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Recommendation

ITU-T Q.4140 (07/2023)

SERIES Q: Switching and signalling, and associated measurements and tests

Protocols and signalling for computing power networks

Signalling requirements for service deployment in computing power networks

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Recommendation ITU-T Q.4140

Signalling requirements for service deployment in computing power networks

Summary

Recommendation ITU-T Q.4140 provides the signalling procedures and signalling requirements for service deployment in computing power networks (CPNs) based on Recommendation ITU-T Y.2501. The signalling requirements for service deployment include centralized mode and distributed mode.

History*

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Q.4140	2023-07-14	11	11.1002/1000/15585

Keywords

Centralized mode, computing power network, distributed mode, service deployment, signalling requirements.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

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Recommendation ITU-T Q.4140

Signalling requirements for service deployment in computing power networks

1 Scope

The scope of this Recommendation includes:

– overview for service deployment in computing power network (CPNs);

– data model for service deployment in CPNs;

– signalling procedures for service deployment in CPNs;

– signalling requirements for service deployment in CPNs;

The appendix to this Recommendation also provides an example of:

– modelling computing power.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.2501] Recommendation ITU-T Y.2501 (2021), *Computing power network-framework and architecture*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CPN	Computing Power Network
CPU	Central Processing Unit
DPU	Data Processing Unit
FLOPS	Floating Point Operations Per Second
GPU	Graphics Processing Unit
ISIS	Intermediate System-to-Intermediate System
OAM	Operation Administration and Maintenance

5 Conventions

In this Recommendation, the keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

In the body of this Recommendation and its appendices, the words shall, shall not, should and may sometimes appear, in which case they are to be interpreted, respectively as, is required to, is prohibited from, is recommended and can optionally. The appearance of such phrases or keywords in an appendix or in material explicitly marked as informative are to be interpreted as having no normative intent.

{A}: indicates that the parameter A is mandatory.

[B]: indicates that the parameter B is optional.

*: indicates that the parameter may be multiple items.

6 Overview for service deployment in CPNs

6.1 Introduction

As specified in [ITU-T Y.2501], a CPN is a new type of network that realizes optimized resource allocation by distributing computing, storage, network and other resource information of service nodes through a network control plane (such as a centralized controller, distributed routing protocol, etc.).

Service deployment is a major activity in a CPN. Based on user request, service deployment is realized through the joint selection of computing power resources and network resources. There are two modes for realizing service deployment. One is the centralized mode, that is, service deployment based on the resource selection by a centralized manner. The other one is the distributed mode, that is, service deployment based on extended distributed routing protocol which combines computing power resources and network resources.

Service deployment based on the centralized mode can better meet the user's complex requirements. Service deployment based on the distributed mode can be quickly deployed and more suitable for time sensitive scenarios.

6.2 Interface reference model

Based on the functional architecture of the CPN specified in [ITU-T Y.2501], the functions of resource reporting and service deployment are performed by functional components in different layers, whose messages are exchanged over the interfaces shown in Figure 6-1.

