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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Frameworks and functional architecture models

Distributed service networking traffic optimization control functions

Recommendation ITU-T Y.2081

International Telecommunication Union

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Recommendation ITU-T Y.2081

Distributed service networking traffic optimization control functions

Summary

Recommendation ITU-T Y.2081 specifies the functional architecture for traffic optimization control functions (TOCFs), in support of steering traffic distribution according to certain optimization objectives in the environment of DSN described in Recommendation ITU-T Y.2080.

The main objective of this Recommendation is to specify the functional entities of the TOCF and reference points, including information flows, between these functional entities.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2081	2012-07-29	13

Keywords

Distributed service networking, DSN, functional architecture, functional entities, functions, reference points, traffic optimization control function, TOCF.

FOREWORD

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Distributed service networking traffic optimization control functions

1 Scope

This Recommendation specifies the traffic optimization control functions (TOCFs) and reference points between TOCF functional entities in support of steering traffic distribution according to certain optimization objectives in the environment of distributed service networking (DSN) and next generation networks (NGN). The TOCF supports application traffic optimization based on network awareness features (including topology information and traffic information) and provides capabilities for service providers (SPs) and network providers to work jointly to optimize the transfer of service traffic.

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.2012] Recommendation ITU-T Y.2012 (2010), *Functional requirements and architecture of next generation networks*.

[ITU-T Y.2080] Recommendation ITU-T Y.2080 (2012), *Functional architecture for distributed service networking*.

[ITU-T Y.2206] Recommendation ITU-T Y.2206 (2010), *Requirements for distributed service networking capabilities*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 content node [ITU-T Y.2080]: A distributed service networking (DSN) node which can be used for media content distribution, storage and/or caching.

3.1.2 distributed service networking [ITU-T Y.2206]: An overlay networking which provides distributed and manageable capabilities to support various multimedia services and applications.

3.1.3 DSN node [ITU-T Y.2206]: A node used in DSN providing distributed functionalities, including distributed routing and distributed storage.

3.1.4 functional entity [ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.1.5 reference point [ITU-T Y.2012]: A conceptual point at the conjunction of two non-overlapping functional entities that can be used to identify the type of information passing between these functional entities.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 management and optimization policies: The policies used in the traffic optimization control function (TOCF) for improving the resource management efficiency or optimizing the traffic transportation. These policies can be defined according to demands of the network provider, application provider, and also can be adjusted based on static and dynamic network information.

3.2.2 point of presence (POP): A point representing one or several distributed service networking (DSN) nodes, which support DSN users to access services directly without having intermediate DSN nodes.

3.2.3 traffic optimization control function (TOCF): A function which optimizes application traffic distribution by the cooperation between network providers and application providers. The TOCF supports traffic optimization based on network awareness features (including topology information and traffic information).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADSL Asymmetric Digital Subscriber Line

AF Application Function

AS Autonomous System

CDF Content Delivery Function

CSAF Content Service Application Function

DSN Distributed Service Networking

DTIC-FE Dynamic Traffic Information Collection Functional Entity

HTTP Hypertext Transfer Protocol

ID Identifier

NEF Node Enrolment Function

NGN Next Generation Network

OPP-FE Optimization Policy Processing Functional Entity

OPS-FE Optimization Policy Specification Functional Entity

P2P Peer to Peer

PID Partition ID

POP Point Of Presence

QoS Quality of Service

RF Relay Function

RLF Resource Location Function

STIC-FE Static Topology Information Collection Functional Entity

TOCF Traffic Optimization Control Function

5 Conventions

None.

6 Overview of TOCFs

Traffic optimization control functions (TOCFs) make the delivery of application traffic, especially content application traffic and real-time application traffic (such as P2P traffic and multimedia telephony traffic) more efficient and cost-effective. TOCFs also achieve efficient transportation, which improves service quality of the DSN network.

TOCFs retrieve network information such as topology-related information, traffic-related information from underlying transport network(s) and traffic optimization policy(ies) from the network operator, which help to realize traffic optimization in applications running on top of these underlying networks. TOCFs support the following aspects:

a) They provide suitable topology related information for the DSN node located within their network. This information can be coarser or finer depending on the different traffic localization requirements. It mainly includes domains (e.g., AS domain) that the DSN nodes belong to, the IP address of those DSN nodes and the relative topological distance based on route hops or traversed number of AS domains.

b) They provide suitable traffic-related information for the DSN node selection. This information can be provided in long-time or in real-time formats to reflect the traffic congestion situation. It mainly includes dynamic loads in links or paths between DSN nodes or POPs.

c) They provide information about optimal routing of voice, multimedia telephony and other real-time services.

d) They provide the geographic information and property information (e.g., ADSL, cable or other access type) of DSN nodes to help the RLF make decisions regarding which content node is a better one to cache new content or to respond to a new content request.

e) They hide the network's topology from applications.

TOCFs support controlling traffic distribution according to certain optimization objectives in the environment of DSN.

Figure 6-1 shows the relationship between the TOCF and other DSN functions as defined in [ITU-T Y.2080].

