, AND COMPUTER READABLE MEDIA FOR HYPERTEXT TRANSFER PROTOCOL (HTTP) STREAM TUNING FOR LOAD AND OVERLOAD CONTROL

5   PRIORITY CLAIM

This application claims the priority benefit of U.S. Patent Application Serial No. 17/203,693, filed March 16, 2021, the disclosure of which is incorporated herein by reference in its entirety.

10   TECHNICAL FIELD

The subject matter described herein relates to load and overload control in communications networks. More particularly, the subject matter described herein relates to methods, systems, and computer readable media for HTTP stream tuning for load and overload control.

15

                                      BACKGROUND

In 5G telecommunications networks, a network function that provides service is referred to as a producer network function (NF) or NF service producer. A network function that consumes services is referred to as a
20   consumer NF or NF service consumer. A network function can be a producer NF, a consumer NF, or both, depending on whether the network function is consuming, producing, or consuming and producing services. The terms "producer NF" and "NF service producer" are used interchangeably herein. Similarly, the terms "consumer NF" and "NF service consumer" are used
25   interchangeably herein.

A given producer NF may have many service endpoints, where a service endpoint is the point of contact for one or more NF instances hosted by the producer NF. The service endpoint is identified by a combination of Internet protocol (IP) address and port number or a fully qualified domain
30   name that resolves to an IP address and port number on a network node that hosts a producer NF. An NF instance is an instance of a producer NF that provides a service. A given producer NF may include more than one NF

instance. It should also be noted that multiple NF instances can share the same service endpoint.

Producer NFs register with a network function repository function (NRF). The NRF maintains service profiles of available NF instances identifying the services supported by each NF instance. The terms "service profiles" and "NF profiles" are used interchangeably herein. Consumer NFs can subscribe to receive information about producer NF instances that have registered with the NRF.

In addition to consumer NFs, another type of network node that can subscribe to receive information about NF service instances is a service communications proxy (SCP). The SCP subscribes with the NRF and obtains reachability and service profile information regarding producer NF service instances. Consumer NFs connect to the service communications proxy, and the service communications proxy load balances traffic among producer NF service instances that provide the required services or directly routes the traffic to the destination producer NF instances.

In addition to the SCP, another example of an intermediate proxy node that routes traffic between producer and consumer NFs is the security edge protection proxy (SEPP). The SEPP is the network node used to protect control plane traffic that is exchanged between different 5G public land mobile networks (PLMNs). As such, the SEPP performs message filtering, policing and topology hiding for all application programming interface (API) messages that are transmitted between PLMNs.

One problem in 5G communications networks is ineffective mechanisms for preventing a consumer NF from overwhelming the resources of a producer NF. For example, existing 3GPP-defined procedures allow NF service producers to signal service consumers of load information of the service producers. However, the load information is optional and may be ignored by service consumers. In addition, the load information may be sent in low priority messages that may not reach the service consumer at all or in time to prevent the producer NF from becoming overloaded. 3GPP also mentions TCP and HTTP procedures that can be used by a producer NF for overload control. However, the TCP procedures are connection specific, and

while HTTP procedures are mentioned, a method for dynamically adjusting load and overload control thresholds that addresses the changing needs of a network is not described. As a result, the resources of the NF service producer can be overwhelmed, resulting in retries on the part of the consumer NF with an alternate NF service producer, and such retries waste network resources and resources of the NF service consumer.

Accordingly, in light of these and other difficulties, there exists a need for improved methods, systems, and computer readable media for throttling traffic from an NF service consumer.

SUMMARY

A method for hypertext transfer protocol (HTTP) stream tuning during load and overload control includes, at a first network function (NF) including at least one processor and a memory, determining a load/overload level of the first NF. The method further includes determining an initial value for an HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter. The method further includes publishing the initial value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to a second NF that sends traffic to the first NF. The method further includes determining that the load/overload level of the first has changed. The method further includes, in response to determining that the load/overload level has changed, adjusting the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter based on the load/overload level and a direction of change in the load/overload level. The method further includes publishing the adjusted value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to the second NF.

According to another aspect of the subject matter described herein, the first NF comprises a producer NF and the second NF comprises a consumer NF that sends traffic to the producer NF

According to another aspect of the subject matter described herein, the first NF comprises a producer NF and the second NF comprises a service communications proxy (SCP) or security edge protection proxy (SEPP) that sends traffic to the producer NF.

According to another aspect of the subject matter described herein, the first NF comprises a service communications proxy (SCP) or a security edge protection proxy (SEPP) and the second NF comprises a consumer that sends traffic to the SCP or SEPP.

According to another aspect of the subject matter described herein, determining the initial value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter includes calculating the initial value based on a desired transaction rate per second for the second NF and a roundtrip time for messaging between the first and second NFs.

According to another aspect of the subject matter described herein, determining the initial value based on the desired transaction rate and the roundtrip time includes determining the initial value using the following equation:

$$MaxConStrms = RTT(ms)\left(\frac{RequestRate\ (Requests/s)}{1000\ (ms/s)}\right),$$

where MaxConStrms is the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter, RTT is the roundtrip time between the first and second NFs, and RequestRate is a desired request rate from the second NF.

According to another aspect of the subject matter described herein, determining that the load/overload level has changed includes determining that the load/overload level has increased.

According to another aspect of the subject matter described herein, adjusting the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter includes reducing the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by a fixed amount upon expiration of a timer and repeating the reducing until a minimum stream count for a current load/overload level is reached.

According to another aspect of the subject matter described herein, determining that the load/overload level has changed includes determining that the load/overload level has decreased.

According to another aspect of the subject matter described herein,

5   adjusting   the   value   of   the   HTTP SETTINGS_MAX_CONCURRENT_STREAMS   parameter   includes increasing   the   value   of   the   HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by a fixed amount upon expiration of a timer and repeating the increasing until a maximum

10   stream count for a current load/overload level is reached.

According to another aspect of the subject matter described herein, A system for hypertext transfer protocol (HTTP) stream tuning during load and overload control is provided. The system includes a first network function (NF) including at least one processor and a memory. The system further includes

15   a load/overload controller implemented by the at least one processor for determining a load/overload level of the first NF, determining an initial value for an HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter, publishing   the   initial   value   of   the   HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to the second NF,

20   determining that the load/overload level of the first NF or the second NF has changed,   in response to determining that the load/overload level has changed,   adjusting   the   value   of   the   HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter based on the load/overload level and a direction of change in the load/overload level, and

25   publishing   the   adjusted   value   of   the   HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to the second NF.

According to another aspect of the subject matter described herein, the load/overload controller is configured to determine the initial value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter based on a

30   desired transaction rate per second for the second NF and a roundtrip time for messaging between the first and second NFs.

According to another aspect of the subject matter described herein, the load/overload controller is configured to determine the initial value of the

SETTINGS_MAX_CONCURRENT_STREAMS parameter using the following equation:

$$MaxConStrms = RTT(ms) \left(\frac{RequestRate\ (Requests/s)}{1000\ (ms/s)} \right),$$

5   where MaxConStrms is the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter, RTT is the roundtrip time between the first and second NFs, and RequestRate is a desired request rate from the second NF.

According to another aspect of the subject matter described herein, the
10   load/overload controller is configured to determine that the load/overload level has increased.

According to another aspect of the subject matter described herein, the load/overload controller is configured to adjust the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by reducing the
15   value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by a fixed amount upon expiration of a timer and repeat the reducing until a minimum stream count for a current load/overload level is reached.

According to another aspect of the subject matter described herein, the load/overload controller is configured to determine that the load/overload level
20   has decreased.