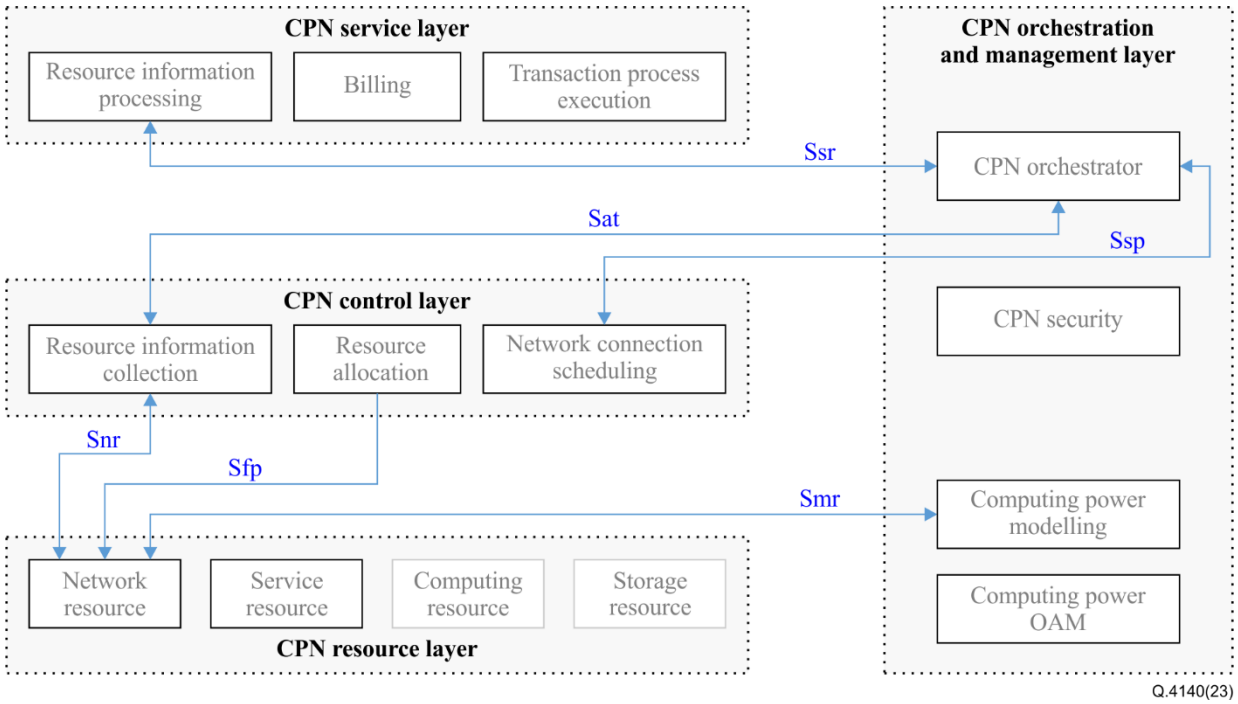

Figure 6-1 – Interfaces between functional entities

NOTE 1 – The network connection scheduling function and the resource allocation function in the CPN control layer share the information for service paths. The CPN orchestrator function and computing power modelling function in the CPN orchestration and management layer share the information for service requests.

NOTE 2 – The computing power operation administration and maintenance (OAM) function obtains computing resource and storage resource from the CPN resource layer through the management interface. The resource information reported to the computing power OAM function is required at a certain interval, or a threshold is required to be set. When the changes exceed the threshold, the resource information is reported. The computing power modelling function obtains the required computing power resource from the computing power OAM function. The CPN orchestrator function obtains computing power resource and modelled computing power resource from the computing power modelling function.

6.2.1 Snr

Snr is defined as the interface between the network resource function in the CPN resource layer and the resource information collection function in the CPN control layer. In the process of resource reporting, through interface Snr, network resource information is transmitted.

6.2.2 Sat

Sat is defined as the interface between the resource information collection function in the CPN control layer and the CPN orchestrator function in the CPN orchestration and management layer. In the process of resource reporting, through interface Sat, abstract topology information is transmitted.

6.2.3 Smr

Smr is defined as the interface between the computing power modelling function in the CPN orchestration and management layer and the network resource function in the CPN resource layer. In the process of service deployment based on distributed mode, through interface Smr, the modelled computing power resource information is transmitted.

6.2.4 Ssr

Ssr is defined as the interface between the resource information processing function in the CPN service layer and the CPN orchestrator function in the CPN orchestration and management layer. In the process of service deployment, through interface Ssr, the service request information is transmitted.

6.2.5 Ssp

Ssp is defined as the interface between the CPN orchestrator function in the CPN orchestration and management layer and the network connection scheduling function in the CPN control layer. In the process of service deployment based on centralized mode, through interface Ssp, the service path information is transmitted.

6.2.6 Sfp

Sfp is defined as the interface between the resource allocation function in the CPN control layer and the network resource function in the CPN resource layer. In the process of service deployment based on centralized mode, through interface Sfp, the forwarding path information is transmitted.