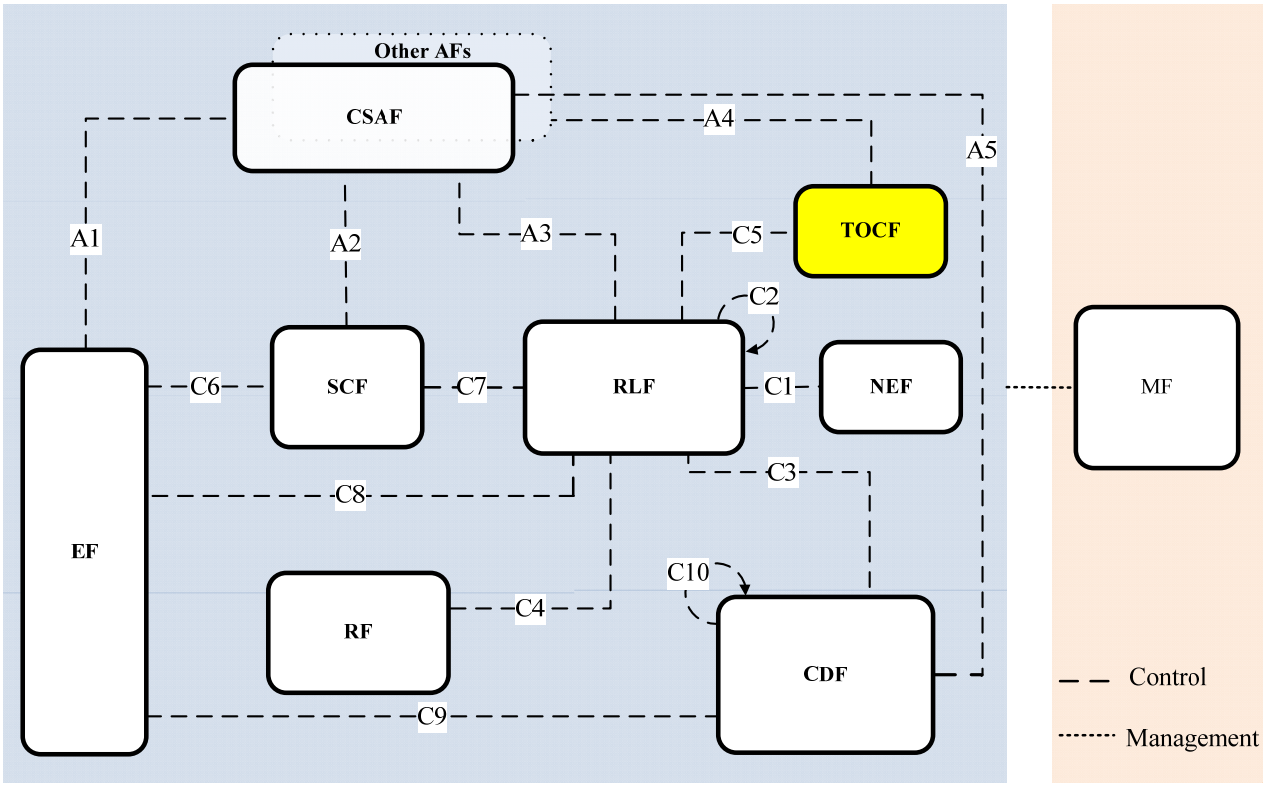

Figure 6-1 – The position of the TOCF in the DSN architecture

7 TOCF functional architecture

7.1 Architecture framework

TOCFs include four functional entities which support more efficient and cost-effective delivery of application traffic. In DSN architecture, TOCFs define traffic optimization policies for the AF and RLF. According to the policies, TOCFs transfer the required traffic optimization information to the AF and RLF.

Figure 7-1 describes the TOCF functional architecture with functional entities and relevant reference points.

