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An Autonomic Mechanism for Resource-based Network Services Auto-
deployment

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Abstract

This document specifies an autonomic mechanism for resource-based network services deployment through the Autonomic Control Plane (ACP) in a network. This mechanism uses the GeneRic Autonomic Signaling Protocol (GRASP) in [[RFC8990](#)] to exchange the information among the autonomic nodes so that the resource along the service path can be coordinated.

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[1.](#) Introduction

With the network development, a class of services with resource requirements (such as bandwidth, queue, and priority) are already emerging, such as video, LR, VR, and so on. To ensure the normal operation of these services, the network needs to allocate sufficient resources for the services in advance. An autonomous network must have an appropriate mechanism to negotiate the network resource.

From the network perspective, this kind of service has a source IP address and a destination IP address. Therefore, once the kind of service is delivered by a domain network, this service clearly has an access node and a departure node in the network. In an autonomic

resources negotiation mechanism, the resources are being negotiated between the access node and departure node.

The core goal of this paper is to establish a set of automatic negotiation mechanism to achieve the negotiation and distribution of network resources in the domain network between the service client and the network. That is, the server client negotiates with the network how many resources can be provided for specific services in the domain network to support the transmission of network services. The benefits of doing so mainly include the following aspects:

- * The resource-based network services auto-deployment satisfies the QoS requirements of the service. If the service wants to ensure its own transmission quality, the most effective solution is to reserve enough transmission resources for the service before the service starts.
- * The mechanism of supporting multiple rounds of negotiations enables the service client to change the resource requirements according to the state of the network. For example, when the network is congested, Video Conference services can reduce the quality of video to ensure the most basic connectivity.
- * The mechanism can ensure that the resources in the network can be used more efficiently, provide different levels of network resources for different levels of services, and give priority to the network resource requirements of services of high importance.

The resource information negotiated in this document is more extensive. Not only negotiation bandwidth resources but also includes and is not limited to queue, priority and other resources. On the one hand, in recent years, the requirements of services for the network have become more complex. Services usually require the network to ensure not only the deterministic bandwidth but also the deterministic end-to-end delay and jitter, so as to deliver the data message to the destination "in time" and "on time". For example, in the telemedicine scenario, in order to ensure that doctors do not feel obvious delay and jitter, it is required that the end-to-end delay should not exceed 20ms and the jitter should be less than 200

μs. On the other hand, with the development of technology, the network has more refined the scheduling of transmission capacity, and also hopes to open its own capacity to the service clients. The negotiation resources established in this document should support not only to negotiate the existing supported resources but also to retain some scalability for the negotiation ability in the future.

This document complete the resource-based self-adaptation among service and network nodes via GRASP. This document defines an autonomic technical objective for resource-based network services auto-deployment. It shows how the ANI can be applied to negotiate resource information for network service auto-deployment. This

document reduces the difficulty of manual operation, avoids the problems of specification limitation and slow response speed in the centralized system, improves the efficiency of service deployment and makes more rational use of network resources. The GeneRic Autonomic Signaling Protocol (GRASP) is specified by [[RFC8990](#)] and can make use of the technical objective to provide a solution for resource-based network services auto-deployment.

[2.](#) Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [[RFC2119](#)] [[RFC8174](#)] .

[3.](#) Terminology & Abbreviations

This document uses terminology defined in [[RFC7575](#)].

RRM ASA: Requester ResourceManager ASA. A kind of ResourceManager ASA which start to request resource in the network.

PRM ASA: Provider ResourceManager ASA. A kind of ResourceManager ASA which provid resource in the network.

APE: Access Provider Edge is the first access provider edge where the service initiator connects to the network or where the path-dependent and resource-based network service starts.

DPE: Departure PE is the last provider edge where the path-dependent and resource-based network service ends.

Transmit node: A transmit node in the domain network.

ASBR: AS Border Router is an edge node of the domain in the cross-domain scenario. It may also be a PE node.

[4.](#) Resource-based Network Services Auto-deployment Solution

This section describes the internal architecture of resource-based network services auto-deployment. As noted in [Section 1](#), this is not a complete description of a solution, which will depend on the detailed design of the relevant Autonomic Service Agents (ASAs). It uses the generic discovery and negotiation protocol defined by [\[RFC8990\]](#) and the relevant GRASP objectives are defined in [Section 5](#).