7 Data model for service deployment in CPN

7.1 Resource

7.1.1 Node

The data model description for a node is specified in Table 7-1.

Table 7-1 – Data model description for a node

Element	Description
NodeID	NodeID uniquely specifies the node identification.
NodeType	NodeType specifies the node type, e.g., provider edge, etc.
NodeRole	NodeRole specifies the node role in the network.
InterfaceList	InterfaceList specifies the list of interfaces. Clause 7.1.2 provides an interface data model description.

7.1.2 Interface

The data model description for an interface is specified in Table 7-2.

Table 7-2 – Data model description for an interface

Element	Description
InterfaceID	InterfaceID uniquely specifies the interface identification.
InterfaceType	InterfaceType specifies the interface type, e.g., the optical interface, etc.
AccessInfo	AccessInfo specifies the interface information, including IP address, mask, etc.
Speed	Speed specifies the interface speed.

7.1.3 Link

The data model description for a link is specified in Table 7-3.

Table 7-3 – Data model description for a link

Element	Description
LinkID	LinkID uniquely specifies the link identification.
SourceNodeID	SourceNodeID specifies the source node identification of the link.
SourceInterfaceID	SourceInterfaceID specifies the source interface identification of the link.

Table 7-3 – Data model description for a link

Element	Description
DestinationNodeID	DestinationNodeID specifies the destination node identification of the link.
DestinationInterfaceID	DestinationInterfaceID specifies the destination interface identification of the link.

7.2 Service

7.2.1 Network resource attributes

The data model description for network resource attributes is specified in Table 7-5.

Table 7-5 – Data model for network resource attributes

Element	Description
Bandwidth	Bandwidth specifies the bandwidth requirement of the service.
Latency	Latency specifies the latency requirement of the service.
Jitter	Jitter specifies the jitter requirement of the service.

7.2.2 Computing power resource attributes

The data model description for computing power resource attributes is specified in Table 7-6.

Table 7-6 – Data model description for computing power resource attributes

Element	Description
Computing	Computing specifies the computing requirement of the service, e.g., CPU, GPU, DPU, etc.
Storage	Storage specifies the storage requirement of the service.
Memory	Memory specifies the memory requirement of the service.

7.2.3 Service attributes

The data model description for service attributes is specified in Table 7-7.

Table 7-7 – Data model description for service attributes

Element	Description
ServiceFunc	ServiceFunc specifies the service function information, e.g., firewall, DPI, etc.
NetworkResourceAttribute	NetworkResourceAttribute specifies the network resource attributes. Clause 7.2.1 provides network resource attribute data model description.
ComputingPowerResourceAttribute	ComputingPowerResourceAttribute specifies the computing power resource attributes. Clause 7.2.2 provides computing power resource attribute data model description.

8 Signalling procedures for service deployment in CPN

8.1 Signalling procedure for resource reporting

8.1.1 Signalling procedure for network resources reporting

Figure 8-1 describes the information flow of network resource reporting procedure via interface Snr. The information exchange is based on push mode.

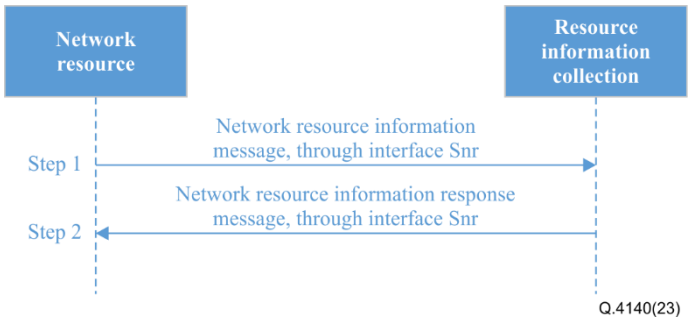

Figure 8-1 – Network resources reporting procedure

Step 1: The network resource function sends a network resource information message to the resource information collection function.

Step 2: The resource information collection function responds to the network resource function to acknowledge that the information is received.