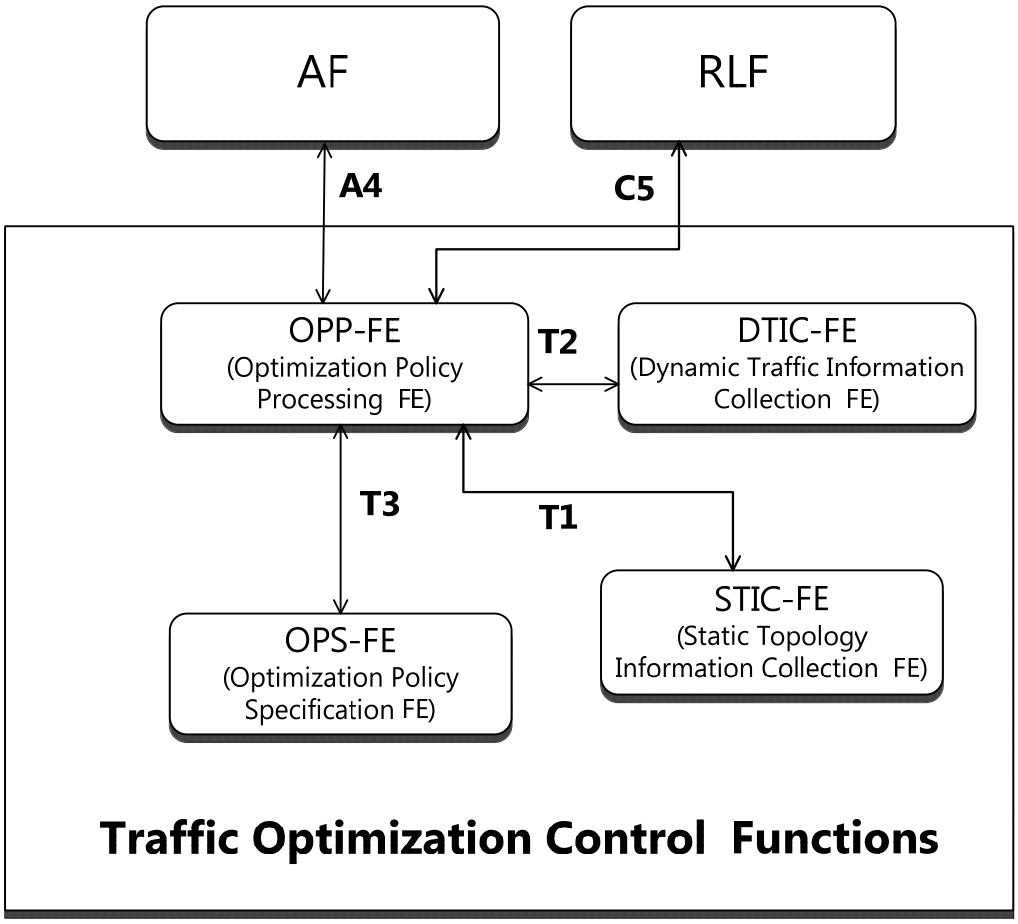

Figure 7-1 – TOCF functional architecture

The TOCF functional architecture includes the following functional entities:

- optimization policy specification functional entity (OPS-FE), whose main role is to define traffic optimization policies according to the demands of the network provider and/or application provider;
- optimization policy processing functional entity (OPP-FE), whose main role is to provide the required traffic optimization information to the AF and RLF according to the traffic optimization policies;
- static topology information collection functional entity (STIC-FE), whose main role is to get the static topology information;
- dynamic traffic information collection functional entity (DTIC-FE), whose main role is to get the dynamic traffic information.

Clause 7.2 provides a detailed description of the TOCF functional entities while clause 8 describes the reference points related to the TOCF.

7.2 Functional entities

7.2.1 Optimization policy specification functional entity (OPS-FE)

OPS-FE defines specific traffic optimization policy which is executed according to the demands of the network provider and/or application provider.

OPS-FE performs the following function:

- It generates and maintains a policy database about the traffic optimization policies, which includes:
  - intra-operator's network traffic localization;
  - inter-operator traffic minimization;
  - real-time application performance optimization;
  - link congestion minimization.

7.2.2 Optimization policy processing functional entity (OPP-FE)

OPP-FE performs the following functions:

- It collects static topology information and node property information from the STIC-FE and dynamic traffic information from the DTIC-FE.
- It processes specific traffic optimization policy which is requested by the OPS-FE, and provides a process result (such as network map and cost map between different POPs) to other functional entities in the DSN architecture. The process result can be provided to the RLF and AF to optimize the traffic of content delivery application, voice and multimedia real-time applications.
- It proposes ranking recommendations based on the specific traffic optimization policy and returns the node/PID/path priority to the requesting network entity.
- It responds to the query for QoS values, such as delay and delay jitter, between different POPs.

7.2.3 Static topology information collection functional entity (STIC-FE)

STIC-FE performs the collection of static information as follows:

- STIC-FE collects the static information from the transport network, which includes:
  - groups of IP addresses of DSN nodes according to different domains of networks;
  - absolute physical distance between two POPs based on knowledge of the approximate geo-location;
  - relative topological distance between two POPs based on route hops or traversed numbers of AS domains;
  - cost of links between two POPs;
  - routes to other operators' networks.
- STIC-FE collects node property information, which includes:
  - node access type information (i.e., ADSL, cable or other types).
- STIC-FE provides static topology information and node property information to the OPP-FE after such information is updated.

7.2.4 Dynamic traffic information collection functional entity (DTIC-FE)

DTIC-FE performs the collection of dynamic information as follows:

- DTIC-FE collects the dynamic information from the transport stratum:
  - the link load status (being congested or not) between two POPs, with selected DSN nodes and inter-operator links;
  - the transport quality parameters between two POPs, including selected DSN nodes, including delay, delay jitter and packet loss rate.
- DTIC-FE processes the basic dynamic information above and provides necessary information to the OPP-FE.
- DTIC-FE provides the policy-related dynamic traffic information to the OPP-FE periodically or on demand from the OPP-FE.

8 Reference points and information flows

This clause describes the reference points related to the TOCF. As shown in Figure 7-1, the following interactions apply:

– OPP-FE interacts with the STIC-FE via the T1 reference point to obtain the static information of the network.

– OPP-FE interacts with the DTIC-FE via the T2 reference point to obtain the dynamic information of the network.

– OPS-FE interacts with the OPP-FE via the T3 reference point to transfer the management and optimization policies.

– OPP-FE implements the RLF and AF's traffic optimization request with policy information from OPS-FE and information collected from the STIC-FE and DTIC-FE.

– OPP-FE interacts with the RLF via the C5 reference point and interacts with the AF via the A4 reference point.