According to another aspect of the subject matter described herein, the load/overload controller is configured to adjust the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by increasing the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter
25   by a fixed amount upon expiration of a timer and repeat the increasing until a maximum stream count for a current load/overload level is reached.

According to another aspect of the subject matter described herein, a non-transitory computer readable medium having stored thereon executable instructions that when executed by a processor of a computer controls the
30   computer to perform steps. The steps include, at a first network function (NF) including at least one processor, determining a load/overload level of the first NF. The steps further include determining an initial value for a hypertext

transfer protocol (HTTP) SETTINGS_MAX_CONCURRENT_STREAMS parameter. The steps further include publishing the initial value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to a second NF that sends traffic to the first NF. The steps further include determining that the load/overload level of the first NF has changed. The steps further include, in response to determining that the load/overload level has changed, adjusting the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter based on the load/overload level and a direction of change in the load/overload level. The steps further include publishing the adjusted value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to the second NF.

The subject matter described herein can be implemented in software in combination with hardware and/or firmware. For example, the subject matter described herein can be implemented in software executed by a processor. In one exemplary implementation, the subject matter described herein can be implemented using a non-transitory computer readable medium having stored thereon computer executable instructions that when executed by the processor of a computer control the computer to perform steps. Exemplary computer readable media suitable for implementing the subject matter described herein include non-transitory computer-readable media, such as disk memory devices, chip memory devices, programmable logic devices, and application specific integrated circuits. In addition, a computer readable medium that implements the subject matter described herein may be located on a single device or computing platform or may be distributed across multiple devices or computing platforms.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a network diagram illustrating an exemplary 5G system network architecture;

Figure 2 is a message flow diagram illustrating exemplary messages exchanged for 3GPP-defined load/overload control procedures;

Figure 3 is a timing diagram illustrating roundtrip times (RTTs) that can be used to determine a value for the

SETTINGS_MAX_CONCURRENT_STREAMS to achieve a desired request rate from a consumer NF;

Figure 4 is a flow chart illustrating an exemplary process for setting the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter during load and overload control;

Figure 5 is a graph illustrating adjustment of the SETTINGS_MAX_CONCURRENT_STREAMS based on load/overload level;

Figure 6 is a flow chart illustrating an exemplary process for dynamically adjusting the SETTINGS_MAX_CONCURRENT_STREAMS parameter during load and overload control; and

Figure 7 is a block diagram illustrating an exemplary producer NF, SCP, or SEPP for dynamically adjusting the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter during load and overload control.

DETAILED DESCRIPTION

Figure 1 is a block diagram illustrating an exemplary 5G system network architecture. The architecture in Figure 1 includes NRF **100** and SCP **101**, which may be located in the same home public land mobile network (HPLMN). As described above, NRF **100** may maintain profiles of available producer NF service instances and their supported services and allow consumer NFs or SCPs to subscribe to and be notified of the registration of new/updated producer NF service instances. SCP **101** may also support service discovery and selection of producer NF instances. SCP **101** may perform load balancing of connections between consumer and producer NFs.

NRF **100** is a repository for NF or service profiles of producer NF instances. In order to communicate with a producer NF instance, a consumer NF or an SCP must obtain the NF or service profile of the producer NF instance from NRF **100**. The NF or service profile is a JavaScript object notation (JSON) data structure defined in 3GPP TS 29.510. The NF or service profile definition includes at least one of a fully qualified domain name (FQDN), an Internet protocol (IP) version 4 (IPv4) address or an IP version 6 (IPv6) address.

In Figure 1, any of the network functions can be consumer NFs, producer NFs, or both, depending on whether they are requesting, providing, or requesting and providing services. In the illustrated example, the NFs include a PCF **102** that performs policy related operations in a network, a UDM function **104** that manages user data, and an application function (AF) **106** that provides application services.

The NFs illustrated in Figure 1 further include a session management function (SMF) **108** that manages sessions between access and mobility management function (AMF) **110** and PCF **102**. AMF **110** performs mobility management operations similar to those performed by a mobility management entity (MME) in 4G networks. An authentication server function (AUSF) **112** performs authentication services for user equipment (UEs), such as user equipment (UE) **114**, seeking access to the network.

A network slice selection function (NSSF) **116** provides network slicing services for devices seeking to access specific network capabilities and characteristics associated with a network slice. A network exposure function (NEF) **118** provides application programming interfaces (APIs) for application functions seeking to obtain information about Internet of things (IoT) devices and other UEs attached to the network. NEF **118** performs similar functions to the service capability exposure function (SCEF) in 4G networks.

A radio access network (RAN) **120** connects user equipment (UE) **114** to the network via a wireless link. Radio access network **120** may be accessed using a g-Node B (gNB) (not shown in Figure 1) or other wireless access point. A user plane function (UPF) **122** can support various proxy functionality for user plane services. One example of such proxy functionality is multipath transmission control protocol (MPTCP) proxy functionality. UPF **122** may also support performance measurement functionality, which may be used by UE **114** to obtain network performance measurements. Also illustrated in Figure 1 is a data network (DN) **124** through which UEs access data network services, such as Internet services.

SEPP **126** filters incoming traffic from another PLMN and performs topology hiding for traffic exiting the home PLMN. SEPP **126** may communicate with a SEPP in a foreign PLMN which manages security for the

foreign PLMN. Thus, traffic between NFs in different PLMNs may traverse two SEPP functions, one for the home PLMN and the other for the foreign PLMN.

As described above, one problem that can occur in 5G networks is the
5   lack of an effective mechanism for load and overload control. 3GPP TS 29.500 defines load and overload control procedures to be used by an NF service producer. For example, Section 6.3.1 of 3GPP TS 29.500 states:

- Load control enables an NF Service Producer to signal its load
10   information to NF Service Consumers, either via the NRF (as defined in clause 6.3.2) or directly to the NF Service Consumer (as defined in clause 6.3.3). The load information reflects the operating status of the resources of the NF Service Producer.
- Load control allows for better balancing of the load across NF
15   Service Producers, so as to attempt to prevent their overload in first place (preventive action). Load control does not trigger overload mitigation actions, even if the NF Service Producer reports a high load.

20   In the above-quoted passage, 3GPP TS 29.500 defines procedures for NF service producers to inform NF service consumers of load conditions. Figure 2 illustrates both of these load control mechanisms. In Figure 2, in line 1 of the message flow diagram, a consumer NF **200** sends a discovery request to NRF **100**. It is assumed that producer NF **202** has previously registered with NRF
25   **100**. In line 2 of the message flow diagram, NRF **100** responds to the discovery request with the NF profile of producer NF **202**. The NF profile includes load information of producer NF **202**. This corresponds to the first mechanism described above with regard to 3GPP TS 29.500 for conveying load information to a consumer NF during service discovery. In line 3 of the
30   message flow diagram, consumer NF **200** sends a service based interface (SBI) service request to producer NF **202**. In line 4 of the message flow diagram, producer NF **202** sends an SBI service response to consumer NF **200**. The SBI service response may include load control information specified

or carried in a header of the SBI service response. One problem with both of these mechanisms, as will be described in more detail below, is that consumer NF **200** may ignore the load information or load control information and may still overwhelm the resources of producer NF **202**.

5   Overload control for 5G networks is defined in section 6.4 of 3GPP TS 29.500. In Section 6.4.1, 3GPP TS 29.500 states as follows:

- Service Based Interfaces use HTTP/2 over TCP for communication between the NF Services. TCP provides transport level congestion control mechanisms as specified in IETF RFC 5681 [16], which may be

10   used for congestion control between two TCP endpoints (i.e., hop by hop). HTTP/2 also provides flow control mechanisms and limitation of stream concurrency that may be configured for connection level congestion control, as specified in IETF RFC 7540 [7].

