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

Cloud Computing

Framework of inter-cloud computing

Recommendation ITU-T Y.3511

ITU-T

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

GLOBAL INFORMATION INFRASTRUCTURE

General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899

INTERNET PROTOCOL ASPECTS

General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999

NEXT GENERATION NETWORKS

Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999

FUTURE NETWORKS

CLOUD COMPUTING	Y.3500–Y.3999
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Recommendation ITU-T Y.3511

Framework of inter-cloud computing

Summary

Recommendation ITU-T Y.3511 describes the framework for interactions of multiple cloud service providers (CSPs), which is referred to as inter-cloud computing. Based on several use case, and after considering the different types of service offerings, this Recommendation describes the possible relationships (peering, federation or intermediary) among multiple CSPs. By introducing the concept of primary CSP and secondary CSP, the Recommendation further describes CSP interactions for the cases of federation and intermediary patterns. Finally, relevant functional requirements are derived.

History

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* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/11830-en>.

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Table of Contents

	Page
1 Scope.....	1
2 References.....	1
3 Definitions	1
3.1 Terms defined elsewhere	1
3.2 Terms defined in this Recommendation.....	1
4 Abbreviations and acronyms	2
5 Conventions	2
6 Introduction.....	3
7 Patterns of inter-cloud.....	4
7.1 Inter-cloud peering	4
7.2 Inter-cloud federation	5
7.3 Inter-cloud intermediary	5
8 Overview of inter-cloud computing.....	6
8.1 Relationship between intra-cloud and inter-cloud handling of resources	6
8.2 Overview of inter-cloud federation	7
8.3 Overview of inter-cloud intermediary	11
9 Functional requirements for inter-cloud	14
9.1 SLA and policy negotiation.....	14
9.2 Resource monitoring	14
9.3 Resource performance estimation and selection	15
9.4 Resource discovery and reservation	15
9.5 Resource set-up and activation.....	16
9.6 Cloud services switchover and switchback	16
9.7 Resource release	16
9.8 CSC information exchange.....	16
9.9 Primary CSP role delegation	17
9.10 Inter-cloud service handling.....	17
10 Security considerations	18
Appendix I – Use cases from the inter-cloud perspective	19
I.1 SLA mapping in intermediary pattern	19
I.2 Performance guarantee against an abrupt increase in load (offloading)	19
I.3 Performance guarantee regarding delay (optimization for user location)	21
I.4 Guaranteed availability in the event of a disaster or large-scale failure.....	23
I.5 Service continuity (in the case of service termination of the original CSP) ..	25
I.6 Market transactions in inter-cloud intermediary pattern	26
Appendix II – Use cases from cloud service providers' views	28
II.1 Use case 1 – Cloud service rebranding.....	29

	Page
II.2 Use case 2 – Discovery.....	29
II.3 Use case 3 – Intermediary	29
II.4 Use case 4 – Platforming.....	29
II.5 Use case 5 – Offloading	29
II.6 Use case 6 – Virtual data centre expansion	29
II.7 Use case 7 – Distributed media	29
II.8 Use case 8 – Cloud storage expansion	30
II.9 Use case 9 – Service delivery platform components.....	30
Appendix III – Abstract service offering models for inter-cloud computing	31
III.1 Service item expansion.....	31
III.2 Service operation enhancement.....	32
III.3 Consideration on network connectivity.....	33
Appendix IV – Inter-cloud security aspects.....	36
Bibliography.....	37

Recommendation ITU-T Y.3511

Framework of inter-cloud computing

1 Scope

This Recommendation describes the framework for interactions between multiple cloud service providers (CSPs), which is referred to as inter-cloud computing. Based on use cases involving several CSPs and after considering different types of service offerings (given in the appendices), this Recommendation describes the possible relationships among multiple CSPs, interactions between CSPs and relevant functional requirements.

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 X.1601] Recommendation ITU-T X.1601 (2014), *Security framework for cloud computing*.
- [ITU-T Y.3501] Recommendation ITU-T Y.3501 (2013), *Cloud computing framework and high-level requirements*.
- [ITU-T Y.3520] Recommendation ITU-T Y.3520 (2013), *Cloud computing framework for end to end resource management*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 cloud service customer [ITU-T Y.3501]: A person or organization that consumes delivered cloud services within a contract with a cloud service provider.