The procedures described below are carried out by an ASA in each device that participates in the solution. We will refer to this as the ResourceManager ASA. If a device containing a ResourceManager ASA is used up its resource, it can request more resources according to its requirements. It should decide the type and value of the requested resource and request it via the mechanism described in [Section 6](#).

[4.1.](#) ResourceManager ASA Discovery

A ResourceManager ASA that needs additional resources should firstly discover peers that may be able to provide extra resources. The ASA should send out a GRASP Discovery message that contains a ResourceManager Objective option to discover peers also supporting that option.

A GRASP device that receives a Discovery message with a ResourceManager Objective option should respond with a GRASP Response message if it contains a ResourceManager ASA. If it does not contain ResourceManager ASA, the device ignores this message. Further details of the discovery process are described in [Section 2.5.4 of \[RFC8990\]](#).

[4.2.](#) Resource Negotiation

After the discovery step, the RRM ASA (Requesting ResourceManager ASA) will act as a GRASP negotiation initiator by sending a GRASP Request message with a ResourceManager Objective option. The RRM ASA indicates in this option the value of the requested resource. And ResourceManager GRASP Objective allows multiple types of resources to be requested simultaneously.

When the PRM ASA (Provider ResourceManager ASA) receives a subsequent Request message, it should conduct a GRASP negotiation sequence, using Negotiate, Confirm Waiting, and Negotiation End messages as appropriate. The Negotiate messages carry a ResourceManager Objective option, which will indicate the resource type and value offered to the requesting ASA.

During the negotiation, the RRM ASA will decide at each step how large a resource needs to offer. That decision, and the decision to end the negotiation, are implementation choices. As to the PRM ASA responses how large resources they can offer and reserve enough resources during this negotiation step. A resource shortage may cause a device to indicate the existing available value within a ResourceManager Objective option to the RRM ASA. The RRM ASA compares whether the resource data received is the same locally. If they are not the same, the RRM ASA might decide whether to accept the request of the resource. If not, the RRM ASA might terminate the negotiation via Negotiation End messages with an error code string.

As described in [Section 2.8.8 of \[RFC8990\]](#), negotiation will continue until either end stops it with a Negotiation End message. If the negotiation succeeds, the ASA that provides the resource will remove

the negotiated resource from its pool, and the requesting ASA will add it. If the negotiation fails, the party sending the Negotiation End message may include an error code string.

[4.3.](#) Behavior after Negotiation

Upon receiving a GRASP Negotiation End message that indicates that the acceptable resource is available. The resource-providing device removes the acceptable resource from its resource pool and the requesting device may use the negotiated resource without further messages.

[5.](#) Autonomic Resource Management Objectives

This section defines the GRASP technical objective options that are used to support autonomic resource management.

[5.1.](#) ResourceManager Objective option

The ResourceManager Objective option is a GRASP Objective option conforming to the GRASP specification [[RFC8990](#)]. Its name is "ResourceManager", and it carries the following data items as its value: the resource value. Since GRASP is based on CBOR (Concise Binary Object Representation) [[RFC8949](#)], the format of the ResourceManager Objective option is described in the Concise Data Definition Language (CDDL) [[RFC8610](#)] as follows:

```
objective = ["ResourceManager", objective-flags, loop-count,  
?objective-value]
```

```
objective-name = "ResourceManager"
```

```
objective-flags = uint .bits objective-flag ; as in the GRASP  
specification
```

```
loop-count = 0..255 ; as in the GRASP specification
```

The 'objective-value' field expresses the actual value of a negotiation or synchronization objective. So a new objective-value named n-s-deployment-value is defined for Network Service Auto-

deployment as follows. The autonomic node can know that it is serving Network Service Auto-deployment according to the objective-value after receiving the GRASP message. The 'objective value' contains two parts, one represents the information of the service itself, and the other represents the requirements of resources.

objective-value = n-s-deployment-value ; An n-s-deployment-value is defined as Figure-1.

```
n-s-deployment-value
+ service-information
    + source-ip-address
    + destination-ip-address
    + service-tag
+ resource-information
    + resource-requirement-pair
        + resource-type
        + resource-value
```

Figure-1: Format of n-s-deployment-value

service-information = [source-ip-address, destination-ip-address, service-tag]

The source-ip-address and the destination-ip-address represent the source address and destination address. IPv4 and IPv6 addresses are allowed.

resource-information = [resource-requirement-pair 1, resource-requirement-pair 2, ... , resource-requirement-pair n]

Resource requirements of different types can be described in an objective option. The ResourceManager objective option supports multi-faceted resource requirements and negotiation.

resource-requirement-pair = [resourcetype, resval]

resourcetype /= 0...4; requested or offered resource type, such as bandwidth, queue, and priority.

resval /= 1...1000000; If the restype is bandwidth, the value ranges

in Mbit/s; If the restype is latency, the value ranges in microsecond; If the restype is jitter, the value ranges in microsecond.