15 In the above-quoted passage, 3GPP TS 29.500 mentions that TCP and HTTP/2 provide flow control mechanisms, but does not define procedures for incorporating these mechanisms to dynamically control the message rate of a consumer NF.

One issue with using existing 3GPP-defined load control mechanisms

20 in 5G networks is that the above-described NRF-based model of publishing load information is slow, as it requires 3 nodes (the producer NF, NRF, and consumer NF) to react to the producer NF's load level. To address this issue, 3GPP TS 29.500 recommends optional load control information (LCI) and overload control information (OCI) headers that can be published directly from

25 producer NFs or consumer NFs (and also for notification paths). 3GPP TS 29.500 recommends that load and overload indications piggy back on responses to service requests or notifications for an endpoint. This means that processing of load and overload information in response messages is governed by the values of 3gpp-Sbi-Message-Priority and stream priority

30 attributes. One issue with piggybacking LCI and OCI information on existing response messages with message or stream-based priority is the that the message or stream-based priority may be low, and a low priority means the message is likely to be rejected at intermediate nodes if the intermediate

nodes become congested. In addition, processing of low priority messages may be delayed at the consumer NF due to other high priority responses being processed first. Further, because load and overload indications are optional data, consumer NFs can ignore the load and overload control indications.

5 Because consumer NFs can ignore load and overload control indications, a producer NF cannot expect a consumer NF to throttle the load on the producer NF. When a consumer NF keeps loading a producer NF and leads into an overload condition at the producer NF, then the producer NF has no choice but to throttle the traffic. This process leads to wasting of resources and can

10 also lead to delayed processing of traffic.

One example of resources that are wasted by overloading a producer NF are the processing resources at the consumer NF. Another example of resources that are wasted by overloading a producer NF are the network resources between the consumer and producer NF. Producer NF processing

15 resources may also be wasted in deciding to reject a message from a consumer NF. Consumer NF and network resources are further wasted by the consumer NF needing to retry a service request through an alternate producer NF.

Having an overload avoidance and control strategy that reduces the

20 number of rejections, will lead to the following benefits:

- Better utilization of network and compute resources; and
- Consumer NFs can achieve higher throughput with better latency for SBI interfaces in the 5G network.

The proposed solution described herein allows a producer NF to

25 specify a maximum number of concurrent HTTP/2 streams that the producer NF will allow, forcing the consumer NF to throttle traffic. The producer NF dynamically adjusts the maximum number of concurrent HTTP/2 streams to maintain a desired load level at the producer NF. This mechanism works seamlessly with the above-described 3GPP-defined load and overload

30 procedures. Using HTTP/2 concurrent streams to control loading of a producer NF complements the 3GPP-defined solutions and forces consumer NFs to reduce traffic as per the load/overload level of the producer NF.

The subject matter described herein utilizes the HTTP concurrent streams parameter to control the message rate of a consumer NF. The HTTP/2 specification (IETF RFC 7540) allows an endpoint to control "concurrent streams" at runtime. This means that an HTTP/2 server (i.e., the

5   producer NF) can control the number of active/open streams that an HTTP/2 client (i.e., the consumer NF) can have for a given connection. The subject matter described herein provides a mechanism for the HTTP/2 server to manipulate the maximum number of allowed concurrent streams during load and overload conditions.

10   Section 5.1.2 of IETF RFC 7540 states as follows:

A peer can limit the number of concurrently active streams using the SETTINGS_MAX_CONCURRENT_STREAMS parameter (see Section 6.5.2) within a SETTINGS frame.

15   The maximum concurrent streams setting is specific to each endpoint and applies only to the peer that receives the setting.

...

Endpoints MUST NOT exceed the limit set by their peer.

20   ...

An endpoint that wishes to reduce the value of SETTINGS_MAX_CONCURRENT_STREAMS to a value that is below the current number of open streams can either close streams that exceed the new value or

25   allow streams to complete.

In the above-quoted passage, IETF RFC 7540 indicates that the SETTINGS_MAX_CONCURRENT_STREAMS parameter may be set and used by an endpoint to control the maximum number of open streams allowed from a peer endpoint. Section 6.5 of IETF RFC 7540 states as follows:

30

A SETTINGS frame MUST be sent by both endpoints at the start of a connection and MAY be sent at any other

<u>time by either endpoint over the lifetime of the connection.</u>
(<u>Emphasis</u> added.)

In Section 6.5, IETF RFC 7540 indicates that the SETTINGS frame, which
5   carries the SETTINGS_MAX_CONCURRENT_STREAMS parameter, must
be sent at the beginning of a connection and may be sent by endpoints at
other times during the lifetime of a connection. The subject matter described
herein   provides   for   a   producer   NF   to   set   the
SETTINGS_MAX_CONCURRENT_STREAMS parameter to an initial value
10   based on a desired processing latency at the producer NF and then to adjust
the SETTINGS_MAX_CONCURRENT_STREAMS parameter to control
loading of the producer NF by a consumer NF.

The   HTTP/2   SETTINGS_MAX_CONCURRENT_STREAMS
parameter can be used to control the message rate of a consumer NF. Figure
15   3 is a timing diagram illustrating minimum, average, and maximum message
roundtrip time (RTT) between a client and a server application. In Figure 3,
the minimum RTT is 50 ms, the average RTT is 65 ms, and the maximum RTT
is 100 ms. For the minimum RTT of 50 ms, a stream created at t0 will be
responded and processed at t50. Thus, if the number of concurrent streams
20   from   the   consumer   NF   reaches   a   number   equal   to   the
SETTINGS_MAX_CONCURRENT_STREAMS parameter during 50 ms
window, then the consumer NF cannot send further requests until producer
NF responds at t50. Thus, by controlling maximum number of concurrent
streams, the producer NF can control traffic rate from the consumer NF on a
25   given   connection.   For   example,   if   the
SETTINGS_MAX_CONCURRENT_STREAMS parameter is set to 32, then
the maximum request rate can be calculated as follows:

$$\left(\frac{32\ requests}{50\ ms}\right) * \left(\frac{1000\ ms}{1s}\right) = 640\ requests/s \qquad (1)$$

30

Writing　Equation　1　in　general　form　and　solving　for SETTINGS_MAX_CONCURRENT_ STREAMS yields:

$$\left(\frac{MaxConStrms}{RTT(ms)}\right) * \left(\frac{1000\ ms}{1s}\right) = RequestRate(Requests/s)$$

5　　$MaxConStrms = RTT(ms)\left(\frac{RequestRate\ (Requests/s)}{1000ms/s}\right)$　　　　　　(2)

From Equation 2, if the RTT and the desired request rate are known, the value of　MaxConStrms,　which　is　the　value　of　the SETTINGS_MAX_CONCURRENT_STREAMS can be calculated.

10　　　　Table　1　shown　below　illustrates　how　the SETTINGS_MAX_CONCURRENT_STREAMS　parameter　from server/producer NF can be used to define the maximum request rate from a client (consumer NF) on a single HTTP/2 connection:

SETTINGS_MAX_ CONCURRENT_STREAMS	RTT	Calculation	Possible Request Rate
32	Min RTT 50 ms	32*(1000/50)	640
	Avg RTT 65 ms	32*(1000/65)	~490
	Max RTT 100 ms	32*(1000/100)	320
100	Min RTT 50 ms	100(1000/50)	2000
	Avg RTT 65 ms	100(1000/65)	~1540

	Max RTT 1000 ms	100*(1000/100)	1000
1000	Min RTT 50 ms	1000*(1000/50)	20000
	Avg RTT 65 ms	1000*(1000/65)	~15000
	Max RTT 100 ms	1000*(1000/100)	10,000

Table 1: Maximum Possible Request Rates Given Maximum Concurrent
Streams Settings and RTT Values

5   The maximum message rates in Table 1 are computed using the same calculation as Equation 1 above for each RTT and SETTINGS_MAX_CONCURRENT_STREAMS parameter value. Accordingly, based on the SBI service request processing latency at the producer NF, if the producer NF adjusts the

10   SETTINGS_MAX_CONCURRENT_STREAMS parameter value, the producer NF can control the amount of traffic flow from the consumer NF.