8.1 Reference point T1 between STIC-FE and OPP-FE

The T1 reference point uses Query, Response, Subscribe and Notify information flows to query and subscribe the static topology information between the STIC-FE and OPP-FE.

NOTE – The recommended underlying protocol is HTTP, or other transport protocol (e.g., TCP) that can support the reliable transfer of the defined information flows.

8.1.1 Information flows across the T1 reference point

Figure 8-1 shows the procedures supported across the T1 reference point.

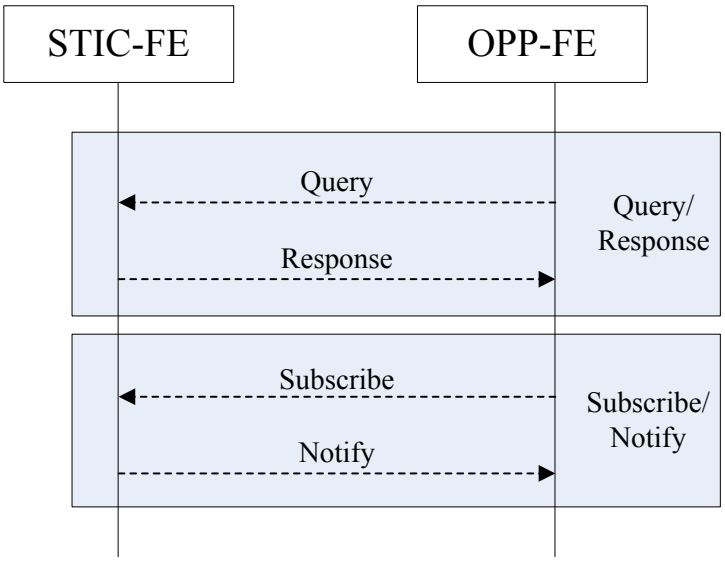

Figure 8-1 – Information flows of T1

8.1.2 Description of information flows

8.1.2.1 Query information flow

The Query information flow is sent from the OPP-FE to the STIC-FE, to request the static network information from the STIC-FE. The Query information flow may or may not include parameters. If no parameter is included, it means that static information among all POPs is requested to be provided in the Response information flow.

Table 8-1 provides the description of the information components included in the Query information flow.

Table 8-1 – Query information components

Information components	Description
POP_1, … POP_i	Identification of each interested POP; if POP is not specified, it means all POPs.

8.1.2.2 Response information flow

The Response information flow is sent from STIC-FE to OPP-FE to provide the required static network information. It includes the IP address field information of every requested POP, node property information and metric between POPs whose information is included in the Response message.

Table 8-2 provides the description of the information components included in the Response information flow.

NOTE – When deployed, the concrete node property name and value need to be defined.

Table 8-2 – Response information components

Information components	Description
(POP_i; IP_field1, IP_field2, node property list ...) (POP_i, POP_j, metric)	POP_i: identification of each requested POP. IP_field1, IP_field2: the continuous IPv4/IPv6 address space. Metric: network cost value between two different POPs, such as POP_i and POP_j. Node property: property of the node, such as access type.

8.1.2.3 Subscribe information flow

The Subscribe information flow is sent from the OPP-FE to the STIC-FE to request notification on the modification of cost between specific POPs which reflects the timeliness of the carrier's management and optimization policies.

Table 8-3 provides the description of the information components included in the Subscribe information flow.

Table 8-3 – Subscribe information components

Information components	Description
(POP_i, POP_j)	POP_i, POP_j: A pair of identification of POPs. Notification of the cost between two POPs will be sent from the STIC-FE, if the subscription request is accepted.

8.1.2.4 Notify information flow

The Notify information flow is sent from STIC-FE to OPP-FE, to request the updated static network information. Once there is any change within the information components in STIC-FE, STIC-FE will send a Notify information flow (including POPs) about which metric values or properties have been changed.

Table 8-4 provides the description of the information components included in the Notify information flow.

Table 8-4 – Notify information components

Information components	Description
(POP_i; IP_field1, IP_field2, node property list ...) (POP_i, POP_j, metric)	POP_i: identification of each requested POP. IP_field1, IP_field2: the continuous IPv4/IPv6 address space. Metric: network cost value between two different POPs, such as POP_i and POP_j. Node property: property of the node, such as access type.

8.2 Reference point T2 between DTIC-FE and OPP-FE

The T2 reference point uses Query, Response, Subscribe and Notify information flows to query and subscribe the dynamic traffic information and QoS parameters between the DTIC-FE and the OPP-FE.

NOTE – The recommended transfer protocol is HTTP, or other transport protocol (e.g., TCP) that can provide reliable transfer of the defined messages.

8.2.1 Information flows across the T2 reference point

Figure 8-2 shows the procedures supported across the T2 reference point.

