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SERIES Y: GLOBAL INFORMATION
INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS,
NEXT-GENERATION NETWORKS, INTERNET OF
THINGS AND SMART CITIES

Cloud Computing

Cloud computing – Overview and functional requirements for data storage federation

Recommendation ITU-T Y.3505

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

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	Y.3000–Y.3499
CLOUD COMPUTING	**Y.3500–Y.3999**
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.3505

Cloud computing – Overview and functional requirements
for data storage federation

Summary

Recommendation ITU-T Y.3505 provides an overview and functional requirements for data storage federation. Data storage federation provides a single virtual volume from multiple data sources in heterogeneous storages. In this Recommendation, configuration for logical components and an ecosystem of data storage federation as well as cloud computing based data storage federation are introduced for data storage federation. Functional requirements are derived from use cases.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Cloud computing, data storage federation, functional requirement.

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Table of Contents

Recommendation ITU-T Y.3505

Cloud computing – Overview and functional requirements
for data storage federation

1   Scope

This Recommendation provides overview and functional requirements for data storage federation (DSF) including benefits, configuration for logical components and ecosystem of data storage federation as well as cloud computing based data storage federation. The functional requirements provided in this Recommendation are derived from use cases.

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.3500]   Recommendation ITU-T Y.3500 (2014), *Information technology – Cloud computing – Overview and vocabulary*.

[ITU-T Y.3502]   Recommendation ITU-T Y.3502 (2014), *Information technology – Cloud computing – Reference architecture*.

3   Definitions

3.1   Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1   activity [ITU-T Y.3502]: A specified pursuit or set of tasks.

3.1.2   cloud computing [ITU-T Y.3500]: Paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand.

NOTE – Examples of resources include servers, operating systems, networks, software, applications and storage equipment.

3.1.3   cloud service customer [ITU-T Y.3500]: Party which is in a business relationship for the purpose of using cloud services.

NOTE – A business relationship does not necessarily imply financial agreements.

3.1.4   cloud service provider [ITU-T Y.3500]: Party which makes cloud services available.

3.1.5   metadata [b-ISO/IEC 2382]: Data about data or data elements, possibly including their data descriptions, and data about data ownership, access paths, access rights and data volatility.

3.1.6   role [ITU-T Y.3502]: A set of activities that serves a common purpose.

3.1.7   sub-role [ITU-T Y.3502]: A subset of the activities of a given role.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 data storage federation (DSF): A processing to provide a single virtual volume from the multiple heterogeneous data storages using storage virtualization.

NOTE – In this Recommendation, heterogeneous storage refers to DSF local storage.

3.2.2 DSF local storage: A physical storage to be integrated.

NOTE – DSF local storage includes on-premises storage such as main memory, non-volatile memory express (NVMe), solid state disk, hard disk drive, serial attached small computer system interface (SCSI), Internet SCSI storage and network-attached storage, object-based storage device, intelligent storage device, etc. and cloud storage with different management units such as block, object and file.

3.2.3 single virtual volume: A virtual storage unit provided in forms of a block device, disk, or object device.

NOTE – Customer of single virtual volume includes an end-user, server, operating system and application.

3.2.4 storage virtualization: An abstraction of storage resource to provide logical storage.

NOTE – The abstraction includes consolidating the different type of storages into a virtual storage pool as well as dividing a virtual storage pool into a single virtual volume.

3.2.5 virtual storage pool: A logical storage by integration of DSF local storage.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API   Application Programming Interface

CCRA   Cloud Computing Reference Architecture

CRUD   Create Read Update Delete

CSC   Cloud Service Customer

CSP   Cloud Service Provider

CSU   Cloud Service User

DMP   Data Manipulation Provider

DSF   Data Storage Federation

FTP   File Transfer Protocol

GUI   Graphical User Interface

iSCSI   Internet Small Computer System Interface

NFS   Network File System

NVMe   Non-Volatile Memory express

PCIe   Peripheral Component Interconnect express

SCSI   Small Computer System Interface

SFP   Storage Federation Provider

SFTP   SSH File Transfer Protocol

SMB   Server Message Block

SSD   Solid State Disk

SSH   Secure Shell

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.

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.

6 Overview of data storage federation

6.1 Introduction to data storage federation

Increasing data services in many industries, which use big volumes of data with various data types has led to a tremendous growth in storage capacity needs. A storage user may encounter difficulties utilizing various storages due to the different access mechanisms and storage capabilities of each storage type. In order to resolve these difficulties, data storage federation (DSF) helps customers to utilize their data storages efficiently by federating heterogeneous storages including cloud storage and on-premises storage.

DSF integrates DSF local storage into a virtual storage pool and provides a single virtual volume in the virtual storage pool as shown in Figure 6-1.
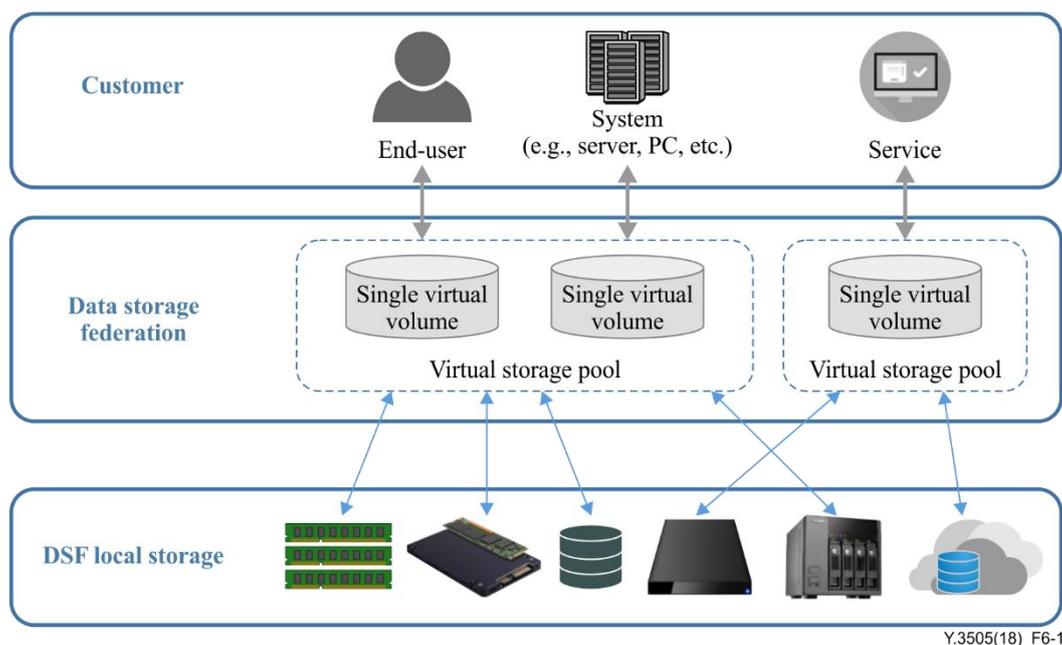
Figure 6-1 – Concept of data storage federation

DSF provides a single virtual volume for a customer with a single access point and also provides storage access mechanisms to DSF local storage.

When a customer requests the single virtual volume, DSF creates a single virtual volume in the virtual storage pool through storage operations. In accordance with customer requests to use the single virtual volume, storage operations such as creating, deleting and scaling are performed by DSF.