6. Process of Network Service Auto-deployment

The network service auto-deployment system includes Service Initiator(SI), Service Terminator(ST), RRM ASA, PRM ASA and even ASBR.

The service initiator is the resource demander, which ensures the connection of services through negotiation resources with ResourceManager ASA in the domain network. Service Terminator is the end of service. APE represents the first access provider edge where the service initiator connects to the network or where the path-dependent and resource-based network service starts. There may be multiple Transmit nodes between APE and Service Terminator in the network or even cross multiple network domains through ASBRs. RRM ASA starts a negotiation process to get enough resources in the network. After RRM ASA gets the result about the resource, it sends a response message to Service Initiator. And PRM ASA manages resources from APE to ST hop-by-hop.

6.1. An example of End-to-End Service

In an End-to-End service, Service Initiator is a kind of access terminal of the network. And the End-to-End service initiator uses ResourceManager ASA to negotiate resources with the ResourceManager ASA in the APE. Figure 2 shows the architecture of the End-to-End service. In the figure, the RRM ASA in SI will act as a GRASP negotiation initiator by sending a GRASP Request message with a ResourceManager Objective option. The RRM ASA indicates in this option the value of the requested resource. When this RRM ASA receives a subsequent Request message, it should conduct a GRASP negotiation sequence, using Negotiate, Confirm Waiting, and Negotiation End messages as appropriate. The Negotiate messages carry a ResourceManager Objective option with the resource value offered to the PRM ASA.

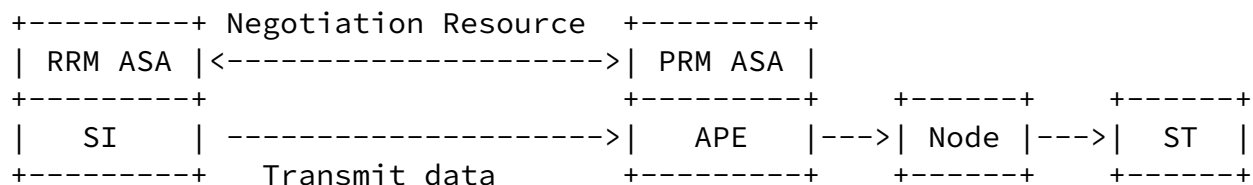


Figure-2: An example of End-to-End Service

PRM ASA processes receive resource requests and ensure the nodes resource it can manage. If PRM ASA can't manage all nodes in the data transport root or can't have enough resources, PRM ASA should act as a GRASP negotiation initiator to negotiate resources with other ASA in the network.

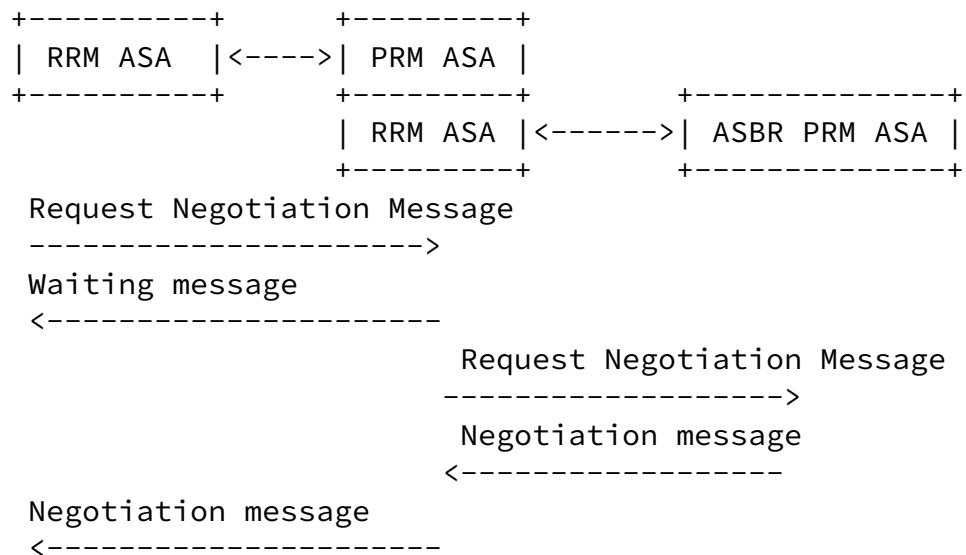
When the RRM ASA receives a Negotiation response message, it should check whether the resource value within the Negotiate message is the same as the resource value requested. If it is the same, the RRM ASA should send GRASP Negotiation End messages indicating that the negotiation was successful. If it is not the same, the RRM ASA should communicate with Service Initiator about the result and decide whether to accept this negotiation. If accepting this negotiation, RRM ASA should send GRASP Negotiation End messages indicating that the negotiation was successful. If not accepting this negotiation, it should send GRASP Negotiation End messages indicating that the negotiation fails.