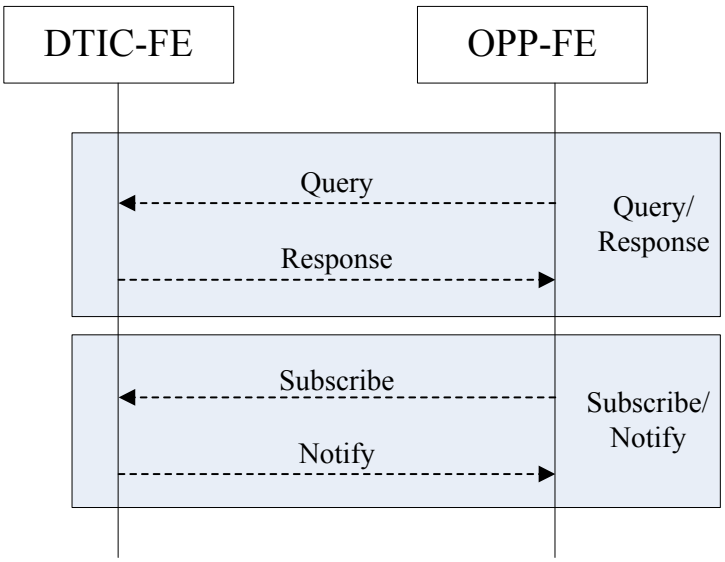

Figure 8-2 – Information flows of T2

8.2.2 Description of information flows

8.2.2.1 Query information flow

The Query information flow is sent from the OPP-FE to the DTIC-FE to get the dynamic network information from the DTIC-FE. The Query message may or may not include parameters. If no parameter is included, it means that the OPP-FE requires dynamic information among all POPs.

Table 8-5 provides the description of the information components included in the Query information flow.

Table 8-5 – Query information components

Information components	Description
POP_1, … POP_i	Identification of each requested POP; if POP is not specified, it means all POPs.
Cthreshold	Congestion threshold value defined by the OPS-FE. A link will be labelled as "congestion" when the load percentage of the link exceeds the value of Cthreshold.
HQthreshold (delay, delay jitter, loss rate)	High quality threshold value defined by the OPP-FE. A route will be labelled as "high quality" when its QoS parameters (delay, delay jitter, packet loss rate) are lower than the value of HQthreshold.
QoS value request	If this component is 1, it means that the query message is requesting the original QoS value between the interested POPs. Otherwise, it means no detailed QoS value is requested.

8.2.2.2 Response information flow

The Response information flow is sent from DTIC-FE to OPP-FE to provide the required dynamic network information. It includes the congestion status and traffic quality between every two requested POPs whose information is included in the Response message.

Table 8-6 provides the description of the information components included in the Response information flow.

Table 8-6 – Response information components

Information component	Description
(POP_i, POP_j, congestion)	POP_i, POP_j: a pair of identification of POPs to which the network information belongs. Congestion: congestion (true)/no congestion (false)
(POP_i, POP_j, high quality)	High quality: high quality (true)/low quality (false)
(POP_i, POP_j, delay, delay jitter, loss rate)	Delay, delay jitter, loss rate: the QoS parameters between every two different POPs and measurement of specific execution policy.

8.2.2.3 Subscribe information flow

The Subscribe information flow is sent from the OPP-FE to the DTIC-FE to request notification on the modification of cost between specific POPs to reflect the timeliness of the carrier's management and optimization policies.

Table 8-7 provides the description of the information components included in the Subscribe information flow.

Table 8-7 – Subscribe information components

Information component	Description
(POP_i, POP_j)	A pair of identification of POPs. Notification of the cost between two POPs will be sent from the DTIC-FE, if the subscription request is accepted.

8.2.2.4 Notify information flow

The Notify information flow is sent from DTIC-FE to OPP-FE, to provide the updated dynamic network information. Once there is any change within the information components in DTIC-FE, DTIC-FE will send a Notify information flow (including POPs) about which congestion status or QoS parameters have been changed.

Table 8-8 provides the description of the information components included in the Notify information flow.

Table 8-8 – Notify information components

Information component	Description
(POP_i, POP_j, congestion)	POP_i, POP_j: a pair of identification of POPs to which network information belongs. Congestion: congestion (true)/no Congestion (false)
(POP_i, POP_j, high quality)	High quality: high quality (true)/low quality (false)
(POP_i, POP_j, delay, delay jitter, loss rate)	Delay, delay jitter, loss rate: the QoS parameters between two POPs and measurement of specific execution policy.

8.3 Reference point T3 between OPS-FE and OPP-FE

The T3 reference point uses the PolicyProcessRequest information flow to provide the specific execution policies.

NOTE – The recommended transfer protocol is HTTP, or other transport protocol (e.g., TCP) that can provide reliable transfer of the defined messages.

8.3.1 Information flows across the T3 reference point

Figure 8-3 shows the procedures supported across the T3 reference point.

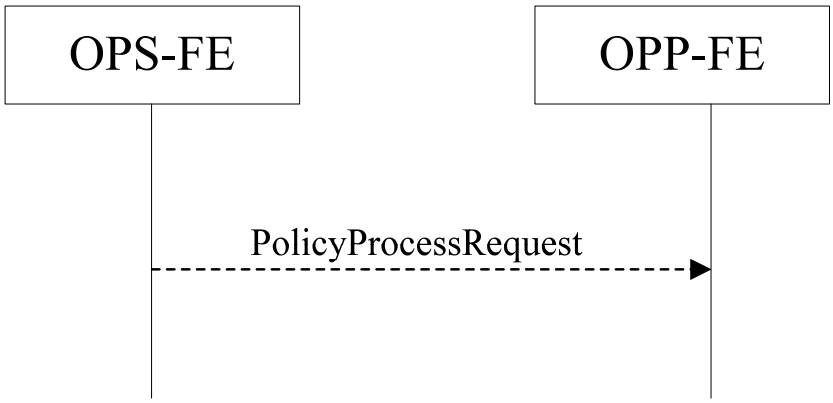

Figure 8-3 – Information flows of T3

8.3.2 Description of information flows

8.3.2.1 PolicyProcessRequest information flow

The PolicyProcessRequest information flow is sent from the OPS-FE to the OPP-FE to provide the specific optimization policy.