Examples of basic storage operations are described in detail as follows:

– **creating**: connecting DSF local storage, creating virtual storage pool and creating a single virtual volume;

– **deleting**: deleting a single virtual volume, deleting a virtual storage pool and disconnecting DSF local storage;

– **scaling**: extending a single virtual volume, extending a virtual storage pool and attaching another DSF local storage.


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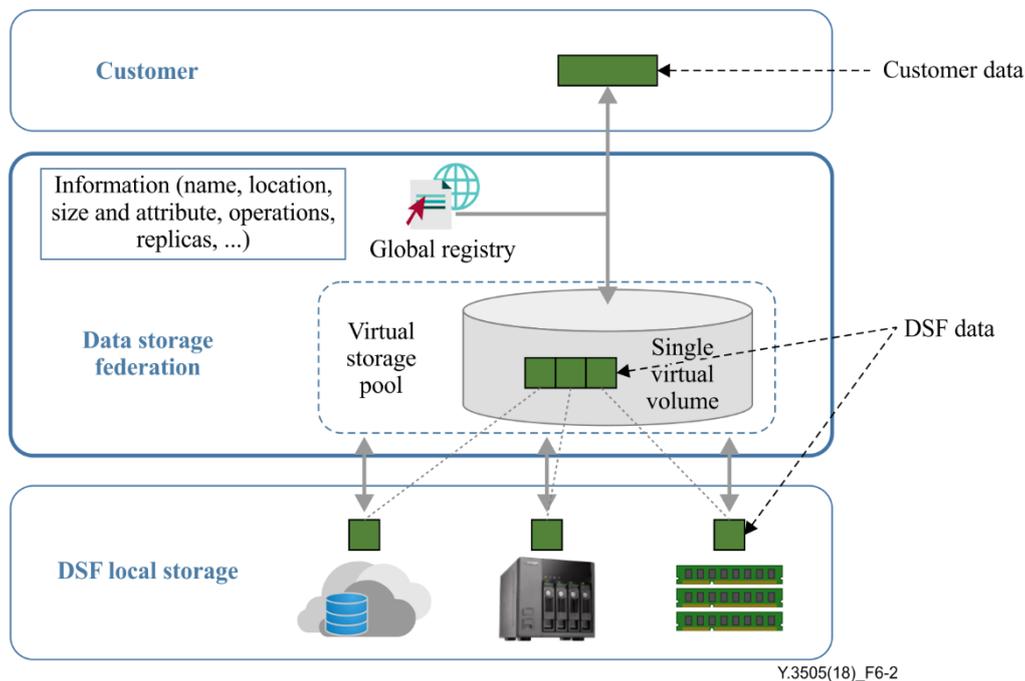
Figure 6-2 – Example of customer data manipulation in DSF

Figure 6-2 shows an example flow of customer data manipulation in DSF. When a customer stores customer data in a single virtual volume, DSF manipulates the customer data through data operations. Through the creating data operation, the customer data is fragmented into DSF data and stored in DSF local storage. The name and location of the customer data is registered to a global registry. The global registry is a data set for the information on customer data.

NOTE 1 – DSF data is a manipulated customer data in DSF and is permanently stored on DSF local storage. It includes fragmented, encrypted and compressed customer data.

NOTE 2 – The information on customer data includes the location, size and attributes, etc. This information is taken from data operation metadata and storage management metadata.

According to customer requests to use data in a single virtual volume, the basic data operations such as creating, reading, updating, deleting, searching and sharing are performed by DSF.

Examples of basic data operations in DSF are described as follows:

– **creating**: fragmenting customer data, storing it to DSF local storage and registering data name and locations to the global registry;

– **reading**: searching for a data name and location in the global registry, loading fragmented data from the DSF local storage and combining the fragmented data;

– **updating**: searching for a data name and location in the global registry, updating customer data to DSF local storage, updating changes to the global registry;

– **deleting**: searching for a data location in the global registry, removing data location from the global registry and deleting fragmented data in the DSF local storage;

– **searching**: searching for a data name in the global registry;

– **sharing**: searching for a data name and changing an attribute in the global registry to share data.

6.2 Benefits of data storage federation

DSF provides not only a single virtual volume federated from DSF local storage, but also from a customer perspective beneficial features such as cost, technical function, service enhancement and resource utilization. Beneficial features include:

– **Easy storage management**: simplified management by using a single user interface and centralized monitoring.

– **Cost-effectiveness**: reduction of storage usage costs by moving rarely used customer data to a cheaper DSF local storage.

– **Performance enhancement**: improvement of data access performance by storing data to high-speed storages such as solid state disk (SSD), main memory, etc.

– **Data reliability**: increased reliability by replicating the data storing to another DSF local storage.

– **Storage scalability**: support of on-demand storage capacity by scaling storage resources.

– **Storage utilization efficiency**: increased of storage capacity by combining two or more DSF local storages to store a large sized file.

– **Data security**: stores secure data by splitting important files into multiple fragments and storing them on different DSF local storages.

– **Data management transparency**: convenient data management for data discovery, use of data without knowledge of data location, storage type and data format.

6.3 Configuration of logical components for data storage federation

Figure 6-3 shows the general configuration environment for logical components of DSF. The logical components consist of customer, storage connection, data manipulation, data distribution and storage, DSF local storage management, provision and policy management and DSF local storage including cloud and on-premises storage.


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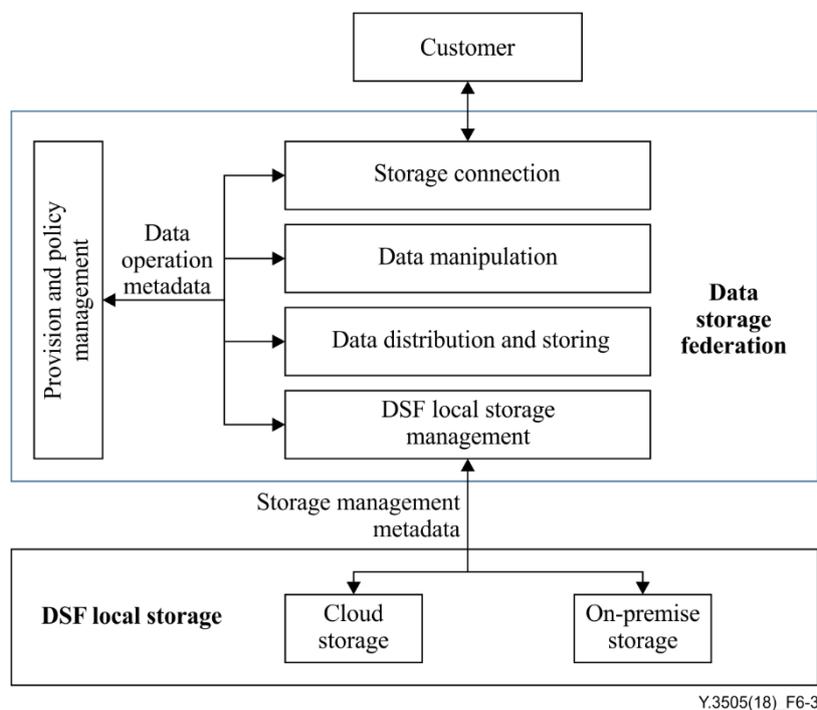
Figure 6-3 – General configuration for DSF

Storage connection component provides:

– an interface for a single virtual volume for a customer;

– a customer access mechanism to connect a single virtual volume;

NOTE 1 – The customer access mechanism includes the different types of protocols according to the storage type such as Internet small computer system interface (iSCSI) for block device storage, server message block (SMB), network file system (NFS), SSH file transfer protocol (SFTP), file transfer protocol (FTP) for file-based storage and the restful API for object-based storage, etc.