3.1.2 cloud service provider [ITU-T Y.3501]: An organization that provides and maintains delivered cloud services.

3.1.3 resource management [ITU-T Y.3520]: A way to access, control, manage, deploy, schedule and bind resources when they are provided by service providers and requested by customers.

3.1.4 service level agreement [b-ISO/IEC 20000-1:2011]: Documented agreement between the service provider and customer that identifies services and service targets

NOTE 1 – A service level agreement can also be established between the service provider and a supplier, an internal group or a customer acting as a supplier.

NOTE 2 – A service level agreement can be included in a contract or another type of documented agreement.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 inter-cloud computing: The paradigm for enabling the interworking between two or more cloud service providers.

NOTE – Inter-cloud computing is also referred as inter-cloud.

3.2.2 primary cloud service provider: In inter-cloud computing, a cloud service provider which is making use of cloud services of peer cloud service providers (i.e., secondary cloud service providers) as part of its own cloud services.

3.2.3 secondary cloud service provider: In inter-cloud computing, a cloud service provider which provides cloud services to a primary cloud service provider.

NOTE – The primary cloud service provider can use the services of secondary cloud service providers as part of its services offered to cloud service customers.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

B2B Business-to-Business

CaaS Communications as a Service

CDN Content Distribution Network

CPU Central Processing Unit

CSC Cloud Service Customer

CSP Cloud Service Provider

DRM Digital Rights Management

IaaS Infrastructure as a Service

ID Identifier

IT Information Technology

LAN Local Area Network

NaaS Network as a Service

P-CSP Primary CSP

PaaS Platform as a Service

QoS Quality of Service

S-CSP Secondary CSP

SaaS Software as a Service

SDP Service Delivery Platform

SLA Service Level Agreement

VM Virtual Machine

VPN Virtual Private Network

5 Conventions

In this Recommendation:

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

The keywords **"is recommended"** indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

In the body of this Recommendation and its appendices, the words should, and may sometimes appear, in which case they are to be interpreted, respectively, as 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.

6 Introduction

Inter-cloud computing describes the interworking of cloud service providers (CSPs) in order to deliver services for the users. Inter-cloud relationship between CSPs can be realized by using a service from the peer CSP or by providing a service to the peer CSP.

The case where two peer CSPs interact with each other through an inter-cloud relationship is illustrated in Figure 6-1. As shown by a pair of two arrows pointing in opposite directions in Figure 6-1, CSP A is making use of the services provided by CSP B. In this relationship, CSP A is considered as being the primary CSP while CSP B is the secondary CSP. Note that the reverse situation where CSP B is using the services offered by CSP A may also exist and in such case CSP A and CSP B are involved in two inter-cloud relationships, one for providing services to the peer CSP and the other for using the services of the peer CSP.

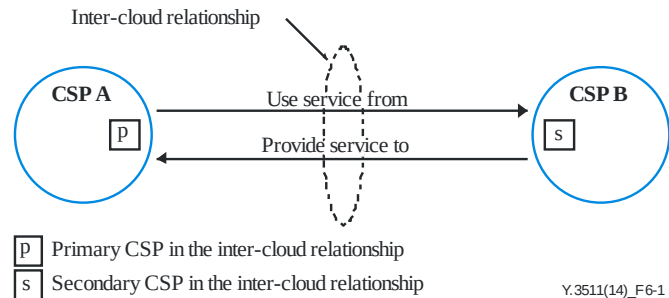


Figure 6-1 – Inter-cloud relationship between peer CSPs

Figure 6-2 illustrates in a different way the inter-cloud relationship between CSP A and CSP B, i.e., CSP A uses the service of CSP B through the application programming interface (API) provided by CSP B, shown as API (B). Although the arrow in Figure 6-2 is only one and is shown as unidirectional from CSP A to CSP B, it should be understood as being equivalent to the inter-cloud relationship shown in Figure 6-1, i.e., covering the "use service from" and "provide service to" arrows in Figure 6-1.