The subject matter described herein includes a recommended strategy that a producer NF can follow to adjust the HTTP/2 SETTINGS_MAX_CONCURRENT_STREAMS value with consumer NFs.

15   The solutions described herein are applicable to intermediate nodes, such as the SCP or SEPP, as well, to control traffic rates from consumer NFs. If implemented at an SCP or SEPP, the SETTINGS_MAX_CONCURRENT_STREAMS parameter of the consumer NF may be adjusted based on the load or overload levels of SCP or SEPP.

20   As indicated above with respect to Figure 3 and Table 1, HTTP/2 concurrent stream manipulation can help a producer NF control the traffic flow. However, there can be "N" different consumer NFs connected to a producer

NF and each consumer NF may have "M" HTTP/2 connections set up with the producer NF. Thus, a fixed value of SETTINGS_MAX_CONCURRENT_STREAMS parameter to avoid congestion during connection setup is not a viable option for a producer NF.

5   Regardless of the number of connections, the following rules will still hold true:

More traffic means more message processing and thus higher resource utilization.

Increased traffic processing leads to an increase in average processing
10   time of messages (due to waiting on compute and other resources). Hence, with an increase in traffic (beyond the break-even point), average processing time of requests and responses will increase. Therefore, average processing time and/or load/overload level (based on CPU utilization and/or other parameters) may be used by a producer NF to decide when and by how much
15   to adjust the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter.

The value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter cannot be static. The subject matter described herein allows the producer NF to adjust (increase or decrease) the value of the
20   SETTINGS_MAX_CONCURRENT_STREAMS parameter dynamically, so that consumer NFs can adjust their traffic rates accordingly.

Inspiration for the subject matter described herein can be obtained from TCP's slow start behavior during congestion. However, the subject matter described herein is not a direct application of TCP congestion control
25   behavior, i.e., the producer NF will adjust (increase or decrease) the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter dynamically with change in load level and/or RTT at the producer NF.

The following steps may be performed by a producer NF or an intermediate node to utilize the
30   SETTINGS_MAX_CONCURRENT_STREAMS parameter to control load/overload at the producer NF or at the intermediate node. The steps are illustrated by the flow chart in Figure 4.

1. Determine load/overload level for individual producer NF service(s) (step **400** in Figure 4).

   Load/Overload level for a producer NF service instance can be an aggregation of load/overload levels of CPU, average processing time of requests/responses and other parameters, such as queue depth. The subject matter described herein is not limited to any particular method for defining load/overload levels of a producer NF. If the load/overload control is being implemented at an intermediate node (SCP or SEPP), the load/overload level used to trigger the load/overload control processes described herein may be the load/overload level of the CPU, average processing time of requests/responses, queue depth, etc., of the intermediate node.

2. Determine the initial value of SETTINGS_MAX_CONCURRENT_STREAMS parameter of a connection for a given NF service instance/source IP address (step **402** in Figure 4). With the expected processing time (i.e. RTT) and maximum supported message rate, calculate the initial value of SETTINGS_MAX_CONCURRENT_STREAMS as described above with regard to Figure 3 and Table 1.

3. Publish the initial value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter to the consumer NF when the consumer NF connects to the producer NF to access a service (step **404** in Figure 4).

   If the consumer NF is allowed to consume multiple services of a producer NF on a single connection, then the max supported message rate is the sum of rates for the services that the consumer NF is allowed to consume. If the node being throttled is an SCP or SEPP, step **404** will be implemented by publishing the initial value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter to the SCP or SEPP. If the node being throttled is an SCP or SEPP, step **404** will be implemented by publishing the initial value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter to the SCP or SEPP.

4. Determine if the load or overload state of the producer NF (or intermediate node) has increased or decreased to a new level (step **406** in Figure 4) and if so, adjust the SETTINGS_MAX_CONCURRENT_STREAMS parameter based on the load/overload level and the direction of the change in the load/overload level, i.e., whether the level has increased or decreased (step **408** in Figure 4).

When a service provided by a producer NF (or intermediate node) goes into a higher load/overload level, do the following:

When a regular interval/timer (referred to as "CT" in Table 2) expires, decrease the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter by a fixed percentage (referred as "D" in Table 2 below) until a floor (referred to as "M" in Table 2) is reached or the system comes out of the present load/overload level.

For example, when the initial value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter is 8000 and the producer NF enters load level L1 from L0, drop the value of the SETTINGS_MAX_CONCURRENT_STREAMS PARAMETER by 5% after every 10 seconds, until value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter reaches 6000 or the producer NF comes out of L1.

When a producer NF (or intermediate node) moves to a lower load/overload level, do the following:

Upon expiration of a regular interval/timer (referred to as "RT" in Table 2), increase the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter by a percentage (referred to as "D" in Table 2) until a maximum increase amount (referred to as "M" in Table 2) is reached.

For example, when a producer NF enters level L1 from L2, increase the SETTINGS_MAX_CONCURRENT_STREAMS parameter by 5% (which was the drop rate of level L1) after every 8 seconds, until the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter reaches 6000.

For a given service (at a producer NF or intermediate node) and considering 4 (L1 to L4) configured load/overload levels, Table 2 illustrates parameters that can be used in adjusting the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter.

LO=Load/Overload Level	CT=Congestion Trigger Duration (ms)	RT=Recovery Trigger Duration (ms)	D=% change on each trigger (drop/rise) (relative to initial stream)	M=Max change on each trigger (drop/rise) (relative to initial stream)
L0 (Normal)	0	8000	1%	100%
L1	5000	4000	2%	20%
L2	5000	4000	3%	20%
L3	3000	3000	5%	10%
L4	3000	3000	7%	10%

Table 2: SETTINGS_MAX_CONCURRENT_STREAMS Adjustment Control Parameters

The values in Table 2 are shown for illustrative purposes only and may be adjusted based on parameters, such as the producer NF's processing latency, maximum transactions per second (TPS) per connection, producer NF capacity, etc.

Table 3 shown below illustrates examples of the parameters in Table 2 populated with exemplary values based on a producer NF or intermediate node with a processing latency of 100 ms and a maximum traffic rate of 5000 TPS per connection. From Equation 1 above, the initial value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter is set to 500 (500*100/1000). Based on this initial value and configuration, the stream adjustment at various load/overload levels will be as follows:

LO	D	M	CD= D*Initial	CM= M*Initial
0	0.01	1	5	500
1	0.02	0.2	10	400
2	0.03	0.2	15	300
3	0.05	0.3	25	150
4	0.07	0.1	35	100

Table 3: Example Values for Adjusting
SETTINGS_MAX_CONCURRENT_STREAMS Parameter

As described above, CT is the timer for the current LO level which is used to decrease the number of concurrent streams when the producer NF enters into (higher) congestion level. RT is the timer for the current LO level which is used to increase the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter when the producer NF or intermediate node moves to lower/normal congestion level. Figure 5 is a graph illustrating adjustment of the message rate at the producer NF based on the data in Table 3.