– corresponding protocols or I/O interfaces of a single virtual volume;

– performance acceleration of protocols.

Data manipulation component provides:

– virtual storage pool;

– configuration for virtual storage pool without considering the actual storage location of the data;

– the write buffer or read cache function for customer data;

– enhancement of the read and write response time using high-speed storages for buffer and cache;

NOTE 2 – The high-speed storage includes main memory, non-volatile memory express (NVMe), SSD and peripheral component interconnect express (PCIe) flash cards.

– data management for snapshots, fast replication and distributed transaction logs.

Data distribution and storing component provides:

– the optimization of writing data to DSF local storage to minimize writing and accessing time;

– data fragmentation to distribute and store in DSF local storage;

NOTE 3 – Data fragmentation is a method to distribute and store customer data in other storages.

– the encryption/decryption and compression/decompression of data fragments;

NOTE 4 – The encryption and compression are taken into account by customer's demands.

DSF local storage management component provides:

– connections to DSF local storage;

– storage tiering of data according to the storage performance, time of data usage and data access frequency;

NOTE 5 – Storage tiering is the action to distribute and collocate data across multiple storage tiers in a hierarchical manner.

NOTE 6 – This component automatically moves data between the various storage tiers according to the characteristics of the data.

NOTE 7 – When data is initially created, it is stored in high-speed storage. When data access frequency is low, it is moved to a lower-speed storage.

Provisioning and policy management component provides:

– the configurations and controls of logical components;

– the policy management of data storage and data manipulation;

NOTE 8 – Policy for data storage includes back-up, snapshot, scaling, recovery, data caching, thin-provisioning, tiering, storage type (file, block, object), etc.

NOTE 9 – Policy of data manipulation includes sharing support, read/write, replication, data migration, fragmentation, encryption, compression, de-duplication, etc.

– the provision of single virtual volume in a virtual storage pool.

Two kinds of metadata are shown in Figure 6-3 as follows:

– Data operation metadata is a description required to perform data operations. It includes the attributes of virtual storage pool and single virtual volume. It includes a transaction log and DSF data attributes of read/write caching, snapshot, replication, fragmentation, etc.

– Storage operation metadata is a description required to perform storage operations. It includes the location of DSF local storage, interface, API for customer data operation, read/write speed, storage capacity, etc.

6.4 Ecosystem of data storage federation

This clause identifies roles and sub-roles of the DSF ecosystem. In addition, relationships among roles and sub-roles are specified.
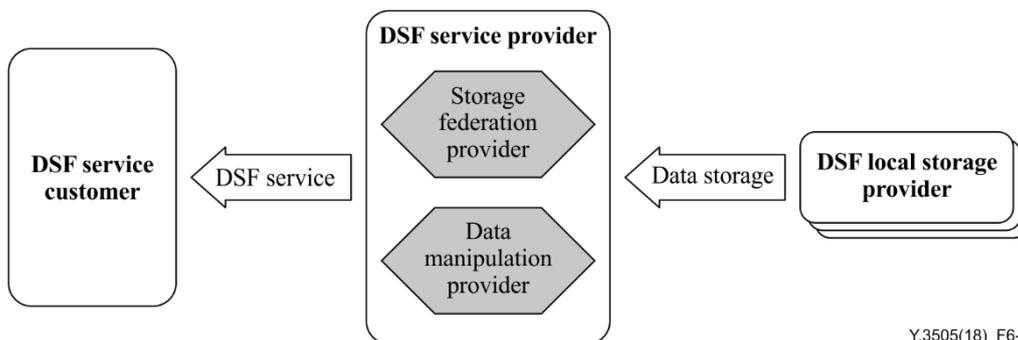
Figure 6-4 – Data storage federation ecosystem

DSF service is a service to provide single virtual volumes and policies and it is offered by a DSF service provider.

The DSF ecosystem includes the following roles as shown in Figure 6-4:

– DSF service customer;

– DSF service provider;

– DSF local storage provider.

6.4.1 DSF service customer

The DSF service customer uses a DSF service including a single virtual volume and policies from a DSF service provider. A DSF service customer's activity includes:

– Use of DSF service.

6.4.2 DSF service provider

The DSF service provider federates DSF local storages and provides a DSF service with an access mechanism.

The DSF service provider role consists of two sub-roles:

– Storage federation provider;

– Data manipulation provider.

6.4.2.1 Storage federation provider

The storage federation provider (SFP) provides a single virtual volume by federation of DSF local storages. A storage federation provider's activities include:

– provide virtual storage pool;

– provide single virtual volume;

–   manage storage management metadata;

–   manage data storage policy.

6.4.2.2   Data manipulation provider

The data manipulation provider (DMP) provides DSF data by manipulation and manages data operation metadata and data manipulation policy (see clause 6.3). A data manipulation provider's activities include:

–   manipulate DSF data;

–   manage data operation metadata;

–   manage data manipulation policy.

6.4.3   DSF local storage provider

The DSF local storage provider provides DSF local storage and interfaces to use it. A DSF local storage provider's activity includes:

–   provide DSF local storage.

7   Cloud computing based data storage federation system context

This clause describes how cloud computing can support the three main roles of the DSF ecosystem: DSF service customer, DSF service provider and DSF local storage provider.

By using cloud computing roles, sub-roles and activities, cloud computing based DSF supports more extensible features by facilitating on-premises storage resources which connect personal and enterprise storage resources.

The cloud computing based DSF context is defined with new sub-roles and activities based on cloud computing reference architecture (CCRA) [ITU-T Y.3502]. For cloud computing based DSF, CSP:storage federation provider (CSP:SFP) for federation of DSF local storage and CSP:data manipulation provider (CSP:DMP) for management of DSF data and policies are defined to utilize DSF local storage as shown in Table 7-1.

Table 7-1 – Mapping roles and sub-roles between data storage federation ecosystem and cloud computing based DSF system context

Roles and sub-roles of data storage federation ecosystem	Sub-roles of cloud computing based data storage federation system context
DSF service customer	CSC: cloud service user (CSC:CSU)
DSF service provider : storage federation provider, DSF service provider : data manipulation provider	CSP: storage federation provider (CSP:SFP), CSP: data manipulation provider (CSP:DMP)
DSF local storage provider	CSP: cloud service manager (CSP:CSM)