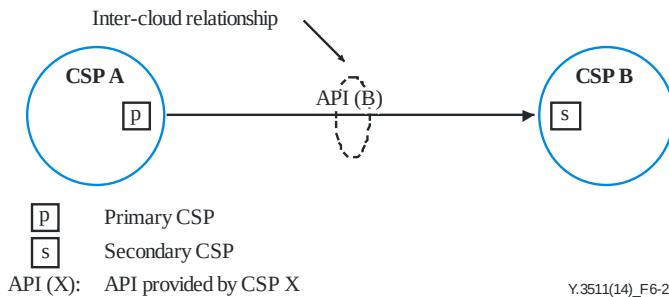


Figure 6-2 – Inter-cloud relationship using API

7 Patterns of inter-cloud

This clause introduces three patterns of inter-cloud for describing relations and interactions involving multiple CSPs, i.e.,:

- The inter-cloud peering;
- The inter-cloud federation;
- The inter-cloud intermediary.

7.1 Inter-cloud peering

In inter-cloud peering, two CSPs interwork directly with each other in order to use the services provided by the peer CSP.

NOTE 1 – Inter-cloud peering does not necessarily imply reciprocal relationships in terms of service use and service providing between the two CSPs.

NOTE 2 – Inter-cloud peering is a fundamental pattern, which may exist on its own or can be used in the two patterns described in clauses 7.2 (inter-cloud federation) and 7.3 (inter-cloud intermediary).

In inter-cloud peering, each CSP exposes its own API for cloud interworking and the CSPs interwork with each other directly by using the other CSP's API. As shown in Figure 7-1, CSP A interworks with CSP B using the API provided by CSP B and vice versa. Since the inter-cloud peering pattern can be used in the other pattern described in clauses 7.2 and 7.3, use of a common API between CSP A and CSP B is not precluded (see Figure 7-2).

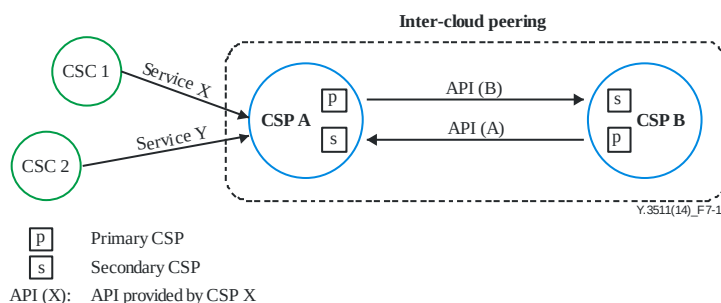


Figure 7-1 – Inter-cloud peering

As shown in Figure 7-1, the inter-cloud peering pattern consists of two inter-cloud relationships, CSP A to CSP B relationship and CSP B to CSP A relationship. CSP A is a primary CSP when using the services of CSP B provided by API (B) for providing services to its own customers (CSC1 and CSC2) and is also a secondary CSP when providing services to CSP B through its own API (A).

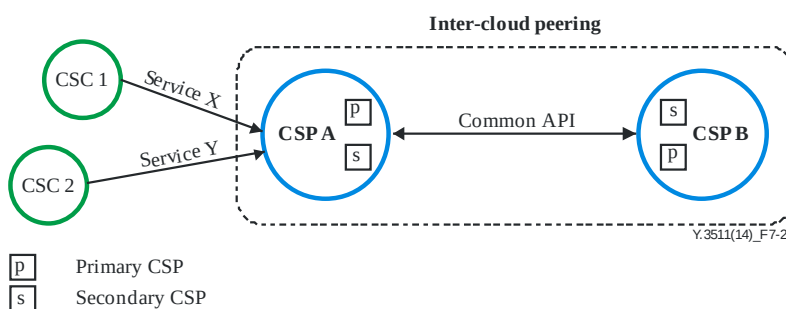


Figure 7-2 – Common API in the peering pattern

Figure 7-2 illustrates the case where a common API is used between CSP A and CSP B, i.e., API (A) and API (B) in Figure 7-1 are the same.

7.2 Inter-cloud federation

Inter-cloud federation involves using the cloud services within a group of peer CSPs who mutually combine their service capabilities in order to provide the set of cloud services required by cloud service customers (CSCs).

The multiple CSPs, which form the inter-cloud federation, establish and share the common agreement which may range from service-related policies, service level agreements (SLAs) and procedures which are relevant to the service offering and resource handling.

Based on the agreement, a CSP in the inter-cloud federation can offer its cloud services with the help of other CSPs.

A common API for cloud interworking is defined in the inter-cloud federation. As shown in Figure 7-3, each CSP interworks with the other CSPs in the inter-cloud federation through this common API.