Figure 6 is a flow chart illustrating the process for adjusting the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter in more detail. In Figure 6, OldLoLevel and NewLoLevel refer to the objects used to store the current load level and its corresponding values of CT, RT, CD and CM. Referring to Figure 6, in step **600**, the process begins with the current count of concurrent streams and the objects OldLoLevel and NewLoLevel, which store the current values of the CT, RT, CD, and CM variables. Control then proceeds to step **602**, where the process includes determining whether the current load/overload level is less than the new load/overload level. This determination is made by the producer NF or intermediate node based on the load metrics (e.g., processing capacity, queue depth, memory utilization, etc.) set by the network operator. If the current load/overload level is less than the new load/overload level, this means that the load on the producer NF or

intermediate node has increased over one of the thresholds defined for increasing the level, and control proceeds to step **604** where the process includes determining whether the current stream count is greater than NewLoLevel.CM, which stores the value of the maximum change on each trigger value for the new level (see column 5 in Tables 2 and 3). If the current stream count is greater than NewLoLevel.CM, the number of streams can be reduced, and control proceeds to step **606** where the current stream count is decreased by the amount NewLoLevel.CD, which stores the value of the % change on each trigger value for the new level (see column 4 in Tables 2 and 3). Control then proceeds to step **608** where the value of the variable SETTINGS_MAX_CONCURRENT_STREAMS is set to the value of the current stream count variable after being decreased in step **606**. Performing step **608** includes adjusting the SETTINGS_MAX_CONCURRENT_STREAMS parameter by sending a message to the consumer NF(s), providing the consumer NF(s) with a new setting for the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter that achieves the desired reduction in concurrent streams, which reduces the processing load on the producer NF or intermediate node. Control then proceeds to step **610** where the process waits for the expiration of NewLoLevel.CT timer before returning to step **604** where the process determines whether further decreases in the maximum concurrent streams can occur given the floor determined for the current load/overload level. If further decreases cannot occur, control proceeds to step **612** where the process ends.

Returning to step **602**, if OldLoLevel is not less than NewLoLevel, control proceeds to step **614** where it is determined whether the current stream count can be increased (because the producer NF is in recovery mode). If the current stream count can be increased, control proceeds to step **616** where the stream count is increased by the amount NewLoLevel.CD defined for the new level. Control then proceeds to step **618** where the value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter is set to the value of the CurrentStreamCount variable after being increased in step **616**. The producer NF communicates the new value of the

SETTINGS_MAX_CONCURRENT_STREAMS parameter to consumer NF(s) or intermediate node(s), which in turn reduce the number of concurrent streams to the new value, which starts increasing the traffic load on the producer NF or intermediate node. Control then proceeds to step **620** where the process waits for the expiration of the NewLoLevel.RT timer. When the timer expires, control returns to step **614** where it is determined whether the stream count can be further increased, given the maximum defined for the current load/overload level. If the current stream count can be increased, steps **616-620** are repeated. If the stream count cannot be further increased, the process ends.

At higher values of the LO level, values of "D", "CT" and "M" may be set aggressively, i.e., the drop in value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter may be at lower rate for lower "LO" levels versus a higher rate at higher "LO" levels. At early load/overload level, do not close the "flow gates" fast but "hold and move" to cut traffic. At higher load/overload levels, "slow down" faster to ensure system stability. At a given level, an RT value that is lower than the CT value helps aggressively increase the number of concurrent streams when congestion is abating. For example, when a system moves from L0 to L1, CT drives the interval when the number of concurrent streams will decrease. When a system moves from L2 to L1, RT drives the interval when the number of concurrent streams will increase. Keeping RT>CT helps to increase the number of concurrent streams faster. The network operator can set RT=CT or RT<CT (for very slow recovery) if desired. The value of "M" may be determined based on the maximum number of TPS that the producer NF wants to support per connection at a given LO level. The solution can be enhanced further to add additional limits on the number of HTTP/2 connections from a given consumer NF, in a given LO level. With this enhancement, producer NFs and intermediate nodes can effectively control TPS that a given consumer or intermediate node can achieve in a specific load/overload level. This is an add-on to the proposed solution to control overall traffic over multiple connections from a consumer NF or intermediate node.

In the case where the producer NF is connected to the consumer NF through an SCP or SEPP, then load/overload and other parameters can be calculated based on an aggregation of load/overload levels of all services provided by the producer NF, e.g., the minimum load/overload level of all producer NF services. Similarly, the maximum TPS per connection may be based on the sum of maximum TPS that the producer NF can provide considering all services provided by the producer NF.

LCI/OCI notifications, when combined with tuning of the SETTINGS_MAX_CONCURRENT_STREAMS parameter, will force consumer NFs to slow down and/or send only higher priority traffic to a producer NF. If any consumer NF ignores LCI/OCI header data, the consumer NF will be forced to throttle traffic due to lower concurrent streams per connection.

Figure 7 is a block diagram illustrating an example of a producer NF, SCP, or SEPP **202**, **101**, or **126** that performs load/overload control using the SETTINGS_MAX_CONCURRENT_STREAMS parameter as described above. Referring to Figure 7, producer NF, SCP, or SEPP **202**, **101**, or **126** includes at least one processor **700** and a memory **702**. Load/overload control data structures **704** may be stored in memory **702**. Load/overload control data structures **704** may include data structures, such as those illustrated above in Tables 1 and 2 for controlling adjustment of the SETTINGS_MAX_CONCURRENT_STREAMS parameter based on the current load/overload level, changes in the level, and the direction of change in the level. A load/overload controller **706** may be implemented using computer executable instructions stored in memory **702** and executable by processor **700**. Load/overload controller **706** may perform the steps described herein for adjusting the SETTINGS_MAX_CONCURRENT_STREAMS parameter based on the current load/ overload level, changes in the level, and the direction of changes in the level.

The disclosure of each of the following references is hereby incorporated herein by reference in its entirety.

References

1. 3GPP TS 29.500 V16.7.0 (2020-12); 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; 5G System; Technical Realization of the Service Based Architecture; Stage 3 (Release 17).

2. 3GPP TS 29.510 V17.0.0 (2020-12); 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; 5G System; Network Function Repository Services; Stage 3 (Release 17).

3. Belshe et. al, "Hypertext Transfer Protocol Version 2 (HTTP/2)," IETF RFC 7540 (May 2015).

4. TCP   Congestion   Control, https://en.wikipedia.org/wiki/TCP_congestion_control   (last   edited March 4, 2021)

It will be understood that various details of the subject matter described herein may be changed without departing from the scope of the subject matter described herein. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation, as the subject matter described herein is defined by the claims as set forth hereinafter.

CLAIMS

What is claimed is:

1.　　A method for hypertext transfer protocol (HTTP) stream tuning during load and overload control, the method comprising:

at a first network function (NF) including at least one processor and a memory:

determining a load/overload level of the first NF;

determining an initial value for an HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter;

publishing the initial value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to a second NF that sends traffic to the first NF;

determining that the load/overload level of the first NF has changed;

in response to determining that the load/overload level has changed, adjusting the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter based on the load/overload level and a direction of change in the load/overload level; and

publishing the adjusted value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to the second NF.

2.　　The method of claim 1 wherein the first NF comprises a producer NF and the second NF comprises a consumer NF that sends traffic to the producer NF.

3.　　The method of claim 1 wherein the first NF comprises a producer NF and the second NF comprises a service communications proxy (SCP) or security edge protection proxy (SEPP) that sends traffic to the producer NF.

4.　　The method of claim 1 wherein the first NF comprises a service communications proxy (SCP) or a security edge protection proxy (SEPP) and the second NF comprises a consumer NF that sends traffic to the SCP or SEPP.

5.   The method of any one of the preceding claims wherein determining the initial value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter includes calculating the initial value based on a desired transaction rate per second for the second NF and a roundtrip time for messaging between the first and second NFs.