Figure 7-1 illustrates the cloud computing sub-roles related to DSF. This figure also identifies activities specific for DSF and assigns them to cloud computing sub-roles and illustrates how cloud computing supports DSF service from the perspective of CSP:SFP and CSP:DMP. The cloud computing based DSF utilizes other sub-roles of CSP.
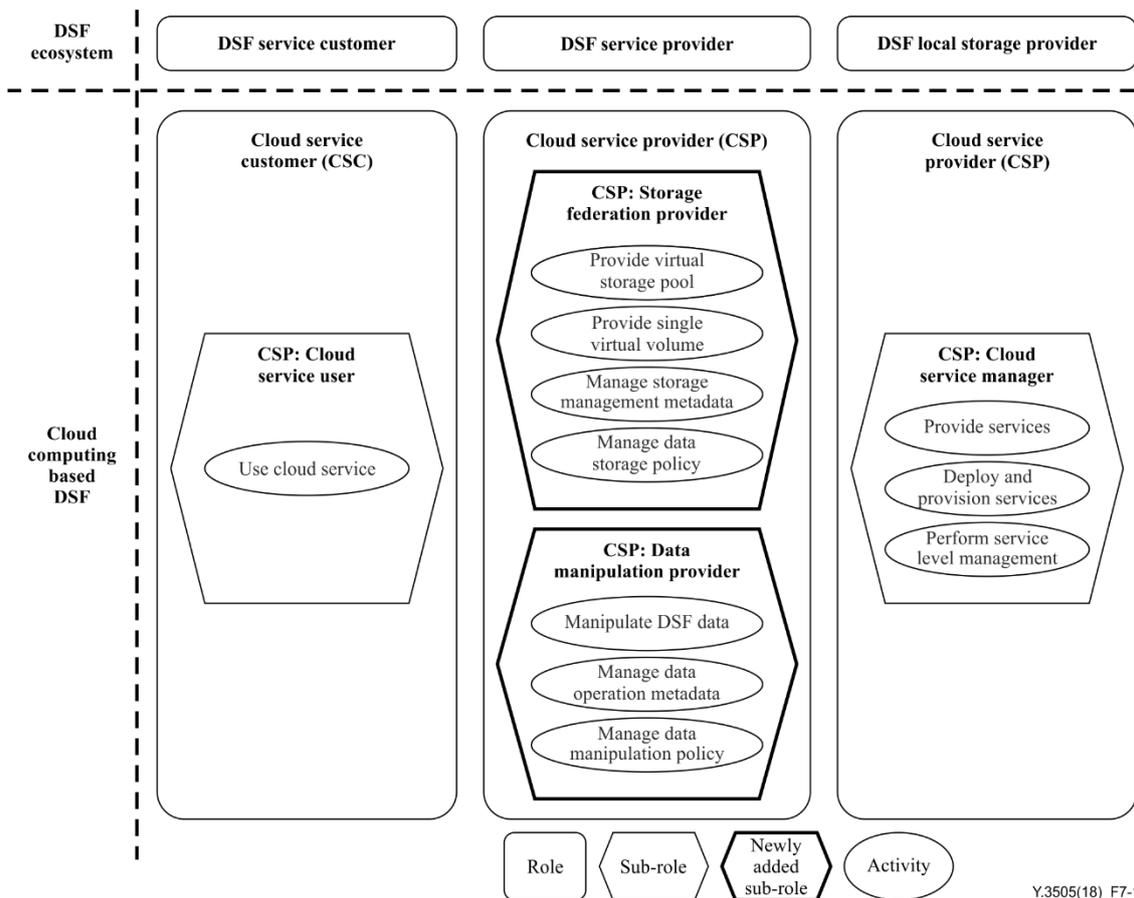
Figure 7-1 – Cloud computing based DSF context and its relationship with DSF ecosystem

7.1 CSP:storage federation provider (CSP:SFP)

CSP:storage federation provider (CSP:SFP) is responsible for the federation of DSF local storage. CSP:SFP's activities include:

–   provide virtual storage pool;

–   provide single virtual volume;

–   manage storage management metadata;

–   manage data storage policy.

7.1.1 Provide virtual storage pool

This activity involves integrating and managing DSF local storage to make a logical storage.

This activity involves:

–   performing storage operation (see clause 6.1);

–   managing virtual storage pool;

–   delegating customer credentials of DSF local storage.

7.1.2 Provide single virtual volume

This activity involves providing and processing a way to use a single virtual volume for a CSC:CSU.

This activity involves:

–   managing single virtual volume;

–   providing a user access mechanism for CSC:CSUs;

–   performing storage operation (see clause 6.1).

7.1.3   Manage storage management metadata

This activity involves creating, updating and deleting metadata (see clause 6.3) for a virtual storage pool and single virtual volume.

This activity involves:

–   creating storage management metadata of DSF data;

–   updating storage management metadata on changes;

–   deleting storage management metadata.

7.1.4   Manage data storage policy

This activity involves management of data storage policy.

This activity involves:

–   creating data storage policy;

–   triggering data storage policy;

–   updating data storage policy;

–   deleting data storage policy.

7.2   CSP:data manipulation provider (CSP:DMP)

CSP:data manipulation provider (CSP:DMP) is responsible for operation for DSF data and management of data manipulation policy. CSP:DMP's activities include:

–   manipulate DSF data;

–   manage data operation metadata;

–   manage data manipulation policy.

7.2.1   Manipulate DSF data

This activity involves DSF data operation for CSC:CSU by data virtualization.

This activity involves:

–   performing data operation (see clause 6.1).

NOTE 1 – Data virtualization is an abstraction of multiple data resources into the logical data resource.

NOTE 2 – Multiple data resources include object storage, file storage and block storage.

7.2.2   Manage data operation metadata

This activity involves creating, updating and deleting metadata (see clause 6.3) for DSF data.

This activity involves:

–   creating data operation metadata of DSF data;

–   updating data operation metadata on changes;

–   deleting data operation metadata.

7.2.3   Manage data manipulation policy

This activity involves management of data manipulation policy.

This activity involves:

–   creating data manipulation policy;

–   triggering data manipulation policy;

–   updating data manipulation policy;

–   deleting data manipulation policy.

8   Functional requirements for data storage federation

This clause describes the requirements for data storage federation.

8.1   Storage connection requirements

(1)   It is required that CSP:SFP provide an interface to connect DSF local storage.

> NOTE 1 – The interface to DSF local storage refers to the direct interfaces (i.e., object or block storage interface), or a proxy interface to configure several types of storages interface with a software program.

> NOTE 2 – The software program includes software agent, daemon, web worker and RESTful API for an interface to DSF local storage.

> NOTE 3 – The proxy interface connects DSF local storage by automatically detecting the interface with a software program.

(2)   It is required that CSP:SFP provide a user interface for CSC:CSU to use a single virtual volume.

> NOTE 4 – User interface includes graphical user interface, web application, or specific client for CSC:CSU to access a single virtual volume.

(3)   It is recommended that CSP:SFP support the change of CSC:CSU's access mechanism according to the storage type of single virtual volume.

(4)   It is required that CSP:DMP provide translation between data operation and a corresponding interface of DSF local storage.

> NOTE 5 – Corresponding interface include API, I/O interface, etc.

(5)   It is recommended that CSP:SFP provide a secure access mechanism to use a single virtual volume for CSC:CSU.

(6)   It is required that CSP:DMP provide the registration of the CSC:CSU's requirements.

> NOTE 6 – The requirements of CSC:CSU include data storage capacity, access mechanism, storage types of single virtual volume, policy, etc.

(7)   It is required that CSP:SFP provide the seamless connection of DSF local storage interface to communicate with DSF local storage.

8.2   Data manipulation requirements

(1)   It is required that CSP:DMP provide the execution of CSC:CSU's create, read, update, delete (CRUD) data operation.

> NOTE 1 – CRUD data operation includes create, read, update and delete data.

(2)   It is required that CSP:DMP provide a search data operation from CSC:CSU's data using query to a global registry.

(3)   It is recommended that CSP:DMP provide a sharing data operation by updating of sharing status of DSF data in a global registry after checking sharing status of DSF data.

> NOTE 2 – Data sharing means that the same DSF data is shared during data operation.