It should be noted that the inter-cloud federation pattern does not necessarily require the fully meshed configuration of CSPs interacting with each other as shown in Figure 7-3.

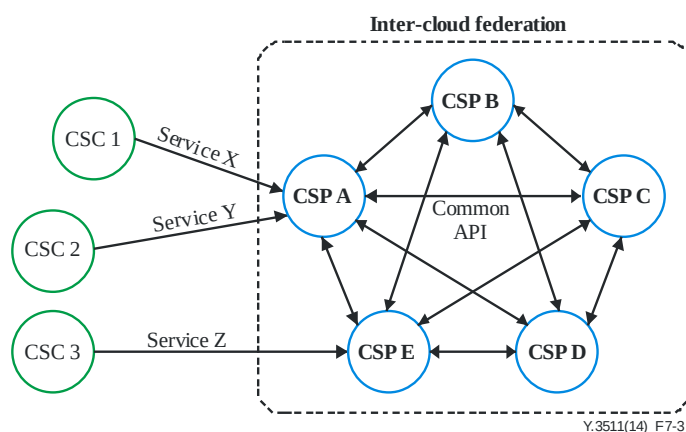


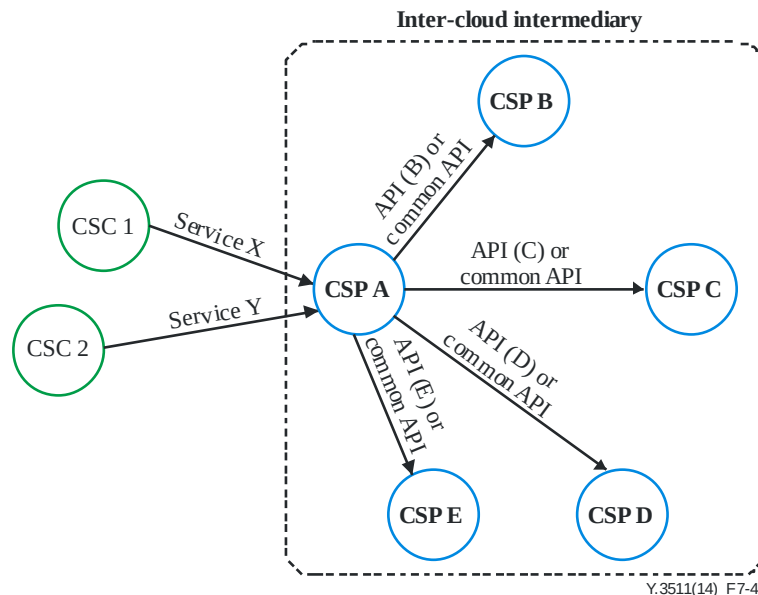
Figure 7-3 – Inter-cloud federation

7.3 Inter-cloud intermediary

In the inter-cloud intermediary pattern, the CSP interworks with one or more peer CSPs and provides intermediation, aggregation and arbitrage of services provided by these CSPs.

Service intermediation consists in conditioning or enhancing the cloud service of a peer CSP. Service aggregation relates to the composition of a set of services provided by the peer CSPs. Service arbitrage is about selecting one service offering from a group of services offered by the peer CSPs.

Interworking between a CSP providing service intermediation, aggregation and arbitrage and the peer CSPs can rely on either the inter-cloud peering pattern or the inter-cloud federation pattern. Figure 7-4 illustrates the inter-cloud intermediary pattern where CSP A provides intermediation, aggregation and arbitrage of cloud services provided by CSPs B, C, D and E.



NOTE – API (X): API provided by cloud service provider X

Figure 7-4 – Inter-cloud intermediary

8 Overview of inter-cloud computing

8.1 Relationship between intra-cloud and inter-cloud handling of resources

For collaboration among CSPs, two types of resources can be distinguished. One includes underlying physical resources of a cloud infrastructure which are controlled and managed by the CSP who owns these resources. The other type includes resources which are abstracted from the underlying physical resources and are offered as services to CSPs. During the collaboration of CSPs, such abstracted resources are also utilized during interactions between these CSPs.

Based on the abstraction, underlying physical resources will become abstracted resources. Detailed information of underlying physical resources, such as total central processing unit (CPU) cores and memories available in the infrastructure, will be hidden. During the collaboration among CSPs, only the information of abstracted resources, such as the CPU cores and memories dedicated to the given service, will be subject for interactions.