8.1.2 Signalling procedure for abstract topology reporting

Figure 8-2 describes the information flow of abstract topology reporting procedure via interface Sat. The information exchange is based on push-mode.

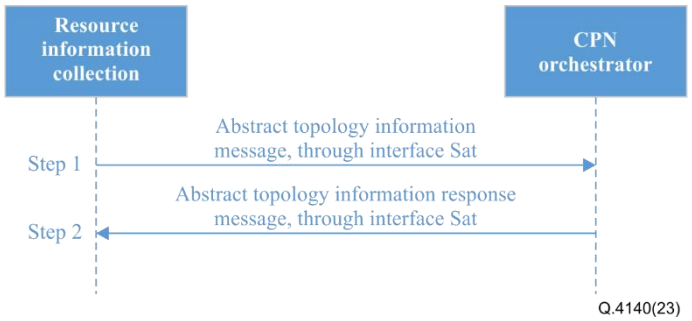

Figure 8-2 – Abstract topology reporting procedure

Step 1: The resource information collection function generates and sends an abstract topology information message to the CPN orchestrator function.

Step 2: The CPN orchestrator function responds to the resource information collection function to acknowledge that the information is received.

8.2 Signalling procedure for service deployment based on centralized mode

Figure 8-3 describes the information flow of service deployment procedure based on centralized mode via interfaces Ssr, Ssp and Sfp, and the functional entities: resource information processing function, CPN orchestrator function, network connection scheduling function, resource allocation function and network resource function. The information exchange is based on push mode.

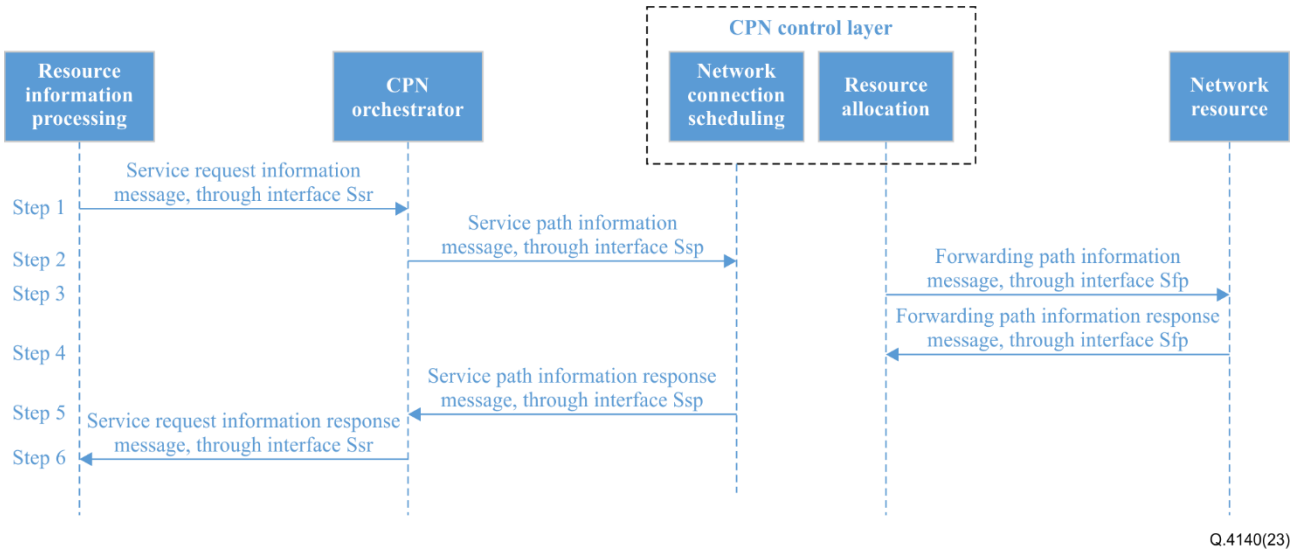

Figure 8-3 – Service deployment procedure based on centralized mode

Step 1: The resource information processing function sends a service request information message to the CPN orchestrator function.