> NOTE 3 – Sharing status of DSF data is information about whether DSF data is shared or not.

(4)   It is recommended that CSP:DMP provide the capacity saving of data storage using de-duplication of DSF data.

(5)   It is recommended CSP:DMP provide DSF data encryption/decryption for data transfer to DSF local storage.

(6)   It is required that CSP:DMP provide data recovery of CSC:CSU from system failure.

NOTE 4 – Data recovery refers to restoring the most recently used CSC:CSU's data preventing data loss due to errors from the storage and network connection failure.

(7)   It is recommended that CSP:DMP provide DSF data migration to available DSF local storage for resilience and cost efficiency of the storage space.

NOTE 5 – The data migration for the resilience and cost efficiency of the data storage space is automatically performed without user intervention or recognition.

(8)   It is required that the CSP:DMP provide the validation of DSF data on data operation to check the data integrity.

(9)   It is required that CSP:DMP support CSC:CSU's data consistency for replicated DSF data.

NOTE 6 – The data consistency means that CSP:DMP correctly backup current DSF data in order to recover CSC:CSU's data on storage failure.

(10)   It is required that CSP:DMP support CSC:CSU's data transparency.

NOTE 7 – The data transparency means to access CSC:CSU's data without knowing location.

8.3   Storage federation requirements

(1)   It is recommended that CSP:SFP provide the performance information of DSF local storage from storage management metadata.

NOTE 1 – Performance information are read/write I/O speed, network bandwidth, storage capacity, storage types, etc.

(2)   It is recommended that CSP:SFP provide virtual storage pool optimization considering the performance of DSF local storage.

NOTE 2 – Virtual storage pool optimization includes storage mirroring, storage prioritization, CSC:CSU's access geo-location and their combinations.

(3)   It is recommended that CSP:SFP provide single virtual volume optimization based on CSC:CSU's purpose.

NOTE 3 – Single virtual volume optimization include storage size, data safety, storage performance, mobility of the usage environment and their combinations.

(4)   It is required that CSP:SFP provide the configuration of single virtual volume from CSC:CSU requests.

(5)   It is required that CSP:SFP provide a read/write cache to access data.

NOTE 4 – The read/write cache enables to enhance the performance of the storage and the device storing the data is used by various devices for fast cache operation.

NOTE 5 – The various devices for fast cache are main memory, RAM based disk, SSD, etc.

(6)   It is recommended that CSP:SFP provide hierarchical cache management using cache multi-tiering.

NOTE 6 – Cache multi-tiering means that for the high-speed access, cache hierarchy is extended to various devices for fast caching.

NOTE 7 – For capacity limit, if a main-memory cache area is exhausted, it is automatically expanded to a RAM based disk cache and expanded to SSD cache.

NOTE 8 – When CSC:CSU performs the data operation, the data operation is performed in the memory area in advance for fast write response.

(7)   It is required that CSP:SFP provide the backup of global registry for high availability.

NOTE 9 – The backup of the global registry is synchronized with most recently updated CSC:CSU's data.

(8)   It is recommended that CSP:SFP provide in-parallel access to DSF local storage.

(9)   It is required that CSP:SFP provide the registration of CSC:CSU's credentials to a DSF local storage.

(10)   It is recommended that CSP:SFP support monitoring the performance information of DSF local storage.

(11)   It is required that CSP:SFP provide the management of DSF local storage interface.

(12)   It is recommended that CSP:SFP support access to the secured storage interface for DSF local storage.

(13)   It is required that CSP:SFP provide the storage operation for DSF local storage.

        NOTE 10 – Storage operation for DSF local storage includes create, delete, scaling, partitioning and checking volume, etc.).

(14)   It is required that CSP:SFP provide scaling of single virtual volume on CSC:CSU demand.

8.4   Metadata and policy management requirements

(1)   It is recommended that CSP:SFP provide a configuration of a single virtual volume by data storage policy for CSC:CSU.

(2)   It is recommended that CSP:SFP provide default data storage policies when policy is not configured.

        NOTE 1 – Default data policy is reconfigured by customer's requests.

(3)   It is recommended that CSP:DMP provide a transformation of DSF data by data manipulation policy.

        NOTE 2 – Data manipulation policy for transformation of DSF data includes the policies of fragmentation, encryption, compression, de-duplication, etc.

(4)   It is recommended that CSP:DMP provide a default data manipulation policy.

(5)   It is required that CSP:SFP provide a global registry for customer data access.

(6)   It is required that CSP:SFP provide high-speed access of global registry.

(7)   It is required that CSP:DMP provide management of data operation metadata automatically according to execution of data operation.

(8)   It is required that CSP:SFP provide storage management metadata to communicate with DSF local storage.

9   Security considerations

It is recommended that the security framework for cloud computing described in [b-ITU-T X.1601] be considered for data storage federation. [b-ITU-T X.1601] analyses security threats and challenges in the cloud computing environment and describes security capabilities that could mitigate these threats and meet security challenges.

[b-ITU-T X.1631] provides guidelines supporting the implementation of information security controls for cloud service customers and cloud service providers. Many of the guidelines guide the cloud service providers to assist the cloud service customers in implementing the controls and guide the cloud service customers to implement such controls. Selection of appropriate information security controls and the application of the implementation guidance provided, will depend on a risk assessment as well as any legal, contractual, regulatory or other cloud-sector specific information security requirements.

It is also recommended that the guidelines for cloud service customer data security described in [b-ITU-T X.1641] be considered. It provides generic security guidelines for the cloud service customer (CSC) data in cloud computing, analyses the CSC data security lifecycle and proposes security requirements at each stage of the data lifecycle.