Table 8-9 provides the description of the information components included in the PolicyProcessRequest information flow.

Table 8-9 – PolicyProcessRequest information components

Information component	Description
P-int <P_1, P_2, P_3 ... P_n>	<P_1, P_2, P_3, …, P_n> represent a policy sequence in the order of priority with P_1 having the highest priority. P_n can be any type of the following: preference given to inter-area traffic-localization, preference given to inter-operator traffic-minimization or preference given to application-performance.
Cthreshold	Congestion threshold value defined by the OPS-FE. A link will be labelled as "congestion" when the load percentage of this link exceeds the value of Cthreshold.

8.4 Reference point A4 between AF and OPP-FE

The A4 reference point uses the Query/Response/Subscribe/Notify information flow to transfer the specific information.

NOTE – The recommended transfer protocol is HTTP, or other transport protocol (e.g., TCP) that can provide reliable transfer of the defined messages.

8.4.1 Information flows across A4

Figure 8-4 shows the procedures supported across the A4 reference point.

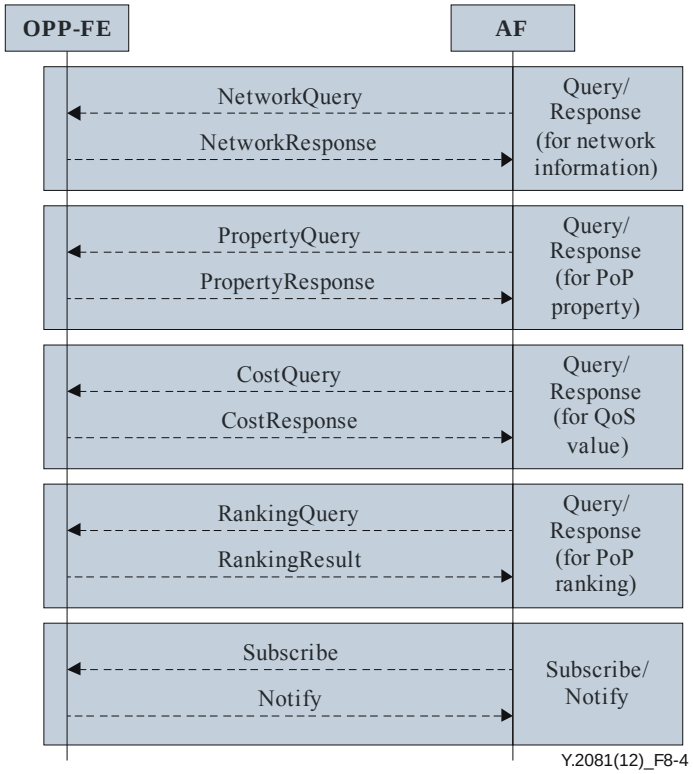

Figure 8-4 – Information flows of A4

8.4.2 Description of information flows

8.4.2.1 NetworkQuery information flow

The NetworkQuery information flow is sent from AF to OPP-FE to request information on which POP has the listed IP addresses. A NetworkQuery message can include multiple IP addresses.

Table 8-10 provides the description of the information components included in the NetworkQuery information flow.

Table 8-10 – NetworkQuery information components

Information component	Description
IP_1, IP_2, IP_3 ... IP_i	IP address of the requested POP.

8.4.2.2 NetworkResponse information flow

The NetworkResponse information flow is sent from OPP-FE to AF to provide information on which POP has the required IP address. A NetworkResponse message can include multiple mappings between the requested IP address and the corresponding POP.

Table 8-11 provides the description of the information components included in the NetworkResponse information flow.

Table 8-11 – NetworkResponse information components

Information component	Description
(POP_i, IP_i)	The mapping of the IP address to the identification of POP.

8.4.2.3 PropertyQuery message

The PropertyQuery information flow is sent from AF to OPP-FE to request the property of the POP. A PropertyQuery message can include identifications of multiple POPs.

Table 8-12 provides a description of the information components included in the PropertyQuery information flow.

Table 8-12 – PropertyQuery information components

Information component	Description
POP_1, ... POP_i	Identification of the requested POP.

8.4.2.4 PropertyResponse information flow

The PropertyResponse information flow is sent from OPP-FE to AF to provide the property of the requested POPs.

Table 8-13 provides the description of the information components included in the PropertyResponse information flow.

Table 8-13 – PropertyResponse information components

Information component	Description
(POP_i, node property list)	A mapping between the requested POP and its node property.

8.4.2.5 CostQuery information flow

The CostQuery information flow is sent from AF to OPP-FE to request the cost or QoS values between different POPs.