Step 2: The CPN orchestrator function selects the computing power resource pool according to computing power resource and abstract topology, which are stored in the database, and then generates and sends a service path information message to the network connection scheduling function.

Step 3: The resource allocation function calculates the related forwarding path based on network topology and the resource allocation function sends forwarding path information message to the network resource function.

Step 4: The network resource function responds to the resource allocation function by the creation result of forwarding path.

Step 5: The network connection scheduling function responds to the CPN orchestrator function by the creation result of service path.

Step 6: The CPN orchestrator function responds to the resource information processing function by the service deployment result.

8.3 Signalling procedure for service deployment based on distributed mode

The premise of realizing service deployment by distributed routing is that computing power resource information is carried by the routing protocol to be announced in the network.

NOTE 1 – The expansion for the distributed routing protocols using computing power resource information is out of the scope of this Recommendation.

Figure 8-4 describes the information flow of service deployment based on distributed mode via interfaces Ssr and Smr, based on the functional entities: resource information processing function, CPN orchestrator function, computing power modelling function and network resource function.

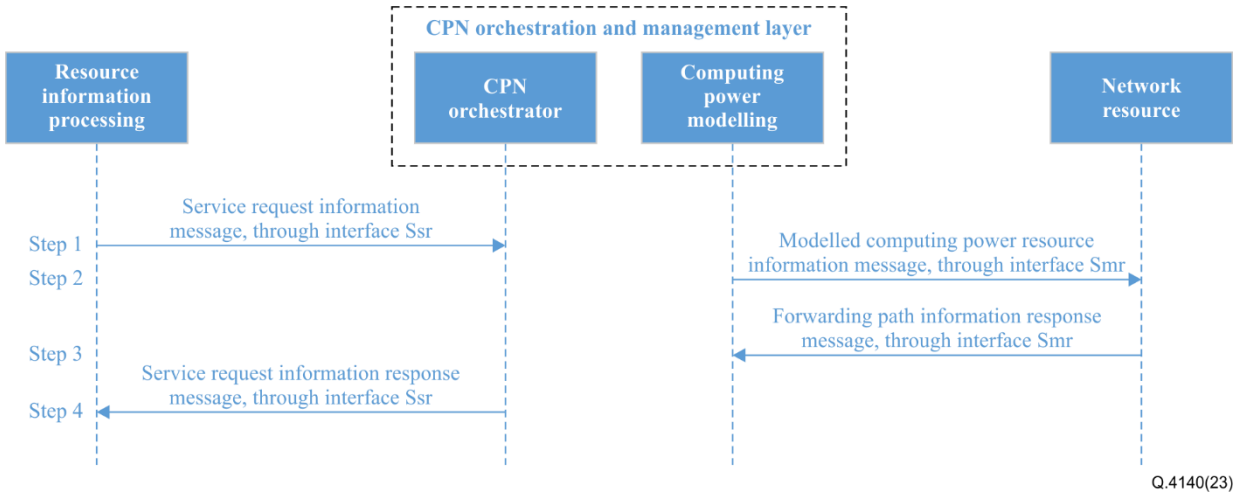

Figure 8-4 – Service deployment procedure based on distributed mode

Step 1: The resource information processing function sends a service request information message to the CPN orchestrator function.

Step 2: The computing power modelling function realizes modelling and evaluation through the unified modelling evaluation method based on the real-time obtained computing power resource information from the computing power OAM function. After modelling, the computing power modelling function sends the modelled computing power resource information message to the network resource function.

NOTE 2 – The method for modelling computing power resource is out of the scope of this Recommendation. There is an example in Appendix I describing how to read the model for computing power resource and how to support the routing table generation of the extended distributed routing protocol.

Step 3: The network resource function queries the mapping between the user access node and the computing power resource pool and establishes forwarding paths based on the routing table including the modelled computing power resource information. The network resource function responds to the computing power modelling function by the result of the forwarding path.

Step 4: The CPN orchestrator function responds to the resource information processing function by the service deployment result.