6.   The method of claim 5 wherein determining the initial value based on the desired transaction rate and the roundtrip time includes determining the initial value using the following equation:

$$MaxConStrms = RTT(ms) \left(\frac{RequestRate\ (Requests/s)}{1000\ (ms/s)} \right),$$

where MaxConStrms is the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter, RTT is the roundtrip time between the first and second NFs, and RequestRate is a desired request rate from the second NF.

7.   The method of any one of the preceding claims wherein determining that the load/overload level has changed includes determining that the load/overload level has increased.

8.   The method of claim 7 wherein adjusting the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter includes reducing the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by a fixed amount upon expiration of a timer and repeating the reducing until a minimum stream count for a current load/overload level is reached.

9.   The method of any one of the preceding claims determining that the load/overload level has changed includes determining that the load/overload level has decreased.

10.   The method of claim 9 wherein adjusting the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter includes increasing the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by a fixed amount upon expiration of a timer and repeating the increasing until a maximum stream count for a current load/overload level is reached.

11.   A system for hypertext transfer protocol (HTTP) stream tuning during load and overload control, the system comprising:

a first network function (NF) including at least one processor and a memory; and

5   a load/overload controller implemented by the at least one processor for determining a load/overload level of the first NF, determining an initial value for an HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter, publishing the initial value of the HTTP

10   SETTINGS_MAX_CONCURRENT_STREAMS parameter to a second NF that sends traffic to the first NF, determining that the load/overload level of the first NF has changed, in response to determining that the load/overload level has changed, adjusting the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter based on

15   the load/overload level and a direction of change in the load/overload level, and publishing the adjusted value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to the second NF.

12.   The system of claim 11 wherein the first NF comprises a producer NF

20   and the second NF comprises a consumer NF that sends traffic to the producer NF.

13.   The system of claim 11 wherein the first NF comprises a producer NF and the second NF comprises a service communications proxy (SCP) or security edge protection proxy (SEPP) that sends traffic to the

25   producer NF.

14.   The system of claim 11 wherein the first NF comprises a service communications proxy (SCP) or a security edge protection proxy (SEPP) and the second NF comprises a consumer NF that sends traffic to the SCP or SEPP.

30 15.   The system of any one of claims 11 to 14 wherein the load/overload controller is configured to determine the initial value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter based on a

desired transaction rate per second for the second NF and a roundtrip time for messaging between the first and second NFs.

16.   The system of claim 15 wherein the load/overload controller is configured to determine the initial value of the SETTINGS_MAX_CONCURRENT_STREAMS parameter using the following equation:

$$MaxConStrms = RTT(ms) \left(\frac{RequestRate\ (Requests/s)}{1000\ (ms/s)} \right),$$

where MaxConStrms is the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter, RTT is the roundtrip time between the first and second NFs, and RequestRate is a desired request rate from the second NF.

17.   The system of any one of claims 11 to 16 wherein the load/overload controller is configured to determine that the load/overload level has increased.

18.   The system of claim 17 wherein the load/overload controller is configured to adjust the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by reducing the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by a fixed amount upon expiration of a timer and repeat the reducing until a minimum stream count for a current load/overload level is reached.

19.   The system of any one of claims 11 to 18 wherein the load/overload controller is configured to determine that the load/overload level has decreased and, in response to adjust the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by increasing the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter by a fixed amount upon expiration of a timer and repeat the increasing until a maximum stream count for a current load/overload level is reached.

20.   A non-transitory computer readable medium having stored thereon executable instructions that when executed by a processor of a computer controls the computer to perform steps comprising:

at a first network function (NF) including at least one processor and a memory:

determining a load/overload level of the first NF;

determining an initial value for a hypertext transfer protocol (HTTP) SETTINGS_MAX_CONCURRENT_STREAMS parameter;

publishing the initial value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to a second NF that sends traffic to the first NF;

determining that the load/overload level of the first NF has changed;

in response to determining that the load/overload level has changed, adjusting the value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter based on the load/overload level and a direction of change in the load/overload level; and

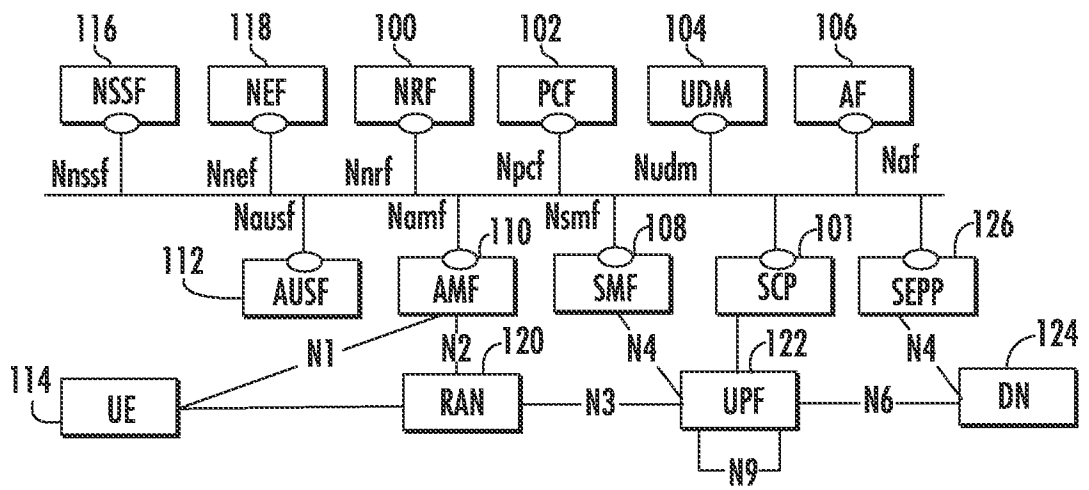publishing the adjusted value of the HTTP SETTINGS_MAX_CONCURRENT_STREAMS parameter to the second NF.
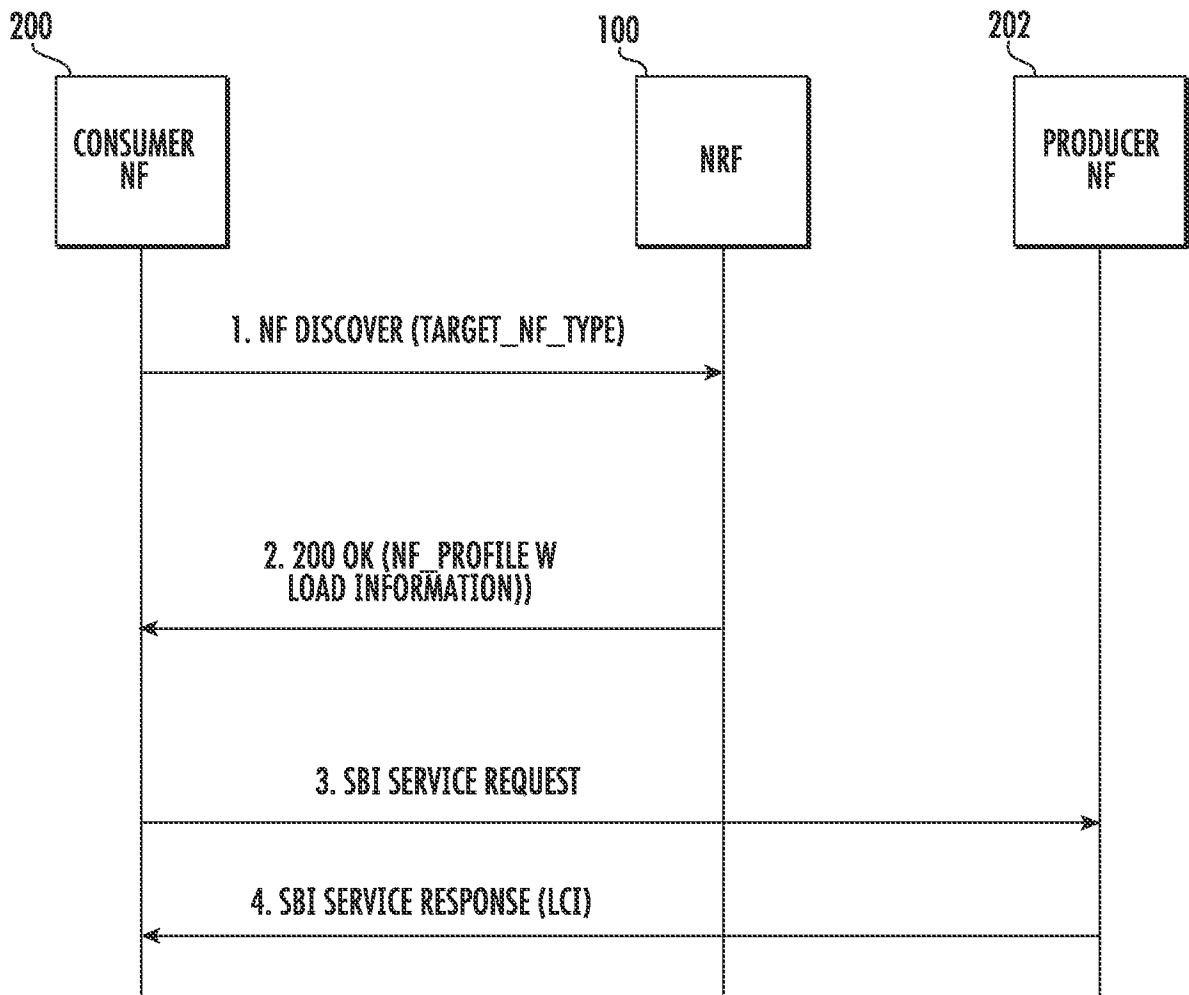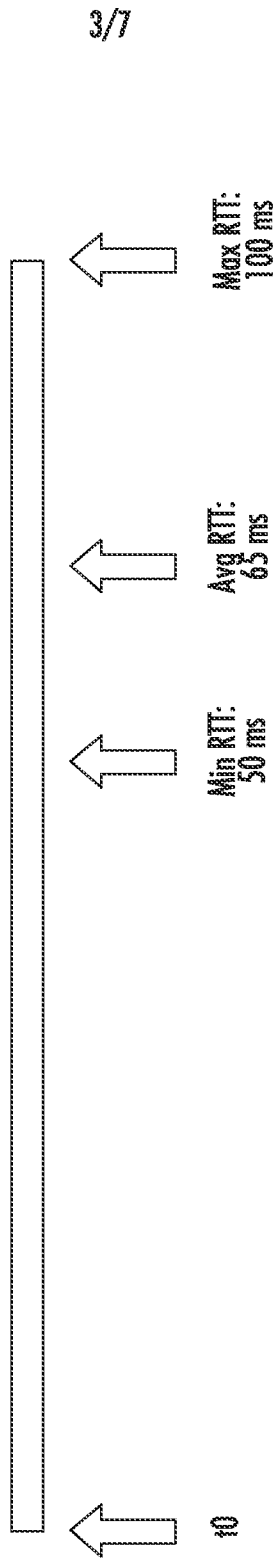
FIG. 1