Figure 8-1 shows the relationship between intra-cloud and inter-cloud and their handling of resources.

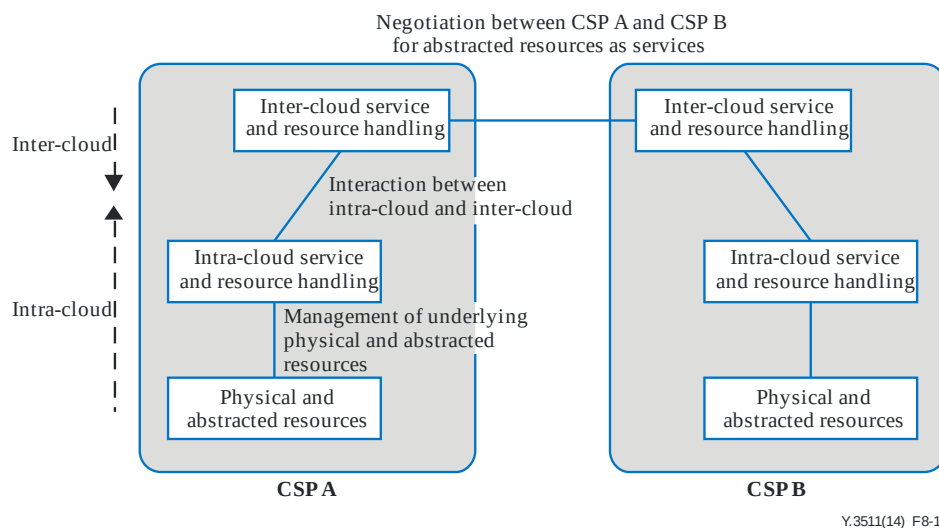


Figure 8-1 – Intra-cloud and inter-cloud relationship and handling of resources

In Figure 8-1, intra-cloud service and resource handling allows a CSP (A or B) to manage its own resources including underlying physical resources and abstracted resources. Inter-cloud service and resource handling allows a CSP to negotiate for the use of peer CSPs' abstracted resources provided as cloud services.

For example, when CSP A decides to use resources from CSP B, its intra-cloud service and resource handling will interact with its inter-cloud service and resource handling, which will then interact with CSP B. When the inter-cloud service and resource handling of CSP B receives the request from CSP A, the request will be relayed towards its own intra-cloud service and resource handling in order for CSP B to decide whether to provide the service and associated abstracted resources to the CSP A.

8.2 Overview of inter-cloud federation

8.2.1 Introduction

In the inter-cloud federation pattern, a number of CSPs provide services to CSCs. When needed (e.g., in the event of a serious shortage in resource pool), CSPs within the inter-cloud federation utilize other CSPs' resources to provide services to their customers.

Figure 8-2 illustrates the inter-cloud federation pattern.

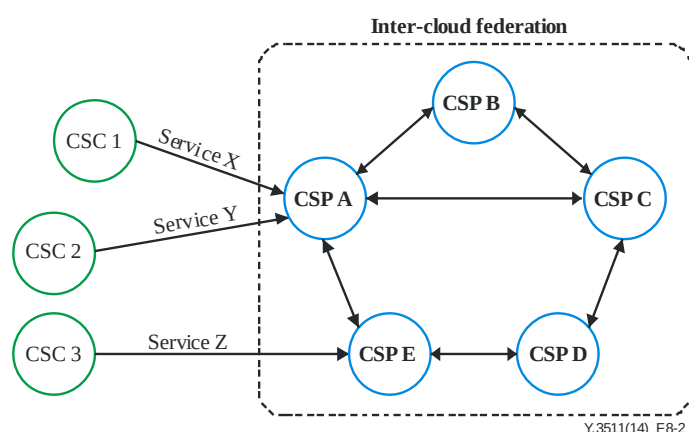


Figure 8-2 – Inter-cloud federation

As shown in Figure 8-2, CSC 1 and CSC 2 use services X and Y provided by CSP A, but the resources used for services X and Y may actually be provided by CSPs B, C or E.