9 Signalling requirements for service deployment in CPN

9.1 Overview

NOTE – No transport protocol for the signalling messages is specified here. No message content format is specified here either. The signalling messages may be extensible markup language (XML)-based messages over (or carried by) transmission control protocol (TCP), user datagram protocol (UDP), stream control transmission protocol (SCTP), transport layer security (TLS), etc. All the messages consist of the message header and the message body. The message format is described in Figure 9-1.

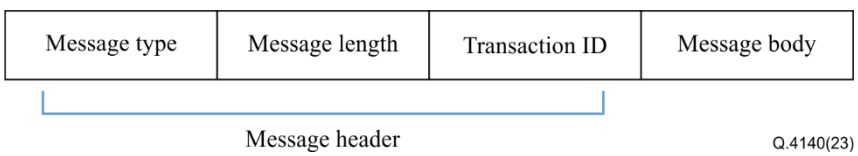

Figure 9-1 – Message composition

The message header field contains the following information:

– message type: uniquely specifies the type of message;

– message length: specifies the length of the message body;

– message transaction ID: generated by the sender of the message.

If there is a response message for the request message, the transaction IDs of the request and response messages are the same.

The message body field contains the message contents.

9.2 Signalling requirements for resource reporting

9.2.1 Signalling requirements for interface Snr

The network resource information message is defined as NetRes message.

The NetRes message, indicated by the message type in the message header field, is sent by the network resource function to the resource information collection function.

Message format:

```
< NetRes-Message > ::=< Message Header >
            {Node-List}
            {Link-List}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

(1) `Node-List` uniquely specifies the node information. Each node in `Node-List` is described using the data model defined in clause 7.1.1.

(2) `Link-List` uniquely specifies the link information, which is described using the data model defined in clause 7.1.3.

The network resource information response message is defined as NetRes-R message.

The NetRes-R message, indicated by the message type in the message header field, is sent by the resource information collection function to the network resource function in order to acknowledge that the information has been received.

Message format:

```
< NetRes-R-Message > ::=< Message Header >
          {NetRes-Result}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

`NetRes-Result` specifies the acknowledgement of the network resource information collection.

9.2.2 Signalling requirement for interface Sat

Abstract topology is a kind of logical topology including some key network nodes and links, which are used for orchestrating service paths.

The abstract topology resource information message is defined as AbstractTopology message.

The AbstractTopology message, indicated by the message type in the message header field, is sent by the resource information collection function to the CPN orchestrator function.

Message format:

```
< AbstractTopology-Message >::=< Message Header >
                    {Node-List}
                    {Link-List}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

(1) `Node-List` uniquely specifies the node information, whose node roles are access node, the node connected to computing power resource pools and the node connected to the other network domain which is described using the data model defined in clause 7.1.1.

(2) `Link-List` uniquely specifies the virtual link information in the abstract topology, which connects the nodes above and is described using the data model defined in clause 7.1.3.

The abstract topology resource information response message is defined as AbstractTopology-R message.

The AbstractTopology-R message, indicated by the message type in the message header field, is sent by the CPN orchestrator function to the resource information collection function.

Message format:

```
< AbstractTopology-R-Message > ::=< Message Header >
                    {AbstractTopology-Result}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

`AbstractTopology-Result` specifies the acknowledgement of receiving abstract topology.

9.3 Signalling requirement for service deployment based on centralized mode

9.3.1 Signalling requirement for interface Ssr

The service request information message is defined as Servicetemplate message.

The Servicetemplate message, indicated by the message type in the message header field, is sent by the resource information processing function to the CPN orchestrator function.