Appendix I

Use case of data storage federation

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

I.1 Storing a user file dispersedly

Title	Storing a user file dispersedly
Description	In this scenario, a data storage customer having two data storages on DSF local storage requests a large file storing from a DSF service provider. The DSF service provider splits the file into several parts in case that DSF local storage have not enough space (Case 1) or needs to access it in parallel for better performance (Case 2) and stores the parts into different distributed DSF local storages.
Role/Sub-role	DSF service provider (CSP:SFP) DSF service customer (CSC:CSU)
Figure (optional)	Case 1: limited capacity of data storage in DSF local storage Y.3505(18)_FI.1-1 Case 2: CSC:CSU's parallel access requirement Y.3505(18)_FI.1-2
Pre-conditions (optional)	– CSP:SFP is available to access DSF local storage. – CSC:CSU requests a single virtual volume to CSP:SFP.
Post-conditions (optional)	
Derived requirements	– Clause 8.1 requirement (2) – Clause 8.4 requirement (2) – Clause 8.1 requirement (4)
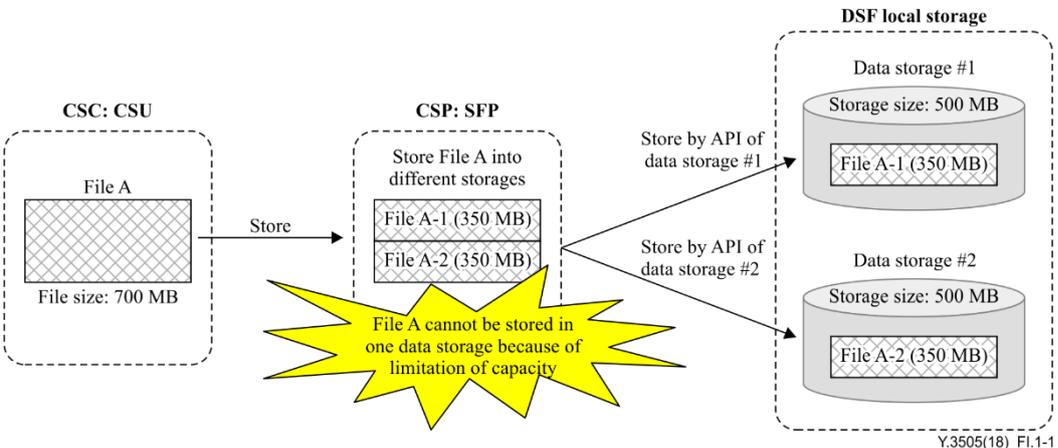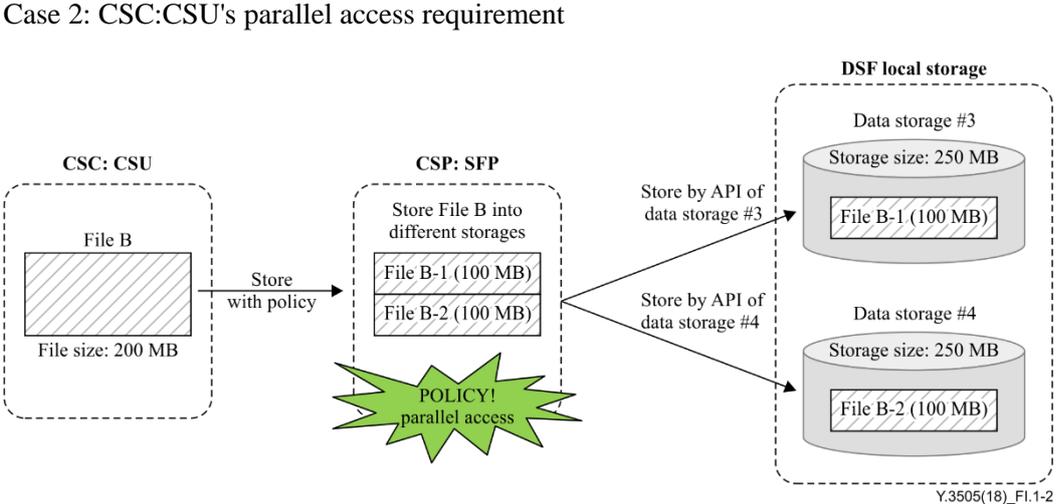
I.2 Data sharing between customers

Title	Data sharing between customers
Description	In this scenario, the DSF service customer #1 stored file A~D with data sharing mode policy setting. The file A is non-sharing mode, the file B is read-only data sharing mode, the file C is over-writable data sharing mode and the file D is replicable data sharing mode. The other DSF service customer #2 uses file A~D with data sharing policy set by DSF service customer #1. DSF service customer #2 cannot access file A because of non-sharing mode policy setting and DSF service customer #2 can read file B but it is not writable. In file C case, DSF service customer #2 can overwrite it and store it with changes. In file D case, by a replication request by DSF service customer #2, the original file D is preserved and a new file E is generated and stored to DSF service customer #2's single virtual volume.
Role/sub-role	DSF service provider (CSP:DMP) DSF service customer (CSC:CSU)
Figure (optional)	
Pre-conditions (optional)	
Post-conditions (optional)	
Derived requirements	− Clause 8.1 requirement (2)

I.3 Multiple storage types and access mechanisms for data access

Title	Multiple storage types and access mechanisms for data access
Description	In this scenario, a DSF service customer requests a variety of service interfaces and storage types from a DSF service provider. Also, the DSF service provider provides service interfaces to the DSF service customer with the corresponding access mechanisms.
Role/Sub-role	DSF service customer (CSC:CSU) DSF service provider (CSP:SFP, CSP:DMP)

Title	Multiple storage types and access mechanisms for data access
Figure (optional)	
Pre-conditions (optional)	– CSC:CSU use its own storage types – CSC:CSU can be general users (which own storage individually), some application programs, application servers and another cloud system.
Post-conditions (optional)	
Derived requirements	– Clause 8.4 requirement (3) – Clause 8.1 requirement (3)

I.4   Policy-driven provision and management of DSF local storage

Title	Policy-driven provision and management of DSF local storage
Description	A DSF service provider manages and provides a single virtual volume based on DSF local storage policies. The DSF service provider organizes DSF local storage policies by using default policies configured by DSF service provider and re-configured by DSF service provider from multiple data storages. That is, the DSF service provider's policies are dependent on storage provider storage policies in DSF local storage. DSF service provider provides the default policies as multiple options (e.g., backup, replication, snapshot, auto-scaling and storage type). DSF service customer selects options and DSF service provider applies options onto metadata. The options are matched onto corresponding storage policies in DSF local storage. The DSF service provider manages the DSF local storage by matched functions onto storage policies. All communications with DSF local storage between the DSF service provider and DSF local storage provider are performed by storage APIs.

Title	Policy-driven provision and management of DSF local storage
Role/Sub-role	DSF service customer (CSC:CSU) DSF service provider (CSP:SFP, CSP:DMP) DSF local storage provider (CSP:CSM)
Figure (optional)	 Y.3505(18)_FI.4
Pre-conditions (optional)	
Post-conditions (optional)	
Derived requirements	– Clause 8.4 requirement (1) – Clause 8.4 requirement (4)

I.5 Policy-driven provisioning and management of data

Title	Policy-driven provisioning and management of data
Description	DSF service provider provides a unified interface to use DSF local storage and options to set data manipulation policies. DSF service provider configures the data manipulation policies because the data manipulation policies are independent from multiple data storages in DSF local storage. DSF service customer uses a single virtual volume (e.g., upload, download, copy, modify, delete and so on) and sets data manipulation policies (e.g., non-sharing, read-only, overwrite, replicate and so on) to saved files. DSF service provider applies data manipulation policies onto data operation metadata. DSF service provider manipulates data by corresponding functions and APIs with data manipulate policies. DSF service customer #1 sets data manipulation policy. DSF service provider modifies data operation metadata of target data. Another DSF service customer (e.g., DSF service customer #2) searches and gets data by using catalogue. In this procedure, the data operation metadata is used in order to lookup data from DSF local storage.
Role/Sub-role	DSF service customer (CSC:CSU) DSF service provider (CSP:SFP) DSF locals storage provider (CSP:CSM)

Title	Policy-driven provisioning and management of data
Figure (optional)	
Pre-conditions (optional)	− Policies for data storage are configured by CSP:SFP and selected by CSC:CSU, or set to default. − CSC:CSU save files on a single virtual volume.
Post-conditions (optional)	
Derived requirements	− Clause 8.1 requirement (7) − Clause 8.2 requirement (2) − Clause 8.2 requirement (3)