[6.2.](#) An example of multiple rounds

In the process of automatic resource management mechanism, RRM ASA and PRM ASA are allowed to negotiate resources for multiple rounds. A very common situation is that the network resources can not meet the resources required by the service, but the service is willing to reduce its resource requirements to ensure the successful deployment of the service. The PRM ASA using Resource Management Objectives contains the resources that the network can provide to the service at present in the response message. The RRM ASA changes the resource requirements according to the specific requirements of the received resources and services, to carry out the next round of service negotiation.

[6.3.](#) An example of multiple domain network

In a multiple network, PRM ASA doesn't have the resource status of other domains. So PRM ASA should negotiate with ASBR PRM ASA before response RRM ASA. The PRM ASA should send a Confirm Waiting message to the RRM ASA, to extend its timeout. When the new resource becomes available confirmed by ASBR, the PRM ASA responds with a GRASP Negotiate message with a resource value offered. The process as Figure 3 shows. The Confirm Waiting message is described in [Section 2.8.9 of \[RFC8990\]](#).



Other processes between APE and ASBR are the same as between Service Initiator and APE.

Figure-3: An example of a path-based resource negotiation

[6.4.](#) An example of changing resource requirements

In the process of automatic resource management mechanism, RRM ASA and PRM ASA are allowed to change and negotiate the resource requirements. In the course of using network services, there will be service requirement change which will lead to the problem of network resource requirement change. ResourceManager ASA needs to be able to handle resource changes in a timely manner to meet service requirements.

During the renegotiation process, RRM ASA resends the service's resource requirements by using ResourceManager GRASP Objective. And the resource renegotiation process does not require the use of the same PRM ASA as at the last negotiation on the mission. PRM ASA receives the resource negotiation message and makes the determination. If the resource requirements are lower than those allocated, the response confirms the information and releases the excess resources. If more resources are required than have been allocated, the resource

negotiation process follows [Section 6.1](#).

PRM ASA does not change existing resource allocation until negotiation on resource changes is complete. After negotiation, PRM ASA makes changes to the resource pool by using response to the negotiated resource requirements and synchronizes them with other ASA nodes.

[6.5](#). An example of releasing resource requirements

After the service is completed, a mechanism is needed to release network resources so that network resources can be used more efficiently. This process can be seen as a change in resource requirements negotiation, where the resource requirements of the service to the network become zero. A negotiation with PRM ASA was initiated by RRM ASA in SI to reduce the resource footprint of the service. Upon completion of the negotiation, PRM ASA released the resources occupied by the service.

[7](#). Compatibility with Other Technologies

A gateway device is used between the GRASP network and the MPLS network. As is known, the RSVP belongs to the distribution mechanism for resource reservation, but it is only coupled with MPLS. Then this device uses the GRASP protocol in the GRASP network, and the MPLS protocol in the MPLS network, so that resource information can be shared.

[8](#). Security Considerations

It complies with GRASP security considerations. Relevant security issues are discussed in [[RFC8990](#)]. The preferred security model is that devices are trusted following the secure bootstrap procedure [[RFC8995](#)] and that a secure Autonomic Control Plane (ACP) [[RFC8994](#)] is in place.

[9](#). IANA Considerations

This document defines a new GRASP Objective option names: "ResourceManager" which is need to be added to the "GRASP Objective

Names" registry.

10. Acknowledgements

Valuable comments were received from Michael Richardson and Brian Carpenter.

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