Message format:

```
< Servicetemplate-Message > ::=< Message Header >
                    {Service-ID}
                    {Access-Node-ID}
                    {Service-Attribute-List}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

(1) `Service-ID` uniquely specifies the service identification.

(2) `Access-Node-ID` uniquely specifies the node identification, indicating the access node of the user.

(3) `Service-Attribute-List` specifies the service request information including the required service function, the required network resource and the required computing power resource, which is described using the data model in clause 7.2.3.

The service request information response message is defined as Servicetemplate-R message.

The Servicetemplate-R message, indicated by the message type in the message header field, is sent by the CPN orchestrator function to the resource information processing function.

Message format:

```
< Servicetemplate-R-Message > ::=< Message Header >
                {Servicetemplate-Result}
```

The detailed information indicates but is not limited to:

`Servicetemplate-Result` information specifies the results of service deployment.

9.3.2 Signalling requirement for interface Ssp

Service path is a path generated by CPN orchestrator function based on abstract topology and computing power resource.

The service path information message is defined as Servicepath message.

The Servicepath message, indicated by the message type in the message header field, is sent by the CPN orchestrator function to the network connection scheduling function.

Message format:

```
< Servicepath-Message > ::=< Message Header >
                  {Service-ID}
                  {Access-Node-ID}
                  {Network-Resource-Attributes}
                 *{Pool-ID}
                  {Link-List}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

(1) `Service-ID` uniquely specifies the service identification.

(2) `Access-Node-ID` uniquely specifies the node identification, indicating the access node of the user.

(3) `Network-Resource-Attributes` specifies the required network resource attributes, which is described using the data model defined in clause 7.2.1.

(4) `Pool-ID` uniquely specifies the pool identification, indicating the selected computing power resource pool.

(5) `Link-List` uniquely specifies the virtual link information, which connects the access node of the user and the computing power resource pools and is described using the data model defined in clause 7.1.3.

The service path information response message is defined as Servicepath-R message.

The Servicepath-R message, indicated by the message type in the message header field, is sent by the network connection scheduling function to the CPN orchestrator function.

Message format:

```
< Servicepath-R-Message > ::=< Message Header >
                    {Servicepath-Result}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

`Servicepath-Result` specifies the acknowledgement of receiving service path.

9.3.3 Signalling requirement of interface Sfp

The forwarding path information message is defined as Forwardingpath message.

The Forwardingpath message, indicated by the message type in the message header field, is sent by the resource allocation function to the network resource function.

Message format:

```
< Forwardingpath-Message > ::=< Message Header >
                {Service-ID}
                *{Forwarding-Node-ID}
                *{Forwarding-Interface-ID)
```

Meanings and explanations:

The detailed information indicates but is not limited to:

(1) `Service-ID` uniquely specifies the service identification.

(2) `Forwarding-Node-ID` specifies the node identification, indicating the forwarding node. The access node of the user is the first forwarding node.

(3) `Forwarding-Interface-ID` specifies the interface identification, indicating the forwarding interface.

NOTE – The forwarding nodes are arranged in an order to form a path. `Forwarding-Node-ID` and `Forwarding-Interface-ID` have one to one relationship.

The forwarding path information response message is defined as Forwardingpath-R message.

The Forwardingpath-R message, indicated by the message type in the message header field, is sent by the network resource function to the resource allocation function.

Message format:

```
< Forwardingpath-R-Message > ::=< Message Header >
                    {Forwardingpath-Result}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

`Forwardingpath-Result` specifies the creation result of forwarding path.

9.4 Signalling requirement for service deployment based on distributed mode

NOTE – The signalling requirements for interface Ssr for distributed mode and centralized mode are the same.

The modelled computing power resource information message is defined as ModelledResource message.

The ModelledResource message, indicated by the message type in the message header field, is sent by the computing power modelling function to the network resource function via the interface Smr.

Message format:

```
< ModelledResource-Message > ::=< Message Header >
                        {Service-ID}
                        {Access-node-ID}
                        *{Pool-ID}
                        *{Evaluation-Value}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

(1) `Service-ID` uniquely specifies the service identification.

(2) `Access-node-ID` uniquely specifies the node identification, indicating the access node of the user.

(3) `Pool-ID` uniquely specifies the computing power resource pool identification.

(4) `Evaluation-Value` specifies the evaluation value of modelled computing power resources.

`Evaluation-Value` is integrated by the distributed routing protocols with computing power resource information.

NOTE – `Pool-ID` and `Evaluation-Value` have a one to one relationship.

The forwarding path information response message is defined as Forwardingpath-R message.

The Forwardingpath-R message, indicated by the message type in the message header field, is sent by the network resource function to the computing power modelling function.

Message format:

```
< Forwardingpath-R-Message > ::=< Message Header >
                        {Forwardingpath-Result}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

`Forwardingpath-Result` specifies the creation result of forwarding path.