I.6 Data virtualization CSP:SFP

Title	Data virtualization by CSP:SFP
Description	This scenario shows data virtualizations through the description of read and write data. DSF service customer #1 writes a file through the DSF service. DSF service provider prepares to write data because file A, shown in Figure 1, is saved on a single virtual volume. As the preparation information (e.g., owner, policies and corresponding APIs of data storage, etc.), data operation metadata for the file A is generated. The file A namely data A, is saved and managed by the data operation metadata, such as number of data portioning, data location, etc. In this procedure, the file A was abstracted for data provisioning and management by policies. DSF service customer #1 reads a file through the DSF service. DSF service provider gathers data based on the data operation metadata. DSF service provider aggregates partitions of data and then data is provided to DSF service customer #1. It is possible for the provided data to be used again. Therefore, the data is cached and reflected on data operation metadata. For this reason, DSF service customer #2 quickly reads the cached data. In this procedure, data A was virtualized because the partitioned data A was aggregated as if originally single data A was and then was used for multiple DSF service customers. That is, DSF service customer #1 and #2 read same data.
Role/Sub-role	DSF service customer (CSC:CSU) DSF service provider (CSP:SFP) DSF local storage provider (CSP:CSM)

Title	Data virtualization by CSP:SFP
Figure (optional)	Figure 1 – Writing data by abstracting data Figure 2 – Read data by virtualized data
Pre-conditions (optional)	– CSC:CSU has one or more data storage. – CSC:CSU sets policies for DSF local storage. – The data A is shared in Figure 2.
Post-conditions (optional)	
Derived requirements	– Clause 8.4 requirement (7) – Clause 8.4 requirement (7) – Clause 8.4 requirement (8) – Clause 8.1 requirement (2) – Clause 8.2 requirement (10) – Clause 8.2 requirement (9)

I.7 Efficient data storage management

Title	Efficient data storage management
Description	As shown in Figure 1, DSF service provider efficiently manages data to support better storage access performance and to reduce management burden. Tiering is a technique to fulfil efficient data management. By organizing tiered caches, frequently accessed files are stored in high speed cache. While access files are rarely stored in a low speed cache. Cached files are stored on corresponding data storages by managed API. As shown in Figure 2, a DSF service customer saves a same file on a single virtual volume. To avoid waste of data storage capacity DSF service provider performs a de-duplicate data operation. For example, when a file is stored, data replication checking is accomplished. As the result of the checking, a file is stored. If a same file is already stored, the file is managed by data operation metadata.
Role/Sub-role	DSF service customer (CSC:CSU) DSF service provider (CSP:SFP)
Figure (optional)	 **Figure 1 – Tiered caches for access performance** **Figure 2 – De-duplication data for saving storage capacity**
Pre-conditions (optional)	

Title	Efficient data storage management
Post-conditions (optional)	
Derived requirements	– Clause 8.3 requirement (10) – Clause 8.3 requirement (6) – Clause 8.2 requirement (4)

I.8 The data read/write cache and parallel distributed file for performance enhancement

Title	The data read/write cache and parallel distributed file for performance enhancement
Description	DSF service provider provides a cache function for data stored in a public cloud storage. Data stored in public cloud storage is slower than on-premises storage because data is transmitted over the Internet. In addition, since the data is automatically distributed to the public cloud storage in the state DSF service customer does not recognize, the data stored in the public cloud storage needs a high-speed access function. DSF service provider caches the data stored in the public cloud storage to the storage device inside the cloud integrated storage operating platform to provide an on-premises storage-level access speed to the public cloud storage.
Role/Sub-role	DSF service provider (CSP:SFP, CSP:DMP) DSF local storage provider (CSP:CSM)
Figure (optional)	 NOTE – This figure is aligned with logical component.
Pre-conditions (optional)	– CSC:CSU requests single virtual volume to CSP:SFP and has own data storage. – CSP:SFP provide storage system, appliance or device to federate the other storages
Post-conditions (optional)	

Title	The data read/write cache and parallel distributed file for performance enhancement
Derived requirements	– Clause 8.3 requirement (5) – Clause 8.4 requirement (16) – Clause 8.3 requirement (7) – Clause 8.2 requirement (5) – Clause 8.3 requirement (8) – Clause 8.3 requirement (9)

I.9 Data storage federation and management

Title	The use case for data storage federation and management
Description	In this scenario, it is a use case for one storage system connected to various storage types. In the figure on this use case, no matter what type of storage the storage system has, the DSF service customer is seen as the federated storage and DSF service customer does not care about what storage they use. Thus, a federated storage system or appliance in this figure is responsible for making multiple storage systems of a storage visible to a single system. Similarly, management has a unified management interface.
Role/Sub-role	DSF service customer (CSC:CSU) DSF service provider (CSP:SFP/DMP) DSF local storage provider (CSP:CSM)
Figure (optional)	
Pre-conditions (optional)	– CSC:CSU requests a data storage to DSF service provider and has own data storage. – CSP:SFP provide storage system, appliance or device to federate the other storages
Post-conditions (optional)	
Derived requirements	– Clause 8.2 requirement (7) – Clause 8.3 requirement (14) – Clause 8.1 requirement (2) – Clause 8.2 requirement (6) – Clause 8.4 requirement (5) – Clause 8.1 requirement (8) – Clause 8.2 requirement (8)
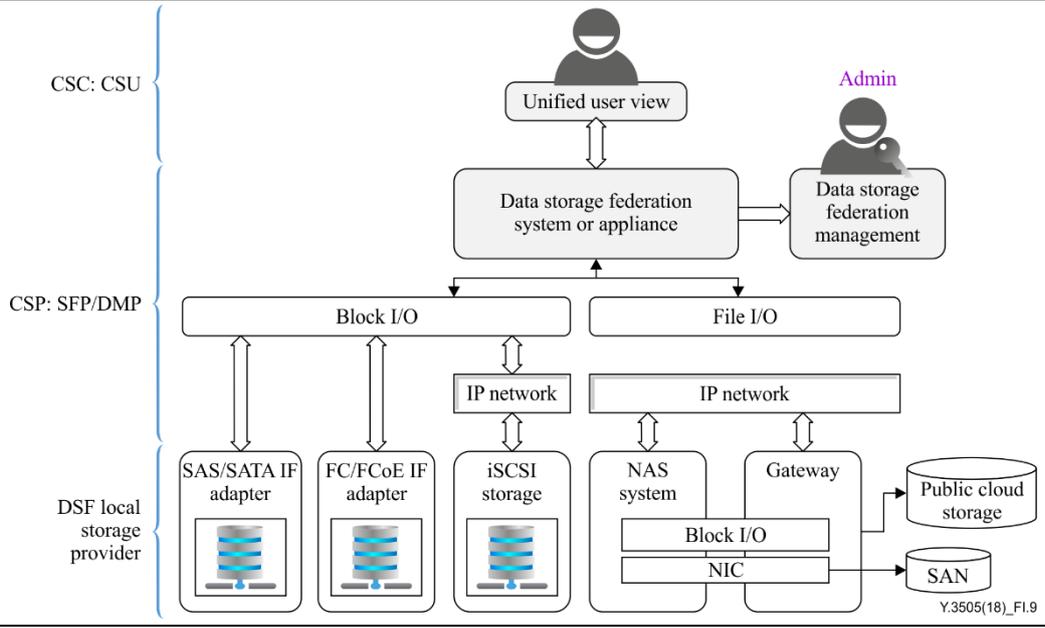
I.10   A use case of storage optimization