FIG. 2

Min RTT: 50 ms

Avg RTT: 65 ms

Max RTT: 100 ms

10

FIG. 3

```
┌─────────────────────────────────┐
│                                 │
│   DETERMINE LOAD/OVERLOAD LEVEL FOR │────400
│      PRODUCER NF SERVICE(S)      │
│                                 │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│                                 │
│      DETERMINE INITIAL VALUE OF  │────402
│  SETTINGS_MAX_CONCURRENT_STREAMS │
│  PARAMETER FOR PRODUCER NF SERVICE(S) │
│                                 │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│                                 │
│      PUBLISH INITIAL VALUE OF    │────404
│  SETTINGS_MAX_CONCURRENT_STREAMS │
│     PARAMETER TO CONSUMER NF     │
│                                 │
└─────────────────────────────────┘
                │
                ▼
         ◇───────────────◇
    NO  ╱                  ╲
 ◄──────   HAS LOAD/OVERLOAD   ────406
        ╲ LEVEL INCREASED OR DECREASED? ╱
         ◇───────────────◇
                │
               YES
                │
                ▼
┌─────────────────────────────────┐
│      ADJUST VALUE OF             │
│  SETTINGS_MAX_CONCURRENT_STREAMS │────408
│  PARAMETER BASED ON LOAD/OVERLOAD│
│  LEVEL AND DIRECTION OF CHANGE AND│
│   PUBLISH NEW VALUE TO CONSUMER NF│
└─────────────────────────────────┘
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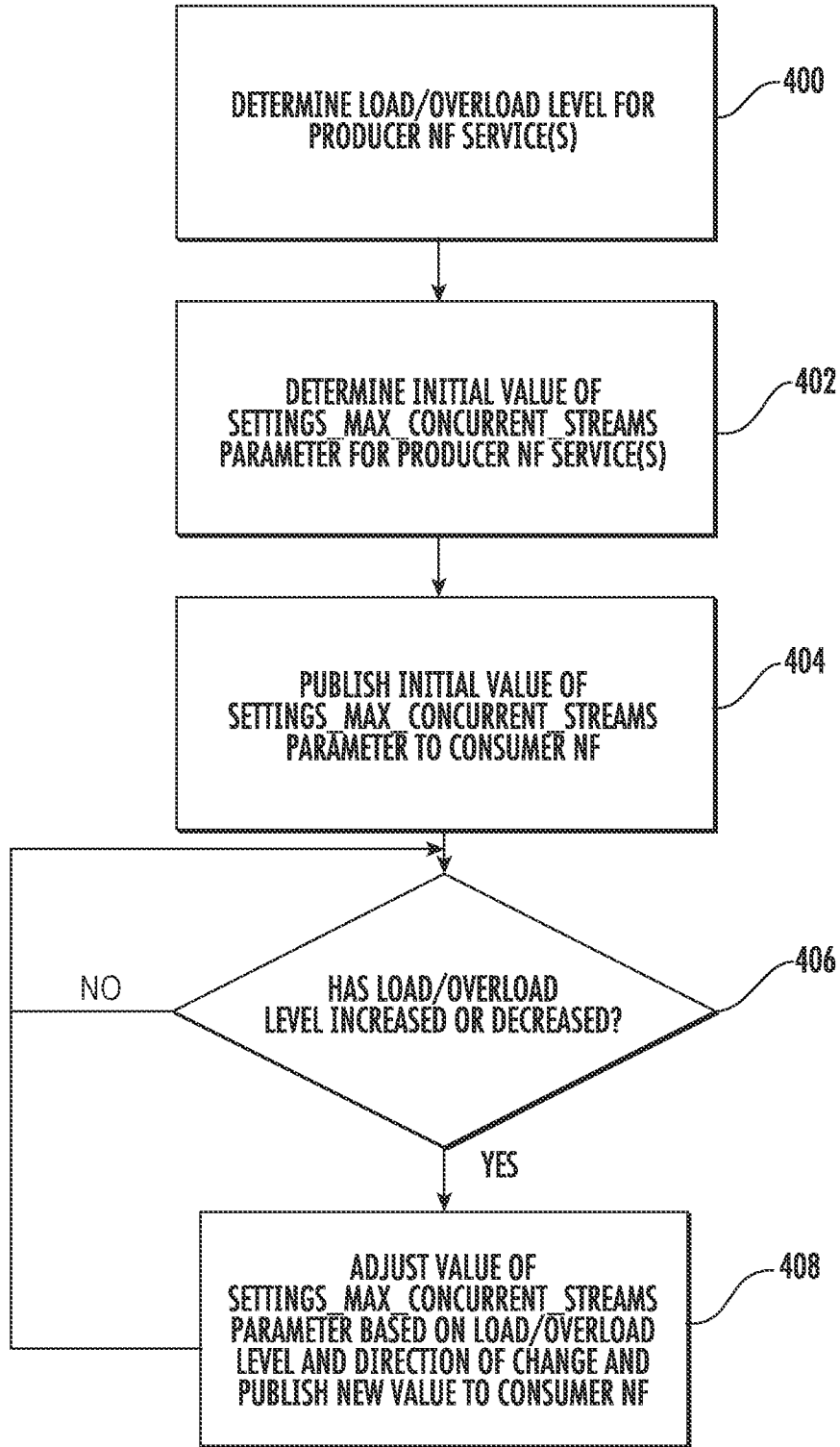
FIG. 4

ADJUSTED CONCURRENT STREAM BASED ON
LOAD/OVERLOAD LEVEL

FIG. 5

6/7
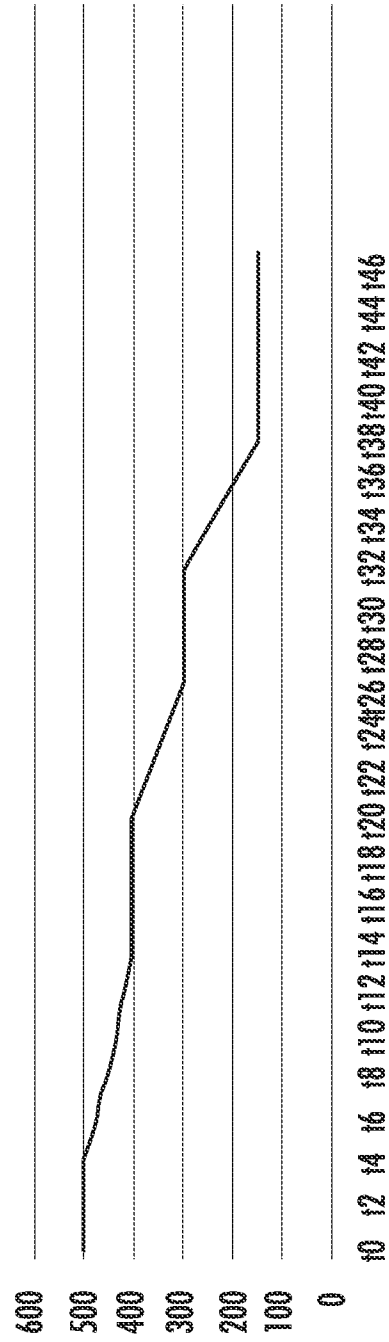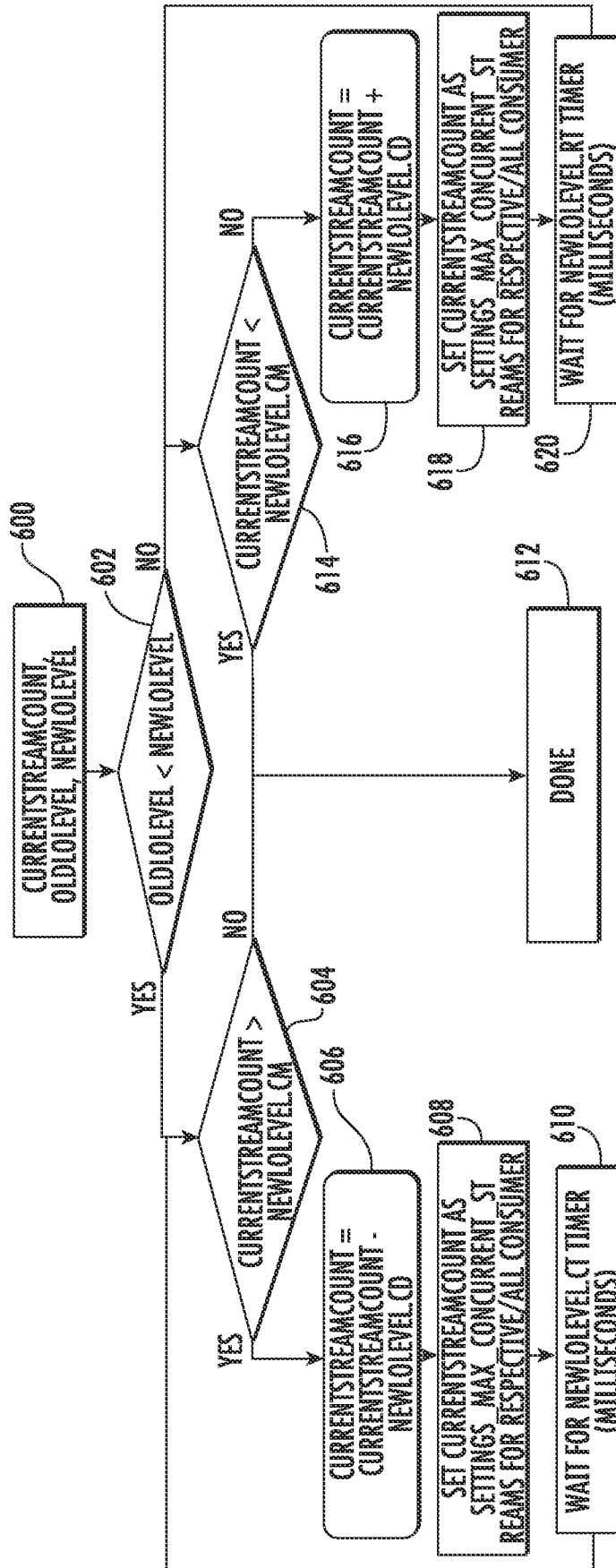
FIG. 6

FIG. 7