Appendix I

An example of modelling computing power

(This appendix does not form an integral part of this Recommendation.)

Modelling itself provides a general method to evaluate the capacities of computing power resources.

In the process of modelling, on the one hand, the same type of computing power resources should be unified into the same unit of measurement. On the other hand, some integrated index values can be used to comprehensively reflect the service support capabilities.

An example is given to illustrate how to read the model for computing power resource and how to support generation of the routing table.

As shown in the Figure I.1, there are two computing power resource pools providing services, and a user access the service from R1.

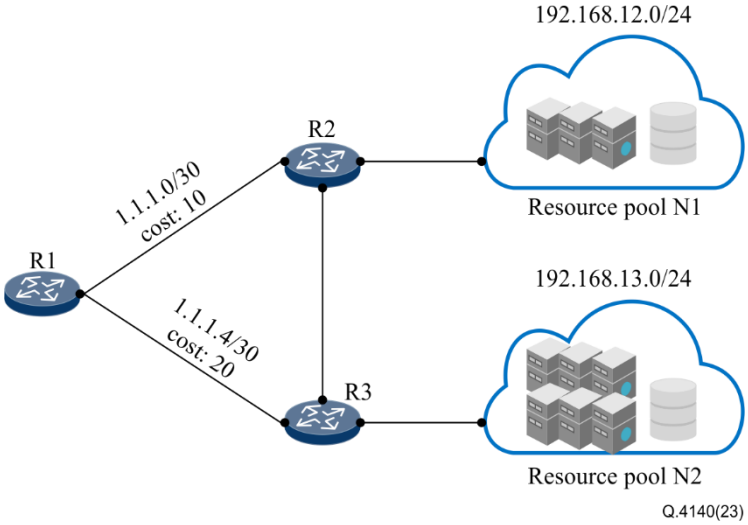

Figure I.1 – An example of network topology

Traditionally, the appropriate node is selected according to the network resources, that is, querying the routing table of R1, as shown in Table I.1.

Table I.1 – Routing table of R1

Destination IP	Protocol	Priority	Cost	Flag	NextHop	Interface
192.168.12.0/24	ISIS	15	10	D	1.1.1.2	GE0/0/1
192.168.13.0/24	ISIS	15	20	D	1.1.1.6	GE0/0/2

When services are deployed in both computing power resource pools, R1 node queries the cost value in the routing table to find that the R2 node as the next hop is more efficient. Therefore, traffic is scheduled to R2 to access service.

In the CPN, the computing power modelling function obtains computing power resource information, such as the CPU capacity (e.g., 2.4 GHz), GPU capacity (e.g., 100TFLOPS) and so on. Based on the obtained information, CPU utilization (e.g., 40%), GPU utilization (e.g., 60%) and other factors are estimated.

When computing resource parameters are combined, routing table information is expressed in Table I.2.

Table I.2 – Routing table of R1 including computing power parameter

Destination IP	Protocol	Priority	Computing power cost	Network cost	Flag	NextHop	Interface
192.168.12.0/24	ISIS	15	10	10	D	1.1.1.2/30	GE0/0/1
192.168.13.0/24	ISIS	15	20	10	D	1.1.1.6/30	GE0/0/2

More specific methods of measurement, modelling and distributing the computing metric are under research in the IETF CATS working group.

When services are deployed in both computing power resource pools, R1 node queries the computing power cost and network cost to select appropriate next hop. In this example, the network cost is the same, R2 node is more efficient in terms of computing power cost. Therefore, traffic is scheduled to R2 to access service.

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