| Title	A use case for storage optimization based on the customer's purpose in data storage federation
Description	When a DSF local storage provider provides the information of his/her cloud storage services with a DSF service provider, the DSF service provider optimizes a single virtual volume according to the requirements of the user, such as data safety and storage performance. A detailed explanation is as follows: The DSF service provider configures the single virtual volume based on the cloud storages provided by DSF local storage provider. The following optimization policies can be applied and the decision of the optimization policy can be done by the DSF service customer according to his requirements. (1) The DSF local storage provider registered multiple cloud storages to the DSF service provider. (2) DSF service provider provides optimization tool for a single virtual volume. (3) DSF service customer chooses optimization policy related with; A. **data safety and storage performance (a)**: DSF service providers provide a binding function that configures a virtual, single data storage for efficient management of distributed data storage that is available to customers. In addition, DSF service providers provide real-time monitoring of the performance of each data storage and use it with a mirroring mechanism to provide optimized services for stability and performance. For example, when a DSF service customer uses his or her own data, virtual data storage provides a service by selecting a data storage that can provide optimal service among the mirrored data storage; B. **enhancement of performance without storage mirroring (b)**: DSF service provider provides real-time performance monitoring for each data storage. Using this, the DSF service provider determines the priority of the data storage that can provide the optimal service and then transfers the data to that storage in appropriate timing. Therefore, customers can always receive service from optimal data storage; C. **enhancement of performance considering user mobility (c)**: Basically, since the DSF service is affected by the data transmission performance of the network, the performance of the DSF service can be greatly influenced by the location of the customer. Therefore, the DSF service provider provides optimization not only for the performance for each data storage but also for the network situation at the user's location. Virtual data storage provides real-time switching function to the best possible data storage depending on the customer's location. (4) Based on the optimization policy selected by the customer, the DSF service provider optimizes the service. After this processing, (5) DSF service customers use services optimized for their purposes.
Role/Sub-role	DSF service provider (CSP:SFP) DSF service customer (CSC:CSU) DSF local storage provider (CSP:CSM)

Title	A use case for storage optimization based on the customer's purpose in data storage federation
Figure (optional)	 a) Mirroring and binding storage for data safety and performance b) Prioritization of data storages and move data for performance c) Real-time prioritization and switching data storage related with user's access geo-location for performance Y.3505(18)_FI.10
Pre-conditions (optional)	– CSP:SFP has an access interface with multiple DSF local storage.
Post-conditions (optional)	

Title	A use case for storage optimization based on the customer's purpose in data storage federation
Derived requirements	– Clause 8.1 requirement (1) – Clause 8.3 requirement (1) – Clause 8.3 requirement (2) – Clause 8.3 requirement (3)

I.11 The use case for data storage federation management

Title	The use case for data storage federation management
Description	The management is generally separate from the data path and the management control path and management is driven through the provisioning and policy management. The management provides the ability to display, create, modify and delete the contents of on-premises and public cloud services integrated into a single storage. In backend storage management, the storage configuration is different from the on-premises and the public cloud storage service. The interfaces for backend storage are made in the form of the separate software daemon. When there are multiple cloud storage devices, DSF local storage management can be configured and a proxy interface can be configured to interface with them and an interface for registering and using on-premises storage is provided.
Role/Sub-role	DSF service customer (CSC:CSU) DSF service provider (CSP:SFP/DMP) DSF local storage provider (CSP:CSM)
Figure (optional)	 Y.3505(18)_FI.11
Pre-conditions (optional)	– Each logical component consists of one server or several servers. – Each logical component is organized into a network through servers, virtual machines or containers
Derived requirements	– Clause 8.3 requirement (11) – Clause 8.1 requirement (5)

I.12 Registration of data storage for federation service

Title	Registration of data storage for federation service
Description	A DSF service customer requests data storage service from a DSF service provider. For the data storage registration, DSF service customer logs in through the already registered authentication information and registers the cloud storage and on-premises storage to use. The registration process is provided by DSF service provider through the graphical user interface (GUI). DSF service customer registers the service name, storage specification, data storage service protocol and cloud storage name and cloud storage type through the GUI for setting virtual data storage and creates the virtual data storage.
Role/Sub-role	DSF service customer (CSC:CSU) DSF service provider (CSP:SFP/DMP)
Figure (optional)	 CSC: CSU for single virtual volume Login Registering for cloud storage Registering for On-premise storage Setting single virtual volume Invoking single virtual volume Y.3505(18)_FI.12 The example operation of CSP for data storage service
Pre-conditions (optional)	– CSC:CSU for virtual data storage is a registered user to CSP:DMP. – CSP:DMP has each of the cloud storage service interfaces
Derived requirements	– Clause 8.1 requirement (6) – Clause 8.3 requirement (4)
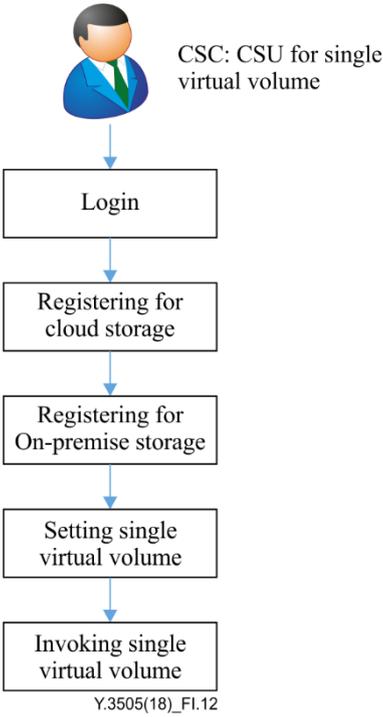
Appendix II

Comparison analysis between cloud computing and data storage federation

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

Table II.1 shows the mapping between data storage federation ecosystem and the CCRA user view. The DSF service customer has two sub-roles and these sub-roles are mapped onto the CSC:cloud service user because two sub-roles have a relationship of using service. The DSF local storage provider and CSP:cloud service manager and CSP:cloud service operations manager, which provide data storage, are mapped in the perspective of providing service. However, for the DSF service provider, the additional considerations in data storage perspective are needed in cloud computing. To federate and provide data storage from DSF local storages, such as cloud storage and non-cloud storage, they are properly described in CSP as new sub-roles, activities and involvements.

Table II.1 – Mapping between data storage federation ecosystem and CCRA user view

ITU-T Y.3505 (DSF)		ITU-T Y.3502 (Cloud computing)		Note
Roles	**Activities**	**Sub-roles**	**Activities**	
DSF service customer	• use DSF service	CSC:cloud service user	• use cloud service	• The additional considerations in data storage and data perspective on the federated storage environment are needed.
DSF service provider	• provide virtual storage pool • provide single virtual volume • manage storage management metadata • manage data storage policy	–	–	• The additional considerations in data storage perspective are needed as sub-roles and activities in CSP. • The sub-roles and activities support the data storage federation service.
	• manipulate DSF data • manage data operation metadata • manage data manipulation policy	–	–	• The additional considerations in data storage perspective are needed as sub-roles and activities in CSP. • The sub-roles and activities support the data storage federation service.
DSF local storage provider	• provide DSF local storage	CSP:cloud service manager	• provide services e	• Activities and their involvements of the two sub-roles in ITU-T Y.3502 are supported to provide cloud data storage.

Bibliography

[b-ITU-T X.1601]   Recommendation ITU-T X.1601 (2015), *Security framework for cloud computing.*

[b-ITU-T X.1631]   Recommendation ITU-T X.1631 (2015), *Information technology – Security techniques – Code of practice for information security controls based on ISO/IEC 27002 for cloud services.*

[b-ITU-T X.1641]   Recommendation ITU-T X.1641 (2016), *Guidelines for cloud service customer data security.*

[b-ISO/IEC 2382]   ISO/IEC 2382 (2015), *Information technology – Vocabulary.*

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