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W28/02   H04L47/10   H04L43/0894   H04L43/16
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L   H04W

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

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

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2021/012787 A1 (ZTE CORP [CN]) 28 January 2021 (2021-01-28) figures 1-3 paragraphs [0007] - [0016], [0025] - [0042] ----- -/--	1-20

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

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 May 2022	08/06/2022

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Tyszka, Krzysztof

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ORANGE: "HTTP2 connection flow control usage", 3GPP DRAFT; C4-184243_HTTP2 CONNECTION FLOW CONTROL USAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. CT WG4, no. Osaka, Japan; 20180521 – 20180525 11 May 2018 (2018-05-11), XP051460975, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg%5Fct/WG4%5Fprotocollars%5Fex%2DCN4/TSGCT4%5F85%5FOsaka/Docs [retrieved on 2018-05-11] the whole document -----	1-20
X	US 2019/116217 A1 (DHANABALAN PRAVEEN RAJA [IN]) 18 April 2019 (2019-04-18) figures 1A, 3 paragraphs [0010], [0011], [0019], [0025], [0026], [0028], [0032], [0033], [0050] – [0060] -----	1-20

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2022/019850

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
WO 2021012787	A1		28-01-2021	CN	112291180	A	29-01-2021
				EP	3975497	A1	30-03-2022
				WO	2021012787	A1	28-01-2021
US 2019116217	A1		18-04-2019	US	2019116217	A1	18-04-2019
				US	2020153886	A1	14-05-2020
				US	2021281628	A1	09-09-2021