8.2.2 Primary CSP and secondary CSP

In an inter-cloud federation, two or more CSPs interact to provide cloud services to CSCs. The CSP that is responsible for providing the services to a given CSC is called the primary CSP while the peer CSPs in the inter-cloud federation offering their own resources as services to the primary CSP are called secondary CSPs.

When needed, the primary CSP will make request in order to utilize the resources of secondary CSPs. The primary CSP determines which secondary CSPs will actually provide such resources (e.g., in terms of processing power, storage and networks) to the CSC. In some cases, the primary CSP may provide none of its own resources and will have to obtain all resources required for the support of services from secondary CSPs.

The roles of primary CSP and secondary CSP depend on the individual service. For example, in Figures 8-3 and 8-4, CSP A is the primary CSP and CSPs B, C and E are secondary CSPs for services X and Y. For service Z, CSP E is the primary CSP and CSPs A and D are secondary CSPs.

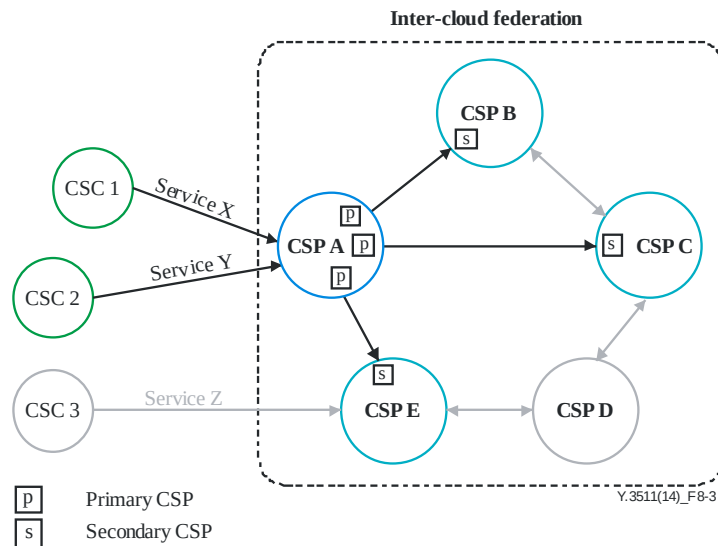


Figure 8-3 – CSP A offering services as the primary CSP with the help of secondary CSPs

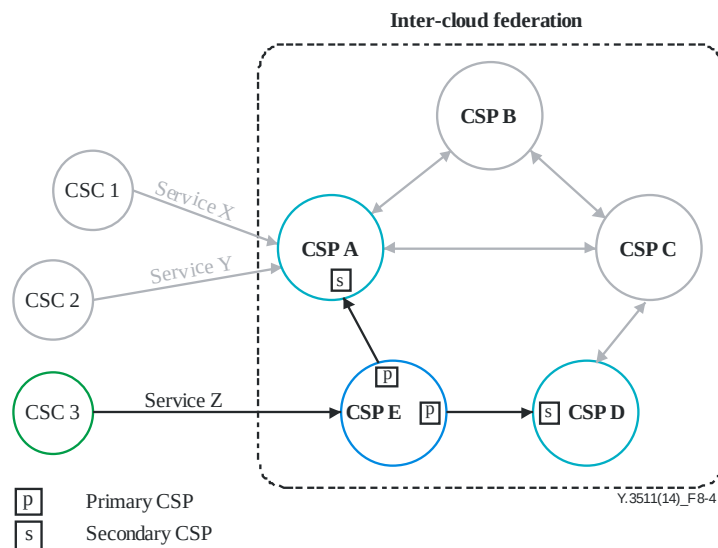


Figure 8-4 – CSP E offering services as the primary CSP with the help of secondary CSPs

A given CSP can act as a primary CSP and secondary CSP, i.e., using the services of secondary CSPs (e.g., CSP A in Figure 8-3) and providing services to a primary CSP (e.g., CSP A in Figure 8-4).

8.2.3 Network connectivity

In order to deliver cloud services based on the use of inter-cloud computing, network connectivity is required among the involved CSCs, primary CSPs and secondary CSPs. Specifically, this includes:

- Connectivity between peer CSPs. By means of this connectivity, a primary CSP can interwork with the secondary CSPs to request a service (e.g., backup of data or transfer of virtual machines between connected CSPs). In some cases, this connectivity is provided on-demand; the connectivity is established instantaneously as the need arises and removed after the need disappears;