Table 8-14 provides the description of the information components included in the CostQuery information flow.

Table 8-14 – CostQuery information components

Information component	Description
Source POP_i Destination POP_i QoS value request	Identification of requested source POPs. Identification of requested destination POPs. NOTE – One POP may appear in both source and destination. QoS value request: if this component is 1, it indicates that the query message is requesting the QoS value between requested POPs; otherwise, it means no detailed QoS value is requested.

8.4.2.6 CostResponse information flow

The CostResponse information flow is sent from OPP-FE to AF to provide the required cost or QoS values.

Table 8-15 provides the description of the information components included in the CostResponse information flow.

Table 8-15 – CostResponse information components

Information component	Description
(POP_i, POP_j, cost)	POP_i, POP_j: a pair of identification of POPs to which network information belongs. Cost: network cost value between every two source and destination POPs and measurement of specific execution policy.
(POP_i, POP_j, delay, delay jitter, loss rate)	The QoS parameters between every two POPs and measurement of specific execution policy.

8.4.2.7 RankingQuery information flow

The RankingQuery information flow is sent from AF to OPP-FE to request the ranking list of candidate POPs from the OPP-FE.

Table 8-16 provides the description of the information components included in the RankingQuery information flow.

Table 8-16 – RankingQuery information components

Information component	Description
POP_1, … POP_i	An identifying list of candidate POPs sorted in the order of the HQthreshold.
HQthreshold (delay, delay jitter, loss rate)	HQthreshold: the AF wants to achieve the preferred POPs according to QoS parameters, which are defined by the high quality threshold value.

8.2.4.8 RankingResult information flow

The RankingResult information flow is sent from OPP-FE to AF to provide the ranking result of candidate POPs to the AF.

Table 8-17 provides the description of the information components included in the RankingResult information flow.

Table 8-17 – RankingResult information components

Information component	Description
POP_a, POP_b, POP_c ... POP_m	List of the requested POPs in the order of preference, with POP_a having the highest preference.

8.4.2.9 Subscribe information flow

The Subscribe information flow is sent from AF to OPP-FE to request the information flow about modification of cost between specific POPs to reflect the timeliness of the carrier's management and optimization policies. Once there is any cost change between the requested POPs, the AF can obtain the notification in time.

Table 8-18 provides the description of the information components included in the Subscribe information flow.

Table 8-18 – Subscribe information components

Information component	Description
(Application identification)	Application identification is used to inform the OPP-FE who has subscribed for notification.
(POP_i, POP_j)	A pair of identification of POPs. Notification of the cost between two POPs will be sent from the OPP-FE, if the subscription request is accepted.

8.4.2.10 Notify information flow

The Notify information flow is sent from OPP-FE to AF to reflect the changed cost between the interested/subscribed POP. Once there is any change in the cost, the OPP-FE will send this Notify information flow.

Table 8-19 provides the description of the information components included in the Notify information flow.

Table 8-19 – Notify information components

Information component	Description
(POP_i, POP_j, cost)	POP_i, POP_j: a pair of identification of POPs. Cost: the changed cost value between two POPs.

8.5 Reference point C5 between RLF and OPP-FE

The C5 reference point uses the Query/Response/Subscribe/Notify information flow to transfer the specific execution policies and information.

NOTE – The recommended transfer protocol is HTTP, or other transport protocol (e.g., TCP) that can provide reliable transfer of the defined messages.

8.5.1 Information flows of C5

Figure 8-5 shows the procedures supported across the C5 reference point.

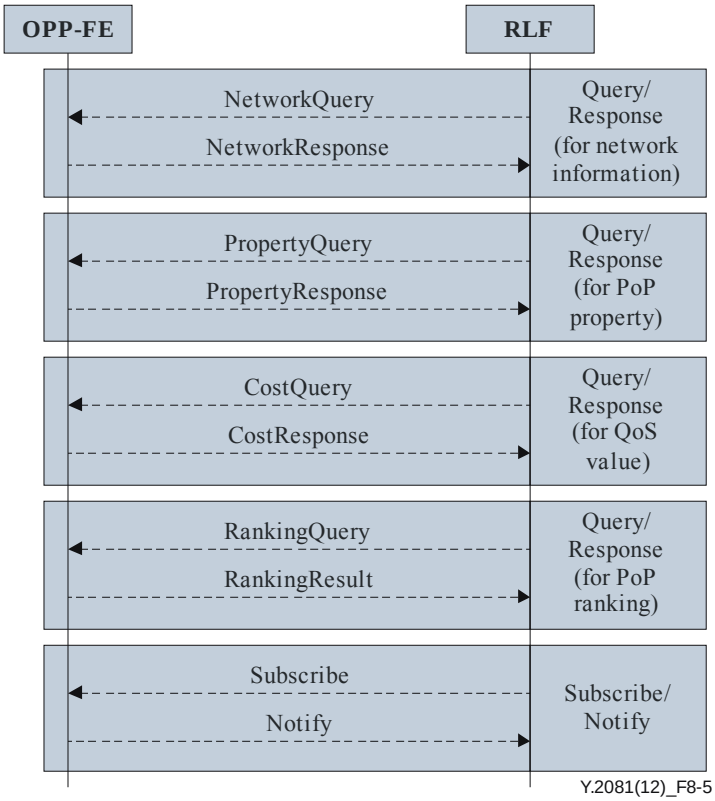

Figure 8-5 – Information flows of C5

8.5.2 Description of information flows

8.5.2.1 NetworkQuery information flow

The Query information flow is sent from RLF to OPP-FE to request information on which POP has the listed IP address. The RLF is able to know of the network topology with the IP address of the node.

Table 8-20 provides the description of the information components included in the NetworkQuery information flow.

Table 8-20 – NetworkQuery information components

Information component	Description
IP_1, … IP_i	IP address of requested POP.

8.5.2.2 NetworkResponse information flow

The NetworkResponse information flow is sent from OPP-FE to RLF to provide information on which POP has the required IP address.

Table 8-21 provides the description of the information components included in the NetworkResponse information flow.

Table 8-21 – NetworkResponse information components

Information component	Description
(POP_i, IP_i)	The mapping of the IP address to the identification of POP.

8.5.2.3 PropertyQuery information flow

The PropertyQuery information flow is sent from RLF to OPP-FE to request the property of the POP.

Table 8-22 provides the description of the information components included in the PropertyQuery information flow.

Table 8-22 – PropertyQuery information components

Information component	Description
POP_1, … POP_i	Identification of the requested POP.

8.5.2.4 PropertyResponse information flow

The PropertyResponse information flow is sent from OPP-FE to RLF to provide the property of the requested POPs.

Table 8-23 provides the description of the information components included in the PropertyResponse information flow.

Table 8-23 – PropertyResponse information components

Information component	Description
(POP_i, node property list)	A mapping between the requested POP and its node property.

8.5.2.5 CostQuery information flow

The CostQuery information flow is sent from RLF to OPP-FE to request the cost or QoS values between different POPs from the OPP-FE.

Table 8-24 provides the description of the information components included in the CostQuery information flow.

Table 8-24 – CostQuery information components

Information component	Description
Source POP_i Destination POP_i	Identification of requested source POPs. Identification of requested destination POPs. NOTE – One POP may appear in both source and destination.
QoS value request	If this component is 1, it indicates that the query message is requesting the QoS value between requested POPs; otherwise, it means no detailed QoS value is requested.

8.5.2.6 CostResponse information flow

The CostResponse information flow is sent from OPP-FE to RLF to provide the required cost or QoS values.

Table 8-25 provides the description of the information components included in the CostResponse information flow.

Table 8-25 – CostResponse information components

Information component	Description
(POP_i, POP_j, cost) …	POP_i, POP_j: a pair of identification of POPs to which the following cost information belongs. Cost: network cost value between every two source and destination POPs and measurement of specific execution policy.
(POP_i, POP_j, delay, delay jitter, loss rate)	Delay, delay jitter, loss rate: the QoS parameters between every pair of POPs and measurement of the specific execution policy.

8.5.2.7 RankingQuery information flow

The RankingQuery information flow is sent from RLF to OPP-FE to request the ranking list of requested POPs from the OPP-FE.

Table 8-26 provides the description of the information components included in the RankingQuery information flow.

Table 8-26 – RankingQuery information components

Information component	Description
POP_1, … POP_n	A list of identification of candidate POPs sorted in the order of the HQthreshold.
HQthreshold (delay, delay jitter, loss rate)	High quality threshold value used as criterion in sorting the listed POPs.

8.5.2.8 RankingResult information flow

The RankingResult information flow is sent from OPP-FE to RLF to indicate the ranking result of candidate POPs to the RLF.

Table 8-27 provides the description of the information components included in the RankingResult information flow.

Table 8-27 – RankingResult information components

Information component	Description
POP_a, POP_b, POP_c ... POP_m	List of the requested POPs in the order of preference, with POP_a having the highest preference.

8.5.2.9 Subscribe information flow

The Subscribe information flow is sent from RLF to OPP-FE to request the information flow about modification of cost between specific POPs to reflect the timeliness of the carrier's management and optimization policies. Once there is any change in cost between the requested POPs, the RLF can obtain the notification in time.

Table 8-28 provides the description of the information components included in the Subscribe information flow.

Table 8-28 – Subscribe information components

Information component	Description
(Application identification)	Application identification: to tell the OPP-FE which application subscribes to the notification information flow.
(POP_i, POP_j)	A pair of identification of POPs. Notification of the cost between two POPs will be sent, if the subscription request is accepted.

8.5.2.10 Notify information flow

The Notify information flow is sent from OPP-FE to RLF to provide the changed cost between requested POPs. Once there is any change in the cost, the OPP-FE will send this Notify information flow.

Table 8-29 provides the description of the information components included in the Notify information flow.

Table 8-29 – Notify information components

Information component	Description
(POP_i, POP_j, cost)	POP_i, POP_j: a pair of identification of POPs. Cost: the changed cost value between two POPs.

9 Security considerations

TOCFs provide the network topology information and traffic information to the AF and RLF. TOCFs should evaluate how much information is revealed and the associated risks. TOCFs may optionally use authentication (and potentially encryption) to protect the information provided. In order to limit un-authenticated access to TOCFs or to prevent denial-of-service attacks by arbitrary hosts, TOCFs may employ access control.

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